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Spatial equilibrium and regional comparative advantages in American agriculture

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CHAPTER I. INTRODUCTION

In recent years, economists have been trying to make operational the highly abstract Walrasian concept of one point spaceless general equilibrium by simplifying assumptions and introducing an additional dimension of space. In the spatial equilibrium analysis, there are at one extreme the abstract general equilibrium of continuous location type (Isard, 1952) and, at the other, the basically empirical and completely determinate interregional input-output models (Liontief, 1953). In between the two extremes is the linear programming interregional competition model which, like the general spatial equilibrium model, provides a mechanism for optimizing shipping patterns and allowing substitution between different activities of production, and which, like the input-output model, is based on a linear homogeneous production function, but without its fixed shipping patterns among regions. (Stevens 1958.)

Contributions towards making spatial equilibrium analysis operational were exemplified by (1) Koopmans-Hichcock's transportation model (Koopmans, 1949) which can be generalized to application to problems other than transportational; (2) Samuelson's Enke-Samuelson model of spatial price equilibrium using linear programming (Samuelson, 1952); (3) Isard's general location principle of a continuous space-economy (1952); (4) Koopmans-Beckman's model of location assignment (1957); (5) Lefeber's discussion of allowing both location and transport cost to vary (1958); (6) Takayama-Judge's quadratic programming model solving equilibrium prices and quantities simultaneously (1964); and (7) Plessner-Heady's (1965) quadratic programming model for agriculture.

The ability of linear programming to analyze the interrelationships among activities and constraints among regions gives it overwhelming advantage for regional analysis. However, to facilitate application of linear programming to spatial equilibrium analysis, it is often assumed that either demand or supply is inelastic. When inelasticity is assumed for neither demand nor supply, solving a series of linear programs is necessary in order to approximate an equilibrium (Fox, 1953).

Empirical studies of spatial equilibrium using linear programming have been made by Henderson (1955, 1956) on the coal industry using cost-minimizing approach, and assuming inelastic demand; by Fox-Taeuber (1955) on livestock and feeds using two linear programming models (one for livestock; the other for feeds) with iterative solving of the models to determine the equilibrium prices, quantities and trade patterns; by Heady-Egbert (1962) on wheat and feed grains using both cost-minimizing and profit-maximizing approaches and assuming inelastic demand. Hall-Heady (1971) applied quadratic programming to agricultural sector to determine equilibrium prices, and equilibrium production, consumption and shipping patterns, by allowing elastic demand and supply.

Spatial Equilibrium Analysis in Agriculture

Agriculture is one of the few industries that closely approximate perfect competition, and, therefore, is suitable for spatial equilibrium analysis. American agriculture is characterized by rising productivity, accumulation of product surpluses, over-capacity, and price support and production control policies adopted to bolster farm incomes and curtail surplus accumulation. However, such price support and production control policies tend to hinder regional adjustments towards spatial equilibrium in response to changing demand or to differential rates of technological progress in different regions, because (a) pricing policies may encourage regions with diminished comparative advantage to retain specialization in particular products, and (b) production control policies through acreage allotments may prohibit a region from becoming more specialized in the production of a crop or may prevent crop specialization from shifting into new regions where technological or price change now affords comparative advantage. Besides exerting such restraining forces on the interregional adjustment of production, the price policy has caused an excess acreage to be devoted to particular crops, and, thus an accumulation of surplus stocks by the public.

One possible policy to solve these problem is to divert public funds from price support and surplus storage to retiring resources from production and to allowing interregional adjustments to bring production into line with changing demand and comparative advantages. Therefore, it is a legitimate interest to ascertain the spatial equilibrium allocation of production, shipping patterns and excess capacity that would exist in the absence of the various price support and production control programs, or under various assumptions about the pricing and control programs.

Since the mid 1950's a series of spatial equilibrium studies of American agriculture have been done at Iowa State University under the direction of Professor Earl O. Heady to determine, under various assumptions, its optimum resource allocation, shipping patterns among regions, excess capacity and adjustments to assumed projected changes in demand, technology or resource supply.

This series of studies consist of work by Egbert (1958), Heady-Egbert (1959, 1962), Egbert-Heady(1961, 1963, 1964), Skold (1963), Whittlesey (1964), Heady (1965), Heady-Skold (1965), Heady-Whittlesey (1965), Brokken (1965), Plessner-Heady (1965), Skold-Heady (1966), Whittlesey-Heady (1966), Mayer (1967), Heady-Mayer (1967), Brokken-Heady (1968), Hall-Heady-Plessner (1968), Mayer-Heady (1969), Hall (1969), Eyvindson (1970), Heady-Hall (1971), and Hall-Heady (1971). The series started with studies on crops only, were later expanded to include livestock products (Brokken, 1965; Brokken-Heady 1968), and culminated in the Eyvindson-Heady model (Eyvindson, 1970) which included 6,837 equations and 41,677 real variables and encompassed all Commercial Farms Classes I to V (U.S. Census of Agriculture, 1964) in the continental United States delineated into 21 consuming regions and 157 producing areas with each area having 3 land quality classes, 3 farm sizes, and a potential of 5 crops (wheat, feed grains, soybeans, cotton, hay) and 3 livestock products (milk, beef, pork).

Linear programs were used and inelastic demand were assumed in all the above-mentioned empirical studies except the one by Hall-Heady (Hall, 1969; Hall-Heady, 1971) which assumed elastic demand and supply and used a quadratic program to solve for equilibrium price and quantities. Comparative statics, a powerful technique, was employed in most of the linear program studies to evaluate the impact of changes in technology or the levels of constraints on production and shipping patterns. It permits studies of simulation of real world situation by various policy models, analogous to controlled experiments in physical sciences, for better understanding of equilibrium solutions and the interdependency among activities and constraints in different producing areas and consuming regions under various assumed circumstances. Resource (land) allocations have been thoroughly studied under various assumptions.

Application of mathematical programming to spatial equilibrium analysis has not yet known its limits. A mathematical programming model may be used to measure the magnitude of changes in technology (an exogenous variable) required to achieve a certain target---say, equal farm income for different regions (an endogenous variable). This follows, of course, the pattern of Tinbergen's policy model, with the changes in technology being the instrument variable and the equal farm income being the target variable (Tinbergen, 1956; Fox et al. 1966). This permits (a) evaluations of the required magnitude of technological improvements in the lower-farm-income region against its known past performance, and (b) formulation of judgment as to the possibility and probability of achieving the target within a certain period of time. A mathematical programming model may also be used to investigate the comparative advantage of a region in the framework of spatial equilibrium. A spatial equilibrium solution indicates that the regions producing a certain commodity have comparative advantage over those not producing it. Yet, comparative advantage is by no means enduring and may disappear when the relative competitive positions of regions alter as a result of differential rate of change in technology or demand over time. Thus the comparative advantage of a region as indicated in such a solution is valid only under the strong assumption that no parameter in the model changes through time.

A different approach to the investigation of a region's comparative advantages, present and potential, may be envisaged: If the rate of change in technology may be treated as stochastic (subject, of course, to necessary physical and biological upper bound), over time the region with a greater lead of comparative advantage is more likely to stay competitive than a region with only a slight edge of advantage, while a region not in production because of a slight disadvantage has a better chance of becoming competitive and entering production than a region with a greater disadvantage. Therefore, it is desirable to compare regions in production for their magnitudes of advantage and regions not in production for their magnitudes of disadvantage. Comparison of advantages may be made by using the results of a single solution. But comparison of disadvantages (activities not in the solution) can only be made from results of a series of solutions, obtained by systematically varying upward certain yield coefficients to gauge the gap of technology to be filled before an activity enters the solution.

A region may be defined as possessing an overall comparative advantage of production over another region if it has stronger cost advantages of producing some items and weaker cost disadvantages of producing others[1].

The Present Study

As regions in a country change at uneven rates of advance, some become

[1] It is conceivable that comparison of two regions may result in indeterminancy of their overall comparative advantage. However, comparison in terms of the value of products may avoid such possible indeterminancy. Other meaningful criteria can also be devised to reveal the comparative strength of a region over another in an empirical study.

relatively progressive and prosperous and others, relatively poor and backward. The South has traditionally been a region of relatively lower income, compared with the rest of the United States.

"It has been said that 'every country has a South' - a social South if not a geographical South" (Thompson, 1967, p. ix). However, "... every generation of Americans has been told that the South of its day was a 'New South'" (Thompson, 1967, p. xi). It reflects the natural desire of the South to improve its economic position so as to "catch up" with the rest of the country.

In a sense, the agriculture of a "New South" has gradually come into being, as in the Southeast[1] the agriculture has long been in the transition of moving from its dependence on its two historical cash crops of cotton and tobacco into a more diversified farming pattern. From 1950 to 1965, the average farm income in the Southeast has risen from approximately 80 percent of the national average to over 90 percent, with certain fluctuations (USDA ERS 1969). The increases however, were mainly due to Florida's [2] rapid growth in the productions of fruit, vegetable, and other cash crops.[3]

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[1]The Southeast as defined in this study includes Consuming Regions Nos. 3 - 8 (see Figure 2 in Chapter II) and constitutes the major part of the South whatever its geographical boundaries generally agreed upon.

[2]Consuming Region No. 5 in this study.

[3]From 1950 to 1964 the total value of all crops produced in Florida increased nearly three times (from $253 million to $728 million). Among the crops, orange increased 2.5 times (from $125 million to $317 million); vegetable, 2.6 times (from $60 million to $146 million); sugar cane, 7 times (from $7 million to $48 million); and tobacco, 1.5 times (from $18 million to $26 million) (USBC 1961, USBC 1976). These crops are not to be included in the present study.

With the exclusion of Florida from the Southeast, farm income in the rest of the Southeast hovered around the mark of 65 percent of the national average during the same period.

Compared with the Midwest, there did occur in the Southeast some higher rates of yield increases and some favorable changes in the composition of farms. For instances, during 1959-1965, the yield of wheat and corn increased about 20 percent and 40 percent, respectively, in the Southeast but only 5 percent and 20 percent, respectively, in the Midwest[1] (USDA 1966). During the same period, milk production per cow increased about 23 percent in the Southeast and about 18 percent in the major dairy region of Minnesota - Wisconsin (USDA 1966). But in these three cases, the absolute yield were still lower in the Southeast.

From 1959 to 1964, farm size in the Southeast increased at a faster rate (by 15%) than did that in the Midwest (by 13.5%) (USBC 1961; USBC 1967b).

Since the gaps in technology and income still exist between the Southeast and the rest of the country, the trend of faster rate of technological progress and of farm size increase must continue before a "catch-up" of the Southeast with the rest of the country is in sight. Then naturally arise such questions as: What comparative advantages does the Southeast have in agricultural production? What are the chances of bridging the gap in farm income between the Southeast and the national

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[1]A higher rate of yield increase in a region does not necessarily mean a lower cost per unit of output than that in the regions with a lower rate of yield increase. That the relative farm income in the Southeast (excluding Florida) did not improve with respect to the national average, is apparently due to yield and cost variations in other farm enterprises.

average? How much technological progress is required in the Southeast in order to catch up with rest of the country? How long would it take for the Southeast to catch up with the rest of the country, or the national average, in yield or farm income, if the trend of a faster rate of change in favor of the Southeast continues? These are typical questions usually asked of a region of lower farm income.

It would be a worthy research effort to investigate the comparative advantage and the potential of agricultural production in the Southeast in the setting of spatial equilibrium of the continental United States, with a view to providing answers to the above questions. The technique of varying yield coefficients to gauge the gap in technology as described above can well be applied to such a study.

A cost-minimizing linear programming model is used in the present study of spatial equilibrium. The model consists of 2,100 equations and 8,056 real variables, and includes 138 producing areas and 15 consuming regions encompassing the continental United States (See Figures 1 and 2 in Chapter II). All the major crops (cotton, wheat, feed grains, soybeans, hay, silage) and livestock products (milk, beef, pork, broilers) are included in the model, and the year for which the model is formulated is 1965. The data used in the model were obtained mainly from Eyvindson (1970) and Brokken (1965).

The resources of small farms[1] not included in previous studies are included because they constitute an important proportion of the total

[1]Small farms refer, for short, in this study to part-time farms, part-retirement farms, and commercial farm class VI as defined in the 1964 U.S. Census of Agriculture, though some part-time farms and part-retirement farms may not be small in size or income.

agricultural resources in the Southeast (about 20 percent land and 50 percent labor) and therefore, are too important to be excluded from any study on the Southeast. Broiler production, an important enterprise in the Southeast, is also included in the present study.

Since, however, investigation of the potential of the Southeast by solving a series of solutions based on various assumptions or a Tinbergen-type policy model proved beyond the resources of the present study due to its high computing costs,[1] a more moderate and limited goal was set instead, making use of the results of two solutions of the basic model.

The objectives of the present spatial equilibrium study of American agriculture including small farm resources are: (1) to identify regional comparative advantage in production in terms of the components of the shadow price of a product (production cost, opportunity cost of inputs, and locational (disadvantage); (2) to analyze production and shipping patterns in terms of regional comparative advantage and interdependency among activities and constraints; (3) to reveal the extent to which resources of small farms contribute to production, and the extent of excess resources in regions; and (4) to compare resource use between the Southeast, the Midwest and the national level and to analyze the comparative advantages of the Southeast.

The basic assumptions of the model of the present study are: (1) the model covers a short-run period (one-year) in which demand, resources, technology, and product on cost remain unchanged; (2) the resources of the model (farm land and farm labor) have no alternative use during the short-

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[1]The computing time required to obtain a solution of the model on an IBM 360 model 45 computer was about 36 hours.

run period under study, and therefore no cost is charged for their uses; (3) the products are homogeneous and consumers are indifferent to their sources of origin; (4) demand is inelastic during the short-run period under study; (5) the model is static and does not allow accumulation or depletion of inventories, and therefore, demand must be met from current output; (6) there are inter-(consuming) regional transportations, but no inter-regional transportations among producing areas, and therefore, each consuming region is treated as a point in the transportation net work; (7) the solutions describe the normative situation of the short-run equilibrium, and do not predict future situations[1] (unless coefficients representing the future are adopted); and (8) the model can be used to provide answers for questions of comparative statics (upon making changes in coefficients).

In a sense the present study may be viewed as an extension of the series of previous studies, as small farms resources are brought into the model for possible participation in production.

Since no special coefficient variations were done for regions in the Southeast in obtaining the two solutions, the same technique of analyzing regional comparative advantage is applied to all regions, both within and without the Southeast, and the results of analysis are, therefore, more general than if special treatments had been given to parameters in the Southeast.

In addition to analysis of resource allocation in terms of land input, the present study is intended also to analyze the output side -- the

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[1]In a sense, it predicts what would have been if the real world had been as assumed by the model.

distribution of production in units of output, which in turn permits further analysis of each region's relative position in yield and production cost.

In the process of analysis shadow price will be accorded the key role, with its components (cost coefficient, opportunity costs, and transportation cost) to be evaluated separately, so that a region's comparative advantage may be properly attributed to its true causes, be it lower production cost, locational advantage, lower (or lack of) opportunity costs of inputs, or a combination of these. Regions will also be compared in their cost of producing each product -- in terms of cost advantage index -- so as to reveal the magnitude of their relative cost differential with respect to the national average production cost. Overall regional cost advantages will be also studied.

Being normative in nature and employing linear programming as an optimizing tool, the present spatial equilibrium study is perfectly equipped to answer the question of how to minimize the total cost of meeting a prescribed total demand,[1] and to elucidate the complex interdependency of the model, and to provide a miniature example of what the real world adjustments would be if the real world were as the model assumes it to be.

No model is a perfect representation of reality. But, the real world does not permit manipulations and experimentations without high cost. A

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[1]However, the model cannot provide answers to such "pre-solution" questions, though important as they are, as why the production cost of a certain product in an area is such, or such questions as how the yield of a product in region can be increased, etc. Each of such questions would warrant a separate study in itself, to be under taken in close cooperation with physical and biological scientists, if an answer of a nature of more than a general observation is desired. The present study will concentrate in the economic aspect of the spatial equilibrium problem.

model, which isolates itself from extraneous influeonces, permits direct inferences from parametric programming solutions and thus focuses more sharply upon the cause-effect relationships which might be difficult to discern in the real world. It also permits detailed analyses of the myriad interdependency of the variables with such a degree of "precision" which is impossible to attain in the analysis of the real world phenomena. For all its imperfections, a model can always shed some insights into the real world by exploring or experimenting under various assumption (e.g. a sudden increased in demand for export, a drought in a region, etc.). Therefore, a study of solutions of a model elucidates them as examples, and thus contributes towards gaining insights and a better understanding of the real world phenomena.

The differences between the solutions and the real world signify the extent the real world deviates from the ultimate cost-minimizing efficiency as given by the solutions under the assumptions of the model. Such deviations may be attributed to either model (or data) imperfections, or institutional restraints left out of the model (e.g. milk shed regulations), or the real world's failure to adjust itself instantaneously towards a spatial equilibrium, or a combination of these.

In the next chapter, the model of the present study is described in details. In chapter III, some salient points related to the present study are discussed. The sources and processing procedures of data are presented in Chapter IV. Results of the two solutions of the present study are analysed in Chapter V, followed by the last chapter on the summary and conclusions.

CHAPTER II. MODEL

In this chapter the cost-minimizing linear programming model will be presented with respect to: (1) a general description, (2) the matrix form of the model, and (3) the mathematical model

General Description of Model

A linear programming model is used in this study in order to minimize the cost of producing the major crops and livestock products to meet the consumption demand of the continental United States in 1965 adjusted for imports and exports, subject to the constraints of land and farm family labor supply. The major crops and livestock products included in the model are: cotton, wheat, feed grains (corn, oats, barley, grain sorghum), soybeans, hay, silage, beef (grain-fed and non-grain-fed), pork, broilers, fluid milk, and manufactured milk.

In this study the continental United States is divided into 138 producing areas (or areas) and 15 consuming regions (or regions), shown in Figures 1 and 2, respectively.[1] Each area in the model is considered to be sufficiently homogeneous with respect to soil type, climate, historical yields, and production costs.

There are 4 distinct sets of activities (columns) in the model: crops, livestock, transfer, and transportation. In total, there are 2,100

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[1]The 138 areas are based on the 157 areas delineated by Brokken (1965), with some consolidations where the coefficient differentials of Brokken's areas were within specified tolerance, and with some redelineations where smaller area size is desired.

Note:
a = Area No. 122
b = Area No. 91

Figure 1. 138 producing areas

Figure 2. 15 consuming regions

constraints (rows) and 8,056 activities (columns).

The constraints of the linear programming model may be grouped into 3 sets. At the national level there are 5 constraints (cotton lint demand, supplies of 4 exogenous feed concentrates) plus the objective function of the model---the cost row. At the consuming region level, there are, in each of the 15 regions, 8 consumption demand constraints (wheat, grain-fed beef, non-grain-fed beef, pork, broilers, fluid milk, manufactured milk, supply of off-farm pasture) and 12 accounting rows (feed grains, soybeans, cotton seeds, beef calf, yearling calf, 3 TDN's (Total Digestible Nutrients), 3 proteins, hay).

At the producing area level, there are in each of the 138 areas a maximum of 11 resource supply constraints (3 cropland, 3 crop-hay land, cotton land, wild hay land, pasture, crop-season family labor, non-crop-season family labor) and 2 accounting rows (hay, roughage). In areas where cotton or wild hay is not grown, no cotton land or wild hay land constraint is included.

Though land and family labor are two obvious constraints on the production of crops, land is actually the ultimate constraint because hired labor is assumed available at the market rate for crop and livestock production. The pasture constraint can be relaxed by converting crop-hay land into pasture. Production of cotton and wild hay are constrained, respectively, by the cotton land allotment and the wild hay land acreage. While hay may be grown on either hay land or cropland, crops can be planted on cropland only.

Certain restraints are placed on the movements of products. All intermediate and final products, except hay and silage, may move among areas within a region without transportation cost and among regions with transportation cost. Hay may move among areas within a region at a transportation cost slightly higher (by 1¢) than the transportation cost between the regional center and the farthest area in the region, so as to avoid concentration of hay production of a region in one or two areas. Silage is not allowed to move out of the area in which it is produced.

Some products are restricted to "one way" movements in the model. For instance corn is allowed to move from Corn Belt regions to the Southeast regions, but not vice versa. In addition, certain product movements do not exist in the model. For instance, since cotton is not grown in the northern areas, no activity for the movement of cotton from northern regions to the rest of the country is allowed. As a result, the total number of transportation activities is less than the potential maximum number.

Crops produced in an area either satisfy the human consumption directly (e.g., cotton demand is satisfied at the national level, wheat demand, at the regional level) or they are accumulated into the various regional accounting rows (e.g. feed grains, soybeans, cotton seeds) for transfer to the regional TDN and protein accounting rows for consumption by livestock. Livestock, fed from the regional TDN and protein accounting rows and produced at the area level under the constraints of labor, pasture and roughage, satisfy consumption demand at the regional level. Wheat may be used as feeds.

National constraints

The following products have a national constraint: cotton lint and the four exogenous concentrate feeds which are mainly the byproducts of food-processing industry over the country. These feed concentrates are: F1, oil meals other than soybean oil meal and cotton seed oil meal; F2, animal proteins; F3, grain proteins; F4, other byproduct feeds including wheat and rice mill-feeds. Regions compete for the exogenous concentrates at their observed regional prices (cost).

Consuming region constraints

In this study demand constraint for crops is created by (a) direct human consumption, (b) use by food processing industries, (c) exports, and (d) use as feeds by exogenous livestock. Requirements for human consumption were based on the U.S.D.A. 1965 Food Consumption Survey (USDA ARS 1968) data multiplied by population in the region. All grains are expressed in the unit of TDN. Requirements by food processing industries were estimated by the requirements of such plants in the region. Export demand was proportioned among coastal regions according to the relative shipments through the various ports in the past. Demand for wheat consists of the sum of the above first three components of demand. Feed grain exports plus demand by food processing industries make up the constraints for feed grains, expressed in negative value in the RHS (right-hand side) of the feed grain accounting row. Feed grains moving from producing areas into their accounting row must first satisfy such demand (in negative value) before they can be transferred to the TDN and protein accounting rows to feed livestock. The negative value in the RHS of the soybean accounting row represents its export figure. The negative value in the RHS of the hay accounting row represents demand by feed industry for making alfalfa pellets in the region. Demand for livestock products was computed from the 1965 Food Consumption Survey (USDA ARS 1968).

Feed requirements by various livestock are classified into 3 classes (TDN 1 and protein 1, TDN 2 and protein 2, TDN 3 and protein 3) according to the TDN/protein ratio required in the ration. The rationale for doing so is as follows. Each type of concentrate feeds has its own fixed TDN/protein ratio. If the ratio in feeds is greater than the ratio required in the ration of livestock, then the accounting row will show a "surplus" of TDN, though in actuality there is no such surplus TDN available for consumption by other types of livestock because TDN and protein are consumed in the same fixed proportion as that in the feeds. This book value of "surplus" TDN may be consumed in the model by other types of livestock in whose ration the TDN/protein ratio is greater than the ratio in the feeds, thus resulting in a "double use" of feeds and in a solution that underestimates the actual feed requirements of the model. By grouping livestock whose TDN/protein ratio requirements in ration are similar to one another and feeding them from the same pair of TDN and protein accounting rows reduces, but does not eliminate, such bias in the solution.

Therefore, dairy cows, beef cows, and broilers whose rations require a similar TDN/protein ratio are fed from the same pair of TDN and protein accounting rows (TDN 1 and protein 1); yearlings and calves are fed from the same pair of TDN and protein accounting rows (TDN 2 and protein 2); and feeder cattle and hogs utilize the same pair of TDN and protein accounting rows (TDN 3 and protein 3). Demand for feeds by exogenous livestock was computed by adding all such livestock from county data and multiplying them by their respective feed requirements in TDN and protein, and is expressed as negative value in the TDN 1 and protein 1 accounting rows (as their TDN/protein ratio is closest to that classified as TDN 1 and protein 1). Off-farm pasture is computed by adding all acres of public grazing land obtained by permits or on lease from Bureau of Land Management or Forest Service.

Producing area constraints

In each producing area, cropland is divided into 3 quality classes according to the land capability classifications of Conservations Needs Inventory (CNI) (USDA 1962) shown as follows:

Cropland quality classes	CNI classification
1	I AND II
2	III
3	IV, V, VI, VII, VIII

Commercial farms Class VI, part-time farms, and part-retirement farms, which were not included in previous studies, are incorporated into the present model.

The total acreage of cropland in each area was obtained by adding the 1965 harvested acreage of all crops grown in all counties within each area over all classes of farms included in the study, plus the idle acreage set aside under the Federal wheat program, the feed grain program, and the soil conservation program in the area. The total acreage was then divided into the 3 land classes defined above, according to their proportions in the Soil and Water Conservations Needs Inventory. Hay land acres are similarly proportioned among the 3 cropland classes to make the 3 crop-hay land classes.

The constraint on cotton acreage was the 1953 acreage of cotton harvested in the area. Wild hay land acreage was obtained from the 1964 U.S. Census of Agriculture.

Family labor supply includes all available family labor of commercial farms, part-time farms, and part-retirement farms, minus work hours spent on off-farm jobs and on exogenous crops (rye, flax, rice, tobacco, Irish potatoes, peanuts, beans, peas) and on exogenous livestock (horse, mule, sheep, goats, turkey, chickens other than broilers). Family labor supply is further divided into crop-season labor constraint and non-crop-season labor constraint according to the length of the growing season in each area.

The pasture constraint was obtained by adding the acreage of the four classes of pasture (cropland pasture, woodland pasture, improved open permanent pasture, unimproved open permanent pasture) in the counties of the areas from the 1964 U.S. Census of Agriculture

Roughage requirements of all the exogenous livestock defined above were obtained by adding all the numbers of such livestock in the counties of the area and multiplying them with their respective individual roughage requirements, and are treated as negative value in the roughage accounting row.

Crop activities

For each crop and crop rotation system, there are three activities, one for each land class, differing only in yields, with land class 1 having the highest yield. The following crops and crop rotational systems are included in this study: cotton, wheat, feed grains, tame hay, wild hay, and the rotational systems of feed grain-soybean, feed grain-silage, feed grain-soybean-silage, and hay-silage.

Feed grains consist of corn, oats, barley, and grain sorghum. Yield is the average of the yields of the 4 component crops weighted by their harvested acreages in the area. Cost and labor requirements for crops are computed similarly.

A typical crop activity consists of the following coefficients: cost, yield, aftermath (pasture) yield, cropland (and crop-hay land in the case of hay), and crop-season labor. The crop yield goes to the respective regional row; the aftermath yield, to the area pasture row.

Livestock activities

The 12 area livestock activities are: Broilers, hogs, dairy cows, beef cows, yearling-calf, and the 7 cattle fattening processes (deferred calif, calf on extended silage, calf on silage, calf no silage, short-fed yearling, yearling on silage, yearling no silage).

Livestock production activities draw feeds from one of the three pairs of TDN and protein accounting rows at the regional level and are constrained at the area level by labor, pasture, and roughage supplies. Theoretically, the ultimate constraint is land which produces feeds and provides pasture (by converting crop-hay land), because labor supply may be augmented through hiring. However, before the ultimate constraint is met, there are still such intermediate constraints as the costs of hiring labor, of converting crop-hay land into pasture, and of importing hay from other areas within the region. Production of broilers does not require pasture and roughage. An area channels its livestock products to the regional livestock rows to meet the regional consumption demand.

Transfer activities

There are 28 transfer activities in each consuming region and 6 transfer activities in each producing area. The transfer activities are included in the model: (1) to transfer grains without cost, and exogenous feed concentrates at cost, to each of the 3 TDN and 3 protein accounting rows to be used as feeds; (2) to convert crop-hay land into pasture at cost; (3) to add to family labor by hiring labor at cost; (4) to transfer off-farm pasture to area pasture constraint; (5) to transfer without cost hay into roughage which consists of silage and hay; (6) to transfer hay from area to area via the regional center at cost; (7) to convert fluid milk to manufactured milk without cost; (8) to allow calf and yearling slaughter to provide non-grain-fed beef without cost; and (9) to allow grain-fed beef to be consumed as non-grain-fed beef without cost.

Transportation activities

Transportation activities exist only among regions for all intermediate and final products of grains and livestock, except hay and silage. There is a total of 1,914 transportation activities in the model. The model has a potential of (14 x 15 x 12) = 2,520 transportation activities. However, some of the transportation activities are inoperative (e.g. some crops are not grown in certain regions) or restricted to one-way flows.

In general, the transportation costs are computed on the basis of rail rates. Where other transport modes of lower costs exist, a composite of the lower rates based on the actual pattern of transport modes was used.[1] For instance, a composite of rail and barge rates is used for shipping grains from the Midwest to the Southeast.

A metaphorical presentation of the model

A metaphorical way of describing the model may help elucidate its structure. Since the linear programming model is essentially a centralized decision-making model, we may imagine a giant agricultural corporation which owns all the agricultural resources in the 138 producing areas on the continental United States has contracted itself with the government representing the consumers, to supply all the agricultural needs to the society, to be distributed to 15 consuming (region) centers over the country, in predetermined quantities for a set of fixed prices. Since the agricultural corporation wants to maximize its profit and the prices are already fixed, it can only do so by minimizing its costs of providing all the contracted products, thus maximizing the differential between prices and costs---profits.

Each of the 138 producing area has a given set of production functions with costs, yield, and input requirements known. Each area's resources are also known, with land fixed and labor supply increasable by hired labor. Let us further assume that goods moving among areas within a region bear no transportation cost, but goods moving among regions shall bear transportation cost.

[1] Data provided by Transportation Branch, Division of Property and Supply, Tennessee Valley Authority.

To minimize the total cost, the corporation first converts the production cost data into cost per unit of final product called for by the contract to be supplied (e.g. so much per 1,000 lbs. TDN of wheat, not so much per acre of wheat), to facilitate comparison of costs among the 138 areas.

In other words, each of the 138 areas tries to bid for the opportunity to supply goods to each of the 15 consumption centers. Of course, the area which can supply a product at the lowest cost wins the bidding and can produce that product to as much as the contract calls for or as much as its resources permit. Of course, an area trying to supply goods to regions other than its own has the disadvantage of having to pay for transportation cost. But, as long as its production cost advantage (i.e. having cost lower than that in other regions) outweighs its transportation disadvantage, it still gets to supply goods to other regions.

If there were only one commodity (e.g. wheat) to be supplied to a single consumption center, the problem of selecting from the 138 producing areas the one with the lowest cost (production cost plus transportations cost where applicable) is simple. After the most efficient area (i.e. the area with the lowest cost) exhausts one of its resources and yet the contracted quota (consumption demand) is still not filled, then the next most efficient area will go into production. Once an area starts producing a commodity it will not stop until the quota is filled or one of its resources is exhausted. Of course, extra labor can always be hired at cost. But that would change the ranking of an area on the efficiency list, and make it less competitive against other areas.

When there are 15 consumption centers to be supplied with a commodity at once, then the list of production activities to be selected from grows rapidly. Now, we have 138 x 15 = 2,070 possible production activities (each area able to supply to 15 consumption centers).

When there are a dozen products to be supplied to 15 consumption centers, among which some are intermediate goods (e.g. feed grains) and some are multiple-input and multiple-output commodities (e.g. products of milk cows), then the difficulties involved in choosing the most efficient production activity for each of these product will greatly multiply.

An example will illustrate the difficulties. To compare two areas for their efficiency of milk cow activities will entail comparisons of not only costs of producing milk (in $/per 1000 lbs. milk, not $/per head of cow), but also costs of producing other outputs (beef from culled cow to satisfy the demand for non-grain-fed beef; calves for fattening to satisfy grain-fed beef; calves to raise to yearling also for fattening; culled calves to satisfy non-grain-fed beef). Cost advantage in producing one form of output (say, beef) may outweigh cost disadvantage in producing another form of output (say, milk) such that the area with higher cost of producing milk may be selected because its cost of producing all outputs (of a milk cow activity) is lower, though it is impossible to express cost of the various outputs <u>simultaneously</u> in the same units specified in the RHS (right hand side of the inequalities in the model). Therefore, the natural way to express cost is in terms of dollars per head of milk cow, which alone is, however, misleading in the interpretation of cost when comparing milk cow activities of different areas.

It may also happen that an area with lower costs in producing every output of a milk cow than another area in a different region may still be defeated by the latter, because its disadvantages of high feed cost outweighs its cost advantage of milk cow production (which does not include feed cost that, in this model, is charged to crop production activities).

Here, comparison of cost of milk cow leads us into comparison of cost of feeds. First, we must determine what kind of feeds are fed to the milk cow from the TDN and protein elevators. Many different grains have been channelled into the TDN and protein elevators (now all in the form of TDN and protein; their orginal identity of grains no longer discernible). We have three sets of TDN and protein elevators in each consuming region, each set containing TDN and protein of different ratios. The set containing higher protein ratio feeds milk cows, beef cows, and broilers. The set containing lower protein ratio feeds feeder cattle and hogs. The set containing the lowest protein ratio feeds yearlings and calves. In the real world, TDN and protein come in a fixed ratio in the form of grain. In our model, we store TDN and protein in separate elevators. In the real world, if we feed high protein feeds to a type of livestock requiring only low protein feeds, the livestock eat the feeds fed them, and there will be no more excess protein left. But in our model, TDN and protein are separately stored and each type of livestock is fed the exact amount of TDN and protein it needs (i.e. in a specific TDN and protein ratio). If the fixed protein/TDN ratio of a type of grain is greater than the protein/TDN ratio specified in the feed ration, the "surplus" protein will accumulate in the protein elevator, showing in the protein accounting row of the model as residual available for feeding to other livestock, while in the real world, the grain fed to livestock is gone, with its excess protein going also into the stomach of the animal. Realizing such discrepancy between the real world and the model, we group our livestock into three classes according to different protein/TDN ratio in their rations, and feed them separately, so that the discrepancies will be reduced, though not entirely eliminated.

Production areas and consuming region   We may have a solution showing hogs are produced in an area at one corner of the region while feeds are produced in an area at the opposite corner of the region. How to explain such an awkward solution? Since no transportation cost is charged for movements of products between areas within a region, such a solution is only normal. (To charge cost on inter-area transportation would entail construction of a transportation net work of 12 x 138 x 137 = 226,872 activities, clearly beyond the resources of an ordinary researcher.) We may consider a consuming region as a factor plant, and all the production activities of the various areas in the region as mere production processes optional to the management. The manager in an attempt to reduce cost would be indifferent to any of the production options open to him as long as it saves money for the plant. Therefore, in interpreting the above-cited awkward solution, we have to transcend the geographical difference. We may accept the solution as an indicator of the comparative efficiency of the two areas with respect to hog and feeds production, one area being more efficient in hog production and the other being more efficient in feeds production. In the real world, perhaps both areas produce both products, with one area producing more hog and the other, more feeds. Further, a solution may be viewed as an indication of the direction towards which optimal production adjustments are to be made.

Linear Programming Matrix

The complete matrix of 2,100 by 8,056 of the model is presented here in two separate matrices: (1) the matrix consisting of all the constraints, crop activities, livestock activities, and transfer activities; and (2) the matrix of transportation activities only.

The following notes describe the notations in Table 1:

(1) In the matrix, a represents an input-output coefficient, b, the level of constraint, and c, the cost coefficient in the objective function.

(2) The superscripts (1, 2, 3, and 4) on the constraint b denote:

1 -- human consumption demand.

2 -- consumption demand by exogenous livestock.

3 -- export demand.

4 -- demand by industries for making alfalfa pellets.

Table 1. Linear programming matrix (excluding transportation activities)

Constraint Row No.	Code	Description	Unit
	National		
1	COST	Cost	$10
2	COTTON	Demand for Cotton	CWT
3	EXGFD p	Exogenous Concentrate Feed, Type p (p=1,4)	1,000 lbs, TDN
	Consuming Region i (i=1,15)		
4	i WHEAT	Demand for Wheat	1,000 lbs, TDN
5	i FDGR	Demand for Feed Grain	1,000 lbs, TDN
6	i SOYBN	Demand for Soybean	CWT TDN
7	i CTNSD	Demand for Cotton Seed	CWT TDN
8	i BFCALF	Beef Cow and Calf	Head
9	i YRCALF	Yearling and Calf	Head
10	i BFGF	Demand for Beef, Grain-fed	CWT
11	i BFOR	Demand for Beef, Non-Grain-fed	CWT
12	i PORK	Demand for Pork	CWT
13	i FMILK	Demand for Fluid Milk	1,000 lbs.
14	i MFGMK	Demand for Manufactured Milk Products	1,000 lbs.
15	i BROILR	Demand for Broiler	1,000 lbs.
16	i TDN1	Total Digestible Nutrient, Type 1	1,000 lbs.
17	i TDN2	Total Digestible Nutrient, Type 2	1,000 lbs.
18	i TDN3	Total Digestible Nutrient, Type 3	1,000 lbs.
19	i PROTN1	Protein, Type 1	CWT
20	i PROTN2	Protein, Type 2	CWT
21	i PROTN3	Protein, Type 3	CWT
22	i HAYRG	Demand for Hay	Ton
23	i PASTRG	Pasture Off-Farm	10 AUMs
	Producing Area k (k=1, 138)		
24	k CHL q	Crop Hay Land, Class q (q=1,3)	Acre
25	k CL q	Crop Land, Class q (q=1,3)	Acre
26	k CTNL	Cotton Land	Acre
27	k WHL	Wild Hay Land	Acre
28	k PASTA	Pasture	AUM
29	k LBCS	Labor, Crop Season	10 hrs.
30	k LBNCS	Labor, Non-Crop Season	10 hrs.
31	k HAYAR	Hay	Ton
32	k RUFAG	Roughage (Hay Equivalent)	Ton

Type	Level	(Type of Activity)	Crop Activities, Producing Area k, Land Class q (k=1,138; q=1,3)				Row No.
		(Code)	kCOTNq	kWHEAq	kFDGRq	kHAYYq	
		(Description)	Cotton	Wheat	Feed Grain	Hay	
		(Activity Unit)	Acre	Acre	Acre	Acre	
			c	c	c	c	1
≥	b		a				2
=	b						3
≥	b			a			4
≤	-b[1,3]				-a		5
≤	-b[3]						6
≤	-b[3]		-a				7
≤	0						8
≤	0						9
≥	b						10
≥	b						11
≥	b						12
≥	b						13
≥	b						14
≥	b						15
≤	-b[2]						16
≤	0						17
≤	0						18
≤	-b[2]						19
≤	0						20
≤	0						21
≤	-b[4]						22
≤	b						23
≤	b		1	1	1	1	24
≤	b		1	1	1	1	25
≤	b		1				26
≤	b						27
≤	b		-a	-a	-a	-a	28
≤	b		a	a	a	a	29
≤	b						30
≤	b					-a	31
≤	-b[2]						32

Table 1. (Continued)

Row No.	Code	kWHAY	kFGSBq	kFGSGq	kHASGq	kFGSSq
		Wild Hay	Feed Grain -Soybean Rotation	F.G.- Silage Rotation	Hay- Silage Rotation	F.G.-S.B. -S.G. Rotation
		Acre	Acre	Acre	Acre	Acre
1	COST	c	c	c	c	c
2	COTTON					
3	EXFGD p					
4	i WHEAT					
5	i FDGR		-a	-a		-a
6	i SOYBN		-a			-a
7	i CTNSD					
8	i BFCALF					
9	i YRCALF					
10	i BFGF					
11	i BFOR					
12	i PORK					
13	i FMZLK					
14	i MFGMK					
15	i BROILR					
16	i TDN1					
17	i TDN2					
18	i TDN3					
19	i PROTN1					
20	i PROTN2					
21	i PROTN3					
22	i HAYRG					
23	i PASTRG					
24	k CHL q		1	1	1	1
25	k CL q		1	1	a	1
26	k CTNL					
27	k WHL	1				
28	k PASTA		-a	-a	-a	-a
29	k LBCS	a	a	a	a	a
30	k LBNCS					
31	k HAYAR	-a			-a	
32	k RUFAG			-a	-a	-a

Table 1. (Continued)

Row No.	Code	Livestock Activities, Producing Area k (k=1, 138)					Feeder
		kBROILR	kHOGGG	kDYCOW	kBFCOW	kYLCAF	kDEFRD
		Broiler	Hog	Dairy Cow	Beef Cow	Yearling -Calf	Deferred Plan
		CWT	CWT	Head	Head	Head	Head
1	COST	c	c	c	c	c	c
2	COTTON						
3	EXGFD p						
4	i WHEAT						
5	i FDGR						
6	i SOYBN						
7	i CTNSD						
8	i BFCALF			-a	-a	1	1
9	i YRCALF					-a	
10	i BFGF						a
11	i BFOR			a	a		
12	i PORK		a				
13	i FMZLK			a			
14	i MFGMK						
15	i BROILR	a					
16	i TDN1	a		a	a		
17	i TDN2					a	
18	i TDN3		a				a
19	i PROTN1	a		a	a		
20	i PROTN2					a	
21	i PROTN3		a				a
22	i HAYRG						
23	i PASTRG						
24	k CHL q						
25	k CL q						
26	k CTNL						
27	k WHL						
28	k PASTA		a	a	a	a	a
29	k LBCS	a	a	a	a	a	a
30	k LBNCS	a	a	a	a	a	a
31	k HAYAR						
32	k RUFAG			a	a	a	a

Table 1. (Continued)

Row No.	Code	Calf Fattening			Feeder Yearling Fattening		
		kEXTSG	kCFOSG	kCFNSG	kSFYRL	kYLOSG	kYLNSG
		Extended Silage Plan	On Silage Plan	No Silage Plan	Short -fed Plan	On Silage Plan	No Silage Plan
		Head	Head	Head	Head	Head	Head
1	COST	c	c	c	c	c	c
2	COTTON						
3	EXGFD p						
4	i WHEAT						
5	i FDGR						
6	i SOYBN						
7	i CTNSD						
8	i BFCALF	1	1	1			
9	i YRCALF				1	1	1
10	i BFGF	a	a	a	a	a	a
11	i BFOR						
12	i PORK						
13	i FMZLK						
14	i MFGMK						
15	i BROILR						
16	i TDN1						
17	i TDN2						
18	i TDN3	a	a	a	a	a	a
19	i PROTN1						
20	i PROTN2						
21	i PROTN3	a	a	a	a	a	a
22	i HAYRG						
23	i PASTRG						
24	k CHL q						
25	k CL q						
26	k CTNL						
27	k WHL						
28	k PASTA	a	a	a	a	a	a
29	k LBCS	a	a	a	a	a	a
30	k LBNCS	a	a	a	a	a	a
31	k HAYAR						
32	k RUFAG	a	a	a	a	a	a

Table 1. (Continued)

Row No.	Code	Consuming Region i Transfer Activities (i=1, 15)				
		iFMMGMK	iCFSLAU	iYLSLAU	iWHETP1	iWHETP2
		Fluid Milk to Manufactured Milk	Calf Slaughter	Yearling Slaughter	Wheat to TDN-Protein Type 1	Wheat to T.P. Type 2
		1,000 lbs.	Head	Head	1,000 lbs.	1,000 lbs.
1	COST					
2	COTTON					
3	EXGFD p					
4	i WHEAT				-1	-1
5	i FDGR					
6	i SOYBN					
7	i CTNSD					
8	i BFCALF		1			
9	i YRCALF			1		
10	i BFGF					
11	i BFOR		a	a		
12	i PORK					
13	i FMZLK	-1				
14	i MFGMK	1				
15	i BROILR					
16	i TDN1				-1	
17	i TDN2					-1
18	i TDN3					
19	i PROTN1				-a	
20	i PROTN2					-a
21	i PROTN3					
22	i HAYRG					
23	i PASTRG					
24	k CHL q					
25	k CL q					
26	k CTNL					
27	k WHL					
28	k PASTA					
29	k LBCS					
30	k LBNCS					
31	k HAYAR					
32	k RUFAG					

Table 1. (Continued)

Row No.	Code	iWHETP3 Wheat to T.P. Type 3	iFGTP1 Feed Grain to T.P. Type 1	iFGTP2 Feed Grain to T.P. Type 2	iFGTP3 Feed Grain to T.P. Type 3	iSBTP1 Soybean to T.P. Type 1
		1,000 lbs.	1,000 lbs.	1,000 lbs.	1,000 lbs.	CWT
1	COST					
2	COTTON					
3	EXGFD p					
4	i WHEAT	-1				
5	i FDGR		1	1	1	
6	i SOYBN					1
7	i CTNSD					
8	i BFCALF					
9	i YRCALF					
10	i BFGF					
11	i BFOR					
12	i PORK					
13	i FMZLK					
14	i MFGMK					
15	i BROILR					
16	i TDN1		-1			-1
17	i TDN2			-1		
18	i TDN3	-1			-1	
19	i PROTN1		-a			-a
20	i PROTN2			-a		
21	i PROTN3	-a			-a	
22	i HAYRG					
23	i PASTRG					
24	k CHL q					
25	k CL q					
26	k CTNL					
27	k WHL					
28	k PASTA					
29	k LBCS					
30	k LBNCS					
31	k HAYAR					
32	k RUFAG					

Table 1. (Continued)

Row No.	Code	iSBTP2 Soybean to T.P. Type 2 CWT	iSBTP3 Soybean to T.P. Type 3 CWT	iCSTP1 Cotton Seed to T.P. Type 1 CWT	iCSTP2 Cotton Seed to T.P. Type 2 CWT	iCSTP3 Cotton Seed to T.P. Type 3 CWT
1	COST					
2	COTTON					
3	EXGFD p					
4	i WHEAT					
5	i FDGR					
6	i SOYBN	1	1			
7	i CTNSD			1	1	1
8	i BFCALF					
9	i YRCALF					
10	i BFGF					
11	i BFOR					
12	i PORK					
13	i FMZLK					
14	i MFGMK					
15	i BROILR					
16	i TDN1			-1		
17	i TDN2	-1			-1	
18	i TDN3		-1			-1
19	i PROTN1			-a		
20	i PROTN2	-a			-a	
21	i PROTN3		-a			-a
22	i HAYRG					
23	i PASTRG					
24	k CHL q					
25	k CL q					
26	k CTNL					
27	k WHL					
28	k PASTA					
29	k LBCS					
30	k LBNCS					
31	k HAYAR					
32	k RUFAG					

Table 1. (Continued)

Row No.	Code	(t=1,4) iXFtTP1	(t=1,4) iXFtTP2	(t=1,4) iXFtTP3	iBFGBFO
		Exogenous Feed t to T.P.Type 1	Exogenous Feed t to T.P.Type 2	Exogenous Feed t to T.P.Type 3	Grain-fed Beef to Other Beef
		1,000 lbs.	1,000 lbs.	1,000 lbs.	CWT
1	COST	c	c	c	
2	COTTON				
3	EXGFD p	1	1	1	
4	i WHEAT				
5	i FDGR				
6	i SOYBN				
7	i CTNSD				
8	i BFCALF				
9	i YRCALF				
10	i BFGF				1
11	i BFOR				-1
12	i PORK				
13	i FMZLK				
14	i MFGMK				
15	i BROILR				
16	i TDN1	-1			
17	i TDN2		-1		
18	i TDN3			-1	
19	i PROTN1	-a			
20	i PROTN2		-a		
21	i PROTN3			-a	
22	i HAYRG				
23	i PASTRG				
24	k CHL q				
25	k CL q				
26	k CTNL				
27	k WHL				
28	k PASTA				
29	k LBCS				
30	k LBNCS				
31	k HAYAR				
32	k RUFAG				

Table 1. (Continued)

Row No.	Code	Producing Area k Transfer Activities (k=1,138) (q=1,3) kCHPSq	kPASRA	kHARUF	kHAYAG
		Crop Hay Land q to Pasture	Pasture, Region to Area	Hay to Roughage	Hay, Area to Region
		Acre	10 AUMs	Ton	Ton
1	COST	c	c		
2	COTTON				
3	EXGFD p				
4	i WHEAT				
5	i FDGR				
6	i SOYBN				
7	i CTNSD				
8	i BFCALF				
9	i YRCALF				
10	i BFGF				
11	i BFOR				
12	i PORK				
13	i FMZLK				
14	i MFGMK				
15	i BROILR				
16	i TDN1				
17	i TDN2				
18	i TDN3				
19	i PROTN1				
20	i PROTN2				
21	i PROTN3				
22	i HAYRG				-1
23	i PASTRG		1		
24	k CHL q	1			
25	k CL q				
26	k CTNL				
27	k WHL				
28	k PASTA	-a	-10		
29	k LBCS	a			
30	k LBNCS				
31	k HAYAR			1	1
32	k RUFAG			-1	

Table 1. (Continued)

Row No.	Code	kHAYRA Hay Region to Area Ton	kLBCSH Labor Hired, Crop Season 10 hrs.	kLBNH Labor Hired, Non-Crop Season 10 hrs.
1	COST	c	c	c
2	COTTON			
3	EXGFD p			
4	i WHEAT			
5	i FDGR			
6	i SOYBN			
7	i CTNSD			
8	i BFCALF			
9	i YRCALF			
10	i BFGF			
11	i BFOR			
12	i PORK			
13	i FMZLK			
14	i MFGMK			
15	i BROILR			
16	i TDN1			
17	i TDN2			
18	i TDN3			
19	i PROTN1			
20	i PROTN2			
21	i PROTN3			
22	i HAYRG	1		
23	i PASTRG			
24	k CHL q			
25	k CL q			
26	k CTNL			
27	k WHL			
28	k PASTA			
29	k LBCS		-1	
30	k LBNCS			-1
31	k HAYAR			
32	k RUFAG	-1		

Table 2. Linear programming matrix (transportation activities only)

Constraint Row No.	Code	Description	Unit
1	COST		$10
	Consuming Region i (i-1,15)		
2	i WHEAT	Demand for Wheat	1,000 lbs, TDN
3	i FDGR	Demand for Feed Grain	1,000 lbs, TDN
4	i SOYBN	Demand for Soybean	CWT TDN
5	i CTNSD	Demand for Cotton Seed	CWT TDN
6	i BFCALF	Calf Account	Head
7	i YRCALF	Yearling Account	Head
8	i BFGF	Demand for Beef, Grain-fed	CWT
9	i BFOR	Demand for Other Beef	CWT
10	i PORK	Demand for Pork	CWT
11	i FMILK	Demand for Fluid Milk	1,000 lbs.
12	i MFGMK	Demand for Manufactured Milk Products	1,000 lbs.
13	i BROILR	Demand for Broiler	1,000 lbs.
	Consuming Region i' (i'=1,15; i'≠i)		
14	i' WHEAT	Demand for Wheat	1,000 lbs, TDN
15	i' FDGR	Demand for Feed Grain	1,000 lbs, TDN
16	i' SOYBN	Demand for Soybean	CWT TDN
17	i' CTNSD	Demand for Cotton Seed	CWT TDN
18	i' BFCALF	Calf Account	Head
19	i' YRCALF	Yearling Account	Head
20	i' BFGF	Demand for Beef, Grain-fed	CWT
21	i' BFOR	Demand for Other Beef	CWT
22	i' PORK	Demand for Pork	CWT
23	i' FMILK	Demand for Fluid Milk	1,000 lbs.
24	i' MFGMK	Demand for Manufactured Milk Products	1,000 lbs.
25	i' BROILR	Demand for Broiler	1,000 lbs.

(Activity)	Transportation Activities, Consuming Region i to Consuming Region i' (i=1,15; i'=1,15, i≠i')				
(Code)	iWHEAi'	iFDGRi'	iSYBNi'	iCNSDi'	Row
(Description)	Wheat, from i to i'	Feed Grains	Soybeans	Cotton Seeds	No.
(Activity Unit)	1,000 lbs. TDN	1,000 lbs. TDN	CWT TDN	CWT TDN	
	c	c	c	c	1
	-1				2
		1			3
			1		4
				1	5
					6
					7
					8
					9
					10
					11
					12
					13
	1				14
		-1			15
			-1		16
				-1	17
					18
					19
					20
					21
					22
					23
					24
					25

Table 2. (Continued)

Row No.	Code	iCALFi' Calf	iYRLCi' Yearling	iBFGFi' Beef, grain-fed	iBFORi' Beef, non-grain-fed	iPORKi' Pork
		Head	Head	CWT	CWT	CWT
1	COST	c	c	c	c	c
2	i WHEAT					
3	i FDGR					
4	i SOYBN					
5	i CTNSD					
6	i BFCALF	1				
7	i YRCALF		1			
8	i BFGF			-1		
9	i BFOR				-1	
10	i PORK					-1
11	i FMILK					
12	i MFGMK					
13	i BROILR					
14	i' WHEAT					
15	i' FDGR					
16	i' SOYBN					
17	i' CTNSD					
18	i' BFCALF	-1				
19	i' YRCALF		-1			
20	i' BFGF			1		
21	i' BFOR				1	
22	i' PORK					1
23	i' FMILK					
24	i' MFGMK					
25	i' BROILR					

Table 2. (Continued)

Row No.	Code	iFMLKi' Fluid Milk	iMFMKi' Manufactured Milk Products	iBRLRi' Broilers
		1,000 lbs.	1,000 lbs.	1,000 lbs.
1	COST	c	c	c
2	i WHEAT			
3	i FLGR			
4	i SOYBN			
5	i CTNSD			
6	i BFCALF			
7	i YRCALF			
8	i BFGF			
9	i BFOR			
10	i PORK			
11	i FMILK	-1		
12	i MFGMK		-1	
13	i BROILR			-1
14	i' WHEAT			
15	i' FDGR			
16	i' SOYBN			
17	i' CTNSD			
18	i' BFCALF			
19	i' YRCALF			
20	i' BFGF			
21	i' BFOR			
22	i' PORK			
23	i' FMILK	1		
24	i' MFGMK		1	
25	i' BROILR			1

Mathematical Model

Subscripts and superscripts

The subscripts and superscripts are:

$k = 1, 2, \ldots, 138$	denotes the Producing Areas in Figure 1
$i = 1, 2, \ldots, 15$	denotes the Consuming Regions in Figure 2
$j = 1, 2, \ldots, d$	is used with j to denote the Producing Areas in a Consuming Region, where d varies with the Consuming Region (Table A-16)
$n = 1, 2, \ldots, 46$	denotes the activities of a Producing Area
$m = 1, 2, \ldots, 28$	denotes the activities of a Consuming Region
$h = 1, 2, \ldots, 12$	denotes the transportation activities among regions
$t = 0, 1, \ldots, 4$	denotes the constraints at the national level
$r = 1, 2, \ldots, 20$	denotes the constraints at the regional level
$a = 1, 2, \ldots, 13$	denotes the constraints at the area level

The 46 activities in a Producing Area, denoted by n, are:

(n) 1 = cotton, cropland 1

2 = cotton, cropland 2

3 = cotton, cropland 3

4 = wheat, cropland 1

5 = wheat, cropland 2

6 = wheat, cropland 3

7 = Feed grains, cropland 1

8 = Feed grains, cropland 2

9 = Feed grains, cropland 3

10 = Hay, crop-hay land 1

11 = Hay, crop-hay land 2

12 = Hay, crop-hay land 3

13 = Wild hay, wild hay land

14 = Feed grain - soybean rotation, cropland 1

15 = Feed grain - soybean rotation, cropland 2

16 = Feed grain - soybean rotation, cropland 3

17 = Feed grain - silage rotation, cropland 1

18 = Feed grain - silage rotation, cropland 2

19 = Feed grain - silage rotation, cropland 3

20 = Feed grain - soybean - silage rotation, cropland 1

21 = Feed grain - soybean - silage rotation, cropland 2

22 - Feed grain - soybean - silage rotation, cropland 3

23 - Hay - silage rotation, cropland 1

24 - Hay - silage rotation, cropland 2

25 = Hay - silage rotation, cropland 3

26 - Conversion of crop-hay land into pasture, crop-hay land 1

27 = Conversion of crop-hay land into pasture, crop-hay land 2

28 = Conversion of crop-hay land into pasture, crop-hay land 3

29 = Broilers

30 = Dairy cows

31 = Beef cows

32 = Yearling production

33 = Calves, fattened on the deferred feeding plan

34 = Calves, fattened on the extended silage feeding plan

35 = Calves, fattened on the calf on silage feeding plan

36 = Calves, fattened on the calf no silage feeding plan

37 = Yearlings, fattened on the short-fed feeding plan

38 = Yearlings, fattened on the silage feeding plan

39 = Yearlings, fattened on the no silage feeding plan

40 = Pork

41 = Off-farm pasture, Region to Area

42 = Hay to roughage

43 = Hay, Area to Region

44 = Hay, Region to Area

45 = Hired labor, crop-season

46 = Hired labor, non-crop-season

The 28 activities of a Consuming Region, denoted by m, are:

(m) 1 = Conversion of fluid milk into manufactured milk products

2 = Calf slaughter

3 = Yearlings slaughter

4 = Conversion of wheat to TDN 1 and protein 1

5 = Conversion of wheat to TDN 2 and protein 2

6 = Conversion of wheat to TDN 3 and protein 3

7 = Conversion of feed grains to TDN 1 and protein 1

8 = Conversion of feed grains to TDN 2 and protein 2

9 = Conversion of feed grains to TDN 3 and protein 3

10 = Conversion of soybeans to TDN 1 and protein 1

11 = Conversion of soybeans to TDN 2 and protein 2

12 = Conversion of soybeans to TDN 3 and protein 3

13 = Conversion of cottonseeds to TDN 1 and protein 1

14 = Conversion of cottonseeds to TDN 2 and protein 2

15 = Conversion of cottonseeds to TDN 3 and protein 3

16 = Conversion of exogenous feed 1 to TDN 1 and protein 1

17 = Conversion of exogenous feed 1 to TDN 2 and protein 2

18 = Conversion of exogenous feed 1 to TDN 3 and protein 3

19 = Conversion of exogenous feed 2 to TDN 1 and protein 1

20 = Conversion of exogenous feed 2 to TDN 2 and protein 2

21 = Conversion of exogenous feed 2 to TDN 3 and protein 3

22 = Conversion of exogenous feed 3 to TDN 1 and protein 1

23 = Conversion of exogenous feed 3 to TDN 2 and protein 2

24 = Conversion of exogenous feed 3 to TDN 3 and protein 3

25 = Conversion of exogenous feed 4 to TDN 1 and protein 1

26 = Conversion of exogenous feed 4 to TDN 2 and protein 2

27 = Conversion of exogenous feed 4 to TDN 3 and protein 3

28 = Conversion of grain-fed beef to non-grain-fed beef

The 12 Transportation activities among Regions, denoted by h, are:

(h) 1 = Wheat transportation

2 = Feed grain transportation

3 = Soybean transportation

4 = Cottonseed transportation

5 = Feeder calf transportation

6 = Yearling transportation

7 = Beef, grain-fed, transportation

8 = Beef, non-grain-fed, transportation

9 = Pork transportation

10 = Fluid milk transportation

11 = Manufactured milk transportation

12 = Broiler transportation

The 5 constraints at the national level, denoted by t, are:

(t) 0 = National cotton demand

1 = National supply of exogenous feed 1

2 = National supply of exogenous feed 2

3 = National supply of exogenous feed 3

4 = National supply of exogenous feed 4

The 20 constraints at the regional level, denoted by r, are:

(r) 1 = Regional wheat demand

2 = Regional feed grain demand

3 = Regional soybean demand

4 = Regional cottonseed demand

5 = Regional beef cow and calf account

6 = Regional yearling and calf account

7 = Regional grain-fed beef demand

8 = Regional non-grain-fed beef demand

9 = Regional pork demand

10 = Regional fluid milk demand

11 = Regional manufactured milk demand

12 = Regional broiler demand

13 = Regional TDN 1 account

14 = Regional TDN 2 account

15 = Regional TDN 3 account

16 = Regional protein 1 account

17 = Regional protein 2 account

18 = Regional protein 3 account

19 = Regional hay demand

20 = Regional off-farm pasture supply

The 13 constraints at the area level, denoted by a, are:

(a) 1 = Area class 1 crop-hay land supply

2 = Area class 2 crop-hay land supply

3 = Area class 3 crop-hay land supply

4 = Area class 1 cropland supply

5 = Area class 2 cropland supply

6 = Area class 3 cropland supply

7 = Area cotton land supply

8 = Area wild hay land supply

9 = Area on-farm pasture supply

10 = Area crop-season family labor supply

11 = Area non-crop-season family labor supply

12 = Area hay account

13 = Area roughage account

Activities

The three types of activities are:

X_{kn} The level of the n-th activity in the k-th area

Y_{im} The level of the m-th activity in the i-th region

$Z^h_{ii'}$ The level of the h-th transportation activity from the i-th region to the i'-th region

Constraints

The three types of constraints are:

F^t The t-th constraints at the national level

R^r_i The r-th constraint of the i-th region

A_k^a The a-th constraint of the k-th area

Input-output coefficients

The seven types of input-output coefficients are:

$_1X_{kn}^t$ Coefficient for activity X_{kn} in the t-th constraint at the national level (indicated by subscript 1)

$_2X_{kn}^r$ Coefficient for activity X_{kn} in the r-th constraint at the regional level (indicated by subscript 2)

$_3X_{kn}^a$ Coefficient for activity X_{kn} in the a-th constraint at the area level (indicated by subscript 3)

$_1Y_{im}^t$ Coefficient for activity Y_{im} in the t-th constraint at the national level

$_2Y_{im}^r$ Coefficient for activity Y_{im} in the r-th constraint at the regional level

$_3Y_{im}^a$ Coefficient for activity Y_{im} in the a-th constraint at the area level

$_2Z_{ii}^h$ Coefficient for activity Z^h (since its absolute value being always 1, it is omitted in the mathematical model.)

Objective function

The objective function, Equation 1, is to minimize the costs of production and transportation of crops and livestock products to meet the national and regional consumption demands adjusted for exports and imports, subject to the constraints, Equations 2 to 40.

$$\text{Minimize } f(X, Y, Z) = \sum_{k=1}^{138} \sum_{n=1}^{46} (C_{X_{kn}}) X_{kn} + \sum_{i=1}^{15} \sum_{m=1}^{28} (C_{Y_{im}}) Y_{im}$$

$$+ \sum_{h=1}^{12} \sum_{i=1}^{15} \sum_{\substack{i'=1 \\ i' \neq i}}^{15} (C_{Z_{ii'}}) \, Z^{h}_{ii'}, \qquad (1)$$

Some of the notations in the objective function and in the constraints are explained in the following notes:

(a) The capital letters represent activities and constraints; the small letters, input-output coefficients.

(b) The C coefficients are the cost per unit of the activity indicated by the subscripts.

(c) Though the full ranges of the variables are presented in the objective function, some of the variables may be zero in certain areas or regions.

(d) In the constraint inequalities below, multiple subscripts and superscripts are used for summations. For instance, in Equation 8 the summation $\sum_{\substack{n=7 \\ n=14}}^{\substack{22 \\ 9}}$ ranges from n = 7 to n = 9, and then from n = 14 to n = 22. In some cases, the summation ranges over the value of every fourth n. For instance, in Equation 27 the values of n are 1, 4, 7, 10, and then 14, 17, 20, 23, 26. In some cases, for instance Equation 30, some single value of n (n = 26) is added to the summation.

<u>Constraint equalities or inequalities</u>

National cotton lint demand constraint is:

$$\sum_{k=1}^{138} \sum_{n=1}^{3} {}_{1}x^{t}_{kn} \, X_{kn} \geq F^{0} \qquad \text{where } t = 0 \qquad (2)$$

National supplies of exogenous feed concentrates are:

$$\sum_{i=1}^{15} \sum_{m=16}^{18} {}_1y^1_{im} \, Y_{im} = F^1 \qquad (3)$$

$$\sum_{i=1}^{15} \sum_{m=19}^{21} {}_1y^2_{im} \, Y_{im} = F^2 \qquad (4)$$

$$\sum_{i=1}^{15} \sum_{m=22}^{24} {}_1y^3_{im} \, Y_{im} = F^3 \qquad (5)$$

$$\sum_{i-1}^{15} \sum_{m=25}^{27} {}_1y^4_{im} \, Y_{im} = F^4 \qquad (6)$$

The regional demands for wheat are:

$$\sum_{j=1}^{d} \sum_{n=4}^{6} {}_2x^r_{ijn} \, X_{ijn} - \sum_{m=4}^{6} {}_2y^r_{im} \, Y_{im} + \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z^h_{i'i} - \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z^h_{ii'} \geq R^r_i \qquad (7)$$

where r = 1; i = 1, 2,..., 15; d varies with i as shown in Table A-16; h = 1.

The regional demand for feed grain is:

$$- \sum_{j=1}^{d} \sum_{\substack{n=7 \\ n=14}}^{\substack{22 \\ 9}} {}_2x^r_{ijn} \, X_{ijn} + \sum_{m=7}^{9} {}_2y^r_{im} \, Y_{im} - \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z^h_{i'i} + \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z^h_{ii'} \leq - R^r_i \qquad (8)$$

where r = 2; h = 2, i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional demand for soybean is:

$$- \sum_{j=1}^{d} \sum_{\substack{n=14 \\ n=20}}^{\substack{22 \\ 16}} {}_2x^r_{ijn} \, X_{ijn} + \sum_{m=10}^{12} {}_2y^r_{im} \, Y_{im} - \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z^h_{i'i} + \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z^h_{ii'} \leq - R^r_i \qquad (9)$$

where r = 2; h = 3; i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional demand for cottonseed is:

$$-\sum_{j=1}^{d}\sum_{n=1}^{3} {}_2x^r_{ijn} X_{ijn} + \sum_{m=13}^{15} {}_2y^r_{im} Y_{im} - \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{i'i} + \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{ii'} \leq - R^r_i \quad (10)$$

where r = 4; h = 4; i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional account of beef calf is:

$$-\sum_{j=1}^{d}\sum_{n=30}^{31} {}_2x^r_{ijn} X_{ijn} + \sum_{j=1}^{d}\sum_{n=32}^{36} X_{ijn} + Y_{im} + \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{i'i} - \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{ii'} \leq R^r_i \quad \ldots (11)$$

where r = 5; h = 5; m = 2; i = 1, 2,..., 15; d varies with i as shown in Table A-16; $R^r_i = 0$.

The regional account of beef yearling is:

$$-\sum_{j=1}^{d} {}_2x^r_{ijn} {}_{n=32} X_{ijn} + \sum_{j=1}^{d}\sum_{n=37}^{39} X_{ijn} + Y_{im} + \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{i'i} - \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{ii'} \leq R^r_i \quad \ldots (12)$$

where r = 6; h = 6; m = 3; i = 1, 2,..., 15; d varies with i as shown in Table A-16; $R^r_i = 0$.

The regional demand for grain-fed beef is:

$$\sum_{j=1}^{d}\sum_{n=33}^{39} {}_2x^r_{ijn} X_{ijn} - {}_2y^r_{im} Y_{im} + \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{i'i} - \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{ii'} \geq R^r_i \quad (13)$$

where r = 7; h = 7; i = 1, 2,..., 15; m = 28; d varies with i as shown in Table A-16.

The regional demand for other beef is:

$$\sum_{j=1}^{d}\sum_{n=30}^{31} {}_2x^r_{jin} X_{ijn} + \sum_{\substack{m=2 \\ n=28}}^{3} {}_2y^r_{im} Y_{im} + \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{i'i} - \sum_{\substack{i'=1 \\ i'\neq i}}^{15} Z^h_{ii'} \geq R^r_i \quad (14)$$

where r = 8; h = 8, i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional demand for pork is:

$$\sum_{j=1}^{d} {}_2x_{ijn}^{r} X_{ijn} + \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{i'i}^{h} - \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{ii'}^{h} \geq R_i^r \qquad (15)$$

where r = 9; h = 9, n = 40; i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional demand for fluid milk is:

$$\sum_{j=1}^{d} {}_2x_{ijn}^{r} X_{ijn} - {}_2y_{im}^{r} Y_{im} + \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{i'i}^{h} - \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{ii'}^{h} \geq R_i^r \qquad (16)$$

where r = 10; h = 10; n = 30; m = 1, i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional demand for manufactured milk is:

$$2y^{r} Y_{im} + \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{i'i}^{h} - \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{ii'}^{h} \geq R_i^r \qquad (17)$$

where r = 11; m = 1; i = 1, 2,..., 15; h = 11.

The regional demand for broiler is:

$$\sum_{j=1}^{d} {}_2x_{ijn}^{r} X_{ijn} + \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{i'i}^{h} - \sum_{\substack{i'=1 \\ i' \neq i}}^{15} Z_{ii'}^{h} \geq R_i^r \qquad (18)$$

where r = 12; h = 12; n = 29; i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional accounts of TDN 1 and protein 1 are:

$$\sum_{j=1}^{d} \sum_{n=29}^{31} {}_2x_{ijn}^{r} X_{ijn} - \sum_{m=4,7}^{25} Y_{im} \leq R_i^r \qquad (19),(22)$$

where r = 13 (for TDN 1); r = 16 (for protein 1); i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional accounts of TDN 2 and protein 2 are:

$$\sum_{j=1}^{d} {}_2x^r_{ijn} X_{ijn} - \sum_{m=5,8}^{26} Y_{im} \leq R^r_i \tag{20),(23}$$

where r = 14 (for TDN 2); r = 17 (for protein 2); n = 32; i = 1, 2,..., 15; d varies with i as shown in Table A-16; $R^r_i = 0$.

The regional accounts of TDN 3 and protein 3 are:

$$\sum_{j=1}^{d} \sum_{n=33}^{40} {}_2x^r_{ijn} X_{ijn} - \sum_{m=6,9}^{27} Y_{im} \leq R^r_i \tag{21),(24}$$

where r = 15 (for TDN 3); r = 18 (for protein 3); i = 1, 2,..., 15; d varies with i as shown in Table A-16 $R^r_i = 0$.

The regional demand for hay is:

$$-\sum_{j=1}^{d} X_{ijn} + \sum_{j=1}^{d} X_{ijn} \leq - R^r_i \qquad \begin{matrix} n=43 & n=44 \end{matrix} \tag{25}$$

where r = 19; i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The regional supply of pasture-not-on-farm is:

$$\sum_{j=1}^{d} {}_2x^r_{ijn} X_{ijn} \leq R^r_i \tag{26}$$

where r = 20; n = 41; i = 1, 2,..., 15; d varies with i as shown in Table A-16.

The area supply of crop-hay land class 1 is:

$$\sum_{\substack{n=1,4 \\ n=14,17}}^{\substack{26 \\ 10}} x_{kn} \leq A^a_k \tag{27}$$

where a = 1; k = 1, 2,..., 138.

The area supply of crop-hay land class 2 is:

$$\sum_{\substack{n=2,5 \\ n=15,18}}^{\substack{27 \\ 11}} X_{kn} \leq A_k^a \tag{28}$$

where a = 2; k = 1, 2,..., 138.

The area supply of crop-hay land class 3 is:

$$\sum_{\substack{n=3,6 \\ n=16,19}}^{\substack{28 \\ 12}} X_{kn} \leq A_k^a \tag{29}$$

where a = 3; k = 1, 2,..., 138.

The area supply of cropland class 1 is:

$$\sum_{\substack{n=1,4 \\ n=14,17 \\ n=26}}^{\substack{20 \\ 7}} X_{kn} + \underset{n=23}{3 x_{kn}^{a} X_{kn}} \leq A_k^a \tag{30}$$

where a = 4; k = 1, 2,..., 138.

The area supply of cropland class 2 is:

$$\sum_{\substack{n=2,5 \\ n=15,18 \\ n=27}}^{\substack{21 \\ 8}} X_{kn} + \underset{n=24}{3 x_{kn}^{a} X_{kn}} \leq A_k^a \tag{31}$$

where a = 5; k = 1, 2,..., 138.

The area supply of cropland class 3 is:

$$\sum_{\substack{n=3,6 \\ n=16,19 \\ n=28}}^{\substack{22 \\ 9}} X_{kn} + \underset{n=25}{3 x_{kn}^{a} X_{kn}} \leq A_k^a \tag{32}$$

where a = 6; k = 1, 2,..., 138.

The area supply of cotton land is:

$$\sum_{n=1}^{3} X_{kn} \leq A_k^a \qquad (33)$$

where a = 7; k = 1, 2,..., 138.

The area supply of wild hay land is:

$$X_{kn} \leq A_k^a \qquad (34)$$

where a = 8; n = 13; k = 1, 2,..., 138.

The area supply of pasture-on-farm is:

$$-\sum_{n=1}^{28} {}_3x_{kn}^a \; X_{kn} + \sum_{n=30}^{40} {}_3x_{kn}^a \; X_{kn} - \underset{n=41}{X_{kn}} \leq A_k^a \qquad (35)$$

where a = 9; k = 1, 2,..., 138.

The area supply of crop-season family labor is:

$$\sum_{n=1}^{40} {}_3x_{kn}^a \; X_{kn} - \underset{n=45}{X_{kn}} \leq A_k^a \qquad (36)$$

where a = 10; k = 1, 2,..., 138.

The area supply of non-crop-season family labor is:

$$\sum_{n=29}^{40} {}_3x_{kn}^a \; X_{kn} - \underset{n=46}{X_{kn}} \leq A_k^a \qquad (37)$$

where a = 11; k = 1, 2,..., 138.

The area account of hay is:

$$\sum_{\substack{n=10\\n=23\\n=44}}^{\substack{25\\13}} {}_3x_{kn}^a \; X_{kn} + \sum_{n=42}^{43} X_{kn} \leq A_k^a \qquad (38)$$

where a = 12; k = 1, 2,..., 138; $A_k^a = 0$

The area account of roughage is:

$$- \sum_{\substack{n=17 \\ n=42 \\ n=44}}^{25} 3^{x_{kn}^a} X_{kn} + \sum_{n=30}^{39} 3^{x_{kn}^a} X_{kn} \leq A_k^a \qquad (39)$$

where a = 13; k = 1, 2,..., 138.

All the variables are non-negative:

$$X_{kn}, \; Y_{im}, \; Z_{ii}^{h}1 \leq 0 \qquad (40)$$

where k = 1, 2,..., 138; n = 1, 2,..., 46; i = 1, 2,..., 15;

m = 1, 2,..., 27; h = 1, 2,..., 12; i = 1, 2,..., 15; i' = 1, 2,..., 15.

CHAPTER III. SOME SALIENT POINTS

In the course of a normative and quantitiative economic research, new problems related to any of the following categories may occur: knowledge of the facts under study, economic theories to formulate the frame work of the model, theories and techniques of mathematical programming to build a valid mathematical programming model, statistical techniques to collect, measure, evaluate and analyse data for the model, and, if the model is a large scale one, a computer programming language to process data to fit them into the mathematical model for solving by a computer and to extract information from solutions of the model.

Discussed in this chapter will be the following topics which, though not necessarily new problems, are related to the present study: (1) the justification of applying cost-minimizing linear programming to agricultural sector; (2) the theoretical background of shadow price; (3) some problems in the delineation of consuming regions and producing areas; and (4) differences between a linear programming solution and the real world.

Cost-minimizing Model and Agricultural Industry

This normative study on spatial equilibrium of American agricultural production and consumption by means of a linear programming model has an objective (cost) function to be minimized, subject to minimum (consumption) demand constraints and maximum (resources) supply constraints.

A linear programming model is essentially a centralized decision-making model. But agriculture is often cited as an industry which exhibits market characteristics closest to the classical concept of perfect competition in which every firm is trying to maximize its profits in atomistic competition. Then, naturally arises the question of how to reconcile the agricultural industry with a cost-minimizing and centralized decision-making model.

First, the cost-minimizing model has a dual model which maximizes the shadow prices of constraints. For instance, the primal problem is to:

$$\text{Minimize} \quad c'x$$

$$\text{Subject to} \quad \begin{bmatrix} A_1 \\ \cdots \\ -A_2 \end{bmatrix} \begin{bmatrix} x \end{bmatrix} \geq \begin{bmatrix} b_1 \\ \cdots \\ -b_2 \end{bmatrix}$$

$$x \geq 0$$

where c is the vector of cost; b is the vector of constraints (b_1, consumption demand; b_2, resources), $\begin{bmatrix} A_1 \\ \cdots \\ -A_2 \end{bmatrix} = A$ is the matrix of input-output coefficients; and x is the vector of solution to the model. Then its dual problem is to:

$$\text{Maximize} \quad b'y$$

$$\text{Subject to} \quad \begin{bmatrix} A_1' & \vdots & -A_2' \end{bmatrix} \begin{bmatrix} y \end{bmatrix} \leq \begin{bmatrix} c \end{bmatrix}$$

$$y \geq 0$$

where y is the vector of shadow prices of the constraints.

The original cost-minimizing model can also be expressed as a profit-maximizing problem:

$$\text{Maximize} \quad r'x$$

$$\text{Subject to} \quad \begin{bmatrix} -A_1 \\ \cdots\cdots \\ A_2 \end{bmatrix} \begin{bmatrix} x \end{bmatrix} \leq \begin{bmatrix} -b_1 \\ \cdots \\ b_2 \end{bmatrix}$$

$$x \geq 0$$

where r is a vector of net profit (price minus cost), with **A** matrix and b vector remaining unchanged except their signs. But since the present study is more interested in finding out the total cost of meeting the national consumption demand of major agricultural products (with land and labor treated as free resources in the model), the cost-minimizing model[1] is used.

Since the linear model implies constant return to scale in production, the number of farms in each producing areas is indeterminate. It may, however, be imagined that there are a great number of farms, all of some given small size, in each producing area in atomistic competition with one another and also with farms in other producing areas. Therefore, the centralized decision-making linear programming model achieves the same goal of competitive efficiency as the competitive profit-maximizing process by numerous farms in a decentralized and atomistic way (Dorfman-Samuelson-Solow, 1958, pp. 407-8).

Shadow Price

Associated with each linear programming problem the primal, is

[1] Admittedly, the solutions of the cost-minimizing model and the profit-maximizing model are not identical, though very close in value (after changing the inequalities of the demand constraints in the profit-maximizing model into equalities). The profit-maximizing model involves additional computation of profits and, hence, commodity prices.

another linear problem, a dual, whose solution are generally interpreted as shadow prices, equilibrium prices, inputed cost, accounting prices, or accounting value of the constraints (e.g. resources, etc.) in the primal.

A dual solution is essentially a mathematical property of a mathematical programming. A single shadow price is the partial derivative of the objective function with respect to a constraint, i.e. $y_i = \frac{\partial F}{\partial b_i}$ where F is the objective function, b_i is the ith constraint, and y_i is the dual related to the ith constraint. It refers to a (shadow) cost in a cost-minimizing model, but to a (shadow) profit in a profit-maximizing model, with the (shadow) cost or the (shadow) profit to be mainly determined by the cost coefficient or the profit coefficient, respectively, in the model. In a model whose objective function is devoid of economic meaning, a dual still refers to the "value" of the objective function, be it an abstract unit of happiness (in a personal happiness-maximizing model), or an abstract unit of crime (in a public crime-fighting (minimizing) model).

The meanings of dual solutions will be obvious after two related theorems are discussed. Now the dual solution (shadow prices) related to the primal can be illustrated by the duality theorem (stated without proof), and the complementary slackness theorem.

The duality theorem of linear programming states that if feasible solutions to both the primal and the dual systems exist, then there exist an optimum solution to both systems and the minimum (maximum) value of the primal is equal to the maximum (minimum) value of the dual (i.e. there exists a saddle point solution of the Lagrangean) (Dantzig, 1963,

p. 129). The concept of duality was first initiated by John von Neuman in 1947 and an explicit duality theorem was formulated and proved by Gale, Kuhn, and Tucker (1951) by means of the classical lemma of Farkas (Dantzig 1963, pp. 123-4).

Complementary slackness

The concept of complementary slackness is: of the two inequalities, $p \geq 0$ and $q \geq 0$, one must be an equality. The theorem of complementary slackness states that:

$\sum_{j=1}^{m} b_j x_j$ is the minimum value of a primal (min $b'x$, such that $Ax \geq c$, $x \geq 0$) and $\sum_{i=1}^{n} c_i y_i$ is the maximum value of its dual (max $c'y$, such that $yA \leq b$, $y \geq 0$) and $\sum_{j=1}^{m} b_j x_j = \sum_{i=1}^{n} c_i y_i$ if, and only if,

(i) either $y_i = 0$ or $\sum_{j=1}^{m} a_{ij} x_j = c_i$ $\quad i = 1, 2, \ldots, n$

and (ii) either $x_j = 0$ or $\sum_{i=1}^{n} y_i a_{ij} = b_j$ $\quad j = 1, 2, \ldots, m$

(i) means if a constraint, i, in the primal is binding (i.e. $\sum_{j=1}^{m} a_{ij} x_i = c_i$ (e.g. resource exhausted) then it has positive shadow price, y_i, or if a constraint, c_i, is non-biding (i.e. $-\sum_{j=1}^{m} a_{ij} x_j > -c_i$; e.g. surplus resource), then the shadow price $y_i = 0$. (ii) can be interpreted analogously.

Proof of this complementary slackness theorem is the same as the proof of $\sum_{j=1}^{m} b_j x_j = \sum_{i=1}^{n} c_i y_i$, the saddle point (Duffin-Peterson-Zener, 1967, pp. 23-24).

Proof: From the dual

$$b_j \geq \sum_{i=1}^{n} y_i a_{ij} \qquad j = 1, 2, \ldots, m$$

post-multiplying both sides by x_j (this is legitimate because $x_j \geq 0$), and summing over j:

$$\sum_{j=1}^{m} b_j x_j \geq \sum_{j=1}^{m} \left(\sum_{i=1}^{n} y_i a_{ij}\right) x_j = \sum_{i=1}^{n} y_i \left(\sum_{j=1}^{m} a_{ij} x_j\right) \qquad (1)$$

The inequality (1) becomes an equality only if

$$\sum_{i=1}^{n} y_i a_{ij} = b_j \qquad j = 1, 2, \ldots, m,$$

or $x_j = 0$ $\qquad j = 1, 2, \ldots, m,$

or a combination of both, but not for the same j.

From the primal

$$\sum_{j=1}^{m} a_{ij} x_j \geq c_i \qquad i = 1, 2, \ldots, n$$

and because $y_i \geq 0$ $\qquad i = 1, 2, \ldots, n$

hence $$\sum_{i=1}^{n} y_i \left(\sum_{j=1}^{m} a_{ij} x_j\right) \geq \sum_{i=1}^{n} y_i c_i \qquad (2)$$

The inequality (2) becomes an equality only if

$$\sum_{j=1}^{m} a_{ij} x_j = c_i \qquad i = 1, 2, \ldots, n,$$

or $y_i = 0$ $\qquad i = 1, 2, \ldots, n,$

or a combination of both, but not for the same i.

Therefore $\sum_{j=1}^{m} b_j x_j = \sum_{i=1}^{n} y_i c_i$ if, and only if, conditions (i) and (ii) are satisfied.

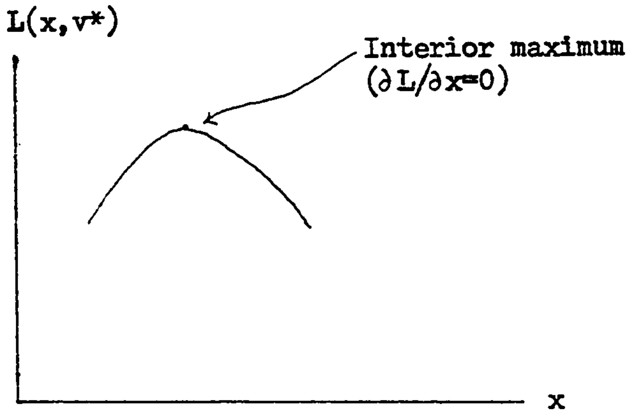

Figure 3a. Interior maximum

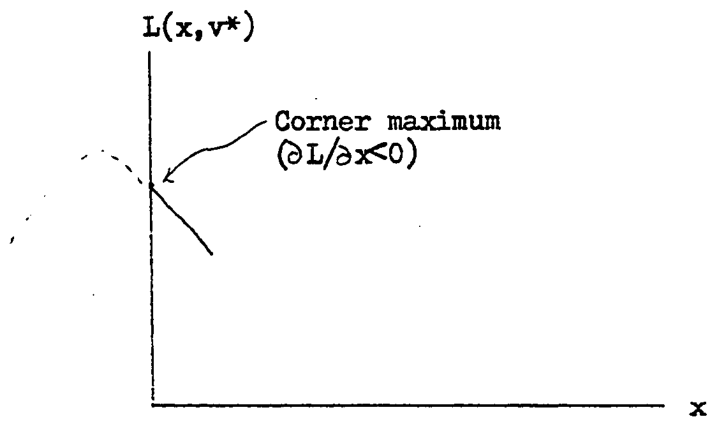

Figure 3b. Corner maximum

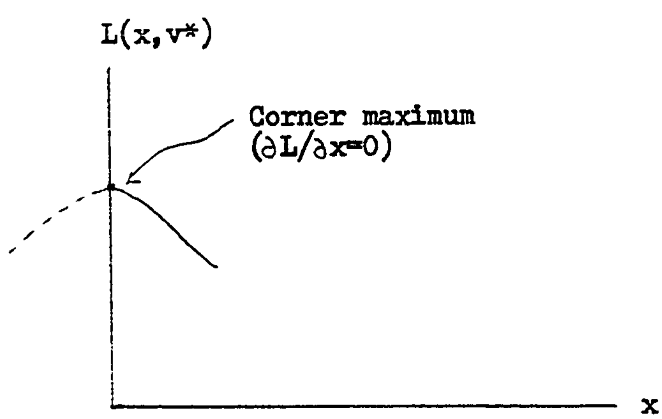

Figure 3c. Corner maximum

Lagrangean

The shadow price may also be derived from the classical Lagrangean form:

Maximize $f(x)$ (e.g. $c'x$)

Subject to $h(x) \leq b$ (e.g. $Ax \leq b$)

$x \geq 0$

The Lagrangean form is:

$$L = L\ (x,\ v) = f(x) + v'\ (b - h(x))$$

Since it is to maximize a concave function, then by the Kuhn-Tucker conditions (1950) the optimal solution of the Lagrangean function with respect to x is:

(i) $L\ (x^*,\ v^*)_{x^*} \leq 0$ or $f_{x^*} - v^{*\prime}h_{x^*} \leq 0$

where $L\ (x^*,\ v^*)_{x^*} = \left.\frac{\partial L\ (x,v)}{\partial x}\right|_{x^*,\ v^*}$

The other Kuhn-Tucker conditions are:

(ii) $L\ (x^*,\ v^*)_{x^*} \cdot x^* = 0$ or $f_{x^*} \cdot x^* - v^{*\prime}h_{x^*} \cdot x^* = 0$;

(iii) $L\ (x^*,\ v^*)_{v^*} \geq 0$ or $b - h(x^*) \geq 0$;

(iv) $L\ (x^*,\ v^*)_{v^*} \cdot v^* = 0$ or $v^*(b-h(x^*)) = 0$;

(v) $x \geq 0$; and

(vi) $y \geq 0$.

Under (i), the concave function $f(x)$ to be maximized can only be **positioned** in one of the three ways (Figures 3a, 3b, and 3c). In the first case, $L(x^*,\ v^*)_{x^*} = 0$; in the second case, $L(x^*,\ v^*)_{x^*} < 0$; hence $L(x^*,\ v^*)_{x^*} \leq 0$.

In $f_{x^*} - v^{*\prime}h_{x^*} \leq 0$, f_{x^*} is the value of marginal product (VMP) and $v^{*\prime}h_{x^*}$ is the imputed value (shadow price) of input (VMI), if f_{x^*} -

$v^{*\prime}h_{x^*} = 0$, the VMP equals the VMI, and $L(x, v)$ is maximized.

Under K-T condition (ii), $L(x^*, v^*)_{x^*} \cdot x^* = 0$. This means either

(a) $L(x^*, v^*)_{x^*} = 0$ and $x^* > 0$ (Figure 3a),

or (b) $L(x^*, v^*)_{x^*} < 0$, $x^* = 0$ (Figure 3b),

or (c) $L(x^*, v^*)_{x^*} = 0$, $x^* = 0$ (Figure 3c).

(iv) implies: either $v^* = 0$, or $b - h(x^*) = 0$.

Here v^* is the Lagrangean multiplier. If $b - h(x^*) > 0$, i.e. surplus resource exists, then v^*, its shadow price, is zero. If $b - h(x^*) = 0$, i.e. a resource is exhausted, then $v^* > 0$, i.e. its shadow price is positive (another way) of proving complementary slackness). Free disposal of resource is implied here (i.e. it is costless to have resources idle).

Shadow price indicates the change of the value of the objective function with respect to a change in the magnitude of a constraint by a unit - the value of marginal product of a constraint (Heady-Candler, 1958, p. 85, pp. 90-91), and hence, an opportunity valuation of the constraint (Hadley, 1962, pp. 484-5), be it an input (e.g. supply of resource) constraint or an output (e.g. consumption demand) constraint. It may also be viewed as a functional relation between a variable (constraint) and its function (value of the objective function). Such functional relationship has its sensitivity, i.e. a shadow price may be fixed for a certain range of the magnitude of a constraint, beyond that a new shadow price and a new basis will occur. Study of the variation of the range of the magnitude of a constraint, within which its shadow price remains unchanged, is the sensitivity analysis.

The Lagrangean form also leads to the expression of a saddle-point where the maximum (minimum) value of the primal equals the minimum (maximum) value of its dual (see above for proof of $\sum_{j=1}^{m} b_j x_j = \sum_{i=1}^{n} c_i y_i$):

$$f(x) + v^{*\prime}g(x) \leq f(x^*) + v^{*\prime}g(x^*) \leq f(x^*) + v'g(x^*)$$

where $g(x) = b - h(x)$ in the Lagrangean form (Uzawa, 1958, pp. 33-4).

Though shadow price is not directly related to the actual cost of a constraint, the existence of a saddle-point implies an equilibrium between, e.g. in a profit-maximizing model, imputed costs (shadow prices) of constraints (recources, etc.) and the value of outputs such that a firm can control or adjust the constraints (use of resources, etc.) while facing given prices of outputs (Karlin, 1959, p. 201). Therefore, shadow prices serve as a guide to a firm for it to make possible profitable adjustments of its constraints (relaxing or contracting) in the light of actual costs of outputs and resources.

Shadow price and equilibrium

For a primal min cx, such that $Ax \geq b$, $x \geq o$, the dual $yA \leq c$ or

$$\sum_{i=1}^{m} y_i a_{ij} \leq c_j \qquad (j = 1, 2, \ldots, n) \qquad (1)$$

implies that the inner product of the vector of the input-output coefficients of the jth activity (a production function) of the primal and the vector of the dual solution (shadow prices) of the primal is equal to or less than the cost coefficient of the jth activity in the objective function of the primal of a cost-minimizing problem (or $\geq$ the profit coefficient of the jth activity of the primal of a profit-maximizing problem).

Since a cost-minimizing primal is conventionally written as $Ax \geq b$

where demand constraints are written as $\sum_{j=1}^{n} a_{ij}x_j \geq b_i$ for i=1,2,..., k

and resource constraints are written as $\sum_{j=1}^{n} -a_{ij}x_j \geq -b$ for i=k+1, i=k+2, ..., m, then (1) can be written as

$$\sum_{i=1}^{k} y_i a_{ij} - \sum_{i=k+1}^{m} y_i a_{ij} \leq c_j \qquad (j = 1, 2, \ldots, n)$$

$$\text{or} \quad \sum_{i=1}^{k} y_i a_{ij} \leq c_j + \sum_{i=k+1}^{m} y_i a_{ij} \qquad (j = 1, 2, \ldots, n) \qquad (2)$$

The left-hand side of (2) is the total value of output of the jth activity of the primal in terms of the shadow prices (duals) of the demand constraints, while the right-hand side of (2) is the total cost of the inputs of the jth activity of the primal, which consists of the cost coefficient of the jth activity and the shadow prices of the resource constraints which are binding.

When equality holds the total value of outputs of the jth activity equals the total cost of inputs, implying a condition of perfect competition with the shadow prices being the equilibrium prices, i.e. the value of marginal product (VMP) (the left-hand side) equals the value of marginal inputs (VMI) (the right-hand side). When inequality holds, VMP < VMI, it does not pay to have the jth activity in the solution and the jth x equals zero (Lancaster, 1968, p. 33). It is also to be interpreted that the total value of shadow prices of outputs should not exceed the total cost of inputs (which may include shadow prices of binding resource constraints) so that the dual problem, i.e. the (shadow-price) maximizing model, will not have an unbounded solution. The objective function of the dual problem, whose value is to be maximized, consists of the demand constraints (in positive sign) and the resources constraints (in negative sign) of the primal, and its variables are the shadow prices of the primal and their values are to be maximized (see Section Dairy Cows, Chapter V, for numerical examples).

Problems in Delineation of Regions and Areas

The structure of the model is limited by the restraints in research fund and time available for the research project. Two obvious examples are delineations of consuming regions and producing areas.

Delineation of consuming regions

The idealistic criterion of delineating consuming regions is the population center, with the iso-population line between two population centers being the boundary between two consuming regions, like the trough between two hills being the natural line separating them. Combining several states into a consuming region in this model was done to take advantage of the existence of most data on a state basis, with the awareness that a state line might not be a natural boundary of a consuming region.

Delineation of producing areas

To make more intensive study of certain areas in a national spatial equilibrium model, those areas are normally divided into smaller sub-areas so as to reveal the comparative advantages and disadvantages of the smaller sub-areas, which would otherwise be submerged in the larger areas of which they are originally parts.

The criteria in delineating producing areas in this model are: closeness in yield, soil type, climate conditions, production cost, etc. Counties of similar average yield were grouped into one area. Since there are variations in yield in counties, there are variations in yield within each area, and overlappings in the range of yield of areas. Suppose an area did not appear in the solution and is further divided into smaller areas according to different yield, then the range of the yield (in terms of county data) of the smaller areas must be smaller than that of the oroginal areas, and the average yield for the smaller areas will also differ from that of the original area. Thus the smaller area with a higher yield (assuming same production cost per acre for all areas for simplicity) will have a chance to go into the solution even the original area did not have, to displace the other original areas in the new solution if the smaller area with a higher yield is still large enough to produce enough to satisfy the consumption need of the region. If the smaller area cannot produce enough to satisfy the demand, the other original area which was in the solution will still be in the solution to satisfy the remaining need of the region. Therefore, sub-division of an area will enhance the chances of some of its sub-areas to go into the solution, at the expense of the other original areas which are not sub-divided.

An example will illustrate this: A consuming region consists of two producing areas, No. 1 and No. 2, and has a consumption demand for wheat of 1000 units. Area 1 has an average yield of 110 units ranging from 100 to 120 and a total production capacity of 1000 units. Area 2 has an average yield of 107 ranging from 97 to 117, and a capacity of 2000 units. Obviously Area 1 is in the solution producing 1000 units to satisfy the regional demand. After Area 2 is divided into two sub-areas, 2a and 2b, with a yield of 112 and 102, respectively, and a capacity of 1000 units each, the solution changes from Area 1 to Area 2a, as shown below.

	Area 1	Area 2	Sub-Area 2a	Sub-Area 2b
Yield	110	107	112	102
Capacity	1000	2000	1000	1000
Solution before Sub-division	1000	--		
Solution after Sub-division	--		1000	--

If area 2 has a capacity of only 1200 units, and Areas 2A and 2B, only 600 units each, then the solution will be

	Area 1	Area 2a	Area 2b
Yield	110	112	102
Capacity	1000	600	600
Solution	400	600	--

Since Area 2a satisfies only part of the regions demand, Area 1 comes into the solution to produce 400 units to satisfy the remaining demand.

Therefore the producing capacity of a sub-area (Area 2a) relative to the magnitude of the regional demand will also determine whether the other original area (Area 1) will remain in the solution (being partially displaced) or will be displaced entirely.

Obviously, it is desirable for all areas to have the same standard deviation (within a pre-set tolerance) for such critical data that determine the selection of activities in the solution, i.e.

$$P\left\{|x - \mu| \geq k\sigma\right\} \leq \delta \qquad \left(\delta > \frac{1}{k^2} \right)$$

where x is a random variable; μ, the mean; σ, standard deviate; δ, an arbitrary number of small value.

If $x \sim N(\mu, \sigma^2)$ then we can obtain an exact probability level, since

$$P\left\{-Z_{\frac{\alpha}{2}} \leq \frac{x-\mu}{\sigma} \leq Z_{\frac{\alpha}{2}}\right\} = (1-\alpha) \in (0, 1)$$

where Z is the standard normal (0, 1) deviate.

The variance of the critical data of all the tentatively delineated areas should be examined. Areas having greater variance should be divided into smaller areas so as to reduce their variance to approximate those of other areas. After a somewhat uniform variance is attained for all areas, further division of areas into smaller areas is not advisable. Division of areas into smaller areas in Region 7 in this model was partly prompted by other considerations.

Solution versus Real World

In addition to the usual causes of discrepancies between an abstract model and the real world, such as structural errors, data errors, etc, a normative study introduces another cause of the discrepancy --- time required by the real world to complete its adjustment towards the optimality if the real world is converging towards such an optimality as indicated by the study. If the time required is relatively long compared with the time period during which changes may occur in the parameters of the model, then the real world is constantly in the process of reacting to changes in exogenous variables and cannot be expected to attain a stable equilibrium. If the reverse is true, the optimality can be attained and a stable equilibrium can be expected. This is valid under the strong assumptions that the model approximates reality reasonably well and there are no serious data errors and structural errors (either intentionally or unintentionally).

The present model deliberately left out many institutional restraints and was intended as the basic model on which modifications could be made with respect to institutional restraints as well as technological progress and changes in demand or resources. Demand for food is considered not volatile, and adjustment of resources, not prompt either. Periodical analysis would determine the magnitude of changes in demand and resource adjustment in the real world.

Therefore, the discrepancies between solutions of the present model and the real world may be attributed to all the possible causes mentioned above: institutional restraints left out from the model, imperfection of data and model structure, the time lag between reality and optimality (providing, in between, no significant disturbances occur in demand, technology, cost structure, and resources).

Another cause of discrepancies on the micro level is due to the process of averaging. Averaging produces an abstract quality of a set of data and eases the task of handling data, but loses or submerges the distinct statistic of each element in the set. Even each producing area is reasonably homogenous in physical environments and farming culture, variances in coefficients such as yield, cost, and other input-output coefficients do exist in reality among farms in an area. Even each producing area is treated in the model as if it were a single farm, in reality each area consists of tens of thousands of farms, each being an individual decision-maker and with a distinct set of coefficients. Discrepancies in a producing area between the solution and the real world may be attributed to the variances of such coefficients.

In a solution of an abstract linear model, in which each area is represented by the average value of the coefficients of the numerous farms in it, an area either produces a crop or does not produce it. In the former case, the discrepancy between the solution and reality may be attributed to those farms in the area with coefficients inferior to the average. In the latter case, it may be attributed to those farms with coefficients superior to the average.

If all farms in an area were represented in the model, discrepancies between a solution and reality would be greatly reduced. Whatever discrepancies remain could be attributed to imperfection of data, or the criteria of decision-making by individual farmers (such as hedging against uncertainty, etc.) which are different from the optimizing criterion of the model, or the adjustment process towards optimality, or simply a stochastic process.

For all these discrepancies between a solution and the real world, then what can be inferred from a solution? As long as a model captures the essential relations between variables in the real world, its solution would reasonably indicate the direction of production adjustments towards optimality, providing there will not occur such changes in the real world as to necessitate a structural change in the model. This is, of course, a rather strong assumption. In order to ascertain whether there are such changes in reality, periodical studies should be made, and the model, modified up to date.

CHAPTER IV. DATA

The present model with 2,100 constraints and 8,056 real activities has a total of 44,710 non-zero elements. Most data for the model were not readily available from official publications, and had to be estimated and computed from various sources, mainly the series of studies on American agricultural spatial equilibrium, particularly, by Eyvindson (1970) and Brokken (1965). Data of the model were for the year of 1965.

The procedures of collecting and processing data for the model are presented in this chapter, in the order of (1) national constraints, (2) consuming region constraints, (3) producing area constraints, (4) crop activities, (5) livestock activities, (6) transfer activities, and (7) transportation activities.

The levels of constraints are shown in Tables A-1, 2, 3 for Solution I and in Tables A-11, 12, 13 for Solution II. Input-output coefficients are not printed out here because of the great number of pages needed (about 800 pages). Instead, several conversion tables for converting Eyvindson's coefficients for use in this model are included in the Appendix.

Conversion Procedures

Most of the data used in this model were adopted from Eyvindson (1970) who culminated in a series of studies by improving, refining, and updating data from previous studies (see Chapter I). In view of the enormous amount of data processed and, in many cases, the laborious procedures used by Eyvindson, it is considered advisable to present at the beginning of each section a verbal summary of his procedures of collecting and processing data, his basic assumptions underlying those procedures, and the important sources of data, to be followed by a description of the specific procedure used in converting his data for use in the present model.

Since the present model differs from Eyvindson's, among other aspects, in the numbers of producing areas (138 vs. 157, respectively), of consuming regions (15 vs. 21), and of farm size in each producing area (1 vs. 3), conversions of Eyvindson's data into the present model were generally made according to one of the following two procedures:

(1) The procedure of summation (for resource or demand constraints): To combine two or more areas or regions into one, the process is straight forward addition. However, where re-delineation of areas or regions involved breaking down old areas or regions into parts and re-combining parts of different old areas or regions into new ones, the disaggregating and aggregating processes had to be executed on a lower data level, i.e. on the county data level, thus necessitating the compilation of county data for all counties involved. For instance, to form the eight new producing areas in the new Consuming Region No. 7 (the Tennessee Valley Region), the following matrix of data had to be computed.

	NA_j	
OA_i	(IN_{ij})	(OUT_i)

where OA_i denotes the ith (old) area of Eyvindson's model, which, or part of which, is in Region 7 of the present model; NA_j denotes the jth (new) area of the present model, which is in Region 7; IN_{ij} denotes the part of OA_i that is in Region 7 and is also part of NA_j; OUT_i denotes the part of OA_i that is out of Region 7. The relations between OA_i, IN_{ij}, OUT_i, and NA_j are:

$$OA_i = IN_{ij} + OUT_i \qquad (i = 16,20,21,22,27,28,140,141,143)$$

$$NA_j = \sum_i IN_{ij} \qquad (j = 131,132,\ldots, 138).$$

For instance, the crop land acreage of each OA_i is divided into IN_{ij} and OUT_i according to the weights of harvested acreage of the intensive crops for IN_{ij} and OUT_i, computed from the 1964 U.S. Census of Agriculture (USBC, 1967b) data of the counties concerned (i.e. summing the harvested acreage over counties in each IN_{ij} in Region 7 and over counties in OUT_i out of Region 7, and then computing the weights for those sums). Summing IN_{ij} over i results in the crop land constraint for NA_j. OUT_i are then incorporated into their respective adjacent areas outside Region 7.

This procedure of summation involves (a) horizontal disaggregation by weights, and (b) vertical simple aggregation, and will hereafter be referred to as Type 1 disaggregating-and-aggregating conversion procedure in this study.

Another example is where a consuming region consists of parts of different states. Consumption demand by this region was computed by summing all the county population and multiplying the total population by per caput consumption demand. When additional resources (e.g. land of small farms) were added to area resource constraints, they were first added to Eyvindson's 157 areas and, and then, the 157 areas were converted into the 138 areas of this model according to Type 1 procedure described above.

(2) The procedure of taking weighted average: When two or more areas are combined into one, the input-output coefficients (such as yield, cost, labor requirement, etc.) of the new area were computed by taking the weighted average of the coefficients of the original areas.

First, it should be determined what should be used as weights (e.g. the acreages of crop land of different areas as weights for weighting the costs of wheat production; the acreage of crop-hay land as weights for hay; the numbers of dairy cows as weights for milk yield). Next, the coefficients of the original areas were disaggregated horizontally by weights (see (1) above) and then aggregated vertically by weights (which were computed, using the example in (1), among IN_{ij} over i for each j) to form the coefficients of the new area (NA_j). In other words, coefficients of the old areas were broken down according to the set of horizontal weights, and coefficients for the new areas were obtained by summing vertically over the fractions of the old coefficients.

This procedure involves (a) horizontal disaggregation by weights, and (b) vertical aggregation by weights, and will hereafter be referred to as Type 2 disaggregating-and-aggregating conversion proceure in the study.

In aggregating Eyvindson's three farm sizes into one, weighted averages were taken of all input-output coefficients, based on appropriate weights (e.g. acreages for crop production cost, herd sizes for livestock production cost).

National Constraints

The five constraints at the national level are: demand for cotton lint, and supply of four types of exogenous concentrate feeds. The demand for cotton lint was based on the actual disappearance of cotton lint in 1965 (USDA ERS 1968) which included both domestic consumption and net exports. The four types of exogenous concentrates, F1, F2, F3, and F4, were originally computed by Brokken (1965). Their total digestable nutrients (TDN) contents are, respectively, 76.9%, 70.5%, 77.0%, and 69.1% (Hodges, 1964), and their conversion into the unit of TDN was adopted from Eyvindson (1970). (See the section on general description of the model, Chapter II.)

Consuming Region Constraints

At the consuming regional level, there are two types of constraints: (a) supply of off-farm pasture, and (b) demand for crops and livestock products. Except for demand for broilers, all regional constraints were obtained from Eyvindson (1970) and Brokken (1965) and adjusted for regions of this model, with the over-estimations of demand for wheat and feed grains (by 8% and 1%, respectively) by Eyvindson (1970, pp. 346-7) corrected.

Demand for wheat

The national domestic consumption of wheat in 1965 (USDA 1967) was distributed among the 15 regions according to regional proportions of the national flour production (USBC 1967a). Commercial export for

1965 was estimated, using a time trend regression equation for exports of 1950-1966. Government export for 1965 was averaged over the 1960-1966 period. National exports were distributed among exporting ports according to Mayer (1967). (Eyvindson, 1970 pp. 344-346.)

Demand for feed grains

The national domestic consumptions of corn, barley, oats and grain sorghum (USDA 1967) were each distributed among the 15 regions according to regional proportions of the national demand for each of them as food and by industry in 1950 (Jennings, 1954). Procedures used in estimating commercial exports and distributing exports among ports are the same as for wheat. The government exports for 1965 were averaged over 1962-1964. In the process, the four component crops were first converted into TDN to facilitate aggregation. (Eyvindson, 1970, pp. 346-347.)

Demand for soybeans

The demand constraints include only exports set equal to the 1965 actual exports (USDA 1967) which were distributed among consuming regions (Mayer, 1967). The 1965 actual exports figure was used because soybean exports do not fluctuate widely through the years. (Eyvindson, 1970, pp. 347-348.)

Demand for cotton seeds

Demand includes only exports, set equal to the 1965 actual exports (USDA 1967), which were distributed among consuming regions where cotton is grown (Eyvindson, 1970, p. 348).

Demand for hay

Demand in each region was set equal to the regional industrial demand for hay for producing alfalfa meal, estimated from state data (Brokken, 1968) (Eyvindson, 1970, pp. 348-349).

Demand for grain-fed beef, non-grain-fed beef, and pork

Same procedures were used in estimating demand for beef and demand for pork. First, per caput consumption was estimated for each of the four regions of the U.S. (Northeast, South, West, and North Central) by adjusting the 1965 national per caput consumption figure (USDA ERS 1967) according to regional variations based on the Household Food Consumption Survey (USDA ARS 1956) (Eyvindson, 1970, p. 338).

Then per caput consumption was estimated for each state within each of the four regions by adjusting the regional per caput consumption for income differences among states, using income elasticities of demand for beef and pork (Brokken, 1968). Demand of each of the consuming region was obtained by (a) aggregating the state per caput consumption over the 1965 state population for the states within the region, and (b) aggregating the demand of the states in the region.

Next, the average net annual import (the U.S. is a net importer of both beef and pork) of 1961-65 was assumed as the normal net import of 1965, and then distributed among consuming regions proportional to regional consumption to reduce regional demand accordingly. Regional beef demand was divided into 63% grain-fed beef and 37% non-grain-fed beef (Brokken, 1965). (Eyvindson, 1970, pp. 338-41.)

Demand for milk

Per caput consumption of eight dairy products (fluid milk, cream, evaporated milk, condensed milk, dry milk, ice cream, cheese, butter; all in fluid milk equivalents (USDA ERS 1965a) was estimated for each of the four regions of the U.S. (Northeast, South, West, and North Central) by adjusting the 1965 national per caput consumption data (Brokken, 1968), according to Whittlesey's (1964) regional variation data based on the Food Consumption Survey (USDA ARS 1956) (Eyvindson, 1970, p. 342). Fluid milk is defined in the model as consisting of fluid milk and cream, while manufactured milk, consisting of the remaining six dairy products listed above, each multiplied by a factor 0.8313 to correct the double counting resulting from the joint manufacture of dairy products (Brokken, 1968). Domestic consumption of a consuming region was obtained by aggregating the regional per caput consumption computed as above over the total population of the states within the consuming region.

The 1965 net export of manufactured milk (USDA 1966) (fluid milk is neither exported nor imported) was assumed to equal the annual average of 1961-65, and distributed among consuming regions proportional to domestic consumptions (Eyvindson, 1970, pp. 341-44).

Demand for broilers

The 1965 national per caput consumption (USDA 1966) was adjusted to obtain the four (Northeast, South, West, and North Central) regional per caput consumptions by the relative proportions of chicken consumptions among those regions computed from the 1965-66 Household Food Consumption Survey (USDA ARS, 1968). The above regional per caput consumption was then aggregated over the total population of the states in a consuming region to obtain the consuming region's domestic demand.

The 1965 broiler export (USDA ERS 1966a) was distributed among ports in coastal consuming regions according to their export destinations (UN Trade Book, 1966) and proportional to regional domestic demand.

Demand for TDN and protein by exogenous livestock

Feeds consumed by exogenous livestock are all of Type 1 TDN and protein (see Section Consuming Region Constraints, Chapter II). First, the national TDN and protein requirements per grain-consuming animal unit (equivalent to an average milk cow) (Hodges, 1963) were estimated for all six types of exogenous livestock (horses and mules, stock sheep, feeder sheep, hens and pullets, turkeys, other chickens except broilers) by dividing the total national amounts of TDN and protein of the five types of concentrate feeds (corn, grain sorghum, other grains, high protein feeds, other by-product feeds) (Allen-Devers, 1966; Hodges, 1964) fed to each type of exogenous livestock, by the total number of the respective exogenous livestock in the U.S. in unit of grain-consuming animal. Then the above national requirements per grain-consuming animal unit were adjusted to obtain the per unit requirements for various states by the different levels of grain consumptions by such livestock in those states.

Imports of feeder cattle

Imports of feeder cattle, all from Mexico and Canada, are assumed to enter this country in Texas (Consuming Region 12) and North Dakota (Consuming Region 11), respectively. Weighing 200-700 lbs. each, they are assumed to be feeder calves. The annual average of 1961-65 imports (USDA ERS, 1967) were assumed to be the 1965 normal figure, and distributed between imports from Mexico (516,702 head) and imports from Canada (249,918 head) according to the Bureau of Census data (Bureau of Census Report FT110, 1962b) (Eyvindson, 1970, pp. 327-8). They were entered into the beef calf constraints of Consuming Regions 12 and 11 as positive figures.

Supply of off-farm pasture

Supply of off-farm pasture was estimated by Brokken (1965) from data of Forest Service (USDA FS 1951 and 1963) and U.S.D.I. Bureau of Land Management (USDI BLM 1962 and 1966) administering grazing land, and brought up to date by Eyvindson (1970, p. 337).

Producing Area Constraints

The resource (supply) constraints in a typical producing area consist of (1) cropland, classes 1, 2, and 3, (2) crop-hay land, classes 1, 2, and 3, (3) cotton land, (4) wild hay land, (5) pasture on farm, (6) crop-season labor, and (7) non-crop-season labor. Besides, there is a constraint of demand for roughage by exogenous livestock. All the constraint levels were obtained by adding to Eyvindson's (1970) data, the data of commercial farm class VI, part-time farms, and part-retirement farms, all of which were not included in Eyvindson's model (1970), and are referred to as small farms in this study.

The addition of the resources of small farms considerably arguments the supply of land and labor in many producing areas, particularly those in the Southeast of the United States. (See the section on resource analysis in Chapter V.)

Cropland and crop-hay land

Definitions of cropland and crop-hay land were given in Chapter II. Estimations were first made of the planted acreage and then of the harvested acreage which is then used as the land constraint. The procedure Eyvindson (1970, pp. 259-64) used in estimating the cropland available in 1965 was: First, the total planted acreage of the intensive crops in this study and of "other small grains" (small grains used for purposes other than grain and hay) (Eyvindson, 1970, p. 260) was estimated for each state by first subtracting from the planted acreage of all intensive crops planted for all purposes, the harvested acreages of small grain hay, soybean hay, corn forage and sorghum forage, and then adding to it the acreage idled under the governmental conservation reserve programs, and the 1965 feed and grain programs of the U.S. Department of Agriculture (USDA 1963 to 1965; USDA ASCS 1966). Then the state planted acreage was divided into producing areas according to the proportions of areas in the state computed by Brokken (1965) for 1953. Then the ratio of the harvested acreage of the intensive crops to the planted acreage of both intensive crops and other small grains for each state for 1965 was set equal to the ratio of the 1950-65 harvested acreage of the intensive crops in that state to the 1950-65 planted acreage of the intensive crops for all purpose minus harvested acreage of small grain hay, soybean hay, corn forage and sorghum forage in that state. Then Egbert's (1958) ratios of harvested acreage to planted acreage for producing areas were used in obtaining producing area ratios from the state ratio computed above.

Finally, multiplying the planted acreage available in each area by the area ratio of the harvested acreage to the planted acreage resulted in cropland constraint for that area.

The available hay land for each area for 1965 was computed by multiplying the 1965 state harvested acreage of tame hay by the area/state ratio of harvested acreage of tame hay computed by Brokken (1965) for 1953. Adding the cropland constraint to the hay land available computed above makes the constraint of crop-hay land for a producing area.

After small farms were incorporated into Eyvindson's (1970) model, his 157 producing areas were re-delineated into the 138 producing areas used in the present model. Nine areas in Eyvindson's model were divided into parts and then re-grouped, across state borders, into eight new areas to form Consuming Region 7, (Tenneessee Valley) with the remaining parts outside Region 7 to be incorporated into other areas. Type 1 conversion procedure (see Section Conversion Procedure) was used in obtaining area crop-hay land, and pasture constraints.

Land quality classes

Cropland and crop-hay land in each producing area were classified into three land quality classes based on the land capability classifications used in the Conservations Needs Inventory of the U.S. Department of Agriculture (1962) (Eyvindson, 1970). Land capability classes I and II are treated as land quality class 1 in this study, class III as class 2, and classes IV through VIII as class 3. Proportions of the 3 land quality classes for each area were computed by adding county data of land capability classes from the Conservation Needs Inventory.

The Conservation Needs Inventory sub-classifies all land capability classes, except class I, into four sub-classes according to the kinds of limitations or hazards recognized: (1) erosion hazard, (2) wetness, (3) soil limitation in the root zone, and (4) adverse climate. Therefore, acreage of each land capability class with hazard or limitations were adjusted downward by a (shrinking) factor (class III can be used three out of four years, hence a factor 0.75; class IV, a factor 0.6; classes VI and VII, a factor 0.4) (Eyvindson, 1970, pp. 264-8). New proportions among land quality classes 1, 2 and 3 were computed for cropland and crop-hay land in each area, and cropland and crop-hay land were re-distributed among the three land quality classes accordingly.

Cotton land

The 1953 harvested acreage of cotton in each producing area was set as the ceiling of the total acres that can be used in growing cotton in that area, as 1953 was the year the maximum cotton acreage was attained in most states during the period 1950-65. The 1953 harvested acreage was obtained by adjusting the 1953 planted acreage of an area with the ratio of the 1950-65 harvested acreage of cotton to the 1950-65 planted acreage of cotton for the state in which the area is located (Eyvindson, 1970, pp. 270-272).

Wild hay land

The 1964 harvested acreage of wild hay in each area was used as the wild hay constraint (Eyvindson, 1970, p. 272).

Pasture

Pasture constraint is in the unit of total animal unit months (A.U.M.) available, computed from pasture yield and the 1964 acreage of pasture available, minus the amount of A.U.M. consumed by exogenous livestock. The present model includes also pasture on small farms. The pasture requirements of all exogenous livestock were estimated by (1) computing the ratio of the state total of an exogenous livestock (minus the number on abnormal farms not included in the model) to the sum of that exogenous livestock on commercial farms classes I to V, and (2) adjusting upward the pasture requirements of the sum of that exogenous livestock on commercial farms classes I to V as estimated by Eyvindson (1970 pp. 272-283), by multiplying it with the ratio obtained in (1). The same ratio was used for all areas within the same state. This was done for all exogenous livestock: horse and mule, feeder sheep, stock sheep, turkey, chickens other than broilers. Estimations of pasture yields were illustrated in the section of crop yield in this chapter.

The acreage of pasture available consists of (1) cropland pasture, (2) woodland pasture, (3) improved permanent pasture, and (4) unimproved permanent pasture, compiled from U.S. Census of Agriculture (USBC, 1959, 1964), (Eyvindson, 1970). To construct Type 1 and Type 2 disaggregating-and-aggregating conversion tables (see Section Conversion Procedure) of pasture for the eight producing areas in Region 7, county data on the four types of pasture and on all exogenous livestock were obtained from the 1964 U.S. Census of Agriculture for the eight areas. Weights thus computed from the Type 2 conversion table were used in adjusting yield, cost, and other input-output coefficients of pasture for these areas.

The pasture requirements per unit of exogenous livestock were computed by Eyvindson (1970, pp, 280-2) from various sources (Allen and Devers, 1966; Hodges, 1963).

Roughage consumption by exogenous livestock

The area roughage consumption constraint for exogenous livestock (horses and mules, stock sheep, feeder sheep; poultry being excluded for not consuming roughage) was estimated by (1) adjusting the national average roughage consumption per head of exogenous livestock according to the different state consumption levels to obtain the state consumption per head (2) using the state consumption per head for areas within the state and multiplying it by the number of exogenous livestock in each area to obtain the area roughage consumption for that type of exogenous livestock, (3) summing the area roughage consumption by all exogenous livestock, and (4) subtracting the supply of exogenous roughage (peanut hay and wet beet pulp) from the total area roughage consumption by exogenous livestock. The national average roughage consumption per head was 0.373 ton of hay for stock sheep or feeder sheep, and 1.82 ton of hay for horse or mule. (Sources: Eyvindson, 1970, pp. 325-327; Allen and Devers, 1966; Brokken, 1968.)

For the present model, the area roughage consumption constraints were obtained by (1) adjusting each of Eyvindson's (1970) area constraints to allow the affects of including small farms, by multiplying the roughage consumption by each type of exogenous livestock in his area with the ratio of the number of that type of exogenous livestock on all farms to the number on commercial farms; (2) converting Eyvindson's 157 areas into the

138 areas; (3), for Region 7, constructing new disaggregating-and-aggregating conversion tables for the conversion (see Section Conversion Procedure).

The sign of the roughage constraints for some areas is the opposite to that of other areas because the supply of exogenous roughage is in excess of demand by exogenous livestock in those areas.

Family labor

Family labor constraints (i.e. family labor available for producing the crops and livestock included in the model) were computed by (1) subtracting from the total supply of family labor, the labor for producing exogenous crops and livestock and the operator labor in off-farm work, and (2) dividing the net labor supply into crop-season labor and non-crop-season labor according to planting and harvesting dates of crops (Burkhead-Kirkbridge-Losleben, 1965) in each producing areas. Labor supply on fruit and nut, vegetable, and miscellaneous farms (e.g. horse farms) as defined in 1964 U.S. Census of Agriculture were excluded from this study. The annual labor supply by farm operators was estimated for each area by multiplying the number of operators, (identical to the number of farms (1964 U.S. Census of Agriculture)), by the annual hours worked per operator based on the average hours worked per week in various months as reported in Farm Labor (USDA SRS CRB 1965b) for the state in which the area is located. The annual labor supply was then divided into crop-season and non-crop-season labor supply. Off-farm work done by operators was estimated by (1) multiplying the number of operators doing off-farm work (excluding those on fruit and nut, vegetable, and miscellaneous farms) by their average days working off-farm (50 days for the less than 99 days off-farm class; 200 days for the more than 99 days off-farm class, 70% of which working 200 days or more) (1959 U.S. Census of Agriculture), and (2) converting the days into hours on the basis of eight hours per day. The labor supply of family workers (other than operators) was estimated for each area by (1) estimating the monthly number of farm workers for each area on the base of the number reported by 1964 U.S. Census of Agriculture "during the calendar week preceding the week of enumeration" for that area, adjusted proportionally to the ratio of monthly number of farm workers of October and November (during the Census of Agriculture) for the relevant state as reported in "Farm Labor" (USDA 1963) to the monthly average, (2) multiplying the monthly number of farm workers by the average hours worked for that month based on the relevant weekly hours worked reported by "Farm Labor" (USDA, 1965b) for the relevant state, multiplied by 4.33, and (3) aggregating the monthly total of labor computed above according to crop-season and non-crop-season for the area.

Next, the labor requirement for exogenous crops and livestock were estimated by (1) computing the productions of exogenous crops (rye, flax, rice, tobacco, Irish potatoes, peanuts, dry field and seed peas, and dry field and seed beans) for each area based on the 1959 U.S. Census of Agriculture, and the productions of exogenous livestock (stock sheep, feeder sheep, chicken other than broilers, hens and pullets, turkeys) as described in the section of pasture constraint (note: labor on horses and mules were initially excluded from the estimation of labor available; labor on broilers, now not an exogenous livestock in the present model, was not removed from the labor available), (2) estimating the labor requirement per unit of exogenous crops from McElroy et al. (1964) and then per unit of exogenous livestock from Hecht (1963) for each state and using the state data for areas located within the state, and (3) multiplying productions of exogenous crops and livestock by their respective per unit labor requirement, with labor requirements for exogenous crops allocated to crop season, and labor requirements for exogenous livestock evenly distributed over the year. The proportion of family labor required for exogenous crops and livestock for each state was estimated by adjusting the above-computed labor requirement by the ratio of the sum of operator labor and other family member labor (in unit of operator equivalents computed from the hours worked during the week preceding the census enumeration (1964 U.S. Census of Agriculture)) to the sum of operator labor, other family member labor, and labor of regular hired workers (also in unit of operator equivalents, assuming hired workers working the same number of hours as the operator). Adjusting the total labor requirements for exogenous crops and livestock in each area by the above-computed proportion from the relevant state results in the area family labor for exogenous production. Summing up the area operator labor (minus off-farm work) and the area other family labor, and subtracting from it the family labor requirement for exogenous production produced the area labor constraints. Where original computations were made of 1959 Census of Agriculture data, an adjustment factor (the area ratio of the number of farms in 1964 to the number of farms in 1959, assuming no change in the amount of family labor per farm) was used to update the data to the 1964 level. (Source for the above two paragraphs: Eyvindson, 1970, pp. 284-304.)

For the present study, first the family labor available for an area was estimated by (1) computing the state ratio of the sum of the hours worked on the part-time (P.T.) farms and on the part-retirement (P.R.) farms during the week preceding the enumeration in the 1964 Census of Agriculture to the sum of the hours worked on commercial farms I to VI during the same week, and assuming this ratio is valid for October and November when Census of Agriculture was made; (2) multiplying the labor available on all commercial farms (I to VI) in an area (Eyvindson, 1968) by the ratio for the relevant state from (1) to obtain the estimations of labor available on P.T. - P.R. farms for the area; and (3) summing the P.T. - P.R. farms labor and all the commercial farm labor.

The area exogenous production on small farms were obtained from Eyvindson's computer program on primary data (1970), and multiplied by their respective per unit labor requirement of the relevant state to obtain the area total labor requirement for exogenous productions. The rest of the procedure to compute the proportion of family labor in the above labor requirement, and then the net family labor constraints, was the same as Eyvindson's (1970) described above. Finally, a new Type 1 disaggregation-and-aggregating table (see Section Conversion Procedures) based on county data of exogenous productions was constructed to convert the old areas into the new areas for Consuming Region 7.

Crop Activities

All crop activities are defined in unit of harvested acre, and generally consist of such coefficients as production cost, yield (and yield of possible byproduct), aftermath pasture produced, labor requirement, and land requirement (in the unit of an acre). Production costs, labor requirements and aftermath pasture for any type of crops or crop rotation systems are assumed to be the same for the three land classes planted to it; while the yield of a given crop differs with the land class. For feed grain activities, coefficients were first estimated for each component crop (corn, oats, barley and grain sorghum) and then weighted according to the weights in the harvested acreage of the component crops in each producing area computed from the 1964 U.S. Census of Agriculture (1967b), the weight being assumed the same for the three land classes.

Same procedures were used in obtaining coefficients for silage activity (consisting of corn and sorghum silage) and for the various rotation systems (feed grain-soybean feed grain-silage, hay-silage, and feed grain-soybean-silage).

Production cost

The production cost of a crop activity consists of the costs of (1) machine and equipment, (2) fertilizers, (3) pesticides, (4) irrigation water where applicable, (5) miscellaneous cost and (6) summer fallow where it is cultivated. Since seed requirements were subtracted from crop yield (except in the cases of hay and silage), no seed cost was included.

The machinery and equipment costs of the preharvest and the harvest field operations for crops were separately estimated, and then the preharvest machine costs were converted into harvest machine costs by dividing the former by the proportion of the harvested acreage in the planted acreage. Besides, the machine cost for crops in irrigated areas was also separately estimated, and then combined with the dry land machine cost to obtain a weighted average according to their respective proportions in acreage for each crop. The machine cost was treated as a linear function of the time of a machine used in cultivating a crop and the acreage of the crop worked on. For trucks, cost was charged on a mileage per acre basis; for tractors, on a tractor hour per acre basis. A factor (0.8 for pick-up trucks and 0.6 for large trucks) was used to estimate the machine cost attributable to livestock production from the machine cost of crop production. The machine cost consists of the costs of (1) depreciation, (2) interest, (3) shelter, (4) insurance, (5) taxes, (6) repairs, (7) lubrication, and (8) fuel and oil. A 10% salvage value, an adjusted 7.4% interest rate, and 2.5% purchase price as costs for shelter, insurance and taxes (ISU SA 1964) were assumed for all machines. Estimates of costs of repairs, lubrication, fuel and oil (about 15% of fuel cost) were obtained from Agricultural Engineers Yearbook (ASAE c1966).

Miscellaneous costs include such costs as lime, seed for tame hay and silage, and the costs of ginning cotton, shelling corn, drying corn and grain sorghum. They are assumed the same for all classes of land. (Source for above three paragraphs: Eyvindson, 1970, pp. 119-56.)

Since Eyvindson's cost data were for three farm sizes (costs being the same for the three land classes), cost data for the present model were computed by (1) computing the weights in both cropland and crop-hay land acreages for the three farms sizes in each producing area, (2) taking the weighted average of the costs for the three farm sizes for each crop according to their weights computed in (1) (crop-hay land weights for hay, cropland weights for other crops), and (3) converting the average costs from Eyvindson's areas into the areas of this model, using Type 2 Conversion table in cropland and crop-hay land (see Section Conversion Procedures).

Labor requirements for crop activities

Labor requirements are assumed the same for the three land classes. The total labor requirement for a crop production consists of direct labor used in production and indirect labor used in repairing and servicing machines, with the latter being estimated from Van Arsdall (1966) who listed the proportion of direct labor in total labor requirement needed for a crop production. Direct labor requirements were computed for each hand and machine operation in crop production, and then summed up for preharvest and harvest operations for each crop. Such a process was carried out for both dryland and irrigated crops. Then a weighted average of labor requirement for each crop was computed, based on the proportions of irrigated and un-irrigated acreages of each crop.

Many of the procedures and data sources used for estimating direct labor requirements are the same as those used for estimating machine cost: such as the sequence of field operations, machine hours per acre, and the harvested ratio in each area. Direct labor requirement for machine operation were assumed equal to the machine hours with the exception of grain hauling operation which in general is 2.3 times the truck hours (Van Arsdall, 1966) converted from truck mileage on a 30 miles per hour basis. Hired custom operations were charged to the labor requirement. The procedure of estimating the labor requirements for establishing hay stands is analogous to that for machine cost. Finally, the preharvest labor requirements on planted acreage were adjusted by the harvest ratio and added to the harvest labor requirement to make up the total direct labor requirements which, combined with the respective indirect labor requirements, constituted the total labor requirement for each crop. (Source for the above two paragraphs: Eyvindson, 1970, pp. 156-62).

Since Eyvindson's labor requirements differ with the farm sizes, the labor requirements for the present model were obtained by (1) taking weighted average of the labor requirements of the three farm sizes according to the weights in acreages of the three farm sizes in each area, (2) converting his 157 areas into the present 138 areas (see Section Conversion Procedures).

Crop yield

The difference in crop yields in Eyvindson's model was attributed to the difference in land quality, given the same amounts of other inputs (fertilizers, insecticide, etc.). A normal yield for 1965 was estimated for each crop in each of the three land classes of each area from the 1948-65 yield trends, based on the assumption that the average weather conditions had prevailed in 1965. First, a time trend regression equation was fitted for each crop in each state using the 1948-65 state data (USDA AMS CRB 1956). The 1965 state normal yields of crops were obtained from such regression equations. The 1965 gross area yields (including quantity for seeds) were estimated by adjusting the state normal yields by the area/state yield ratio obtained from Whittlesey (1964). Subtracting from it the seed requirement resulted in the net area yield. Cotton seed yield was estimated from the yield of cotton lint according to Whittlesey's (1964) cotton seed/lint ratio. Area seed requirements were estimated by adjusting state seed requirements per acre for 1947, 1954, 1964 by the 1965 area/state yield ratio (Egbert, 1958). Crop yield by land class in each area was estimated according to Whittlesey's (1964, p. 80) regression equations of yield index, fitting yields against the proportion of a land class in the total acreage. Eyvindson (1970) converted the yields of wheat, feed grains, soybeans, cotton seeds into unit of total digestible nutrients (T.D.N.), and that of silage into ton of hay equivalent (one ton silage equal to 0.36 ton of hay (Brokken, 1965)) for facility in use in the linear programming model. The T.D.N. contents by weight of the various crops are: wheat, 0.800; corn, 0.786; oats, 0.701; barley, 0.777; grain sorghum, 0.799; soybeans, 0.608 (0.780 T.D.N. x 78% of soybean as oil meal); and cotton seeds, 0.321 (0.717 T.D.N. x 44.8% of cotton seeds as oil meal) (Hodges, 1964). State data on the aftermath pasture (the crop residual for grazing, left over from harvest) were obtained from Jenning (1955), the only source available, and then converted from the cropland pasture acre equivalents into animal unit months (A.U.M.). (Source: Eyvindson, 1970, pp. 163-74.)

For the present model, crop yields were computed by (1) converting Eyvindson's data (stored in his computer programs on primary data) on yield of each land class in bushels or tons into yield data for this model according to the Type 2 Conversion table using the weights of acreage (see Section Conversion Procedures), (2) in the case of feed grains, (a) decomposing feed grains into its component crops, (b) converting each component crop yield in bushels from the old areas to the new areas using the procedure in (1), (c) converting the yield of component crops from bushels into T.D.N., and (d) combining them into feed grains in T.D.N., and (3) in the case of crop rotation systems, (a) converting individual crops of rotation systems in bushels or tons from the old areas to the new areas, using the procedure in (1), and (b) converting the yield in bushels into T.D.N. Such decomposition processes in (2) above were necessary because each area has different weights in the feed grain composition and different weights in contributions to T.D.N. by the component crops. Therefore, Eyvindson's final yield data in T.D.N. for feed grains, in which composition of component crops was not discernible, cannot be directly used in the convertion from the old areas to the new areas, and the conversion had to be done in terms of component crops.

Livestock Activities

A typical livestock activity consists of such coefficients as production cost, output (including byproduct), feed requirement, and labor requirement. Production cost includes (1) depreciation, interest, insurance, and taxes on building, equipment, and livestock (where applicable), (2) breeding, veterinary, and medicine cost, (3) feed supplements (salt and minerals), (4) power and fuel, (5) pasture custom fertilization, (6) marketing cost, and (7) other supplies (Eyvindson, 1970, p. 176). Cost of feed is excluded because the cost of endogenous feed is already included in the crop activities and the cost of exogenous feeds are also already charged to the transfer activities of such feeds.

Some livestock activities produce only one type of output (e.g. pork from the hog activity), while others, several (e.g. milk, calf, and non-grain-fed beef from the milk cow activity). For most livestock activities, the feeds required consist of concentrates (in terms of total digestible nutrients (T.D.N.)), harvested roughage (in tons of hay-equivalent), and pasture (in animal unit months (A.U.M.)). Broilers require only concentrates; and hogs require concentrates and pasture.

Labor requirements are divided into crop season and non-crop season according to the planting and harvesting dates for crops in the producing area. The indirect labor (such as on the maintenance of building and equipment associated with the livestock activities) was small in quantity compared with the direct labor, and its being left out in the calculation of the total labor requirements for livestock activities did not constitute too serious an underestimation of the labor coefficients. (Eyvindson, 1970, pp. 174-183.)

Dairy cow activities

The dairy cow activity is based on a basic dairy cow unit which consists of (1) a milk cow, (2) replacement heifers, (3) calves, and (4) other dairy cattle associated with the milk cow. This activity produces (1) fluid milk, (2) dairy feeder calves, and (3) non-grain-fed beef. Data on milk production were obtained from the 1964 U.S. Census of Agriculture (USBC 1967b and 1968, USDA SRS CRB 1965a). Production of beef from the basic dairy cow unit includes (1) culled cows and heifers 1-2 years old, (2) culled heifers less than 1 year old, and (3) veal calves (Brokken, 1965). Brokken (1965) estimated that, of the dairy calves not retained as replacement heifers, 30% are sold as veal calves (114 obs. each) and 70% as dairy feeders and that the dressing weights are 0.485, 0.534, and

0.570, respectively, for culled cow and heifer 1 year old and older, culled heifer less than 1 year old, and veal calves.

Feed requirements were estimated for the basic dairy cow unit in each state by first estimating feed requirements by its components (the milk cow, replacement heifers, calves, other dairy cattle) and then combining their feed requirements.

Production costs were based on the costs of the four dairy herd sizes (10, 10-29, 30-50, and over 50 cows) in the seven dairy regions in the United States (Northeast, Lake States, Corn Belt and Northern Plains, South except Florida, Florida, Mountain and Pacific Regions except Arizona and California, and Arizona and California) as defined by the U.S. Department of Agriculture. The average dairy herd size for each state was calculated from the U.S. Census of Agriculture and the cost for various herd sizes in each state were set equal to that of the corresponding herd sizes in the dairy region in which the state is located. If there is housing for the dairy herd, the cost of stanchion, barn or loose housing was also included. (Source for the above paragraphs: Eyvindson, 1970 pp. 185-203.) The Type 2 conversion procedure, using the herd sizes as weights, was used here and also for all the other livestock activities, except broilers (see Section Conversion Procedures).

Beef cow and calf activities

The basic cow unit on which the beef cow and calf activity is based consists of (1) a beef cow, (2) the calves produced, (3) sharing of the bull, and (4) replacement heifers. Coefficients for areas in the same state are assumed to be the same. Some of the basic assumptions as made by Brokken are: (1) 0.05 bull required by a cow, (2) 3% annual death loss for cows, (3) 12% annual culling rate for cows, (4) 2% annual death loss for beef heifers, (5) 10% annual culling rate for replacement heifers due to sterility, (6) half of the heifers will calve at two years of age, and the other half, at three years of age. A zero-population-growth was assumed for the cow population. This activity produces two types of outputs: (1) 400 lbs. feeder calves, and (2) non-grain-fed beef from culled animals. The dressing weight for beef cows and heifers is 0.535.

Feed requirements include feed for the beef cows, bulls, and heifers, and were estimated from Hodges (1963, 1964) and Jennings (1954, 1955), following the procedures developed by Brokken (1965). The average production cost for beef cow herds was obtained from Brokken (1965) for the four regions of the United States (1) Northeast, (2) North Central, (3) West, and (4) South, and assumed to be the same for all the states located in the same region. Labor requirements were estimated in the same way as for dairy cows, with data obtained from Hecht (1963). (Source for the above paragraphs: Eyvindson, 1970, pp. 203-14.) Eyvindson's data for three farm size groups in each of his 157 areas were first aggregated into one farm size group, using herd sizes as the appropriate weights.

Calf-yearling activities

These activities provide for the 400 lbs. calves to be raised to 675 lbs. yearling feeders. A 1% annual death loss was assumed for such a fattening process. Feed requirements were derived from Brokken (1965), using procedures similar to those for beef cows. Cost estimates were obtained from Brokken (1965), and assumed to be the same for all the states within a consuming region. The labor requirement was assumed to be 40% of the annual labor requirement for a beef cow (Brokken, 1965). (Source: Eyvindson 1970, pp. 214-8.)

Feeder cattle activities

Included in the model are seven feeding systems developed by Brokken (1965) : (1) calves, deferred plan; (2) calves, extended silage plan; (3) calves, on silage plan; (4) calves, no silage plan; (5) short-fed yearlings plan; (6) yearlings, on silage plan; and (7) yearlings, no silage plan. Coefficients were assumed to be the same in all the areas within a consuming region. A shrinkage and death loss of 5% and a dressing weight of 0.593 were assumed for feeder cattle (Brokken, 1965). Feed requirements were also due to Brokken (1965).

For the seven feeder cattle plans, production cost was obtained from Brokken (1965) for (1) 75 head feed lots in the eastern United States; (2) 75 head feed lots in the southern United States; and (3) 75, 866, 2,696, and 8,233 head feed lots in the western United States. From Gibbons (1963), production cost by herd sizes of feeder cattle was also obtained. Eyvindson (1970) calculated per farm fat cattle sales for his three farm size groups in each consuming region from the U.S. Census of Agriculture data and then arrived at the cost for different farm sizes in different consuming regions by extrapolating Brokken's cost data.

Labor requirements were divided into five stages according to the sequence in the total feeding period (1) rest, (2) fall feeding, (3) wintering, (4) pasture, and (5) full feeding, and, in the case of the 75 head feed lots, were obtained from Suter and Washburn (1962). Brokken (1965) provided data on the number of days for each of the five feeding stages. Gibbons' (1963) data on labor requirements by herd sizes were used in deriving labor requirements for other herd sizes. (Source for the above paragraphs: Eyvindson, 1970, pp. 218-24.)

Hog activities

Hog production is in terms of hundred weight of live hog produced. Hog activities cover hogs from birth to marketing and include the breeding stock. Coefficients were estimated for each state, and the same coefficients were used for producing areas within a state. The same pork output coefficient, 61.1 lbs, net of lard per hundred weight of live hog, was obtained from USDA Livestock and Meat Statistics (USDA ERS 1966b) and used for all producing areas in the model.

Feed requirements (T.D.N., protein, and pasture) and production cost were obtained from Brokken (1965), and also from consultation with animal scientists at Iowa State University. Labor requirements data were obtained from Hecht (1963) for each state, and assumed to be the same for areas in the same state. (Source for the above paragraphs: Eyvindson, 1970, pp. 224-8.)

Broiler activities

Broiler activities are in terms of hundred weight of broilers in the form of final product in the food market. Coefficients are assumed to be the same for all producing areas, in view of the more uniform technology employed by the broiler industry in the United States. Broilers are assumed to weigh 3.5 lbs. each and have a dressing weight of 73% and a condemnation rate of 2% in the processing plant (Swanson, Carlson, and Fry, 1964), this resulting in a net conversion rate of 71.54% from live weight to the net weight in the food market and in a net weight of 2.5039 lbs. per bird.

Feed requirements were estimated from Hodges (1963, 1964) and in consultation with poultry scientists at Iowa State University. Labor requirements and production cost were estimated from Gallimore and Vertrees (1968). Production cost included such fixed costs as depreciation, maintenance, interest, insurance and taxes on buildings and equipment; and such variable cost items as chick, medication, litter, heat, electricity, insurance against loss of chickens by fire, miscellaneous, and financing charges. Feed cost was removed from the list of variable costs of the above cited source, as it was already included in the model in either the crop production activities or the transfer activities of exogenous feeds.

Since abundant rural labor supply is conductive to the development of broiler industry, areas with abundant labor supply can be distinguished from other areas by charging in all areas the family labor employed in raising broilers a wage equal to that of hired labor in the same area. Since the wage of hired labor is generally lower where labor supply is abundant, this accords the areas with abundant labor supply an advantage, which they actually have, in the form of lower production cost. The wages charge to the family labor in the broiler activities are to be subtracted from the value of the objective function of the model.

Transportation Activities

In this model, commodities are allowed to be transported among consuming regions, but not among producing areas within a consuming region. Movements of goods among areas within a region are assumed to be free of transportation costs. Rail transportation rates were used among all regions, except for grain transport from Corn Belt and Northern Plains to the Southeast, in which cases a multitude of transportation modes consisting of barge, truck, and rail are used.

In each consuming region two centers were selected, a production center and a consumption center, the latter being the population center of the consuming region while the former being a composite production center of all the crops and livestock produced in the region, obtained by interpolating the production centers of the various crops and livestock in the region, with due regard to the relative importance of different crops and livestock. The composite production center of a region is the point of origin for transportation activities from the region, while the consumption centers of all the other consuming regions are the points of destination for such transportation activities. Idealistically, there should be a production center for each different type of crops or livestock product, to be used as the point of origin of the transportation activity for that particular type of crops or livestock product. Thus, the composite production center as distinguished from the consumption center is still a compromise. The point selected as the theoretical consumption center or production center may be located in the countryside. In such cases, the nearest town was chosen as the consumption center or production center.

The names of the regional production centers and consumption centers are listed in Table A-17.

Eyvindson (1970) developed regression equations to fit the transportation cost and distance from data in "Carload Waybill Statistics" (Interstate Commerce Commission, 1966) for transporting various crops. The regression equations are of the general form

$$C = aD^{b}$$

when C denotes per ton-mile; D, the short line rail miles; a and b the regression coefficients. The five railroad class rate territories are shown in Figure 4 (Eyvindson, 1970, p. 232). The cost of shipping feed grains was obtained by (1) computing the cost of shipping individual component crops of feed grains (corn, oats, barley, and grain sorghum), and (2) taking weighted average of the shipping cost of the four compponent crops according to their composition weights as determined by their proportions of production in the areas within the region.

A typical regression equation for transporting wheat between the Western Truck Line territory and the Official territory is:

$$C = 89.164\ D^{-0.65424}$$

The regression equations fitting transportation cost and distance for shipping meat and feeder cattle were developed by Brokken (1965) based on information from Maki (1965). Brokken's (1965) estimated cost of transporting fluid milk ($0.00128283 per CWT/mile) and manufactured milk were adopted in the model. (Source for the above two paragraphs: Eyvindson, 1970, pp. 228-251.) The regression equations developed by Eyvindson (1970) and Brokken (1965) were adopted for direct use in the

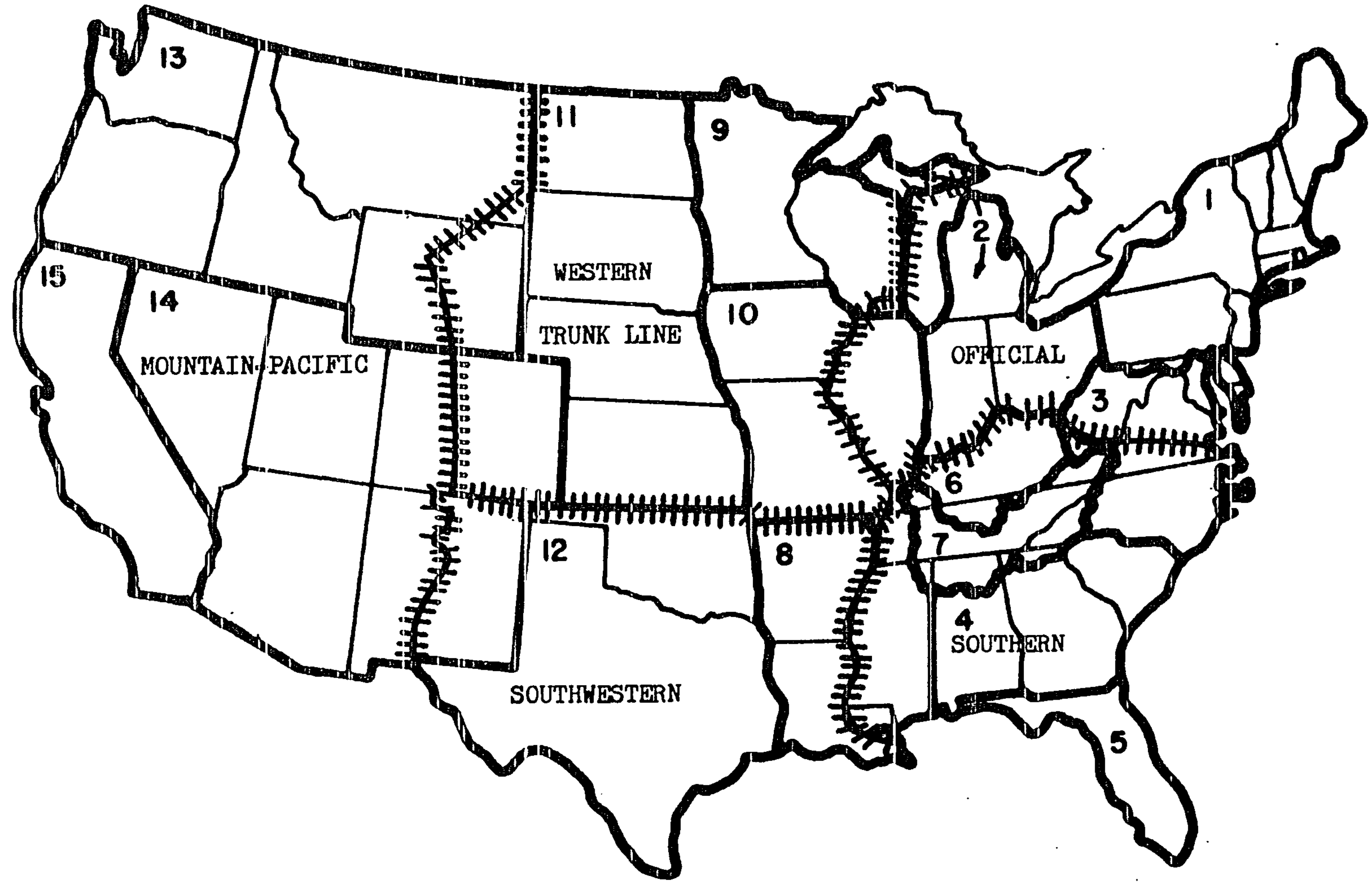

Figure 4. Geographic location of railroad class rate territories

model. The equation for transporting meat were also used for transporting broilers.

As pointed out earlier, the composite rate for grains representing the actual various transportation modes in use (barge, truck and rail) from Regions 9, 10, and 11 in the Midwest to Regions 4, 5, 7, and 8 in the Southeast, was computed by Tenneessee Valley Authority and used in the present model to reflect more faithfully the actual transportation advantage held by the receiving regions through the use of barge as a chief mode of shipping grains down the Mississippi and its tributaries.

Transfer Activities

Grain to feed activities

The transfer activities allow transfer, without cost, of wheat, feed grains, soybeans, cotton seeds to concentrate feeds in terms of T.D.N. and protein for consumption by livestock at the consuming regional level. Since yield coefficients of all crops are already in unit of T.D.N., the input-output coefficients for protein are the protein content of these concentrate feeds, which are shown in Table 4:

The protein content of feed grains is the weighted average of the protein contents of corn, oats, barley, and grain sorghum computed according to their composition weights in cropland acreages in the consuming region. Such weights in cropland acreages were calculated by (1) summing the harvested acreages of each component crop over all the producing areas within the consuming region and then (2) computing the weights among those four sums of harvested acreages for the component crops.

Table 4. Protein content of concentrate feeds[a]

Concentrate feeds	Protein content (% by weight)
Wheat	11.5
Corn	8.6
Oats	12.0
Barley	10.5
Grain sorghum	11.0
Soybeans	35.1[b]
Cotton seeds	18.4[c]
Exogenous concentrate 1	36.9
Exogenous concentrate 2	55.0
Exogenous concentrate 3	28.0
Exogenous concentrate 4	18.0

[a]Source: Eyvindson, 1970, p. 252.

[b]Soybeans are 78% soybean oil meal which has a protein content of 45%.

[c]Cotton seed is 44.8% cotton seed oil meal which has a protein content of 41%.

Hay transfer activities

In each area, there are activities to transfer, without cost, (1) hay to roughage at the area level, and (2) hay from an area to the regional center.

But the transfer activity, which allows transport of hay from the regional center to any area in the region, carries a cost charge slightly higher (by 1¢) than the computed transportation cost between the regional center and the farthermost area. Such a cost charge was designed to avoid the possible unrealistic solution of concentrating all hay production of a region in one or two areas which have higher efficiency in hay production than other areas in the region. Such concentration of hay production would certainly occur if free transport of hay were allowed among areas in a region. Since hay is a relatively bulky and low-value commodity, an area should produce its own hay unless the cost advantage of another area in the same region outweighs the transportation cost between them. That the transportation cost from the regional center to all the areas in the region is constant, instead of being variant with different areas, is a compromise analogous to taking the average value, aimed at keeping the number of hay transfer activities from increasing.

Milk transfer activities

The transfer activities, whcih convert fluid milk into manufactured milk without cost, have unity input-output coefficients because manufactured milk is in unit of fluid milk equivalent.

Calf-yearling slaughter activities

The calf slaughter and yearling slaughter activities allow, without cost, culled calf and culled yearling to produce, respectively, 221.6 lbs. and 368.2 lbs. of non-grain-fed beef at the regional level (Brokken, 1968).

Exogenous feeds activities

The transfer activities allow the four types of exogenous concentrate feeds to be purchased and converted to T.D.N. and protein for consumption by livestock at the regional level. Their protein contents are shown in Table 4, and their prices per T.D.N. unit were estimated by Eyvindson based on the prices from Brokken (1965) and the T.D.N. contents from Hodges (1964). (Eyvindson, 1970, pp. 253-4.)

Pasture-renting activities

These activities allow farms to use off-farm pasture from the federally-owned grazing land administered by the Bureau of Land Management (BLM) and pasture administered by the Forest Service (FS). Rent for off-farm pasture not federally-owned was set, for lack of data, equal to the fee paid federally-owned one. The 1965 grazing fee for BLM pasture was $0.294 per animal unit month (A.U.M.) (USDA ERS 1965b; USDA SRS CRB 1965a). The 1965 grazing fee for the Forest Service pasture was computed from the total A.U.M. of grazing permitted and the total grazing fee receipts of the Forest Service (Jennings 1955; USDA 1966; USDI BLM 1966, 1967). Finally, a weighted average of the grazing fees for the BLM and the FS land was taken as the rent for off-farm pasture in the region. (Source: Eyvindson, 1970, pp. 254-6).

The rent of off-farm pasture were converted from Eyvindson's 21 regions into the 15 Regions for the present model according to Type 2 conversion procedure which was also used for the following two types of activities (see Section Conversion Procedure).

Crop-hay land to pasture activities

Each producing area is allowed to convert its crop-hay land into pasture. The cost and labor required of such a conversion are assumed to be the same as those for establishing a stand of tame hay. The pasture yield for the three land classes in each area was estimated according to the same procedure used in estimating crop yield by land class. (Source: Eyvindson, 1970, pp. 256-7.)

Labor-hiring activities

The model permits each area to hire non-family labor to meet its needs in crop season and non-crop season. The hourly wage rates for each state were obtained from Farm Labor (USDA SRS CRB 1963). Same wage rates were assigned to areas in the same state (Source: Eyvindson, 1970, p. 257).

CHAPTER V. ANALYSIS OF RESULTS

Introduction

Two solutions have been obtained from the model and are tabulated into tables attached in the Appendix. The solution as solved by the IBM Mathematical Programming System and printed out by the computer consists of two parts: (1) the part about rows which indicates the level of a constraint in the solution and its shadow price, if the constraint is binding, or the level of slack, if the constraint is not binding; and (2) the part about columns which gives the value of a variable (activity) that is in the solution, and the amount of cost increase in the objective function that would occur if an activity not in the solution is forced into the solution.

Included in the tables in the Appendix are such information as the levels of a constraints in the solution, the shadow price (or slack) of constraints, and the values of the variables in the solution.

The solutions are tabulated in the following tables in the Appendix:

Solution I	Solution II	Titles of tables
Table A-1	Table A-11	National constraints
Table A-2	Table A-12	Regional constraints
Table A-3	Table A-13	Area constraints
Table A-4	Table A-14	Regional transfer activities
Table A-5	Table A-15	Area crop and livestock activities

The transportation activities in the solutions are indicated in the various commodity "balance sheet" tables in this chapter.

Solution II differs from Solution I in the following assumptions: (1) coefficients of feeder cattle, dairy cow, and beef cow activities for medium herd size, instead of all herd sizes, are used for all the 138 areas; (2) no calf imports from Canada and Mexico are allowed; (3) no substitution of grain-fed beef for non-grain-fed beef is allowed; (4) demand for wheat and feed grains are, respectively, 8% and 1% higher (see Chapter IV).

The results of a spatial equilibrium solution may be analyzed from the view points of different disciplines, such as physical and biological sciences, geography, economics, etc. The present study will be mainly concerned with the economic aspect of the model.[1]

Minimizing cost is the key scheme of this model and every conceivable question about the solution can find its answer in it. Yet such an overall answer is too general to be meaningful. And the intrigue and hidden interdependency among activities, constraints, and cost coefficients, all interwoven around the cost-minimizing scheme, is not always readily evident in the solution.

The present study is intended to interpret the results in more details in terms of the components of a shadow price (production cost coefficient, opportunity cost of imputs, and transportation cost). Thus hopefully casting new light into the comparative strength and weakness of areas and regions. Efforts have also been made to bring to the surface the above-mentioned hidden interdependency among activities, constraints, producing areas, and consuming regions. Comparison of production cost of commodities will be made on regional basis, in terms of cost advantage

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[1] A more comprehensive approach comprising analyses of factors considered essential in different disciplines would be more informative. However, given research resources, a more comprehensive analysis can only be made at the expense of detailed economic analysis.

index, and then regions will be compared in their overall cost advantage index of all crops or livestock products (see the section on cost advantage index).

The solutions are in units of the variables (an acre of feed grains, a head of dairy cow, etc.). It is, however, also highly desirable to analyze the results in units of the yield of the intermediate or the final goods (bushels of feed grains, pounds of fluid milk, etc.) which indirectly or directly satisfy human consumption demand. This type of information permits the construction of yield index, and, particularly, cost advantage index for the analysis of regional comparative advantage (see the section on cost advantage index). It also provides a two-pronged approach in evaluating a region, and illustrates the principle of compensatory adjustment -- to produce a given output, the higher the yield, the less the input needed, and vice versa.

For each commodity, the following tables were prepared on regional basis: (a) a table (in unit of variable) showing the two solutions, Eyvindson's solution (1970), and the actual 1965 and 1969 productions (b) a table (in unit of production) showing the two solutions and the actual 1965 and 1969 productions; (c) a table showing cost advantage index and yield index for the two solutions; and (d) a "balance sheet", showing production and consumption (and their components, if any) in each region, and the shipping patterns among regions. Such a balance sheet presents a bird's eye view of a commodity and also reveals the connection of different products. For instance, the output in the balance-sheet of calves, minus calf and yearling slaughters, is the input to the balance-sheet of feeder cattle.

Comparison of the solutions with the 1965 real world situation will be emphasized.[1] Comparison of the solutions with the 1964 agricultural census data as shown on the maps published by the Bureau of Census will be made where the difference is significant. Solutions in unit of variables on area basis are shown in Tables A-5 and A-15 in the Appendix.[2] Actual productions on regional basis were obtained from the state data, with adjustments for regions crossing the state borderlines (Regions 3, 4, 6, 7, and 8).

The model, despite its size, is still too simplified an approximation of the real world. However, on the other hand, the real world, even in equilibrium, could never match in precision and "tightnens" the solution of a mathematical model which, like a highly-calibrated machine, leaves no room for errors.

The model is used in this study not only to achieve spatial equilibrium, but also to anatomize regional comparative advantages and the

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[1]Comparison of solutions of a 1965 model with the 1969 actual situation is less justified because of the likely changes in technology on the one hand and shifting demand on the other hand, and will be made only occasionally.

[2]Comparison of solutions with the actual productions is not made on area basis because of (1) the high cost of gathering census data from the over 3,000 counties in order to obtain the actual production figures for the 138 areas, which would require time in terms of man-year; and (2) the spaceless structure and lack of transportation cost within each region makes comparison on area basis much less meaningful. For instance, livestock production and feed grain production may be concentrated in different areas within the same region in the solution, while in the real world, feed grain and livestock productions tend to be concentrated in the same area (perhaps the same farm). For models having inter-area transportation activities, comparison on area basis would be highly meaningful and desirable, despite the high cost involved.

interdependency among activities and constraints of various areas and regions.[1] The details in such interdependency are the logical outgrowth of the integrity and internal consistency of a spatial equilibrium model. A slight change in demand, technology, or production cost may, however, have far-reaching effects through the model and thus alter the solution and the details in interdependency. Therefore, caution should be used in trying to identify such myriad interrelationships with the more complex, and sometimes unknow, interrelationships in the real world. (See the section on solution vs. real world, Chapter III, for more discussions on this point.)

The following often-cited passage from Dorfman-Samuelson-Solow (1958) is quoted here to show the general limitations of a mathematical model.[2]

> "The linear-programming models we shall develop will, of course, not be strictly accurate representations of the economic situations with which they deal. Strict descriptive faithfulness is an unreasonable demand to make of any conceptualization. The most completely accepted of economic concepts -- the production function, the demand curve, or what not -- would fall if held up to that standard. What we have a right to ask of a conceptual model is that it seize on the strategic relationships that control the phenomenon it describes and that it thereby permit us to manipulate, i.e., think about, the situation."

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[1]Though linear programming does not provide direct indicators of the intrigue interrelationships among activities and constraints, yet tracing them through the solutions by reasoning will yield fruitful insights into the complexity of the interdependency in a large-scale model. But there is no assurance that all tracing efforts will be successful. For instance, pooled feeds will baffle perhaps most tracing efforts to identify their sources of origin.

[2]R. Dorfman, P.A. Samuelson, and R. M. Solow: "Linear Programming and Economic Analysis" (McGraw-Hill, New York, 1958), Chapter 2: Basic concepts of Linear Programming", p. 9.

Analyses on individual commodities, resources, and overall regional cost advantages will follow discussions on topics useful to the understanding of such analyses.

Interpretation of results

Two points are to be kept in mind in interpreting a solution of a linear programming model. One is the characteristics of a linear programming solution in general; the other is whatever features particular to the model in question.

The L.P. solutions in general present a sharp contrast between activities in solution and activities not in solution. Once a production activity is in the solution, it will continue producing until it exhausts one of its resources used in the production, or the consumption demand is satisfied. The next alternative activity slightly higher in cost will never have a chance to enter the solution unless the consumption demand exceeds the capacity of the first activity. Thus the solution contrasts areas producing the entirety of a commodity with areas producing absolutely none of it. Figuratively, the picture painted by the solution may look black in one area (where the entirety of a commodity is produced) and complete blank in another area (where the commodity is not produced). such a picture is very abrupt in appearance, differing from the real world where production of a commodity may be concentrated in an area but often gradually tapering off away from the center, perhaps into neighboring areas, before vanishing. Therefore a solution may be viewed as an indication of the tendency of concentration of production in the long process of adjustment towards optimality.

The scene of the real world can be more closely approximated by dividing the areas of the present sizes into many more areas of much smaller sizes. This would preserve in the linear programming solutions more of the "gradualness" of the real world. Of course, the scene of abruptness versus that of gradualness is relative. A picture of abruptness in close look will appear more gradual in distance in its entirety.

One feature particular to the present model is the absence of transportation cost among areas within a region. This may lead to a solution in which a final product is produced in one area while its input, an intermediate product, is produced in another area, without apparent connections between them. Awareness of this particular structure of the model will permit transcending the geographical difference and reconciling the solution with a meaningful interpretation.

Components of shadow price Since a shadow price of a demand constraint consists of three possible components (production cost, transportations cost, and opportunity cost of inputs), its composition differs with circumstances. In a self-sufficient region, the shadow price equals production cost if none of the factor constraints is binding, but includes the opportunity cost (shadow price) of any factor which is binding. In an importing region, it consists of the shadow price of the exporting region and the transportation cost. In an exporting region, it is the same as in a self-sufficient region (see Table 5).

Limitations of the model

Since this study inherits a major part of data from the series of previous studies on agricultural spatial equilibrium, it contains some

Table 5. Composition of shadow price of demand constraint

	Self-sufficient or exporting region factor constraints		Importing region[a] factor constraints	
	Binding	Non-binding	Binding	Non-binding
Production cost	X	X	X	X
Transportation cost			X	X
Factor Opportunity cost (Factor shadow price)	X		X	

[a]The production cost and factor opportunity cost belong to the exporting region from which the importing region receives the product.

of the same limitations in data as the previous studies. Besides, a linear programming model has all the limitations of a linear model in general.

Fixed proportions in data This is typical of any linear economic model where coefficients are often a composite of several component data collected on the level of a small geographic area (e.g. county). When a production activity expands, it carries, so to speak, the same fixed proportions in its coefficients to cover a much larger geographical area where proportions of the component data are most likely to be different. For instance, the cost, labor and yield coefficients of some crops that grow on both dry land and irrigated field, are the weighted average of the two sets of coefficients, one for dry land and one for irrigated field. When this production activity expands, it implies that in a larger geographic area the same proportions of dry land and irrigated field prevails when actually they are most likely not. Another example is the protein content of feed grains which is determined by the fixed proportions of the four component crops of feed grains (corn, barley, oats, and grain sorghum) in an area. The proportion also vary with regions. After one unit of feed grains is transported from one region to another, it loses its identify and hence, its original proportions of the component crops, by mixing itself with the feed grains of the importing region in the feed grain accounting row. Now the imported unit of feed grains takes on the protein content of its host region when it is transferred to the TDN and protein accounting rows as feeds. All such problems can be rectified at the cost of expanding the model to treat each component crop as separate activities.

Time dimension Labor in different time periods should be treated as different resources, not interchangeable. In the present study, annual labor is divided into only crop-season and non-crop-season labor. Improvement in this respect can be made only at the cost of greatly expanding the model by further dividing labor on monthly or even daily basis.

Off-farm pasture The federally-owned land rented as pasture in a region is assumed to be equally available to all areas in the region, disregarding the actual location of such off-farm pasture for lack of data regarding its location.

Transportation activities It is impossible to add transportation activities between areas (12 x 138 x 137 = 226,872) while keeping the model at a manageable size. Therefore, transportation activities are allowed only on the regional level. More transportation activities among producing areas would reveal more of the comparative advantages of such areas.

Yield index and cost advantage index

In comparing the comparative advantage in producing a crop among regions, the ratio between a region's share of the national total production and its share of the national total acreage may serve as an indicator of its yield advantage (or as its yield advantage index). Similarly, the ratio between a region's production share and its cost share may serve as an indicator of its cost advantage (or as its cost advantage index).

Suppose, a region's production share is 0.11; its acreage share, 0.10; and its cost share, 0.12. Then it has a yield advantage index of 0.11/0.10 = 1.10 and a cost advantage index of 0.11/0.12 = 0.92. An index value of 1.00 means its yield or cost (per unit of yield) is on par with the national average. Since high yield is an advantage, yield index is defined as (yield share)/(acreage share); whereas low cost is an advantage, a cost index is defined as (yield share)/(cost share). In both cases, the greater the value of the index, the stronger the advantage. The yield index can, of course, also be computed by comparing regional yield per acre with the national yield per acre.

Cost advantage index reflects the criterion by which the cost minimizing model selects its activities in the solution. A region's cost advantage indices of all crops produced in the solution can be weighted by their crop values to form an overall crop cost advantage index for the region.

Similarly, an overall livestock cost advantage index can be computed. Since in this study, livestock cost coefficients do not include the cost of feeds, which are treated as intermediate goods, computation of a true livestock cost advantage index including the cost of feeds requires tracing the sources of feeds and their costs -- sometimes an impossible job owing to the pooling of feeds from different producing areas, both within and without a region. Therefore, only the livestock production cost coefficient is used in computing the livestock cost advantage index, which, though a partial cost advantage indicator, does have its merits of dichotomizing the total cost of producing a livestock product into the feed cost and the cost of "managing" the livestock, so as to permit their separate evaluation.

Pre-solution comparison of the cost per unit of yield of all activities of the same enterprise in the model does not reveal the cost advantage in the setting of spatial equilibrium, for the reason that an area with a lower production cost may not supply to a remote region simply because of its disadvantage in transportation cost compared with a higher-cost region nearer to the importing region.[1] Post-solution comparison of cost of only those activities in the solution reflects the cost advantage in the setting of spatial equilibrium in the sense that all those activities in the solution have comparative advantage over the activities not in the solution. However, the cost advantage index as defined above still reflects only the production cost of those activities in the solution,[2] and is only one, albeit a major one, of the techniques analyzing regional comparative advantages.

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[1]Comparison of multiple-output activities by ranking is impossible. Lack of value (market price or shadow price) in the pre-solution state does not permit comparison on the basis of total value of output either.

[2]Inclusion of transportation cost into the computation of the cost advantage index of the exporting region with respect to the regions to which it exports would greatly complicate both the computation and the meaning of the index.

Cotton

Cotton, historically one of the two major cash crops (the other being tobacco) in the Southeast, is shifting out of the Southeast. The major causes for such a shift are: on the one hand, soil-exhaustion, uneven topography and small land-holdings unsuitable for large-scale mechanization, and relatively limited access to capital inputs owing to the historical structure of the cotton culture in the Southeast; and on the other hand, mechanization of cotton cultivation on level topography and high yield in irrigated areas in the Southwest and Southern California. Mechanization has relieved the cotton culture from its heavy dependency on intensive labor input, thus permitted its shift out of the Southeast where abundant agricultural labor is an advantageous production factor. (Perloff, et al. 1960; Highsmith, 1958.)

Since cotton lint demand is set at the national level in the model, there are no cotton lint transport activities among regions. Both solutions indicate an even heavier shift of cotton production out of the Southeast into Southern Plains (Region 12) and the Southwest (Region 14) than the 1965 actual distributions, and a downward shift by two thirds in Southeast Atlantic (Region 4) in terms of share of the national production (see Table 7). In terms of the share of national cotton acreage, the same pattern is true, though less pronounced (see Table 6). Explanations for such a shift can be found in the cost advantage index in Table 8.

The total cotton production in the model is predetermined by a projected normal annual demand. Since cotton production through the years fluctuates it is only natural to find the 1965 and 1969 actual total productions significantly different from the solutions. Both solutions are about 80% of the 1965 actual production, while in terms of acreage Solution I and Solution II are, respectively, 72% and 65% of the 1965 actual acreage, as the spatial equilibrium solutions recommend cotton to be produced in high-yield land. Checking Tables 83 and 84 of land use confirms that over 90% of the land planted to cotton is of land quality class 1. Cotton land in Solution II is of higher average yield than that in Solution I, judging from the less acreage of cotton land required to satisfy the same demand. The interdependent mechanism which causes Solution II to use more high-yield cotton land will be described later in this section.

Southeast Atlantic (Region 4), a historically important cotton producing region, declines greatly in importance in the solutions because of its weak cost advantage (indices: 0.84, 0.80).[1] The solutions show that only central and southern Alabama (Areas 18, 19, 20) remain in production in Region 4. This differs very much from the 1964 agricultural census results according to which South Carolina and Georgia produced cotton. Northern Alabama (Areas 133, 134), an actual cotton producing area which now is in Region 7 in this study, retains its productive position in the solutions because of its slightly stronger cost advantage (indices: 0.88, 0.84) than areas in Georgia and South Carolina.

The cotton producing areas in Region 12 (Southern Plains) are concentrated in central and western Oklahoma (Areas 88, 89) and northwestern Texas (Areas 92, 93, 94). Less are produced in southeastern Texas (Area 99). This coincides fairly well with 1964 agricultural census

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[1]Indices are listed in the order of Solution I and Solution II.

results, except the census shows more scattering of producion in eastern and southern Texas. In the solutions concentration of production in areas of stronger cost advantage leads to elimination of such scattered production.

Region 12 despite its low yield (indices: 0.86, 0.83) shows expansion of cotton production in both solutions because of its still lower production cost which more than offsets its low yield disadvantage, thus resulting in the greatest cost advantage indices (1.12, 1.10) among all regions.

The cotton acreage in Solution I is greater than that in Solution II because (a) central Oklahoma (Area 88), a low cost area, enters 644,000 acres into production in Solution I, but produces no cotton in Solution II (as it diverts the land to wheat production for foreign export), and (b) southern California (Area 117), a high yield area, devotes half a million acres more to cotton production in Solution II than in Solution I.

The chain reaction which causes such a discrepancy between the two solutions is as follows: Solution II does not allow grain-fed beef to substitute for non-grain-fed beef as Solution I does, and therefore produces non-grain-fed beef from the most economical source, namely, the activity of yearling slaughter by rearing calves to yearlings. By the cost-minimizing criterion, rearing calves to yearlings to produce non-grain-fed beef has the priority over maintaining dairy cows to produce milk in Southern California (Area 117) (i.e. it is cheaper to import milk than to import non-grain-fed beef). Rearing calves to yearlings exhausts the supply of pasture (see Table A-13), which precludes the possibility of producing dairy cows (obviously converting crop-hay land into pasture does not pay). Therefore, the remaining land and labor go into the production of cotton, which obviously has a lower priority than both calf-rearing and milk-producing activities. In Solution I, which allows grain-fed beef to substitute for non-grain-fed beef, Region 15 (California) imports grain-fed beef and reduces drastically its calf-rearing activities, which releases pasture to dairy cow activities, which in turn bid away land and labor from the cotton activity in Area 117. Cotton, being a product without regional demand requirement, easily shifts to whatever area it can be produced next economically -- i.e. Area 88 in central Oklahoma.

Such a diversion of nearly 500,000 acres of high-yield cotton land in San Joaquin Valley (Area 117; 12.87 CWT cotton/acre) to growing feed grains and forage to maintain dairy cows results in making up the loss by growing more cotton on low-yield land in central Oklahoma (Region 12, Area 88; 3.75 CWT/acre) and on slightly higher yield land in eastern Louisiana-southwestern Mississippi (Region 8, Area 120; 5.83 CWT/acre). Therefore, Solution I uses about 900,000 more acres of cotton land than Solution II. This example illustrates some of the interdependency of activities and constraints in the model.

The Delta Region (Region 8) increases in importance in Solution I but declines in Solution II, because in Solution II, wheat activities bid away class 1 land in central Louisiana and southwestern Mississippi (Area 120) from cotton production. Production in the Delta Region is concentrated in Mississippi (Area 21) and the tri-state Mississippi Valley area of Mississippi, Arkansas, and Louisiana (Area 122). This production pattern matches the 1964 census results closely. The increases in production in the Southwest (Region 14) and California (Region 15) (in Solution I only) is evidently due to both the factors of high yield and low cost resulting from irrigation in southern Arizona (Area 49) and San Joaquin Valley (Area 117) in Southern California. Solution II, however, produces very little cotton in San Joaquin Valley (see above for explanations). Mid-Atlantic (Region 3) produces cotton to the limit of the cotton land constraint set at the lower end of the previous production data.

In sum, the two solutions are generally consistent with the historical trend of shifting cotton production out of the Southeast and into Southern Plains and the Southwest, except in some isolated cases where competition from other crops bids away class 1 land and the shift does not materialize. Apparently the model is too crude an approximation of the real world and has some built-in rigidities due to area delineations.

Eyvindson's solution (1970) indicates a shift of cotton production out of the Southeast and into the Southwest and California, but not Southern Plains apparently due to increased demand for hay and silage to maintain increased feeder cattle in that region.[1]

The 1969 actual cotton production was not appreciably different from the 1965's in terms of regional shares of the national total, except Region 4's downward shift which seems to confirm the direction of shifting recommended by the two solutions as well as Eyvindson's solution.

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[1]Comparison of the two solutions with Eyvindson's solution on the area level is not attempted here because of (a) the high cost of converting his vast amount of data of results of a linear programming model of 6,837 x 41,677, to the same area basis used in this study, and (b) that such a post-solution conversion of results is hardly justified, and hence undesirable, because of the differences in structure and delineations in areas and regions of the two models. (footnote continued on following page)

Cost-minimization alone does not determine the pattern of cotton production. Cotton allotments in producing areas prevent the cost-minimizing scheme from working to its fullest extent. If cotton allotment were removed completely, the shift from the Southeast to Southern Plains (Region 12) would be much greater. Support for such a prediction can be found in not only strong cost advantages in cotton production in Southern Plains, but also, for instance in Solution I, in the binding cotton land constraints in all the six cotton producing areas in Southern Plains (Areas 88, 89, 92, 93, 94, and 99) and in the idle cotton land in five of the six cotton-producing areas (Areas 21, 23, 24, 120, and 122) in Delta (Region 8). Only cotton allotments limit Southern Plains' further expansion at the expense of the Delta region.

Though demand for cotton is treated at the national level, cotton seeds in the form of cotton oil meal are allowed to move among regions as feeds. Both solutions show that cotton seeds move from the cotton-producing regions, Nos. 4, 8, 12, and 15, to Regions 2, 3, 6, 7, 13 and 14 (Solution II only) as shown in Tables 5a and 5b.

Table A-4 (Solution I) and A-14 (Solution II) in the Appendix show that in none of the cotton seed-exporting regions are cotton seeds used as feeds. Region 12, itself an important livestock producer, exports all

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(footnote continued from previous page) The greater the difference are between two models, the less justified and convincing is any inference drawn from comparing their solutions. An ideal comparison would be between two solutions of the same model, obtained by varying a single parameter. Then all the differences in the two solutions can be rightly attributed to the variation of that single parameter.

Comparison of the present model with Eyvindson's on the regional level, though still not completely justified, is, however, less objectionable because of the more aggregate nature of the data of the solutions at the regional level.

Table 5a. Cotton seed movements, Solution I (unit: 1,000 CWT)

From Region	To Region	Quantity
4 (Southeast Atlantic)	3 (Mid-Atlantic)	199
	7 (Tennessee Valley	2,642
8 (Delta)	2 (East Corn Belt)	11,077
	6 (Kentucky)	13,792
12 (Southern Plains)	2 (East Corn Bel)	40,625
15 (California)	13 (Northwest)	859
Total		69,195

Table 5b. Cotton seed movements, Solution II (unit: 1,000 CWT)

From Region	To Region	Quantity
4 (Southern Atlantic)	7 (Tennessee Valley)	2,952
8 (Delta)	3 (Mid-Atlantic)	165
	6 (Kentucky)	17,762
	7 (Tennessee Valley)	2,468
12 (Southern Plains)	2 (East Corn Belt)	36,442
	3 (Mid-Atlantic)	33
15 (California)	13 (Northwest)	7,667
	14 (Southwest)	3,150
Total		70,639

of its cotton seeds.

This is another example of the model's economizing scheme at work. In most regions cotton seeds are the second most expensive source of TDN, next only to soybeans, but a cheap source of protein because of its high protein content. (See Tables A-2 and A-12 for their shadow prices and Table 4 for their protein contents.) And yet as a byproduct of cotton, its total production is chiefly pre-determined as cotton is, and must be used up in the solutions. Its high cost (in terms of the shadow price of TDN) is partly due to the cost of soybeans, a competing source of protein. Cotton seeds are used as feeds only by regions which can afford to absorb an input with such a high shadow price. (See the section on dairy cows for explanations and examples on shadow prices of inputs.) The movement of cotton seeds indicates the scarcity of protein in the importing regions.

Wheat and feed grains, the much cheaper sources of TDN, fail to substitute for cotton seeds as a source of protein because cotton seed's much higher content of protein results in a lower cost per unit of protein than wheat or feed grains. The ratio between the protein content of cotton seeds, 57.3% of TDN, and that of wheat, 14.4% of TDN, or of feed grains, approximately 12% of TDN, is greater than the ratio of their costs in terms of the shadow price per unit of TDN (shadow prices of grains are not in $/protein). Therefore, cotton seeds are a cheaper source of protein, though an expensive source of TDN. This also explains why the major portion of cotton seeds are converted into type 1 TDN and protein which feed livestock requiring high protein/TDN ratio in their rations, such as dairy cows, beef cows, and broilers.

Table A-2 shows cotton seeds are converted in Region 2 into Type 1 TDN and protein to feed dairy cows, the most important livestock enterprise in that region, and in Regions 6 and 7 into both Types 1 and 3 TDN and protein (for dairy cows, broilers, and feeder cattle).

Apparently, cotton seeds are not used in the cotton-producing regions as feeds because (a) they are too expensive as a TDN source and (b) they

Table 6. Cotton acreage (unit: acre)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	13,601	0.1	13,601	0.2	83,900	0.9	360,900	2.7	164,000	1.5
4	443,607	4.5	459,155	5.1	535,500	6.0	1,725,000	12.7	1,120,000	10.1
5	-	-	-	-	31,900	0.4	25,000	0.2	14,000	0.1
6	401	0.0	401	0.1	420,800	4.7	349,500	2.6	279,000	2.5
7	549,038	5.6	429,673	4.8	256,300	2.9	361,100	2.7	259,000	2.3
8	2,736,238	27.9	2,258,710	25.2	1,519,700	17.1	3,101,700	22.8	2,633,000	23.8
9	-	-	-	-	-	-	-	-	-	-
10	489,726	5.0	461,966	5.2	586,700	6.6	334,000	2.5	305,000	2.8
11	-	-	-	-	-	-	-	-	-	-
12	4,955,202	50.5	4,209,721	47.0	4,016,400	45.1	6,120,000	45.0	5,140,000	46.4
13	-	-	-	-	-	-	-	-	-	-
14	586,903	6.0	585,263	6.5	620,200	7.0	513,000	3.8	456,000	4.1
15	42,433	0.4	534,234	6.0	829,600	9.3	725,000	5.3	705,000	6.4
TOTAL	9,817,143	100.0	8,952,721	100.2	8,901,000	100.0	13,615,000	100.3	11,075,000	100.0

Table 7. Cotton production (unit: 1,000 500-pound bales)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	13.2	0.1	13.2	0.1	219.7	1.5	101.0	1.0
4	425.2	3.6	439.8	3.7	1,760.0	11.8	872.0	8.7
5	-	-	-	-	16.0	0.1	10.0	0.1
6	-	-	0.4	-	444.5	3.0	294.0	2.9
7	591.6	5.0	458.0	3.9	407.1	2.7	243.0	2.4
8	3,541.0	29.9	2,991.8	25.3	3,988.7	26.6	2,922.0	29.2
9	-	-	-	-	-	-	-	-
10	595.9	5.0	561.7	4.8	390.0	2.6	326.0	3.3
11	-	-	-	-	-	-	-	-
12	5,157.6	43.6	4,598.0	38.9	5,037.0	33.6	3,141.0	31.4
13	-	-	-	-	-	-	-	-
14	1,391.4	11.8	1,387.5	11.7	1,020.0	6.8	791.0	7.9
15	109.2	0.9	1,375.1	11.6	1,690.0	11.3	1,315.0	13.1
TOTAL	11,825.7	99.9	11,825.7	100.0	14,973.0	100.0	10,015.0	100.0

Table 8. Cost advantage index and yield index, cotton

Region No.	Solution I (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	0.1	0.1	0.1	1.00	1.00	0.2	0.1	0.1	1.00	0.50
4	4.5	3.6	4.3	0.84	0.80	5.1	3.7	4.6	0.80	0.73
5	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	5.6	5.0	5.7	0.88	0.89	4.8	3.9	4.5	0.87	0.81
8	27.9	29.9	33.2	0.90	1.07	25.2	25.3	27.7	0.91	1.00
9	-	-	-	-	-	-	-	-	-	-
10	5.0	5.0	5.9	0.85	1.00	5.2	4.8	5.7	0.84	0.93
11	-	-	-	-	-	-	-	-	-	-
12	50.5	43.6	39.1	1.12	0.86	47.0	38.9	35.2	1.11	0.83
13	-	-	-	-	-	-	-	-	-	-
14	6.0	11.8	10.8	1.09	1.97	6.5	11.7	11.1	1.05	1.80
15	0.4	0.9	0.8	1.12	2.25	6.0	11.6	11.0	1.05	1.93
Total	100.0	99.9	99.9			100.2	100.0	99.9		

are not needed as a protein supplement because of the higher proportion of livestock requiring low protein/TDN ratio in rations in these regions, whose feeding needs are satisfied by feeds of low protein/TDN ratio, such as feed grains or wheat. The much lower shadow prices of protein in these regions reflects the absence of severe scarcity of protein.

Solution II is generally similar to Solution I, except that in Solution II cotton seeds also serve as a protein supplement to Type 3 TDN and protein in Regions 2, 6, 13, and 14, perhaps owing to less total quantities of wheat and feed grains used as feeds in these regions in Solution II (by 78 million bushels and 84 million bushels, respectively) than in Solution I.

Wheat

Both solutions have nearly identical wheat productions, exceeding the 1965 actual production by nearly 1/3 or 430 million bushels, and show noticeable regional shifts in their shares of the national production (see Table 10).

As shown in the wheat "balance sheets", Tables 12 and 13, the regions may be divided into two main categories: those phased out of production and deficient (Mid-Atlantic, Region 3; Florida, Region 5; Tennessee Valley, Region 7) and those in the production. The later can further be divided into three sub-categories: (a) the deficit regions (Northeast, Region 1; Delta, Region 8; Southern Plains, Region 12), (b) the self-sufficient regions (Eastern Corn-Belt, Region 2, in Solution II; Southeast Atlantic, Region 4; Kentucky, Region 6; Northwest, Region 13, Southwest, Region 14; California, Region 15), and (c) the surplus regions

(Minnesota-Wisconsin, Region 9; Western Corn-Belt, Region 10; Northern Plains, Region 11; Eastern Corn-Belt; Region 2, in Solution I).

In terms of changes in regional share of the national wheat production, both solutions show noticeable downward shift in the marginal regions (Nos. 1, 2, 3, 5, 6, 7, and 14) and upward shift in Regions 4, 8, 9, 10, 12, 13, and 15. Meanwhile, Region 11 (Northern Plains), the major wheat-producing region, maintains its absolute productions, thus sliding in its share (see Tables 9 and 10).

Explanations on production shifts and trade patterns must be sought in a comprehensive interpretation of the shadow price and its three possible components: (a) production cost in terms of the cost advantage index, (b) opportunity cost in terms of factor constraints or demand constraints, and (c) transportation cost in terms of locational advantage (or disadvantage).

Most regions with a cost advantage index value of over 0.90 expand in production (see Table 11 "Cost advantage Index"). The exceptions are Northern Plains (Region 11; cost index 1.09) whose production does not expand beyond the 1965 actual figure because it is shielded from the main wheat-importing regions (the Northeast, the Southeast, the South) by two other, though less important, wheat-exporting regions (Minnesota-Wisconsin, Region 9; West Corn-Belt, Region 10) which have the locational advantage of being closer to the wheat-importing regions. Therefore, Northern Plains produce wheat for export only after Minnesota-Wisconsin and West Corn-Belt exhaust their wheat-producing class 1 land.[1] This is evidenced in Solution I by the existence of shadow prices of class 1 land

[1]This does not include the class 1 land in areas where no class 1 land wheat activities enter the solution.

producing wheat in southern Wisconsin (Area 43) and northwestern Minnesota (Area 60) of Region 9, and in eastern Missouri-Southern Illinois (Area 34) and southern Illinois (Area 47) of Region 10, on the one hand, and the lack of shadow prices for class 1 land in eastern North Dakota (Area 61) and western North Dakota (Area 63) of Region 11 on the other hand. Northern Plains may be said to serve as a reserve in the production of wheat for the country. In terms of shadow price of demand constraints, Northern Plains has the lowest ($0.82/bushels in solution I; $0.87/bushel in solution II) in the country.

Normally, all exporting regions have stronger cost advantage than their respective importing regions (some of which being phased out of production have no cost advantage indices). This is true, in both solutions, with the three most important surplus regions (No. 9, Minnesota-Wisconsin; 10, West Corn-Belt; 11, Northern Plains) with respect to their importing regions.

Among the three major surplus regions, West Corn-Belt (Region 10), with its weaker cost advantage (index 0.96), exports to its nearby regions (No. 7, Tennessee Valley; 8, Delta; 12, Southern Plains), while Minnesota-Wisconsin (Region 9) exports to the farther Northeast (Region 1) and Mid-Atlantic (Region 3) because it has a stronger cost advantage (index 1.10) to absorb the longer distance transportation cost. Northern Plains (Region 11), with its strong cost advantage (index 1.09), can afford to satisfy the needs of not only Southern Plains (Region 12) but also the farther Northeast (Region 1) and Florida (Region 5), after Minnesota-Wisconsin (Region 9) exhausts its land resources of wheat-producing activities.

Since the existence of a shadow price means the constraint is binding and its absence means the constraint is not, figuratively speaking, the "order" in which production activities go into the solution may roughly be established: i.e. the activity whose resources are not binding is the last to go into the solution and satisfies the last unit of demand.

In Solution I, Area 63 of Region 11 in southwestern North Dakota, with its idle land in wheat activity, may be said to produce the last unit of wheat to meet the demand of the model,[1] which is exported either to Northeast (Region 1) to be used as feeds, or to Florida (Region 5) or Southern Plains (Region 12) to be used as food grain (see Table 12.).

Among the 57 wheat-producing areas in Solution I, the only other area where slack of factor(s) exists for a wheat activity is in southern Kentucky (Area 27; Region 6), a region of self-sufficiency. This occurs only when the cost advantage in a region is great enough to permit local production (to ward off imports) but not great enough to compensate for transportation cost to allow exports (i.e. to successfully compete with other exporting regions). (See Table 12 and A-3.)

It is worthwhile to note the relationship between the shadow price of a demand constraint and the cost advantage index of a region. The cost advantage index is an index of the average production cost advantage of a region (which may be converted back into the average production cost of a region in terms of dollars), while the shadow price is the marginal

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[1]This is established by economic reasoning, rather than by indication from the mathematical model. The only conceivable indicator as to the order of activities entering the solution is the order of iteration in the process of solving the model, which is, however, indefinite because activities may exit and re-enter the basis a number of times during iteration.

cost of producing the last unit to satisfy the regional demand, if its production does not incur transportation cost and/or opportunity cost. For instance, the shadow price in Region 11 (Northern Plains), $0.82/bushel, is the production cost on class 1 land in Area 63 (southern North Dakota), ($18.76/11.01 CWT TDN = $1.71/CWT TDN = $0.82/bushel).[1]

As an example including transportation cost, the shadow price in Region 1 (Northeast), $1.09/bushels, is the sum of the production cost of Area 63 (southwestern North Dakota) in Region 11 (Northern Plains), $0.82/bushels, and the transportation cost from Region 11 to Region 1, $0.27/bushel.

A third example illustrates the three components of a shadow price: Tennessee Valley (Region 7) imports wheat from only West Corn-Belt (Region 10) and has a shadow price of wheat, $0.99/bushel, which is the sum of (a) the production cost on class 2 land in Area 36 (eastern Missouri-southwestern Illinois), $23.8/14.6 CWT TDN = $1.63/CWT TDN, (b) the transportation cost from Region 10 to Region 7, $0.298/CWT TDN, and (c) the opportunity cost (shadow price) of land in sacrificing another crop to produce wheat because of the binding land constraint, $2.0166/acre, i.e. $0.138/CWT TDN -- totaling $1.630 + $0.298 + $0.138 = $2.066/CWT TDN, i.e. $0.993/bushel.

Solution II exhausts one of the factors (land or crop-season labor) in all of its 113 wheat activities because there exist shadow prices of land in the 111 wheat activities, and of crop-season labor in the two

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[1]Pasture, a byproduct of wheat activity, usually constitutes only a very small fraction (0.29% in this case) of the total value (in terms of shadow price) of the output of the activity should its shadow price exist, and, therefore, is ignored here. (See Section Shadow Price in Chapter III.)

remaining activities (south central Washington, Area 114; and eastern Calorado, Area 106) whereas class 3 land in these two areas are still in slack. The implication of such a universally factor constraint binding situation is that since wheat used as feeds has been produced to its economically justifiable limits, it is now more economical for the model to leave wheat production at the present level and to produce more of other crops as feeds, rather than produce more wheat on land of lower class with lower yield. Production stops because, on the supply side factor resources at the prevailing marginal cost level are exhausted. Solution I constrasts this by being a case where production stops because on the demand side, all demand for wheat are satisfied and there is no more need for more wheat at the prevailing marginal cost level. This is illustrated in Figures 5a and 5b.

In Figures 5a and 5b the horizontal axis, OQ represents both the output of concentrate feeds produced (in terms of TDN) and the inputs (land or labor) used in proportion to the feeds produced, and the vertical axis represents the production cost (as indicated by cost coefficients).

The step-wise marginal cost curve (also the supply curve), S, consists of as many horizontal segments as there are activities producing concentrate feeds in the solution. The segment, ab, represent the most economical activity, say, class 1 land feed grain activity, which produces OQ_1 TDN and uses OQ_1 factors (one of which is exhausted at Q_1). At Q_1, the next economical activity, say, class 1 land wheat, represented by segment cd, takes over and can produce Q_1Q_2 inputs (one of which is exhausted at Q_2).

In Solution I, however, demand is satisfied at Q_s (where the inelas-

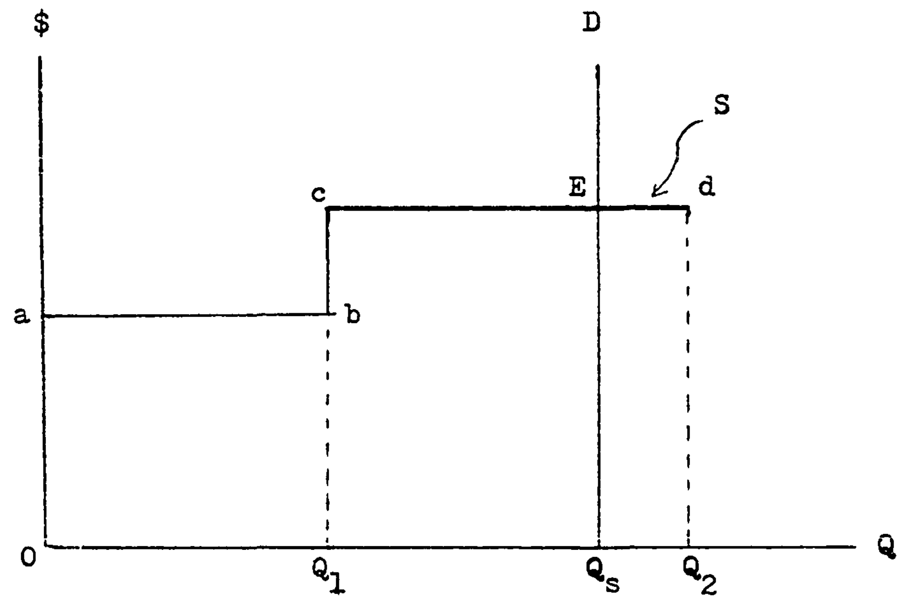

Figure 5a. Non-binding constraint, cd, in supply function, Solution I.

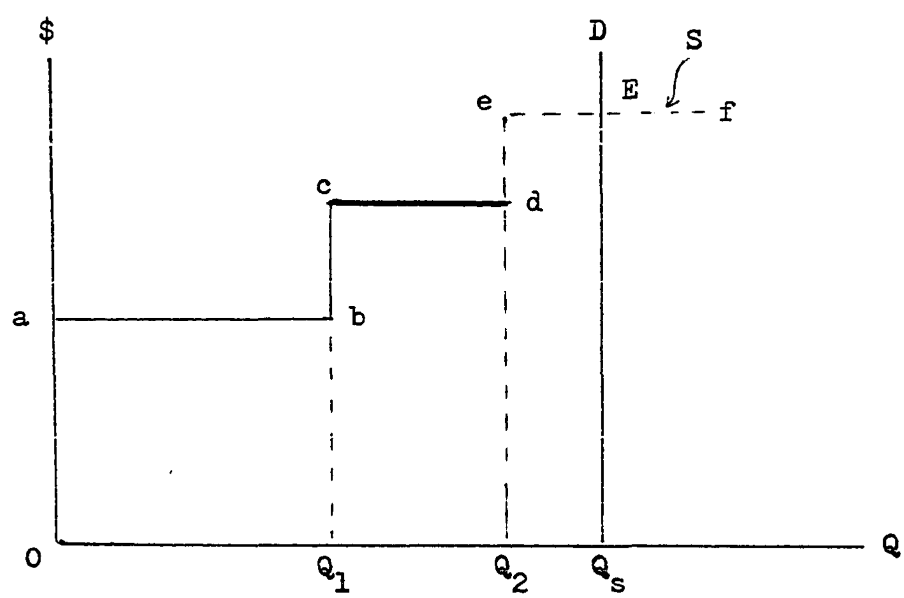

Figure 5b. Binding constraint, cd, in supply function, Solution II.

tic demand curve, D, intersects the marginal cost curve, S, at point E. This leaves some of the capacity of the wheat activity unused (Q_sQ_2), and the quantity of wheat produced is Q_1Q_s.

In Solution II, the capacity of wheat activity is exhausted at Q_2 where the demand for total feeds is short of being satisfied. Then, segment <u>ef</u>, a third feed-producing activity, say, soybeans, takes over and satisfies the remaining portion of demand, yet still with idle resources, <u>Ef</u>, left over. It would be a very rare coincidence that the activity satisfying the last portion of demand stops (because of one of its factors is exhausted) at exactly the point of E.

The solutions recommend 23-28% (407-480 million bushels) of the wheat produced be used as feeds. Such an optimization decision made by the model has its far-reaching "substitution effect" on other crops. Because of the higher TDN content of wheat, consequently, feed grains production decline by over 20%, or about 1.3 billion bushels, and soybeans, by 35% or about 300 million bushels. Obviously, it is economical to substitute wheat for feed grains as feeds, even granting some discrepancy between the 1965 production and the exact quantities required to meet the food and feed demand.

Of course, the solutions also dictate production of more of the better breed of dairy cows, beef cows and feeder cattle with higher rate of feed utilization and, therefore, less head of such livestock are needed to meet given demand for the final products. This also accounts partly for the great decreases of feed grains and soybeans production. Apparently, in the real world, the wheat price-support program has hindered the tendency of increased use of wheat as feeds.

Despite certain regional shifts in both absolute production and the relative importance from the 1965 actual production, the two solutions retain the basic and traditional pattern of wheat production as shown in Tables 9 and 10.

The major wheat-producting areas in the solutions coincide with the three actual important wheat regions in this country: (a) the Spring Wheat Belt of western Minnesota (Area 60; Region 9), North Dakota (Areas 61, 62, 63; Region 11) and Montana (Areas 102, 103, 104; Region 13); (b) the Winter Wheat Belt of western and southern Nebraska (Areas 72, 73, 75, 76; Region 11), Kansas (Areas 79, 80, 82, 84, 86; Region 11), Oklahoma (Areas 85, 87, 88, 89, 90; Region 12), northern and western Missouri (Area 51; Region 10), and eastern Colorado (Area 106; Region 114); and (c) the Columbia Basin of Washington (Areas 112, 114; Region 13), Oregon (Area 113; Region 13) and western Idaho (Areas 28, 112; Region 13).

Since the solutions call for an increase of 30% over the 1965 production and an acreage increases by about 10 million acres or 20%, the production expands not only in traditional wheat country such as western Minnesota (Area 60, Region 9) but also into areas where actual productions are insignificant such as southern Wisconsin (Area 43; Region 9) and western Tennessee-Arkansas-Louisiana (Areas 23, 25, 122; Region 8). Missouri and southern Illinois in West Corn-Belt (Areas 36, 47, 51; Region 10) more than double their acreage and production. All these heavy expansions are obviously due to increased demand for wheat as feeds in Northeast (Region 1), Mid-Atlantic (Region 3), and Northwest (Region 13), and the phasing-out of several regions which produced insignificant quantities in 1965. Subsequent adjustment of the production and trade

Table 9. Wheat acreage (unit: acre)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	172,488	0.3	221,831	0.4	1,375,100	2.2	772,000	1.6	680,000	1.4
2	2,342,018	3.9	2,276,346	3.7	2,384,800	3.8	3,174,000	6.4	2,594,000	5.5
3	-	-	-	-	-	-	320,500	0.6	347,000	0.7
4	450,444	0.7	450,374	0.7	387,800	0.6	167,400	0.3	227,000	0.5
5	-	-	-	-	-	-	23,000	0.0	43,000	0.1
6	104,902	0.2	113,294	0.2	437,000	0.7	217,400	0.4	281,000	0.6
7	-	-	-	-	244,800	0.4	138,400	0.3	173,000	0.4
8	1,954,031	3.2	2,875,531	4.7	1,459,000	2.3	553,400	1.1	459,000	1.0
9	5,014,615	8.3	5,797,342	9.4	3,410,700	5.4	869,000	1.8	882,000	1.9
10	6,768,507	11.2	4,656,032	7.6	6,501,300	10.4	2,826,000	5.7	2,379,000	5.0
11	19,589,340	32.4	20,104,460	32.6	24,968,100	39.8	21,707,000	43.8	21,311,000	44.8
12	10,959,770	18.1	12,675,120	20.6	8,854,700	14.1	8,219,000	16.6	7,019,000	14.8
13	10,914,260	18.1	10,441,990	17.0	11,802,000	18.8	8,553,000	17.3	8,188,000	17.2
14	1,545,299	2.6	1,305,228	2.1	628,000	1.0	1,740,000	3.5	2,617,000	5.5
15	629,613	1.0	682,722	1.1	305,000	0.5	278,000	0.6	355,000	0.7
TOTAL	60,445,230	100.0	61,600,240	100.0	62,758,300	100.0	49,558,100	100.0	47,555,000	100.1

Table 10. Wheat production (unit: 1,000 bushels)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	6,069.4	0.3	7,805.7	0.4	27,351.0	2.1	25,503.0	1.7
2	85,397.9	4.9	83,392.0	4.8	102,927.0	7.8	99,660.0	6.8
3	-	-	-	-	9,439.5	0.7	14,558.0	1.0
4	12,300.1	0.7	12,298.1	0.7	4,568.7	0.3	7,553.0	0.5
5	-	-	-	-	575.0	0.0	1,204.0	0.1
6	3,579.8	0.2	3,866.2	0.2	6,549.5	0.5	9,239.0	0.6
7	-	-	-	-	4,087.4	0.3	5,875.0	0.4
8	60,440.2	3.5	85,451.5	4.9	14,368.9	1.1	13,641.0	0.9
9	166,557.4	9.5	184,783.7	10.6	24,352.0	1.9	26,121.0	1.8
10	223,400.3	12.8	154,179.4	8.8	90,755.0	6.9	82,633.0	5.7
11	504,173.8	28.9	509,860.9	29.2	505,704.0	38.4	637,381.0	43.7
12	264,908.7	15.2	308,348.9	17.7	209,300.0	15.9	187,131.0	12.8
13	362,034.5	20.8	343,544.8	19.7	275,178.0	20.9	274,932.0	18.8
14	32,454.8	1.9	25,758.0	1.5	33,573.0	2.6	61,361.0	4.2
15	23,091.4	1.3	24,940.9	1.4	7,383.0	0.6	12,080.0	0.8
TOTAL	1,744,407.0	100.0	1,744,229.0	99.9	1,315,612.0	100.0	1,458,872.0	99.8

Table 11. Cost advantage index and yield index, wheat

Region No.	Solution I (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	0.3	0.3	0.5	0.60	1.00	0.4	0.4	0.6	0.67	1.00
2	3.9	4.9	5.7	0.86	1.26	3.7	4.8	5.5	0.87	1.30
3	-	-	-	-	-	-	-	-	-	-
4	0.7	0.7	1.0	0.70	1.00	0.7	0.7	1.0	0.70	1.00
5	-	-	-	-	-	-	-	-	-	-
6	0.2	0.2	0.3	0.67	1.00	0.2	0.2	0.3	0.67	1.00
7	-	-	-	-	-	-	-	-	-	-
8	3.2	3.5	4.2	0.83	1.09	4.7	4.9	6.0	0.82	1.04
9	8.3	9.5	8.6	1.10	1.14	9.4	10.6	9.9	1.07	1.13
10	11.2	12.8	13.4	0.96	1.14	7.6	8.8	9.1	0.97	1.16
11	32.4	28.9	26.5	1.09	0.89	32.6	29.2	26.5	1.10	0.90
12	18.1	15.2	17.0	0.89	0.84	20.6	17.7	19.6	0.90	0.86
13	18.1	20.8	19.2	1.08	1.15	17.0	19.7	18.1	1.09	1.16
14	2.6	1.9	2.1	0.90	0.73	2.1	1.5	1.7	0.88	0.71
15	1.0	1.3	1.4	0.93	1.30	1.1	1.4	1.6	0.88	1.27
Total	100.0	100.0	99.9			100.1	99.9	99.9		

Table 12. Consumption, production and transport of wheat, Solution I (unit: 1,000 bushels)

Region No.	Consumption				Production	
	Food, export	Feeds	Total	%	Quantity	%
1	139,169	283,352	422,521	24.2	6,068	0.3
2	77,225		77,225	4.4	85,398	4.9
3	23,714	22,549	46,263	2.7	-	-
4	9,470	2,830	12,300	0.7	12,300	0.7
5	2,374		2,374	0.1	-	-
6	3,580		3,580	0.2	3,580	0.2
7	5,631		5,631	0.3	-	-
8	166,263		166,263	9.5	60,440	3.5
9	83,947		83,947	4.8	166,557	9.5
10	92,955		92,955	5.3	223,400	12.8
11	107,509		107,509	6.2	504,174	28.9
12	306,258		306,258	17.6	264,909	15.2
13	198,589	163,446	362,035	20.8	362,035	20.8
14	20,181	12,274	32,455	1.9	32,455	1.9
15	23,091		23,091	1.3	23,091	1.3
Total	1,259,956	484,451	1,744,407	100.0	1,744,407	100.0

Imports			Exports			Shadow price ($/bu.)	Cost advantage index
From region	Quantity	%	To region	Quantity	%		
9	44,520					1.09	0.60
11	371,933						
(total)	416,453	67.4					
			3	8,173	1.3	0.88	0.86
2	8,173					1.08	-
9	38,090						
(total)	46,263	7.5					
						0.99	0.70
11	2,374	0.4				1.09	-
						0.97	0.67
10	5,631	0.9				0.99	-
10	105,823	17.1				1.03	0.83
			1	44,520		0.83	1.10
			3	38,090			
			(total)	82,610	13.4		
			7	5,631		0.85	0.96
			8	105,823			
			12	18,991			
			(total)	130,445	21.1		
			1	371,933		0.82	1.09
			5	2,374			
			12	22,358			
			(total)	396,665	64.2		
10	18,991					1.15	0.89
11	22,358						
(total)	41,349	6.7					
						0.99	1.08
						0.97	0.90
						1.27	0.93
	617,893	100.0		617,893	100.0		

Table 13. Consumption, production and transport of wheat, Solution II (unit: 1,000 bushels)

Region No.	Consumption				Production	
	Food, export	Feeds	Total	%	Quantity	%
1	139,394	259,377	398,771	22.9	7,806	0.4
2	83,392		83,392	4.8	83,392	4.8
3	25,653		25,653	1.5	-	-
4	9,475	2,823	12,298	0.7	12,298	0.7
5	2,564		2,564	0.1	-	-
6	3,866		3,866	0.2	3,866	0.2
7	6,081		6,081	0.3	-	-
8	179,582		179,582	10.3	85,452	4.9
9	90,654		90,654	5.2	184,784	10.6
10	100,169		100,169	5.7	154,179	8.8
11	116,128		116,128	6.7	509,861	29.2
12	330,829		330,829	19.0	308,349	17.7
13	199,029	144,520	343,559	19.7	343,549	19.7
14	25,758		25,758	1.5	25,758	1.5
15	24,941		24,941	1.4	24,941	1.4
Total	1,337,515	406,720	1,744,235	100.0	1,744,235	99.8

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/bu.)	advantage index
11	390,965	72.2				1.14	0.67
						0.94	0.87
10	22,885					1.13	-
11	2,768						
(total)	25,653	4.7					
						1.02	0.70
10	2,564	0.5				1.14	-
						1.01	0.67
10	6,081	1.1				1.03	-
9	94,130	17.4				1.10	0.82
			8	94,130	17.4	0.91	1.07
			3	22,885		0.89	0.97
			5	2,564			
			7	6,081			
			12	22,480			
			(total)	54,010	10.0		
			1	390,965		0.87	1.10
			3	2,768			
			(total)	393,733	72.7		
10	22,480	4.1				1.19	0.90
						1.00	1.09
						0.94	0.88
						1.22	0.88
	541,873	100.0		541,873	100.1		

patterns also influence the location of expansions in the solutions.

Differences between the two solutions are attributed to the differences in demand and assumptions (see Chapter III). As Solution II has a greater human consumption demand to meet, the amount available as feeds in Solution II is less than in Solution I, and consequently Region 2 (East Corn-Belt) has no surplus to export to Region 3 (Mid-Atlantic). The subsequent trade pattern in Solution II also differs slightly from that of Solution I.

Another aspect is the trend towards increased average yield. According to the solutions, wheat acreage increases by 20% while wheat production increases by 30% because over half of the wheat acreage is on class 1 land, no wheat acreage by land class in actual production is readily available for comparison with the solutions. But the 1969 figures bear out this phenomenon by showing a decrease in total acreage accompanied by an increase in total output.

As expected, wheat production on class 2 and 3 land is much less than that on class 1 land because of the higher production cost in the former (see Table 83 and 84).

Feed Grains

Expansion of wheat production for use as feeds in the solutions results in a reduction of feed grain production by over 20% or about 1.3 billion bushels, and a reduction of their acreage by 30% or 28-30 million acreas, implying withdrawing land of lower yield, and hence, of lower quality (see Tables 14 and 15).

Despite such a heavy reduction, West Corn-Belt (Region 10) retains its absolute production, thus gaining in its regional share. Both the yield index and the cost advantage index of this region are among the highest in the country. West Corn-Belt supplies feed grains to the Southeast (Regions 3, 4, 5, 6, 7, and 8) which has nearly been phased out of production because of its lack of cost advantage on the one hand, and the lower transportation cost by means of barge from West Corn-Belt to the Southeast on the other hand. Production costs in Southeast Atlantic (Region 4), Kentucky (Region 6) and Delta (Region 8) are among the highest in the solutions as shown in Table 16.

Feed grain production is closely tied with livestock activities to form commercial crop-livestock enterprises. For instances, West Corn-Belt produces nearly half of the hogs of the country and is also a major producer of grain-fed beef. East Corn-Belt (Region 2), the next major region showing a gain in regional share, is a major dairy region. Minnesota-Wisconsin (Region 9) and Northern Plains (Region 11) decline in their regional shares of feed grains, as the former reduces its hog production from 9% to 4% of the national total (see Section Hogs) and the latter changes its role from a feed grain exporting region in the real world to a non-exporting region, because of its increased production of hogs.

Again, as in the case of wheat production, the geographic location is an important factor. Northern Plains (Region 11) is shielded from the consuming regions in the Southeast by West Corn-Belt (Region 10) which, with an additional advantage of lower production cost, satisfies all the needs of feed grains in the Southeast. The existence of idle hand in feed grain activities in eastern and central Nebraska (Area 71, 75; Region

11) attests to the explanations given above. Both solutions show Mid-Atlantic (Region 3), Florida (Region 5), and Tennessee Valley (Region 7) are phased out of production of wheat, feed grains, and soybeans, apparently for reasons cited above: higher production cost and low transportation cost from West Corn-Belt (Region 10) to these regions by barge which also causes transshipment of feed grains from Region 10 to Region 3 via Region 7 (see Tables 17 and 18).

On the producing area level, production distributions in the solutions are generally consistent with the 1965 distribution of production in (a) West Corn-Belt (Region 10) -- the entire state of Iowa (Areas 52, 53), northern Illinois (Area 45) and southeastern Missouri (Area 26); (b) East Corn-Belt (Region 2) -- north and central Indiana (Area 38) and Western Ohio (Area 33); (c) Minnesota-Wisconsin (Region 9) -- southwestern Minnesota (Area 54), and some scattering through the rest of Minnesota; and (d) Southern Plains (Region 12) -- northwestern Texas (Area 94), southern Texas (Areas 98, 100, 130).

The weights of component crops of feed grains (corn, barley, oats, grain sorghum) vary in different geographic locations. Corn is by far the most important component in Corn-Belt; grain sorghum, in Southern Plains; oats and barley are more important in the northern parts of the country; and barley, in the western parts. Typical of a linear programming solution, there are more concentrated and less scattered productions.

The regional distributions of feed grains (and soybeans) in the two solutions are not as smooth as those in Eyvindson's solution, mainly for the reason that the transportation routes in the present study are too

Table 14. Feed grain acreage (unit: acre)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	1,879,256	2.8	1,864,259	2.8	704,200	1.0	3,129,000	3.3	3,097,000	3.7
2	8,643,732	12.8	8,497,173	12.9	10,626,600	15.1	10,792,000	11.2	10,066,000	12.2
3	-	-	-	-	295,600	0.4	2,165,800	2.3	2,069,000	2.5
4	25,423	0.04	27,045	0.04	669,900	0.9	2,780,300	2.9	2,503,000	3.0
5	-	-	-	-	68,000	0.1	363,000	0.4	410,000	0.5
6	144,387	0.2	215,864	0.3	170,200	0.2	1,380,700	1.4	1,167,000	1.4
7	-	-	-	-	157,300	0.2	1,010,600	1.1	866,000	1.0
8	206,513	0.3	193,358	0.3	369,300	0.5	1,005,900	1.0	726,000	0.9
9	7,191,698	10.7	7,347,820	11.2	7,396,400	10.5	11,415,000	11.9	11,670,000	14.1
10	26,173,700	38.9	27,008,880	41.0	27,312,500	38.7	26,057,000	27.1	24,596,000	29.7
11	9,968,248	14.8	9,213,600	14.0	12,504,100	17.7	21,049,000	21.9	17,150,000	20.7
12	5,887,503	8.7	4,976,164	7.6	4,828,300	6.8	7,862,000	8.2	2,069,000	2.5
13	3,559,604	5.3	3,555,930	5.4	3,448,200	4.9	3,311,000	3.4	3,849,000	4.7
14	1,968,861	2.9	1,790,186	2.7	793,700	1.1	1,692,000	1.8	1,034,000	1.2
15	1,656,494	2.5	1,151,154	1.7	1,205,900	1.7	1,971,000	2.1	1,458,000	1.8
TOTAL	67,305,370	99.9	65,841,380	99.9	70,550,200	99.8	95,984,300	100.0	82,730,000	99.9

Table 15: Feed grains production (unit: 1,000 bushels)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	117,382.7	2.5	116,357.6	2.5	190,657.0	3.1	215,877.0	3.4
2	717,640.2	15.2	702,919.5	15.1	841,058.0	13.9	857,878.0	13.7
3	-	-	-	-	138,355.9	2.3	142,481.0	2.3
4	1,083.4	0.0	1,152.5	0.0	124,406.0	2.0	102,147.0	1.6
5	-	-	-	-	15,906.0	0.3	16,507.0	0.3
6	9,616.7	0.2	14,377.3	0.3	82,919.3	1.4	76,780.0	1.2
7	-	-	-	-	49,288.3	0.8	53,031.0	0.8
8	8,552.1	0.2	7,969.7	0.2	38,164.5	0.6	53,858.0	0.9
9	440,493.7	9.4	454,882.8	9.8	690,649.0	11.4	822,454.0	13.1
10	2,154,432.0	45.7	2,207,150.6	47.4	2,127,395.0	35.1	2,224,167.0	35.5
11	579,122.2	12.3	533,764.4	11.5	1,046,932.0	17.3	1,241,270.0	19.8
12	354,526.2	7.5	320,440.6	6.9	373,906.0	6.2	113,177.0	1.8
13	109,573.3	2.3	109,457.6	2.4	145,824.0	2.4	180,121.0	2.9
14	110,432.4	2.3	103,922.9	2.2	89,023.0	1.5	75,355.0	1.2
15	106,774.5	2.3	80,108.8	1.7	113,686.0	1.9	87,646.0	1.4
TOTAL	4,709,628.0	99.9	4,652,503.0	99.8	6,068,170.0	100.2	6,262,749.0	99.9

Table 16. Cost advantage index and yield index, feed grains

Region No.	Solution I (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	2.8	2.5	4.1	0.61	0.89	2.8	2.5	4.1	0.61	0.89
2	12.8	15.2	16.7	0.91	1.19	12.9	15.1	16.6	0.91	1.17
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
6	0.2	0.2	0.3	0.67	1.00	0.3	0.3	0.4	0.75	1.00
7	-	-	-	-	-	-	-	-	-	-
8	0.3	0.2	0.3	0.67	0.67	0.3	0.2	0.2	1.00	0.67
9	10.7	9.4	9.0	1.04	0.88	11.2	9.8	9.4	1.04	0.88
10	38.9	45.7	41.4	1.10	1.17	41.0	47.4	43.4	1.09	1.16
11	14.8	12.3	12.8	0.96	0.83	14.0	11.5	11.9	0.97	0.82
12	8.7	7.5	8.1	0.93	0.86	7.6	6.9	7.3	0.95	0.91
13	5.3	2.3	1.9	1.21	0.43	5.4	2.4	1.9	1.26	0.44
14	2.9	2.3	2.7	0.85	0.79	2.7	2.2	2.5	0.88	0.81
15	2.5	2.3	2.8	0.82	0.92	1.7	1.7	2.0	0.85	1.00
Total	99.9	99.9	100.0			99.9	100.0	99.7		

Table 17. Consumption, production and transport of feed grain, Solution I (unit: 1,000 bushels)

Region No.	Consumption				Production	
	Feed, export	Feeds	Total	%	Quantity	%
1	98,753	18,530	117,283	2.5	117,283	2.5
2	85,447	632,193	717,640	15.2	717,640	15.2
3	63,348	64,107	127,455	2.7	-	-
4	15,980	97,747	113,727	2.4	1,083	-
5	389	37,451	37,840	0.8	-	-
6	23,205	54,963	78,168	1.7	9,617	0.2
7	19,481	65,105	84,586	1.8	-	-
8	331,892	71,687	403,579	8.6	8,552	0.2
9	175,060	265,434	440,494	9.4	440,494	9.4
10	320,780	1,007,549	1,328,329	28.2	2,154,432	45.7
11	5,049	574,073	579,122	12.3	579,122	12.3
12	104,651	249,875	354,526	7.5	354,526	7.5
13	45,304	64,269	109,573	2.3	109,573	2.3
14	953	98,364	99,317	2.1	110,432	2.3
15	22,134	95,756	117,890	2.5	106,775	2.3
Total	1,312,426	3,397,103	4,709,529	100.1	4,709,529	99.9

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/bu.)	advantage index
						0.84	0.61
						0.67	0.91
7	127,455	13.2				0.87	-
10	112,644	11.7				0.79	-
10	37,840	3.9				0.83	-
10	68,551	7.1				0.76	0.67
10	212,041	22.0	3	127,455	13.2	0.74	-
10	395,027	40.9				0.79	0.67
						0.56	1.04
			4	112,644		0.61	1.10
			5	37,840			
			6	68,551			
			7	212,041			
			8	395,027			
			(total)	836,103	85.6		
						0.60	0.96
						0.84	0.93
						0.70	1.21
			15	11,115	1.2	0.83	0.85
14	11,115	1.2				0.98	0.82
	964,673	100.0		964,673	100.0		

Table 18. Consumption, production and transport of feed grains, Solution II (unit: 1,000 bushels)

Region No.	Consumption				Production	
	Food, export	Feeds	Total	%	Quantity	%
1	95,987	64,248	160,235	3.4	116,358	2.5
2	86,310	616,610	702,920	15.1	702,920	15.1
3	63,988	93,483	157,471	3.4	-	-
4	16,141	91,605	107,746	2.3	1,153	-
5	393	31,808	32,201	0.7	-	-
6	23,439	99,993	123,432	2.7	14,377	0.3
7	19,683	88,068	107,751	2.3	-	-
8	352,218	63,512	415,730	8.9	7,970	0.2
9	176,828	278,055	454,883	9.8	454,883	9.8
10	324,020	962,300	1,286,320	27.6	2,207,151	47.4
11	5,182	528,582	533,764	11.5	533,764	11.5
12	126,660	169,904	276,564	5.9	320,441	6.9
13	45,762	63,696	109,458	2.4	109,458	2.4
14	959	78,548	79,507	1.7	103,923	2.2
15	21,933	82,592	104,525	2.2	80,109	1.7
Total	1,339,503	3,313,004	4,652,507	99.9	4,652,507	99.8

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/bu.)	advantage index
12	43,877	3.8				0.91	0.61
						0.70	0.91
7	157,471	13.7				0.89	-
10	106,593	9.3				0.81	-
10	32,201	2.8				0.85	-
10	109,055	9.5				0.78	0.75
10	265,222	23.1	3	157,471	13.7	0.76	-
10	407,760	35.6				0.81	1.00
						0.64	1.04
			4	106,593		0.64	1.09
			5	32,201			
			6	109,055			
			7	265,222			
			8	407,760			
			(total)	920,831	80.3		
						0.59	0.97
			1	43,877	3.8	0.79	0.95
						0.69	1.26
			15	24,416	2.1	0.80	0.88
14	24,416	2.1				0.96	0.85
	1,146,595	99.9		1,146,595	99.9		

simplified (only among 15 regions), as compared with Eyvindson's model (among 21 regions and, also, between areas and regions). Besides, the lower barge rate from the Mid-West to the Southeast used in this model makes it economical for some regions in the Southeast to import feed grains, instead of growing the crops.

Soybeans

The solutions show a reduction of soybean productions from the 1965 figure by as much as 35% or 300 million bushels, and a decrease of its acreage by 40% or about 14 million acres, implying withdrawal of land of lower quality and yield. As in the case of feed grains, the demand for soybeans for human consumptions are predetermined in the model, therefore, the reduction of production reflects a great decrease in the use of soybean oil meals as feeds, obviously owing to the increased use of wheat as feeds.

Since soybeans are produced only in such crop rotations as feed grain-soybean, and feed grain-soybean-silage, their production pattern is closely related to that of feed grains. The regional shift of soybean production is somewhat similar to that of feed grains -- the regional share increases in West Corn-Belt (Region 10), and decreases in Minnesota-Wisconsin (Region 9) and Northern Plains (Region 11). The regions in the Southeast (Nos. 3, 4, 5, 6, and 7) are phased out, with the exception of Delta (Region 8) which maintains its relative position. (See Tables 19 and 20.) Northern Plains (Region 11) has idle land for feed grain-soybean activities, as pointed out in the previous discussions on feed grains.

The explanations proposed above for feed grain shifts may equally be applied to soybean shifts: (a) changes in livestock, mainly hogs, production; (b) the locational advantage West Corn-Belt (Region 10) has over Northern Plains (Region 11); and (c) the transportation advantage the Southeast has by the use of barge from the Midwest. As in the case of feed grains, transshipments of soybeans from Region 10 to Regions 1 and 3 via Region 7 also occurs here (see Tables 22 and 23).

Region 8 (Delta) has the largest demand for soybeans among all regions because of the shipment of soybeans for foreign exports through the seaport of New Orleans. It decreases in production, though retaining its regional share, because its producing area in eastern Arkansas (Area 121) has a high production cost (cost advantage index: 0.67 vs. 1.10 for West Corn-Belt) (see Table 21). Therefore, it imports heavily from West Corn-Belt (Region 10) and Minnesota-Wisconsin (Region 9), a total of 130 million bushels, for foreign exports.

Its distribution is similar to that of feed grains in East Corn-Belt (Region 2), West Corn-Belt (Region 10), Minnesota-Wisconsin (Region 9), Northern Plains (Region 11); and is concentrated in eastern Arkansas (Area 121) in the Delta (Region 8); in Delaware and eastern Maryland (Area 4) in the Northeast (Region 1); in coastal Alabama (Area 18) in Region 4; in the Indiana-Kentucky border (Area 35) in Region 6 in Solution I. Such a distribution is nearly the same as in 1965, except the marginal regions being phased out.

The soybean distributions in the two solutions are similar to that in Eyvindson's solution, except the formers indicate more phasing-out in marginal regions. Again, the same reasons given for feed grains apply here in explaining the discrepancies.

Table 19. Soybean acreage (unit: acre)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	282,334	1.4	282,064	1.3	336,800	1.6	397,000	1.2	443,000	1.1
2	2,899,376	14.0	3,335,378	15.6	3,100,700	14.6	5,355,000	15.5	6,136,000	15.0
3	-	-	-	-	234,100	1.1	1,053,700	3.1	1,216,000	3.0
4	57,660	0.3	61,337	0.3	421,100	2.0	1,143,600	3.3	1,902,000	4.7
5	-	-	-	-	14,600	0.1	78,000	0.2	169,000	0.4
6	75,503	0.4	-	-	89,800	0.4	708,600	2.1	1,158,000	2.8
7	-	-	-	-	126,000	0.6	541,400	1.6	844,000	2.1
8	3,741,061	18.0	3,502,760	16.4	3,376,900	15.9	5,576,700	16.2	8,045,000	19.7
9	1,475,411	7.1	1,393,363	6.5	1,954,400	9.2	3,326,000	9.7	3,341,000	8.2
10	11,308,470	54.5	11,866,680	55.5	10,880,100	51.1	13,922,000	40.4	15,029,000	36.8
11	913,692	4.4	955,116	4.5	733,000	3.4	2,113,000	6.1	2,108,000	5.2
12	-	-	-	-	28,900	0.1	234,000	0.7	466,000	1.1
13	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-
TOTAL	20,753,500	100.1	21,396,690	100.1	21,296,400	100.1	34,449,000	100.1	40,857,000	100.1

Table 20 . Soybeans production (unit: 1,000 bushels)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	7,337.0	1.3	7,329.9	1.3	10,228.0	1.2	13,606.0	1.2
2	76,241.4	14.0	88,184.4	15.7	140,146.0	16.6	184,694.0	16.6
3	-	-	-	-	24,883.7	2.9	31,286.0	2.8
4	1,580.6	0.3	1,681.4	0.3	24,127.9	2.9	43,727.0	3.9
5	-	-	-	-	2,028.0	0.2	4,563.0	0.4
6	1,862.7	0.3	-	-	16,754.6	2.0	29,126.0	2.6
7	-	-	-	-	12,439.5	1.5	20,561.0	1.8
8	80,945.0	14.8	75,431.7	13.4	121,344.3	14.3	165,930.0	14.9
9	30,652.1	5.6	27,303.5	4.9	61,611.0	7.3	79,314.0	7.1
10	325,966.3	59.8	339,783.9	60.5	383,046.0	45.3	477,205.0	42.7
11	20,526.2	3.8	21,576.6	3.8	44,359.0	5.2	55,798.0	5.0
12	-	-	-	-	4,640.0	0.5	11,066.0	1.0
13	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-
TOTAL	545,110.9	99.9	561,291.4	99.9	845,608.0	99.9	1,116,876.0	100.0

Table 21. Cost advantage index and yield index, soybeans

Region No.	Solution I (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	1.4	1.3	2.0	0.65	0.93	1.3	1.3	1.9	0.68	1.00
2	14.0	14.0	15.9	0.88	1.00	15.6	15.7	17.7	0.89	1.01
3	-	-	-	-	-	-	-	-	-	-
4	0.3	0.3	0.4	0.75	1.00	0.3	0.3	0.4	0.75	1.00
5	-	-	-	-	-	-	-	-	-	-
6	0.4	0.3	0.4	0.75	0.75	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-
8	18.0	14.8	17.5	0.85	0.82	16.4	13.4	15.9	0.84	0.82
9	7.1	5.6	6.3	0.89	0.79	6.5	4.9	5.7	0.86	0.75
10	54.5	59.8	53.2	1.12	1.10	55.5	60.5	54.1	1.12	1.09
11	4.4	3.8	4.3	0.88	0.86	4.5	3.8	4.4	0.86	0.84
12	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-
Total	100.1	99.9	100.0			100.1	99.9	100.1		

Table 22. Consumption, production and transport of soybean, Solution I (unit: 1,000 bushels)

Region No.	Consumption				Production	
	Industrial use, etc.	Feeds	Total	%	Quantity	%
1	18,894		18,894	3.5	7,337	1.3
2	35,930	40,311	76,241	14.0	76,241	14.0
3	17,762		17,762	3.3	-	-
4	23,612		23,612	4.3	1,581	0.3
5	-		-	-	-	-
6	-		-	-	1,863	0.3
7	5,313		5,313	1.0	-	-
8	210,486		210,486	38.6	80,945	14.8
9	18,993		18,993	3.5	30,652	5.6
10	30,502	122,311	152,813	28.0	325,966	59.8
11	-	20,526	20,526	3.8	20,526	3.8
12	471		471	0.1	-	-
13	-		-	-	-	-
14	-		-	-	-	-
15	-		-	-	-	-
Total	361,963	183,148	545,111	100.0	545,111	99.9

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/bu.)	advantage index
6	1,863					1.58	0.65
7	9,694						
(total)	11,557	5.4					
						1.45	0.88
7	17,762	8.3				1.54	-
10	22,031	10.3				1.49	0.75
						1.43	-
			1	1,863	0.9	1.45	0.75
10	32,769	15.3	1	9,694		1.46	-
			3	17,762			
			(total)	27,456	12.8		
9	11,659					1.48	0.85
10	117,882						
(total)	129,541	60.5					
			8	11,659	5.4	1.36	0.89
			4	22,031		1.38	1.12
			7	32,769			
			8	117,882			
			12	471			
			(total)	173,153	80.9		
						1.40	0.88
10	471	0.2				1.54	-
						1.26	-
						0.73	-
						1.08	-
	214,131	100.0		214,131	100.0		

Table 23. Consumption, production and transport of soybeans, Solution II (unit: 1,000 bushels)

Region No.	Consumption				Production	
	Industrial use, etc.	Feeds	Total	%	Quantity	%
1	18,894		18,894	3.4	7,330	1.3
2	35,930	52,254	88,184	15.7	88,184	15.7
3	17,762		17,762	3.2	-	-
4	23,611		23,611	4.2	1,681	0.3
5	-		-	-	-	-
6	-		-	-	-	-
7	5,313	5,110	10,423	1.9	-	-
8	210,486		210,486	37.5	75,432	13.4
9	18,986		18,986	3.4	27,304	4.9
10	30,502	120,396	150,898	26.9	339,784	60.5
11	-	21,577	21,577	3.8	21,577	3.8
12	471		471	0.1	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	-
15	-	-	-	-	-	-
Total	361,955	199,337	561,292	100.1	561,291	99.9

Imports			Exports			Shadow price ($/bu.)	Cost advantage index
From region	Quantity	%	To region	Quantity	%		
7	11,564	5.1				1.63	0.68
						1.54	0.89
7	17,762	7.8				1.59	-
10	21,930	9.7				1.54	0.75
						1.49	-
						1.51	-
10	39,749	17.5	1	11,564		1.51	-
			3	17,762			
			(total)	29,326	12.9		
9	8,318					1.54	0.84
10	126,736						
(total)	135,054	59.6					
			8	8,318	3.7	1.44	0.86
			4	21,930		1.43	1.12
			7	39,749			
			8	126,736			
			12	471			
			(total)	188,886	83.4		
						1.50	0.86
10	471	0.2				1.60	-
						1.34	-
						1.35	-
						1.20	-
	226,530	99.9		226,530	100.0		

Tame Hay, Wild Hay, and Silage

Tame hay is either produced in the hay-silage crop rotation or as a single crop, while silage is produced in only such crop rotations as feed grain-silage or feed grain-soybean-silage. Tame hay generally consists of alfalfa, clover, timothy, etc. Since hay and silage are considered interchangeable as roughage to cattle, and the model does not permit interregional movement of hay and inter-area movement of silage, their distributions are, therefore, closely related to that of the cattle population (dairy cows, beef cows, feeder cattle) in each region, and explanations on their distributions must be sought from the relationship between the total regional production of both hay and silage and the total number of roughage-consuming cattle.

Solution I shows total hay production is nearly identical to the 1965 actual production (a difference of only 0.03%), while Solution II's output is about 5% higher (see Table 28). Hay acreage in Solutions I and II is, respectively, 15% and 10% less than the 1965 figure, implying withdrawal of production on low-yield land (see Table 27). Silage reduction in both solutions is in the magnitude of 30% from the 1965 production, while the acreage withdrawn is even greater, about 47%, implying more production on high yield land. The wild hay reduction are 30% and 15% and its acreage decline, 35% and 20%, for solution I and II, respectively. The net result of total hay and silage production is a reduction of 13.5 million tons hay equivalent in Solution I and 6.0 million tons in Solution II from the 1965 actual total production of hay and silage. Such a reduction is caused generally by a decrease in the number of dairy cows and beef cows, given higher yield in milk and beef production per head (see Sections

Dairy Cows and Beef Cows). But the differences between the two solutions is caused by the following assumptions in Solution I (which are not allowed in Solution II): (a) calves are imported from Mexico and Canada; and (b) grain-fed beef is allowed to substitute for non-grain-fed beef. These permit Solution I to satisfy demand for non-grain-fed beef with fewer calves born, fewer beef cows to maintain, practically no calf and yearling slaughters, but many more feeder cattle (see Section Beef Cows). The net result is less roughage but more concentrate feeds consumed.

According to the solutions, hay is the only crop which is produced in every region because of its demand by cows which are also produced in every region because of local demand for fluid milk which is not suitable for long distance transport. Over 10% of the nation's hogs are each produced in Northeast (Region 1), East Corn-Belt (Region 2), Minnesota-Wisconsin (Region 9), West Corn-Belt (Region 10), and Northern Plains (Region 11). Productions in the first three regions are related to their high proportions of dairy cow population, while Region 10, to the large combined population of dairy cows and beef cows, and Region 11, definitely to its beef cow and feeder cattle populations, each constituting 1/4 of the national total.

Silage distribution is similar to that of hay, except in (a) Northeast (Region 1) where hay clearly substitutes for silage to a large extent, and (b) Southern Plains (Region 12) and Southwest (Region 14) where the ratio of silage to hay is greater than in any other region (see Tables 24 and 25). Production of hay and silage is geographically widely spread, and their substitution for each other is mainly determined by their relative cost.

Table 24. Silage acreage (unit: acre)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	68,753	1.4	87,566	1.7	303,500	5.8	1,155,000	12.5	1,164,000	13.7
2	398,302	8.1	306,175	6.1	352,700	6.8	782,000	8.5	774,000	9.1
3	133,549	2.7	142,485	2.8	64,400	1.2	309,200	3.3	311,000	3.6
4	93,679	1.9	87,199	1.7	107,800	2.1	136,100	1.5	150,000	1.8
5	-	-	-	-	-	-	11,000	0.1	11,000	0.1
6	18,913	0.4	52,453	1.0	40,600	0.8	122,800	1.3	163,000	1.9
7	45,311	0.9	101,923	2.0	33,800	0.6	88,000	1.0	109,000	1.3
8	106,670	2.2	100,291	2.0	204,400	3.9	110,900	1.2	122,000	1.4
9	1,126,380	22.8	1,045,574	20.7	759,800	14.6	2,134,000	23.1	1,683,000	19.8
10	501,042	10.2	591,046	11.7	484,200	9.3	955,000	10.3	941,000	11.0
11	895,180	18.2	991,995	19.7	1,068,100	20.5	2,606,000	28.2	2,171,000	25.5
12	796,585	16.2	711,670	14.1	952,100	18.2	215,000	2.3	240,000	2.8
13	211,425	4.3	352,954	7.0	575,800	11.0	186,000	2.0	210,000	2.5
14	408,570	8.3	363,384	7.2	135,900	2.6	328,000	3.6	348,000	4.1
15	127,400	2.6	109,645	2.2	134,500	2.6	91,000	1.0	123,000	1.4
TOTAL	4,931,755	100.2	5,044,353	100.0	5,217,600	100.0	9,230,000	99.9	8,520,000	100.0

Table 25: Silage production (unit: 1,000 tons, hay equivalent)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	350.7	1.4	445.1	1.8	4,833.0	13.9	6,137.0	16.2
2	2,146.9	8.8	1,665.1	6.7	3,056.8	8.8	3,678.0	9.7
3	627.6	2.6	669.3	2.7	1,420.3	4.1	1,630.0	4.3
4	386.3	1.6	362.5	1.4	487.5	1.4	541.0	1.4
5	-	-	-	-	39.6	0.1	44.0	0.1
6	105.1	0.4	287.3	1.1	589.7	1.7	778.0	2.1
7	200.8	0.8	476.6	1.9	402.4	1.2	505.0	1.3
8	383.6	1.6	362.2	1.4	439.5	1.3	498.0	1.3
9	4,835.4	19.9	4,536.0	18.1	7,503.5	21.6	6,586.0	17.4
10	2,739.6	11.3	3,063.3	12.2	4,656.2	13.4	4,741.0	12.5
11	4,185.1	17.2	4,359.8	17.4	7,260.8	20.9	7,526.0	19.9
12	3,276.2	13.5	2,997.6	12.0	788.4	2.3	1,093.0	2.9
13	1,189.9	4.9	2,211.2	8.8	973.8	2.8	1,269.0	3.3
14	2,987.4	12.3	2,783.7	11.1	1,707.1	4.9	2,059.0	5.4
15	921.2	3.8	800.7	3.2	613.8	1.8	822.0	2.2
TOTAL	24,335.7	100.1	25,020.5	100.0	34,772.4	100.2	37,907.0	100.0

Table 26. Cost advantage index and yield index, silage

Region No.	Solution I (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	1.4	1.4	2.5	0.56	1.00	1.7	1.8	3.0	0.60	1.06
2	8.1	8.8	10.1	0.87	1.09	6.1	6.7	7.6	0.88	1.10
3	2.7	2.6	5.0	0.52	0.96	2.8	2.7	5.1	0.53	0.96
4	1.9	1.6	2.1	0.76	0.84	1.7	1.4	1.9	0.74	0.82
5	-	-	-	-	-	-	-	-	-	-
6	0.4	0.4	0.6	0.67	1.00	1.0	1.1	1.5	0.73	1.10
7	0.9	0.8	1.1	0.73	0.89	2.0	1.9	2.7	0.70	0.95
8	2.2	1.6	2.0	0.80	0.73	2.0	1.4	1.8	0.78	0.70
9	22.8	19.9	22.8	0.87	0.87	20.7	18.1	20.5	0.88	0.87
10	10.2	11.3	11.4	0.99	1.11	11.7	12.2	12.8	0.95	1.04
11	18.2	17.2	13.5	1.27	0.95	19.7	17.4	14.0	1.24	0.88
12	16.2	13.5	11.7	1.15	0.83	14.1	12.0	9.7	1.24	0.85
13	4.3	4.9	3.9	1.26	1.14	7.0	8.8	7.8	1.13	1.26
14	8.3	12.3	9.2	1.34	1.48	7.2	11.1	8.1	1.37	1.54
15	2.6	3.8	4.1	0.93	1.46	2.2	3.2	3.6	0.89	1.45
Total	100.2	100.1	100.0			99.9	100.1	100.1		

Table 27. Tame hay acreage (unit: acre)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	6,371,803	13.1	6,407,950	12.4	5,209,800	11.2	7,013,000	12.2	6,244,000	10.1
2	6,629,628	13.6	6,810,217	13.2	4,973,600	10.7	4,820,000	8.4	3,893,000	6.3
3	1,041,658	2.1	1,110,874	2.1	947,400	2.0	2,082,100	3.6	1,925,000	3.1
4	955,738	2.0	868,435	1.7	1,020,300	2.2	1,204,300	2.1	1,068,000	1.7
5	109,823	0.2	23,713	0.0	11,700	0.0	143,000	0.2	163,000	0.3
6	1,320,426	2.7	2,143,271	4.1	1,168,200	2.5	2,132,800	3.7	2,023,000	3.3
7	1,104,366	2.3	1,667,227	3.2	699,300	1.5	1,214,000	2.1	1,141,000	1.8
8	1,594,779	3.3	1,906,973	3.7	2,504,300	5.4	1,796,800	3.1	1,608,000	2.6
9	6,860,243	14.1	6,945,526	13.4	6,850,900	14.8	7,219,000	12.5	7,207,000	11.7
10	5,115,256	10.5	6,054,066	11.7	4,779,700	10.3	7,904,000	13.7	6,694,000	10.8
11	6,277,705	12.9	7,605,763	14.7	6,570,600	14.2	8,616,000	15.0	14,191,000	22.9
12	4,534,763	9.3	3,145,424	6.1	4,080,400	8.8	3,669,000	6.4	3,650,000	5.9
13	4,796,196	9.8	4,971,730	9.6	4,923,300	10.6	5,571,000	9.7	6,976,000	11.3
14	1,379,529	2.8	1,511,472	2.9	747,500	1.6	2,454,000	4.3	3,213,000	5.2
15	716,871	1.5	537,285	1.0	1,929,900	4.2	1,758,000	3.1	1,842,000	3.0
TOTAL	48,808,690	100.2	51,709,860	100.0	46,416,900	100.0	57,597,000	100.1	61,838,000	100.0

Table 28: Hay production (unit: 1,000 tons)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	12,547.0	10.8	12,592.9	10.4	11,675.0	10.1	12,778.0	10.1
2	15,792.0	13.6	16,070.3	13.3	9,360.0	8.1	8,270.0	6.5
3	1,775.2	1.5	1,891.6	1.6	2,832.2	2.4	3,045.0	2.4
4	1,968.5	1.7	1,804.4	1.5	1,909.0	1.6	1,897.0	1.5
5	282.1	0.2	70.8	0.1	231.0	0.2	302.0	0.2
6	2,428.3	2.1	4,022.6	3.3	3,352.7	2.9	3,510.0	2.8
7	2,015.9	1.7	2,976.9	2.5	1,882.0	1.6	1,962.0	1.5
8	2,461.0	2.1	3,098.2	2.6	2,857.1	2.5	2,583.0	2.0
9	19,811.4	17.1	20,078.5	16.6	16,380.0	14.1	18,888.0	14.9
10	12,723.9	11.0	14,597.2	12.0	16,969.0	14.6	16,436.0	12.9
11	17,708.1	15.3	19,618.4	16.2	16,541.0	14.3	21,466.0	16.9
12	7,499.5	6.5	5,595.4	4.6	5,912.0	5.1	6,488.0	5.1
13	11,290.0	9.7	11,870.0	9.8	11,933.0	10.3	14,054.0	11.1
14	3,993.3	3.4	4,409.4	3.6	6,692.0	5.8	7,952.0	6.3
15	3,571.4	3.1	2,453.7	2.0	7,378.0	6.4	7,496.0	5.9
TOTAL	115,867.2	99.8	121,149.8	100.1	115,904.0	100.0	127,127.0	100.1

Table 29. Cost advantage index and yield index, Tame Hay

Region No.	Solution I (1) Acreage %	Solution I (2) Yield %	Solution I (3) Cost %	Solution I (2)/(3) Cost advantage index	Solution I (2)/(1) Yield index	Solution II (1) Acreage %	Solution II (2) Yield %	Solution II (3) Cost %	Solution II (2)/(3) Cost advantage index	Solution II (2)/(1) Yield index
1	12.1	10.8	13.2	0.82	0.82	12.4	10.4	12.7	0.82	0.84
2	13.6	13.6	13.0	1.05	1.00	13.2	13.3	12.7	1.05	1.01
3	2.1	1.5	2.5	0.60	0.71	2.1	1.6	2.5	0.64	0.76
4	2.0	1.7	2.1	0.81	0.85	1.7	1.5	1.8	0.83	0.88
5	0.2	0.2	0.3	0.67	1.00	0.1	0.1	0.1	1.09	1.00
6	2.7	2.1	2.7	0.78	0.78	4.1	3.3	4.1	0.80	0.80
7	2.3	1.7	2.2	0.77	0.74	3.2	2.5	3.1	0.81	0.78
8	3.3	2.1	2.6	0.81	0.64	3.7	2.6	3.0	0.87	0.70
9	14.1	17.1	14.3	1.20	1.21	13.4	16.6	13.8	1.20	1.24
10	10.5	11.0	11.1	0.99	1.05	11.7	12.0	12.5	0.96	1.03
11	12.9	15.3	11.8	1.30	1.19	14.7	16.2	12.7	1.28	1.10
12	9.3	6.5	8.2	0.79	0.70	6.1	4.6	5.6	0.82	0.75
13	9.8	9.7	9.9	0.98	0.99	9.6	9.8	9.7	1.01	1.02
14	2.8	3.4	3.6	0.94	1.21	2.9	3.6	3.8	0.95	1.24
15	1.5	3.1	2.7	1.15	2.07	1.0	2.0	1.9	1.05	2.00
Total	100.2	99.8	100.2			99.9	100.0	100.0		

Table 30. Wild hay acreage (unit: acre)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	800	0.0	-	-	-	-
8	202,803	3.2	202,803	2.5	75,800	1.1	-	-	-	-
9	91,403	1.4	91,403	1.1	133,200	2.0	390,000	3.9	361,000	4.2
10	162,416	2.5	166,344	2.1	192,900	2.8	-	-	-	-
11	3,585,794	56.1	5,261,357	65.6	4,388,300	64.5	7,013,000	69.5	5,813,000	67.9
12	651,814	10.2	622,913	7.8	459,000	6.6	455,000	4.5	371,000	4.3
13	1,349,010	21.1	1,349,010	16.8	1,207,200	17.7	1,462,000	14.5	1,355,000	15.8
14	262,479	4.1	242,732	3.0	275,100	4.0	670,000	6.6	572,000	6.7
15	87,803	1.4	87,803	1.1	82,500	1.2	97,000	1.0	92,000	1.1
TOTAL	6,393,518	100.0	8,024,361	100.0	6,805,800	99.9	10,087,000	100.0	8,564,000	100.0

Table 31. Wild hay production (unit: 1,000 tons)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	325.2	4.9	325.2	3.9	-	-	-	-
9	130.3	2.0	130.3	1.6	488.0	5.1	487.0	5.8
10	295.3	4.4	301.3	3.6	-	-	-	-
11	2,941.7	44.1	4,602.5	55.6	6,170.0	64.1	5,093.0	61.0
12	953.0	14.3	911.9	11.0	569.0	5.9	464.0	5.6
13	1,594.0	23.9	1,594.0	19.3	1,537.0	16.0	1,498.0	17.9
14	329.7	4.9	305.2	3.7	722.0	7.5	676.0	8.1
15	108.5	1.6	108.5	1.3	146.0	1.5	138.0	1.7
TOTAL	6,677.7	100.1	8,279.0	100.0	9,632.0	100.1	8,356.0	100.1

Table 32. Cost advantage index and yield index, wild hay

Region No.	Solution I (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-
8	3.2	4.9	5.1	0.96	1.53	2.5	3.9	4.1	0.95	1.56
9	1.4	2.0	1.9	1.05	1.43	1.1	1.6	1.6	1.0	1.45
10	2.5	4.4	5.1	0.86	1.76	2.1	3.6	4.3	0.83	1.71
11	56.1	44.1	38.6	1.14	0.79	65.6	55.6	51.4	1.08	0.85
12	10.2	14.3	15.7	0.91	1.40	7.8	11.0	11.9	0.92	1.41
13	21.1	23.9	26.0	0.92	1.13	16.8	19.3	21.0	0.92	1.15
14	4.1	4.9	5.8	0.84	1.20	3.0	3.7	4.3	0.86	1.23
15	1.4	1.6	1.8	0.89	1.14	1.1	1.3	1.5	0.87	1.18
Total	100.0	100.1	100.0			100.0	100.0	100.1		

Wild hay is the only crop which the solutions recommed more widely spread cutting, but less acreage, than the 1965 actual acreage showed, because the availability of wild hay land is based on the historic data of the 50's, which were obviously more widely spread than the 1965 actual acreage (see Table 30 and 31). And the low cost per ton of hay harvested justifies such a phenomenon. For instance, in western Arkansas-Louisiana (Area 123, Region 8) the production cost of wild hay is $1.04 per ton, while that of tame hay is $1.69 per ton and that of hay from the hay-silage crop rotation is $1.65 per ton. Therefore, wild hay land is used up in Area 123 while some crop-hay land is still idle.

Preclusion of interregional movement of hay has weakened, though not eliminated, the forces of comparative advantages shaping the pattern of production of hay, and hence, that of cattle, for production cost of roughage also affects the distribution of cattle. Relaxation of the restraint on interregional movements of hay would most probably alter the cattle production and shipping patterns and further reduce the total cost in the objective function.

Livestock

Livestock products constitute the most important sector of the agricultural economy and its importance is rising as per caput income increases because of their relatively high income elasticity of demand. Livestock production is more like a manufacturing activity than a resource activity, as the animal is a biological machine that converts feeds into marketable animal products. Therefore, the location of livestock production activity is determined, as an industry plant, by the access to raw materials (feeds) and the access to market (proximity to consumption centers). Access to high-quality land resources is not as an important locational determinant as in the case of field crop production. The present model assumes availability of slaughtering and packing facilities at the source of livestock production. Capital is also assumed to be not a constraint on the expansion of any livestock (or crop) activity. Both assumptions were made for the sake of simplifying the model.

The location of a livestock activity depends on the relative costs of assembling inputs and marketing outputs, with the former dominating in the cases of pork and beef production and the latter, in the case of fluid milk production. Feeds are by far the major input cost item and therefore livestock production is strongly input-source oriented. But if the final product is mainly for direct human consumption, for instance, fluid milk, then the activity becomes strongly market-oriented. The location as indicated by an optimization model should, therefore, represent an equilibrium among such opposing forces as the tendency towards feed source and the inclination towards consumption center. A greater production cost advantage permits products to overcome transporation cost to compete in a farther market, while a high transportation cost has the effect of reducing the size of the market sphere of a product.

Dairy Cows

Both solutions indicate a smaller herd of dairy cows than the actual 1965 figure (about 1 million head or 7% less), to produce 16 billion pounds, or 12%, more milk. This obviously results from selecting higher yield and more efficient cows for milk production. The distributions in both solutions are quite similar, but differ from the actual 1965 productions in certain important milk-consuming regions, such as Northeast (Region 1) and East Corn-Belt (Region 2). Explanations sought from cost advantage indices and transportation cost are inadequate because of the additional complexity introduced into the livestock activities by the input of feeds, an intermediate good, whose production cost is charged to the crop activities and is not included in the livestock cost coefficient. The shadow price of a livestock product includes also the new component -- the cost of feeds, and is a better indicator of a region's comparative advantage than the cost advantage index.[1]

The shadow prices of milk are fairly consistent with the production shifts of milk in the solution (see Tables 35, 36, 38 and 39). East Corn-Bet (Region 2) doubles its share because its shadow price is the second lowest among all the regions (next to Minnesota-Wisconsin, Region 9) and it has the locational advantage of being close to the major consumption center in Northeast (Region 1). The increased production of fluid milk beyond Region 2's own consumption demand is coverted into manufactured milk which is more suitable for transportation and is exported to the neighboring regions (Northeast, Mid-Atlantic, Southeast Atlantic, and Tennessee Valley) after meeting the local demand.

Since fluid milk is an output mainly for final demand and unsuitable for long-distance transport, the location of its production is strongly oriented towards market access. Therefore, there are very little inter-

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[1]Cost coefficient is a much more important component in the shadow price of crops, than in the shadow price of livestock products. All the cost advantage indices for livestock activities in this study refer to the part of cost of "managing" the livestock, to the exclusion of the cost of "feeding" them.

regional movement of fluid milk in the solution.

Region 9 (Minnesota-Wisconsin) and Region 2 (East Corn-Belt) are by far the two most important ones of the country, with the former converting 90% of its fluid milk into manufactured milk products to satisfy half of the national needs, and the latter converting about 2/3 of its fluid milk, to meet about 30% of the national needs. These two regions have the two lowest shadow prices of milk in the country.

Between these two important regions, Region 2 (East Corn-Belt) has a stronger cost advantage (indices: 1.09, 1.10) than that of Region 9 (Minnesota-Wisconsin) (indices: 1.00, 1.02) (see Table 37). But Region 9 more than makes up its relative weakness by having a greater cost advantage in feed grain production (1.04 and 1.04 vs. 0.91 and 0.91 for Region 2) and also in hay production (1.20 and 1.20 vs. 1.05 and 1.05 for Region 2), thus resulting in having a lower shadow price of milk than Region 2 ($227.40 and $228.70 vs. $233.50 and $234.80) (see Table 16 and 29).

Region 7 (Tennessee Valley) has not only a cost advantage (indices: 0.95, 0.94) in milk production over Region 4 (Southeast Atlantic) (indices: 0.73, 0.75) and Region 5 (Florida) (indices: 0.63, 0.56), but also a lower shadow price of feed grains ($0.74 and $0.76 vs. $0.79 and $0.81 for Region 4; $0.83 and $0.85 for Region 5), and therefore, exports to Regions 4 and 5.[1] These three regions import feed grains from West Corn-Belt (Region 10), but Region 7 clearly has the locational advantage over the other two. The slight cost advantage in hay production Region 4

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[1]Shadow prices, instead of cost advantage indices, of feed grains are used because Regions 5 and 7 do not produce feed grains and, therefore, have no cost advantage indices.

(indices: 0.81, 0.83) has over Region 7 (indices: 0.77, 0.81) evidently is not great enough to compensate for the disadvantages in the other two cost items (production cost of milk and feed grains).

California (Region 15) has the greatest cost advantage (index 1.21) in Solution I. It also has the highest shadow price ($37.99) which is the cost of importing fluid milk from Northwest (Region 13) (Region 13's shadow price $25.02 + transportation cost $12.97), as the crop-reason labor constraints in all of its four producing areas are binding.

Shadow price and activity equilibrium

An example in Solution I further illustrates the composition of a shadow price. The shadow price of fluid milk in Region 6 (Kentucky) is $24.0549/1,000 lbs., decomposition of which can be made from either the input side or the output side. On the input side, there are (a) the production cost of $102.76 per head of dairy cow in Area 22, which happens to be the sole area producing milk in Region 6, and (b) the costs of feeds which are $13.6031 per 1,000 lbs. of TDN, $4.3744 per CWT of protein, and $16.4621 per ton of roughage, all being shadow prices computed in the solution. The total cost of feeds required by a head of dairy cow is thus ($13.6031 x 2.484) + ($4.3744 x 4.88) + ($16.4621 x 3.7) = $116.046942. The total cost of maintaining a diary cow is ($102.76 + $116.0469424) = $218.8069424. The milk yield of a dairy cow in Area 22 is 7,016 lbs. This results in a cost of ($218.8069424 ÷ 7.016) = $31.1868503 per 1000 lbs. if milk were the only output of a dairy cow activity. But, since a dairy cow produces also calves and (non-grain-fed) beef, apportioning the total cost among the three products is necessary.

Based on the shadow prices, the total value of the outputs of a diary cow is (milk: $24.0549 x 7.016) + (beef: $25.3405 x 0.88) + (calf: $71.1236 x 0.39) = $218.8070224. which is nearly identical to the total input cost (the difference in the third place after the decimal point is due to rounding error). Since the value of milk is 77.131519% of the total output value: proportioning the total input cost accordingly result in a shadow price of milk being ($218.8069424 x 0.77131519 =) $24.054891364, the amount given in the solution. Using the shadow prices to apportion the total cost in order to obtain a shadow price for each of the outputs seems to be circular. However, it may be stated that a shadow price represents a state of equilibrium in which all relationships are determined with respect to one another. Therefore, the shadow price is also rightly called the equilibrium price. Since Region 6 does not import milk, the shadow price does not include any transportation cost. Whatever transportation cost and opportunity cost for concentrate feeds (Region 6 imports feed grains from Region 10) that may have occurred is already taken into account in the shadow prices of TDN and protein as inputs.

Another example from Solution I showing the equilibrium condition of the dairy cow activity in Area 132 of Region 7 (Tennessee Valley) is given here to shed some light into the structure of the equilibrium condition as well as the composition of the shadow price of milk (or other outputs of the dairy activity.)

Table 33 shows (a) on the input side, the cost coefficient, the opportunity costs (shadow prices) of the various inputs (whenever such opportunity costs exist), the quantities of inputs, the input costs,

Table 33. Input costs and output value of dairy cow activity, Area 132, Region 7, Solution I (unit: $10)

Inputs	Price or shadow price	Quantity	Unit	Cost
Cost	10.59000	1.000	head	10.59000000
TDN	1.33499	2.388	1,000 lbs.	3.18795612
Protein	0.43419	4.700	CWT	2.04069300
Roughage	1.46646	3.420	Ton	5.01529320
Pasture	-	6.850	AUM	-
Labor, crop-season	0.08616	7.193	10 hrs.	0.61974888
Labor, non-crop-season	-	2.726	10 hrs.	-
Total input cost				21.45369211
Outputs				Value
Milk	2.53312	6.509	1,000 lbs.	16.48807808
Beef	2.54305	0.890	CWT	2.26331450
Calf	7.11136	0.380	head	2.70231680
Total output value				21.45370938

and the total cost; and (b) on the output side, the shadow prices and quantities of outputs, the output values, and the total output value.

On the input side, one of the two "free" inputs, crop-season labor, is constrained, and therefore, has a shadow price, while the other free input, non-crop-season labor, is not exhausted and, therefore, without a shadow price. On the output side, all the three outputs are demand constraints and, therefore, have their shadow prices. The total input cost is idential, or nearly so, to the total output value, implying an equilibrium condition and also a condition of perfect competition with the shadow prices being the equilibrium prices, under which no profit exists for the activity. (see section shadow price, Chapter III.)

The difference between the shadow price of an output of an activity and the cost of the output (as represented by the cost coefficient of the activity) is magnified here in the table under a thorough scrutiny. First, only a portion of the cost coefficient should be assigned to milk because of the existence of other outputs (beef and calf). Secondly, a free input (labor) carries a shadow price when the constraint is binding. Thirdly, other inputs (feeds), which are explicitly excluded from the cost coefficient, always carry their opportunity costs (shadow prices).

The shadow prices of the various output items could be computed from the input side by proportioning the total cost according to the proportions of the values of the output items if such proportions were known, which, of course, again are determined by shadow prices of these output items. This implies that one shadow price can be determined independently of the others.

Another example showing a diary activity (Area 138 of Region 7)

Table 34. Input costs and output value of dairy cow activity, Area 138, Region 7, Solution I (unit: $10)

Inputs	Price or shadow price	Quantity	Unit	Cost
Cost	10.41000	1.000	head	10.41000000
TDN	1.33499	2.481	1,000 lbs.	3.31211019
Protein	0.43419	4.860	CWT	2.11016340
Roughage	1.85046	4.120	Ton	7.62389520
Pasture	-	6.120	AUM	-
Labor, crop-season	-	7.246	10 hrs.	-
Labor, non-crop-season	-	3.107	10 hrs.	-
Total input cost				23.45616879
Outputs				Value
Milk	2.53312	7.185	1,000 lbs.	18.20046720
Beef	2.54305	1.060	CWT	2.69563300
Calf	7,11136	0.360	head	2.56008960
Total output value				23.45618980

Table 35. Dairy cows production (unit: head)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	2,214,729	13.6	2,214,687	13.5	2,080,600	13.8	3,191,000	18.2	2,739,000	19.4
2	3,191,847	19.7	3,226,382	19.7	2,305,500	15.3	1,728,000	9.8	1,286,000	9.1
3	341,728	2.1	341,728	2.1	298,400	2.0	662,700	3.8	504,000	3.6
4	273,021	1.7	288,593	1.8	446,500	3.0	473,800	2.7	353,000	2.5
5	138,413	0.8	138,413	0.8	666,300	4.4	184,000	1.0	194,000	1.4
6	374,043	2.3	174,456	1.1	324,400	2.2	687,200	3.9	519,000	3.7
7	364,410	2.2	351,046	2.1	206,400	1.4	399,700	2.3	301,000	2.1
8	326,834	2.0	403,467	2.5	282,200	1.9	728,600	4.1	535,000	3.8
9	4,118,895	25.4	3,856,200	23.6	3,799,700	25.2	3,785,000	21.5	3,240,000	22.7
10	1,551,051	9.6	1,802,660	11.0	1,367,400	9.1	1,960,000	11.2	1,380,000	9.8
11	649,032	4.0	879,242	5.4	742,000	4.9	1,134,000	6.5	834,000	5.9
12	785,232	4.8	946,955	5.8	580,600	3.9	735,000	4.2	540,000	3.8
13	962,847	5.9	1,024,508	6.3	625,600	4.2	705,000	4.0	561,000	4.0
14	251,446	1.6	326,341	2.0	160,000	1.1	333,000	1.9	301,000	2.1
15	677,316	4.2	375,203	2.3	1,186,300	7.9	867,000	4.9	848,000	6.0
TOTAL	16,220,844	99.9	16,349,881	100.0	15,071,900	100.3	17,574,000	100.0	14,135,000	100.1

Table 36. Milk production (unit: million pounds)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	20,144.9	14.2	20,144.9	14.2	25,662.0	20.5	24,100.0	20.8
2	31,094.1	21.9	31,394.7	22.1	14,063.0	11.3	11,467.0	9.9
3	2,661.1	1.9	2,661.1	1.9	3,768.0	3.0	3,500.0	3.0
4	1,600.8	1.1	1,689.3	1.2	2,228.0	1.8	2,240.0	1.9
5	736.4	0.5	736.6	0.5	1,388.0	1.1	1,559.0	1.3
6	2,624.3	1.9	1,239.9	0.9	3,349.0	2.7	3,153.0	2.7
7	2,561.0	1.8	2,472.0	1.7	1,968.0	1.6	1,862.0	1.6
8	1,978.3	1.4	2,461.3	1.7	2,925.0	2.3	2,803.0	2.4
9	38,647.4	27.3	36,163.8	25.5	29,622.0	23.7	27,745.0	23.9
10	13,041.8	9.2	15,121.3	10.7	12,994.0	10.4	10,884.0	9.4
11	4,503.3	3.2	6,089.3	4.3	6,554.0	5.2	5,982.0	5.2
12	5,619.3	4.0	6,521.4	4.6	4,346.0	3.5	4,357.0	3.7
13	8,435.8	5.9	8,941.4	6.3	5,015.0	4.0	4,884.0	4.2
14	2,302.8	1.6	2,919.7	2.1	2,518.0	2.0	2,673.0	2.3
15	5,841.8	4.1	3,236.1	2.3	8,488.0	6.8	8,940.0	7.7
Total	141,792.2	100.0	141,792.2	101.0	124,888.0	99.9	116,049.0	100.0

Table 37. Cost advantage index and yield index, milk

Region No.	Solution I (1) Dairy cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Dairy cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	13.6	14.2	15.4	.92	1.04	13.5	14.2	15.4	.92	1.05
2	19.7	21.9	20.1	1.09	1.11	19.7	22.1	20.1	1.10	1.12
3	2.1	1.9	1.8	1.06	.90	2.1	1.9	1.9	1.00	.90
4	1.7	1.1	1.5	.73	.65	1.8	1.2	1.6	.75	.67
5	0.8	0.5	0.8	.63	.63	0.8	0.5	0.9	.56	.63
6	2.3	1.9	1.9	1.00	.83	1.1	0.9	1.0	.90	.82
7	2.2	1.8	1.9	.95	.82	2.1	1.7	1.8	.94	.81
8	2.0	1.4	1.6	.88	.70	2.5	1.7	1.9	.89	.68
9	25.4	27.3	27.2	1.00	1.07	23.6	25.5	24.9	1.02	1.08
10	9.6	9.2	9.5	.97	.96	11.0	10.7	10.6	1.01	.97
11	4.0	3.2	4.0	.80	.80	5.4	4.3	5.4	.80	.80
12	4.8	4.0	4.0	1.00	.83	5.8	4.6	4.9	.94	.79
13	5.9	5.9	5.4	1.09	1.00	6.3	6.3	5.6	1.13	1.00
14	1.6	1.6	1.4	1.14	1.00	2.0	2.1	1.8	1.17	1.05
15	4.2	4.1	3.4	1.21	.98	2.3	2.3	2.3	1.00	1.00
Total	99.9	100.0	99.9			100.0	100.0	100.1		

Table 38. Consumption, production and transport of fluid milk, Solution I (unit: million pounds)

Region No.	Consumption				Production	
	Quantity	As mfd. milk	Total	%	Quantity	%
1	20,145	-	20,145	14.2	20,145	14.2
2	11,366	19,728	31,094	21.9	31,094	21.9
3	2,661	-	2,661	1.9	2,661	1.9
4	2,455	-	2,455	1.7	1,601	1.1
5	1,483	-	1,483	1.0	736	0.5
6	1,240	1,384	2,624	1.9	2,624	1.9
7	960	-	960	0.7	2,561	1.8
8	1,978	-	1,978	1.4	1,978	1.4
9	3,733	34,914	38,647	27.3	38,647	27.3
10	8,671	4,371	13,042	9.2	13,042	9.2
11	2,445	2,058	4,503	3.2	4,503	3.2
12	3,336	2,283	5,619	4.0	5,619	4.0
13	3,460	3,401	6,861	4.8	8,436	5.9
14	1,619	684	2,303	1.6	2,303	1.6
15	7,417	-	7,417	5.2	5,842	4.1
Total	72,969	68,823	141,792	100.0	141,792	100.0

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/1,000 lbs)	advantage index
						28.47	0.92
						23.35	1.09
						26.49	1.06
7	854	26.9				27.09	0.73
7	747	23.5				33.46	0.63
						24.05	1.00
			4	854		25.33	0.95
			5	747			
			(total)	1,601	50.4		
						25.07	0.88
						22.74	1.00
						23.78	0.97
						23.43	0.80
						24.60	1.00
			15	1,575	49.6	25.02	1.09
						24.63	1.14
13	1,575	49.6				37.99	1.21
	3,176	100.0		3,176	100.0		

Table 39. Consumption, production, and transport of fluid milk, Solution II (unit: Million pounds)

Region No.	Consumption				Production	
	Quantity	As mfd. milk	Total	%	Quantity	%
1	20,145	-	20,145	14.2	20,145	14.2
2	11,366	20,029	31,395	22.1	31,395	22.1
3	2,661	-	2,661	1.9	2,661	1.9
4	2,455	-	2,455	1.7	1,690	1.2
5	1,483	-	1,483	1.0	736	0.5
6	1,240	-	1,240	0.9	1,240	0.9
7	960	-	960	0.7	2,472	1.7
8	1,978	483	2,461	1.7	2,461	1.7
9	3,733	32,431	36,164	25.5	36,164	25.5
10	8,671	6,450	15,121	10.7	15,121	10.7
11	2,445	3,644	6,089	4.3	6,089	4.3
12	3,336	3,185	6,521	4.6	6,521	4.6
13	3,460	1,300	4,760	3.4	8,941	6.3
14	1,619	1,301	2,920	2.1	2,920	2.1
15	7,417	-	7,417	5.2	3,236	2.3
Total	72,969	68,823	141,792	100.0	141,792	101.0

Imports			Exports			Shadow price ($/1,000 lbs)	Cost advantage index
From region	Quantity	%	To region	Quantity	%		
						28.68	0.92
						23.48	1.10
						26.46	1.00
7	765	13.4				27.56	0.75
7	747	13.1				33.93	0.56
						24.55	0.90
			4	765		25.80	0.94
			5	747			
			(total)	1,512	26.6		
						24.84	0.89
						22.87	1.02
						23.91	1.01
						23.16	0.80
						24.71	0.94
			15	4,181	73.4	25.82	1.13
						24.49	1.17
13	4,181	73.4				38.79	1.00
	5,693	99.9		5,693	100.0		

Table 40. Consumption, production and transport of manufactured milk, Solution I (unit: million pounds, fluid milk equivalent)

Region No.	Consumption		Production	
	Quantity	%	Quantity	%
1	18,702	27.2	-	-
2	9,567	13.9	19,728	28.7
3	2,999	4.4	-	-
4	2,740	4.0	-	-
5	1,656	2.4	-	-
6	1,384	2.0	1,384	2.0
7	1,074	1.6	-	-
8	2,208	3.2	-	-
9	3,143	4.6	34,914	50.7
10	7,298	10.6	4,371	6.4
11	2,058	3.0	2,058	3.0
12	3,725	5.4	2,283	3.3
13	3,401	4.9	3,401	4.9
14	1,589	2.3	684	1.0
15	7,279	10.6	-	-
Total	68,823	100.1	68,823	100.0

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/1,000 lbs)	advantage index
2	3,348					25.11	0.92
9	15,354						
(total)	18,702	44.6					
			1	3,348		23.35	1.09
			3	2,999			
			4	2,740			
			7	1,074			
			(total)	10,161	24.2		
2	2,999	7.2				24.75	1.06
2	2,740	6.5				24.64	0.73
9	1,656	3.9				25.26	0.63
						24.05	1.00
2	1,074	2.6				24.39	0.95
9	2,208	5.3				24.71	0.88
			1	15,354		22.74	1.00
			5	1,656			
			8	2,208			
			10	2,927			
			12	1,442			
			14	905			
			15	7,279			
			(total)	31,771	75.8		
9	2,927	7.0				23.78	0.97
						23.43	0.80
9	1,442	3.4				24.60	1.00
						25.02	1.09
9	905	2.2				24.63	1.14
9	7,279	17.4				25.95	1.21
	41,932	100.1		41,932	100.0		

Table 41. Consumption, production and transport of manufactured milk, Solution II (unit: million pounds, fluid milk equivalent)

Region No.	Consumption Quantity	Consumption %	Production Quantity	Production %
1	18,702	27.2	-	-
2	9,567	13.9	20.029	29.1
3	2,999	4.4	-	-
4	2,740	4.0	-	-
5	1,656	2.4	-	-
6	1,384	2.0	-	-
7	1,074	1.6	-	-
8	2,208	3.2	483	0.7
9	3,144	4.6	32,431	47.1
10	7,298	10.6	6,450	9.4
11	2,058	3.0	3,644	5.3
12	3,725	5.4	3,185	4.6
13	3,400	4.9	1,300	1.9
14	1,589	2.3	1,301	1.9
15	7,279	10.6	-	-
Total	68,823	100.1	68,823	100.0

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/1,000 lbs)	advantage index
2	2,265					25.24	0.92
9	16,437						
(total)	18,702	45.2					
			1	2,265		23.48	1.10
			3	2,999			
			4	2,740			
			6	1,384			
			7	1,074			
			(total)	10,462	25.3		
2	2,999	7.3				24.88	1.00
2	2,740	6.6				24.77	0.75
9	1,656	4.0				25.39	0.56
2	1,384	3.3				24.23	0.90
2	1,074	2.6				24.52	0.94
9	1,725	4.2				24.84	0.89
			1	16,437		22.87	1.02
			5	1,656			
			8	1,725			
			10	848			
			13	2,100			
			15	6,521			
			(total)	29,287	70.9		
9	848	2.1				23.91	1.01
			12	540		23.16	0.80
			14	288			
			15	758			
			(total)	1,586	3.8		
11	540	1.3				24.71	0.94
9	2,100	5.1				25.82	1.13
11	288	0.7				24.49	1.17
9	6,521					26.08	1.00
11	758						
(total)	7,279	17.6					
	41,335	100.0		41,335	100.0		

without binding factor constraints is given in Table 34. It is generally true that when a factor constraint in an activity (of a lower production cost) becomes binding, then the next higher-cost activity goes into the solution. Since both activities must attain equilibrium (i.e. input cost equals output value) and the same set of output shadow prices and feed shadow prices governs both activities, the opportunity cost of the binding factor constraint in the first activity may be viewed as a "stop-gap" or a residual price in its equilibrium condition.

In a crop activity, the shadow price may equal, or nearly so, the cost coefficient if the input constraints are not binding and there were no byproducts.

It is interesting to note that a set of shadow prices at both regional and area levels (roughage is an area constraint; the rest are regional constraints) should be consistent with the equilibrium condition of several activities in different areas and that the same set of opportunity costs of free inputs (e.g. labor) is applicable to all activities of an area, be it wheat, feed grains, dairy cows, or hogs, etc.

Beef Cows, Calves, and Feeder Cattle

All livestock are assumed to be slaughtered and packed within the region where they are raised, implying the existence of adequate slaughtering and packing facilities in every region. Such an assumption is necessary in order to keep the model within manageable size. Calves are, however, allowed to be transported on hoof between regions for fattening and, then packed beef is allowed to move from surplus regions to deficit regions.

Beef calves consist of calves born of dairy cows and calves born of beef cows. Calves may be slaughtered or raised to yearlings for slaughter to satisfy the demand for non-grain-fed beef, or raised as feeder cattle to satisfy the demand for grain-fed beef (see Tables 46, 47, 51, and 52).

Solution I allows substitution of grain-fed beef for non-grain-fed beef to satisfy the demand for the latter, while solution II does not. Such a distinction in the assumptions results in a significant difference in the total numbers of beef cows, calves and feeder cattle produced and also their distributions. Solution I produces 4 million head, or over 20%, more feeder cattle than Solution II, and it also permits imports of 766,620 head of calves from Mexico and Canada. Yet Solution II produces 3 million more calves than Solution I, bringing up the total numbers of head of calves and yearlings slaughtered for non-grain-fed beef to 7 million. In Solution I, nearly all calves born, about 23 million head, are raised to be feeder cattle to satisfy, in addition to meeting all the demand for grain-fed beef, about 40%, or 29 million CWT, of the demand for non-grain-fed beef. Compared with solution I, Solution II produces 4.5 million head, or 16%, more beef cows which produce 3 million extra calves.

The model shows that it is economical to raise calves into feeder cattle to meet whatever remaining demand there is for non-grain-fed beef after culled dairy cows and beef cows are consumed.

Even land rent and wage were taken into account in the model, the results would still favor substitution of grain-fed beef for non-grain-fed beef, considering the total man hours (about 87 million hours) needed to keep 4.5 million beef cows and 3 million yearlings in Solution II against the total man hours (about 56 million hours) required to raise 4 million calves to feeder cattle in Solution I. As to land use, Solution II uses approximately 7 million acres more than Solution I, to produce feeds and forage. Solution I produces and converts more wheat and feed grains (though less soybeans) for feeder cattle use while Solution II uses more silage, hay and pasture to support the extra number of beef cows and yearling. Since levels of other livestock activities are very similar, if not identical, in the two solutions, the difference in acreage in feeds can be attributed to the differences in beef cows, calves, and feeder cattle.

The number of calves born of dairy cows is more or less predetermined by the number of dairy cows which in term are more or less fixed by the predetermined demand for milk, and, therefore, is very close in the two solutions. Beef cows supply 3/4 (Solution I) or more (Solution II) of the total calves, whose number, as pointed out above, is determined by ways how the grain-fed beef demand and the non-grain-fed demand are met.

The shipping pattern of calves among regions is indicated by their shadow prices. All importing regions have a shadow price of $69 or over, and all exporting regions, $67 or less. As pointed out previously, the transportation cost between an exporting region and an importing region makes up the shadow price differential between the two regions. The cost advantage index of calves is constructed out of the cost (without feed cost) of maintaining dairy cows and beef cows in a region, and therefore, is influenced by the composition of cows. Regions comprising only dairy cows have very small cost advantage index, because (a) the higher cost of maintaining a diary cow than a beef cow, and (b) a smaller proportion of calves born of dairy cows, that is available for raising into yearlings or feeder cattle owing to the higher culling rate of dairy cows than beef cows. The cost differentials and the calf yield differentials between dairy cows and beef cows thus magnifies the difference in cost advantage index and creates a greater variance of the indices.

The solutions indicate noticeable upward shifts of the regional shares of beef cows in Regions 11 (Northern Plains) and 12 (Southern Plains), obviously owing to lower production costs (indices: 1.08, 1.10 for Region 11; 1.11, 1.02 for Region 12), and also lower feed costs (see Table 43). Region 11 has very low cost in the production of hay (indices: 1.30, 1.28), silage (indices: 1.27, 1.24), and wild hay (indices: 1.14, 1.08), and fairyly low cost in the production of feed grains (indices: 0.98, 0.97) (see Tables 16, 26, 29 and 32). Region 12 has very low cost in the production of silage (indices: 1.15, 1.24), which apparently more than offsets the rather high cost in hay production (indices: 0.79, 0.82). Its wild hay cost is moderate (indices: 0.91, 0.92) and its feed grains cost is on the low side (indices: 0.93, 0.95).

In Solution I, both Regions 11 (Northern Plains) and 12 (Southern Plains) raise all their calves into feeder cattle, and the total number of calves transported among all regions (2.6 million head) is much smaller than that in Solution II (6.9 million head). Apparently, the cost coefficients of medium-size herds used in Solution II partly encourages calf movements among regions by raising the cost advantage of raising feeder cattle in Regions 6 (Kentucky), 7 (Tennessee Valley), and 8 (Delta) (see Table 50). These three regions import a total of 5.2 million head of calves (4 million head from Region 12 alone) and "consume" 25% of the national total calves (mostly in the form of raising them into fed cattle; some into yearlings for slaughter). Their proximity to major consumption centers (Northeast, Mid-Atlantic) also partly accounts for their heavy imports of calves and exports of grain-fed beef (40% of the national trade) (see the section on beef).

On the other hand, Solution I, using the average cost coefficients of herds of all sizes, assigns cost advantages to regions with large herd sizes such as Regions 12, 13 (Northeast), and 14 (Southwest). This causes Region 12 and 13 to retain all the calves they produce, and the raise them into feeder cattle in Solution I.

Solution II's greater calf movements among regions is also partly attributed to the assumption of non-substitutability of grain-fed beef for non-grain-fed beef, which makes raising calves into yearlings for slaughter a logical means of satisfying the demand for non-grain-fed beef and thus encourages calf movement to take advantage of whatever cost differentials there are between regions in the conversion of calves into yearlings. Such a motivation does not exist in Solution I. Table 43 show the western and southwestern regions have cost advantages in the production of calves from beef cows. But no such clear geographic pattern exists in the case of calf production by diary cows (see Table 44).

Apparently calving is not much directly related to the cost of keeping dairy cows. Lower yield dairy cows is normally associated with lower cost of keeping them which would be necessary in order to justify their up-keeping at all. The culling rate in these regions is also generally lower. This makes the low-yield and low-cost regions' cost advantage indices of producing calves from dairy cows very attractive, such as in Regions 6, 7, and 8.

The major dairy regions such as Region 1 (Northeast) and 9 (Minnesota-Wisconsin) export surplus dairy calves to other regions for fattening. Regions 8 (Delta) and 5 (Florida) are the two important exporters of calves in national trade to Regions 4 (Southeast Atlantic), 6 (Kentucky) and 7 (Tennessee Valley). These calf movements can be explained partly by cost advantages in feeder cattle fattening and partly by the locational advantages of the importing regions being near the Northeast consumption centers (Regions 1, 2, and 3). Region 4, however, imports calves for its own use to attain self-sufficiency in grain-fed beef. Location-wise, Regions 5 (Florida) and 8 (Delta), compared with Regions 6 and 7, are far on the periphery of the Northeast consumption centers. This is clearly an example of the pattern of flow of raw material (calves) from the periphery of a consumption center to the processing plant (feeder cattle fattening) in the middle ground and then finally to the consumption center in the form of finished product (grain-fed beef).

Grain-fed beef and non-grain-fed beef

The distributions of calves and feeder cattle are mutually related. Regions with strong cost advantages in raising feeder cattle, or in feeds and forage production, or in locational advantage (proximity to a major consumption center), or in a combination of the above will bid away calves from regions with weaker advantages, and produce grain-fed beef for either local consumption or for export to deficit regions.

In the national picture, the grain-fed beef importing regions all lie on the periphery of the continent: the Northeast consumption centers

(Region 1, 2, 3), the southeast corner (Region 5, Florida), and the west coast consumption center (Region 15, California), with the northeast three regions importing about 2/3 of grain-fed beef, California, nearly 1/3, and Florida, about 3%.

In Solution I, the major exporting regions are Northern Plains (Region 11), Southern Plains (Region 12) Northwest (Region 13), and Southwest (Region 14), which together account for 95% of the national total trade in grain-fed beef. They supply to all importing regions, with Region 14 exporting across the continent to as far as Region 1. The strength in these four regions lies in their cost advantages both in raising feeder cattle and in growing hay and/or silage, rather than in locational advantage with respect to the northeast and southeast corners. Region 11 is somewhat weaker in the cost advantage of raising feeder cattle, but compensates it with a very strong cost advantage in hay and silage production. Regions 6, and 7 and Region 10 (West Corn-Belt) supply to the remaining 5% market.

As discussed above Regions 6 and 7 export grain-fed beef mainly because of their cost advantage in raising feeder cattle and their locational advantage of being near major consumption centers. Region 10, a major grain-fed beef exporter in reality, specializes in the productions of feed grains, soybeans, and hogs to such an extent that at least one of the factor constraints is binding in any of the nine areas in the region. For instances, in Solution I, land constraints are binding in Areas 26 (southeast Missouri), 36 (southwest Illinois-eastern Missouri), 45 (northern and central Illinois), 47 (southern Illinois), 50 (southwestern Missouri), 51 (northern Missouri), 52 (southwest half or Iowa), and 53 (northeast half of Iowa); crop-season labor constraints are binding in Areas 26, 45, and 46 (south Missouri); non-crop-season labor constraints are binding in Areas 36, 47, 50, and 51; and pasture constraints are binding in Areas 36, 50, 52, and 53. All these binding constraints constrict expansion of activities that are in the solution and exert pressure in the form of high opportunity cost against all activities not in the solution. The grain-fed beef activities in Areas 36, 45, and 50 are constrained by exhaustions of crop-season labor (Area 45), non-crop-season labor (Areas 36 and 50), and pasture (Areas 36 and 50). Binding constraints of land are less severe on grain-fed beef activities because Region 10 exports feed-grains, part of which could be diverted for domestic use.[1] Obviously, expansion of grain-fed beef activities can be made only at the expense of other activities already in the solution. Here, the principle of comparative advantage dictates that Region 10 should concentrate more on feed grain, soybean and hog productions at the expense of grain-fed beef production.

If the factor constraints were not binding, Region 10's grain-fed beef activities would be at a higher level. Here is a case that absolute advantage cannot work to the limit of demand because of some factor constraints.

In Solution II the variance of the cost advantage indices of grain-fed beef production (minus feeds) is smaller than that in Solution I because of the more uniform cost coefficients of medium-size herds used in Solution II. Therefore, regions with cost advantages due to the economy

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[1]This will most probably change the solution.

of scale in Solution I diminish in importance in Solution II in both the shares of production and the shares of exports to other regions. The total share of production by the four western Regions, 11, 12, 13, and 14, is 63% in Solution I, but 43% in Solution II. Their decline in the share of trade is even more, from 95% to 55%. This is attributed to both changes in cost coefficients and the assumption in Solution II of non-substitutability of grain-fed beef for non-grain-fed beef which exerts a greater demand for calves as a source of non-grain-fed beef. Region 12 (Southern Plains) with a strong cost advantage in calf production exports over 3/4 of its calf crop to other regions in Solution II and thus does not produce any grain-fed beef for exports.

The universally higher shadow prices of calves, grain-fed beef, and, particularly, non-grain-fed beef in Solution II than Solution I attest to the higher production cost coefficients used in Solution II on the one hand, and to the greater pressure on resources caused by demand for more beef cows and yearlings to satisfy the needs of non-grain-fed beef on the other hand. The other assumptions in Solution II (greater consumptions of wheat and feed grains; no foreign imports of calves) also place a greater pressure on the resources.

In Solution II, the decline of importance of Region 12 (Southern Plains) in grain-fed beef production has led to the rise of the combined export share of Regions 6 (Kentucky) and 7 (Tennesse Valley) (from 4% to 34%) and the entrance of Regions 8 (Delta) and 9 (Minnesota-Wisconsin) into the export market (12%).

Explanations of this phenomenon must be sought from the components of their shadow prices, plus the locational advantage (transportation cost does not appear in the shadow price of exporting regions). Region 6 exports 22% of the total national trade to Region 1 (Northeast) because of (a) its fairly strong cost advantage (index: 1.04), (b) its absence of opportunity costs of its non-binding labor constraints in the three grain-fed beef producing Areas (22, 27, and 29) and its only binding pasture constraint in the less important producing Area 29, and (c) its proximity to Region I.

Its cost advantage in feeds production (both feed grains and forage) are among the lowest, and therefore, do not support its eminent exporting position. Its shadow price is in the medium-low range because of a mix of the above mentioned conflicting forces (components). This leaves its locational advantage as the important determinant of its important production (13% of national share) and exporting role in Solution II, as it is the nearest region to the three importing Regions (1, 2, and 3), the country's largest consumption center which consumes 45% of the country's grain-fed beef. It satisfies nearly half of the import demand by Region 1 (Northeast).

Region 7 (Tennessee Valley) has an export share of 12% in Solution II (versus 1.5% in Solution I). It has a cost advantage of 1.05, similar to that of Region 6 (Kentucky), but a slightly higher shadow price ($26.93 vs. $26.84 for Region 6) which means either higher cost of producing (or importing) feeds or higher opportunity cost of its binding factor constraints. Checking the cost advantage indices reveals the similarity of forage production costs between these two regions (indices: 0.80 for Region 6 and 0.81 for Region 7 for hay production; 0.73 for Region 6 and 0.70 for Region 7 for silage production; shadow prices of feed grains: \$0.78 for Region 6 and \$0.76 for Region 7).[1] (See Tables 16, 26, and 29.)

Searching through the factor constraints in the six areas of Region 7 producing grain-fed beef confirms the above reasoning that binding factor constraints impose opportunity cost and thus raise up the shadow price. Crop-season labor constraint is binding in Areas 131, 132, 133, 134, and 137; pasture constraint is binding in Areas 132, 133, 134, and 137; and class 1 land constraint is binding in every area. All these increase the shadow prices of hay and silage produced therein (see Table A-13). Since shadow prices of inputs contribute to the shadow price of outputs, such shadow prices (opportunity cost) of factors lead to a higher shadow price of beef produced.

Region 7, like Region 6, has proximity to the major northeast consumption center and thus the locational advantage. It exports to both Regions 1 (Northeast) and 3 (Mide-Atlantic), a neighboring region.

Region 8 (Delta) has a share about 8% of the national trade in grain-fed beef. It has a strong cost advantage (index 1.13) which more than compensate the higher shadow price of feed grains it imports from Region 10 (West Corn-Belt) (\$0.81 vs. \$0.76 for Region 7 which is closer to Region 10 from which Region 7 also imports feed grains). It also has a cost advantage in forage production over Region 7 (indices: 0.87 vs. 0.81 for hay; 0.78 vs. 0.70 for silage) and slightly less opportunity cost (no labor constraints are binding) than Region 7. A combination of all these

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[1]Shadow prices, instead of cost advantage indices, are used because Region 7 does not produce feed grains and, therefore, has no cost advantage index.

results in a lower shadow price than Region 7's ($26.22 vs. $26.93). However, its location of being farther away from the northeastern consumption centers and being closer to the other two corners of continent, Region 5 (Florida) and Region 15 (California), determines its exporting to Regions 5 and 15. Region 4 (Southeast Atlantic) is closer to Region 5 but, because of its higher shadow price ($26.93), cannot compete with Region 8 in satisfying Region 5's needs.

The Regions (11, 13, 14) west of Region 8 and east of Region 15 (California) all export grain-fed beef to California. Region 12 (Southern Plains) exports no grain-fed beef because it exports all its surplus calves.

Region 11 (Northern Plains), the most important exporting region (14% of the national trade), has its strength not as much in its cost advantage of producing beef as in its cost advantages in producing feed grains (though its index is merely 0.97, its shadow price, $0.59, is the lowest because of lack of, or smaller, opportunity cost of its factors), and producing hay (index 1.28, the highest) and silage (index 1.24, the second highest). These give Region 11 the lowest shadow price of grain-fed beef ($25.76) in the country, which permits it to export half way across the continent eastward to Region 1 (Northeast) and westward to Region 15 (California). Region 10 (West Corn-Belt) does not export because as in Solution I, all the areas producing grain-fed beef (Areas 36, 45, 47, 50, and 51) have their essential factor constraints binding, such as pasture and labor. Regions 13 (Northwest) and 14 (Southwest) have their strength in strong cost advantages in beef production (indices: 1.17 and 1.18, respectively) and in silage production (indices: 1.13 and

1.37, respectively).

Solution II, which portrays the spatial competition among regions based on coefficients of medium-size herds shows Regions 6, 7, and 8 can compete successfully with the western regions owing partly to their strong cost advantage and partly to their locational advantage. They lose out to the western regions in Solution I because of the latter's strong cost advantage due to the economy of scale in raising feeder cattle in large herd sizes.

The differences in grain-fed beef production between the solutions (particularly Solution I) and the real world as reported in the 1964 U.S. Census of Agriculture are mainly due to the major feeder cattle fattening activity -- the deferred feeding (calf) plan -- in the solutions, which proves to be the most economical of the seven fattening activities but requires heavy pasturing before fattening on concentrate feeds. Such heavy requirements of pasture cause upward shift in regions with ample pasture supply such as Region 12 (Southern Plains) at the expense of regions in which pasture supply is at a premium and the prevailing fattening practices differ from the deferred calf plan, such as Region 10 (West Corn-Belt). Specialization in the production of other commodities dictated in the solution also affect the distribution of grain-fed beef production.

As shown in Table 48,[1] Solution I is almost identical to Eyvindson's solution in the number of feeder cattle produced, because of the same assumptions regarding calf imports and grain-fed beef substitution, though

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[1]The 1964 data were obtained from Eyvindson, 1970, Table 58, p.456, computed from the 1964 Census of Agriculture.

their distributions differ owing partly to an error in data in Eyvindson's model.[1] Solution II is nearly identical to the 1964 production, owing to, apparently, the similarity between Solution II and the real world regarding the non-substitutability of grain-fed beef for non-grain-fed beef. Even without allowing calf imports, Solution II produces fewer head of feeder cattle than the actual 1964 figure, because of more efficient feeder cattle being selected in the solution. Productions of grain-fed beef and non-grain-fed beef are shown in Table 49.[2]

Non-grain-fed beef is produced in every region as dairy cows are. As shown in the balance sheets, the regions (Nos. 1, 2, and 3) in the Northeast are heavy importers (95% of the national total trade in Solution I and 85% in Solution II). In Solution I, Region 11 (Northern Plains) exports 70% of the national total, mostly grain-fed beef substituting for non-grain-fed beef, to Regions 1 and 2. Explanations as to each region's comparative advantages (or disadvantages) can be sought by following the method of analysis illustrated for grain-fed beef production. For regions which substitute grain-fed beef for non-grain-fed beef, the explanations advanced earlier also apply.

The cost advantage index of non-grain-fed beef should be interpreted with the following points on mind: (a) it consists of the weighted cost

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[1]See Eyvindson, 1970, p. 459.

[2]No regional data for 1965 and 1969 are presented in Table 49 because of lack of actual data regarding the division of total beef production into grain-fed and non-grain-fed on regional (or state) basis. Neither the marketed nor the slaughtered quantities shown in Livestock and Meat Statistics USDA ERS 1966b) conform with the simplified concept of production used in the model, which assumes marketing and slaughtering done within the same region as the cattle fattening activities, though in actuality marketing and slaughtering activities do not observe regional (or state) boundaries.

and yield of dairy cows, beef cows, and calves; (b) beef produced from dairy cows, beef cows, and calves born of dairy cows are byproducts, and the cost is not necessarily directly related to the beef yield; and (c) as usual the cost does not include the cost of feeds (grains and forage).

In Solution II, a combined reading of Tables 47 (calf) and 57 (non-grain-fed beef) reveals the composition of non-grain-fed beef produced in each region. For instance, Region 12 (Southern Plains) exports 80% of its calves and raises 4% to yearlings for slaughtering, which constitutes about 1/8 of the total non-grain-fed beef produced by the region. Therefore, the non-grain-fed beef consumed in Region 12 or exported to other regions consists of 7/8 beef from culled cows (about 95% of which are beef cows) and 1/8 veal. In Solution I, it consists of 20% grain-fed beef as substitute, and 80% non-grain-fed beef which is composed of 95% beef from culled dairy cows.

Region 10 (West Corn-Belt) does not export any non-grain-fed beef because of binding factor constraints (see the part above on grain-fed beef). Region 15 (California) in Solution I does not import any non-grain-fed beef because it imports sufficient grain-fed beef as substitute to make up whatever deficit there is left by the supply from its culled dairy cows.

The assumption of subsituting grain-fed beef for non-grain-fed beef in Solution I can be used to assess the effect of cost differential between these two types of activities. In this cost-minimizing model, demand is assumed perfectly inelastic, and market prices are not considered, and no cost is assinged to the substitution activity. If, however, demand and prices were to be determined as endogenous variables (as in a quadratic

Table 42. Beef cows production (unit: head)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	-	-	-	-	-	-	232,000	0.7	250,000	0.7
2	-	-	-	-	-	-	829,000	2.5	875,000	2.4
3	-	-	-	-	-	-	793,000	2.4	952,000	2.6
4	694,858	2.5	1,024,984	3.2	718,900	2.6	1,482,000	4.5	1,812,000	5.0
5	515,525	1.9	682,480	2.2	648,700	2.3	838,000	2.6	893,000	2.5
6	-	-	-	-	336,700	1.2	1,098,000	3.4	1,330,000	3.7
7	74,549	0.3	192,079	0.6	224,000	0.8	700,000	3.1	846,000	2.3
8	2,381,360	8.7	1,497,028	4.7	1,008,800	3.6	2,541,000	7.8	2,985,000	8.3
9	921,995	3.4	1,745,735	5.5	1,808,800	6.5	661,000	2.0	756,000	2.1
10	2,384,337	8.7	3,141,530	9.9	2,815,400	10.2	3,472,000	10.6	3,939,000	10.9
11	7,202,821	26.4	8,353,078	26.3	6,129,700	22.1	5,982,000	18.3	6,287,000	17.4
12	7,798,642	28.6	9,331,980	29.4	7,960,100	28.7	7,031,000	21.5	7,640,000	21.1
13	2,614,531	9.6	3,000,397	9.5	3,724,600	13.4	3,555,000	10.9	3,887,000	10.8
14	2,681,261	9.8	2,749,060	8.7	2,124,300	7.7	2,527,000	7.7	2,707,000	7.5
15	-	-	-	-	236,800	0.9	956,000	2.9	973,000	2.7
TOTAL	27,269,879	99.9	31,718,340	99.9	27,736,800	100.0	32,697,000	99.9	36,132,000	100.0

Table 43. Cost advantage index and yield index, calves (from beef cows)

Region No.	Solution I (1) Beef cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Beef cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	2.5	2.3	3.1	.74	.92	3.2	2.7	4.1	0.66	0.84
5	1.9	1.6	3.0	.53	.84	2.2	1.7	3.3	0.52	0.77
6	-	-	-	-	-	-	-	-	-	-
7	0.3	0.3	0.4	.75	1.00	0.6	0.5	0.7	0.71	0.83
8	8.7	7.7	10.1	.76	.89	4.7	3.9	5.6	0.70	0.83
9	3.4	3.3	3.6	.92	.97	5.5	5.8	5.8	1.00	1.05
10	8.7	9.2	9.4	.98	1.06	9.9	11.3	10.5	1.08	1.14
11	26.4	28.6	26.5	1.08	1.08	26.3	28.4	25.9	1.10	1.08
12	28.6	27.6	24.8	1.11	.97	29.4	26.9	26.4	1.02	0.91
13	9.6	10.1	9.6	1.05	1.05	9.5	10.4	9.2	1.13	1.09
14	9.8	9.4	9.7	.97	.96	8.7	8.6	8.4	1.02	0.99
15	-	-	-	-	-	-	-	-	-	-
Total	99.9	100.1	100.2			100.0	100.2	99.9		

Table 44. Cost advantage index and yield index, calves (from dairy cows)

Region No.	Solution I (1) Dairy cows %	Solution I (2) Yield %	Solution I (3) Cost %	Solution I (2)/(3) Cost advantage index	Solution I (2)/(1) Yield index	Solution II (1) Dairy cows %	Solution II (2) Yield %	Solution II (3) Cost %	Solution II (2)/(3) Cost advantage index	Solution II (2)/(1) Yield index
1	13.6	14.7	15.4	.95	1.08	13.5	14.5	15.4	.95	1.07
2	19.7	19.7	20.1	.98	1.00	19.7	19.7	20.1	.98	1.00
3	2.1	2.2	1.8	1.22	1.05	2.1	2.2	1.9	1.16	1.05
4	1.7	1.6	1.5	1.07	.94	1.8	1.7	1.6	1.06	.94
5	0.8	0.7	0.8	.88	.86	0.8	0.7	0.9	.78	.88
6	2.3	2.6	1.9	1.37	1.13	1.1	1.2	1.0	1.20	1.09
7	2.2	2.5	1.9	1.32	1.14	2.1	2.4	1.8	1.33	1.14
8	2.0	2.0	1.6	1.25	1.00	2.5	2.4	1.9	1.26	.96
9	25.4	25.3	27.2	.93	.97	23.6	23.5	24.9	.94	1.00
10	9.6	9.3	9.5	.98	.97	11.0	10.7	10.6	1.01	.97
11	4.0	4.0	4.0	1.00	1.00	5.4	5.4	5.4	1.00	1.00
12	4.8	4.6	4.0	1.15	.96	5.8	5.8	4.9	1.18	1.00
13	5.9	5.4	5.4	1.00	.92	6.3	5.7	5.6	1.02	.90
14	1.6	1.4	1.4	1.00	.88	2.0	1.8	1.8	1.00	.90
15	4.2	4.0	3.4	1.18	.95	2.3	2.2	2.3	.96	.96
Total	99.9	100.0	99.9			100.0	99.9	100.1		

Table 45. Cost advantage index and yield index, calves (all)

Region No.	Solution I (1) Cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	5.1	3.6	11.3	0.32	0.71	4.6	3.2	10.8	0.30	0.70
2	7.3	4.8	14.8	0.32	0.66	6.7	4.3	14.1	0.30	0.64
3	0.8	0.5	1.3	0.38	0.63	0.7	0.5	1.4	0.36	0.71
4	2.2	2.2	1.9	1.16	1.00	2.7	2.7	2.4	1.13	1.00
5	1.5	1.4	1.4	1.00	0.93	1.7	1.6	1.6	1.00	0.94
6	0.9	0.6	1.4	0.43	0.67	0.4	0.3	0.7	0.43	0.75
7	1.0	0.8	1.5	0.53	0.80	1.1	1.0	1.5	0.67	0.91
8	6.2	6.3	3.9	1.62	1.02	4.1	3.8	3.0	1.27	0.93
9	11.6	8.6	20.9	0.41	0.74	11.6	9.3	19.2	0.48	0.80
10	9.0	9.3	9.4	0.99	1.03	10.3	10.5	10.6	0.99	1.02
11	18.1	22.6	10.0	2.26	1.25	19.2	23.4	11.3	2.07	1.22
12	19.7	22.0	9.5	2.32	1.12	21.3	23.4	11.2	2.09	1.10
13	8.2	8.9	6.5	1.37	1.09	8.4	9.0	6.7	1.34	1.07
14	6.7	7.4	3.6	2.06	1.10	6.4	6.8	3.7	1.84	1.06
15	1.6	1.0	2.5	0.40	0.63	0.8	0.5	1.6	0.31	0.63
Total	100.0	100.0	99.9			100.0	100.3	99.8		

Table 46. Consumption, production and transport of calves, Solution I (unit: 1,000 head)

Region No.	Consumption: Feeder cattle	Consumption: Yearling slaughter	Consumption: Total	%	Production: From dairy cows	Production: From beef cows	Production: Total	%
1	528		528	2.3	824	-	824	3.6
2	1,106		1,106	4.8	1,106	-	1,106	4.8
3	422		422	1.8	126	-	126	0.5
4	1,010		1,010	4.4	91	410	501	2.2
5	208		208	0.9	40	284	324	1.4
6	716		716	3.1	146	-	146	0.6
7	533		533	2.3	140	44	184	0.8
8	599		599	2.6	112	1,347	1,459	6.3
9	841		841	3.6	1,422	581	2,003	8.6
10	2,853		2,853	12.3	522	1,621	2,143	9.2
11	5,242		5,242	22.6	228	5,014	5,242	22.6
12	5,096		5,096	22.0	261	4,835	5,096	22.0
13	2,068		2,068	8.9	304	1,764	2,068	8.9
14	1,874		1,874	8.1	80	1,644	1,724	7.4
15	-	73	73	0.3	223	-	223	1.0
Total	23,096	73	23,169	100.0	5,625	17,544	23,169	99.9

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/head)	advantage index
			3	296	11.5	67.33	0.32
						69.57	0.32
1	296	11.5				70.36	0.38
5	116					71.20	1.16
8	393						
(total)	509	19.7					
			4	116	4.5	66.45	1.00
8	118					71.12	0.43
9	452						
(total)	570	22.1					
8	349	13.5				71.11	0.53
			4	393		67.85	1.62
			6	118			
			7	349			
			(total)	860	33.3		
			6	452		67.03	0.41
			10	710			
			(total)	1,162	45.0		
9	710	27.5				69.97	0.99
						69.76	2.26
						67.10	2.32
						67.81	1.37
15	150	5.8				69.26	2.06
			14	150	5.8	63.28	0.40
	2,584	100.1		2,584	100.1		

Table 47. Consumption, production and transport of calves, Solution II (unit: 1,000 head)

Region No.	Consumption				Production			
	Feeder cattle	Yearling slaughter	Total	%	From dairy cows	From beef cows	Total	%
1	590	20	610	2.3	824	-	824	3.2
2	408	508	916	3.5	1,119	-	1,119	4.3
3	543	-	543	2.1	126	-	126	0.5
4	707	-	707	2.7	97	607	704	2.7
5	2	413	415	1.6	40	375	415	1.6
6	2,458	314	2,772	10.6	68	-	68	0.3
7	1,448	144	1,592	6.1	135	113	248	1.0
8	1,279	875	2,154	8.3	138	842	980	3.8
9	1,251	-	1,251	4.8	1,332	1,100	2,432	9.3
10	2,040	692	2,732	10.5	608	2,124	2,732	10.5
11	4,478	1,625	6,103	23.4	308	5,795	6,103	23.4
12	1,058	266	1,324	5.1	326	5,769	6,095	23.4
13	1,448	407	1,855	7.1	323	2,025	2,348	9.0
14	1,317	464	1,781	6.8	103	1,678	1,781	6.8
15	-	1,344	1,344	5.1	124	-	124	0.5
Total	19,027	7,072	26,099	100.0	5,671	20,428	26,099	100.3

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/head)	advantage index
			3	214	3.1	74.37	0.30
			3	203	3.0	73.47	0.30
1	214					77.40	0.36
2	203						
(total)	417	6.1					
12	3	-				75.09	1.13
						75.27	1.00
9	1,181					75.14	0.43
12	1,523						
(total)	2,704	39.4					
12	1,344	19.6				75.02	0.67
12	1,174	17.1				73.41	1.27
			6	1,181	17.2	71.05	0.48
						73.86	0.99
						72.85	2.07
			4	3		70.69	2.07
			6	1,523			
			7	1,344			
			8	1,174			
			15	727			
			(total)	4,771	69.5		
			15	493	7.2	71.54	1.34
						72.29	1.84
12	727					76.97	0.31
13	493						
(total)	1,220	17.8					
	6,862	100.0		6,862	100.0		

Table 48. Feeder cattle production (unit: head)

Region No.	Solution I	%	Solution II	%	Solution E	%	1964	%
1	528,197	2.2	590,252	3.1	-	-	237,900	1.2
2	1,106,116	4.6	407,930	2.1	83,000	0.3	1,210,500	6.3
3	422,132	1.8	542,864	2.9	482,878	2.0	84,694	0.4
4	1,010,445	4.2	706,691	3.7	1,300,420	5.4	211,600	1.1
5	207,231	0.9	1,737	0.0	2,800	0.0	111,000	0.6
6	715,158	3.0	2,457,940	12.9	355,281	1.5	138,276	0.7
7	532,439	2.2	1,447,845	7.6	330,780	1.4	87,039	0.5
8	600,218	2.5	1,279,699	6.7	2,701,017	11.3	109,791	0.6
9	841,565	3.5	1,249,947	6.6	69,200	0.3	1,001,200	5.2
10	2,853,277	12.0	2,040,269	10.7	2,246,600	9.4	5,351,600	28.0
11	5,491,945	23.0	4,478,164	23.5	6,009,300	25.2	4,494,600	23.5
12	5,612,344	23.5	1,057,051	5.6	5,094,600	21.3	1,675,500	8.8
13	2,068,381	8.7	1,448,617	7.6	3,502,200	14.7	1,856,500	9.7
14	1,873,868	7.9	1,317,433	6.9	729,200	3.1	392,900	2.1
15	-	-	-	-	970,800	4.1	2,153,000	11.3
Total	23,863,300	100.0	19,026,410	99.9	23,878,076	100.0	19,116,100	100.0

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Table 49. Beef production (unit: 1,000 lbs.)

Region No.	Grain-fed beef Solution I	%	Solution II	%	Non-grain-fed beef Solution I	%	Solution II	%
1	327,482	2.2	365,956	3.1	258,670	6.5	265,993	3.9
2	685,791	4.7	252,916	2.2	451,264	11.3	640,868	9.3
3	261,722	1.8	336,576	2.9	37,084	0.9	37,084	0.5
4	626,475	4.3	438,148	3.7	68,997	1.7	89,259	1.3
5	128,483	0.9	1,077	0.0	41,718	1.0	201,393	2.9
6	443,398	3.0	1,523,921	13.0	32,916	0.8	130,848	1.9
7	330,112	2.3	897,663	7.7	37,048	0.9	95,034	1.4
8	372,135	2.5	793,413	6.8	169,465	4.2	446,868	6.5
9	521,771	3.6	774,966	6.6	629,874	15.7	653,815	9.5
10	1,769,030	12.1	1,264,966	10.8	399,703	10.0	742,916	10.8
11	3,405,004	23.3	2,776,462	23.7	617,990	15.4	1,328,525	19.3
12	3,378,632	23.1	635,288	5.4	592,139	14.8	793,458	11.5
13	1,233,079	8.4	869,170	7.4	331,849	8.3	517,430	7.5
14	1,119,539	7.7	790,459	6.7	215,096	5.4	399,456	5.8
15	-	-	-	-	118,261	3.0	540,801	7.9
Total	14,602,640	99.9	11,720,960	100.0	4,002,069	99.9	6,883,743	100.0

Table 50. Cost advantage index and yield index, grain-fed beef

Region No.	Solution I (1) Feeder cattle %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Feeder cattle %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	2.2	2.2	3.0	.73	1.00	3.1	3.1	3.4	.91	1.00
2	4.8	4.7	6.3	.75	.98	2.1	2.2	2.5	0.88	1.05
3	1.8	1.3	1.9	.95	1.00	2.9	2.9	3.2	0.91	1.00
4	4.3	4.3	4.6	.93	1.02	3.7	3.7	3.6	1.03	1.00
5	0.9	0.9	0.9	1.00	1.00	-	-	-	-	-
6	3.0	3.0	3.3	.91	1.00	12.9	13.0	12.5	1.04	1.01
7	2.2	2.3	2.2	1.05	1.05	7.6	7.7	7.3	1.05	1.01
8	2.5	2.5	3.0	.83	1.00	6.7	6.8	6.0	1.13	1.01
9	3.5	3.6	4.5	.80	1.03	6.6	6.6	7.1	.93	1.00
10	12.0	12.1	14.8	.82	1.01	10.7	10.8	11.9	.91	1.01
11	23.0	23.3	26.6	.88	1.01	23.5	23.7	25.1	.94	1.01
12	23.5	23.1	19.8	1.17	.98	5.6	5.4	5.3	1.02	.96
13	8.7	8.4	4.9	1.71	.97	7.6	7.4	6.3	1.17	.97
14	7.9	7.7	4.3	1.79	.97	6.9	6.7	5.7	1.18	.97
15	-	-	-	-	-	-	-	-	-	-
Total	100.2	99.9	100.1			99.9	100.0	99.9		

Table 51. Consumption, production and transport of grain-fed beef, Solution I (unit: 1,000 CWT)

Region No.	Consumption				Production	
	Quantity	As non-grain-fed beef	Total	%	Quantity	%
1	31,946		31,946	21.9	3,275	2.2
2	16,355		16,355	11.2	6,858	4.7
3	4,980		4,980	3.4	2,617	1.8
4	4,381	1,884	6,265	4.3	6,265	4.3
5	2,868		2,868	2.0	1,285	0.9
6	2,228	979	3,207	2.2	4,434	3.0
7	1,734	648	2,382	1.6	3,301	2.3
8	3,412	309	3,721	2.5	3,721	2.5
9	5,218		5,218	3.6	5,218	3.6
10	12,650	3,431	16,081	11.0	17,690	12.1
11	3,311	13,204	16,515	11.3	34,050	23.3
12	6,353	1,629	7,982	5.5	33,786	23.1
13	6,042	230	6,272	4.3	12,331	8.4
14	2,651		2,651	1.8	11,195	7.7
15	13,082	6,501	19,583	13.4	-	-
Total	117,211	28,815	146,026	100.0	146,026	99.9

Imports			Exports			Shadow price ($/CWT)	Cost advantage index
From region	Quantity	%	To region	Quantity	%		
6	1,227					26.88	0.73
7	919						
11	9,647						
12	8,334						
14	8,544						
(total)	28,671	46.5					
10	1,609					25.97	0.75
11	7,888						
(total)	9,497	15.4					
12	2,363	3.8				26.41	0.95
						25.43	0.93
12	1,583	2.6				26.01	1.00
			1	1,227	2.0	25.34	0.91
			1	919	1.5	25.43	1.05
						25.42	0.83
						24.83	0.80
			2	1,609	2.6	24.81	0.82
			1	9,647		24.26	0.88
			2	7,888			
			(total)	17,535	28.4		
			1	8,334		24.12	1.17
			3	2,363			
			5	1,583			
			15	13,524			
			(total)	25,804	41.8		
			15	6,059	9.8	24.32	1.71
			1	8,544	13.8	24.18	1.79
12	13,524					26.17	-
13	6,059						
(total)	19,583	31.7					
	61,697	100.0		61,697	99.9		

Table 52. Consumption, production and transport of grain-fed beef, Solution II (unit: 1,000 CWT)

Region No.	Consumption		Production	
	Quantity	%	Quantity	%
1	31,946	27.3	3,660	3.1
2	16,355	13.9	2,529	2.2
3	4,980	4.2	3,366	2.9
4	4,381	3.7	4,381	3.7
5	2,868	2.4	11	-
6	2,228	1.9	15,239	13.0
7	1,734	1.5	8,976	7.7
8	3,412	2.9	7,934	6.8
9	5,218	4.5	7,750	6.6
10	12,650	10.8	12,650	10.8
11	3,311	2.8	27,764	23.7
12	6,353	5.4	6,353	5.4
13	6,042	5.2	8,692	7.4
14	2,651	2.3	7,905	6.7
15	13,082	11.2	-	-
Total	117,211	100.0	117,211	100.0

Imports			Exports			Shadow price ($/CWT)	Cost advantage index
From region	Quantity	%	To region	Quantity	%		
6	13,011					28.38	0.91
7	5,628						
11	9,647						
(total)	28,286	47.4					
9	2,532					27.47	0.88
11	11,294						
(total)	13,826	23.2					
7	1,614	2.7				28.08	0.91
						26.93	1.03
8	2,857	4.8				27.78	-
			1	13,011	21.8	26.84	1.04
			1	5,628		26.93	1.05
			3	1,614			
			(total)	7,242	12.1		
			5	2,857		26.22	1.13
			15	1,665			
			(total)	4,522	7.6		
			2	2,532	4.2	26.08	0.93
			-	-		26.48	0.91
			1	9,646		25.76	0.94
			2	11,294			
			15	3,513			
			(total)	24,453	41.0		
			-	-		27.11	1.02
			15	2,650	4.4	26.87	1.17
			15	5,254	8.8	26.69	1.18
8	1,665		-	-		28.72	-
11	3,513						
13	2,650						
14	5,254						
(total)	13,082	21.9					
	59,664	100.0		59,664	99.9		

Table 53. Cost advantage index and yield index, non-grain-fed beef (from beef cows)

Region No.	Solution I (1) Beef cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Beef cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	2.5	2.1	3.1	.68	.84	3.2	2.7	4.1	.66	.84
5	1.9	1.5	3.0	.50	.79	2.2	1.7	3.3	.52	.77
6	-	-	-	-	-	-	-	-	-	-
7	0.3	0.2	0.4	.50	.69	0.6	0.5	0.7	.71	.83
8	8.7	7.3	10.1	.72	.84	4.7	3.9	5.6	.70	.83
9	3.4	3.6	3.6	1.00	1.06	5.5	5.8	5.8	1.00	1.05
10	8.7	10.0	9.4	1.06	1.15	9.9	11.3	10.5	1.08	1.14
11	26.4	28.5	26.5	1.08	1.08	26.3	28.4	25.9	1.10	1.08
12	28.6	26.4	24.8	1.06	.92	29.4	26.9	26.4	1.02	.91
13	9.6	10.6	9.6	1.10	1.10	9.5	10.4	9.2	1.13	1.09
14	9.8	9.8	9.7	1.01	1.00	8.7	8.6	8.4	1.02	0.99
15	-	-	-	-	-	-	-	-	-	-
Total	99.9	100.0	100.0			100.0	100.2	100.2		

Table 54. Cost advantage index and yield index, non-grain-fed beef (from dairy cows)

Region No.	Solution I (1) Dairy cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Dairy cows %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	13.6	12.2	15.4	0.79	.90	13.5	12.1	15.4	.79	.90
2	19.7	21.2	20.1	1.05	1.08	19.7	21.3	20.1	1.06	1.08
3	2.1	1.7	1.8	0.94	.81	2.1	1.7	1.9	.89	.81
4	1.7	1.4	1.5	0.93	.82	1.8	1.5	1.6	.94	.83
5	0.8	0.7	0.8	.88	.88	0.8	0.7	0.9	.78	.88
6	2.3	1.5	1.9	.79	.65	1.1	0.8	1.0	.80	.73
7	2.2	1.5	1.9	.79	.68	2.1	1.5	1.8	.83	.71
8	2.0	1.6	1.6	1.00	.80	2.5	2.0	1.9	1.05	.80
9	25.4	26.5	27.2	.97	1.04	23.6	24.7	24.9	.99	1.05
10	9.6	10.1	9.5	1.06	1.05	11.0	11.5	10.6	1.08	1.05
11	4.0	4.2	4.0	1.05	1.05	5.4	5.7	5.4	1.06	1.06
12	4.8	4.9	4.0	1.23	1.02	5.8	5.3	4.9	1.08	.91
13	5.9	6.4	5.4	1.19	1.08	6.3	6.8	5.6	1.21	1.08
14	1.6	1.6	1.4	1.14	1.00	2.0	2.1	1.8	1.17	1.05
15	4.2	4.3	3.4	1.26	1.02	2.3	2.4	2.3	1.04	1.04
Total	99.9	99.8	99.9			100.0	100.1	100.1		

Table 55. Cost advantage index and yield index, non-grain-fed beef (all)

Region No.	Solution I (1) Cows, calves %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Cows, calves %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	5.1	6.5	11.3	.58	1.27	4.1	3.9	10.3	.38	0.95
2	7.3	11.3	14.8	.76	1.55	6.8	9.3	13.8	.67	1.37
3	0.8	0.9	1.3	.69	1.13	0.6	0.5	1.3	.38	0.83
4	2.2	1.7	1.9	.89	0.77	2.4	1.3	2.3	.57	0.54
5	1.5	1.0	1.4	.71	0.67	2.2	2.9	2.0	1.45	1.32
6	0.9	0.8	1.4	.57	0.89	0.9	1.9	0.9	2.11	2.11
7	1.0	0.9	1.5	.60	0.90	1.2	1.4	1.5	.93	1.17
8	6.2	4.2	3.9	1.08	0.68	5.0	6.5	3.5	1.86	1.30
9	11.6	15.7	20.9	.75	1.35	10.2	9.5	18.4	.52	0.93
10	9.0	10.0	9.4	1.06	1.11	10.2	10.8	10.5	1.03	1.06
11	18.0	15.4	10.0	1.54	0.86	19.7	19.3	11.9	1.62	0.98
12	19.7	14.8	9.5	1.56	0.75	19.1	11.5	10.8	1.06	0.60
13	8.2	8.3	6.5	1.28	1.01	8.0	7.5	6.6	1.14	0.94
14	6.7	5.4	3.6	1.50	0.81	6.4	5.8	3.8	1.53	0.91
15	1.7	3.0	2.5	12.0	1.76	3.1	7.9	2.4	3.29	2.55
Total	99.9	99.9	99.9			99.9	100.0	100.0		

Table 56. Consumption, production and transport of non-grain-fed beef, Solution I (unit: 1,000 CWT)

Region No.	Consumption Quantity	Consumption %	Production Quantity	Grain-fed beef as substitute	Total	%
1	18,762	27.3	2,587		2,587	3.8
2	9,605	14.0	4,513		4,513	6.6
3	2,925	4.2	371		371	0.5
4	2,573	3.7	689	1,884	2,573	3.7
5	1,684	2.4	417		417	0.6
6	1,308	1.9	329	979	1,308	1.9
7	1,018	1.5	370	648	1,018	1.5
8	2,004	2.9	1,695	309	2,004	2.9
9	3,064	4.5	6,298		6,298	9.1
10	7,429	10.8	3,998	3,431	7,429	10.8
11	1,945	2.8	6,180	13,204	19,384	28.2
12	3,732	5.4	5,924	1,629	7,553	11.0
13	3,548	5.2	3,318	230	3,548	5.2
14	1,557	2.3	2,151		2,151	3.1
15	7,683	11.2	1,182	6,501	7,683	11.2
Total	68,837	100.1	40,022	28,815	68,837	100.1

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/CWT)	advantage index
11	15,581					26.88	0.58
14	594						
(total)	16,175	64.5					
9	3,234					25.97	0.76
11	1,858						
(total)	5,092	20.3					
12	2,554	10.2				26.41	0.69
						25.43	0.89
12	1,267	5.1				26.01	0.71
						25.34	0.57
						25.43	0.60
						25.42	1.08
			2	3,234	12.9	24.58	0.75
						24.81	1.06
			1	15,581		24.26	1.54
			2	1,858			
			(total)	17,439	69.5		
			3	2,554		24.12	1.56
			5	1,267			
			(total)	3,821	15.2		
						24.32	1.28
			1	594	2.4	24.18	1.50
						26.17	1.20
	25,088	100.1		25,088	100.0		

Table 57. Consumption, production and transport of non-grain-fed beef, Solution II (unit: 1,000 CWT)

Region No.	Consumption		Production	
	Quantity	%	Quantity	%
1	18,762	27.3	2,660	3.9
2	9,605	14.0	6,409	9.3
3	2,925	4.2	371	0.5
4	2,573	3.7	893	1.3
5	1,684	2.4	2,014	2.9
6	1,308	1.9	1,308	1.9
7	1,018	1.5	905	1.4
8	2,004	2.9	4,469	6.5
9	3,064	4.5	6,537	9.5
10	7,429	10.8	7,429	10.8
11	1,945	2.8	13,286	19.3
12	3,732	5.4	7,934	11.5
13	3,548	5.2	5,174	7.5
14	1,557	2.3	3,995	5.8
15	7,683	11.2	5,408	7.9
Total	68,837	100.1	68,837	100.0

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/CWT)	advantage index
5	330					32.62	0.38
9	277						
11	11,341						
12	1,716						
14	2,438						
(total)	16,102	62.2					
9	3,196	12.4				32.62	0.67
8	2,465					32.15	0.38
12	89						
(total)	2,554	9.9					
12	1,680	6.5				31.32	0.57
			1	330	1.3	30.95	1.45
						31.28	2.11
12	68	0.3				31.30	0.93
			3	2,465	9.5	30.23	1.86
			1	277		30.23	0.52
			2	3,196			
			(total)	3,473	13.4		
						30.50	1.03
			1	11,341	43.8	30.00	1.62
			1	1,716		29.86	1.06
			3	89			
			4	1,680			
			7	68			
			15	649			
			(total)	4,202	16.2		
			15	1,626	6.3	30.06	1.14
			1	2,438	9.4	29.92	1.53
12	649		-	-		31.91	3.29
13	1,626		-	-			
(total)	2,275	8.8					
	25,875	100.1		25,875	99.9		

programming model), then such a "free" substitution assumption would not by valid.

Hogs

Both solutions show greater concentration of pork production in Regions 2 (East Corn-Belt) and 11 (Northern Plains), with Region 10 (West Corn-Belt) retaining about the same share as in 1965. In Region 2, a strong cost advantage in hog-raising (indices: 1.02, 1.00) in combination with a moderate cost advantage in feed grain production (indices: 0.91, 0.91) results in a shadow price ($16.01, $16.47) being the fourth lowest in both solutions (see Tables 16, 59, 60, and 61). However, the deciding factor of boosting Region 2's production is its locational advantage -- the proximity to Region 1 (Northeast) which consumes 1/4 of the national total pork production, but produces very little of its own (1.5% of the national total in 1965, and none in the solutions) because of (a) its high cost of producing feed grains (index 0.61), and (b) its exhausting all class 1 land mianly in producing feeds, hay, and silage to support dairy cows. Area 38 (northern Indiana) produces all the hogs in Region 2, obviously because of its low production cost among all areas within the region, and meets about 1/3 of Region 1's needs. Region 10 satisfies the remaining needs of Region 1. Hog production is constrained by the exhaustion of crop-season labor in Area 38. (See Tables A-5 and A-15).

Region 10 (West Corn-Belt) produces nearly half of the country's pork because of its strong cost advantages in both rearing hogs (indices: 1.02, 1.02) and in producing feed grains (indices: 1.10, 1.09), the combination of which results in the second lowest shadow price among the regions ($15.30 and $15.76 for Solutions I and II, respectively). The additional locational advantage assigns Region 10 the role of supplying pork to the eastern half of the continent -- Regions 1 (Northeast), 3 (Mid-Atlantic), 4 (Southeast Atlantic), 5 (Florida), 6 (Kentucky), 7 (Tennessee Valley), and 8 (Delta) -- a total volume of export equal to nearly 60% of the national trade. The three porducing areas (45, northern Illinois; 51, northern Missouri; 53, northeastern half of Iowa) in Solution I and the two producing areas (45, 53) in Solution II exhaust their labor or pasture supplies.

Region 11 (Northern Plains) has the same strong cost advantage in hog-raising (index 1.02) as Region 10 in Solution I, but is less favorable in Solution II (index 0.95). Its cost advantages in feed grain production is much less (indices: 0.96, 0.97) than those of Region 10 (indices: 1.10, 1.09). And yet, Region 11 has the lowest shadow price of pork among the regions ($15.11 and $15.52 for Solutions I and II, respectively), apparently owing to the lower opportunity costs (shadow prices) of its feed grains. Region 11's locational advantage leads it to supply pork to the western part of the continent -- Regions 12 (Southern Plains), 14 (Southwest), and 15 (California) -- and to Region 8 (Delta) in Solution I.

Regions 9 (Minnesota-Wisconsin) and 13 (Northwest) neither export nor import in Solution I. Region 9, despite its strong cost advantage in hog-raising (index: 1.02), and its low shadow price of pork ($15.42, the third lowest), is located in such a situation that it is surrounded by three exporting regions (Region 2 to the east, Region 10 to the south, and Region 11 to the west) which shield it from all the importing regions of the country. Apparently, it would start to supply pork to other regions only (a) if Regions 2, 10, and 11, after exhausting their resources, still cannot meet the demand of the deficit regions and (b) if Region 9 still has surplus resources to permit expansion of its pork production. A review of Region 9's essential factor constraints (particlarly labor) shows they are already binding, apparently due to its devotion of such resources to milk production for satisfying other regions' needs. This also explains Region 9's decreased production of pork in the solutions, as compared with the actual 1965 figure.

Region 13 does not import pork as it does in reality, because its shadow price which, in Solution I at $17.47, is still lower than the cost of importing pork from Region 11 ($15.11 + $2.64 = $17.75). Its cost advantage index in hog-raising is the lowest among regions producing pork. Despite its strong cost advantage in feed grains production (index: 1.21), Region 13 has the highest shadow price of pork among regions. Apparently the binding labor and land constraints in Areas 28 (Idaho), 102 (western Montana), 103 (eastern Wyoming and southeastern Montana), 104 (southern Montana), 110 (southeastern Idaho), and 112 (northwestern Idaho and eastern Washington), with their accompanying opportunity costs, sustain the shadow price to as high a level as it is. The situation of Region 13 in Solution II is similar.

Region 12 enters pork production and become self-sufficient in pork in Solution II, because apparently the resources released in Solution I from the reduced levels in feeder-cattle raising (Region 12 ships out all of its excess calves and does not export grain-fed beef in Solution II) permit it to produce pork with less opportunity cost.

Two examples illustrate some of the limitation of the present model.

In Region 11, as pointed out above, pork production is concentrated in South Dakota (Areas 64, 67, 68, 69, 70) while grains production is concentrated mostly in Nebraska (Areas 71, 75) and South Dakota (Area 70). This occurs because no transportation cost is assigned to intra-regional movements of products between areas. The production pattern would certainly alter if transportation cost were charged to inter-area movements of goods, and pork production would be mostly likely to be concentrated in areas where feed grains are produced.

The results may be interpreted as follows: the areas in South-Dakota have a strong cost advantage in rearing hogs (without considering the transportation cost of feeds) than the areas in Nebraska, as the solutions indicate. However, when transportation cost were charged to intra-regional movements of feeds between areas, the areas in South Dakota would maintain their production of hogs if their cost advantage differentials still more than compensate the newly-added transportation cost, but would lose their production if their cost advantage differentials do not. In such a case, hog production would probably shift to the feeds-producing areas in Nebraska. This is still a simplied conjecture, because when inter-area transportation were allowed, it should be extended to areas of all regions. This would certainly create a new inter-area trade pattern. The exact answer cannot be known without actually solving the new model with inter-area transportations.

Further division of the present regions into smaller regions would also alter the trade pattern. If Region 13 were divided into five smaller regions, with each of the five states in Region 13 as a new region, then Montana and Wyoming would most probably import pork from the neigh-

Table 58. Hogs production (unit: CWT liveweight)

Region No.	Solution I	%	Solution II	%	Solution E	%	1965	%	1969	%
1	-	-	-	-	7,595,100	4.2	2,785,280	1.5	3,308,290	1.6
2	39,752,140	21.8	39,864,470	21.8	30,786,100	16.9	25,400,590	14.0	27,404,640	13.5
3	-	-	-	-	10,118,600	5.5	5,945,709	3.3	7,606,310	3.7
4	-	-	-	-	5,424,100	3.0	6,239,412	3.4	8,703,510	4.3
5	-	-	-	-	1,310,800	0.7	772,750	0.4	872,380	0.4
6	-	-	-	-	4,808,000	2.6	5,233,560	2.9	5,338,070	2.6
7	878,692	0.5	268,672	0.1	3,353,500	1.8	3,294,532	1.8	3,670,470	1.8
8	1,705,087	0.9	-	-	7,512,800	4.1	2,093,909	1.1	2,956,900	1.5
9	7,708,359	4.2	7,708,359	4.2	9,262,100	5.1	17,559,490	9.6	18,816,550	9.2
10	86,566,670	47.4	81,855,290	44.8	57,928,200	31.7	83,518,460	45.9	89,183,580	43.8
11	38,412,810	21.0	32,018,770	17.5	36,018,700	19.7	22,073,220	12.1	27,095,280	13.3
12	-	-	13,308,190	7.3	4,075,800	2.2	3,448,550	1.9	4,641,510	2.3
13	7,491,579	4.1	7,491,582	4.1	3,868,400	2.1	1,885,920	1.0	1,838,850	0.9
14	-	-	-	-	446,700	0.2	1,088,370	0.6	1,609,840	0.8
15	-	-	2	0.1	-	-	742,240	0.4	432,240	0.2
TOTAL	182,515,337	99.9	182,515,335	99.9	182,508,900	99.8	182,081,990	99.9	203,478,420	99.9

Table 59. Cost advantage index and yield index, pork

Region No.	Solution I (1) Production %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Production %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	-	0.0	0.0	-	-	-	0.0	0.0	-	-
2	21.8	21.8	21.4	1.02	1.00	21.8	21.5	21.5	1.00	.99
3	-	0.0	0.0	-	-	-	0.0	0.0	-	-
4	-	0.0	0.0	-	-	-	0.0	0.0	-	-
5	-	0.0	0.0	-	-	-	0.0	0.0	-	-
6	-	0.0	0.0	-	-	-	0.0	0.0	-	-
7	0.5	0.5	0.5	1.00	1.00	0.1	0.1	0.1	1.00	1.00
8	0.9	0.9	0.9	1.00	1.00	-	0.0	0.0	-	-
9	4.2	4.2	4.1	1.02	1.00	4.2	4.2	4.1	1.02	1.00
10	47.4	47.4	46.3	1.02	1.00	44.8	44.8	43.8	1.02	1.00
11	21.0	21.0	22.1	.95	1.00	17.5	17.5	18.4	.95	1.00
12	-	0.0	0.0	-	1.00	7.3	7.3	7.4	.99	1.00
13	4.1	4.1	4.6	.89	1.00	4.1	4.1	4.7	.87	1.00
14	-	0.0	0.0	-	1.00	-	0.0	0.0	-	-
15	-	0.0	0.0	-	1.00	0.1	0.0	0.0	-	-
Total	99.9	99.9	99.9			99.9	99.5	100.0		

Table 60. Consumption, production and transport of pork, Solution I (unit: 1,000 CWT carcas weight)

Region No.	Consumption		Production	
	Quantity	%	Quantity	%
1	27,692	24.8	-	-
2	14,551	13.0	24,288	21.8
3	6,460	5.8	-	-
4	5,792	5.2	-	-
5	3,641	3.3	-	-
6	2,938	2.6	-	-
7	2,282	2.0	537	0.5
8	4,590	4.1	1,041	0.9
9	4,710	4.2	4,710	4.2
10	11,180	10.0	52,894	47.4
11	3,038	2.7	23,470	21.0
12	8,131	7.3	-	-
13	4,577	4.1	4,577	4.1
14	2,074	1.9	-	-
15	9,861	8.8	-	-
Total	111,517	99.8	111,517	99.9

Imports			Exports			Shadow price ($/CWT)	Cost advantage index
From region	Quantity	%	To region	Quantity	%		
2	9,737					17.52	-
10	17,955						
(total)	27,692	38.5					
			1	9,737	13.5	16.01	1.02
10	6,460	9.0				17.25	-
10	5,792	8.1				16.67	-
10	3,641	5.1				17.13	-
10	2,938	4.1				16.40	-
10	1,745	2.4				16.53	1.00
10	3,183					16.70	1.00
11	366						
(total)	3,549	4.9					
						15.42	1.02
			1	17,955		15.30	1.02
			3	6,460			
			4	5,792			
			5	3,641			
			6	2,938			
			7	1,745			
			8	3,183			
			(total)	41,714	58.0		
			8	366		15.11	0.95
			12	8,131			
			14	2,074			
			15	9,861			
			(total)	20,432	28.4		
11	8,131	11.3				16.57	-
						17.47	0.89
11	2,074	2.9				16.53	-
11	9,861	13.7				18.07	-
	71,883	100.0		71,883	99.9		

Table 61. Consumption, production and transport of pork, Solution II (unit: 1,000 CWT carcas weight)

Region No.	Consumption		Production	
	Quantity	%	Quantity	%
1	27,692	24.8	-	-
2	14,551	13.0	24,357	21.8
3	6,460	5.8	-	-
4	5,792	5.2	-	-
5	3,641	3.3	-	-
6	2,938	2.6	-	-
7	2,282	2.0	164	0.1
8	4,590	4.1	-	-
9	4,710	4.2	4,710	4.2
10	11,180	10.0	50,015	44.8
11	3,038	2.7	19,563	17.5
12	8,131	7.3	8,131	7.3
13	4,577	4.1	4,577	4.1
14	2,074	1.9	-	-
15	9,861	8.8	-	-
Total	111,517	99.8	111,517	99.8

Imports			Exports			Shadow price	Cost
From region	Quantity	%	To region	Quantity	%	($/CWT)	advantage index
2	9,806					17.98	-
10	17,886						
(total)	27,692	42.5					
-			1	9,806	15.0	16.47	1.00
10	6,460	9.9				17.71	-
10	5,792	8.9				17.13	-
10	3,641	5.6				17.59	-
10	2,938	4.5				16.86	-
10	2,118	3.3				16.99	1.00
11	4,590	7.0				17.11	-
						16.16	1.02
			1	17,886		15.76	1.02
			3	6,460			
			4	5,792			
			5	3,641			
			6	2,938			
			7	2,118			
			(total)	38,835	59.6		
			8	4,590		15.52	0.95
			14	2,074			
			15	9,861			
			(total)	16,525	25.4		
						16.98	0.99
						17.74	0.87
11	2,074	3.2	-	-		16.94	-
11	9,861	15.1	-	-		18.48	-
	65,166	100.0		65,166	100.0		

boring Region 11, rather than produce pork themselves. Besides, a slight change in the location of the center point of a region may also alter the trade pattern, because a slightly difference in transportation cost in the critical range can convert a non-producing and importing region into a producing and self-sufficient region, or vice versa.

The solutions differ from the actual 1965 production pattern in (a) phasing-out of marginal regions, and (b) greater intensity of specialization of pork production in important producing regions, except Region 10 which maintains its share because it devotes, instead, its resources to the expansion of feed grain and soybean production. Region 10 captures most of the eastern market while Region 11 dominates the western market. The part of Region 11 (eastern Nebraska and southeastern South Dakota) is geographically a part of Corn Belt, and together with Regions 10 and 2, produce 85% - 90% of pork of the country, while in 1965 Corn Belt produced 72%. The solutions definitely suggest a greater concentration of pork production in Corn Belt.

Broilers

Both solutions indicate self-sufficiency in broilers in all but one (California) regions, and therefore, considerable differences from the 1965 actual production pattern in which Regions 3, 4, 7 and 8 in the Southeast were exporters (see Table 62). The assumption of same technology in broiler production leads to nearly every region producing its own broilers for local consumption. Apparently, the differences in wage rates between regions do not outweigh interregional transportation cost. (See the section on data on broilers in Chapter IV.)

Broiler production is a highly vertically-integrated industry, with the broiler farmers supplying housing and labor and the feeds companies supplying chicks, feeds and other capital. An input (chicks and feeds) distributing and output (Broilers) collecting system is essential to the deveopment of a broiler industry. The decision to establish such a system apparently rests with the feeds companies which obviously considers abundant and low-cost rural labor supply conductive to the development and expansion of the industry. In areas where available farm labor is sparsely distributed over large geographic regions, the incentive for feeds companies to establish a distributing and collecting network is understandably weak. If such hidden cost as establishing and operating distribution network were included in the broiler activities, a solution approximating the actual situation would probably have resulted. The production cost as available to the public does not reflect such hidden cost.

Since the Southeast itself possesses 25% population of the country and is adjacent to the consumption centers in the Northeast, (Regions 1 and 2 containing 24% and 13% population, respectively) and has abundant rural labor supply at relatively lower cost, all these have attracted the feeds industry to develop broiler industries in the Southeast. It seems, however, necessary to include a new component in the cost coefficient of broiler production in order to reflect the density of abundant farm labor, hence the lower cost of establishing and maintaining a distributing-collecting network in such a region. The ratio of farm labor to farm land would seem a logical choice for such a new component in the computation of a new cost coefficient.

Region 15 (California)'s importing broilers from Region 12 (Southern Plains) is due to the former's shortage of labor in both solutions. (See the sections on cotton, dairy cow, or resources.)

Total broiler production increased 20% from 1965 to 1969. During this period the Southeast increased its share slightly from 68% to 70% of the national total, and therefore gained tremendously in absolute terms -- about one billion pounds in a national total production of 7 billion pounds, indicating an abundant reserve of farm labor in the Southeast in 1965.

The cost advantage indices in both solutions are identical (Table 63) because productions are identical in each region (Table 62).[1] Regions 3, 4, 7, and 8 in the Southeast have strong cost advantage because of lower farm wage rates in these regions than the national average wage rate. It is no coincidence that these four regions are exporters of broilers in the real world as shown by their 1965 productions versus their self-sufficient production levels in the two solutions. In reality Regions 3, 4, 7 and 8 produce, respectively, twice, five times, twice, and five times the amount consumed within the region; and all other regions are deficient in broiler production.

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[1]In regions where producing areas differ in the two solutions, the differences in wage are not significant enough to affect the cost advantage indices.

Table 62. Broilers production (unit: 1,000 lbs.)

Region No.	Solution I	%	Solution II	%	1965	%	1969	%
1	1,649,898.0	28.4	1,649,898.0	28.4	979,315.0	16.8	1,111,288.0	15.9
2	652,694.0	11.2	652,694.0	11.2	89,427.0	1.5	62,002.0	0.9
3	336,386.0	5.8	336,386.0	5.8	708,373.0	12.1	848,845.0	12.2
4	307,330.0	5.3	307,330.0	5.3	1,622,406.0	27.8	1,887,064.0	27.1
5	185,687.0	3.2	185,687.0	3.2	32,188.0	0.6	96,994.0	1.4
6	150,996.0	2.6	150,996.0	2.6	96,111.0	1.6	92,123.0	1.3
7	117,148.0	2.0	117,148.0	2.0	242,484.0	4.2	276,749.0	4.0
8	247,709.0	4.3	247,709.0	4.3	1,287,969.0	22.0	1,691,515.0	24.2
9	208,493.0	3.6	208,493.0	3.6	56,132.0	1.0	67,743.0	1.0
10	484,308.0	8.3	484,308.0	4.3	84,940.0	1.5	61,100.0	0.9
11	136,567.0	2.4	136,567.0	2.4	4,267.0	0.1	5,075.0	0.1
12	961,839.0	16.6	961,839.0	16.6	389,074.0	6.7	468,667.0	6.7
13	253,851.0	4.4	253,851.0	4.4	92,346.0	1.6	110,352.0	1.6
14	113,479.0	2.0	113,479.0	2.0	7,021.0	0.1	4,136.0	0.1
15	-	-	-	-	149,863.0	2.6	192,192.0	2.8
TOTAL	5,806,385.0	100.0	5,806,385.0	100.0	5,841,917.0	100.2	6,975,770.0	100.2

Table 63. Cost advantage index and yield index, broilers

Region No.	Solution I (1) Production %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Production %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	28.4	28.4	28.2	1.01	1.00	28.4	28.4	28.2	1.01	1.00
2	11.2	11.2	11.5	0.97	1.00	11.2	11.2	11.5	0.97	1.00
3	5.8	5.8	5.6	1.04	1.00	5.8	5.8	5.6	1.04	1.00
4	5.3	5.3	4.9	1.08	1.00	5.3	5.3	4.9	1.08	1.00
5	3.2	3.2	3.2	1.00	1.00	3.2	3.2	3.2	1.00	1.00
6	2.6	2.6	2.6	1.00	1.00	2.6	2.6	2.6	1.00	1.00
7	2.0	2.0	1.9	1.05	1.00	2.0	2.0	1.9	1.05	1.00
8	4.3	4.3	4.1	1.05	1.00	4.3	4.3	4.1	1.05	1.00
9	3.6	3.6	3.6	1.00	1.00	3.6	3.6	3.6	1.00	1.00
10	8.3	8.3	8.4	0.99	1.00	8.3	8.3	8.4	0.99	1.00
11	2.4	2.4	2.4	1.00	1.00	2.4	2.4	2.4	1.00	1.00
12	16.6	16.6	16.8	0.99	1.00	16.6	16.6	16.8	0.99	1.00
13	4.4	4.4	4.6	0.96	1.00	4.4	4.4	4.6	0.96	1.00
14	2.0	2.0	2.1	0.95	1.00	2.0	2.0	2.1	0.95	1.00
15	-	-	-	-	-	-	-	-	-	-
Total	100.1	100.1	99.9			100.1	100.1	99.9		

Objective Function, National Constraints, and Transfer Activities

The value of the objective functions of Solution I and Solution II are, resepctively, $13,165,465,560 and $13,562,117,950, both higher than the value of Eyvindson's, $13,115,839,810 (1970). Subtracting the wage in broiler production,[1] about $64 million, from both solutions results in $13,101 million and $13,498 million. Then, the cost of Solution I is already lower than Eyvindson's. Further subtracting the cost of broiler production (without wage), about $432 million, from Solutions I and II results in, respectively, $12,670 million and $13,067 million, -- both lower than Eyvindson's $13,116 million. None of Solution I and II is identical to Eyvindson's model in both final demand and the assumption about non-grain-fed beef substitution. If Solution II were allowed to substitute grain-fed beef for non-grain-fed beef, its final demand and basic assumptions would be the same as Eyvindson's model. But substitution of grain-fed beef for non-grain-fed beef would further reduce the total cost (otherwise such substitution activities would not have entered Solution I which allows such substitutions). Therefore, both solutions definitely have a lower total cost than Eyvindson's.

Eyvindon's model contains three farm sizes. Generally, farm size 1 has the economy of scale in crop and livestock production and has the highest rate of resource utilization among the 3 farm sizes in Eyvindson's solution (see Eyvindson, 1970). The present study contains only one farm size, with coefficients being the weighted average of the 3 farm sizes in

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[1]Wage is allowed in broiler production only. (See the section on data on broilers, Chapter IV.)

Eyvindson's model. The explanations for the lower cost of both solutions than Eyvindson's lie in the more abundant land resource in the present study than in Eyvindson's. Obviously, more high quality land input in the present model outweighs more large size farm operation in Eyvindson's model in the effect of reducing total production cost.

Solution II carries a higher cost than Solution I because of (a) greater demand for wheat and feed grains for human consumption and (b) non-substitution of grain-fed beef for non-grain-fed beef. (See the section on beef.)

National constraints

The shadow prices of all the five national constraints in Solution I are higher than those in Solution II (Table 64) because (a) there are more cotton land planted to cotton in Solution I and any further increase in demand will have to be met from lower quality cotton land in Solution I than in Solution II, thus incurring higher production cost, and (b) Solution I has a greater demand for concentrate feeds owing to more grain-fed beef produced, which leads, therefore, to higher shadow prices of the exogenous concentrates.

Transfer activities

The transfer activities on the regional level, such as transferring grains into feeds, etc. are shown in Tables A-4 and A-14 in the Appendix and in various commodity balance sheets. Transfer activities on the area level, such as converting pasture and hiring labor, are shown in Tables A-5 and A-15.

Table 64. Shadow prices of national constraints (unit: dollar)

Constraints	Unit	Solution I	Solution II
Cotton	CWT	17.13	16.90
Exogenous Feeds F1	1,000 lbs. TDN	23.92	22.62
Exogenous Feeds F2	1,000 lbs. TDN	29.00	25.03
Exogenous Feeds F3	1,000 lbs. TDN	11.68	10.52
Exogenous Feeds F4	1,000 lbs. TDN	17.72	16.77

Pasture converted from crop-hay land Solution II converts 8.7 million more acres of land into pasture than Solution I, owing to the greater demand for pasture by more beef cows, yearlings, and dairy cows (See Table 65 and the section on beef cows). The distribution of such converted pasture does not seem much related to that of cattle population. It reflects rather the relative scarcity of pasture in each region. For instance, Region 12 (Southern Plains), a major cattle-producing region, has a regionl share of 6% of the total national coverted pasture in Solution I. The cost advantage in grazing cattle clearly lies in Regions 11 (Northern Plains), 12, and 14 (Southwest), the first two regions being major beef cows producers (see Table 66).

Hired labor Table 67 shows there are more hired labor in crop season than in non-crop season because of the demand for labor by crop activities in addition to that by livestock activities. All the regions hiring crop-season labor have longer growing season (Florida,

Table 65. Pasture converted from crop-hay land

Region No.	Acreage (unit: acre) Solution I	%	Solution II	%	Production (unit: AUM) Solution I	%	Solution II	%
1	-	-	-	-	-	-	-	-
2	1,442,598	9.3	1,390,378	5.7	4,698,262	8.8	4,545,779	5.9
3	-	-	-	-	-	-	-	-
4	-	-	77,190	0.3	-	-	371,284	0.5
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	24,524	0.2	425,402	1.7	117,960	0.2	1,706,084	2.2
8	-	-	-	-	-	-	-	-
9	1,832,109	11.8	3,653,050	15.0	6,840,544	12.8	10,943,380	14.2
10	620,717	4.0	1,286,694	5.3	3,053,926	5.7	5,157,924	6.7
11	10,366,290	66.5	13,566,800	55.8	33,343,620	62.4	38,435,220	49.9
12	933,961	6.0	2,320,732	9.5	3,919,348	7.3	10,093,350	13.1
13	-	-	160,100	0.7	-	-	377,724	0.5
14	365,439	2.3	1,435,035	5.9	1,427,759	2.7	5,386,700	7.0
15	-	-	-	-	-	-	-	-
Total	15,585,640	100.1	24,315,380	99.9	53,401,390	99.9	77,017,400	100.0

Table 66. Cost advantage index and yield index, pasture converted from crop-hay land

Region No.	Solution I (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index	Solution II (1) Acreage %	(2) Yield %	(3) Cost %	(2)/(3) Cost advantage index	(2)/(1) Yield index
1	-	-	-	-	-	-	-	-	-	-
2	9.3	8.8	13.9	0.63	0.95	5.7	5.8	7.8	0.74	1.02
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	0.3	0.5	0.7	0.71	1.67
5	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	0.2	0.2	0.4	0.50	1.00	1.7	2.2	3.7	0.59	1.29
8	-	-	-	-	-	-	-	-	-	-
9	11.8	12.8	14.7	0.87	1.08	15.0	15.7	19.5	0.81	1.05
10	4.0	5.7	7.3	0.78	1.43	5.3	6.5	8.8	0.74	1.23
11	66.5	62.4	55.9	1.12	0.94	55.8	48.8	44.8	1.09	0.87
12	6.0	7.3	5.3	1.38	1.22	9.5	12.8	8.3	1.54	1.35
13	-	-	-	-	-	0.7	0.5	0.7	0.71	0.71
14	2.3	2.7	2.6	1.04	1.17	5.9	7.3	5.7	1.28	1.24
15	-	-	-	-	-	-	-	-	-	-
Total	100.1	99.9	100.1			99.9	100.1	100.0		

Table 67. Hired labor, crop-season and non-crop-season (unit: 10 hours)

Region No.	Hired crop-season labor				Hired non-crop-season labor			
	Solution I	%	Solution II	%	Solution I	%	Solution II	%
1	-	-	-	-	41,410	2.7	32,839	1.7
2	-	-	-	-	572,810	37.0	499,294	26.2
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	14,958	0.1	58,818	3.8	132,566	7.0
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	5,809	0.0	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
11	-	-	-	-	644,548	41.6	866,678	45.5
12	7,660,450	64.2	7,553,800	64.1	-	-	-	-
13	-	-	-	-	-	-	135,675	7.1
14	3,290,781	27.6	3,527,580	29.9	231,833	15.0	235,858	12.4
15	978,182	8.2	691,584	5.9	-	-	-	-
Total	11,929,413	100.0	11,787,922	100.0	1,549,419	100.1	1,902,910	99.9

Southern Plains, Southwest, and California). Hired labor has the effect of increasing the shadow price of labor in the producing area. For instance, in Area 30 (Ohio) of Region 2, both the crop-season labor and the non-crop season labor constraints are binding, but the shadow price of non-crop-season labor ($0.78/hour) is much higher than that of crop-season labor ($0.11/hour), because of hired non-crop-season labor (for its dairy enterprise).

Hired labor is generally an indicator of the strength (cost advantage) of the hiring area (otherwise the area would not be able to afford hired labor). The occurence of hired labor confirms strong cost advantage of that enterprise for which the labor is hired.

The hired non-crop season labor is for (the activities of) dairy cows in Region 1 (Northeast), 2 (East Corn-Belt), and 13 (Northwest), for grain-fed beef in Region 5 (Florida), and for beef cows in Regions 11 (Northern Plains). The hired crop-season labor is for hay in Region 5 (Florida), for cotton in Region 8 (Delta), 12 (Southern Plains), and 15 (California), and for beef cows in Regions 12 (Southern Plains) and 14 (Southwest) in whcih Areas 49 (Arizona) and 55 (New Mexico) have a year-round growing season.

Feeds transfer The quantities of the four types of grains that are used as feeds are shown in Table 68. Solution I converts 20% more wheat into feeds than Solution II to feed the extra 4 million head of feeder cattle (see the section on beef cows). Both solutions use more wheat as feeds than Eyvindson's owing to the broiler activities included. All the three optimum solutions show as several times of wheat used as feeds as, but much less feed grains, soybeans, and cotton seeds used as

Table 68. Grains used as feeds

Crop	Unit	Solution I	Solution II	Solution E[a]	1965[a]
Wheat	1,000 bushels	484,451	406,720	377,707	68,711
Feed Grains	1,000 bushels	3,397,103[b]	3,313,004[b]	3,403,309	3,987,800
Soybeans	1,000 bushels	183,148	199,337	191,455	394,785
Cotton seeds	1,000 CWT	89,996	90,079	89,849	119,716

[a]Eyvindson, 1970, Table 20, P. 364. The original TDN unit was converted into the units used here. Feed grain TDN were converted into bushels of corn equivalent.

[b]Feed grain TDN were converted into component crops in TDN according to each region's weights of such component crops in TDN. Each component crop was then converted from TDN into bushels for summing up.

feeds than, the actual 1965 figures. As pointed earlier, the government wheat program has sustained the price of wheat and thus deters its increased use as feeds. Increased use of wheat as feeds in the solutions leads to reduced consumptions of feed grains and soybeans as feeds. Cotton seeds production is predetermined by the prescribed national cotton demand. Despite the exact same quantity of cotton produced in both solutions, Solution II produces roughly 0.1% more cotton seeds than Solution I, because more cotton is produced in Solution II than in Solution I in the high-yield cotton land in Southern California (Area 117, Region 15) which produces cotton with a higher cotton seed TDN/cotton lint ratio (6.50 CWT TDN/12.87 CWT lint = 0.556) than cotton produced in central Oklahoma (Area 88, Region 12) (1.77 CWT TDN/3.75 CWT lint = 0.472) in Solution I (to compensate for reduced cotton production in Southern California) (see the section on cotton).

All concentrate feeds are expressed in TDN in Table 69a to facilitate summation of different grains for comparisons. More TDN but less roughage are consumed in Solution I than in Solution II, in consistency with the assumption of substituting grain-fed beef for non-grain-fed beef in Solution I. But Eyvindson's solution (1970) calls for more TDN than Solution I despite the latter's inclusion of one extra enterprise -- broilers. Checking Eyvindson's solution on feeder cattle reveals that more feeder cattle are produced under the feeding plans of calf on extended silage and calf on silage, and less feeder cattle are produced under the plan of calf on deferred feeding, in his solution than in Solution I (see Table 69b). Since the plan of deferred feeding consumes the least TDN among the seven feeder cattle fattening plans, less TDN and more roughage are

Table 69a. Feeds, concentrates and roughage

Crop	Unit	Solution I	Solution II	Solution E[a]	1965[a]
Wheat	1,000 tons TDN	11,626.8	9,761.3	9,079.5	1,651.7
Feed grains	1,000 tons TDN	71,757.8	68,726.3	74,872.8	87,731.6
Soy beans	1,000 tons TDN	3,340.6	3,635.9	3,493.7	7,204.1
Cotton seeds	1,000 tons TDN	1,444.5	1,445.9	1,442.2	1,921.6
Total grains and oil seeds	1,000 tons TDN	88,169.7	83,569.4	88,888.2	98,509.0
Silage	1,000 tons hay equivalent	24,335.7	25,020.5	24,880.6	34,128.0
Hay	1,000 tons	122,544.9	129,428.8	117,979.3	119,406.0
Total roughage	1,000 tons hay equivalent	146,880.6	154,449.3	142,859.9	153,534.0

[a]Eyvindson, 1970, Table 20, p.364.

consumed in Solution I than in Eyvindson's solution.

Table 69b. Feeder cattle produced under various feeding plans

Feeding plans	Solution I	Solution E
(a) Deferred	19,921,050	18,174,400
(b) Extended silage	1,820,669	743,800
(c) On silage	2,121,577	4,838,300
Sum of (b) and (c)	3,942,246	5,582,100

Overall Cost Advantage Index

Since a region may have a strong cost advantage in producing one commodity and a weak one in producing another, it would be desirable and informative to compute an overall cost advantage index for a region by weighting the cost advantage indices of all the commodities it produces by their values. However, since the cost coefficients of livestock activities from which the cost advantage indices for livestock products are computed do not contain cost of feeds (an intermediate product which may be imported from other regions), the overall livestock cost advantage index does not reflect any cost advantage or disadvantage of producing feeds, and is therefore computed separately from the overall crop cost advantage index.[1] However, such a dichotomy has its analytical advantage.

Tables 70 and 71 (Solution I) show the proportions of value of crops

[1]It is impossible to compute the true cost advantage indices for livestock products without involving massive computations and estimations because of the pooling of different feedstuff from different production sources.

Table 70. Regional overall cost advantage index for crops, and percentage of value of crops, Solution I

Region No.	Cotton % of value	Cotton Cost advantage index	Wheat % of value	Wheat Cost advantage index	Feed Grains % of value	Feed Grains Cost advantage index	Soybeans % of value	Soybeans Cost advantage index
1	-	-	1.82 (0.3)	0.60	27.61 (2.2)	0.61	4.14 (1.3)	0.65
2	-	-	7.54 (4.9)	0.86	52.57 (14.5)	0.91	12.67 (14.0)	0.88
3	3.22 (0.1)	1.00	-	-	-	-	-	-
4	43.92 (3.6)	0.84	12.19 (0.7)	0.70	0.08 (0.02)	-	2.95 (0.3)	0.75
5	-	-	-	-	-	-	-	-
6	-	-	6.08 (0.2)	0.67	14.03 (0.2)	0.67	5.95 (0.3)	0.75
7	61.81 (5.0)	0.88	-	-	-	-	-	-
8	58.03 (29.9)	0.90	9.50 (3.5)	0.83	0.08 (0.1)	0.67	23.95 (14.8)	0.85
9	-	-	16.87 (9.5)	1.10	34.38 (8.2)	1.04	5.84 (5.6)	0.89
10	2.12 (5.0)	0.85	7.61 (12.8)	0.96	60.34 (43.0)	1.10	20.89 (59.8)	1.12
11	-	-	33.38 (28.9)	1.09	36.64 (13.4)	0.96	2.56 (3.8)	0.88
12	37.14 (43.6)	1.12	18.30 (15.2)	0.89	31.76 (11.2)	0.93	-	-
13	-	-	53.64 (20.8)	1.08	11.54 (1.9)	1.21	-	-
14	34.84 (11.8)	1.09	7.80 (1.9)	0.90	27.52 (2.8)	0.85	-	-
15	5.51 (0.9)	1.12	11.19 (1.3)	0.93	45.22 (2.3)	0.82	-	-
% of Total value	11.70		16.56		39.10		9.74	

Table 70. (continued)

Silage		Tame Hay		Wild Hay		All Crops	Regional
% of value	Cost advantage index	% of value	Cost advantage index	% of value	Cost advantage index	% of total value	cost advantage index
1.81 (1.4)	0.56	64.59 (10.8)	0.82	-	-	(3.2)	74.60
3.26 (8.8)	0.87	23.96 (13.6)	1.05	-	-	(10.7)	93.47
25.26 (2.6)	0.52	71.50 (1.5)	0.60	-	-	(0.4)	59.26
6.58 (1.6)	0.76	33.52 (1.7)	0.81	-	-	(1.0)	79.79
-	-	100.00 (0.2)	0.67	-	-	(0.05)	67.00
3.05 (0.4)	0.67	70.88 (2.1)	0.78	-	-	(0.6)	75.27
3.46 (0.8)	0.73	34.73 (1.7)	0.77	-	-	(0.9)	83.66
1.04 (1.6)	0.80	6.65 (2.1)	0.81	0.07 (4.9)	0.96	(6.0)	86.81
8.42 (19.9)	0.87	34.49 (17.1)	1.20	0.02 (2.0)	1.05	(9.3)	108.24
1.60 (11.3)	0.99	7.45 (11.0)	0.99	0.01 (4.4)	0.86	(27.65)	107.85
4.76 (17.2)	1.27	20.15 (15.3)	1.30	2.58 (44.1)	1.14	(14.3)	108.24
3.89 (13.5)	1.15	8.91 (6.5)	0.79	0.85 (14.3)	0.91	(13.6)	99.71
3.03 (4.9)	1.26	28.75 (9.7)	0.98	3.04 (23.9)	0.92	(6.4)	106.68
12.33 (12.3)	1.34	16.48 (3.4)	0.94	1.02 (4.9)	0.84	(4.0)	101.26
7.67 (3.8)	0.93	29.74 (3.1)	1.15	0.68 (1.6)	0.89	(2.0)	95.60
3.97		18.91		0.82		100.00 (100.00)	

Table 71. Regional overall cost advantage index for livestock products, Solution I

Region No.	Hogs % of value	Hogs Cost advantage index	Broilers % of value	Broilers Cost advantage index	Milk % of value	Milk Cost advantage index
1	-	-	23.58 (28.4)	1.01	63.59 (16.4)	0.92
2	32.60 (21.8)	1.02	5.45 (11.2)	0.97	47.17 (20.9)	1.09
3	-	-	23.39 (5.8)	1.04	40.87 (2.2)	1.06
4	-	-	16.46 (5.3)	1.08	18.93 (1.3)	0.73
5	-	-	29.53 (3.2)	1.00	25.85 (0.6)	0.63
6	-	-	10.20 (2.6)	1.00	33.40 (1.8)	1.00
7	6.14 (0.5)	1.00	8.33 (2.0)	1.05	40.24 (2.1)	0.95
8	9.72 (0.9)	1.00	14.38 (4.3)	1.05	25.35 (1.6)	0.88
9	6.37 (4.2)	1.02	2.31 (3.6)	1.00	70.62 (23.6)	1.00
10	55.76 (47.4)	1.02	3.18 8.3)	0.99	17.12 (9.6)	0.97
11	32.46 (21.0)	0.95	1.17 (2.4)	1.00	7.46 (3.2)	0.80
12	-	-	10.89 (16.6)	0.99	12.46 (4.1)	1.00
13	14.01 (4.1)	0.89	4.83 (4.4)	0.96	31.48 (6.1)	1.09
14	-	-	3.99 (2.0)	0.95	16.39 (1.7)	1.14
15	-	-	-	-	90.10 (4.8)	1.21
% of Total value	21.92		7.10		33.10	

Table 71. (Continued)

Grain-fed beef		Non-grain-fed beef		All livestock regional	
% of value	Cost advantage index	% of value	Cost advantage index	% of total	Cost advantage index
8.40 (2.2)	0.73	4.43 (6.5)	0.58	8.55	91.02
10.27 (4.7)	0.75	4.52 (11.3)	0.76	14.65	101.09
32.65 (1.8)	0.95	3.09 (0.9)	0.69	1.76	100.80
60.18 (4.3)	0.93	4.42 (1.7)	0.89	2.28	91.50
36.66 (0.9)	1.00	7.95 (1.0)	0.71	0.77	88.12
53.74 (3.0)	0.91	2.67 (0.8)	0.57	1.81	94.03
42.13 (2.3)	1.05	3.16 (0.9)	0.60	1.72	99.25
38.75 (2.5)	0.83	11.80 (4.2)	1.08	2.11	92.03
10.35 (3.6)	0.80	8.35 (15.7)	0.75	11.05	93.97
20.80 (12.1)	0.82	3.14 (10.0)	1.06	18.65	99.81
52.53 (23.3)	0.88	6.37 (15.4)	1.54	14.21	94.01
68.61 (23.1)	1.17	8.04 (14.8)	1.56	10.80	116.06
42.11 (8.4)	1.71	7.57 (8.3)	1.28	6.42	133.12
70.56 (7.7)	1.79	9.06 (5.4)	1.50	3.48	162.37
-	-	9.90 (3.0)	1.20	1.75	120.90
32.02		5.87		100.00 (100.00)	

and livestock products, respectively, in each region, weighted by their cost advantage indices to obtain the overall cost advantage index for crops and livestock, separately, for each region in Solution I. In both tables, the regional shares (in parentheses) of the national total value of a product read vertically, and the product percentages (not in parentheses) of the regional total value of production read horizontally.

A joint reading of these two tables, with frequent reference to locational advantage (or disadvantage) of particular regions (see Figure 2) and to opportunity costs (shadow prices) at both the regional level (see the tables of "balance sheet" of commodities) and the area level (see Tables A-3 and A-13), will reveal the complementary relationships between crops and livestock and the explanations why the distributions of livestock productions are such.

An efficient feed producer tends also to be an efficient producer of livestock using the type of feeds produced. Or a moderately efficient livestock producer may be compensated by very efficient production of feeds, or vice versa, and thus becomes a major livestock producer. Or locational advantage may compensate production inefficiency and permit a less efficient region to compete with more efficient but distant regions in supplying to nearby consumption centers. Since commodities not produced in a region do not enter into the computation of the overall cost advantage index for the region, the index represents the strength of a region in the framework of a spatial equilibrium.

The solution I overall cost advantage indices for crops seem to conform with the actual strength of agricultural production. The Midwest regions (9, Minnesota-Wisconsin; 10, West Corn Belt; 11, Northern Plains) have the strongest overall cost advantages (indices: 108.24, 107.85, and 108.24, respectively) in crop productions. Each region has its strong cost advantage in the major crop(s) it produces and also in the crops related to its major livestock activities.

For instance Region 9 has a strong cost advantage in the productions of its major crops -- tame hay (index 1.20; 34.5%) and feed grains (index 1.04; 34.4%), both essential inputs to its eminent dairy industry (70.6%).[1] It also has a strong cost advantage in producing wheat (index 1.10; 16.9%) and exports it to deficit regions on the east coast (Northeast and Mid-Atlantic). Region 10 (West Corn Belt) has its strongest cost advantage in producing soybeans (index 1.12; 20.9%), feed grains (index 1.10; 60.3%), both being essential inputs to its prominent hog production activity (55.8%).

Region 11 (Northern Plains) has a very strong cost advantage in producing tame hay (index 1.30; 20.2%), silage (index 1.27; 4.8%), and wheat (index 1.09; 33.4%), both the cost advantage indices of hay and wheat being the highest among the regions. In this region the most important crop, feed grains (36.6%), has a moderate cost advantage (index 0.96). The strong cost advantage in silage and hay and a moderate cost advantage in feed grains make Region 11 a major grain-fed beef producer and exporter. Additional locational advantage permits it to be the second major pork producer to supply pork to the western regions.

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[1]The percentage indicates the proportion of the value of the crop (or livestock product) among all crops (or livestock products) produced in the region.

Region 12 (Southern Plains)'s strong cost advantage in silage (index 1.15; 3.9%) and moderate cost advantage in feed grains (index 0.93; 31.8%), together with a strong cost advantage in rearing feeder cattle (index 1.17; 68.6%) and beef cows (index 1.56), makes it an equally important grain-fed beef producer as Region 11. Region 12 also has the strongest cost advantage in cotton production (index 1.12; 37.1%) and is the major cotton producer of the country.

Region 13 (Northwest) derives its strong overall cost advantage (index 1.07) from wheat (index 1.08; 53.6%) and feed grains (index 1.21; 11.5%) production. With a very strong cost advantage in silage (index 1.26; 3.0%) and a moderately strong cost advantage in tame hay (index 0.98; 28.8%), in addition to that of feed grains, Region 13 produces grain-fed beef (index 1.71; 42.1%) and fluid milk (index 1.09; 31.5%), both also for export to Region 15 (Calfornia), and pork (index 0.89; 14.0%) for local consumption. Areas in this region have binding labor and class 1 land constraints. This, together with its locational disadvantage with respect to the major consumption centers of the country, explains why it does not play a more important role than it does now in agricultural production in the solution.

Region 14 (Southwest) has a moderately strong overall cost advantage in crop production with its greatest cost advantage in silage and cotton production, both attributable partly to the benefit of irrigation. Its strong cost advantage in silage (index 1.34; 12.3%) and grain-fed beef production (index 1.79; 70.6%) makes grain-fed beef its most important livestock product.

The three Midwest region (9, 10, and 11) and Region 13 (northwest) not only have the strongest overall cost advantages, but also are major crop-producing regions. The other two important crop producing regions, No. 2 (East Corn-Belt) and No. 12 (Southern Plains) also have moderately strong overall cost advantage. A high correlation exists between the overall cost advantage and the share of national production value of a region. This is also generally true of individual crops. For instance, Southern Plains (Region 12), with its strong cost advantage in cotton production (index 1.12), has the greatest share of the national cotton production (43.6%). West Corn Belt (Region 10) produces the greatest share of feed grains (43.0%) and soybeans (59.8%). Northern Plains (Region 11) is the leading region in the production of wheat (28.9%), silage (17.2%), tame hay (15.3%), and wild hay (44.1%). Their cost advantage indices for the respective crops are among the highest, if not the highest, in the nation.

Regions with similar or stronger cost advantage than the above-mentioned major regions may produce a very small share of the crop in question because of either binding resource constraints or locational disadvantage or high opportunity cost of resources exerted by competing activities, or a combination of these. Examples to this have been given in the sections on individual crops.

As to the relationships between crop and livestock distributions, regions producing milk as their major livestock product grow hay and feed grains as their major crops, for instances, Regions 1 (Northeast) and 15 (California). Leading feed grain producers are also leading pork producers, such as Regions 10 (West Corn Belt), 2 (East Corn Belt), and 11 (Northern Plains).

Since silage and tame hay are interchangeable as roughage, their proportions vary according to their relative production cost. The ratio of total silage production to total hay production is roughly 1 to 5. Less cropland than crop-hay land available in each region and the existence of other crops competing for cropland also partly account for such a ratio.

Except for cotton and most final livestock products whose demand, and hence productions, are predetermined, the crops used as concentrate feeds (or as roughage) are interchangeable. Their productions and substitutions of one for another are dictated by the model's economizing scheme.

Since wheat, feed grains, and soybeans are inter-substitutable as concentrate feeds, their production variations from the actual 1965 figure are examples of the model's economizing scheme. Table 72a shows the actual 1965 production proportions among crops within regions as well as within the country. Percentage-wise the model recommend an increase in wheat and tame hay production, but a reduction in feed grains, soybeans, silage, and wild hay. Substituting wheat for feed grains and soybeans, and concentrating on the deferred feeding plan of feeder cattle activities in producing grain-fed beef lead to greater demand for wheat and hay. But the leading production regions of each crop in solution I are identical to the actual 1965 data: cotton in Region 12 (Southern Plains); wheat and wild hay in Region 11 (Northern Plains); feed grains and soybeans in Region 10 (West Corn Belt); and silage in Region 9 (Minnesota-Wisconsin), except in the case of tame hay the leading region of which is Region 9 (Minnesota-Wisconsin) in the solution, instead of Region 10 (West Corn

Table 72a. Percentage of value of crops produced in 1965

Region No.	Cotton	Wheat	Feed Grains	Soybean	Silage	Tame Hay	Wild Hay	All Crops % of total value
1	-	5.70	31.19	4.01	17.03	41.80	-	
		(2.1)	(2.8)	(1.2)	(13.9)	(10.1)		(3.85)
2	-	8.06	54.61	20.64	4.11	12.59	-	
		(7.8)	(13.2)	(16.6)	(8.8)	(8.1)		(10.25)
3	8.38	3.46	44.27	17.14	8.94	17.82	-	
	(1.5)	(0.7)	(2.3)	(2.9)	(4.1)	(2.4)		(2.19)
4	49.24	1.23	26.24	12.19	2.25	8.81	-	
	(11.8)	(0.3)	(1.9)	(2.9)	(1.4)	(1.6)		(2.99)
5	6.78	2.34	56.49	15.50	2.77	16.13	-	
	(0.1)	(0.0)	(2.6)	(0.2)	(0.1)	(0.2)		(0.20)
6	20.74	2.93	31.89	14.11	4.54	25.79	-	
	(3.0)	(0.5)	(1.3)	(2.0)	(1.7)	(2.9)		(1.79)
7	27.87	2.68	28.29	15.37	4.54	21.24	-	
	(2.7)	(0.3)	(0.8)	(1.5)	(1.2)	(1.6)		(1.22)
8	56.29	1.95	3.18	30.91	1.02	6.65	-	
	(26.6)	(1.1)	(0.4)	(14.3)	(1.3)	(2.5)		(5.93)
9	-	2.24	48.86	10.64	11.84	25.85	0.58	
		(1.9)	(10.1)	(7.3)	(21.6)	(14.1)	(5.1)	(8.74)
10	1.37	3.05	58.84	24.24	2.69	9.81	-	
	(2.6)	(6.9)	(33.1)	(45.3)	(13.4)	(14.6)		(23.85)
11	-	24.33	48.14	4.02	6.00	13.68	3.83	
		(38.4)	(18.9)	(5.2)	(20.9)	(14.3)	(64.1)	(16.68)
12	38.88	15.50	35.90	0.65	1.00	7.52	0.54	
	(33.6)	(15.9)	(9.2)	(0.5)	(2.3)	(5.1)	(5.9)	(10.84
13	-	44.35	16.71	-	2.70	33.05	3.19	
		(20.9)	(2.0)		(2.8)	(10.3)	(10.0)	(4.98)
14	27.55	8.70	23.93	-	7.60	29.81	2.41	
	(6.8)	(2.6)	(1.7)		(4.9)	(5.8)	(7.5)	(3.10)
15	41.73	1.75	23.54	-	2.50	30.04	0.45	
	(11.3)	(0.6)	(1.9)		(1.8)	(6.4)	(1.5)	(3.39)
% of Total Value	12.52	10.56	42.37	12.77	4.80	15.98	1.00	100.00
								(100.00)

Belt) in actuality, obviously due to the upward shift of dairy activity in Region 9 and the downward shift of grain-fed beef activity in Region 10 in the solution, the latter being caused in turn by upward shifts in feed grain and soybean productions in the region.

As noted before, the concept of cost advantage of livestock production does not include feed cost. Therefore, the overall cost advantage index refers to the cost of "managing" livestock as opposed to the cost of feeding them. As shown in Table 71, the western and southwestern regions have the strongest overall cost advantage which is derived mostly from the economy of scale in producing grain-fed beef in large herds. Regions 12 (Southern Plains) and 14 (Southwest) produce chiefly grain-fed beef (68.6% and 70.6%, respectively) while Region 13 (Northwest) produces mainly grain-fed beef and milk and Region 15 (California), milk (90.10%).

The strong cost advantage of managing a livestock activity does not always belong to the leading producing regions. Only in the case of hog production, the leading region (No. 10, West Corn Belt) has one of the strongest cost advantage. In other cases, low feeding cost and locational advantage may more than compensate for whatever relative cost disadvantage a region may have. For instance, Region 11, the leading region in grain-fed beef, has a rather weak cost advantage only to be bolstered by a very strong cost advantage in feeds to attain its leading role. More examples have been given in the sections on individual livestock products.

The overall regional advantage indices for crops in Solution II (Table 72b) are very similar to those in Solution I (Table 70), because of the same crop coefficients used. Region 5's (Florida) overall index shows

Table 72b. Regional overall cost advantage index for crops, and percentage of value of crops, Solution II

Region No.	Cotton		Wheat		Feed Grains		Soybeans	
	% of value	Cost advantage index	% of value	Cost advantage index	% of value	Cost advantage index	% of value	Cost advantage index
1	-	-	2.32 (0.4)	0.67	27.11 (2.5)	0.61	4.09 (1.3)	0.68
2	-	-	7.33 (4.8)	0.87	51.28 (15.1)	0.91	14.59 (15.7)	0.89
3	3.03 (0.1)	0.50	-	-	-	-	-	-
4	46.09 (3.7)	0.80	12.37 (0.7)	0.70	0.91 (0.0)	-	3.18 (0.3)	0.75
5	-	-	-	-	-	-	-	-
6	-	-	4.28 (0.2)	0.67	13.68 (0.3)	0.75	-	-
7	44.58 (3.9)	0.84	-	-	-	-	-	-
8	43.82 (25.3)	0.90	16.22 (4.9)	0.80	0.93 (0.2)	1.00	26.94 (13.4)	0.84
9	-	-	18.27 (10.6)	1.06	34.65 (9.8)	1.04	5.08 (4.9)	0.86
10	1.97 (4.8)	0.82	5.18 (8.8)	0.98	61.02 (47.4)	1.09	21.49 (60.5)	1.12
11	-	-	33.37 (29.2)	1.10	33.12 (11.5)	0.97	2.66 (3.8)	0.86
12	35.36 (38.9)	1.10	22.75 (17.7)	0.90	30.12 (0.9)	0.95	-	-
13	-	-	50.23 (19.7)	1.09	11.38 (2.4)	1.26	-	-
14	36.43 (11.7)	1.06	4.87 (1.5)	0.79	26.57 (2.2)	0.88	-	-
15	48.29 (11.6)	1.05	8.40 (1.4)	0.88	23.99 (1.7)	0.85	-	-
% of Total value	10.87		16.41		38.02		9.97	

Table 72b. (Continued)

Silage % of value	Silage Cost advantage index	Tame Hay % of value	Tame Hay Cost advantage index	Wild Hay % of value	Wild Hay Cost advantage index	All Crops % of total value	Regional cost advantage index
2.27 (1.8)	0.59	64.21 (10.4)	0.82	-	-	(3.18)	74.86
2.52 (6.7)	0.77	24.28 (13.3)	0.99	-	-	(10.74)	92.00
25.34 (2.7)	0.52	71.63 (1.6)	0.62	-	-	(0.43)	59.10
6.26 (1.4)	0.71	31.18 (1.5)	0.71	-	-	(0.94)	74.50
-	-	100.00 (0.1)	1.00	-	-	(0.01)	100.00
5.47 (1.1)	0.75	76.57 (3.3)	0.81	-	-	(0.85)	79.25
7.65 (1.9)	0.75	47.77 (2.5)	0.81	-	-	(1.01)	81.88
1.18 (1.4)	0.79	10.11 (2.6)	0.84	0.80 (3.9)	1.0	(4.97)	86.20
7.71 (18.1)	0.88	34.12 (16.6)	1.21	0.17 (1.6)	1.0	(9.55)	108.01
1.77 (12.2)	0.95	8.43 (12.0)	0.97	0.13 (3.6)	0.87	(28.08)	107.24
4.90 (17.4)	1.23	22.07 (16.2)	1.28	3.88 (55.6)	1.06	(14.43)	109.51
3.80 (12.0)	1.22	7.10 (4.6)	0.83	0.87 (11.0)	0.95	(12.80)	99.34
5.56 (8.8)	1.12	29.83 (9.8)	1.00	3.00 (19.3)	0.94	(6.46)	107.97
12.05 (11.1)	1.38	19.09 (3.6)	0.95	0.99 (3.7)	0.89	(3.75)	101.49
4.64 (3.2)	0.87	14.21 (2.0)	1.10	0.47 (1.3)	0.94	(2.80)	98.60
4.06		19.66		1.01		100.00 (100.00)	

Table 72c. Regional overall cost advantage index for livestock products, Solution II

Region No.	Hogs		Broilers		Milk	
	% of value	Cost advantage index	% of value	Cost advantage index	% of value	Cost advantage index
1	-	-	23.32 (28.4)	1.01	62.89 (14.2)	0.92
2	34.64 (21.8)	1.00	5.68 (11.2)	0.97	49.60 (22.1)	1.10
3	-	-	21.40 (5.8)	1.04	37.37 (1.9)	1.00
4	-	-	19.53 (5.3)	1.08	23.72 (1.2)	0.75
5	-	-	31.38 (3.2)	1.00	27.47 (0.5)	0.56
6	-	-	4.55 (2.6)	1.00	8.26 (0.9)	0.90
7	1.09 (0.1)	1.00	4.85 (2.0)	1.05	22.62 (1.7)	0.94
8	-	-	9.11 (4.3)	1.05	18.88 (1.7)	0.89
9	8.29 (4.2)	1.02	2.28 (3.6)	1.00	65.61 (25.5)	1.02
10	54.98 (44.8)	1.02	3.31 (4.3)	0.99	20.11 (10.7)	1.01
11	28.66 (17.5)	0.95	1.24 (2.4)	1.00	10.21 (4.3)	0.80
12	23.33 (7.3)	0.99	17.16 (16.6)	0.99	22.20 (4.6)	0.94
13	14.54 (4.1)	0.87	5.01 (4.4)	0.96	37.41 (6.3)	1.13
14	-	-	4.41 (2.0)	0.95	21.93 (2.1)	1.17
15	-	-	-	-	52.43 (2.3)	1.00
% of Total value	22.39		7.25		33.81	

Table 72c. (Continued)

Grain-fed beef		Non-grain-fed beef		All livestock	Regional
% of	Cost advantage index	% of Value	Cost advantage index	% of Total	Cost advantage index
9.28	0.91	4.51	0.38		91.57
(3.1)		(3.9)		(8.83	
3.95	0.88	6.69	0.67		102.67
(2.2)		(9.3)		(14.35)	
38.40	0.91	2.83	0.38		95.65
(2.9)		(0.5)		(1.96)	
49.94	1.03	6.81	0.57		94.20
(3.7)		(1.3)		(1.96)	
0.33	-	40.81	1.45		105.94
(0.0)		(2.9)		(0.74)	
82.46	1.04	4.73	2.11		107.72
(13.0)		(1.9)		(4.14)	
66.71	1.05	4.72	0.93		101.88
(7.7)		(1.4)		(3.01)	
52.31	1.13	19.70	1.86		122.12
(6.8)		(6.5)		(3.40)	
15.23	0.93	8.58	0.52		96.28
(6.6)		(9.5)		(11.40)	
15.51	0.91	6.09	1.03		100.05
(10.8)		(10.8)		(18.26)	
45.37	0.94	14.51	1.62		102.79
(23.7)		(19.3)		(13.70)	
20.33	1.02	16.97	1.06		99.68
(5.4)		(11.5)		(7.00)	
30.79	1.17	12.25	1.14		109.72
(7.4)		(7.5)		(6.32)	
55.06	1.18	18.60	1.53		123.28
(6.7)		(5.8)		(3.22)	
-	-	47.57	3.29		208.94
		(7.9)		(1.70)	
26.25		10.30		100.00	
				(99.99)	

a marked increase from Solution I to Solution II because more tame hay, the only crop produced in the region in both solutions, was produced in Solution I on marginal land (Classes 2 and 3) than in Solution II, thus lowering Solution I's overall cost advantage index. This illustrates the case where two identical sets of coefficients (of hay activities) result in different cost advantage indices because of variation of coefficients of other (livestock) activities (which affected the quantity of hay produced). It also shows a region's position of strong cost advantage will deteriorate if further expansion of production brings less efficient activities into the solution, because the cost advantage index is an indicator of the average strength of the region.

The overall cost advantage indices for livestock in Solution II (Table 72c) differ considerably from those in Solution I (Table 71) as coefficients in Solution I represent the weighted average of various herd sizes in the activities of dairy cows, beef cows, and feeder cattle, while those in Solution II are for the medium herd size only. Regions 5, 6, 7, and 8 in the Southeast register higher overall indices in Solution II than in Solution I due to their greater cost advantages in producing grain-fed beef and non-grain-fed beef in medium herd size in Solution I.

The Southeast

Both solutions show the Southeast (Regions 3-8) contracts in crop productions in comparison with the 1965 actual productions. The Southeast produces 9% and 8.2% of the total value of the national crop productions in Solutions I and II, respectively, but actually produced 14.3% in 1965 (see Table 72d).

Table 72d. The Southeast's share (percentage) of the total value of national crop production

Crops	Solution I	Solution II	1965
Cotton	38.6	33.0	45.7
Wheat	4.4	5.8	2.9
Feed grains	0.3	0.5	9.3
Soybeans	15.4	13.7	23.8
Silage	7.0	5.8	9.8
Tame hay	9.3	11.6	11.2
Wild hay	4.9	3.9	0
All crops	9.0	8.2	14.3

As discussed earlier, such a decline is due partly to the shifting of cotton production out of the Southeast into Southern Plains and the Southwest and partly to reduced production of soybeans and feed grains which are now more concentrated in Corn Belt. The increase of wheat in the Southeast is partly due to increased use of wheat as feeds.

In livestock productions, the Southeast's overall position is weakened in the solutions by the concentrations of pork production in Corn Belt and of manufactured milk production in the country's major dairy regions, and also by the assumption of same technology in broiler production for all regions (see Table 72e).

But the solutions call for much more grain-fed beef production than in 1965. In both solutions the Southeast is a net importer of feeder calves (for fattening into grain-fed beef) while in actuality it is

Table 72e. The Southeast's share (percentage) of the total value of national livestock production

Livestock	Solution I	Solution II	1965
Pork	1.4	0.1	12.9
Broilers	23.2	23.2	68.3
Milk	9.6	7.9	12.5
Grain-fed beef	14.8	34.1	3.9[a]
Non-grain-fed beef	9.5	14.5	20.0[b]
All livestock products	10.45	15.21	15.17

[a]Estimated by the number of feeder cattle.

[b]Estimated by the number of beef cows and dairy cows.

an exporter of calves. This implies that the Southeast's comparative advantage in producing grain-fed beef is not fully exploited. Considering the high proportion of small farms in this region, it seems that capital requirement, which is not included in the model, is one of the real world constraints hindering the expansion of grain-fed beef production in the Southeast. In the solutions, over 80 percent of grain-fed beef is produced under the deferred feeding plan which uses the least amount of concentrate feeds and the most heavy pasturing among the seven cattle fattening activities. It is the most economical feeder cattle fattening activity in general and producesall grain-fed beef in the Southeast.

In view of the Southeast's long growing season and deficiency in feed grains, the deferred feeding plan works to the benefit of the Southeast. It seems that the actual feeding practice in 1965 did not take full advantage of such a feeding plan.

Since 1965, there have been changes in the relative strength of various regions in beef production, not all of which due to uneven technological advance. Some of such shiftings were perhaps caused by promotions of beef production by the competing states through easy credit, reduced tax, etc.[1] Through time the average size of feed lots has been increasing, and there are signs that large-size feed lots are becoming economically more vertically integrated.

Upon incorporating the effects of such institutional changes, realized or imaginary, into the cost coefficients, the model would then be equipped to analyze regional competition in the new setting. Quantitative analysis about a new situation would, however, not be possible without actually solving the model based on the new coefficients.

In terms of the more permanent aspects of agriculture, the Southeast is less endowed in good quality soil and even topography for farming than the Midwest. Continuous cotton cultivation in the past has caused soil exhaustion and even erosions in some areas. It seems cover cropping, and hence together with cattle-raising, rather than row cropping, are the rational utilization of the land and the long growing season in the Southeast. (Dunn, 1962; Joint Committee on the Economic Report, 1949).

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[1]"From 1966 to 1970, Iowa beef cow numbers grew by approximately 2 percent per year. But from 1970 to 1971 the figure jumped 7 percent and from 1971 to 1972 the increase was a colossal 15 percent, the highest of any state. Part of the recent increase was thought to be due to the elimination of the property tax on cows. The Iowa Legislature dropped the tax in 1970." Iowa's money sources favor cow-calf herd loans, Des Moines Sunday Register, March 5, 1972, p. 1-F.

Location-wise, the Southeast with a quarter of the country's population within its own boundary, also has relatively easy market access to the Northeast, a great consumption center with another quarter of the country's population. Within the Southeast increasing income and deficit meat supply in the past have provided favorable markets for meat production.

Abundant farm labor at low wage and warm climate have attracted the broiler industry into the Southeast. The low wages are reflected in the strong cost advantage indices of producing broilers, for instance, Region 3 (Mid-Atlantic), 1.04; Region 4 (Southeast Atlantic), 1.08; Region 7 (Tennessee Valley), 1.05; and Region 8 (Delta), 1.05. Regions 5 (Florida) and 7 in Solution I and Regions 4, 6 (Kentucky), 7, and 8 in Solution II have cost advantage in producing grain-fed beef.

With the cost of feeds taken into account, the cost advantage indices in producing livestock products in these regions would be weakened because of either their weak cost advantage in feed production or their needs of importing feeds from the Midwest, thus incurring transportation cost. However, having a production activity in the solution means unmistakably a cost advantage over competing activities in other regions not in the soltuion. Apparently, the Southeast's cost advantage in rearing feeder cattle and its locational advantage in supplying to the major consumption center in the Northeast (Region 1) have overcome its disadvantage of importing feed grains from the Midwest.

Shadow Price

A shadow price is the effect on the value of the objective function per unit change in a (binding) constraint, be it a resource supply constraint or a consumption demand constraint. A shadow price occurs whenever a constraint is reached (i.e. it become binding). Each shadow price is effective for a range of the levels of a constraint, within which the constraint may vary, without effecting a change in the shadow price and the basis of the solution. A sensitivity analysis of a linear programming studies such a range.

The shadow prices of resources of all the producing areas within a consuming region are averaged (by the number of areas where a shadow price occurs) to provide some information that a shadow price on a regional level would perhaps provide. This is done for illustrative purpose and it may be called "pseudo-shadow price".[1] Shadow prices of area resources are shown in Tables A-3 and A-13 in the Appendix.

In the cost minimizing model, a unit change of a resource constraint leads to a change of the value of the objective function in the opposite direction, while a unit change of a demand constraint leads to a change of the value of the objective function in the same direction. Therefore, the shadow price of a resource represents the cost differential in producing given output between the (binding) resource in question (e.g. class 1 land) and the less efficient resource (e.g. class 2 land) whose use is to be increased by the reduction of one unit of the more efficient

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[1]For simplicity, the "pseudo-shadow price" on the regional or national level will be referred to in the text as shadow price, even though the resource constraint is on the area level, instead of the regional or national level.

one (e.g. class 1 land).

Table 73 shows such pseudo-shadow prices for land, pasture, and labor constraints for each region and the country.

Shadow price of land

From an economic planner's viewpoint a shadow price may serve as a criterion for investment in the binding resources, since it indicates how much one more unit of the binding resource will affect the value of the objective function. Therefore, he would logically recommend addition of the binding resource to the area where the shadow price has the greatest value.

Interpretations of Table 73 requires some explanations. A shadow price may exist for crop-hay land but not for cropland of the same class in an area. As explained in Chapter II, hay may grow in either cropland or crop-hay land while other crops can grow on only cropland; and crop-hay land is the sum of cropland and hay land. Therefore, when hay occupies all the crop-hay land, the crop-hay land becomes binding while cropland, being a separate constraint and not used by other crops, is completely "idle" in the face value and, hence, not finding, even though it is used up by hay.[1]

This can also be the case where cropland is not completely used up by crops other than hay, and hay uses up the remaining cropland and also all the hay land, thus causing a shadow price of the crop-hay land

[1]Crops using cropland are required to use an equal amount of the crop-hay land.

Table 73. Pseudo-shadow prices of resources for consuming regions and the U.S., Solution I (unit: $10)

Region No.	CHL1	CHL2	CHL3	CL1	CL2	CL3	CTNL	WHL	PASTU	LBCS	LBNCS
1	0.45	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.04	0.00	0.52
2	0.46	0.00	0.00	0.63	0.06	0.00	0.00	0.00	0.11	0.32	0.69
3	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.03	0.00	0.25
4	0.27	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.09	0.15	0.05
5	2.88	1.54	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.78
6	0.32	0.00	0.00	0.63	0.00	0.00	1.89	0.00	0.00	0.00	0.00
7	0.37	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.11	0.15	0.00
8	0.58	0.08	0.00	0.61	0.39	0.00	1.69	0.97	0.06	0.30	0.39
9	0.56	0.35	0.10	0.59	0.30	0.00	0.00	0.23	0.10	0.00	0.50
10	0.74	0.23	0.00	0.90	0.36	0.00	0.00	0.41	0.67	0.10	0.29
11	0.55	0.18	0.09	0.36	0.17	0.28	0.00	0.18	0.10	0.58	0.59
12	1.01	0.46	0.07	0.43	0.28	0.28	0.42	0.72	0.12	0.42	0.73
13	1.13	0.43	0.00	1.16	0.75	0.41	0.00	0.49	0.07	0.26	0.28
14	0.83	0.23	0.32	0.83	0.47	0.41	2.06	0.55	0.09	0.68	0.57
15	1.63	0.38	0.00	1.33	0.79	0.00	0.00	0.48	0.06	1.23	0.04
U.S.	0.84	0.43	0.14	0.65	0.40	0.35	1.27	0.50	0.08	0.37	0.44

to occur while leaving cropland without a shadow price.

Region 5 (Florida) illustrates the first case, while Region 7 (Tennessee Valley), the second.

As shown in Table 73, the shadow prices of land constraints drop rapidly with the decrease of quality. In some regions there are no shadow prices for classes 2 and 3 land. The highest shadow price for land constraints ($12.7) is for cotton land. Crop-hay land has a wider range of shadow prices among its three classes than cropland. The last unit of crop-hay land used is more likely to be hay land than cropland, and a change in crop-hay land will most probably affect hay production and thus cattle production (dairy cow, beef cow, or feeder cattle). Since hay has less mobility (restricted within a region) than grain, and its substitute, silage, has no mobility at all (restricted within an area), the severity of the binding constraint of the last unit of hay land is understandably greater than that of the last unit of cropland, whose products, grains, have complete mobility and are in most cases mutually substitutable when used as feeds.

An extraordinary example is the shadow price ($28.80) of class 1 crop-hay land in Area 16 in Region No. 5 (Florida) (in this case the other area in the region, No. 17, has no shadow price; therefore, Area 16's shadow price is identical to the region's pseudo-shadow price). This shadow price is extraordinary high. Area 16, which comprises the entire central and southern Florida and part of northern Florida, has only 11,871 acres of class 1 crop-hay land. With a regional consumption demand for beef and milk being in the magnitude of 2.5% of the national demand, and with a rather isolated corner location resembling an offshore island with less access to other parts of the country, Area 16 is under a great pressure of demand on its resources. The severe scarcity of a resource leads to such an unusually high shadow price.

In Region 7 (Tennesse Valley), the shadow prices of class 1 crop-hay land exist in Areas 133 to 138, but the class 1 cropland constraints in these areas are not binding. Yet part of class 1 cropland in these areas (except Area 138) is planted to silage in the hay-silage rotation system, with the rest of the cropland and all the hay land being planted to tame hay. Obviously the ratio of hay to silage in the hay-silage rotational system exceeds the ratio of hay land to cropland, and thus the crop-hay land is exhausted before cropland is.

More meaningful information can be derived from the resource shadow prices. For instance, the presence of shadow price of class 3 cropland in Regions 11 (Northern Plains), 12 (Southern Plains), 13 (Northwest) and 14 (Southwest) means all the cropland in some of the areas in these regions are exhausted -- an indication of greater pressure on cropland in these regions.

The crops that cause such pressure (i.e. grown on class 3 cropland) are wheat in Region 11 (Areas 72, 73 in Nebraska); chiefly wheat in Region 13 (Areas 28 in Idaho; Areas 102, 102, 104 in Montana; Area 105 in Wyoming; Areas 112, 112, 115 in Washington and Oregon); wheat in Areas 88, 89 (Oklahoma) and hay-silage in Area 100 (Texas) in Region 12; and feed grains and hay in Area 74 (Colorado) in Region 14.

There are other areas in these regions that do not produce any of the pressure-causing crops (i.e. wheat, etc.) or do not exhaust their class 1 cropland even when producing them. For instance, there is idle class 1 land in Area 63 (western North Dakota) of Region 11, which produces wheat. This implies the areas exhausting their class 3 cropland have a cost advantage over the areas which do not produce any wheat or which do not exhaust their class 1 cropland when producing wheat. The cost of producing wheat on class 3 cropland in Areas 72 and 73 in western Nebraska are, respectively, $\$1.35 \div 1.01 = \$1.34/1{,}000$ lbs. TDN, and $\$1.31 \div 0.96 = \$1.36/1{,}000$ lbs. TDN, while that on class 1 cropland in Area 63 in western North Dakota is $\$1.88 \div 1.1 = \$1.71/1{,}000$ lbs. TDN, higher than those in Areas 72 and 73.

The difference in the shadow prices of cotton land among regions is also reflected in the difference in the yield or output value of cotton. Regions 14 (Southwest) and 8 (Delta) are high-yield regions and have a high shadow prices ($20.6/acre and $16.90/acre, respectively), while Region 12 (Southern Plains) is a low yield region (though having a strong cost advantage) and has a low shadow price ($4.20/acre).

Region 10 (West Corn Belt) has the highest shadow price of pasture among the regions because in Areas 52 and 53 in Iowa pasture is the factor that really limits the beef cow and dairy cow activities in these two areas, in view of the presence of idle crop-reason and non-crop-season labor. The pressure of demand for pasture is further evidenced in Area 52 (southwestern half of Iowa)'s transferring all the pasture from the regional public grazing land for area use and in Area 53 (northeastern half of Iowa)'s converting 620,000 acres of class 2 crop-hay land into pasture.

Shadow price of labor

Shadow prices of labor are lacking in several regions, indicating that labor is not a binding constraint in these regions. For instance, there are idle labor in Region 7 during non-crop season and in Region 6 during both crop season and non-crop season. The shortage of crop-season labor is most severe in Region 15 (California) and limits its productions of milk as well as crops. The shortage of non-crop season labor limits the activities of beef cows and deferred feeder cattle in Area 16 (central lower Florida) in Region 5 (see Table A-3 and A-13).

Table 74 shows pseudo-shadow prices of resources in Solution II. Comparison of the resource shadow price of Solution II with those of Solution I reveals the differences caused by the assumptions of the two models. For instance, Area 16 in Region 5 (Florida) does not have the highest shadow price of class 1 crop-hay land in Solution II as it does in Solution I, because in Solution II it produces yearlings for slaughter to satisfy its demand for non-grain-fed beef while in Solution I it produces grain-fed beef which has a much greater demand for hay, the only crop produced in Area 16, which in turn exerts greater pressure on the resource of land. Another example: Region 7 (Tennessee Valley) produces much more grain-fed beef in Solution II (nearly 9 million CWT) than in Solution I (3.3 million CWT) and therefore exerts a greater pressure on its land resources in Solution II than in Solution I, and hence, a higher shadow price of class 1 crop-hay land in Solution I ($5.6) than in Solution II ($3.7). In general, Solution I has higher shadow price of classes 1 and 2 crop-hay land than Solution II not because more total hay is required and produced in Solution I, but because of greater variance

Table 74. Pseudo-shadow prices of resources for consuming regions and the U.S., Solution II (unit: $10)

Region No.	(Acre) CHL1	CHL2	CHL3	CL1	CL2	CL3	CTNL	WHL	(10 aums) PASTU	(10 hrs) LBCS	(10 hrs) LBNCS
1	0.58	0.06	-	0.47	-	-	-	-	0.05	0.04	0.57
2	0.56	-	-	0.87	0.26	-	-	-	0.13	0.38	0.71
3	0.20	-	-	-	-	-	0.33	-	0.03	-	0.36
4	0.43	-	-	0.22	-	-	-	-	0.09	0.13	0.15
5	1.18	-	-	-	-	-	-	-	0.01	0.48	0.78
6	0.40	-	-	0.57	-	-	1.49	-	0.04	-	-
7	0.56	0.07	-	-	-	-	0.74	-	0.10	0.13	-
8	0.55	0.12	0.08	0.65	0.33	-	1.31	1.02	0.11	0.40	0.40
9	0.70	0.27	0.28	0.71	0.34	0.16	-	0.31	0.13	-	0.61
10	1.05	0.43	0.06	0.65	0.31	-	-	0.63	0.08	0.11	0.38
11	0.55	0.27	0.15	0.41	0.19	0.33	-	0.14	0.13	0.51	0.64
12	0.94	0.40	0.13	0.38	0.32	0.37	0.75	0.67	0.16	0.40	0.73
13	1.21	0.52	0.04	1.04	0.70	0.42	-	0.53	0.11	0.28	0.37
14	0.87	0.24	0.21	1.14	0.65	0.38	2.42	0.53	0.13	0.56	0.60
15	1.53	-	-	0.83	0.72	-	-	0.45	0.10	1.23	-
U.S.	0.75	0.26	0.14	0.66	0.42	0.33	1.17	0.54	0.09	0.30	0.53

of the shadow prices which simply indicates more severe pressure on land resource in certain regions (e.g. Region 5, Florida).

The difference in shadow prices of crop-season labor and non-crop-season labor between the two solutions merits some explanations. The shortage of crop-season labor is more severe in Solution II. Recall the main difference in final products between these two solutions -- Solution I produces 30 million CWT more grain-fed beef (as substitute for non-grain-fed beef) than Solution II while Solution II maintain 4.5 million more beef cows to produce 3 million more calves as a source of non-grain-fed beef (see Tables 46 and 47).

Due to the above difference, Solution II requires about 29 million hours more labor than Solution I. Such greater pressure on the demand for labor leads to a higher shadow price of labor. This is so in the case of non-crop-season labor which shows a higher shadow prices in nearly all regions, and, hence, a higher national pseudo-shadow price in Solution II. But the situation with respect to crop-season labor is reversed. Explanations of this are not so straight forward as regarding non-crop-season labor because of the complications introduced by variations of crop activities in a region. Besides, even an activity variation in a single area may upset the pseudo-shadow price of a region as to affect the value of the national pseudo-shadow price.[1]

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[1]For instance, in Region 14, shadow prices of crop-season labor appear in five areas in Solution I but six areas in Solution II. And yet the pseudo-shadow price of Region 14 is higher ($0.68) in Solution I and lower ($0.56) in Solution II. Four areas (Nos. 49, 55, 107, and 109) have identical shadow prices in both Solutions I and II. But Area 106 has a shadow price higher in Solution I ($0.47) (due to more beef cows kept) than in Solution II ($0.34). Area (footnote continued on following page)

The average shadow prices (or pseudo-shadow prices) only approximate the regional or national situation. Comparison of the shadow prices of demand constraints (commodities) with those in Eyvindson's solution and the 1965 actual national average prices (Table 75) leads to the following observations:

The shadow prices of Solution I are consistently lower than those of Solution II and Eyvindson's. The greater pressure on labor and land resources in Solution II than in Solution I creates higher shadow prices of all products that use labor and land as inputs, directly or indirectly. (See the section on dairy cows.) The lower cost coefficients of dairy cows, beef cows, and feeder cattle in some regions, obtained from weighting various herd sizes and used in Solution I, than those of medium herd size used in Solution II, also partly account for the lower shadow prices of these products in Solution I.

Greater pressures on resources in Eyvindson's model, which consist of commercial farms only, have caused higher shadow prices. All the shadow prices are lower than the 1965 actual prices because the input shadow prices in the model are still lower than the actual rent and wages in 1965.

<u>Shadow prices of demand constraints</u>

As previously explained the shadow price of a regional demand (consumption) constraint is the change in the value of the objective function of the model per unit change in the level of the regional demand cons-

(footnote continued from previous page) 74 has a low shadow price in Solution II (caused by class 1 land feed grains production) but none in Solution I. A combination of these results in a higher pseudo-shadow price for Region 14 in Solution I.

Table 75. Shadow prices of demand constraints and 1965 prices

Product	Unit	Solution I	Solution II	Solution E[a]	1965 prices[a]
Wheat	$/bushel	0.82-1.27	0.87-1.22	0.95-1.49	1.35
Feed grain	$/bushel	0.56-0.98	0.59-0.96	0.76-1.25	1.16
Soybean	$/bushel	1.36-1.58	1.43-1.63	1.65-1.99	2.54
Cotton seeds	$/CWT	0.98-1.27	1.05-1.35	1.49-1.64	2.34
Feeder calves	$/head	63.28-71.20	70.69-77.40	87.55-92.01	93.12
Feeder yearlings	$/head	89.33-98.97	109.94-120.10	117.97-123.90	146.88
Grain-fed beef	$/carcass CWT	24.12-26.88	25.76-28.72	29.74-32.77	40.76
Non-grain-fed beef	$/carcass CWT	24.12-26.88	29.86-32.62	29.74-32.77	-
Pork	$/carcass CWT	15.11-18.07	15.52-18.48	19.15-22.08	33.72
Fluid milk	$/CWT	2.27-3.80	2.29-3.88	2.90-3.88	4.63
Manufactured milk	$/CWT, fluid milk equivalent	2.27-2.60	2.29-2.61	2.90-3.21	3.34
Broilers	$/CWT	14.30-16.03	14.64-16.69	-	20.97[b]

[a] Source: Eyvindson, 1970, Table 70, p.528

[b] Source: Agr. Statistics (USDA 1966). Price for live weight is converted into price for ready-to-cook weight used here.

Table 76. Shadow prices of minimum consumption constraints, consuming regions, Solution I(unit:$10)

Region No.	WHEAT (1,000 lbs. TDN)	FDGR[a] (1,000 lbs. TDN)	SOYBN (CWT TDN)	CTNSD (CWT TDN)	BFCALF (Head)	YRLCAF (Head)	BFGF (CWT)	BFOR (CWT)	PORK (CWT)	FMILK (1,000 lbs.)	MFGMK (1,000 lbs. FMILK)	BROILR (1,000 lbs.)
1	2.27	2.22	0.43	0.35	6.73	9.89	2.69	2.69	1.75	2.85	2.51	15.76
2	1.83	1.64	0.39	0.39	6.96	9.56	2.60	2.60	1.60	2.33	2.33	15.54
3	2.24	2.14	0.42	0.39	7.04	9.72	2.64	2.64	1.72	2.65	2.47	15.56
4	2.06	1.95	0.41	0.37	7.12	9.36	2.54	2.54	1.67	2.71	2.46	14.86
5	2.27	2.04	0.39	0.37	6.66	9.58	2.60	2.60	1.71	3.35	2.53	16.03
6	2.01	1.85	0.40	0.39	7.11	9.33	2.53	2.53	1.64	2.41	2.41	15.47
7	2.07	1.82	0.40	0.38	7.11	9.36	2.54	2.54	1.65	2.53	2.44	15.02
8	2.15	1.95	0.41	0.36	6.78	9.36	2.55	2.54	1.67	2.51	2.47	14.60
9	1.73	1.55	0.37	0.33	6.70	9.05	2.48	2.46	1.54	2.27	2.27	14.54
10	1.77	1.52	0.38	0.37	6.99	9.14	2.48	2.48	1.53	2.38	2.38	14.89
11	1.70	1.49	0.38	0.38	6.98	8.93	2.43	2.43	1.50	2.34	2.34	14.80
12	2.39	1.87	0.42	0.35	6.71	9.35	2.41	2.41	1.66	2.46	2.46	14.30
13	2.06	2.06	0.35	0.34	6.78	9.43	2.43	2.43	1.75	2.51	2.50	15.79
14	2.01	2.01	0.20	0.20	6.93	9.51	2.42	2.42	1.65	2.46	2.46	14.92
15	2.65	2.56	0.30	0.31	6.33	9.64	2.62	2.62	1.81	3.80	2.59	16.35

[a]FDGR: feed grain; SOYBN: soybean; CTNSD: cotton seed meal; BFCALF: beef calf; YRLCAF: yearling; BFGF: grain-fed beef; BFOR: nongrain-fed beef; FMILK: fluid milk; MFGMK: manufactured milk.

traint. In a surplus region, the shadow price of (the demand for) a commodity is its production cost coefficient plus whatever opportunity costs (shadow prices), if any, of inputs in the activity. (See Section Shadow Price Chapter III, and various commodity sections in this chapter.)

To cite one more example: The shadow price of grain-fed beef is the lowest in Region No. 12, the major surplus regions, and is the highest in Region No. 1, the major deficit region. Since Region No. 1 imports from Region Nos. 6, 11, 12, and 14, the shadow price in Region No. 1 reflects, instead of its own production cost, the production cost of any of the four regions exporting grain-fed beef to Region No. 1 plus opportunity costs, if any, of inputs, and the transport cost between the two regions. (See Table 76.)

As explained earlier, the shadow price can serve as a criterion for economic planning -- that is, in the present case, where to produce a unit of commodity in the least cost way, disregarding geographical consideration.

Resource Analysis

The resource constraints of land and labor in each producing area were computed at two levels: (1) the amount of land and labor available to commercial farms, and (2) the amount of land and labor available to all farms (commercial farms and small farms) used in this model (see Chapter II). Whether in the solution a resource in a producing area is exhausted (a binding constraint) or not (a non-binding constraint) is shown in Tables A-3 and A-13. But it would also be of interest to know the proportion of a resource used in a consuming region or even a larger geographical region. This will reveal the average extent of slackness, if any, in a region, and thus, the potential for future expansion of production should technology or demand change in favor of this region in the future. Table 77 shows such proportions, or ratios, for the Southeast and Midwest as well as at the national level.

Note that for any producing area (or region as shown in Tables 78 and 79) the ratio of resource used to resource available to all farms (R1 in Tables 78 and 79) for crop-hay land may be greater than, equal to, or less than the ratio of R1 for cropland (e.g. Region 13 in Table 79). Some explanations would be in order here, using the following symbols:

X = the amount of crop-hay land used,
Y = the amount of cropland land used,
CHL = the amount of crop-hay land available,
CL = the amount of cropland land available,
R1 = (resource used / resource available to all farms)
R2 = (resource used / resource available to commercial farms)
$R1_{CHLi} = (Xi / CHLi)$ (i=land class 1,2, and 3)
$R1_{CLi} = (Yi / CLi)$

By definition:

$$CHL \geq CL$$
$$CHL \geq X$$
$$CL \geq Y$$

By the structure of the model (see Section Linear Programming Matrix, Chapter III), $X \geq Y$ (i.e. whenever a unit of CL is used a unit of CHL is automatically used, but not vice versa).

Then $R1_{CHLi} = \frac{X}{CHLi} \gtreqless \frac{Y}{CLi} = R1_{CLi}$ (i=1,2,3)

For example: let CHL1 = 5 and CL1 = 4.

For X = 3, Y = 2: $\frac{3}{5} = \frac{X}{CHL1} > \frac{Y}{CL1} = \frac{2}{4}$

For X = 2, Y = 2: $\frac{2}{5} = \frac{X}{CHL1} < \frac{Y}{CHl} = \frac{2}{4}$

Table 77. Ratio of resource uses, Southeast, Midwest and National, Solution I[a]

Region	Ratio	CHL1	CHL2	CHL3	CL1	CL2	CL3	LBCS	LBNCS
Southeast	R1	0.607	0.244	0.098	0.423	0.266	0.008	0.627	0.324
	R2	0.730	0.290	0.125	0.507	0.313	0.010	1.322	0.585
	R3	1.203	1.192	1.277	1.199	1.178	1.254	2.108	1.803
Midwest	R1	0.947	0.700	0.205	0.822	0.552	0.029	0.746	0.864
	R2	0.990	0.739	0.219	0.857	0.581	0.031	0.855	0.999
	R3	1.046	1.056	1.067	1.043	1.053	1.062	1.145	1.156
National	R1	0.904	0.682	0.274	0.765	0.595	0.198	0.748	0.738
	R2	0.967	0.732	0.299	0.816	0.634	0.213	1.011	0.949
	R3	1.070	1.073	1.089	1.066	1.066	1.075	1.353	1.287

[a]Symbols and terms used in this table and in Tables 78, 79, 80, 81, and 82:
R1: Ratio = (resource used / resource available to all farms);
R2: Ratio = (resource used / resource available to commercial farms);
R3: Ratio = (resource available to all farms / resource available to commercial farms);
CHLi: Class i crop-hay land (i = 1, 2, 3);
CLi: Class i cropland;
LBCS: Crop-season labor;
LBNCS: None-crop-season labor;
Southeast: Regions Nos. 3 to 8;
Midwest: Regions Nos. 9 to 11;
National: Regions Nos. 1 to 15.

Table 78. Ratios of resource uses, consuming regions Nos. 1 - 8, Solution I

Region	Ratio	CHL1	CHL2	CHL3	CL1	CL2	CL3	LBCS	LBNCS
1	R1	0.986	0.489	0.000	0.636	0.000	0.000	0.657	0.691
	R2	1.123	0.558	0.000	0.717	0.000	0.000	0.818	0.861
	R3	1.140	1.142	1.150	1.129	1.131	1.143	1.245	1.246
2	R1	0.975	0.482	0.000	0.716	0.362	0.000	0.930	0.961
	R2	1.062	0.542	0.000	0.778	0.404	0.000	1.147	1.221
	R3	1.089	1.125	1.149	1.086	1.117	1.134	1.232	1.271
3	R1	0.291	0.000	0.000	0.043	0.000	0.000	0.229	0.204
	R2	0.359	0.000	0.000	0.054	0.000	0.000	0.527	0.321
	R3	1.233	1.268	1.296	1.269	1.212	1.236	2.305	1.575
4	R1	0.345	0.000	0.000	0.190	0.000	0.000	0.473	0.320
	R2	0.414	0.000	0.000	0.227	0.000	0.000	1.022	0.594
	R2	1.200	1.230	1.320	1.196	1.226	1.309	2.162	1.857
5	R1	0.045	0.136	0.348	0.000	0.000	0.000	1.000	0.871
	R2	0.061	0.184	0.463	0.000	0.000	0.000	2.050	1.531
	R3	1.355	1.347	1.331	1.358	1.356	1.347	2.050	1.758
6	R1	0.679	0.000	0.000	0.205	0.000	0.000	0.389	0.352
	R2	0.911	0.000	0.000	0.270	0.000	0.000	0.954	0.682
	R3	1.342	1.048	1.324	1.316	1.055	1.295	2.456	1.937
7	R1	0.844	0.000	0.000	0.372	0.000	0.000	0.732	0.394
	R2	1.088	0.000	0.000	0.478	0.000	0.000	1.641	0.838
	R3	1.290	1.373	1.374	1.283	1.367	1.357	2.243	2.129
8	R1	0.918	0.593	0.315	0.879	0.598	0.025	0.978	0.359
	R2	1.035	0.666	0.370	0.988	0.666	0.029	1.804	0.649
	R3	1.127	1.123	1.175	1.124	1.114	1.171	1.844	1.810

Table 79. Ratios of resource uses, consuming regions Nos. 9 - 15, Solution I

Region	Ratio	CHL1	CHL2	CHL3	CL1	CL2	CL3	LBCS	LBNCS
9	R1	0.985	0.662	0.244	0.816	0.541	0.000	0.609	1.000
	R2	1.037	0.708	0.265	0.854	0.573	0.000	0.692	1.149
	R3	1.053	1.068	1.086	1.046	1.059	1.080	1.136	1.149
10	R1	0.997	0.870	0.000	0.959	0.892	0.000	0.835	0.739
	R2	1.027	0.919	0.000	0.987	0.942	0.000	0.949	0.833
	R3	1.029	1.057	1.083	1.030	1.056	1.083	1.137	1.127
11	R1	0.856	0.640	0.354	0.736	0.364	0.057	0.640	0.789
	R2	0.886	0.663	0.366	0.761	0.377	0.059	0.710	0.874
	R3	1.035	1.037	1.035	1.034	1.036	1.034	1.109	1.109
12	R1	0.927	0.917	0.435	0.804	0.872	0.321	0.977	0.635
	R2	1.003	0.969	0.461	0.858	0.915	0.337	1.618	1.006
	R3	1.070	1.057	1.059	1.067	1.048	1.051	1.656	1.585
13	R1	1.000	0.951	0.738	0.905	1.000	0.958	0.791	0.907
	R2	1.042	0.986	0.772	0.937	1.031	0.995	1.123	1.242
	R3	1.042	1.037	1.046	1.035	1.031	1.039	1.419	1.369
14	R1	0.955	0.764	0.414	0.751	0.757	0.399	0.867	0.976
	R2	1.015	0.813	0.437	0.792	0.800	0.419	1.379	1.679
	R3	1.062	1.065	1.056	1.055	1.056	1.050	1.591	1.721
15	R1	0.958	0.435	0.000	0.988	0.590	0.000	1.000	1.000
	R2	0.974	0.443	0.000	1.004	0.600	0.000	1.274	1.253
	R3	1.016	1.018	1.018	1.016	1.017	1.016	1.274	1.253

For X = 2.5, Y = 2: $\frac{2.5}{5} = \frac{X}{CHL1} = \frac{Y}{CL1} = \frac{2}{4}$

There is a constrast between the slackness of resource in the Southeast and that in the Midwest. In the Midwest, class 1 crop-hay land available to commercial farms is nearly exhausted (R2 = 0.990), while the counterpart for the Southeast is only 0.730. The R1 for CL3 for either region is nearly zero, indicating the extent of idleness of low quality class 3 crop land. The declining rate of land use (R1) with the decrease of land quality is also evident.

The Midwest has a higher rate of land use than the national average in class 1 land, but a lower rate in class 2 cropland and class 3 crop-hay land. The national average is raised mainly because the Northwest (Regions 13) has nearly used up its classes 2 and 3 land in producing, chiefly, wheat.

Table 78 shows that among the six regions in the Southeast, Regions 6 (Kentucky), 7 (Tennessee Valley) and, particularly, 8 (Delta) have a much higher use rate of class 1 land, indicating a rather intensive farming activity in these three regions. The other three regions, No. 3 (Mid-Atlantic), No. 4 (Southeast Atlantic), and No. 5 (Florida) have the lowest use rate of class 1 land in the country owing to their high production cost of most crops (see cost advantage index tables for crops).[1] Florida (Region 5) is the only region showing a reverse relationship between land use rate and land quality -- higher rate of use in lower

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[1]Florida (Region 5) has merely a 5% rate of use of class 1 land because its Area 17 (upper Florida) has all of its 250,000 acres of class 1 land idle, though its other area, No. 16, exhausts its entirety of 12,000 acres of class 1 land, and has the highest shadow price of class 1 land among all areas in Solution I.

quality land -- because Area 16 (central and lower Florida), in which all three classes of land are exhausted, constitutes a greater percentage of low quality land in the regional total.

In terms of the ratio of land used to land available to commercial farms (R2), most regions use more land than available to their commercial farms, thus drawing from the resource of land of small farms.[1] This means their production levels would have been lower, had the land of small farms not been included in the model. The rate of using small farms' land varies with regions -- from 100% in class 1 crop-hay land and class 2 cropland in Region 13 (Northwest) to a mere 4% in class 1 crop-hay land in Region 12 (Southern Plains). The largest concentration of small farms' land is in Regions 5, 6, and 7 in the Southeast, equal to about 1/3 of the commercial farms' land, with the proportions of small farms' land in the other three regions (Nos. 3, 4, and 8) in the Southeast being about 30%, 25%, and 15%, respectively.

In Solution II, the greater pressure on class 1 crop-hay land is even more pronounced on the regional level (see Tables 80, 81, and 82). In addition to Region 13 (Northwest), which has a 100% utilization of its lass 1 crop-hay land in both solutions, Regions 6 (Kentucky), 7 (Tennessee Valley) and 14 (Southwest) have a full rate of land use. But the major portion of class 1 land in Regions 6 and 7 is used in growing hay (as evidenced by the low use rate of class 1 cropland), while that in Regions 13 and 14 is used in growing crops other than hay (chiefly wheat in Region

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[1]Since no distinction is made between land of commercial farms and land of small farms in the model, this statement is simply made for the expository purpose.

Table 80. Ratio of resource uses, Southeast, Midwest and National, Solution II

Region	Ratio	CHL1	CHL2	CHL3	CL1	CL2	CL3	LBCS	LBNCS
Southeast	R1	0.677	0.288	0.124	0.420	0.267	0.084	0.610	0.350
	R2	0.814	0.343	0.158	0.503	0.314	0.105	1.286	0.632
	R3	1.203	1.192	1.277	1.199	1.178	1.254	2.108	1.803
Midwest	R1	0.980	0.768	0.345	0.819	0.560	0.035	0.765	0.896
	R2	1.025	0.811	0.368	0.854	0.590	0.037	0.876	1.036
	R3	1.046	1.056	1.067	1.043	1.053	1.062	1.145	1.156
National	R1	0.935	0.726	0.361	0.764	0.590	0.202	0.758	0.767
	R2	1.001	0.780	0.393	0.814	0.629	0.217	1.026	0.986
	R3	1.070	1.073	1.089	1.066	1.066	1.075	1.353	1.287

Table 81. Ratios of resource uses, consuming regions Nos. 1 - 8, Solution II

Region	Ratio	CHL1	CHL2	CHL3	CL1	CL2	CL3	LBCS	LBNCS
1	R1	0.986	0.509	0.000	0.649	0.001	0.000	0.661	0.695
	R2	1.123	0.581	0.000	0.733	0.001	0.000	0.824	0.866
	R3	1.140	1.142	1.150	1.129	1.131	1.143	1.245	1.246
2	R1	0.977	0.521	0.000	0.724	0.362	0.000	0.932	0.957
	R2	1.064	0.586	0.000	0.786	0.404	0.000	1.148	1.216
	R3	1.089	1.125	1.149	1.086	1.117	1.134	1.232	1.271
3	R1	0.311	0.000	0.000	0.045	0.000	0.000	0.239	0.211
	R2	0.383	0.000	0.000	0.057	0.000	0.000	0.551	0.333
	R3	1.233	1.268	1.296	1.269	1.212	1.236	2.305	1.575
4	R1	0.345	0.000	0.000	0.192	0.000	0.000	0.486	0.354
	R2	0.414	0.000	0.000	0.230	0.000	0.000	1.052	0.658
	R3	1.200	1.230	1.320	1.196	1.226	1.309	2.162	1.857
5	R1	0.045	0.025	0.000	0.000	0.000	0.000	1.000	0.871
	R2	0.061	0.033	0.000	0.000	0.000	0.000	2.050	1.531
	R3	1.355	1.347	1.331	1.358	1.356	1.347	2.050	1.758
6	R1	1.000	0.076	0.000	0.227	0.000	0.000	0.483	0.397
	R2	1.342	0.079	0.000	0.299	0.000	0.000	1.186	0.768
	R3	1.342	1.048	1.324	1.316	1.055	1.295	2.456	1.937
7	R1	1.000	0.358	0.069	0.330	0.003	0.006	0.764	0.502
	R2	1.290	0.492	0.094	0.423	0.004	0.008	1.714	1.069
	R3	1.290	1.373	1.374	1.283	1.367	1.357	2.243	2.129
8	R1	0.966	0.595	0.384	0.871	0.598	0.259	0.860	0.339
	R2	1.089	0.669	0.451	0.979	0.666	0.304	1.586	0.614
	R3	1.127	1.123	1.175	1.124	1.114	1.171	1.844	1.810

Table 82. Ratios of resource uses, consuming regions Nos. 9 - 15, Solution II

Region	Ratio	CHL1	CHL2	CHL3	CL1	CL2	CL3	LBCS	LBNCS
9	R1	0.990	0.940	0.414	0.810	0.708	0.039	0.610	1.000
	R2	1.042	1.004	0.449	0.847	0.749	0.043	0.693	1.149
	R3	1.053	1.068	1.086	1.046	1.059	1.080	1.136	1.149
10	R1	0.997	0.882	0.117	0.961	0.838	0.000	0.861	0.793
	R2	1.026	0.932	0.126	0.989	0.885	0.000	0.979	0.894
	R3	1.029	1.057	1.083	1.030	1.056	1.083	1.137	1.127
11	R1	0.959	0.697	0.530	0.723	0.380	0.057	0.679	0.859
	R2	0.993	0.723	0.548	0.748	0.393	0.059	0.753	0.952
	R3	1.035	1.037	1.035	1.034	1.036	1.034	1.109	1.109
12	R1	0.937	0.878	0.527	0.841	0.824	0.311	0.999	0.766
	R2	1.003	0.928	0.558	0.897	0.864	0.327	1.653	1.214
	R3	1.070	1.057	1.059	1.067	1.048	1.051	1.656	1.585
13	R1	1.000	0.984	0.680	0.864	1.000	0.916	0.822	0.924
	R2	1.042	1.020	0.711	0.895	1.031	0.952	1.167	1.265
	R3	1.042	1.037	1.046	1.035	1.031	1.039	1.419	1.369
14	R1	1.000	0.836	0.530	0.636	0.680	0.392	0.880	0.994
	R2	1.062	0.890	0.560	0.671	0.718	0.412	1.400	1.710
	R3	1.062	1.065	1.056	1.055	1.056	1.050	1.591	1.721
15	R1	0.902	0.426	0.000	1.000	0.590	0.000	1.000	0.663
	R2	0.917	0.434	0.000	1.016	0.600	0.000	1.274	0.831
	R3	1.016	1.018	1.018	1.016	1.017	1.016	1.274	1.253

13, and feed grains and silage in Region 14).

Yet only Regions 7 and 8 use about 1/3 to 1/4 of small farm class 1 land. Outside of the Southeast, Region 1 (Northeast) has the largest proportion of small farms' land and uses 90% of their class 1 land. All Regions (Nos. 2, 9, 10, 12, 13, and 14) use part of their small farm class 1 land, indicating the pressure of demand for class 1 land. Region 11 (Northern Plains) is the only major farming region which does not need the addition of small farms land to its land resource. Region 15 (California) does not use its small farm's land because of its binding labor constraints.

As to labor supply from small farms, the concentration in the Southeast is even greater than land from such farms, amounting to more than, or nearly equal to, the labor from commercial farms. The rate of using labor also varies greatly among regions. Region 5 (Florida) exhausts all its crop-reason labor, half of which being small farms' labor; Region 9 (Minnesota-Wisconsin) uses up its non-crop-season labor, obviously because of the demand from its dairy activities; Region 15 (California) uses up both its crop-season and non-crop-season labor. (See the sections on commodities.)

Nowhere in the Midwest is the small farms' labor brought into production (the highest R2 being 0.949 in Region 10), while in the West and the Southwest (Regions 12 - 15) small farms' labor do contribute to production (R2's ranging from 1.123 in Region 13 to 1.618 in Region 12 for crop-season labor) according to Solution I.

Since labor is a constraint on the area level, lack of full utilization of labor as shown on the regional level does not necessarily mean labor constraints are not binding in producing areas (see Tables A-3, A-13).

It seems that crop activities are restricted more by land constraints while livestocks activities, particularly dairy, by non-crop-season labor constraints (e.g. Regions 2, 9, and 15).

It is of interest to compare $R2_{CHL1}$ (0.990) with $R2_{LBCS}$ (0.855) in the Midwest. The implication is that agricultural production on commercial farms in the Midwest will find land constraint binding before family labor constraint. In the Southeast, it is the reverse ($R2_{CHL1} = 0.730$; $R2_{LBCS} = 1.322$). The higher extent of farm mechanization on the commercial farms in the Midwest than in the Southeast is one of the attributive factors. Small farm sizes, uneven topography, and relatively less capital input seem to be the factors which make the Southeast less susceptible to large-scale mechanization than the Midwest.

Tables 83 and 84 show land use by crops and by land quality classes at the national level. To produce the same total amount of cotton, less land is used in Solution II than in Solution I, implying more high yield land is used in Solution II. The shift of cotton production from the high-yield area in Southern California (Region 15) to the low-yield (but also of low cost) area in Southern Plains (Region 12) causes such a discrepancy. (See Tables 6 and 7.) Comparing the total wheat and feed grain productions with the total wheat and feed grain acreages in the two solutions reveals a compensatory adjustment between acreage and yield -- the higher the yield, the less the acreage, and vice versa. Solution I uses more high-yield land to produce wheat, while Solution II, to produce feed grains. The soybeans acreage difference is commensurate with the soybean production. Solution II, as pointed out earlier, produce more hay and silage on more acreage.

Table 83. Land use by crops and land quality class, Solution I (unit: acre)

Crops	Land class 1	%	Land class 2	%	Land class 3	%	Total	%
Cotton	9,009,705	6.1	807,440	1.2	-	-	9,817,145	4.3
(%)	(91.8)		(8.2)		-		(100.0)	
Wheat	31,779,100	21.4	24,495,730	37.3	4,170,401	30.7	60,445,231	26.6
(%)	(52.6)		(40.5)		(6.9)		(100.0)	
Feed grain	51,302,490	34.6	14,232,420	21.7	1,770,476	13.0	67,305,386	29.6
(%)	(76.3)		(21.1)		(2.6)		(100.0)	
Soybean	16,087,320	10.8	4,666,176	7.1	-	-	20,753,496	9.1
(%)	(77.5)		(22.5)		-		(100.0)	
Silage	3,964,716	2.7	843,285	1.3	123,755	0.9	4,931,756	2.2
(%)	(80.4)		(17.1)		(2.5)		(100.0)	
Hay	35,223,410	23.7	11,778,660	17.9	1,806,622	13.3	48,808,692	21.4
(%)	(72.2)		(24.1)		(3.7)		(100.0)	
Pasture converted from crop-hay land	977,384	0.7	8,894,305	13.5	5,713,953	42.1	15,585,642	6.8
(%)	(6.3)		(57.0)		(36.7)		(100.0)	
Total	148,344,125	100.0	65,718,016	100.0	13,585,207	100.0	227,647,348	100.0
(%)	(65.1)		(28.9)		(6.0)		(100.0)	

Table 84. Land use by crops and land quality class, Solution II (unit: acre)

Crops	Land class 1	%	Land class 2	%	Land class 3	%	Total	%
Cotton	8,145,282	5.3	807,440	1.2	-	-	8,952,722	3.7
(%)	(91.0)		(9.0)		-		(100.0)	
Wheat	33,833,120	22.1	23,360,270	34.6	4,406,827	24.7	61,600,217	25.8
(%)	(54.9)		(37.9)		(7.2)		(100.0)	
Feed Grain	49,881,150	32.5	14,272,780	21.1	1,687,431	9.4	65,841,361	27.6
(%)	(75.7)		(21.7)		(2.6)		(100.0)	
Soybean	16,096,360	10.5	5,300,327	7.8	-	-	21,396,687	9.0
(%)	(75.2)		(24.8)		-		(100.0)	
Silage	3,979,839	2.6	959,857	1.4	104,661	0.6	5,044,357	2.1
(%)	(78.9)		(19.0)		(2.1)		(100.0)	
Hay	36,890,010	24.1	13,453,250	19.9	1,366,595	7.7	51,709,855	21.6
(%)	(71.3)		(26.0)		(2.7)		(100.0)	
Pasture converted from crop-hay land	4,527,493	2.9	9,493,398	14.0	10,294,490	57.6	24,315,381	10.2
(%)	(18.6)		(39.0)		(42.4)		(100.0)	
Total	153,353,254	100.0	67,647,322	100.0	17,860,004	100.0	238,860,580	100.0
(%)	(64.2)		(28.3)		(7.5)		(100.0)	

The most significant difference in land use between the two solutions is that about 9 million more acres of land is converted into pasture in Solution II than in Solution I. Again, the difference in cattle production explains this (see the section on beef).

As to the distributions of crops by land classes, all crops are mainly grown on class 1 land. Cotton, being a high-valued crop per acre, has the highest concentration on class 1 land (92%), while wheat, being a low-valued crop per acre has the lowest concentration on class 1 land (53-55%), with other crops being in between in both value per acre and the rate of concentration in class 1 land.

Though the model is not a profit-maximizing one and the market prices are not present in it, each activity's cost reflects its value because a high cost activity must have a high output value to justify its existence. Within each crop enterprise, the activity using high quality land always wins over the activities using lower quality land in the bidding for high quality land (because of its higher yield for the same cost coefficient, i.e. lower cost per unit of yield). Therefore, each crop enterprise competes to produce as much as possible on class 1 land. But competition among crop enterprises for class 1 land always results in the one with the highest cost (e.g. cotton) winning, because of its greater cost differential (per unit of yield) between its activity on class 1 land and its activity on class 2 land, than the enterprise of lower production cost (e.g. wheat).

Pasture converted from crop-hay land is concentrated in low quality land -- class 2 land (57%) in Solution I, but class 3 land (42%) in Solution II as the pressure on land in general is greater in Solution II than in Solution I.

Solution II shows higher use rates of all crop-hay land at the national level than Solution I. This is so because there is a greater demand for hay to maintain 4.5 million head more beef cows, 7 million head more yearlings (though 4 million head less feeder cattle) to satisfy demand for non-grain-fed beef, and 130,000 more head dairy cowes (owing to lower milk yield in medium-size dairy herd) (see sections on commodities). And the total demand for wheat and feed grain is also greater in Solution II than in Solution I.

Consequently, the national labor use rate is also higher in Solution II. But the change in crop-season labor use is not uniform among regions. The Southeast uses less labor as a result of Region 8 (Delta)'s reduction in cotton and beef cow production (see the sections on commodities). The increased use of non-crop-season labor in Solution II is almost universal, except Region 8 (Delta) and 15 (California), the latter being due to a reduction of dairy cows which is caused by an increase in cotton production competing for more crop-season labor needed also by dairy cows.

The total crop-hay land supply of all farms in this model, 309,948,900 acres, is 21,367,500 acres more than the 288,581,400 acres of commercial farms' land used in Eyvindson's model (1970). The total acreage in Solution I (227,647,348 acres) and Solution II (238,860,580 acres) are less than the total acreage (240,122,900 acres) in Eyvindson's solution, despite the fact one more enterprise, broilers, are included in this model. Eyvindson's model is more comparable with Solution II in the respect that both demand the same amounts of final products (except broilers), but more comparable with Solution I in that both allow imports of calves from foreign countries and substitution of grain-fed beef for non-grain-fed beef. The explanations of the difference in land use, however, lie in the compositions of land classes in the two models. Eyvindson's model has less of all classes of land than the present model. Therefore, there are more class 1 land in use in this model than in Eyvindson's model. By the principle of compensatory adjustment, more classes 2 and 3 land are used in Eyvindson's model, thus resulting in a greater total acreage in use (see Table 85).

Table 85. Comparison of land use by land quality class (unit: 1,000 acres)

	Land class 1	Land class 2	Land class 3	Total
Solution I	148,344	65,718	13,585	227,647
%	(65.1)	(28.9)	(6.0)	(100.0)
R1	0.904	0.682	0.274	0.735
Solution II	153,353	67,647	17,860	238,860
$	(64.2)	(28.3)	(7.5)	(100.0)
R1	0.935	0.726	0.361	0.779
Solution E	147,684	71,794	20,644	240,122
%	(61.5)	(29.8)	(8.7)	(100.0)
R1	0.962	0.689	0.454	0.832

Eyvindson's solution (1970) has a much higher rate of land use (R1; i.e. land used / land available) than both Solutions I and II, particularly in class 3 land. Bringing small farms' resources into production leads to a reduction of total acreage needed. As pointed out earlier, no distinction is made in this model between the resources of commercial farms and those of small farms. Therefore, incorporating small farms' resources into the model simply increases the supply of land of all classes (by 7%, 7.3%, and 8.9% in class 1, 2, and 3 land, respectively) and permits more high quality land, and thus less low quality land, to be used.

Another cause of this phenomenon is Eyvindson's (1970) three farm size classification which is not used in this model. Farm size 1 group, by virture of its economy of scale, nearly used up all its land including classes 2 and 3 land which, under a unified farm size structure like the present model, will be less likely to enter production. This increases the total acreage used in his solution.

Though Table 86 shows Solution I has higher maximum shadow prices than Solution II in all classes of hay land and in classes 1 and 2 of cropland, the general pressure on land is greater in Solution II than in Solution I as observed above and also attested by the greater number of areas where shadow prices exist in Solution II (see Table 87 below).

Table 86. Maxmum shadow prices for cropland and hay land by land classes (unit: $/acre)

Land class	Solution I		Solution II		Solution E[a]	
	Cropland	Hayland	Cropland	Hayland	Cropland	Hayland
1	24.19	28.76	21.04	27.90	39.21-63.04	39.21-39.09
2	20.71	15.40	18.13	10.71	25.13-27.78	16.72-27.14
3	10.93	6.37	11.24	4.57	12.86-22.47	10.03-22.47

[a]Source: Eyvindson, 1970, Table 71, p.538. The price range spans over three farm size groups, with the upper end for farm size 1 group.

Table 87. Number of areas where shadow prices of land exist

Land class	Solution I Cropland	Solution I Hay land	Solution II Cropland	Solution II Hay land
1	97	47	121	48
2	46	49	67	51
3	16	18	27	17

As to the rate of labor use, the situation is reversed. Eyvindson's solution (1970) indicated use rates (R1) of 0.726 and 0.607 for crop-season and non-crop-season labor, respectively, while Solution I calls for corresponding use rates of 0.748 and 0.738, and Solution II, 0.758 and 0.767.

Even allowing for the extra enterprise of broilers included in this model, Solutions I and II's higher rates of labor use must partly be attributed to the 3 farm size classification in Eyvindson's model which permits farm size 1 group to fully benefit from its economy of scale through a greater degree of mechanization. His farm size 1 group had a much higher rate of labor use than his farm size 2 and 3 groups (Eyvindson, 1970, Tables 28 and 29, p. 383).

Concentration of livestock production on farms of larger sizes in Eyvindson's solution accounts, partly, for the greater difference in the use rate of non-crop-season labor than that of crop-season labor, because larger size farms tend to use more capital-intensive production techniques. Broilers enterprise in this model also accounts for this difference.

CHAPTER VI. SUMMARY AND CONCLUSIONS

This normative spatial equilibrium study of American agriculture for 1965 used linear programming in formulating the spatial model which encompasses the continental United States delineated into 15 consuming regions and, overlappingly, 138 producing areas, and includes the major crops (cotton, wheat, feed grains, soybeans, hay, silage) and livestock products (milk, beef, pork, broilers). Two solutions were obtained, with Solution I assuming calf imports, substitutability of grain-fed beef for non-grain-fed beef, and less final demand for wheat and feed grains.

Both solutions show specializations of productions in regions with strong cost advantages and phasing-out of productions in marginal regions with cost disadvantages. The cropping pattern in the solutions is generally consistent with the actual geographic distributions of such crops and closely related to the distributions of such livestock as hogs and beef cattle, which are relatively more feed source-oriented than other types of livestock. Fluid milk production is more market-oriented and, therefore, is closely related to population distributions.

Compared with the actual 1965 productions, the solutions show upward shifts of cotton productions in Southern Plains (Region 12) and Southwest (Region 14) and downward shifts in the Southeast, except the Delta (Region 8). Wheat productions exceed the 1965 figure by 1/3 because of increased use of wheat as feeds in the feed grain deficient regions -- Northeast (Region 1), Mid-Atlantic (Region 3), and Southeast Atlantic (Region 4) -- and also in the wheat-producing Northwest (Region 13) and Southwest (Region 14) with wheat movements mainly from the Midwest to the Southeast and Southern Plains. Owing to wheat production increase, total feed grain production declines by 1/5, but with more concentrations in Corn Belt and phasing-outs in the marginal regions, the feed grain movements being mainly from Corn Belt to the Southeast. Soybean production decrease by 1/3 and its distributions and movements are similar to those of feed grains. Hay and silage productions, closely tied to cattle productions, show proportional variations with the shifts of cattle populations among regions. Wild hay production is less than the 1965 figure but more widely distributed because of no interregional hay movements allowed in the model.

Dairy activities show upward shifts in regions with strong comparative advantage -- East Corn Belt (Region 2) and Minnesota-Wisconsin (Region 9) which supply 2/3 of the country's manufactured dairy products to other regions -- and downward shifts in other regions. Most regions are self-sufficient in fluid milk. The distributions of beef cows show upward shifts in Northern Plains (Region 11) and Southern Plains (Region 12) and phasing-outs in several other regions. Calf movements differ with the two solutions. Calves shipped among regions in Solution II (mainly from Southern Plains) are over twice as many as in Solution I which allows grain-fed beef to substitute for non-grain-fed beef and, therefore, encourages feeder cattle fattening in regions where calves are born. Regions keeping calves in Solution I export grain-fed beef, while regions export calves in Solution II do not export grain-fed beef. The major cattle-fattening activity in the solution, the deferred feeding plan, requires heavy pasturing, thus favoring regions with plentiful pasture supply and causing upward shifts in grain-fed beef production in those regions (Nos. 11 and

12).

In the solutions pork productions in Corn Belt (Regions 2, 10 and part of 9) increases to 90% of the national total (versus the actual 1965 figure of 72%), thus causing many regions to phase out in pork production. Assumption of same technology in broiler production leads to self-sufficiency in all regions, except California which imports from Southern Plains (Region 12).

Small farms' class 1 crop-hay land enters production in most regions. But Mid-Atlantic (Region 3), Southeast-Atlantic (Region 4), and Florida (Region 5) have their major portions of class 1 land unused. Many regions have left most of their classes 2 and 3 land idle. Only Region 13 (Northwest) nearly exhausts its classes 2 and 3 cropland owing to the pressure of demand for more wheat. Labor from small farms contributes towards production in many regions. In general, commercial farms in the Midwest is more constrained in the resource of class 1 crop-hay land than crop-season labor, while commerical farms in the Southeast is more limited in crop-season labor than class 1 land. Differences in the degree of mechanization and, hence, of labor productivity explain such a phenomenon.

Efforts have been made to identify each region's comparative advantage in producing commodities in terms of the three components of their shadow prices (cost advantage, locational advantage, and lack of (or less) opportunity cost of inputs), and to appraise each region in its overall cost advantage in producing crops or livestock. The Midwest (Regions 9, 10, and 11), the Northwest (Region 13), and the Southwest (Region 14) have strong cost advantage in producing the crops in the solutions, while Regions 12 (Southern Plains), 13, 14, and 15 (California) have strong cost advantage in producing livestock products in the solutions, followed by Regions 2 (East Corn Belt), 3 (Mid-Atlantic), and 7 (Tennessee Valley) as the next efficient producers in livestock.

The model indicates a high degree of specialization in commodity productions, which is caused mainly by the spaceless structure of each region. Eyvindson's (1970) solution showed a less degree of specialization and thus a smoother pattern of production, because of the partial inter-area transportations allowed in his model. Besides, more (21) regions in his model also help produce a less abrupt production pattern. The greater the number of regions in the model the country is divided into, the better the solution approximates reality.

In addition, the absence of capital constraint in the present model also partly accounts for production concentrations. In reality, transition from the actual cropping and livestock enterprises into new enterprises, or expansion of the present enterprises, may be restricted owing to lack of capital. For instance, large feed lots require a large sum of investment which small farms may not be able to secure. Adding a capital constraint in each producing area to represent the area's ability to raise credit based on its collective assets of farms may reduce the degree of specialization in some regions, thus improving other regions' shares of production. Marketing, slaughtering and packing facilities for livestock are also assumed to be available in every region. In reality inadequacy of such facilities will hamper livestock processing, alter shipping routes, and increase cost, etc.

The agriculture in the Southeast, a region of historically lower income, has long been in the transition of moving from its heavy dependency on cotton and tobacco into a more diversified farming pattern. The study was initiated with a view to appraising the agricultural comparative advantage of the Southeast in the setting of spatial equilibrium. The two solutions show that the Southeast has rather weak cost advantage in crop production. Typical of a linear programming solution, production specializations in the solutions cause upward shifts of production in regions with strong cost advantage but downward shifts in other regions. The Southeast's shares of the value of national crop productions are 9 percent and 8 percent, respectively, in Solutions I and II, less than the actual share of 14 percent in 1965. The gradual out-shifing of cotton production from the Southeast into the Southwest and Southern Plains, and the concentrations of feed grain and soybean productions in Corn Belt result in the Southeast's decline in importance in crop production. The low cost of shipping grains from the Midwest (mainly by barge), which benefits the livestock activities in the Southeast, also makes it uneconomical for the Southeast to produce more crops than it does now in the solutions. Wheat is the only crop in the Southeast which increases in importance, partly due to the general increased demand for wheat as feeds and partly due to the locational advantage of Region 8 (Delta) in meeting the demand for wheat for export to foreign countries.

In terms of the share of the value of national livestock productions, the Southeast fares less well in Solution I (10.5%) than in 1965 and Solution II (both 15.2%). In either case, the composition of livestock produced differs significantly from that in 1965. Upward shifts of pork and milk productions in, respectively, Corn Belt and Wisconsin-East Corn Belt account for the downward shifts of these two products in the Southeast.

Broiler production in the solutions does not retain its actual important exporting role, obviously owing to the assumption of same technology in all regions which makes most regions self-sufficient in broiler production. The solutions indicate, however, several-fold upward shifts of grain-fed beef production in the Southeast because of both its cost advantage and its locational advantage (of supplying to the Northeast consumption centers). The deferred feeding plan, the most economical among all, which consumes the least concentrates but the most pasturing, prevails in the solutions. The Southeast, short in feed grain supply but with a relatively longer growing season, can adopt such a feeding plan to its benefit. It seems the actual feeding practice does not take full advantage of the deferred feeding plan. Capital seems to be one of the real world constraints on the expansion of grain-fed beef production.

A region's comparative advantage is by no means enduring. Demand shift, differential rates of technology advancement, or institutional change can easily alter a region's competitive position. The grain-fed beef industry seems to be characterized by the economy of scale and a certain degree of economically vertical integration. Promotion efforts by the competing states in the form of lower tax rates, etc.[1] (e.g. elimination of property tax on cows) may have also altered the relative regional strength in beef production (see the section on the Southeast in Chapter V, p. 286). Such institutional changes can be incorporated into the cost coefficients of the model to analyze the new situation of

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[1]The present model, being partial equilibrium with respect to the whole economy, does not take into account the incidence of reduced or removed taxes upon other sectors of the economy.

regional competition. Simulation of projected institutional changes would yield insights into the adjustment process, and thus enable a region facing competition to make appropriate adjustments.

In the more permanent aspects of agriculture, the Southeast is characterized, in comparison with the Midwest, by among other features uneven topography and less proportion of good quality soil in its natural environment. Smaller landholdings and less mechanization are part of its farming culture. These factors contribute to the Southeast's weak (or lack of) cost advantage in producing crops. Besides, continuous cotton cultivation in the past has depleted soil fertility and caused erosions in some areas and thus necessitates heavier fertilizer application that partly contributes to a higher cost of production. Given the above-mentioned features of natural environment and a favorable factor of longer growing season in the Southeast, it seems that cover cropping, and together with cattle-raising, are more suitable than row cropping, and are a rational utilization of the land resources of the Southeast.

The Southeast contains 1/4 of the country's population. Advancing income and an initial status of deficit meat supply in the Southeast have provided favorable market outlets to induce expansion of meat production. Besides, it has the locational advantage of being close to the Northeast (Region 1), a great industrial and consumption center of 1/4 of the nation's population. The solutions provide some examples that Regions 6 (Kentucky) and 7 (Tennessee Valley) supply grain-fed beef to Region 1 (Northeast) by fattening calves imported from Florida (Region 5) and Delta (Region 8). Besides abundant farm labor supply at relatively low wage has actually attracted broiler industry and its related processing and packing plants into the Southeast.

The present study is based on the production technology of 1965, that is only a thin cross-section of the continuously changing current of technology through time. In order to assess a region's comparative advantage more meaningfully, it is necessary not only to investigate a region's magnitudes of cost advantage in producing commodities already in the solution but also to gauge the gap in technology to be bridged in order to bring its non-competitive activities into the solution of a spatial equilibrium model. The present study has revealed the magnitudes of comparative advantages (in terms of cost advantage index, opportunity cost of inputs, and locational advantage) of the regions, and can serve as the basic model from which further investigation of technological gaps of non-competitive activities may be conducted.

Many other meaningful analyses can also be made to gain new insights into the "potential" of a region. The Southeast is generally considered to have a technological gap in agricultural production. What would be the picture of spatial equilibrium if the Southeast catches up with the rest of the country, or the Midwest, in technology? What if the average productivity of the Southeast is elevated to that of its upper 25 (or 50) percent farms? Results of various policy changes (e.g. changing cotton allotment, reducing tax) or unexpected variable changes (e.g. drought, export increase) may be simulated to study the effects of such changes and to better understand their repercussions through the agricultural sector. The model may also be used to gauge the gap in technology that needs to be filled in order to bring the farm family income of the Southeast to the same level as that of, say, the Midwest.

Economic reasoning can only point to the direction of changes in, perhaps, the first round of a series of adjustments. But exact magnitudes of the changes and their far-reaching repercussions can never be known without obtaining a new solution under new assumptions. Granting that the model is only a crude approximation of reality and that the detailed adjustments in the interdependency among variables can hardly be identified with the real world counterparts should they be ever known, the solutions of a model will nevertheless provide more information for evaluation and more insights for considerations into the complexity of the model as an example of the real world. Since "scientific progress can be made only by a continually closer analysis and finer classification" (Seligman, 1968), efforts towards the construction of better models and the closer analysis of their results are desirable.

Given the fast-developing techniques in operations research and econometrics practically any conceivable problems, real or imagined, can be analyzed in a reasonably satisfactory fashion. However, as a model is expanded in size to improve its capability of simulating the real world, the requirement of research resources also increases rapidly. Therefore, the limitations of a spatial equilibrium model lie in the availability of research resources rather than research techniques.

The spatial equilibrium analysis is only one of the many methodologies on regional analysis. A more comprehensive regional analysis, encompassing variables in other sectors of the economy and demographical variables of the region, would reveal more insights into the real world complexity than the present study, but would certainly be beyond the research resources of most researchers.

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APPENDIX

Table A-1. National constraints, Solution I

Constraints	Unit	Quantity
(Cost-value of objective function)	$	13,165,465,560
Cotton lint	CWT	59,128,498
Exogenous feed, type 1 (F1)	1,000 lbs. TDN	765,925
Exogenous feed, type 2 (F2)	1,000 lbs. TDN	3,773,161
Exogenous feed, type 3 (F3)	1,000 lbs. TDN	2,922,921
Exogenous feed, type 4 (F4)	1,000 lbs. TDN	15,986,976

The following notes explain the format of Table A-2 and Tables A-3, A-12, and A-13:

1. For each constraint, the figure on the first line indicates the value in the solution.

2. For each constraint, the figure in parentheses on the second line denotes the shadow price of the constraint.

3. The figure on the second line without parentheses indicates the slack of the constraint.

4. The figure 0.00001 is to be considered as zero, as it was assigned to any constraint with an initial value of zero, by the IBM Mathematical Programming System to facilitate the linear program solving on the computer.

Table A-2. Consuming region constraints and shadow prices, Solution I

Code	Descriptions	Unit ($x10^5$)
WHEAT	Demand for Wheat	1,000 lbs.
FDGR	Demand for Feed Grains	1,000 lbs.
SOYBN	Demand for Soybeans	CWT
CTNSD	Demand for Cotton Seeds	CWT
BFCALF	Beef Cow and Calf	Head
YRLCAF	Yearling and Calf	Head
BFGF	Demand for Beef, Grain-Fed	CWT
BFOR	Demand for Beef, non-grain-fed	CWT
PORK	Demand for Pork	CWT
FMILK	Demand for Fluid Milk	1,000 lbs.
MFGMK	Demand for Manufactured Milk Products	1,000 lbs.
BROILR	Demand for Broilers	1,000 lbs.
TDN1	TDN, Type 1	1,000 lbs.
TDN2	TDN, Type 2	1,000 lbs.
TDN3	TDN, Type 3	1,000 lbs.
PROTN1	Protein, Type 1	CWT
PROTN2	Protein, Type 2	CWT
PROTN3	Protein, Type 3	CWT
HAYRG	Demand for Hay	Ton
PASTRG	Pasture, Off-Farm	10 AUMs

TABLE A-2. (CONTINUED)

REGION NO.	1	2	3	4
WHEAT	66.90811	37.10027	11.40115	4.55278
	(-2.27314)	(-1.82914)	(-2.24214)	(-2.06052)
FDGR	-37.26942	-35.02254	-25.64904	-6.47009
	(2.22096)	(1.63581)	(2.13920)	(1.94920)
SOYBN	-68.93079	-131.12696	-64.79494	-86.13444
	(0.43181)	(0.39668)	(0.42081)	(0.40821)
CTNSD	0.00001	0.00001	-0.97603	-1.29801
	(0.35373)	(0.39460)	(0.39320)	(0.37020)
BFCALF	0.00001	0.00001	0.00001	0.00001
	(6.73342)	(6.95709)	(7.03642)	(7.12036)
YRLCAF	0.00001	0.00001	0.00001	0.00001
	(9.89740)	(9.56234)	(9.72435)	(9.36187)
BFGF	319.45511	163.54700	49.79826	43.81487
	(-2.68805)	(-2.59705)	(-2.64105)	(-2.54261)
BFOR	187.61673	96.05141	29.24659	25.73245
	(-2.68805)	(-2.59705)	(-2.64105)	(-2.54261)
PORK	276.91930	145.51153	64.59581	57.91516
	(-1.75166)	(-1.60066)	(-1.72466)	(-1.66666)
FMILK	201.44944	113.65667	26.61087	24.54413
	(-2.84683)	(-2.33499)	(-2.64860)	(-2.70912)
MFGMK	187.02461	95.66200	29.99430	27.40479
	(-2.51099)	(-2.33499)	(-2.47499)	(-2.46399)
BROILR	16.49898	6.52694	3.36386	3.07330
	(-15.75726)	(-15.53859)	(-15.55872)	(-14.86334)
TDN1	-35.18778	-22.61635	-18.17565	-15.52917
	(1.84959)	(1.04345)	(1.73794)	(1.51529)
TDN2	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001
TDN3	0.00001	0.00001	0.00001	0.00001
	(1.84959)	(1.04345)	(1.73794)	(1.51529)
PRCTN1	-71.57561	-47.60234	-36.83914	-30.24861
	(0.29464)	(0.50673)	(0.35075)	(0.37929)
PRCTN2	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001
PRCTN3	0.00001	0.00001	0.00001	0.00001
	(0.29464)	(0.50673)	(0.35075)	(0.37929)
HAYRG	-0.38599	-1.28999	0.00001	-0.03699
	(1.56071)	(1.15923)	(1.67778)	(1.49349)
PASTRG	0.27461	1.25441	0.16531	0.79871
	0.28440	(1.37036)	0.71740	(1.39154)

TABLE A-2. (CONTINUED)

REGION NO.	5	6	7	8
WHEAT	1.13944	1.72039	2.70275	79.81339
	(-2.27014)	(-2.01220)	(-2.06514)	(-2.15114)
FOGR	-0.15775	-9.51125	-7.88762	-140.05218
	(2.04520)	(1.84920)	(1.82420)	(1.94620)
SOYBN	0.00001	0.00001	-19.38117	-767.78210
	(0.39281)	(0.39681)	(0.39881)	(0.40581)
CTNSD	0.00001	0.00001	-0.29208	-11.57538
	(0.37208)	(0.38660)	(0.38220)	(0.36260)
BFCALF	0.00001	0.00001	0.00001	0.00001
	(6.64536)	(7.11236)	(7.11136)	(6.78536)
YRLCAF	0.00001	0.00001	0.00001	0.00001
	(9.57707)	(9.33038)	(9.36351)	(9.35812)
BFGF	28.67486	22.27958	17.34292	34.12083
	(-2.60105)	(-2.53405)	(-2.54305)	(-2.54159)
BFCR	16.84078	13.08483	10.18551	20.03922
	(-2.60105)	(-2.53405)	(-2.54305)	(-2.54159)
PORK	36.40648	29.37824	22.82184	45.90494
	(-1.71266)	(-1.63966)	(-1.65266)	(-1.66966)
FMILK	14.82958	12.39859	9.60304	19.78274
	(-3.34612)	(-2.40549)	(-2.53312)	(-2.50663)
MFGMK	16.56040	13.84430	10.74052	22.08338
	(-2.52599)	(-2.40549)	(-2.43899)	(-2.47099)
BROILR	1.85687	1.50996	1.17148	2.47709
	(-16.02769)	(-15.47415)	(-15.02300)	(-14.60531)
TDN1	-4.27333	-3.45510	-7.34522	-15.67474
	(1.63946)	(1.36031)	(1.33499)	(1.64588)
TDN2	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001
TDN3	0.00001	0.00001	0.00001	0.00001
	(1.63946)	(1.36031)	(1.33499)	(1.64588)
PROTN1	-8.65154	-6.20800	-14.45186	-31.76260
	(0.36337)	(0.43744)	(0.43419)	(0.25708)
PROTN2	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001
PROTN3	0.00001	0.00001	0.00001	0.00001
	(0.36337)	(0.43744)	(0.43419)	(0.25708)
HAYRG	0.00001	-0.02899	-0.02099	-0.14399
	(1.55632)	(1.38381)	(1.46646)	(1.27744)
PASTRG	0.0	0.13521	0.49321	6.32831
	0.69501	0.35190	(1.43518)	(0.86650)

TABLE A-2. (CONTINUED)

REGION NO.	9	10	11	12
WHEAT	40.37709	44.39196	51.83555	146.84657
	(-1.73214)	(-1.76714)	(-1.70414)	(-2.39614)
FDGR	-63.43362	-129.88331	-2.01976	-47.14481
	(1.54526)	(1.51820)	(1.49049)	(1.87296)
SOYBN	-69.32694	-111.31927	0.00001	-1.71666
	(0.37381)	(0.37681)	(0.38395)	(0.42281)
CTNSD	0.00001	0.00001	0.00001	-0.02407
	(0.32981)	(0.37480)	(0.38181)	(0.35460)
BFCALF	0.00001	0.00001	2.49919	5.16703
	(6.70336)	(6.99736)	(6.97647)	(6.70978)
YRLCAF	0.00001	0.00001	0.00001	0.00001
	(9.05054)	(9.13523)	(8.93272)	(9.35395)
BFGF	52.17708	126.49669	33.11173	63.52885
	(-2.48326)	(-2.48105)	(-2.42605)	(-2.41205)
BFCR	30.64368	74.29170	19.44657	37.31059
	(-2.45805)	(-2.48105)	(-2.42605)	(-2.41205)
PORK	47.09808	111.80113	30.37944	81.31310
	(-1.54217)	(-1.52966)	(-1.51066)	(-1.65666)
FMILK	37.32819	86.70979	24.45089	33.36144
	(-2.27399)	(-2.37799)	(-2.34280)	(-2.45999)
MFGMK	31.42680	72.98039	20.58209	37.25540
	(-2.27399)	(-2.37799)	(-2.34280)	(-2.45999)
BRCILR	2.08493	4.84308	1.36567	4.17736
	(-14.54257)	(-14.88646)	(-14.80417)	(-14.30004)
TDN1	-24.63416	-29.99696	-14.46760	-13.41307
	(1.03199)	(0.94471)	(0.83114)	(1.74748)
TDN2	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001
TDN3	0.00001	0.00001	0.00001	0.00001
	(1.03199)	(0.94471)	(0.83114)	(1.74748)
PRCTN1	-52.54841	-63.36557	-30.36239	-26.88931
	(0.39561)	(0.48940)	(0.52147)	(0.09331)
PRCTN2	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001
PRCTN3	0.00001	0.00001	0.00001	0.00001
	(0.39561)	(0.48940)	(0.52147)	(0.09331)
HAYRG	-0.32699	-1.13799	-6.76399	-0.87699
	(1.00144)	(1.21198)	(0.92689)	(1.43846)
PASTRG	0.40051	1.57191	1.41941	6.98691
	(1.09610)	(0.91462)	(1.37177)	(1.10923)

TABLE A-2. (CONTINUED)

REGION NO.	13	14	15
WHEAT	95.47555	9.70221	11.08286
	(-2.06250)	(-2.00997)	(-2.65104)
FDGR	-15.30714	-0.39439	-8.41718
	(2.06072)	(2.00997)	(2.55697)
SOYBN	0.00001	0.00001	0.00001
	(0.34503)	(0.20100)	(0.29621)
CTNSD	0.00001	0.00001	0.00001
	(0.34372)	(0.20100)	(0.30572)
BFCALF	0.00001	0.00001	0.00001
	(6.78125)	(6.92607)	(6.32807)
YRLCAF	0.00001	0.00001	0.00001
	(9.42729)	(9.51395)	(9.63598)
BFGF	60.42019	26.51023	130.82078
	(-2.43205)	(-2.41805)	(-2.61705)
BFOR	35.48487	15.56950	76.83125
	(-2.43205)	(-2.41805)	(-2.61705)
PORK	45.77358	20.73845	98.61197
	(-1.74700)	(-1.65266)	(-1.80666)
FMILK	34.60475	16.18999	74.17089
	(-2.50197)	(-2.46299)	(-3.79897)
MFGMK	34.00073	15.88522	72.79030
	(-2.50197)	(-2.46299)	(-2.59499)
BROILR	2.53851	1.13479	5.44103
	(-15.79667)	(-14.91718)	(-16.34703)
TDN1	-10.29103	-7.03554	-36.17511
	(1.60193)	(2.00997)	(2.43414)
TDN2	0.0	0.0	0.00001
	0.00001	0.00001	(2.55697)
TDN3	0.00001	0.00001	0.00001
	(2.02186)	(2.00997)	(2.03494)
PROTN1	-22.23959	-15.82636	-76.08666
	(0.32040)	0.50958	(0.09152)
PROTN2	0.0	0.0	-0.02606
	0.00001	0.00001	0.02607
PROTN3	0.00001	0.00001	0.00001
	(0.02827)	(0.0)	(0.16071)
HAYRG	-1.97999	-0.45999	-3.22899
	(1.35320)	(0.94810)	(1.50702)
PASTRG	9.26991	9.88721	0.01370
	(0.14344)	(1.00929)	1.26961

Table A-3. Producing area constraints and shadow prices, Solution I

Code	Descriptions	Unit $(x10^5)$
CHL1	Crop Hay-Land, Class 1	Acre
CHL2	Crop Hay-Land, Class 2	Acre
CHL3	Crop Hay-Land, Class 3	Acre
CL1	Cropland, Class 1	Acre
CL2	Cropland, Class 2	Acre
CL3	Cropland, Class 3	Acre
CTNL	Cotton Land	Acre
WHL	Wild Hay Land	Acre
PASTA	Pasture	AUM
LBCS	Labor, Crop-Season	10 hrs.
LBNCS	Labor, Non-Crop-Season	10 hrs.
HAYAR	Hay	Ton
RUFAG	Roughage (Hay-Equivalent)	Ton

TABLE A-3. (CONTINUED)

AREA NO.	001(NY)	002(PA)	003(WV)	004(MD)	005(NE)
CHL1	7.14071 (0.33464)	18.90281 (0.43356)	0.31711 (0.82734)	7.02451 0.96030	9.91391 (0.02091)
CHL2	0.0 3.34401	0.0 9.34081	0.0 0.19491	0.0 4.44761	0.0 4.18241
CHL3	0.0 1.23391	0.0 8.07461	0.0 0.16241	0.0 0.67971	0.0 3.75221
CL1	1.72488 3.08953	14.62308 0.04613	0.02822 0.16939	7.02451 (0.27852)	0.62458 1.08443
CL2	0.0 1.99061	0.0 5.79391	0.0 0.09381	0.0 3.75771	0.0 0.61351
CL3	0.0 0.63401	0.0 3.95001	0.0 0.06941	0.0 0.46401	0.0 0.59611
CTNL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
WHL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
PASTA	6.27830 (0.03840)	4.89882 17.34479	1.12647 (0.03840)	-0.49874 5.06375	14.10228 4.21851
LBCS	14.20487 0.95451	27.29529 53.39638	2.10922 (0.00331)	18.91172 4.71312	25.97602 23.71970
LBNCS	7.82925 (0.69298)	5.84057 27.36827	0.66682 (0.71000)	5.77464 1.75824	14.94612 13.59238
HAYAR	0.00001 (1.56071)	0.00001 (1.59620)	0.00001 (2.10871)	0.00001 (1.59189)	0.00001 (1.77996)
RUFAG	-0.11261 (1.56071)	-0.51301 (1.59620)	-0.03174 (2.10871)	-0.15685 (1.59189)	-0.40087 (1.77996)

TABLE A-3. (CONTINUED)

AREA NO.	006(VA)	007(NC)	008(NC)	009(NC)	010(VA)
CHL1	1.23442 1.59659	0.34314 19.86365	0.22604 2.03507	0.04115 2.84136	9.97238 0.72703
CHL2	0.0 0.66931	0.0 6.91171	0.0 1.30561	0.0 1.48471	0.0 7.60971
CHL3	0.0 0.24171	0.0 2.12071	0.0 0.82111	0.0 0.89671	0.0 7.14141
CL1	0.17405 2.33636	0.05456 19.46864	0.0 2.02941	0.00539 2.68522	1.22785 4.71376
CL2	0.0 0.54261	0.0 6.32771	0.0 0.89421	0.0 1.06941	0.0 3.38401
CL3	0.0 0.11031	0.0 1.87991	0.0 0.41801	0.0 0.50281	0.0 2.33141
CTNL	0.0 0.00001	0.0 5.41201	0.0 0.06301	0.0 0.53101	0.13601 (0.57470)
WHL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
PASTA	1.60790 (0.03320)	-0.01788 4.41440	-0.00997 4.20551	-0.00183 5.47338	32.69462 26.28870
LBCS	4.79193 0.80157	0.38089 53.94206	0.17405 14.61275	0.03580 12.96378	33.69844 51.19290
LBNCS	1.77804 (0.25159)	0.0 27.39180	0.0 8.37723	0.0 2.17816	11.00171 14.55340
HAYAR	0.00001 (1.89133)	0.00001 (2.09278)	0.00001 (1.87805)	0.00001 (1.80861)	0.00001 (2.00000)
RUFAG	-0.05838 (1.89133)	-0.77144 (2.09278)	-0.37072 (1.87805)	-0.08601 (1.80861)	-1.23972 (2.00000)

TABLE A-3. (CONTINUED)

AREA NO.	011(SC)	012(GA)	013(GA)	014(SC)	015(SC)
CHL1	0.14943 3.38668	0.03607 2.00524	0.11379 30.29021	0.07095 1.83686	1.84903 2.66378
CHL2	0.0 1.48261	0.0 1.11291	0.0 9.19841	0.0 1.38601	0.0 1.96111
CHL3	0.0 0.07641	0.0 0.14631	0.0 2.40511	0.0 0.56811	0.0 1.13291
CL1	0.00523 3.22608	0.00519 1.92061	0.02014 30.00336	0.00965 1.87656	0.19045 4.14406
CL2	0.0 1.34631	0.0 1.03851	0.0 8.50001	0.0 1.05941	0.0 1.50861
CL3	0.0 0.06751	0.0 0.13001	0.0 1.79641	0.0 0.32671	0.0 0.65001
CTNL	0.0 1.75101	0.0 0.65201	0.0 14.07201	0.0 1.49001	0.0 2.88201
WHL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
PASTA	-0.00717 1.06554	-0.00302 6.63553	-0.00803 35.84460	-0.00310 3.55863	8.94577 12.52080
LBCS	0.18230 13.73655	0.03824 6.04769	2.10689 60.98912	2.79284 7.70270	12.72757 4.34501
LBNCS	0.0 5.49556	0.0 1.35415	0.46100 12.45164	0.77369 0.51613	3.13995 (0.04702)
HAYAR	0.00001 (2.59091)	0.00001 (1.90206)	0.00001 (1.92754)	0.00001 (1.67778)	0.00001 (1.60731)
RUFAG	-0.23013 (2.59091)	-0.06999 (1.90206)	-0.23556 (1.92754)	-0.06456 (1.58253)	-0.12444 (1.60731)

TABLE A-3. (CONTINUED)

AREA NC.	016(FL)	017(FL)	018(AL)	019(AL)	020(AL)
CHL1	C.11871	0.0	1.03741	4.41021	4.11991
	(2.87576)	2.51171	0.04480	(0.0)	(0.03169)
CHL2	0.64891	0.0	0.0	0.0	0.0
	(1.54028)	4.11411	0.45421	3.00541	2.64161
CHL3	C.33061	0.0	0.0	0.0	0.0
	(0.24858)	0.61981	0.07461	1.40121	1.17361
CL1	0.0	0.0	1.02561	4.41021	2.47640
	0.03151	2.43361	(0.21342)	(0.C6870)	1.12871
CL2	C.0	0.0	0.0	0.0	0.0
	0.17101	3.86061	0.41931	2.89921	1.93521
CL3	0.0	0.0	0.0	0.0	0.0
	0.08761	0.52951	0.06121	1.28031	C.65831
CTNL	C.0	0.0	0.19478	1.88291	2.35838
	0.00601	0.74301	0.07623	1.64410	0.66763
WHL	C.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	76.87859	7.00498	-0.14503	15.79054	27.52733
	42.36050	1.36286	3.84543	(0.00905)	(0.11386)
LBCS	9.27945	14.66919	2.66710	16.22268	22.38159
	(0.25137)	(0.33590)	(0.17774)	(0.14724)	(0.12205)
LBNCS	1.51301	2.56264	0.0	0.50273	1.30948
	(0.78000)	0.60160	0.36200	1.91579	2.76448
HAYAR	0.00001	0.00001	C.00001	0.C0001	0.00001
	(2.18932)	(1.55632)	(1.54941)	(1.50737)	(1.49349)
RUFAG	-0.12866	0.09196	-0.01972	0.35230	-0.18155
	(2.18932)	(0.87427)	(1.54941)	(1.50737)	(1.49349)

TABLE A-3. (CONTINUED)

AREA NO.	021(MS)	022(KY)	023(TN)	024(MS)	025(AR)
CHL1	9.48611	9.98771	9.02970	2.05271	7.82511
	(0.57151)	(0.06379)	0.06391	(0.57947)	(0.51627)
CHL2	0.70514	0.0	0.0	0.53304	6.34465
	7.28937	4.28621	3.34771	0.07277	0.08716
CHL3	0.0	0.0	0.0	0.0	0.0
	5.05181	5.71751	2.91991	0.38861	0.61491
CL1	9.18191	0.00401	8.77561	2.00251	7.75703
	(1.16975)	5.85530	(0.07994)	(1.21517)	0.06808
CL2	0.02539	0.0	0.0	0.0	6.34465
	6.93082	2.06491	2.75231	0.54471	0.01586
CL3	0.0	0.0	0.0	0.0	0.0
	3.11521	2.02711	1.96211	0.22551	0.28521
CTNL	9.17055	0.00401	4.61572	2.00251	5.51201
	0.24246	(1.88536)	1.57029	0.03150	(1.69079)
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	64.51040	30.15471	-1.19373	9.90577	-1.68195
	(0.08323)	45.09448	21.82448	(0.09755)	3.20678
LBCS	74.96275	38.33267	39.00467	17.31591	13.26897
	3.08355	21.43619	(0.57048)	(0.18622)	(0.64706)
LBNCS	3.28702	13.64640	0.0	2.65546	0.0
	10.84911	6.77569	11.19368	1.99637	2.88060
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.49664)	(1.64621)	(1.62627)	(1.48581)	(1.27744)
RUFAG	-0.86516	-1.12660	-0.62885	-0.22821	-0.05618
	(1.49664)	(1.64621)	(1.62627)	(1.48581)	(1.27744)

TABLE A-3. (CONTINUED)

AREA NC.	026(MC)	027(KY)	028(ID)	029(KY)	030(OH)
CHL1	3.46581 (0.11624)	1.29219 7.46242	6.31341 (1.11732)	3.13321 (0.58430)	6.53271 (0.49355)
CHL2	10.06201 0.48160	0.0 3.23711	8.59461 (0.34599)	0.0 1.02481	0.0 4.57201
CHL3	0.0 0.57221	0.0 2.52431	1.75171 2.33680	0.0 2.24631	0.0 4.35001
CL1	3.36931 (1.60854)	1.05875 5.67876	3.40731 (1.64081)	0.15979 1.82112	0.22211 5.26230
CL2	10.06201 (0.11676)	0.0 1.97871	2.70311 (1.54588)	0.0 0.51921	0.0 3.15411
CL3	0.0 0.32491	0.0 1.09381	1.75171 (0.90187)	0.0 0.76391	0.0 1.94161
CTNL	3.36931 2.06970	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
WHL	0.01401 (0.08309)	0.0 0.00001	2.33501 (0.19444)	0.0 0.00001	0.0 0.00001
PASTA	-4.66980 8.07136	-0.21089 30.25366	10.10093 36.22046	18.77990 (0.00480)	28.48370 (0.14384)
LBCS	17.66695 (0.10852)	1.33797 24.25069	31.40644 9.52954	7.41954 8.03003	31.83421 (0.11129)
LBNCS	0.77753 4.00363	0.0 10.56851	14.48380 (0.02090)	2.38059 4.67554	11.54465 (0.78000)
HAYAR	0.00001 (1.21198)	0.00001 (1.41905)	0.00001 (1.35320)	0.00001 (1.64889)	0.00001 (1.49423)
RUFAG	-0.05802 (1.21198)	-0.51067 (1.41905)	-0.92428 (1.35320)	-0.35477 (1.64889)	-0.18041 (1.49423)

TABLE A-3. (CONTINUED)

AREA NO.	031(NY)	032(OH)	033(OH)	034(IN)	035(IN)
CHL1	22.72601	6.03891	56.95440	19.93171	2.23221
	(0.63550)	(0.56028)	1.36181	(0.37957)	0.41710
CHL2	21.71824	6.09971	0.0	0.0	0.0
	1.22837	1.90440	11.73211	4.04211	1.06751
CHL3	0.0	0.0	0.0	0.0	0.0
	12.50471	1.87571	1.66031	4.87781	0.47611
CL1	0.0	1.69706	51.36961	1.17597	2.21851
	9.38941	3.38325	(0.20987)	18.17593	(0.63119)
CL2	0.0	6.09971	0.0	0.0	0.0
	8.02531	(0.01154)	9.51231	3.47601	0.82251
CL3	0.0	0.0	0.0	0.0	0.0
	3.61361	1.04931	0.86211	2.66691	0.22571
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	74.58543	9.28193	21.54644	28.93631	-0.39064
	(0.03167)	(0.14384)	(0.11668)	(0.09055)	5.30695
LBCS	105.42154	27.16573	91.39697	36.44454	1.89872
	18.57849	(0.08931)	(0.64454)	1.83041	23.33246
LBNCS	60.53550	10.35984	29.68818	13.81246	0.0
	(0.14794)	(0.78000)	3.21080	(0.54963)	7.44934
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.62948)	(1.43902)	(1.49423)	(1.15923)	(1.38381)
RUFAG	-0.87097	-0.24468	-0.39797	-0.14740	-0.09182
	(1.62948)	(1.43902)	(1.49423)	(1.15923)	(1.37776)

TABLE A-3. (CONTINUED)

AREA NO.	C36(IL)	037(CA)	038(IN)	039(NV)	040(MI)
CHL1	18.80631	10.28641	66.46918	2.46061	36.11661
	(0.69646)	(1.32022)	3.61722	(0.01090)	(0.25830)
CHL2	12.31571	4.35661	10.15541	0.0	8.84119
	2.08800	2.85920	1.59830	3.18571	4.35952
CHL3	0.0	0.0	0.0	0.0	0.0
	5.02731	5.38471	6.65751	2.80001	5.58111
CL1	13.33537	6.66201	64.80541	1.04001	7.03948
	4.87554	(1.15806)	(1.05222)	(0.87433)	21.87923
CL2	12.31571	4.35661	10.15541	0.0	0.0
	(0.20166)	(0.93117)	(0.11528)	1.28931	10.20041
CL3	C.0	0.0	0.0	0.0	0.0
	2.84541	2.54461	4.99281	1.11971	4.00461
CTNL	C.0	0.0	0.0	0.0	0.0
	0.00001	0.41601	0.00001	0.00001	0.00001
WHL	0.04701	0.73801	0.0	2.10675	0.0
	(0.29689)	(0.51301)	0.00001	0.52925	0.00001
PASTA	27.83142	20.76157	33.27509	24.63892	20.82451
	(0.00696)	43.25156	3.52828	(0.05793)	(0.14384)
LBCS	39.09564	48.42798	111.77283	10.75828	75.34874
	15.79756	(1.05564)	(0.42858)	2.09802	20.78230
LBNCS	13.5840C	0.0	33.42421	2.51244	42.58979
	(0.42361)	0.00001	2.99225	(0.78834)	(0.72761)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.27196)	(1.91915)	(1.42918)	(1.23387)	(1.29387)
RUFAG	-0.22424	0.90498	-0.45941	-1.12766	-0.23468
	(1.27196)	(1.91915)	(1.42918)	(1.23387)	(1.29387)

TABLE A-3. (CONTINUED)

AREA NO.	041(MI)	042(WI)	043(WI)	044(CO)	045(IL)
CHL1	3.41291	12.00091	32.06301	0.79051	149.60780
	(0.60630)	(0.10610)	(0.96457)	(1.69032)	(1.10150)
CHL2	3.00393	0.05446	12.06371	1.08001	18.97621
	1.99408	4.91864	(0.32844)	(0.01427)	(0.61890)
CHL3	0.0	0.0	10.68591	0.0	0.0
	2.91451	6.48051	(0.09960)	1.55431	11.23911
CL1	0.26962	2.36141	22.72083	0.08839	141.95390
	1.47159	4.14040	0.50678	0.49381	(0.82509)
CL2	0.0	0.0	0.0	0.00444	14.51951
	2.29031	2.37051	7.08731	0.68877	(0.34135)
CL3	0.0	0.0	0.0	0.0	0.0
	1.29881	2.94971	5.03801	0.73811	7.21611
CTNL	0.0	0.0	0.0	0.02401	0.0
	0.00001	0.00001	0.00001	(2.06063)	0.00001
WHL	0.0	0.0	0.13301	0.0	0.0
	0.00001	0.07701	(0.19939)	0.10701	0.00001
PASTA	13.66210	24.34197	57.93051	37.33853	71.19369
	(0.00087)	(0.13961)	(0.11802)	(0.14833)	17.80309
LBCS	16.93618	36.34033	80.38703	7.70580	186.54025
	6.67703	33.41733	72.70461	2.28518	(0.07370)
LBNCS	10.97292	24.30647	46.76235	1.33653	46.32275
	(0.59024)	(0.32595)	(0.73589)	(0.95000)	13.38292
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.49423)	(1.35179)	(1.11602)	(1.84182)	(1.52368)
RUFAG	-0.06127	-0.20571	-0.47370	-0.52364	-0.95119
	(1.49423)	(1.35179)	(1.11602)	(1.84182)	(1.52368)

TABLE A-3. (CONTINUED)

AREA NO.	046(MO)	047(IL)	048(CA)	049(AZ)	050(MO)
CHL1	1.52795	8.56741	0.48044	6.06728	7.87481
	0.93676	(0.69948)	0.39047	1.33793	(0.14775)
CHL2	0.0	10.20851	0.49771	0.0	0.0
	5.79081	(0.11312)	0.54650	1.97581	13.92871
CHL3	0.0	0.0	0.0	0.0	0.0
	8.98591	2.52851	1.04071	0.90641	4.90921
CL1	1.52795	6.24727	0.47621	5.88481	1.02373
	0.93676	2.24954	(2.36311)	(0.49293)	6.23908
CL2	0.0	9.49701	0.49771	0.0	0.0
	4.24421	(0.09156)	(0.79900)	1.51611	10.55861
CL3	0.0	0.0	0.0	0.0	0.0
	5.51711	1.36751	0.56541	0.68971	2.88571
CTNL	1.52795	0.0	0.0	5.84502	0.0
	0.01906	0.00001	1.14001	2.15798	0.00001
WHL	0.13312	0.0	0.0	0.0	1.25201
	1.57389	0.00001	0.00001	0.00001	(0.02792)
PASTA	-0.37313	9.58756	-0.21158	23.02763	47.03502
	45.39236	5.31900	(0.06260)	(0.08031)	(0.03599)
LBCS	15.08167	19.79877	1.89657	11.89209	33.45727
	(0.12240)	6.69192	(1.12197)	(0.98000)	25.24190
LBNCS	0.0	5.84779	0.0	0.0	12.57679
	3.21409	(0.41828)	0.00001	0.00001	(0.30720)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.59542)	(1.38040)	(1.79044)	(1.95051)	(1.21198)
RUFAG	-0.20369	-0.10703	0.23093	-0.28894	-0.30135
	(1.59542)	(1.38040)	(1.79044)	(1.95051)	(1.21198)

TABLE A-3. (CONTINUED)

AREA NC.	051(MC)	052(IA)	053(IA)	054(MN)	055(NM)
CHL1	37.97491	22.75211	109.95601	61.35741	4.78701
	(0.86321)	(1.59852)	(0.70481)	(0.65062)	(0.30023)
CHL2	36.36031	27.04551	34.30601	9.98791	1.06341
	(0.16203)	0.00499	(0.03648)	1.71050	(0.17075)
CHL3	0.0	0.0	0.0	0.0	0.86491
	14.31631	10.38141	7.66411	1.95621	(0.02165)
CL1	35.56201	22.75211	104.93821	57.93851	4.28331
	(0.27318)	(0.0)	(0.91226)	(0.05981)	(0.28667)
CL2	27.86841	21.95181	25.52331	9.98791	0.0
	(0.20005)	(0.77916)	(0.81140)	(0.14013)	0.89801
CL3	0.0	0.0	0.0	0.0	0.0
	7.19381	6.17671	4.52001	1.33861	0.64671
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	2.11001
WHL	0.17801	0.0	0.0	0.0	0.0
	(1.23482)	0.00001	0.00001	0.86901	0.00001
PASTA	29.35218	73.42125	92.64730	16.64086	25.40400
	55.79092	(0.11936)	(0.10904)	(0.05679)	(0.13079)
LBCS	104.59117	48.70776	153.32642	84.81587	6.38875
	11.15326	32.39539	30.70622	16.38736	(0.84000)
LBNCS	31.75434	9.75097	43.96386	20.77057	0.0
	(0.01937)	17.45399	20.07982	(0.39757)	0.00001
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.60439)	(1.22543)	(1.31047)	(1.35990)	(1.85130)
RUFAG	-0.75320	-0.46180	-0.79657	-0.32843	-0.31091
	(1.60439)	(1.22543)	(1.31047)	(1.35990)	(1.85130)

TABLE A-3. (CONTINUED)

AREA NO.	C56(MN)	057(MN)	058(MN)	059(MN)	060(MN)
CHL1	19.42511	26.87021	2.59249	9.48501	16.44641
	(1.08713)	(0.48383)	2.76781	(0.03942)	(0.56795)
CHL2	5.56891	4.85239	1.32091	0.0	10.15460
	(0.38047)	6.53461	2.84670	6.06621	0.35351
CHL3	0.0	0.0	0.0	0.0	0.0
	1.68061	9.06861	3.92361	6.69561	3.30901
CL1	17.79701	6.01717	1.92861	0.0	14.31261
	(0.16528)	16.01193	(2.06359)	7.08151	(0.05381)
CL2	4.58951	0.0	1.32091	0.0	9.05411
	(0.32833)	7.70191	(0.51460)	4.02871	(0.20604)
CL3	0.0	0.0	0.0	0.0	0.0
	0.95081	5.19151	1.28841	4.49151	2.84271
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.19101	0.59001	0.0	0.0	0.0
	(0.31050)	(0.17469)	0.45701	1.08401	0.96701
PASTA	10.47751	36.62160	12.69938	16.78041	6.93958
	(0.05053)	(0.08777)	(0.13961)	(0.11608)	(0.06663)
LBCS	31.23956	72.70359	19.91731	18.91627	17.10069
	22.64481	28.71703	8.08625	40.73730	9.38389
LBNCS	10.68409	48.25506	14.78736	14.29437	7.11634
	(0.40460)	(0.70269)	(0.26546)	(0.74824)	(0.45445)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.35897)	(1.10971)	(1.38303)	(1.00144)	(1.27089)
RUFAG	-0.14517	-0.37037	0.03335	-0.17643	-0.15571
	(1.35897)	(1.10971)	(1.38303)	(1.00144)	(1.27089)

TABLE A-3. (CONTINUED)

AREA NO.	061(ND)	062(ND)	063(ND)	064(SD)	065(ND)
CHL1	19.84927	54.99431	13.30551	0.0	1.58951
	1.01534	(0.16902)	8.01199	0.08411	1.51170
CHL2	2.60691	12.32961	0.0	0.0	0.0
	0.65390	3.21590	45.90900	0.24161	0.73351
CHL3	0.0	0.0	0.0	0.0	0.0
	0.74281	3.65051	8.11481	0.01721	0.28311
CL1	19.59531	52.27321	6.11527	0.0	1.58951
	(0.75045)	(0.28780)	15.20224	0.03481	(0.16247)
CL2	2.60691	12.32961	0.0	0.0	0.0
	(0.34146)	(0.13304)	39.15150	0.08731	0.31181
CL3	0.0	0.0	0.0	0.0	0.0
	0.56121	2.52181	5.59151	0.00581	0.08811
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.50801	0.66781	0.0	0.0	0.89920
	(0.14862)	5.50420	7.96801	0.09001	0.43781
PASTA	1.98937	14.24318	37.02170	0.09547	2.43669
	(0.10145)	(0.12694)	(0.13789)	2.53804	(0.08530)
LBCS	7.34147	21.46966	9.14318	0.19993	1.27298
	8.09734	25.98787	37.51868	0.33880	11.08158
LBNCS	0.53288	3.11463	6.69562	0.16469	0.40944
	5.05490	13.84402	7.77847	(0.57231)	3.18909
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.04502)	(1.01869)	(0.98476)	(1.35782)	(1.14773)
RUFAG	0.01780	0.08141	0.10728	0.00333	0.01769
	(1.04502)	(1.01869)	(0.98476)	(1.35782)	(1.14773)

TABLE A-3. (CONTINUED)

AREA NO.	066(SD)	067(SD)	068(SD)	069(SD)	070(SD)
CHL1	2.60231	0.0	0.0	5.66781	26.84531
	(0.41370)	24.12360	11.34081	(0.11693)	2.46969
CHL2	0.0	0.0	0.0	0.0	4.25781
	9.47101	15.38001	3.27171	4.03391	1.34790
CHL3	0.0	0.0	0.0	0.0	0.0
	11.24981	6.03681	1.83431	2.14851	6.24911
CL1	0.22380	0.0	0.0	5.06821	26.72301
	2.11221	21.74080	9.70581	(0.12335)	(0.47125)
CL2	0.0	0.0	0.0	0.0	4.25781
	7.02071	11.38811	2.50221	2.91031	(0.00062)
CL3	0.0	0.0	0.0	0.0	0.0
	6.67481	4.72431	1.35581	1.29031	5.13801
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	6.32901	3.57459	0.16248	0.78383	1.80801
	(0.24067)	4.78442	1.40453	2.08218	(0.01778)
PASTA	40.39165	16.32638	3.75228	8.02616	12.64825
	35.02193	(0.09300)	(0.01485)	(0.08528)	(0.03149)
LBCS	7.33552	10.29491	6.44687	5.18039	36.26231
	9.04093	15.75126	10.03129	4.54268	10.07049
LBNCS	5.44768	10.00273	6.45024	2.94302	13.72785
	(0.54416)	(0.47285)	(0.50529)	(0.52660)	(0.55433)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.35810)	(0.94667)	(1.26168)	(0.95946)	(1.19981)
RLFAG	0.18670	0.08807	0.03383	0.02473	0.05528
	(1.35810)	(0.94667)	(1.26168)	(0.95946)	(1.19981)

TABLE A-3. (CONTINUED)

AREA NC.	C71(NB)	072(NB)	073(NB)	074(CO)	075(NB)
CHL1	43.44781 (0.91826)	1.13101 (1.05284)	5.79711 (1.24246)	3.35981 (1.70187)	10.94441 (0.52226)
CHL2	29.58831 (0.15246)	1.23701 (0.35903)	7.23031 (0.37401)	1.79021 (0.45537)	5.99971 (0.04086)
CHL3	0.0 15.81541	1.81941 (0.14591)	3.64441 1.17770	7.11831 (0.63745)	0.0 5.86351
CL1	43.44781 (0.0)	1.02394 0.07917	4.05980 1.73731	3.35981 (0.94181)	7.06049 2.95682
CL2	20.10319 5.01702	0.92341 (0.16553)	6.74441 (0.39128)	1.53251 (0.70093)	4.20461 (0.10649)
CL3	0.0 10.22161	1.06461 (0.22527)	3.64441 (0.33926)	4.62021 (0.73996)	0.0 3.02521
CTNL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
WHL	0.0 2.44401	1.43901 (0.51169)	2.09701 (0.15752)	0.23201 (0.44862)	6.83901 (0.14022)
PASTA	48.80378 (0.12776)	15.20142 8.63853	29.97733 (0.11111)	13.41272 (0.04732)	44.59764 (0.14511)
LBCS	98.53812 15.07631	2.88441 0.77219	11.66941 1.12629	16.74533 0.82872	22.14341 6.94540
LBNCS	27.75046 6.27975	1.26063 (0.54763)	4.25773 (0.00227)	4.35543 (0.19867)	9.13396 (0.45513)
HAYAR	0.00001 (1.19018)	0.00001 (1.38891)	0.00001 (1.26152)	0.00001 (1.40056)	0.00001 (0.97727)
RUFAG	0.07939 (1.19018)	0.02128 (1.38891)	0.01758 (1.26152)	-0.10140 (1.40056)	0.04959 (0.97727)

TABLE A-3. (CONTINUED)

AREA NO.	076(NB)	077(NB)	078(KS)	079(KS)	080(KS)
CHL1	12.05621 (0.58419)	0.89671 (0.46237)	6.03151 (0.51902)	3.57961 (0.51552)	5.82201 (0.12998)
CHL2	4.16581 (0.11943)	0.49700 0.21631	7.44901 (0.04312)	7.06351 (0.14163)	7.97931 (0.01655)
CHL3	3.97301 (0.03264)	0.0 1.20861	0.0 3.56691	2.16231 (0.02344)	0.0 1.36331
CL1	8.91635 3.13986	0.01883 0.55958	2.50344 3.52807	0.45283 3.12677	4.20059 0.11152
CL2	3.70661 (0.07281)	0.01044 0.33647	0.0 6.57841	0.0 6.68201	0.0 4.94021
CL3	0.0 2.38161	0.0 0.42561	0.0 2.30841	0.0 1.50181	0.0 0.66311
CTNL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
WHL	0.0 0.37701	10.59001 (0.20287)	0.0 0.53201	0.0 2.01601	0.0 1.07501
PASTA	23.11156 (0.18868)	45.39235 3.11704	22.52125 (0.09312)	23.54972 (0.11475)	14.12631 (0.08615)
LBCS	14.57089 4.60588	6.07874 (0.38278)	11.15334 8.81014	7.87058 10.03248	7.18765 4.31557
LBNCS	5.74429 (0.07662)	2.05712 (0.97000)	4.43173 (0.42117)	3.65709 (0.40230)	2.12886 (0.96000)
HAYAR	0.00001 (0.98413)	0.00001 (1.12774)	0.00001 (1.08120)	0.00001 (1.11454)	0.00001 (1.15127)
RUFAG	0.02033 (0.98413)	0.04134 (1.12774)	0.02511 (1.08120)	0.02716 (1.11454)	0.01656 (1.15127)

TABLE A-3. (CONTINUED)

AREA NO.	081(KS)	082(KS)	083(TX)	084(KS)	C85(OK)
CHL1	6.22281 (0.42435)	15.06281 (0.29973)	0.0 3.06021	44.56021 (0.57203)	2.94031 (0.83394)
CHL2	5.92671 (0.13422)	12.76551 (0.20732)	0.0 0.42651	23.36871 (0.23370)	1.46851 (0.28459)
CHL3	2.88251 (0.04491)	8.21071 (0.13802)	0.0 0.38791	18.64611 (0.17304)	0.0 0.43321
CL1	1.48574 4.73707	7.83708 7.22573	0.0 2.53251	38.04354 6.51667	1.88211 (0.11274)
CL2	0.0 5.03051	0.0 12.09671	0.0 0.34581	0.0 22.34601	0.71781 (0.08702)
CL3	0.0 1.77721	0.0 5.61351	0.0 0.29871	0.0 15.94011	0.0 0.15481
CTNL	0.0 0.00001	0.0 0.00001	0.0 2.10801	0.0 0.00001	0.0 0.31901
WHL	0.0 2.41901	0.0 0.94401	0.0 0.00001	0.0 0.84701	0.87301 (1.09647)
PASTA	55.14684 (0.10035)	37.97759 (0.12159)	184.93950 (0.06293)	102.97961 (0.12638)	45.08655 (0.13003)
LBCS	11.35473 6.52131	15.86940 14.12651	3.30844 (0.90000)	45.09415 4.92697	11.23923 6.33035
LBNCS	3.58579 (0.96000)	6.82590 (0.67847)	0.0 0.00001	11.15333 (0.96000)	1.35921 1.18525
HAYAR	0.00001 (1.05609)	0.00001 (1.01258)	0.00001 (2.34746)	0.00001 (0.92689)	0.00001 (1.89821)
RUFAG	0.04742 (1.05609)	0.03782 (1.01258)	-0.36527 (2.34746)	0.09871 (0.92689)	-0.09497 (1.89821)

TABLE A-3. (CONTINUED)

AREA NO.	C86(KS)	087(OK)	088(OK)	089(OK)	090(OK)
CHL1	8.42471	4.07511	24.08391	3.71731	3.41711
	(C.78263)	(0.11487)	(1.64162)	(1.53108)	(0.77234)
CHL2	17.47041	0.55201	15.62541	11.25581	0.88421
	(C.39068)	0.29150	(0.70241)	(0.95600)	0.55990
CHL3	0.0	0.0	6.78291	5.01231	0.0
	6.07811	0.13901	3.02450	(0.01570)	1.38031
CL1	5.95975	3.46451	22.20309	2.52107	1.56790
	2.46496	(1.17041)	1.88082	1.19624	1.19150
CL2	17.47041	0.55201	13.84311	11.25581	0.88421
	(0.0)	(0.71021)	(0.31622)	(0.0)	(0.14934)
CL3	C.0	0.0	6.78291	4.20201	0.0
	5.52381	0.06511	(0.37167)	(0.31731)	0.69761
CTNL	C.0	0.0	6.44401	0.67101	0.0
	C.00001	0.00001	(0.00424)	(0.04609)	0.29601
WHL	C.16001	1.43001	0.44801	0.28601	0.53801
	(0.01884)	(0.91714)	(0.51531)	(0.16558)	(0.61768)
PASTA	57.77760	27.09547	42.12366	44.89105	22.28051
	(0.03841)	(0.14651)	(0.15131)	(0.16679)	(0.12737)
LBCS	13.83888	8.48085	47.75462	19.18751	14.25535
	(0.78659)	0.58472	(0.06122)	(0.24017)	(0.06920)
LBNCS	3.28604	2.13839	4.65415	1.85877	1.62055
	(C.96000)	(0.72901)	3.55657	0.42675	C.42716
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.02939)	(1.43846)	(1.78546)	(1.43846)	(1.76200)
RUFAG	C.03277	-0.15801	-0.24864	-0.19251	-0.08647
	(1.02939)	(1.43846)	(1.78546)	(1.43846)	(1.76200)

TABLE A-3. (CCNTINUED)

AREA NO.	091(TX)	092(TX)	093(TX)	094(TX)	C95(TX)
CHL1	3.58881 (C.70078)	14.40271 (2.16492)	17.61621 (1.18847)	7.89561 (2.62254)	3.90781 (0.28140)
CHL2	3.79581 (0.20505)	23.13021 (0.80462)	13.67531 (0.25872)	17.98631 (0.31271)	0.0 1.15721
CHL3	0.0 0.81511	0.0 2.10711	0.0 8.35051	8.52931 (0.10410)	C.0 0.21471
CL1	0.40195 2.40506	14.08414 0.31857	17.05213 0.56408	7.89561 (0.0)	2.69977 1.17154
CL2	0.42513 2.19988	22.93981 (0.34890)	13.29800 0.37730	17.61690 0.36940	0.0 0.86311
CL3	0.0 0.37061	0.0 1.37611	0.0 7.13751	0.0 8.07501	0.0 0.13141
CTNL	0.0 0.95201	7.56401 (0.18982)	16.69601 (0.00487)	15.97001 (1.11197)	0.0 0.51901
WHL	0.43801 (0.72570)	0.10201 (0.10606)	0.0 0.06001	0.0 0.00001	0.0 0.00001
PASTA	93.72783 (0.14477)	56.87960 (0.09431)	84.07830 (0.11256)	74.78905 (0.08881)	15.30924 (0.14931)
LBCS	27.39626 (0.05661)	24.49953 (0.90000)	31.17398 (0.90000)	30.37301 (0.90000)	5.36760 (0.36957)
LBNCS	0.0 0.00001	1.17019 1.93454	1.25935 2.14876	0.99158 0.85537	0.51233 0.07592
HAYAR	0.00001 (1.90665)	0.00001 (1.74398)	0.00001 (1.43846)	0.00001 (1.71340)	0.00001 (1.57923)
RUFAG	-1.03978 (1.90665)	-0.23372 (1.74398)	-0.54472 (1.13911)	-0.11050 (1.71340)	-0.07315 (1.57923)

TABLE A-3. (CONTINUED)

AREA NO.	096(TX)	097(TX)	098(TX)	099(TX)	100(TX)
CHL1	1.58681	23.07351	2.73841	4.51091	13.72821
	(0.64472)	(0.57240)	(0.34991)	(0.49819)	(1.86305)
CHL2	0.65255	12.49681	0.0	0.24718	4.59371
	0.08256	(0.06239)	0.73021	2.65562	(1.19442)
CHL3	0.0	0.0	0.0	0.0	1.03671
	0.26651	5.18931	0.30901	0.84061	(0.08123)
CL1	0.48080	20.74181	1.61882	2.40514	13.31931
	1.10601	(0.41495)	0.60649	1.97056	(0.30706)
CL2	0.19772	8.44971	0.0	0.02126	3.75131
	0.49079	(0.39781)	0.45321	2.15285	(0.22561)
CL3	0.0	0.0	0.0	0.0	0.80101
	0.21001	3.09791	0.15831	0.52681	(0.15751)
CTNL	0.0	0.0	0.0	2.20701	0.0
	1.39801	20.58900	0.93701	(1.14404)	8.22201
WHL	0.0	0.37601	0.0	0.28901	0.19201
	0.00001	(0.92030)	0.00001	(0.18182)	(0.92374)
PASTA	19.51436	54.47294	82.32672	19.91829	67.64382
	(0.13842)	(0.12322)	(0.08182)	(0.15021)	(0.16812)
LBCS	6.39692	51.48490	10.76500	25.88930	35.96875
	(0.49116)	(0.06428)	(0.90000)	(0.08559)	(0.05661)
LBNCS	0.0	2.84812	0.0	0.0	0.0
	0.00001	1.06233	0.00001	0.00001	0.00001
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.43846)	(1.89286)	(1.68335)	(1.71791)	(1.91748)
RUFAG	-0.68997	-0.42622	-0.83050	-0.08938	-0.16876
	(1.36774)	(1.89286)	(1.68335)	(1.71791)	(1.91748)

TABLE A-3. (CONTINUED)

AREA NO.	101(MT)	102(MT)	103(WY)	104(MT)	105(WY)
CHL1	7.00451	5.68031	2.37171	1.36541	2.99301
	(1.45815)	(0.98769)	(0.57056)	(1.12937)	(0.77133)
CHL2	23.47947	15.55411	3.77269	2.94491	3.05128
	1.47853	(0.46523)	0.74222	(0.44967)	2.64573
CHL3	8.59221	3.38421	4.13731	1.21881	11.23241
	0.88100	1.08840	2.98590	0.51260	(0.0)
CL1	7.00451	4.96531	0.09250	1.01701	1.37961
	(0.0)	(0.73308)	1.43251	(0.35146)	(1.20897)
CL2	21.54871	12.30151	2.51151	1.82181	2.40151
	(0.93675)	(0.73992)	(0.01424)	(0.43303)	(1.09342)
CL3	8.59221	3.38421	4.13731	1.21881	4.53691
	(0.29171)	(0.44202)	(0.01424)	(0.32582)	(1.09342)
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.0	1.18501	1.38501	0.07101	4.74501
	1.16701	(0.30728)	(0.36532)	(0.29155)	(0.50619)
PASTA	20.32286	27.36524	39.35028	9.85007	70.67957
	(0.06764)	(0.06764)	(0.06299)	(0.06764)	(0.06764)
LBCS	14.73417	13.36625	9.56121	5.08392	23.92978
	(0.59865)	(0.02075)	3.96266	1.25274	0.17000
LBNCS	3.46339	6.25885	4.80916	2.62292	5.95995
	4.77262	0.31532	(0.05047)	(0.01826)	(0.57288)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.36080)	(1.45121)	(1.67650)	(1.44617)	(1.35320)
RUFAG	-0.38830	-0.45932	-0.84026	-0.14348	-2.19632
	(1.36080)	(1.45121)	(1.67650)	(1.44617)	(1.35320)

TABLE A-3. (CONTINUED)

AREA NO.	106(CO)	107(CO)	108(CO)	109(NM)	110(ID)
CHL1	5.05891	1.71001	0.14471	0.52731	5.80621
	(0.60414)	(1.04424)	(0.52813)	(0.57277)	(1.10461)
CHL2	8.91091	0.69447	0.0	3.71911	8.26541
	(0.0)	0.31514	0.36381	(0.38885)	(0.24605)
CHL3	1.33996	1.83441	0.82608	3.08171	0.0
	13.20955	1.67590	0.66273	(0.29243)	2.24251
CL1	1.43673	1.71001	0.01201	0.52731	5.13791
	3.62218	(0.10612)	0.13270	(2.26111)	(0.57798)
CL2	8.91091	0.69447	0.0	3.71911	5.72851
	(0.06030)	0.29854	0.36381	(1.02140)	(0.77655)
CL3	1.33996	1.83441	0.06856	2.70721	0.0
	11.39395	(0.11318)	1.06424	(0.38895)	1.46191
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	2.65901	0.00001
WHL	0.0	0.01701	0.04901	0.0	0.50301
	0.21201	(0.59639)	(0.50847)	0.05401	(0.41721)
PASTA	24.73134	10.42640	9.63903	18.47355	4.90030
	(0.06189)	1.14631	(0.02584)	(0.14833)	(0.06764)
LBCS	15.37797	4.85057	1.93794	8.70246	18.59167
	(0.47334)	(0.25021)	0.81489	(0.84000)	14.08642
LBNCS	3.67392	0.50193	0.56335	0.81211	6.68859
	(1.01000)	0.53310	(0.20887)	(0.82285)	2.12453
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(0.94810)	(1.63917)	(1.55333)	(1.31134)	(1.61619)
RUFAG	-0.25719	-0.09414	-0.06713	-0.11691	-0.37913
	(0.94810)	(1.63917)	(1.55333)	(1.31134)	(1.61619)

TABLE A-3. (CONTINUED)

AREA NO.	111(UT)	112(ID)	113(OR)	114(WA)	115(WA)
CHL1	3.70091	1.31971	9.73981	8.55531	8.09831
	(1.04005)	(0.57125)	(1.92289)	(1.42312)	(1.38687)
CHL2	1.61551	2.14381	12.48291	7.68821	6.27131
	(0.11609)	(0.03291)	(1.06614)	(0.34917)	(0.46934)
CHL3	0.0	0.47511	5.38301	3.16821	1.97581
	0.54901	0.21080	(0.00287)	1.10790	3.33500
CL1	0.40340	1.19551	8.83324	6.91494	2.60585
	1.97651	(2.41938)	0.90657	1.13287	1.00706
CL2	0.91881	1.54031	10.95431	6.92781	2.53241
	(0.08732)	(2.07084)	(0.05238)	(0.41396)	(0.17504)
CL3	0.0	0.47511	4.08771	3.16821	1.97581
	0.27401	(0.82500)	(0.12565)	(0.02062)	(0.04625)
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.22001	0.02201	0.15301	0.08901	3.00201
	(0.65918)	(0.73195)	(0.75679)	(0.79450)	(0.51887)
PASTA	5.98415	0.89974	7.16564	10.74186	35.16468
	(0.14833)	0.61352	18.14850	15.10428	33.61804
LBCS	20.02351	3.15134	19.08161	18.79054	46.57835
	10.03723	1.43048	(0.16406)	1.98960	21.44576
LBNCS	7.60860	1.57118	5.42430	6.09933	14.49713
	(0.01290)	(0.02209)	0.14934	(1.13247)	(0.11735)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.55362)	(1.67064)	(1.55687)	(1.36035)	(1.66093)
RUFAG	-0.48210	-0.04984	-0.36941	-0.16949	-0.81094
	(1.55362)	(1.67064)	(1.55687)	(1.36035)	(1.66093)

TABLE A-3. (CONTINUED)

AREA NO.	116(CA)	117(CA)	118(GA)	119(AL)	120(LA)
CHL1	1.78901 (1.93401)	11.96827 0.67734	6.08821 (0.49965)	2.46145 0.13886	6.86415 3.57996
CHL2	2.34971 (0.37500)	0.0 5.95821	0.0 4.87831	0.0 1.18041	0.0 6.41761
CHL3	0.0 1.02731	0.0 3.76231	0.0 3.30501	0.0 0.64551	0.0 0.53501
CL1	1.06969 0.21812	9.84041 (0.46766)	0.57838 5.24133	1.99651 (0.01687)	4.24863 4.74428
CL2	1.65681 (0.63115)	0.0 4.51841	0.0 3.69881	0.0 0.80401	0.0 5.20231
CL3	0.0 0.68171	0.0 2.70751	0.0 1.85861	0.0 0.37021	0.0 0.28181
CTNL	0.0 0.00001	0.42433 11.15868	0.0 5.44501	0.0 2.24801	4.24863 4.89838
WHL	0.08701 (0.68295)	0.05301 (0.22959)	0.0 0.00001	0.0 0.00001	0.0 0.00001
PASTA	6.24310 2.55952	14.78445 15.43990	41.06462 17.30646	42.09353 (0.14895)	58.13730 (0.09755)
LBCS	8.27835 (1.38000)	27.80509 (1.38000)	26.10409 7.28028	6.68504 7.01223	51.96296 (0.01418)
LBNCS	0.93000 (0.04216)	0.0 0.00001	4.85620 1.15466	1.84324 0.28153	2.06233 4.54950
HAYAR	0.00001 (1.67675)	0.00001 (1.50702)	0.00001 (1.58563)	0.00001 (1.61798)	0.00001 (1.36161)
RUFAG	0.12208 (1.67675)	0.34019 (1.50702)	-0.38155 (1.58563)	-0.19982 (1.61798)	-0.69679 (1.36161)

TABLE A-3. (CONTINUED)

AREA NO.	121(AR)	122(AR)	123(AR)	124(LA)	125(TX)
CHL1	23.85681	7.21251	1.79523	0.00875	5.89291
	(0.56432)	(0.63611)	2.28858	0.17296	(0.55804)
CHL2	18.74821	3.17911	0.0	0.0	4.54407
	(0.11133)	(0.05161)	2.78751	0.24431	2.82373
CHL3	0.0	5.75179	0.0	0.0	0.0
	1.30221	1.26732	0.42881	0.01061	3.06601
CL1	22.66671	6.50141	0.03590	0.00007	0.43608
	(0.47355)	(0.12121)	3.46530	0.14884	5.01503
CL2	17.44341	2.20891	0.0	0.0	0.33626
	(0.42416)	(0.36153)	1.91181	0.16131	5.14085
CL3	0.0	0.25308	0.0	0.0	0.0
	1.14481	2.53053	0.28961	0.00521	1.89641
CTNL	0.0	1.81298	0.0	0.0	0.0
	22.69800	0.58803	2.42401	0.15701	5.53701
WHL	0.10601	1.62001	0.30201	0.0	0.47201
	(1.03191)	(0.91904)	(0.95597)	0.00001	(0.60728)
PASTA	14.98364	84.57001	16.77365	-0.00252	90.77777
	(0.03798)	(0.02422)	(0.02193)	3.29210	(0.00084)
LBCS	42.03076	56.73656	11.09404	0.00621	37.96696
	2.20529	(0.08195)	0.45305	1.06166	(0.09753)
LBNCS	2.59830	8.63647	1.65941	0.0	2.16984
	5.80119	(0.28242)	(0.49948)	0.09813	0.59498
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.53252)	(1.68802)	(1.65349)	(1.96815)	(1.74387)
RUFAG	-0.53983	-0.83269	-0.14316	-0.01374	-0.25453
	(1.53252)	(1.68802)	(1.65349)	(1.96815)	(1.74387)

TABLE A-3. (CONTINUED)

AREA NO.	126(TX)	127(OK)	128(OK)	129(TX)	130(TX)
CHL1	C.18371	1.05471	1.95031	1.73731	3.54174
	(1.75873)	(0.83746)	(0.79824)	(0.51979)	6.72937
CHL2	0.06831	0.90541	0.49241	1.30841	0.0
	(0.65542)	(0.28452)	(0.12451)	(0.07741)	1.56631
CHL3	C.0	0.0	0.0	0.0	0.0
	0.01511	0.27621	0.23241	0.42091	0.28891
CL1	0.05915	0.02531	1.61141	0.32057	3.54174
	0.11555	0.82970	(0.15950)	1.30594	6.67777
CL2	0.0220C	0.34078	0.31081	0.91871	0.0
	0.02861	0.21723	(0.25815)	(0.05900)	1.37831
CL3	0.0	0.0	0.0	0.0	0.0
	0.00951	0.13831	0.11831	0.21411	0.25621
CTNL	0.0	0.0	0.0	0.0	0.0
	0.17301	0.74501	0.82401	0.70701	7.00101
WHL	0.0	0.21301	0.84601	0.01501	0.0
	C.00001	(1.18501)	(1.42807)	(0.69120)	0.00001
PASTA	12.29139	15.42280	19.57400	14.26035	8.17895
	(0.06076)	(0.13569)	(0.12939)	(0.15565)	(0.08607)
LBCS	0.97846	7.27572	6.19430	8.37315	8.38602
	(0.90000)	(0.02691)	2.92266	(0.06428)	(0.89867)
LBNCS	0.0	0.7C718	0.73658	0.58705	0.0
	0.00001	0.11290	0.58097	0.05609	0.00001
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(2.34746)	(1.84313)	(1.89816)	(1.90799)	(1.50280)
RUFAG	-0.29254	-0.01593	-0.07341	-0.07980	-0.03389
	(2.34746)	(1.84313)	(1.89816)	(1.90799)	(1.50280)

TABLE A-3. (CONTINUED)

AREA NO.	131(TN)	132(TN)	133(AL)	134(AL)	135(TN)
CHL1	0.93164	2.03988	3.71151	2.41141	0.97041
	0.98557	1.30833	(0.04894)	(0.25511)	(0.65205)
CHL2	0.0	0.0	0.0	0.0	0.0
	1.47571	1.91601	2.01551	2.23851	0.90111
CHL3	0.0	0.0	0.0	0.0	0.0
	1.10611	1.44281	0.40671	0.67431	0.74011
CL1	0.87148	1.87759	0.50411	1.99506	0.03203
	0.88532	1.19941	2.93540	0.41635	0.47718
CL2	0.0	0.0	0.0	0.0	0.0
	1.27291	1.70601	1.56611	1.87391	0.36171
CL3	0.0	0.0	0.0	0.0	0.0
	0.66581	0.87791	0.27291	0.42261	0.25461
CTNL	0.86661	1.87101	0.27772	1.96801	0.00101
	0.11140	(1.42547)	2.97829	(0.21104)	(1.68813)
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	-0.13537	-0.16949	12.74035	11.57692	2.65823
	9.14649	15.18715	(0.14892)	(0.07593)	4.77277
LBCS	8.92132	17.25847	9.86131	17.98436	3.97862
	(0.26613)	(0.08616)	(0.12435)	(0.06016)	4.85759
LBNCS	0.0	0.04393	1.12818	0.93579	1.41429
	2.86573	4.51768	0.66681	2.32500	1.36194
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.48585)	(1.46646)	(1.49396)	(1.57391)	(1.95809)
RUFAG	-0.14308	-0.25659	-0.14118	-0.12422	-0.11843
	(1.48585)	(1.46646)	(1.49396)	(1.57391)	(1.95809)

TABLE A-3. (CONTINUED)

AREA NC.	136(TN)	137(TN)	138(NC)
CHL1	3.28031	3.23893	0.64831
	(0.36148)	0.90038	(0.53297)
CHL2	0.0	0.0	0.0
	3.62171	1.29041	0.93031
CHL3	0.0	0.0	0.0
	3.09631	0.93271	1.23751
CL1	0.07401	0.58920	0.0
	1.59820	2.04701	0.45361
CL2	0.0	0.0	0.0
	1.43121	0.66091	0.55431
CL3	0.0	0.0	0.0
	1.03391	0.38481	0.45591
CTNL	0.07401	0.43201	0.0
	(1.03648)	(0.55883)	0.00001
WHL	0.0	0.0	0.0
	0.00001	0.00001	0.00001
PASTA	7.95813	9.04466	1.79473
	22.36919	14.48659	5.60390
LBCS	13.03694	17.15023	3.70398
	16.66907	(0.21150)	12.19350
LBNCS	4.28400	4.48083	1.27254
	5.02474	0.69725	3.42237
HAYAR	0.00001	0.00001	0.00001
	(1.85638)	(1.58638)	(1.85046)
RUFAG	-0.53670	-0.24353	-0.12195
	(1.85638)	(1.58638)	(1.85046)

Table A-4. Consuming region transfer activities, Solution I

Code	Descriptions	Unit ($x10^5$)
FMMGMK	From Fluid Milk to Manufactured Milk	1000 lbs.
CFSLAU	Calf Slaughter (to other Beef)	Head
YLSLAU	Yearling Slaughter (to other Beef)	Head
WHETP1	Wheat to TDN-Protein Type 1	1000 lbs TDN
WHETP2	Wheat to TDN-Protein Type 2	1000 lbs TDN
WHETP3	Wheat to TDN-Protein Type 3	1000 lbs TDN
FGTP1	Feed Grain to TDN-Protein Type 1	1000 lbs TDN
FGTP2	Feed Grain to TDN-Protein Type 2	1000 lbs TDN
FGTP3	Feed Grain to TDN-Protein Type 3	1000 lbs TDN
SBTP1	Soybean to TDN-Protein Type 1	CWT TDN
SBTP2	Soybean to TDN-Protein Type 2	CWT TDN
SBTP3	Soybean to TDN-Protein Type 3	CWT TDN
CSTP1	Cotton Seed to TDN-Protein Type 1	CWT TDN
CSTP2	Cotton Seed to TDN-Protein Type 2	CWT TDN
CSTP3	Cotton Seed to TDN-Protein Type 3	CWT TDN
XF1TP1	Exogenous Feed Type 1 to TDN-Protein Type 1	1000 lbs TDN
XF1TP2	Exogenous Feed Type 1 to TDN-Protein Type 2	1000 lbs TDN
XF1TP3	Exogenous Feed Type 1 to TDN-Protein Type 3	1000 lbs TDN
XF2TP1	Exogenous Feed Type 2 to TDN-Protein Type 1	1000 lbs TDN
XF2TP2	Exogenous Feed Type 2 to TDN-Protein Type 2	1000 lbs TDN
XF2TP3	Exogenous Feed Type 2 to TDN-Protein Type 3	1000 lbs TDN
XF3TP1	Exogenous Feed Type 3 to TDN-Protein Type 1	1000 lbs TDN
XF3TP2	Exogenous Feed Type 3 to TDN-Protein Type 2	1000 lbs TDN
XF3TP3	Exogenous Feed Type 3 to TDN-Protein Type 3	1000 lbs TDN
XF4TP1	Exogenous Feed Type 4 to TDN-Protein Type 1	1000 lbs TDN
XF4TP2	Exogenous Feed Type 4 to TDN-Protein Type 2	1000 lbs TDN
XF4TP3	Exogenous Feed Type 4 to TDN-Protein Type 3	1000 lbs TDN
BFGBFO	Grain-Fed Beef to Other Beef	CWT

TABLE A-4. (CONTINUED)

REGION NO.	1	2	3	4	5
FMMGMK		197.28410			
CFSLAU					
YLSLAU	0.00001	0.00001	0.00001	0.00001	0.00001
WHETP1	128.67783		10.80526		
WHETP2					
WHETP3	7.22599			1.35576	
FGTP1	9.60558	115.45384	20.45974	27.68597	12.47631
FGTP2					
FGTP3		153.70367	5.52035	11.91795	2.69891
SBTP1		31.47581			
SBTP2					
SBTP3		115.25860			
CSTP1	0.00001	165.96479			0.00001
CSTP2					
CSTP3					
XF1TP1					
XF1TP2					
XF1TP3					
XF2TP1	17.09482		4.98029	4.82808	2.37773
XF2TP2					
XF2TP3	0.11066		0.34305	0.76137	0.17952
XF3TP1					
XF3TP2					
XF3TP3					
XF4TP1					
XF4TP2					
XF4TP3					
BFGBFO				18.83274	

TABLE A-4. (CONTINUED)

REGICN NO.	6	7	8	9	10
FMMGMK	13.84430			349.14606	43.70797
CFSLAU					
YLSLAU	0.00001	0.00001	0.00001	0.00001	0.00001
WHETP1					
WHETP2					
WHETP3					
FGTP1	13.44186	16.64551	11.46352	70.41040	82.95506
FGTP2					
FGTP3	9.03749	9.73872	11.12876	39.30714	357.45598
SBTP1					182.23899
SBTP2					
SBTP3					263.47468
CSTP1	35.32368	13.88114		0.00001	
CSTP2					
CSTP3	8.96047	9.08022			16.25264
XF1TP1				4.75194	
XF1TP2					
XF1TP3				2.90731	
XF2TP1		1.84139			
XF2TP2					
XF2TP3					
XF3TP1					
XF3TP2					
XF3TP3					
XF4TP1			24.13662	62.23072	
XF4TP2					
XF4TP3			3.51708		
BFGBFO	9.79321	6.48071	3.09270		34.32135

TABLE A-4. (CONTINUED)

REGION NO.	11	12	13	14	15
FMMGMK	20.58209	22.83166	34.00073	6.83833	
CFSLAU					
YLSLAU	0.00001				0.72850
WHETP1			32.35983		
WHETP2					
WHETP3			45.88329	5.85280	
FGTP1	40.16056	11.40642		13.07320	37.58036
FGTP2					0.06327
FGTP3	200.36437	99.59461	23.00961	28.79362	
SBTP1	60.30956		0.00001		
SBTP2					
SBTP3	14.67611			0.00001	0.00001
CSTP1			2.75818	33.28799	
CSTP2					
CSTP3	0.00001			3.40103	
XF1TP1					
XF1TP2					
XF1TP3					
XF2TP1					
XF2TP2					
XF2TP3	5.21470				
XF3TP1			12.34017		16.88904
XF3TP2					
XF3TP3					
XF4TP1		57.41012	1.13054		
XF4TP2					
XF4TP3	11.36395	0.08073			
BFGBFO	132.03824	16.30367	2.29994		65.00517

Table A-5. Producing area activities (crops, livestock, transfer). Solution I

Code	Descriptions	Unit ($x10^5$)
COTN1	Cotton, Land Class 1	Acre
COTN2	Cotton, Land Class 2	Acre
COTN3	Cotton, Land Class 3	Acre
WHEA1	Wheat, Land Class 1	Acre
WHEA2	Wheat, Land Class 2	Acre
WHEA3	Wheat, Land Class 3	Acre
FDGR1	Feed Grain, Land Class 1	Acre
FDGR2	Feed Grain, Land Class 2	Acre
FDGR3	Feed Grain, Land Class 3	Acre
HAYY1	Hay, Land Class 1	Acre
HAYY2	Hay, Land Class 2	Acre
HAYY3	Hay, Land Class 3	Acre
WHAY	Wild Hay	Acre
FGSB1	Feed Grain-Soybean Rotation, Land Class 1	Acre
FGSB2	Feed Grain-Soybean Rotation, Land Class 2	Acre
FGSB3	Feed Grain-Soybean Rotation, Land Class 3	Acre
FGSG1	Feed Grain-Silage Rotation, Land Class 1	Acre
FGSG2	Feed Grain-Silage Rotation, Land Class 2	Acre
FGSG3	Feed Grain-Silage Rotation, Land Class 3	Acre
HASG1	Hay-Silage Rotation, Land Class 1	Acre
HASG2	Hay-Silage Rotation, Land Class 2	Acre
HASG3	Hay-Silage Rotation, Land Class 3	Acre
FGSS1	Feed Grain-Soybean-Silage Rotation, Land Class 1	Acre
FGSS2	Feed Grain-Soybean-Silage Rotation, Land Class 2	Acre
FGSS3	Feed Grain-Soybean-Silage Rotation, Land Class 3	Acre
BROLR	Broiler	CWT
DYCOW	Dairy Cow	Head
BFCOW	Beef Cow	Head
YLCAF	Calf-Yearling	Head
HOGGG	Hog	CWT
DEFRD	Feeder Calf, Deferred Feeding	Head
EXTSG	Feeder Calf, Extended Silage	Head
CFOSG	Feeder Calf, On Silage	Head
CFNSG	Feeder Calf, No Silage	Head
SFYRL	Feeder Yearling, Short-Fed	Head
YLOSG	Feeder Yearling, On Silage	Head
YLNSG	Feeder Yearling, No Silage	Head
CHPS1	Crop Hay Land Class 1 Converted Pasture	Acre
CHPS2	Crop Hay Land Class 2 Converted Pasture	Acre
CHPS3	Crop Hay Land Class 3 Converted Pasture	Acre
PASRA	Pasture, Region to Area	10 AUMs
HARUF	Hay to Roughage	Ton
HAYAG	Hay, Area to Region	Ton
HAYRA	Hay, Region to Area	Ton
LBCSH	Labor Hired, Crop Season	10 hrs.
LBNH	Labor Hired, Non-Crop Season	10 hrs.

TABLE A-5. (CONTINUED)

AREA NC.	001(NY)	002(PA)	003(WV)	004(MD)	005(NE)
CCTN1					
CCTN2					
COTN3					
WHEA1	1.72488				
WHEA2					
WHEA3					
FCGR1		14.62308			
FDGR2					
FDGR3					
HAYY1	5.41583	4.27973			
HAYY2					
HAYY3					
WHAY					
FGSB1				5.90421	
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1			0.31711		9.91391
HASG2					
HASG3					
FGSS1				1.12030	
FGSS2					
FGSS3					
BRCLR				164.98981	
DYCOW	2.02254	1.62826	0.31708		3.68313
BFCOW					
YLCAF					
HOGGG					
DEFRD					
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA	0.18141		0.09320		
HARUF	11.05456	9.50101	0.53592	0.00001	16.15968
HAYAG	1.13108				
HAYRA			0.74508		
LBCSH					
LBNH			0.41410		

TABLE A-5. (CONTINUED)

AREA NO.	006(VA)	007(NC)	008(NC)	009(NC)	010(VA)
COTN1					0.13601
COTN2					
COTN3					
WHEA1					
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			0.22604		
HAYY2					
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	1.23442	0.34314		0.04115	9.83637
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
CYCCW	0.59111				2.82617
BFCCW					
YLCAF					
HCGGG					
DEFRD					4.22132
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA	0.16531				
HARUF	1.93805	0.40835	0.37072	0.05968	14.85293
HAYAG					
HAYRA		0.10573			
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	011(SC)	012(GA)	013(GA)	014(SC)	015(SC)
COTN1					
COTN2					
COTN3					
WHEA1					
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	0.14943	0.03607	0.11379	0.07095	1.84903
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR			30.73301	33.63861	
DYCOW					1.29965
BFCOW					
YLCAF					
HOGCG					
DEFRD					
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARUF	0.21220	0.05087	0.15477		3.23581
HAYAG				0.10572	
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NC.	016(FL)	017(FL)	018(AL)	019(AL)	020(AL)
CCTN1			0.19478	1.88291	2.35838
CCTN2					
COTN3					
WHEA1				2.52730	
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1	0.11871		0.01180		
HAYY2	0.64891				
HAYY3	C.33061				
WHAY					
FGSB1			0.83083		
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1					1.76153
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR		18.56871			
DYCCW		1.38413			
BFCOW	5.15525			1.29511	1.52989
YLCAF					
HCGGG					
DEFRD	2.C5494	0.01737		0.10087	2.31055
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARUF	2.82061		0.01972	0.00001	3.02808
HAYAG		0.00001			0.03699
HAYRA	0.COC02				
LBCSH					
LBNH	0.58818				

TABLE A-5. (CONTINUED)

AREA NO.	021(MS)	022(KY)	023(TN)	024(MS)	025(AR)
COTN1	9.17C55	0.00401	4.61572	2.00251	5.51201
CCTN2					
COTN3					
WHEA1			4.13071		2.24502
WHEA2					6.34465
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1		9.98370		0.05020	0.06808
HAYY2				0.53304	
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	0.31556		0.28326		
HASG2	0.70514				
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR	24.77091	15.09961			
DYCOW		3.74043			
BFCOW	5.45640			4.23518	
YLCAF					
HOGGG					
CEFRD		2.06484			
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA				4.08397	
HARUF	1.79071	17.67116	0.48439	1.07524	0.05618
HAYAG					0.14399
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	026(MO)	027(KY)	028(ID)	029(KY)	030(OH)
COTN1	3.36931				
COTN2					
COTN3					
WHEA1		1.04902	3.40731		
WHEA2			2.70311		
WHEA3			1.75171		
FDGR1					
FDGR2					
FDGR3					
HAYY1	0.09650		2.90610		
HAYY2			5.89150		
HAYY3					
WHAY	0.01401		2.33501		
FGSB1					
FGSB2	10.06201				
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1		0.24317		3.13321	6.53271
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR	21.59795		25.38511		
DYCOW					4.60401
BFCCW			1.35185		
YLCAF					
HOGGG			11.47823		
DEFRD				5.08674	
EXTSG			7.43603		
CFCSG			10.38705		
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA				0.13521	0.09724
HARUF	0.05802	0.45717	27.64084	6.10977	13.91468
HAYAG	0.21915		0.20135		
HAYRA					5.84644
LBCSH					
LBNH					4.99294

TABLE A-5. (CONTINUED)

AREA NC.	031(NY)	032(OH)	033(OH)	034(IN)	035(IN)
CCTN1					
CCTN2					
CCTN3					
WHEA1		1.25187			
WHEA2		6.09971			
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1	22.72601				
HAYY2	21.71824				
HAYY3					
WHAY					
FGSB1					0.68745
FGSB2					
FGSB3					
FGSG1					0.30367
FGSG2					
FGSG3					
HASG1		4.78704		19.93171	0.01435
HASG2					
HASG3					
FGSS1			51.36961		1.22674
FGSS2					
FGSS3					
BRCLR				65.26941	
DYCOW	14.49629	2.86249	8.09825	2.03706	
BFCCW					
YLCAF					
HOGGG					
DEFRD	5.28197			4.76465	
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1			5.58479		
CHPS2					
CHPS3					
PASRA		0.70670			
HARUF	87.08503	10.62724	0.00001	8.88250	
HAYAG				42.54131	0.02899
HAYRA			32.56854		
LBCSH					
LBNH		0.73516			

TABLE A-5. (CONTINUED)

AREA NO.	036(IL)	037(CA)	038(IN)	039(NV)	040(MI)
COTN1					
COTN2					
COTN3					
WHEA1	12.58226				7.03948
WHEA2	12.31571		9.02914		
WHEA3					
FDGR1					
FDGR2		2.14914			
FDGR3					
HAYY1			1.66378		29.07713
HAYY2					
HAYY3					
WHAY	0.04701	0.73801		2.10675	
FGSB1			29.04121		
FGSB2			1.12627		
FGSB3					
FGSG1		6.42656	35.76419	0.98696	
FGSG2		2.20746			
FGSG3					
HASG1	6.22405	3.85985		1.47365	
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCCW	2.92901	3.56153		0.56528	11.49832
BFCCW				1.91203	
YLCAF					
HCGGG			397.52144		
DEFRD	3.50540		6.19577		
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					8.84119
CHPS3					
PASRA					0.45047
HARUF	14.45653	16.10819	3.92652	6.95966	66.00509
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	041(MI)	042(WI)	043(WI)	044(CO)	045(IL)
COTN1				0.02401	
COTN2					
COTN3					
WHEA1			22.72083		
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			9.34218		
HAYY2	3.00393		12.06371		4.45670
HAYY3					
WHAY			0.13301		
FGSB1					141.18767
FGSB2					14.51951
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	3.41291	11.40779		0.76650	8.42013
HASG2				0.05284	
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR		20.84931			
DYCOW	2.81836	5.98747	10.51404		2.80296
BFCCW			9.21995	6.33542	
YLCAF					
HOGGG					324.97101
DEFRC	0.10074				16.50312
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1		0.59312			
CHPS2		0.05446		1.02717	
CHPS3			10.68591		
PASRA		0.07418		3.75004	
HARUF	12.07861	21.44666	67.81039	2.77020	33.94535
HAYAG					
HAYRA	2.83634				
LBCSH					
LBNH				0.08261	

TABLE A-5. (CONTINUED)

AREA NO.	046(MO)	047(IL)	048(CA)	049(AZ)	050(MO)
COTN1	1.52795			5.84502	
CCTN2					
CCTN3					
WHEA1		6.06726	0.47621		
WHEA2		9.44181	0.49771		
WHEA3					
FDGR1					
FCGR2					
FDGR3					
HAYY1			0.00423		
HAYY2					
HAYY3					
WHAY	0.13312				1.25201
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1		2.50015		0.22226	7.87481
HASG2		0.76670			
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					26.52632
DYCOW		1.50020	0.03930		2.45717
BFCOW				2.27312	
YLCAF					
HCGGG					
DEFRD					8.52426
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA			0.01370		
HARUF	0.20369	6.38637	0.02530	0.98461	16.41323
HAYAG					0.91884
HAYRA					
LBCSH				26.84616	
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	051(MO)	052(IA)	053(IA)	054(MN)	055(NM)
CCTN1					
COTN2					
CCTN3					
WHEA1					4.28331
WHEA2	27.27806				
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			5.01780		0.26956
HAYY2			2.57553		
HAYY3					
WHAY	0.17801				
FGSB1			104.93821	23.22324	
FGSB2			25.52331		
FGSB3					
FGSG1				32.91447	
FGSG2					
FGSG3					
HASG1	2.58064			5.21969	
HASG2	9.08225	5.31702			
HASG3					
FGSS1	35.39427	22.75211			
FGSS2		21.72849		9.98791	
FGSS3					
BROLR	0.30654				
DYCOW	5.58647	0.23470		4.56436	
BFCOW		10.09744	13.74593		3.37426
YLCAF					
HOGGG	144.11069		396.58522	10.91337	
DEFRD				1.50811	
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					0.23414
CHPS2			6.20717		1.06341
CHPS3					0.86491
PASRA		1.57191			
HARUF	22.82397	12.38867	22.37768	10.07402	1.59313
HAYAG					
HAYRA					
LBCSH					1.24812
LBNF					

TABLE A-5. (CONTINLED)

AREA NC.	056(MN)	057(MN)	058(MN)	059(MN)	060(MN)
CCTN1					
CCTN2					
COTN3					
WHEA1					13.96236
WHEA2	4.58951				8.87347
WHEA3					
FDGR1	7.87052				
FDGR2					
FDGR3					
HAYY1	1.62810	20.85304	0.66389	7.34979	
HAYY2	0.97940				
HAYY3					
WHAY	0.19101	0.59001			
FGSB1	9.92648	6.01717			
FGSB2					
FGSB3					
FGSG1			1.92861		
FGSG2			1.32091		
FGSG3					
HASG1					2.48405
HASG2					1.28113
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW	1.05097	11.52469	3.38771	2.70751	1.45226
BFCOW					
YLCAF					
HOGGG	66.17022				
CEFRD	1.73304	1.02828		3.39376	0.75247
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1				2.13522	
CHPS2		4.85239			
CHPS3					
PASRA			0.32633		
HARUF	8.11168	64.64222	1.42072	19.29697	6.35535
HAYAG				0.32699	
HAYRA					
LBCSH					
LBNF					

TABLE A-5. (CONTINUED)

AREA NO.	061(ND)	062(ND)	063(ND)	064(SD)	065(ND)
COTN1					
COTN2					
COTN3					
WHEA1	19.59531	52.27321	6.11527		
WHEA2	2.60691	12.32961			
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1	0.24716	2.72110	7.19025		
HAYY2					
HAYY3					
WHAY	0.50801	0.66781			0.89920
FGSB1					1.58951
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1					
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW					
BFCOW				0.00149	
YLCAF					
HOGGG				2.01360	
DEFRD	0.78712	4.28422	9.24810		0.61755
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1	0.00680				
CHPS2					
CHPS3					
PASRA					
HARUF	1.01332	5.53092	12.00772	0.00001	0.79131
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	066(SD)	067(SD)	068(SD)	069(SD)	070(SD)
COTN1					
COTN2					
COTN3					
WHEA1				5.06821	
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1				0.59960	0.12231
HAYY2					
HAYY3					
WHAY	6.32901	3.57459	0.16248	0.78383	1.80801
FGSB1					26.72301
FGSB2					4.25781
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	2.60231				
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCCW					
BFCCW	3.95481	1.23617	0.09272	0.74378	1.06659
YLCAF					
HCGGG	25.12195	98.80740	70.60376	28.96200	158.61962
DEFRD					
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARUF	7.83934	2.68095	0.17386	1.64133	2.33388
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	071(NB)	072(NB)	073(NB)	074(CO)	075(NB)
COTN1					
COTN2					
COTN3					
WHEA1		1.01463	3.65493		3.52760
WHEA2		0.89614	6.74441		4.20461
WHEA3		0.99897	3.64441		
FDGR1				0.84563	
FDGR2				1.53251	
FDGR3				4.62021	
HAYY1					3.88392
HAYY2	9.48512		0.48590	0.25770	
HAYY3				2.49810	
WHAY		1.43901	2.09701	0.23201	6.83901
FGSB1	43.44781				3.53288
FGSB2	20.10319				
FGSB3					
FGSG1				2.51417	
FGSG2					
FGSG3					
HASG1		0.11638	2.14218		
HASG2		0.34087			
HASG3		0.82043			
FGSS1					
FGSS2					
FGSS3					
BROLR	8.70197		4.95474	1.03300	
DYCOW	5.36155				0.71577
BFCOW		1.58570		1.52270	
YLCAF					
HOGGG					
DEFRD	5.84256		7.87470		11.31148
EXTSG					
CFOSG				7.96801	
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					1.79510
CHPS3					
PASRA					
HARUF	26.17894	3.12509	8.26320	8.02527	17.25216
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	076(NB)	077(NB)	078(KS)	079(KS)	080(KS)
CCTN1					
CCTN2					
CCTN3					
WHEA1	8.02558			0.45283	3.46871
WHEA2	3.70661				
WHEA3					
FDGR1			2.50344		
FDGR2					
FDGR3					
HAYY1			3.52807	3.12677	
HAYY2					
HAYY3					
WHAY		10.59001			
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	4.03063	0.89671			2.35330
HASG2		0.49700			
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCCW	0.01304		0.25509	0.14487	
BFCOW		4.63843	3.12181	4.94641	3.75479
YLCAF					
HCGGG					
DEFRD	11.58057		3.37318		
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2	0.45920		7.44901	7.06351	7.97931
CHPS3	3.97301			2.16231	
PASRA	1.41941				
HARUF	10.31842	10.24279	11.81904	10.56851	4.09475
HAYAG					
HAYRA					
LBCSH					
LBNH		1.63043			0.03390

TABLE A-5. (CONTINUED)

AREA NO.	081(KS)	082(KS)	083(TX)	084(KS)	085(OK)
CCTN1					
CCTN2					
CCTN3					
WHEA1		7.83708		31.47453	1.83341
WHEA2					0.68326
WHEA3					
FDGR1	1.48574				
FDGR2					
FDGR3					
HAYY1	4.73707	6.25121			
HAYY2					
HAYY3					
WHAY					0.87301
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1				13.08567	1.10690
HASG2					0.78525
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCOW					0.36517
BFCOW	7.87158	10.15759	14.32529	23.24591	3.42956
YLCAF					
HCGGG					
DEFRD					
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1		0.97453			
CHPS2	5.92671	12.76551		23.36871	
CHPS3	2.88251	8.21071		18.64611	
PASRA					
HARUF	15.77445	20.37894	0.00001	16.52852	4.17883
HAYAG				6.76399	
HAYRA			6.38188		
LBCSH			17.50620		
LBNH	1.22374			3.39861	

TABLE A-5. (CONTINUED)

AREA NO.	086(KS)	087(OK)	088(OK)	089(OK)	090(OK)
COTN1			6.44401	0.67101	
COTN2					
COTN3					
WHEA1	0.78356	3.46451	15.43496	1.04923	1.41581
WHEA2	17.47041	0.55201	13.53596	11.25581	0.88421
WHEA3			6.78291	4.20201	
FDGR1	5.17619				
FDGR2					
FDGR3					
HAYY1	2.46496	0.61060			
HAYY2					
HAYY3					
WHAY	0.16001	1.43001	0.44801	0.28601	0.53801
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1			2.20494	1.99707	2.00130
HASG2			2.08945		
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW		0.37162	1.79267	0.43704	0.93744
BFCOW	5.61049	1.99535	2.76690	3.67532	1.26891
YLCAF					
HOGCG					
CEFRD					
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3				0.81030	
PASRA					
HARUF	11.24431	3.45081	9.04720	1.63984	5.03149
HAYAG		0.05632		2.18991	
HAYRA					
LBCSH					
LBNH	0.15880				

TABLE A-5. (CONTINUED)

AREA NC.	091(TX)	092(TX)	093(TX)	094(TX)	095(TX)
CCTN1		7.56401	16.69601	7.89561	
COTN2				8.07440	
COTN3					
WHEA1					2.50961
WHEA2			13.05980		
WHEA3					
FDGR1		6.52013			
FDGR2		22.93981			
FDGR3					
HAYY1		0.31857			
HAYY2		0.19040			
HAYY3					
WHAY	0.43801	0.10201			
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2				8.98608	
FGSG3					
HASG1	3.58881		0.92020		1.39820
HASG2	3.79581		0.61550	0.92583	
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR	13.61349				
DYCOW					
BFCOW	3.78462	5.73622	7.07498	9.72135	0.33746
YLCAF					
HCGGG					
DEFRD	12.35039				3.07664
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3				8.52931	
PASRA					
HARUF	8.58773	2.64294		1.75908	1.39820
HAYAG			2.24793		
HAYRA					
LBCSH		22.46663	12.13105	23.10626	
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	096(TX)	C97(TX)	098(TX)	099(TX)	100(TX)
COTN1				2.20701	
COTN2					
CCTN3					
WHEA1		20.58769	0.84600		
WHEA2		8.18220			
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY		0.37601		0.28901	0.19201
FGSB1					
FGSB2					
FGSB3					
FGSG1			0.45150		13.17112
FGSG2					3.44603
FGSG3					0.71559
HASG1	1.58681	2.48582	1.44092	2.30390	0.55708
HASG2	0.65255	4.31461		0.24718	1.14768
HASG3					0.32112
FGSS1					
FGSS2					
FGSS3					
BROLR		48.07072			11.65098
DYCOW		2.14229		0.74719	
BFCOW	0.73377	2.10802	6.42892		10.31185
YLCAF					
HCGGG					
DEFRD	2.80481	4.30756		3.96116	2.22554
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG				0.00001	
CHPS1					
CHPS2					
CHPS3					
PASRA					6.98691
HARUF		8.74816	1.64265	4.00407	2.40447
HAYAG	2.76761				
HAYRA					
LBCSH			0.58289		
LBNH					

TABLE A-5. (CONTINUED)

AREA NC.	101(MT)	102(MT)	103(WY)	104(MT)	105(WY)
CCTN1					
COTN2					
COTN3					
WHEA1		4.96244		1.01701	1.37961
WHEA2		12.28845	2.46033	1.82181	2.40151
WHEA3		3.38421	4.13731	1.21881	4.53691
FDGR1					
FDGR2					
FDGR3					
HAYY1				0.34840	1.61340
HAYY2				1.12310	0.64977
HAYY3					6.69550
WHAY		1.18501	1.38501	0.07101	4.74501
FGSB1					
FGSB2					
FGSB3					
FGSG1	7.00451				
FGSG2	21.36704				
FGSG3	8.59221				
HASG1		0.71787	2.37171		
HASG2	2.11244	3.26566	1.31237		
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCCW					
BFCCW	5.54064	4.63135	3.64283	1.68755	8.89110
YLCAF					
HOGGG		21.79450	18.06134	10.73519	
DEFRC					
EXTSG					
CFCSG					2.86072
CFNSG					
SFYRL					
YLCSG					0.00001
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA	3.88750	1.86891		0.74378	2.64719
HARUF	2.87292	8.80870	6.24070	3.21481	20.90254
HAYAG					1.77864
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NC.	106(CO)	107(CO)	108(CO)	109(NM)	110(ID)
CCTN1					
CCTN2					
CCTN3					
WHEA1					5.13116
WHEA2	8.91091				5.70288
WHEA3	1.33996				
FDGR1					
FDGR2					
FDGR3				0.12986	
HAYY1					
HAYY2					
HAYY3					
WHAY		0.01701	0.04901		0.50301
FGSB1					
FGSB2					
FGSB3					
FGSG1		1.71001		0.52731	
FGSG2		0.69447		3.71911	
FGSG3		1.83441		2.57735	
HASG1	5.05891		0.14471		0.67505
HASG2					2.56253
HASG3			0.82608		
FGSS1					
FGSS2					
FGSS3					
BROLR			3.26472		
DYCCW					1.27606
BFCOW	2.43462	1.02227	0.87638	7.06183	
YLCAF					
HCGGG					7.54367
DEFRD					
EXTSG	10.77066				
CFCSG					
CFNSG					
SFYRL					
YLCSG	0.00001				
YLNSG					
CHPS1					
CHPS2					
CHPS3				0.37450	
PASRA				5.85519	0.12252
HARUF	7.12838	0.02127	1.42594	0.00001	9.55718
HAYAG	0.45999				
HAYRA					
LBCSH				4.81353	
LBNH	2.23572				

TABLE A-5. (CONTINUED)

AREA NO.	111(LT)	112(ID)	113(OR)	114(WA)	115(WA)
CCTN1					
CCTN2					
CCTN3					
WHEA1		1.19501	8.82501	6.78194	2.47655
WHEA2	0.91881	1.54031	10.94043	6.92781	2.44439
WHEA3		0.47511	4.08771	3.16821	1.97581
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2	0.60644	0.60350		0.76040	
HAYY3			1.29530		
WHAY	0.22001	0.02201	0.15301	0.08901	3.00201
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	3.70091	0.12470	0.91480	1.77337	5.62176
HASG2			1.54248		3.82692
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR	7.05019				
DYCCW	1.94918	0.15852	1.59726	1.73671	4.85992
BFCOW					
YLCAF					
HCGGG		5.30290			
DEFRD					
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2	0.09026				
CHPS3					
PASRA	0.28199				
HARUF	13.87843	1.21121	9.53346	9.28407	27.60419
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NC.	116(CA)	117(CA)	118(GA)	119(AL)	120(LA)
CCTN1		0.42433			4.24863
CCTN2					
COTN3					
WHEA1	1.05049	2.63341		1.97714	
WHEA2	1.63831				
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1		2.12786			2.61552
HAYY2					
HAYY3					
WHAY	0.C8701	0.05301			
FGSB1					
FGSB2					
FGSB3					
FGSG1		6.78266			
FGSG2					
FGSG3					
HASG1	0.73852		6.08821	0.48431	
HASG2	0.71140				
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCCW	1.09412	2.07821	1.43056		
BFCOW				4.12358	5.68343
YLCAF		0.73585			
HCGGG					
CEFRD			7.69303		2.57436
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA				0.79871	2.24434
HARUF	6.69203	10.73211	12.11554	0.81850	4.86488
HAYAG		3.22899			
HAYRA					
LBCSH	3.58934	6.19248			
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	121(AR)	122(AR)	123(AR)	124(LA)	125(TX)
COTN1		1.81298			
COTN2					
COTN3					
WHEA1		4.65570			
WHEA2		2.16426			
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY	0.10601	1.62001	0.30201		0.47201
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	1.37903	0.74383	1.79523	0.00875	5.89291
HASG2	1.51194	1.01485			4.54407
HASG3		5.75179			
FGSS1	22.47778				
FGSS2	17.23627				
FGSS3					
BRCLR					
DYCCW	0.35389	2.00437	0.91008		0.30147
BFCOW	0.19412	7.33096	0.91352		
YLCAF					
HOGGG	17.05088				
DEFRD	3.42782				24.20413
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARUF	4.07370	12.32098	3.02338	0.01339	15.48571
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NC.	126(TX)	127(OK)	128(OK)	129(TX)	130(TX)
COTN1					
COTN2					
COTN3					
WHEA1			1.57583	0.23014	
WHEA2		0.32689	0.29175	0.89383	
WHEA3					
FDGR1					0.68311
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY		0.21301	0.84601	0.01501	
FGSB1					
FGSB2					
FGSB3					
FGSG1					2.85863
FGSG2					
FGSG3					
HASG1	0.18371	1.05471	0.37448	1.50717	
HASG2	0.06831	0.57852	0.20066	0.41457	
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR				22.84873	
DYCCW		0.48244	0.27499		
BFCOW	0.95611	0.96197	1.42549	0.20841	0.73609
YLCAF					
HCGGG					
DEFRD				3.19325	
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARLF	0.28189	2.94457	2.27621	1.73951	0.00001
HAYAG					
HAYRA	0.00291				
LBCSH	0.81147				
LBNH					

TABLE A-5. (CONTINUED)

AREA NO.	131(TN)	132(TN)	133(AL)	134(AL)	135(TN)
CCTN1	0.86661	1.87101	0.27772	1.96801	0.00101
CCTN2					
CCTN3					
WHEA1					
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	0.06503	0.16887	3.18854	0.44340	0.96940
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCCW		0.01611			0.45904
BFCOW				0.74549	
YLCAF					
HOGGG				8.78692	
DEFRD			4.76024	0.47631	
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1			0.24524		
CHPS2					
CHPS3					
PASRA			0.49321		
HARUF	0.11511	0.27623	5.54808	0.78483	1.63829
HAYAG		0.02099			
HAYRA					
LBCSH					
LBNH					

TABLE A-5. (CONTINUED)

AREA NC.	136(TN)	137(TN)	138(NC)
CCTN1	0.C7401	0.43201	
COTN2			
CCTN3			
WHEA1			
WHEA2			
WHEA3			
FDGR1			
FCGR2			
FDGR3			
HAYY1	3.20630		0.64831
HAYY2			
HAYY3			
WHAY			
FGSB1			
FGSB2			
FGSB3			
FGSG1			
FGSG2			
FGSG3			
HASG1		2.80692	
HASG2			
HASG3			
FGSS1			
FGSS2			
FGSS3			
BRCLR			11.71481
DYCCW	1.35613	1.50882	0.30400
BFCOW			
YLCAF			
HCGGG			
DEFRD		0.08784	
EXTSG			
CFCSG			
CFNSG			
SFYRL			
YLOSG			
YLNSG			
CHPS1			
CHPS2			
CHPS3			
PASRA			
HARUF	5.77135	4.63143	1.37442
HAYAG			
HAYRA			
LBCSH			
LBNH			

TABLE A-6. WEIGHTS FOR FEED GRAIN COMPONENT CROPS

AREA NO.	CORN	GRAIN SORGHUM	BARLEY	OATS
1	0.398	0.000	0.022	0.580
2	0.627	0.000	0.130	0.243
3	0.599	0.000	0.168	0.233
4	0.846	0.000	0.135	0.020
5	0.075	0.000	0.000	0.925
6	0.749	0.003	0.172	0.076
7	0.945	0.008	0.014	0.033
8	0.784	0.013	0.057	0.146
9	0.488	0.143	0.176	0.193
10	0.707	0.000	0.176	0.117
11	0.930	0.000	0.005	0.064
12	0.962	0.000	0.000	0.036
13	0.877	0.006	0.014	0.103
14	0.463	0.232	0.163	0.142
15	0.501	0.035	0.119	0.345
16	0.966	0.000	0.000	0.034
17	0.973	0.000	0.000	0.027
18	0.757	0.005	0.000	0.238
19	0.978	0.005	0.000	0.017
20	0.972	0.005	0.000	0.022
21	0.955	0.005	0.000	0.040
22	0.902	0.000	0.031	0.067
23	0.963	0.007	0.009	0.021
24	0.954	0.006	0.000	0.040
25	0.852	0.092	0.000	0.056
26	0.972	0.009	0.013	0.006
27	0.880	0.015	0.065	0.040
28	0.075	0.000	0.660	0.265
29	0.905	0.003	0.036	0.056
30	0.848	0.000	0.013	0.139
31	0.306	0.000	0.031	0.663
32	0.662	0.000	0.012	0.326
33	0.849	0.000	0.002	0.149
34	0.941	0.004	0.012	0.043
35	0.988	0.003	0.005	0.004
36	0.928	0.010	0.019	0.043
37	0.053	0.150	0.707	0.090
38	0.908	0.000	0.000	0.092
39	0.019	0.000	0.739	0.242
40	0.728	0.000	0.012	0.260
41	0.372	0.000	0.013	0.615
42	0.238	0.000	0.002	0.760
43	0.507	0.000	0.010	0.483
44	0.629	0.245	0.075	0.051
45	0.868	0.000	0.001	0.131
46	0.815	0.034	0.028	0.123

TABLE A-6. (CONTINUED)

AREA NO.	CORN	GRAIN SORGHUM	BARLEY	OATS
47	0.977	0.003	0.004	0.016
48	0.000	0.343	0.654	0.004
49	0.011	0.461	0.522	0.006
50	0.655	0.160	0.029	0.156
51	0.914	0.021	0.005	0.060
52	0.817	0.008	0.000	0.174
53	0.814	0.000	0.000	0.186
54	0.732	0.000	0.019	0.250
55	0.118	0.502	0.319	0.061
56	0.753	0.000	0.002	0.245
57	0.521	0.000	0.004	0.475
58	0.106	0.000	0.020	0.874
59	0.281	0.000	0.057	0.662
60	0.041	0.000	0.342	0.617
61	0.041	0.000	0.628	0.331
62	0.004	0.000	0.648	0.348
63	0.011	0.000	0.438	0.551
64	0.291	0.000	0.098	0.611
65	0.250	0.000	0.196	0.554
66	0.131	0.078	0.180	0.611
67	0.359	0.018	0.082	0.541
68	0.471	0.000	0.022	0.506
69	0.488	0.104	0.030	0.378
70	0.584	0.053	0.006	0.357
71	0.590	0.314	0.001	0.095
72	0.248	0.008	0.157	0.587
73	0.400	0.239	0.172	0.189
74	0.435	0.031	0.445	0.089
75	0.742	0.198	0.006	0.054
76	0.416	0.557	0.010	0.017
77	0.732	0.086	0.027	0.155
78	0.630	0.288	0.005	0.077
79	0.552	0.326	0.015	0.107
80	0.477	0.296	0.073	0.154
81	0.179	0.626	0.094	0.101
82	0.180	0.668	0.056	0.096
83	0.016	0.654	0.221	0.109
84	0.036	0.757	0.176	0.031
85	0.267	0.308	0.132	0.293
86	0.056	0.898	0.043	0.003
87	0.183	0.435	0.089	0.293
88	0.003	0.288	0.513	0.196
89	0.000	0.792	0.170	0.037
90	0.089	0.250	0.367	0.294
91	0.219	0.276	0.085	0.420
92	0.004	0.976	0.016	0.004

TABLE A-6. (CONTINUED)

AREA NO.	CORN	GRAIN SORGHUM	BARLEY	OATS
93	0.002	0.634	0.083	0.281
94	0.010	0.987	0.002	0.000
95	0.006	0.169	0.145	0.680
96	0.009	0.409	0.057	0.525
97	0.229	0.493	0.045	0.233
98	0.073	0.655	0.037	0.235
99	0.616	0.336	0.011	0.037
100	0.187	0.787	0.003	0.023
101	0.002	0.000	0.858	0.140
102	0.000	0.000	0.917	0.082
103	0.071	0.000	0.574	0.355
104	0.003	0.000	0.849	0.148
105	0.066	0.006	0.602	0.326
106	0.167	0.464	0.334	0.035
107	0.104	0.833	0.039	0.024
108	0.022	0.940	0.027	0.011
109	0.003	0.991	0.004	0.002
110	0.000	0.000	0.928	0.072
111	0.014	0.000	0.903	0.083
112	0.000	0.000	0.838	0.162
113	0.003	0.000	0.951	0.046
114	0.067	0.000	0.869	0.064
115	0.035	0.000	0.545	0.420
116	0.083	0.189	0.678	0.050
117	0.059	0.104	0.819	0.018
118	0.825	0.009	0.046	0.120
119	0.905	0.011	0.000	0.084
120	0.853	0.007	0.000	0.140
121	0.328	0.056	0.000	0.616
122	0.834	0.036	0.000	0.131
123	0.823	0.051	0.000	0.126
124	0.904	0.000	0.000	0.095
125	0.729	0.166	0.000	0.105
126	0.000	0.894	0.023	0.082
127	0.365	0.345	0.107	0.183
128	0.277	0.480	0.061	0.182
129	0.113	0.295	0.068	0.524
130	0.021	0.977	0.000	0.002
131	0.934	0.009	0.021	0.037
132	0.924	0.011	0.020	0.045
133	0.972	0.005	0.000	0.022
134	0.973	0.005	0.000	0.022
135	0.889	0.008	0.042	0.061
136	0.871	0.000	0.056	0.073
137	0.915	0.013	0.024	0.048
138	0.778	0.001	0.116	0.105

TABLE A-7. WEIGHTS FOR FEED GRAIN-SOYBEAN ROTATION

AREA NO.	FEED GRAIN	SOYBEAN	AREA NO.	FEED GRAIN	SOYBEAN	AREA NO.	FEED GRAIN	SOYBEAN
1	1.000	0.000	47	0.421	0.579	93	1.000	0.000
2	0.970	0.030	48	1.000	0.000	94	1.000	0.000
3	1.000	0.000	49	1.000	0.000	95	1.000	0.000
4	0.596	0.404	50	0.739	0.261	96	1.000	0.000
5	1.000	0.000	51	0.600	0.400	97	1.000	0.000
6	0.380	0.620	52	0.745	0.255	98	1.000	0.000
7	0.640	0.360	53	0.719	0.281	99	1.000	0.000
8	0.871	0.129	54	0.686	0.314	100	1.000	0.000
9	0.915	0.085	55	1.000	0.000	101	1.000	0.000
10	0.844	0.156	56	0.673	0.327	102	1.000	0.000
11	0.626	0.374	57	0.789	0.211	103	1.000	0.000
12	0.703	0.297	58	0.000	1.000	104	1.000	0.000
13	0.725	0.275	59	0.873	0.127	105	1.000	0.000
14	0.844	0.156	60	0.888	0.112	106	1.000	0.000
15	0.803	0.197	61	0.918	0.082	107	1.000	0.000
16	0.978	0.022	62	1.000	0.000	108	1.000	0.000
17	0.823	0.177	63	1.000	0.000	109	1.000	0.000
18	0.306	0.694	64	1.000	0.000	110	1.000	0.000
19	0.971	0.029	65	0.825	0.175	111	1.000	0.000
20	0.920	0.080	66	1.000	0.000	112	1.000	0.000
21	0.737	0.263	67	0.999	0.000	113	1.000	0.000
22	0.974	0.026	68	0.943	0.057	114	1.000	0.000
23	0.397	0.603	69	1.000	0.000	115	1.000	0.000
24	0.357	0.643	70	0.925	0.075	116	1.000	0.000
25	0.042	0.958	71	0.898	0.102	117	1.000	0.000
26	0.203	0.797	72	1.000	0.000	118	0.919	0.081
27	0.885	0.115	73	1.000	0.000	119	0.992	0.008
28	0.000	0.000	74	1.000	0.000	120	0.348	0.652
29	0.955	0.045	75	0.985	0.015	121	0.053	0.947
30	0.838	0.162	76	0.998	0.002	122	0.395	0.605
31	0.993	0.007	77	0.998	0.002	123	0.245	0.755
32	0.801	0.199	78	0.828	0.172	124	0.990	0.010
33	0.640	0.360	79	0.663	0.337	125	1.000	0.000
34	0.630	0.370	80	0.600	0.400	126	1.000	0.000
35	0.603	0.397	81	0.859	0.141	127	0.824	0.176
36	0.561	0.439	82	0.969	0.031	128	0.532	0.468
37	1.000	0.000	83	1.000	0.000	129	1.000	0.000
38	0.640	0.360	84	0.963	0.037	130	1.000	0.000
39	1.000	0.000	85	0.657	0.343	131	0.773	0.227
40	0.861	0.139	86	0.999	0.000	132	0.830	0.170
41	0.997	0.003	87	0.750	0.250	133	0.788	0.212
42	0.972	0.028	88	0.996	0.004	134	0.911	0.089
43	0.971	0.029	89	0.999	0.000	135	0.918	0.082
44	1.000	0.000	90	0.983	0.017	136	0.975	0.025
45	0.722	0.278	91	1.000	0.000	137	0.896	0.104
46	0.888	0.112	92	1.000	0.000	138	0.985	0.015

TABLE A-8. WEIGHTS FOR FEED GRAIN-SILAGE ROTATION

AREA	FEED		AREA	FEED		AREA	FEED	
NO.	GRAIN	SILAGE	NO.	GRAIN	SILAGE	NO.	GRAIN	SILAGE
1	0.753	0.247	47	0.973	0.027	93	0.909	0.091
2	0.871	0.129	48	0.937	0.063	94	0.978	0.022
3	0.844	0.156	49	0.869	0.131	95	0.936	0.064
4	0.949	0.051	50	0.901	0.099	96	0.950	0.050
5	0.317	0.683	51	0.969	0.031	97	0.972	0.028
6	0.941	0.059	52	0.983	0.017	98	0.940	0.060
7	0.983	0.017	53	0.969	0.031	99	0.972	0.028
8	0.919	0.081	54	0.917	0.083	100	0.968	0.032
9	0.877	0.123	55	0.840	0.160	101	0.963	0.037
10	0.708	0.292	56	0.939	0.061	102	0.997	0.003
11	0.993	0.007	57	0.835	0.165	103	0.895	0.105
12	0.974	0.026	58	0.000	1.000	104	0.897	0.103
13	0.977	0.023	59	0.779	0.221	105	0.897	0.103
14	0.877	0.123	60	0.957	0.043	106	0.833	0.167
15	0.862	0.138	61	0.945	0.055	107	0.870	0.130
16	0.782	0.218	62	0.899	0.101	108	0.959	0.041
17	0.983	0.017	63	0.760	0.240	109	0.928	0.072
18	0.951	0.049	64	0.870	0.130	110	0.988	0.012
19	0.988	0.012	65	0.872	0.128	111	0.783	0.217
20	0.951	0.049	66	0.827	0.173	112	0.997	0.003
21	0.965	0.035	67	0.773	0.227	113	0.995	0.005
22	0.903	0.097	68	0.845	0.155	114	0.935	0.065
23	0.950	0.050	69	0.849	0.151	115	0.926	0.074
24	0.855	0.145	70	0.853	0.147	116	0.987	0.013
25	0.905	0.095	71	0.980	0.020	117	0.939	0.061
26	0.971	0.029	72	0.873	0.127	118	0.910	0.089
27	0.958	0.042	73	0.890	0.110	119	0.950	0.050
28	0.000	1.000	74	0.701	0.299	120	0.958	0.042
29	0.908	0.092	75	0.956	0.044	121	0.896	0.104
30	0.951	0.049	76	0.952	0.048	122	0.894	0.106
31	0.674	0.326	77	0.935	0.065	123	0.944	0.056
32	0.920	0.080	78	0.950	0.050	124	0.951	0.049
33	0.970	0.030	79	0.883	0.117	125	0.922	0.078
34	0.972	0.028	80	0.917	0.083	126	0.929	0.071
35	0.982	0.018	81	0.811	0.189	127	0.947	0.053
36	0.953	0.047	82	0.879	0.121	128	0.916	0.084
37	0.932	0.068	83	0.943	0.057	129	0.978	0.022
38	0.975	0.025	84	0.809	0.191	130	0.962	0.038
39	0.788	0.212	85	0.871	0.129	131	0.947	0.053
40	0.902	0.098	86	0.915	0.085	132	0.973	0.027
41	0.838	0.162	87	0.893	0.107	133	0.959	0.041
42	0.741	0.259	88	0.930	0.070	134	0.982	0.018
43	0.819	0.181	89	0.907	0.093	135	0.909	0.091
44	0.782	0.218	90	0.884	0.116	136	0.750	0.250
45	0.980	0.020	91	0.964	0.036	137	0.906	0.094
46	0.738	0.262	92	0.972	0.028	138	0.662	0.338

TABLE A-9. WEIGHTS FOR HAY SILAGE ROTATION

AREA NO.	HAY	SILAGE	AREA NO.	HAY	SILAGE	AREA NO.	HAY	SILAGE
1	0.832	0.168	47	0.973	0.027	93	0.613	0.387
2	0.887	0.113	48	0.937	0.063	94	0.399	0.601
3	0.911	0.089	49	0.869	0.131	95	0.864	0.136
4	0.872	0.128	50	0.901	0.099	96	0.697	0.303
5	0.937	0.063	51	0.969	0.031	97	0.938	0.062
6	0.859	0.141	52	0.983	0.017	98	0.777	0.223
7	0.841	0.159	53	0.969	0.031	99	0.914	0.086
8	0.925	0.075	54	0.917	0.083	100	0.734	0.266
9	0.869	0.131	55	0.840	0.160	101	0.914	0.086
10	0.889	0.111	56	0.939	0.061	102	0.996	0.004
11	0.965	0.035	57	0.835	0.165	103	0.961	0.039
12	0.856	0.144	58	0.000	1.000	104	0.931	0.069
13	0.823	0.177	59	0.779	0.221	105	0.972	0.028
14	0.864	0.136	60	0.957	0.043	106	0.716	0.284
15	0.897	0.103	61	0.945	0.055	107	0.848	0.152
16	0.881	0.119	62	0.899	0.101	108	0.917	0.083
17	0.839	0.161	63	0.760	0.240	109	0.576	0.424
18	0.782	0.218	64	0.870	0.130	110	0.990	0.010
19	0.822	0.178	65	0.872	0.128	111	0.891	0.109
20	0.933	0.067	66	0.827	0.173	112	0.996	0.004
21	0.964	0.036	67	0.773	0.227	113	0.991	0.009
22	0.962	0.038	68	0.845	0.155	114	0.925	0.075
23	0.897	0.103	69	0.849	0.151	115	0.977	0.023
24	0.813	0.187	70	0.853	0.147	116	0.974	0.026
25	0.826	0.174	71	0.980	0.020	117	0.915	0.085
26	0.820	0.180	72	0.873	0.127	118	0.905	0.095
27	0.960	0.040	73	0.890	0.110	119	0.960	0.040
28	0.951	0.049	74	0.701	0.299	120	0.964	0.036
29	0.949	0.051	75	0.956	0.044	121	0.863	0.137
30	0.966	0.034	76	0.952	0.048	122	0.956	0.044
31	0.896	0.104	77	0.935	0.065	123	0.980	0.020
32	0.907	0.093	78	0.950	0.050	124	0.992	0.008
33	0.924	0.076	79	0.883	0.117	125	0.926	0.074
34	0.941	0.059	80	0.917	0.083	126	0.678	0.322
35	0.955	0.045	81	0.811	0.189	127	0.976	0.024
36	0.879	0.121	82	0.879	0.121	128	0.905	0.095
37	0.939	0.061	83	0.943	0.057	129	0.940	0.060
38	0.911	0.089	84	0.809	0.191	130	0.493	0.507
39	0.964	0.036	85	0.871	0.129	131	0.925	0.075
40	0.854	0.146	86	0.915	0.085	132	0.961	0.039
41	0.921	0.079	87	0.893	0.107	133	0.929	0.071
42	0.795	0.207	88	0.930	0.070	134	0.939	0.061
43	0.807	0.193	89	0.907	0.093	135	0.968	0.032
44	0.916	0.084	90	0.884	0.116	136	0.921	0.079
45	0.909	0.091	91	0.964	0.036	137	0.944	0.056
46	0.928	0.072	92	0.972	0.028	138	0.862	0.138

TABLE A-10. WEIGHTS FOR FEED GRAIN-SOYBEAN-SILAGE ROTATION

AREA NO.	FEED GRAIN	SOYBEAN	SILAGE	AREA NO.	FEED GRAIN	SOYBEAN	SILAGE
1	0.753	0.000	0.247	47	0.416	0.572	0.012
2	0.848	0.026	0.126	48	0.937	0.000	0.063
3	0.844	0.000	0.156	49	0.869	0.000	0.131
4	0.577	0.391	0.031	50	0.683	0.242	0.075
5	0.317	0.000	0.683	51	0.588	0.393	0.019
6	0.371	0.606	0.023	52	0.735	0.252	0.013
7	0.633	0.356	0.011	53	0.703	0.274	0.022
8	0.809	0.120	0.071	54	0.646	0.295	0.059
9	0.811	0.076	0.113	55	0.840	0.000	0.160
10	0.626	0.116	0.258	56	0.645	0.313	0.042
11	0.623	0.373	0.004	57	0.683	0.182	0.135
12	0.691	0.291	0.018	58	0.000	0.105	0.895
13	0.713	0.270	0.017	59	0.700	0.102	0.198
14	0.754	0.140	0.106	60	0.855	0.107	0.038
15	0.712	0.174	0.114	61	0.872	0.077	0.051
16	0.769	0.017	0.214	62	0.899	0.000	0.101
17	0.812	0.174	0.014	63	0.760	0.000	0.240
18	0.301	0.684	0.015	64	0.870	0.000	0.130
19	0.959	0.029	0.012	65	0.736	0.156	0.108
20	0.878	0.077	0.045	66	0.827	0.000	0.173
21	0.718	0.256	0.026	67	0.772	0.000	0.227
22	0.882	0.023	0.095	68	0.804	0.048	0.148
23	0.388	0.591	0.021	69	0.849	0.000	0.151
24	0.337	0.606	0.057	70	0.797	0.065	0.138
25	0.042	0.954	0.004	71	0.882	0.100	0.018
26	0.202	0.792	0.006	72	0.873	0.000	0.127
27	0.852	0.110	0.038	73	0.890	0.000	0.110
28	0.000	0.000	1.000	74	0.701	0.000	0.299
29	0.871	0.040	0.089	75	0.942	0.015	0.043
30	0.804	0.155	0.041	76	0.950	0.002	0.048
31	0.670	0.005	0.325	77	0.933	0.002	0.065
32	0.749	0.186	0.065	78	0.793	0.165	0.042
33	0.628	0.353	0.019	79	0.609	0.310	0.081
34	0.619	0.363	0.018	80	0.569	0.380	0.051
35	0.596	0.393	0.011	81	0.715	0.118	0.167
36	0.546	0.427	0.027	82	0.855	0.027	0.117
37	0.932	0.000	0.068	83	0.943	0.000	0.057
38	0.629	0.355	0.016	84	0.785	0.030	0.185
39	0.788	0.000	0.212	85	0.599	0.312	0.089
40	0.787	0.127	0.086	86	0.914	0.000	0.085
41	0.836	0.003	0.161	87	0.687	0.230	0.083
42	0.726	0.021	0.253	88	0.927	0.004	0.069
43	0.799	0.024	0.177	89	0.907	0.000	0.093
44	0.782	0.000	0.218	90	0.871	0.015	0.114
45	0.711	0.274	0.015	91	0.964	0.000	0.036
46	0.675	0.085	0.240	92	0.972	0.000	0.028

TABLE A-1C. (CONTINUED)

AREA NO.	FEED GRAIN	SOYBEAN	SILAGE
93	0.909	0.000	0.091
94	0.978	0.000	0.022
95	0.936	0.000	0.064
96	0.950	0.000	0.050
97	0.972	0.000	0.028
98	0.940	0.000	0.060
99	0.972	0.000	0.028
100	0.968	0.000	0.032
101	0.963	0.000	0.037
102	0.997	0.000	0.003
103	0.895	0.000	0.105
104	0.897	0.000	0.103
105	0.897	0.000	0.103
106	0.833	0.000	0.167
107	0.870	0.000	0.130
108	0.959	0.000	0.041
109	0.928	0.000	0.072
110	0.988	0.000	0.012
111	0.783	0.000	0.217
112	0.997	0.000	0.003
113	0.995	0.000	0.005
114	0.935	0.000	0.065
115	0.926	0.000	0.074
116	0.987	0.000	0.013
117	0.939	0.000	0.061
118	0.843	0.074	0.083
119	0.944	0.007	0.049
120	0.343	0.642	0.015
121	0.052	0.942	0.006
122	0.377	0.578	0.045
123	0.241	0.745	0.014
124	0.941	0.010	0.049
125	0.922	0.000	0.078
126	0.929	0.000	0.071
127	0.788	0.168	0.044
128	0.507	0.446	0.047
129	0.978	0.000	0.022
130	0.962	0.000	0.038
131	0.741	0.218	0.042
132	0.811	0.167	0.022
133	0.762	0.205	0.033
134	0.896	0.087	0.017
135	0.841	0.076	0.083
136	0.736	0.019	0.245
137	0.819	0.096	0.085
138	0.655	0.010	0.335

Table A-11. National constraints, Solution II

Constraints	Unit	Quantity
(Cost-value of objective function	$	13,562,117,950
Cotton lint	CWT	59,128,498
Exogenous feed, type 1 (F1)	1,000 lbs. TDN	765,925
Exogenous feed, type 2 (F2)	1,000 lbs. TDN	3,773,161
Exogenous feed, type 3 (F3)	1,000 lbs. TDN	2,922,921
Exogenous feed, type 4 (F4)	1,000 lbs. TDN	15,986,976

Table A- 12. Consuming region constraints and shadow prices, Solution II

Code	Descriptions	Unit ($x10^5$)
WHEAT	Demand for Wheat	1,000 lbs.
FDGR	Demand for Feed Grains	1,000 lbs.
SOYBN	Demand for Soybeans	CWT
CTNSD	Demand for Cotton Seeds	CWT
BFCALF	Beef Cow and Calf	Head
YRLCAF	Yearling and Calf	Head
BFGF	Demand for Beef, Grain-Fed	CWT
BFOR	Demand for Beef, non-grain-fed	CWT
PORK	Demand for Pork	CWT
FMILK	Demand for Fluid Milk	1,000 lbs.
MFGMK	Demand for Manufactured Milk Products	1,000 lbs.
BROILR	Demand for Broilers	1,000 lbs.
TDN1	TDN, Type 1	1,000 lbs.
TDN2	TDN, Type 2	1,000 lbs.
TDN3	TDN, Type 3	1,000 lbs.
PROTN1	Protein, Type 1	CWT
PROTN2	Protein, Type 2	CWT
PROTN3	Protein, Type 3	CWT
HAYRG	Demand for Hay	Ton
PASTRG	Pasture, Off-Farm	10 AUMs

TABLE A-12. (CONTINUED)

REGION NO.	1	2	3	4
WHEAT	72.26076	40.06829	12.31325	4.91700
	(-2.37044)	(-1.96038)	(-2.34044)	(-2.13244)
FDGR	-37.64211	-35.37276	-25.90553	-6.53480
	(2.30992)	(1.70238)	(2.19614)	(2.00614)
SOYBN	-68.93079	-131.12696	-64.79494	-86.13444
	(0.44631)	(0.42156)	(0.43531)	(0.42271)
CTNSD	0.00001	0.00001	-0.97603	-1.29801
	(0.38365)	(0.41932)	(0.42132)	(0.39932)
BFCALF	0.00001	0.00001	0.00001	0.00001
	(7.43668)	(7.34668)	(7.73968)	(7.50907)
YRLCAF	0.00001	0.00001	0.00001	0.00001
	(12.00977)	(11.64157)	(11.83672)	(11.53111)
BFGF	319.45511	163.54700	49.79826	43.81487
	(-2.83796)	(-2.74696)	(-2.80796)	(-2.69309)
BFOR	187.61673	96.05141	29.24659	25.73245
	(-3.26175)	(-3.16175)	(-3.21475)	(-3.13175)
PORK	276.91930	145.51153	64.59581	57.91516
	(-1.79848)	(-1.64748)	(-1.77148)	(-1.71348)
FMILK	201.44944	113.65667	26.61087	24.54413
	(-2.86754)	(-2.34753)	(-2.64577)	(-2.75628)
MFGMK	187.02461	95.66200	29.99430	27.40479
	(-2.52353)	(-2.34753)	(-2.48753)	(-2.47653)
BRCILR	16.49898	6.52694	3.36386	3.07330
	(-16.17667)	(-15.93187)	(-15.91956)	(-15.22418)
TDN1	-35.18778	-22.61635	-18.17565	-15.52917
	(1.87925)	(1.06369)	(1.73650)	(1.51385)
TDN2	0.00001	0.00001	0.0	0.00001
	(2.30992)	(1.70238)	0.00001	(0.0)
TDN3	0.00001	0.00001	0.00001	0.00001
	(1.87925)	(1.06369)	(1.73650)	(1.51385)
PRCTN1	-71.57561	-47.60234	-36.83914	-30.24861
	(0.34170)	(0.54636)	(0.40178)	(0.43033)
PRCTN2	-0.02047	-0.26783	0.0	0.00001
	0.02048	0.26784	0.00001	(0.42904)
PRCTN3	0.00001	0.00001	0.00001	0.00001
	(0.34170)	(0.54636)	(0.40178)	(0.43033)
HAYRG	-0.38599	-1.28999	0.00001	-0.03699
	(1.62869)	(1.19825)	(1.68338)	(1.52571)
PASTRG	0.55901	1.25441	0.16531	0.79871
	(0.14226)	(1.37036)	0.71740	(1.86804)

TABLE A-12. (CONTINUED)

REGION NO.	5	6	7	8
WHEAT	1.23060	1.85802	2.91897	86.19846
	(-2.36544)	(-2.10541)	(-2.15144)	(-2.27585)
FDGR	-0.15933	-9.60636	-7.96650	-141.45270
	(2.10214)	(1.90614)	(1.88114)	(2.02414)
SOYBN	0.00001	0.00001	-19.38117	-767.78210
	(0.40731)	(0.41328)	(0.41331)	(0.42331)
CTNSD	0.00001	0.00001	-0.29208	-11.57538
	(0.40122)	(0.41132)	(0.41132)	(0.38732)
BFCALF	0.00001	0.00001	0.00001	0.00001
	(7.52669)	(7.51407)	(7.50207)	(7.34107)
YRLCAF	0.00001	0.00001	0.00001	0.00001
	(11.39488)	(11.51887)	(11.52375)	(11.12977)
BFGF	28.67486	22.27958	17.34292	34.12083
	(-2.77796)	(-2.68396)	(-2.69296)	(-2.62196)
BFOR	16.84078	13.08483	10.18551	20.03922
	(-3.09475)	(-3.12843)	(-3.12975)	(-3.02275)
PORK	36.40648	29.37824	22.82184	45.90494
	(-1.75948)	(-1.68648)	(-1.69948)	(-1.71094)
FMILK	14.82958	12.39859	9.60304	19.78274
	(-3.39328)	(-2.45493)	(-2.58028)	(-2.48353)
MFGMK	16.56040	13.84430	10.74052	22.08338
	(-2.53853)	(-2.42253)	(-2.45153)	(-2.48353)
BROILR	1.85687	1.50996	1.17148	2.47709
	(-16.19408)	(-15.79951)	(-15.38579)	(-14.87152)
TDN1	-4.27333	-3.45510	-7.34522	-15.67474
	(1.63965)	(1.37113)	(1.33458)	(1.70937)
TDN2	0.00001	0.00001	0.00001	0.00001
	(2.10214)	(1.90614)	(1.88114)	(1.70937)
TDN3	0.00001	0.00001	0.00001	0.00001
	(1.63965)	(1.37113)	(1.33458)	(1.70937)
PRCTN1	-8.65154	-6.20800	-14.45186	-31.76260
	(0.41420)	(0.47872)	(0.48510)	(0.26945)
PRCTN2	-0.02473	-0.04462	-0.02214	0.00001
	0.02473	0.04463	0.02215	(0.26945)
PRCTN3	0.00001	0.00001	0.00001	0.00001
	(0.41420)	(0.47872)	(0.48510)	(0.26945)
HAYRG	0.00001	-0.02899	-0.02099	-0.14399
	(1.29528)	(1.49185)	(1.50582)	(1.34834)
PASTRG	0.69501	0.48711	0.49321	6.32831
	(0.03323)	(0.51948)	(1.60736)	(1.37003)

TABLE A-12. (CONTINUED)

REGION NO.	9	10	11	12
WHEAT	43.60726	47.94331	55.98239	158.59429
	(-1.89185)	(-1.85344)	(-1.80144)	(-2.48244)
FDGR	-64.06795	-131.18214	-2.03995	-47.61626
	(1.62034)	(1.57514)	(1.50855)	(1.76892)
SOYBN	-69.32694	-111.31927	0.00001	-1.71666
	(0.39431)	(0.39131)	(0.41185)	(0.43731)
CTNSD	0.00001	0.00001	0.00001	-0.02407
	(0.34431)	(0.38923)	(0.40947)	(0.37932)
BFCALF	0.00001	0.00001	0.00001	0.00001
	(7.10507)	(7.38619)	(7.28536)	(7.06907)
YRLCAF	0.00001	0.00001	0.00001	0.00001
	(11.12977)	(11.22968)	(11.04509)	(10.99354)
BFGF	52.17708	126.49669	33.11173	63.52885
	(-2.60796)	(-2.64835)	(-2.57596)	(-2.71070)
BFGR	30.64368	74.29170	19.44657	37.31059
	(-3.02275)	(-3.04989)	(-2.99975)	(-2.98575)
PCRK	47.09808	111.80113	30.37944	81.31310
	(-1.61551)	(-1.57648)	(-1.55194)	(-1.69765)
FMILK	37.32819	86.70979	24.45089	33.36144
	(-2.28653)	(-2.39053)	(-2.31553)	(-2.47053)
MFGMK	31.42680	72.98039	20.58209	37.25540
	(-2.28653)	(-2.39053)	(-2.31553)	(-2.47053)
BROILR	2.08493	4.84308	1.36567	4.17736
	(-14.79854)	(-15.12662)	(-15.08561)	(-14.63800)
TDN1	-24.63416	-29.99696	-14.46760	-13.41307
	(1.08660)	(0.97921)	(0.77596)	(1.43031)
TDN2	0.0	0.00001	0.00001	0.00001
	0.00001	(1.57514)	(1.50855)	(1.76892)
TDN3	0.00001	0.00001	0.00001	0.00001
	(1.08660)	(0.97921)	(0.77596)	(1.43031)
PRCTN1	-52.54841	-63.36557	-30.36239	-26.88931
	(0.41139)	(0.50856)	(0.57940)	(0.25181)
PRCTN2	0.0	-0.47369	-1.64318	-0.16844
	0.00001	0.47370	1.64319	0.16845
PRCTN3	0.00001	0.00001	0.00001	0.00001
	(0.41139)	(0.50856)	(0.57940)	(0.25181)
HAYRG	-0.32699	-1.13799	-6.76399	-0.87699
	(1.02970)	(1.31918)	(0.95980)	(1.46536)
PASTRG	0.40051	1.57191	1.41941	6.98691
	(1.90265)	(1.38584)	(1.52117)	(1.51613)

TABLE A-12. (CONTINUED)

REGION NO.	13	14	15
WHEAT	103.11359	10.47839	11.96949
	(-2.07111)	(-1.96073)	(-2.54192)
FCGR	-15.46022	-0.39834	-8.50136
	(2.04765)	(1.93088)	(2.47788)
SCYBN	0.00001	0.00001	0.00001
	(0.36700)	(0.36912)	(0.32913)
CTNSD	0.00001	0.00001	0.00001
	(0.36549)	(0.36749)	(0.32749)
BFCALF	0.00001	0.00001	0.00001
	(7.15407)	(7.22892)	(7.69707)
YRLCAF	0.00001	0.00001	0.00001
	(11.06718)	(11.01563)	(11.74835)
BFGF	60.42019	26.51023	130.82078
	(-2.68696)	(-2.66896)	(-2.87196)
BFOR	35.48487	15.56950	76.83125
	(-3.00575)	(-2.99175)	(-3.19075)
PORK	45.77358	20.73845	98.61197
	(-1.77426)	(-1.69394)	(-1.84794)
FMILK	34.60475	16.18999	74.17089
	(-2.58153)	(-2.44853)	(-3.87853)
MFGMK	34.00073	15.88522	72.79030
	(-2.58153)	(-2.44853)	(-2.60753)
BRCILR	2.53851	1.13479	5.44103
	(-16.01822)	(-16.07680)	(-16.68500)
TDN1	-10.29103	-7.03554	-36.17511
	(1.54048)	(1.38642)	(2.24105)
TDN2	0.00001	0.00001	0.00001
	(2.04765)	(1.81484)	(2.47788)
TDN3	0.00001	0.00001	0.00001
	(1.54048)	(1.38642)	(0.98325)
PRCTN1	-22.23999	-15.31678	-76.08666
	(0.36913)	(0.39952)	(0.17646)
PRCTN2	-0.53808	0.00001	-0.47639
	0.53809	(0.08515)	0.47639
PRCTN3	0.00001	0.00001	0.00001
	(0.36913)	(0.39952)	(0.40007)
HAYRG	-1.97999	-0.45999	-3.22899
	(1.33830)	(1.03308)	(1.50077)
PASTRG	9.26991	9.88721	1.28331
	(0.86090)	(1.46580)	(0.40195)

Table A-13. Producing area constraints and shadow prices, Solution II

Code	Descriptions	Unit ($x10^5$)
CHL1	Crop Hay-Land, Class 1	Acre
CHL2	Crop Hay-Land, Class 2	Acre
CHL3	Crop Hay-Land, Class 3	Acre
CL1	Cropland, Class 1	Acre
CL2	Cropland, Class 2	Acre
CL3	Cropland, Class 3	Acre
CTNL	Cotton Land	Acre
WHL	Wild Hay Land	Acre
PASTA	Pasture	AUM
LBCS	Labor, Crop-Season	10 hrs.
LBNCS	Labor, Non-Crop-Season	10 hrs.
HAYAR	Hay	Ton
RUFAG	Roughage (Hay-Equivalent)	Ton

TABLE A-13. (CONTINUED)

AREA NO.	001(NY)	002(PA)	003(WV)	004(MD)	005(NE)
CHL1	7.14071	18.90281	0.31711	7.02451	9.91391
	(0.50019)	(0.65241)	(0.94853)	0.96030	(0.18729)
CHL2	0.0	0.0	0.19491	0.0	0.0
	3.34401	9.34081	(0.05608)	4.44761	4.18241
CHL3	0.0	0.0	0.0	0.0	0.0
	1.23391	8.07461	0.16241	0.67971	3.75221
CL1	2.21831	14.39304	0.02822	7.02451	0.87297
	2.59609	0.27616	0.16939	(0.47285)	0.83604
CL2	0.0	0.0	0.01735	0.0	0.0
	1.99061	5.79391	0.07646	3.75771	0.61351
CL3	0.0	0.0	0.0	0.0	0.0
	0.63401	3.95001	0.06941	0.46401	0.59611
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	6.27830	5.18051	1.12647	-0.49874	14.36769
	(0.05263)	17.06310	(0.05263)	5.06375	3.95310
LBCS	14.18020	27.58516	2.10922	18.91380	26.57941
	0.97918	53.10652	(0.03878)	4.71105	23.11632
LBNCS	7.82925	6.11074	0.66682	5.77464	15.21405
	(0.73885)	27.09811	(0.71000)	1.75824	13.32446
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.63379)	(1.69478)	(2.17669)	(1.63610)	(1.86528)
RUFAG	-0.13345	-0.60793	-0.03761	-0.18588	-0.47504
	(1.63379)	(1.69478)	(2.17669)	(1.63610)	(1.86528)

TABLE A-13. (CONTINUED)

AREA NO.	006(VA)	007(NC)	008(NC)	009(NC)	010(VA)
CHL1	1.23442	0.39764	0.22604	0.04115	10.69941
	1.59659	19.80916	2.03507	2.84136	(0.19971)
CHL2	0.0	0.0	0.0	0.0	0.0
	0.66931	6.91171	1.30561	1.48471	7.60971
CHL3	0.0	0.0	0.0	0.0	0.0
	0.24171	2.12071	0.82111	0.89671	7.14141
CL1	0.17405	0.06323	0.0	0.00539	1.30855
	2.33636	19.45998	2.02941	2.68522	4.63306
CL2	0.0	0.0	0.0	0.0	0.0
	0.54261	6.32771	0.89421	1.06941	3.38401
CL3	0.0	0.0	0.0	0.0	0.0
	0.11031	1.87991	0.41801	0.50281	2.33141
CTNL	0.0	0.0	0.0	0.0	0.13601
	0.00001	5.41201	0.06301	0.53101	(0.33389)
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	1.60790	-0.02072	-0.00997	-0.00183	37.53544
	(0.03320)	4.41724	4.20551	5.47338	21.44788
LBCS	4.79193	0.44139	0.17405	0.03580	35.49382
	0.80157	53.88158	14.61275	12.96378	49.39752
LBNCS	1.77804	0.0	0.0	0.0	11.51482
	(0.36311)	27.39180	8.37723	2.17816	14.04029
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.89133)	(2.09278)	(1.87805)	(1.80861)	(2.09838)
RUFAG	-0.05838	-0.77144	-0.37072	-0.08601	-1.23972
	(1.89133)	(2.09278)	(1.87805)	(1.80861)	(2.09838)

TABLE A-13. (CONTINUED)

AREA NO.	011(SC)	012(GA)	013(GA)	014(SC)	015(SC)
CHL1	0.15253 3.38358	0.03682 2.00449	0.11616 30.28784	0.07095 1.83686	1.85021 2.66260
CHL2	0.0 1.48261	0.0 1.11291	0.0 9.19841	0.0 1.38601	0.0 1.96111
CHL3	0.0 0.07641	0.0 0.14631	0.0 2.40511	0.0 0.56811	0.0 1.13291
CL1	0.00534 3.22597	0.00530 1.92051	0.02056 30.00294	0.00965 1.87656	0.19057 4.14394
CL2	0.0 1.34631	0.0 1.03851	0.0 8.50001	0.0 1.05941	0.0 1.50861
CL3	0.0 0.06751	0.0 0.13001	0.0 1.79641	0.0 0.32671	0.0 0.65001
CTNL	0.0 1.75101	0.0 0.65201	0.0 14.07201	0.0 1.49001	0.0 2.88201
WHL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
PASTA	-0.00732 1.06569	-0.00309 6.63560	-0.00820 35.84477	-0.00310 3.55863	8.94569 12.52087
LBCS	0.18609 13.73276	0.03903 6.04690	2.10916 60.98686	2.79284 7.70270	12.72856 4.34402
LBNCS	0.0 5.49556	0.0 1.35415	0.46100 12.45164	0.77369 0.51613	3.13995 (0.24997)
HAYAR	0.00001 (2.59091)	0.00001 (1.90206)	0.00001 (1.92754)	0.00001 (1.68338)	0.00001 (1.60731)
RUFAG	-0.23491 (2.59091)	-0.07144 (1.90206)	-0.24045 (1.92754)	-0.06456 (1.57337)	-0.12702 (1.60731)

TABLE A-13. (CONTINUED)

AREA NO.	016(FL)	017(FL)	018(AL)	019(AL)	020(AL)
CHL1	0.11871	0.0	1.06970	4.41021	4.11991
	(1.17625)	2.51171	0.01250	(0.0)	(0.11888)
CHL2	0.11842	0.0	0.0	0.0	0.0
	0.53049	4.11411	0.45421	3.00541	2.64161
CHL3	0.0	0.0	0.0	0.0	0.0
	0.33061	0.61981	0.07461	1.40121	1.17361
CL1	0.0	0.0	1.02561	4.41021	2.61862
	0.03151	2.43361	(0.37327)	(0.18771)	0.98649
CL2	0.0	0.0	0.0	0.0	0.0
	0.17101	3.86061	0.41931	2.89921	1.93521
CL3	0.0	0.0	0.0	0.0	0.0
	0.08761	0.52951	0.06121	1.28031	0.65831
CTNL	0.0	0.0	0.14179	1.88352	2.56624
	0.00601	0.74301	0.12922	1.64349	0.45977
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	119.23911	7.00498	3.70040	15.79054	27.52733
	(0.01282)	1.36286	(0.01787)	(0.05843)	(0.16256)
LBCS	9.27945	14.66919	2.66710	16.22268	22.38159
	(0.81000)	(0.15632)	(0.15447)	(0.12463)	(0.10477)
LBNCS	1.51301	2.56264	0.11773	0.50241	1.34180
	(0.78000)	0.60160	0.24426	1.91611	2.73216
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.92828)	(1.29528)	(1.53636)	(1.54098)	(1.52571)
RUFAG	-0.12866	0.09196	-0.02013	0.34527	-0.18533
	(1.92828)	(0.76506)	(1.53636)	(1.54098)	(1.52571)

TABLE A-13. (CONTINUED)

AREA NO.	021(MS)	022(KY)	023(TN)	024(MS)	025(AR)
CHL1	9.48611	9.98771	9.03883	2.05271	7.82511
	(0.57195)	(0.40265)	0.05478	(0.58072)	(0.61611)
CHL2	C.72254	0.0	0.0	0.53720	6.43181
	7.27197	4.28621	3.34771	0.06861	(0.02284)
CHL3	0.0	0.0	0.0	0.0	0.0
	5.05181	5.71751	2.91991	0.38861	0.61491
CL1	9.18191	0.00401	8.77561	2.00251	7.81697
	(1.11406)	5.85530	(0.31676)	(1.04448)	0.00814
CL2	0.02601	0.0	0.0	0.0	6.36051
	6.93020	2.06491	2.75231	0.54471	(0.04707)
CL3	0.0	0.0	0.0	0.0	0.0
	3.11521	2.02711	1.96211	0.22551	0.28521
CTNL	9.17055	0.00401	4.61464	2.00251	5.51201
	0.24246	(1.49200)	1.57137	0.03150	(1.30997)
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	64.51040	75.24920	-1.19493	9.90577	-1.69230
	(0.13504)	(0.02250)	21.82568	(0.14790)	3.21712
LBCS	74.97723	24.48310	39.00467	17.31591	13.26897
	3.06908	35.28575	(0.52954)	(0.20322)	(0.80000)
LBNCS	3.28711	7.28941	0.0	2.65334	C.C
	1C.84901	13.13269	11.19368	1.99849	2.88060
HAYAR	0.00001	0.C0001	0.00001	0.00001	0.00001
	(1.49281)	(1.83585)	(1.62232)	(1.48903)	(1.34834)
RUFAG	-0.89627	-1.14228	-0.65147	-0.23641	-0.05820
	(1.49281)	(1.83585)	(1.62232)	(1.48903)	(1.34834)

TABLE A-13. (CONTINUED)

AREA NO.	026(MO)	027(KY)	028(ID)	029(KY)	030(OH)
CHL1	3.46581	8.75461	6.31341	3.13321	6.53271
	(0.39451)	(0.15288)	(1.24467)	(0.81331)	(0.49534)
CHL2	10.06201	0.0	8.59461	0.72800	0.0
	0.48160	3.23711	(0.45122)	0.29681	4.57201
CHL3	0.0	0.0	1.75171	0.0	0.0
	0.57221	2.52431	2.33680	2.24631	4.35001
CL1	3.36931	1.43781	3.40731	0.15979	0.22211
	(1.23004)	5.29970	(1.54547)	1.82112	5.26230
CL2	10.06201	0.0	2.70311	0.0	0.0
	(0.23229)	1.97871	(1.46905)	0.51921	3.15411
CL3	0.0	0.0	1.75171	0.0	0.0
	0.32491	1.09381	(0.92614)	0.76391	1.94161
CTNL	3.36931	0.0	0.0	0.0	0.0
	2.06970	0.00001	0.00001	0.00001	0.00001
WHL	0.01401	0.0	2.33501	0.0	0.0
	(0.24459)	0.00001	(0.23790)	0.00001	0.00001
PASTA	-4.66980	29.13415	46.32139	18.77990	28.48370
	8.07136	0.90864	(0.06323)	(0.05675)	(0.14384)
LBCS	17.66695	24.86085	34.24067	8.80782	31.83421
	(0.11512)	0.72781	6.69530	6.64175	(0.21195)
LBNCS	0.77753	7.76719	14.48380	2.80016	11.54465
	4.00363	2.80133	(0.09503)	4.25597	(0.78000)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.31918)	(1.49185)	(1.38853)	(1.74727)	(1.53325)
RUFAG	-0.07514	-0.51777	-1.19617	-0.35971	-0.31529
	(1.31918)	(1.49185)	(1.38853)	(1.74727)	(1.53325)

TABLE A-13. (CONTINUED)

AREA NO.	031(NY)	032(OH)	033(OH)	034(IN)	035(IN)
CHL1	22.72601 (0.63519)	6.03891 (0.68350)	56.95440 1.36181	19.93171 (0.50320)	2.64931 (0.23198)
CHL2	22.41395 0.53265	7.22847 0.77563	0.0 11.73211	0.0 4.04211	0.0 1.06751
CHL3	0.0 12.50471	0.0 1.87571	0.0 1.66031	0.0 4.87781	0.0 0.47611
CL1	0.0 9.38941	3.09076 1.98955	51.36961 (0.33411)	1.17597 18.17593	2.21851 (0.56709)
CL2	0.0 8.02531	6.09971 (0.09539)	0.0 9.51231	0.0 3.47601	0.0 0.82251
CL3	0.0 3.61361	0.0 1.04931	0.0 0.86211	0.0 2.66691	0.0 0.22571
CTNL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
WHL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
PASTA	74.58543 (0.05263)	9.28193 (0.14384)	21.54644 (0.11804)	28.93631 (0.13252)	-0.13879 5.05511
LBCS	105.89237 18.10765	27.16573 (0.22071)	91.39697 (0.74776)	35.90306 2.37190	2.74085 22.49031
LBNCS	60.53550 (0.27005)	10.35984 (0.68490)	29.68818 3.21080	13.81246 (0.66305)	0.18664 7.26270
HAYAR	0.00001 (1.62869)	0.00001 (1.53325)	0.00001 (1.53325)	0.00001 (1.19825)	0.00001 (1.49185)
RUFAG	-1.03213 (1.62869)	-0.42761 (1.53325)	-0.69496 (1.53325)	-0.25759 (1.19825)	-0.09310 (1.42710)

TABLE A-13. (CONTINUED)

AREA NO.	036(IL)	037(CA)	038(IN)	039(NV)	040(MI)
CHL1	18.80631	10.28641	66.80202	2.46061	36.11661
	(0.85651)	(1.60743)	3.28439	(0.04186)	(0.50635)
CHL2	14.40371	4.48244	10.15541	0.0	8.31899
	(0.13255)	2.73337	1.59830	3.18571	4.88172
CHL3	0.0	0.0	0.0	0.0	0.0
	5.02731	5.38471	6.65751	2.80001	5.58111
CL1	14.77036	6.66201	64.80541	1.04001	6.96219
	3.44055	(0.83513)	(1.39672)	(0.74799)	21.95651
CL2	12.31571	4.35661	10.15541	0.0	0.0
	(0.20501)	(0.93636)	(0.41613)	1.28931	10.20041
CL3	C.0	0.0	0.0	0.0	0.0
	2.84541	2.54461	4.99281	1.11971	4.00461
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.41601	0.00001	0.00001	0.00001
WHL	0.04701	0.73801	0.0	1.90928	0.0
	(0.37621)	(0.56957)	0.00001	0.72673	0.00001
PASTA	27.83143	64.01315	36.80337	24.63892	20.82451
	(0.04909)	(0.10176)	(0.10662)	(0.12003)	(0.14384)
LBCS	40.28806	48.42798	111.77283	10.84742	75.31200
	14.60514	(0.92145)	(0.34907)	2.00888	20.81905
LBNCS	13.58400	0.0	32.76843	2.51244	42.58979
	(0.55276)	0.00001	3.64803	(0.83629)	(0.74918)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.31918)	(1.92922)	(1.39531)	(1.23387)	(1.40314)
RUFAG	-0.29040	-1.13408	-0.80285	-1.28169	-0.41013
	(1.31918)	(1.92922)	(1.39531)	(1.23387)	(1.40314)

TABLE A-13. (CONTINUED)

AREA NO.	041(MI)	042(WI)	043(WI)	044(CO)	045(IL)
CHL1	3.41291	12.00091	32.06301	0.79051	149.60780
	(0.60009)	(0.41582)	(1.29717)	(1.86617)	(1.58368)
CHL2	4.66465	4.97311	12.06371	1.08001	18.97621
	0.33336	(0.24842)	(0.61160)	(0.15716)	(1.00333)
CHL3	0.0	6.48051	10.68591	1.55431	0.0
	2.91451	(0.13608)	(0.42328)	(0.11060)	11.23911
CL1	0.26962	2.18666	21.89720	0.08839	141.95390
	1.47159	4.31514	1.33041	0.49381	(0.53537)
CL2	0.0	0.0	0.0	0.01201	14.51951
	2.29031	2.37051	7.08731	0.68120	(0.11292)
CL3	0.0	0.0	0.0	0.0	0.0
	1.29881	2.94971	5.03801	0.73811	7.21611
CTNL	0.0	0.0	0.0	0.02401	0.0
	0.00001	0.00001	0.00001	(2.41819)	0.00001
WHL	0.0	0.0	0.13301	0.0	0.0
	0.00001	0.07701	(0.32602)	0.10701	0.00001
PASTA	13.66210	24.34197	57.93051	37.33853	88.99678
	(0.09190)	(0.22026)	(0.20695)	(0.19398)	(0.02153)
LBCS	18.03508	32.78401	79.41615	8.66116	186.54025
	5.57814	36.97363	73.67548	1.32982	(0.09572)
LBNCS	10.97292	24.30647	46.76235	1.33653	47.41764
	(0.66630)	(0.30755)	(0.72497)	(0.95000)	12.28802
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.48451)	(1.45178)	(1.20276)	(1.87803)	(1.67469)
RUFAG	-0.10708	-0.24148	-0.55608	-0.59512	-1.23183
	(1.48451)	(1.45178)	(1.20276)	(1.87803)	(1.67469)

TABLE A-13. (CONTINUED)

AREA NO.	046(MO)	047(IL)	048(CA)	049(AZ)	050(MO)
CHL1	1.25035	8.56741	0.49393	7.40521	7.87481
	1.21436	(0.85170)	0.37698	(0.15093)	(0.60985)
CHL2	0.0	10.20851	0.49771	1.97581	0.0
	5.79081	(0.24214)	0.54650	(0.05026)	13.92871
CHL3	0.0	0.0	0.0	0.0	0.0
	8.98591	2.52851	1.04071	0.90641	4.90921
CL1	1.25035	5.87874	0.47621	5.88481	1.02373
	1.21436	2.61807	(1.83921)	(1.15154)	6.23908
CL2	0.0	9.49701	0.49771	0.0	0.0
	4.24421	(0.09059)	(0.33948)	1.51611	10.55861
CL3	0.0	0.0	0.0	0.0	0.0
	5.51711	1.36751	0.56541	0.68971	2.88571
CTNL	1.25035	0.0	0.0	5.82862	0.0
	0.29666	0.00001	1.14001	2.17439	0.00001
WHL	0.17240	0.0	0.0	0.0	1.25201
	1.53461	0.00001	0.00001	0.00001	(0.34639)
PASTA	-0.30534	14.90656	-0.21158	23.02763	47.03502
	45.32457	(0.03568)	(0.10280)	(0.12584)	(0.05146)
LBCS	15.08167	19.62179	1.89657	11.89209	32.96878
	(0.11299)	6.86890	(1.26273)	(0.98000)	25.73039
LBNCS	0.93675	5.84779	0.0	0.0	12.57679
	2.27734	(0.56073)	0.00001	0.00001	(0.32607)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.59185)	(1.43579)	(1.87469)	(1.99018)	(1.38601)
RUFAG	-0.26378	-0.13860	0.08254	-0.32837	-0.39027
	(1.59185)	(1.43579)	(1.87469)	(1.99018)	(1.38601)

TABLE A-13. (CONTINUED)

AREA NO.	051(MO)	052(IA)	053(IA)	054(MN)	055(NM)
CHL1	37.97491	22.75211	109.95601	61.35741	4.78701
	(1.27009)	(1.79864)	(1.03003)	(0.69040)	(0.57889)
CHL2	36.36031	27.05051	34.30601	10.90385	1.06341
	(0.49843)	(0.41235)	(0.31072)	0.79456	(0.40032)
CHL3	0.0	0.0	7.66411	0.0	0.86491
	14.31631	10.38141	(0.05860)	1.95621	(0.19470)
CL1	35.56201	22.75211	104.93821	57.93851	2.35275
	(0.05140)	(0.0)	(0.78156)	(0.18892)	1.93056
CL2	20.51116	21.95181	25.52331	9.98791	0.0
	7.35724	(0.53496)	(0.70265)	(0.27675)	0.89801
CL3	0.0	0.0	0.0	0.0	0.0
	7.19381	6.17671	4.52001	1.33861	0.64671
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	2.11001
WHL	0.17801	0.0	0.0	0.0	0.0
	(1.55036)	0.00001	0.00001	0.86901	0.00001
PASTA	71.07296	73.42125	92.64730	16.64086	25.40400
	54.07014	(0.16648)	(0.16478)	(0.07598)	(0.18037)
LBCS	111.41067	48.52212	165.29799	84.66829	6.38875
	4.33376	32.58101	18.73465	16.53493	(0.84000)
LBNCS	31.75434	9.62312	54.14202	20.77057	0.0
	(0.07932)	17.58185	9.90166	(0.55356)	0.00001
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.76137)	(1.37830)	(1.41042)	(1.38619)	(1.88889)
RUFAG	-0.97542	-0.59805	-1.03158	-0.38554	-0.35335
	(1.76137)	(1.37830)	(1.41042)	(1.38619)	(1.88889)

TABLE A-13. (CONTINUED)

AREA NO.	056(MN)	057(MN)	058(MN)	059(MN)	060(MN)
CHL1	19.42511	26.87021	3.54029	9.48501	16.44641
	(1.17490)	(0.66839)	1.82002	(0.11740)	(0.56758)
CHL2	5.56891	11.38701	1.32091	6.06621	10.16571
	(0.45449)	(0.05113)	2.84670	(0.00538)	0.34240
CHL3	0.95081	0.0	0.0	0.0	0.0
	0.72980	9.06861	3.92361	6.69561	3.30901
CL1	17.79701	6.12454	1.92861	0.0	14.31261
	(0.30296)	15.90457	(2.05529)	7.08151	(0.28655)
CL2	4.58951	7.70191	1.32091	0.0	9.05411
	(0.47789)	(0.05786)	(0.50891)	4.02871	(0.40009)
CL3	0.95081	0.0	0.0	0.0	0.0
	(0.15673)	5.19151	1.28841	4.49151	2.84271
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.19101	0.59001	0.0	0.0	0.0
	(0.34882)	(0.25843)	0.45701	1.08401	0.96701
PASTA	10.47751	36.62160	12.69938	16.78041	6.93958
	(0.06963)	(0.10136)	(0.17391)	(0.13496)	(0.08797)
LBCS	32.26710	77.05383	19.98452	18.88175	17.10804
	21.61728	24.36681	8.01904	40.77182	9.37653
LBNCS	10.68409	48.25506	14.78736	14.29437	7.11634
	(0.56315)	(0.81979)	(0.43055)	(0.89174)	(0.61193)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.38539)	(1.16910)	(1.38070)	(1.02970)	(1.28272)
RUFAG	-0.17042	-0.43479	0.02905	-0.20711	-0.18279
	(1.38539)	(1.16910)	(1.38070)	(1.02970)	(1.28272)

TABLE A-13. (CONTINUED)

AREA NO.	061(ND)	062(ND)	063(ND)	064(SC)	065(ND)
CHL1	20.86461 (0.16237)	54.99431 (0.22599)	21.31751 (0.10962)	0.0 0.08411	3.10121 (0.02538)
CHL2	3.26081 (0.09185)	15.54551 (0.13963)	0.0 45.90900	0.0 0.24161	0.0 0.73351
CHL3	0.0 C.74281	3.65051 (0.00932)	0.0 8.11481	0.0 0.01721	0.0 0.28311
CL1	19.59531 (0.73422)	52.27321 (0.34923)	11.82680 9.49071	0.0 0.03481	1.58951 (0.18908)
CL2	2.60691 (0.37240)	12.32961 (0.09332)	0.0 39.15150	0.0 0.08731	0.0 0.31181
CL3	0.0 0.56121	0.0 2.52181	0.0 5.59151	0.0 0.00581	0.0 0.08811
CTNL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
WHL	0.50801 (0.24011)	6.17201 (0.03227)	0.0 7.96801	0.09001 (0.16263)	1.33701 (0.16548)
PASTA	1.98937 (0.16028)	14.24318 (0.20362)	37.02170 (0.20362)	0.30001 2.33350	2.43669 (0.11104)
LBCS	8.02259 7.41621	25.19500 22.26253	12.97661 33.68524	0.22485 0.31387	1.92908 10.42547
LBNCS	1.00720 4.58058	6.11290 10.84576	8.46429 6.00980	0.16469 (0.73485)	0.85228 2.74624
HAYAR	0.00001 (1.12973)	0.00001 (1.04885)	0.00001 (1.04885)	0.00001 (1.60351)	0.00001 (1.33577)
RUFAG	-0.08862 (1.12973)	-0.40542 (1.04885)	-0.53427 (1.04885)	-0.01654 (1.60351)	-0.08805 (1.33577)

TABLE A-13. (CONTINUED)

AREA NO.	C66(SD)	067(SD)	068(SD)	069(SD)	070(SD)
CHL1	2.60231	24.12361	0.0	5.66781	26.99575
	(0.54479)	(0.00430)	11.34081	(0.12336)	2.31926
CHL2	9.47101	0.0	0.0	0.0	4.25781
	(0.01293)	15.38001	3.27171	4.03391	1.34790
CHL3	0.0	0.0	0.0	0.0	0.0
	11.24981	6.03681	1.83431	2.14851	6.24911
CL1	0.22380	0.98967	0.0	5.06821	26.72301
	2.11221	20.75113	9.70581	(0.23075)	(0.52392)
CL2	2.69429	0.0	0.0	0.0	4.25781
	4.32642	11.38811	2.50221	2.91031	(0.04526)
CL3	0.0	0.0	0.0	0.0	0.0
	6.67481	4.72431	1.35581	1.29031	5.13801
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	6.32901	8.35901	0.35154	2.86601	1.80801
	(0.29623)	(0.01869)	1.21547	(0.00025)	(0.01361)
PASTA	75.41358	16.32638	3.75228	8.02616	12.64825
	(0.02211)	(0.14443)	(0.07208)	(0.14242)	(0.08956)
LBCS	11.50708	12.10211	6.50926	5.61765	36.34286
	4.86938	13.94407	9.96890	4.10542	9.98994
LBNCS	5.44768	10.00273	6.45024	2.94302	13.72785
	(0.88000)	(0.59637)	(0.62623)	(0.66099)	(0.68826)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.43748)	(0.97158)	(1.26168)	(0.95980)	(1.19615)
RUFAG	-0.92983	-0.43861	-0.16846	-0.12313	-0.27526
	(1.43748)	(0.97158)	(1.26168)	(0.95980)	(1.19615)

TABLE A-13. (CONTINUED)

AREA NO.	C71(NB)	072(NB)	073(NB)	074(CO)	075(NB)
CHL1	43.44781	1.13101	5.79711	3.35981	10.94441
	(0.99354)	(1.19234)	(1.38914)	(1.50185)	(0.64248)
CHL2	29.58831	1.23701	7.23031	1.79021	5.99971
	(0.21451)	(0.46896)	(0.48019)	(0.27862)	(0.15553)
CHL3	0.0	1.81941	3.64441	7.11831	5.86351
	15.81541	(0.24675)	1.17770	(0.45730)	(0.07346)
CL1	43.44781	0.53607	4.62142	3.35981	5.91721
	(0.0)	0.56704	1.17569	(0.80899)	4.10010
CL2	20.48847	0.92341	6.74441	1.53251	4.20461
	4.63174	(0.16493)	(0.40455)	(0.60336)	(0.09063)
CL3	0.0	1.06461	3.64441	4.62021	0.0
	10.22161	(0.22501)	(0.43438)	(0.63708)	3.02521
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	2.44401	1.43901	2.09701	0.23201	6.83901
	(0.00953)	(0.56790)	(0.19462)	(0.37883)	(0.17425)
PASTA	48.80378	23.83995	29.97733	13.41272	44.59764
	(0.13653)	(0.02736)	(0.12546)	(0.10935)	(0.19541)
LBCS	109.57571	3.36306	11.18859	17.57405	19.86817
	4.03872	0.29353	1.60712	(0.13971)	9.22064
LBNCS	34.03021	1.26063	4.25773	4.22232	9.13396
	(0.09718)	(0.88246)	(0.05190)	0.13311	(0.16737)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.21223)	(1.44935)	(1.30416)	(1.37441)	(1.01638)
RUFAG	-0.39535	-0.10596	-0.08752	-0.11524	-0.24693
	(1.21223)	(1.44935)	(1.30416)	(1.37441)	(1.01638)

TABLE A-13. (CONTINUED)

AREA NO.	076(NB)	077(NB)	078(KS)	079(KS)	C80(KS)
CHL1	12.05621 (0.70636)	0.89671 (0.49136)	6.03151 (0.60620)	3.57961 (0.71068)	5.82201 (0.30056)
CHL2	4.16581 (0.12879)	0.59245 0.12086	7.44901 (0.22272)	7.06351 (0.30906)	7.97931 (0.21352)
CHL3	3.97301 (0.04002)	0.0 1.20861	3.56691 (0.09668)	2.16231 (0.14159)	1.36331 (0.05568)
CL1	9.78366 2.27255	0.01883 0.55958	2.48799 3.54352	0.40480 3.17481	1.29314 3.01897
CL2	3.70661 (0.16324)	0.01244 0.33447	0.0 6.57841	0.0 6.68201	0.0 4.94021
CL3	0.0 2.38161	0.0 0.42561	0.0 2.30841	0.0 1.50181	0.0 0.66311
CTNL	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001	0.0 0.00001
WHL	0.37701 (0.02623)	10.59001 (0.21109)	0.0 0.53201	0.0 2.01601	0.0 1.07501
PASTA	23.11156 (0.19299)	48.50940 (0.03826)	22.52125 (0.14488)	23.54972 (0.16259)	14.12631 (0.14752)
LBCS	14.64086 4.53591	6.07874 (0.58966)	10.62025 9.34324	7.87682 10.02623	6.00478 5.49844
LBNCS	5.74429 (0.17445)	2.05712 (0.97000)	4.43173 (0.52937)	3.65709 (0.48084)	2.12886 (0.81256)
HAYAR	0.00001 (1.01639)	0.00001 (1.19844)	0.00001 (1.10606)	0.00001 (1.17125)	0.00001 (1.20327)
RUFAG	-0.10121 (1.01639)	-0.20586 (1.19844)	-0.12500 (1.10606)	-0.13520 (1.17125)	-0.08242 (1.20327)

TABLE A-13. (CONTINUED)

AREA NO.	081(KS)	082(KS)	083(TX)	084(KS)	085(OK)
CHL1	6.22281	15.06281	0.0	44.56021	2.94031
	(0.60219)	(0.45171)	3.06021	(0.71095)	(0.58276)
CHL2	5.92671	12.76551	0.0	23.36871	1.46851
	(0.32265)	(0.33120)	0.42651	(0.43869)	(0.06190)
CHL3	2.88251	8.21071	0.0	18.64611	0.0
	(0.18584)	(0.24082)	0.38791	(0.35062)	0.43321
CL1	1.40060	0.0	0.0	38.31933	1.88211
	4.82221	15.06281	2.53251	6.24087	(0.42881)
CL2	0.0	0.0	0.0	0.0	0.71781
	5.03051	12.09671	0.34581	22.34601	(0.35388)
CL3	0.0	0.0	0.0	0.0	0.0
	1.77721	5.61351	0.29871	15.94011	0.15481
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	2.10801	0.00001	0.31901
WHL	0.0	0.0	0.0	0.84701	0.87301
	2.41901	0.94401	0.00001	(0.00085)	(0.93043)
PASTA	55.14684	37.97759	184.93950	102.97961	45.08655
	(0.15373)	(0.15857)	(0.10935)	(0.18348)	(0.17639)
LBCS	11.15780	16.14997	3.30844	45.07462	17.56957
	6.71824	13.84595	(0.90000)	4.94650	(0.10279)
LBNCS	3.58579	6.82590	0.0	11.15333	2.34852
	(0.96000)	(0.96000)	0.00001	(0.96000)	0.19594
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.10829)	(1.05838)	(2.37436)	(0.95980)	(1.80742)
RUFAG	-0.23611	-0.18831	-0.41776	-0.49160	-0.10862
	(1.10829)	(1.05838)	(2.37436)	(0.95980)	(1.80742)

TABLE A-13. (CONTINUED)

AREA NO.	086(KS)	087(OK)	088(OK)	089(OK)	C90(CK)
CHL1	8.42471	4.07511	24.08391	3.71731	3.41711
	(0.99560)	(0.37225)	(1.63831)	(1.65525)	(0.84652)
CHL2	17.47041	0.84351	15.62541	11.25581	0.96903
	(0.58127)	(0.05909)	(0.68958)	(1.05946)	0.47508
CHL3	6.07811	0.0	9.80741	5.01231	0.0
	(0.22869)	0.13901	(0.00254)	(0.09887)	1.38031
CL1	5.98632	3.46451	24.08391	1.67224	2.75941
	2.43839	(1.05096)	(0.11346)	2.04507	(0.03357)
CL2	17.47041	0.55201	13.84311	11.25581	0.88421
	(0.0)	(0.76833)	(0.41676)	(0.0)	(0.23466)
CL3	0.0	0.0	6.78291	4.20201	0.0
	5.52381	0.06511	(0.43353)	(0.31516)	0.69761
CTNL	0.0	0.0	0.0	0.19527	0.0
	0.00001	0.00001	6.44401	0.47574	0.29601
WHL	0.16001	1.43001	0.44801	0.28601	0.53801
	(0.10308)	(1.11510)	(0.52296)	(0.21693)	(0.66186)
PASTA	57.77760	27.09547	42.12366	44.89105	22.28051
	(0.13621)	(0.19147)	(0.19698)	(0.20147)	(0.17281)
LBCS	13.83888	8.44604	47.75462	19.18751	14.25535
	(0.43568)	0.61953	(0.10994)	(0.21528)	(0.10286)
LBNCS	3.28604	2.13839	6.79294	2.28552	1.78269
	(0.96000)	(0.70971)	1.41779	(0.74075)	0.26501
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.01308)	(1.56296)	(1.80829)	(1.46536)	(1.80703)
RUFAG	-0.16316	-0.18071	-0.28437	-0.22018	-0.09890
	(1.01308)	(1.56296)	(1.80829)	(1.46536)	(1.80703)

TABLE A-13. (CONTINUED)

AREA NO.	091(TX)	092(TX)	093(TX)	094(TX)	C95(TX)
CHL1	3.58881	14.40271	17.61621	7.89561	3.90781
	(0.63449)	(1.80581)	(1.16477)	(2.78962)	(0.41656)
CHL2	3.79581	23.13021	13.67531	17.98631	0.86311
	(0.13358)	(0.50202)	(0.17532)	(0.49236)	0.29410
CHL3	0.0	2.10711	0.0	8.52931	0.0
	0.81511	(0.12306)	8.35051	(0.30501)	0.21471
CL1	0.94532	14.03809	16.72413	7.89561	3.30254
	1.86169	0.36462	0.89207	(0.0)	0.56877
CL2	2.62501	22.93981	13.67531	8.95625	0.86311
	(0.07890)	(0.34857)	(0.17055)	9.03006	(0.06902)
CL3	0.0	0.0	0.0	0.0	0.0
	0.37061	1.37611	7.13751	8.07501	0.13141
CTNL	0.0	7.56401	16.16095	15.97001	0.0
	0.95201	(0.49043)	0.53506	(0.89968)	0.51901
WHL	0.43801	0.10201	0.0	0.0	0.0
	(0.67988)	(0.02853)	0.06001	0.00001	0.00001
PASTA	93.72783	56.87960	84.07830	74.78905	15.30924
	(0.18453)	(0.14395)	(0.16087)	(0.13478)	(0.20881)
LBCS	27.39626	24.49953	31.17398	30.37301	5.36760
	(0.12760)	(0.90000)	(0.90000)	(0.90000)	(0.23677)
LBNCS	0.0	1.27174	1.25935	1.34124	0.48708
	0.00001	1.83299	2.14876	0.50571	0.10117
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.89260)	(1.67153)	(1.46536)	(1.75386)	(1.60699)
RUFAG	-1.18920	-0.26731	-0.62300	-0.12638	-0.08366
	(1.89260)	(1.67153)	(1.10776)	(1.75386)	(1.60699)

TABLE A-13. (CONTINUED)

AREA NO.	096(TX)	097(TX)	C98(TX)	099(TX)	100(TX)
CHL1	1.58681	23.07351	2.73841	4.51091	13.72821
	(1.00804)	(0.50805)	(0.45349)	(0.15918)	(1.34715)
CHL2	0.73511	11.32329	0.0	0.0	4.59371
	(0.33397)	1.17352	0.73021	2.90281	(0.74915)
CHL3	0.0	0.0	0.0	0.0	0.43049
	0.26651	5.18931	0.30901	0.84061	0.60622
CL1	0.48080	20.74181	1.53159	2.79408	13.31931
	1.10601	(0.56930)	0.69372	1.58163	(0.47348)
CL2	0.22274	8.44971	0.0	0.0	3.75131
	0.46577	(0.53121)	0.45321	2.17411	(0.36445)
CL3	0.0	0.0	0.0	0.0	0.43049
	0.21001	3.09791	0.15831	0.52681	0.37052
CTNL	0.0	0.0	0.0	2.20701	0.0
	1.39801	20.58900	0.93701	(0.84680)	8.22201
WHL	0.0	0.37601	0.0	0.0	0.19201
	0.00001	(0.85794)	0.00001	0.28901	(0.57610)
PASTA	19.51436	54.47294	82.32672	19.91829	67.64382
	(0.20482)	(0.16302)	(0.12776)	(0.16526)	(0.20881)
LBCS	6.39692	51.48490	10.76500	25.88930	35.96875
	(0.29311)	(0.13803)	(0.90000)	(0.20628)	(0.16608)
LBNCS	0.0	2.86051	0.0	0.0	0.0
	0.00001	1.04995	0.00001	0.00001	0.00001
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.46536)	(1.89041)	(1.72264)	(1.58410)	(1.74167)
RUFAG	-0.78913	-0.48747	-0.94984	-0.10223	-0.19302
	(1.46536)	(1.89041)	(1.72264)	(1.58410)	(1.74167)

TABLE A-13. (CONTINUED)

AREA NO.	101(MT)	102(MT)	103(WY)	104(MT)	105(WY)
CHL1	7.00451	5.68031	2.37171	1.36541	2.99301
	(1.46128)	(0.95128)	(0.56849)	(1.08590)	(0.76562)
CHL2	23.88511	15.55411	3.95894	2.94491	5.69701
	1.07289	(0.43905)	0.55597	(0.41712)	(0.0)
CHL3	8.59221	4.47261	4.13731	1.73141	8.66464
	0.88100	(0.00387)	2.98590	(0.06992)	2.56777
CL1	7.00451	4.96531	0.09250	1.01701	1.37961
	(0.0)	(0.80098)	1.43251	(0.42291)	(1.24846)
CL2	21.54871	12.30151	2.51151	1.82181	2.40151
	(0.94384)	(0.79543)	(0.03300)	(0.49106)	(1.12351)
CL3	8.59221	3.38421	4.13731	1.21881	4.53691
	(0.30353)	(0.46430)	(0.03300)	(0.27907)	(1.12351)
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.0	1.18501	1.38501	0.07101	4.74501
	1.16701	(0.28561)	(0.35806)	(0.27063)	(0.49468)
PASTA	20.32286	27.36524	39.35028	9.85007	70.67957
	(0.13939)	(0.13939)	(0.12790)	(0.13866)	(0.13939)
LBCS	14.73417	12.98164	9.67863	5.10046	24.03569
	(0.54927)	0.38461	3.84523	1.23620	0.06410
LBNCS	3.05169	5.74957	4.80916	2.62292	5.95995
	5.18432	0.82459	(0.05339)	(0.0)	(0.39825)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.33830)	(1.42292)	(1.66825)	(1.42292)	(1.34320)
RUFAG	-0.50252	-0.59444	-1.08744	-0.18569	-2.84241
	(1.33830)	(1.42292)	(1.66825)	(1.42292)	(1.34320)

TABLE A-13. (CONTINUED)

AREA NO.	106(CO)	107(CO)	108(CO)	109(NM)	110(ID)
CHL1	5.05891	1.71001	0.14471	0.52731	5.80621
	(1.11820)	(1.00847)	(0.52658)	(0.84668)	(1.58755)
CHL2	8.91091	0.50730	0.0	3.71911	8.26541
	(0.05882)	0.50231	0.36381	(0.60615)	(0.65149)
CHL3	1.78862	3.51031	0.83125	3.08171	1.46191
	12.76089	(0.00665)	0.65756	(0.48006)	0.78060
CL1	1.43673	0.76801	0.01201	0.52731	5.13791
	3.62218	0.94200	0.13270	(1.85637)	(0.12262)
CL2	8.91091	0.0	0.0	3.71911	5.72851
	(0.0)	0.99301	0.36381	(0.70526)	(0.39592)
CL3	1.78862	1.20783	0.06899	2.70721	1.46191
	10.94529	0.62658	1.06382	(0.12116)	(0.01186)
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	2.65901	0.00001
WHL	0.0	0.01701	0.04901	0.0	0.50301
	0.21201	(0.57000)	(0.50302)	0.05401	(0.60689)
PASTA	24.73134	11.57271	9.63903	18.47355	4.90030
	(0.11235)	(0.05545)	(0.07914)	(0.19398)	(0.13939)
LBCS	15.37797	4.85057	1.94195	8.70246	21.79767
	(0.34036)	(0.24513)	0.81088	(0.84000)	10.88043
LBNCS	3.67392	1.03503	0.56335	0.81211	8.81313
	(1.01000)	(0.13212)	(0.31180)	(0.86000)	(0.02637)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.03308)	(1.61656)	(1.54875)	(1.45989)	(1.76098)
RUFAG	-0.29229	-0.10700	-0.07629	-0.13287	-0.49066
	(1.03308)	(1.61656)	(1.54875)	(1.45989)	(1.76098)

TABLE A-13. (CONTINUED)

AREA NO.	111(UT)	112(ID)	113(OR)	114(WA)	115(WA)
CHL1	3.70091	1.31971	9.73981	8.55531	8.09831
	(1.09421)	(0.90893)	(1.93472)	(1.40835)	(1.40297)
CHL2	1.61551	2.14381	12.48291	7.68821	6.27131
	(0.15965)	(0.30944)	(1.07137)	(0.31767)	(0.48235)
CHL3	0.54901	0.47511	4.57410	0.25655	1.97581
	(0.02097)	0.21080	0.80890	4.01956	3.33500
CL1	0.40340	1.19551	7.51332	6.42170	2.52464
	1.97651	(2.10381)	2.22649	1.62610	1.08827
CL2	0.0	1.54031	10.95431	6.92781	2.53241
	0.91881	(1.81273)	(0.05561)	(0.42792)	(0.17502)
CL3	0.0	0.47511	4.08771	0.25655	1.97581
	0.27401	(0.83808)	(0.13286)	2.91166	(0.05675)
CTNL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
WHL	0.22001	0.02201	0.15301	0.08901	3.00201
	(0.67947)	(0.96622)	(0.75952)	(0.79006)	(0.52649)
PASTA	5.98415	0.89059	25.31415	14.26635	35.16468
	(0.16315)	0.62267	(0.00119)	11.57979	33.61804
LBCS	19.73927	3.14931	19.08161	20.78013	46.60661
	10.32148	1.43250	(0.19785)	(0.10117)	21.41750
LBNCS	7.60860	1.57118	5.57364	6.09933	14.49713
	(0.09010)	(0.06972)	(0.36952)	(1.35000)	(0.62850)
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.56654)	(1.84678)	(1.56881)	(1.38392)	(1.66654)
RUFAG	-0.54791	-0.06451	-0.47808	-0.21935	-1.04949
	(1.56654)	(1.84678)	(1.56881)	(1.38392)	(1.66654)

TABLE A-13. (CONTINUED)

AREA NO.	116(CA)	117(CA)	118(GA)	119(AL)	120(LA)
CHL1	1.78901	10.52088	6.08821	2.46359	10.44411
	(1.45786)	2.12473	(0.73818)	0.13671	(0.16499)
CHL2	2.08004	0.0	0.0	0.0	0.0
	0.26967	5.95821	4.87831	1.18041	6.41761
CHL3	0.0	0.0	0.0	0.0	0.0
	1.02731	3.76231	3.30501	0.64551	0.53501
CL1	1.28781	9.84041	0.57838	1.99651	3.66931
	(0.30923)	(0.35565)	5.24133	(0.11357)	5.32360
CL2	1.65681	0.0	0.0	0.0	0.0
	(0.87742)	4.51841	3.69881	0.80401	5.20231
CL3	0.0	0.0	0.0	0.0	0.0
	0.68171	2.70751	1.85861	0.37021	0.28181
CTNL	0.0	5.34234	0.0	0.0	0.0
	0.00001	6.24067	5.44501	2.24801	9.14701
WHL	0.08701	0.05301	0.0	0.0	0.0
	(0.57284)	(0.21928)	0.00001	0.00001	0.00001
PASTA	8.80262	30.22436	58.37109	42.09353	58.13730
	(0.10280)	(0.09879)	(0.01940)	(0.19660)	(0.14790)
LBCS	8.27835	27.80509	28.69167	6.68691	21.95271
	(1.33585)	(1.38000)	4.69270	7.01035	30.01024
LBNCS	0.61653	0.0	6.01086	1.84325	2.35130
	0.31347	0.00001	(0.04881)	0.28152	4.26053
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.56858)	(1.50077)	(1.68448)	(1.61641)	(1.43844)
RUFAG	-0.15297	-0.42630	-0.38923	-0.20398	-0.72185
	(1.56858)	(1.50077)	(1.68448)	(1.61641)	(1.43844)

TABLE A-13. (CONTINUED)

AREA NO.	121(AR)	122(AR)	123(AR)	124(LA)	125(TX)
CHL1	23.85681	7.21251	1.79863	0.02350	5.89291
	(0.65575)	(0.73181)	2.28518	0.15821	(0.04043)
CHL2	18.74821	3.17911	0.0	0.0	0.0
	(0.18991)	(0.13322)	2.78751	0.24431	7.36781
CHL3	0.0	7.01911	0.0	0.0	0.0
	1.30221	(0.08492)	0.42881	0.01061	3.06601
CL1	22.66671	6.50141	0.03597	0.00019	0.43608
	(0.53478)	(0.24069)	3.46524	0.14872	5.01503
CL2	17.44341	2.20891	0.0	0.0	0.0
	(0.47663)	(0.47514)	1.91181	0.16131	5.47711
CL3	0.0	2.61714	0.0	0.0	0.0
	1.14481	0.16647	0.28961	0.00521	1.89641
CTNL	0.0	1.28741	0.0	0.0	0.0
	22.69800	1.11360	2.42401	0.15701	5.53701
WHL	0.10601	1.62001	0.30201	0.0	0.47201
	(1.11383)	(0.99859)	(0.94736)	0.00001	(0.19885)
PASTA	14.98364	84.57001	16.77365	3.28958	90.77777
	(0.09431)	(0.09398)	(0.07807)	(0.04101)	(0.03393)
LBCS	34.69323	56.73656	11.09634	0.35664	37.96696
	9.54283	(0.05831)	0.45076	0.71123	(0.23621)
LBNCS	1.12814	8.63647	1.65941	0.05666	2.15156
	7.27136	(0.31049)	(0.49469)	0.04147	0.61326
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.57933)	(1.73021)	(1.64800)	(1.96062)	(1.51943)
RUFAG	-0.55924	-0.86263	-0.14830	-0.01424	-0.29111
	(1.57933)	(1.73021)	(1.64800)	(1.96062)	(1.51943)

TABLE A-13. (CONTINUED)

AREA NO.	126(TX)	127(OK)	128(OK)	129(TX)	130(TX)
CHL1	0.18371	1.05471	1.95031	1.73731	3.54232
	(1.81233)	(0.72981)	(0.49063)	(0.44076)	6.72879
CHL2	0.06831	0.90541	0.31081	1.30841	0.0
	(0.70182)	(0.18642)	0.18160	(0.00366)	1.56631
CHL3	0.0	0.0	0.0	0.0	0.0
	0.01511	0.27621	0.23241	0.42091	0.28891
CL1	0.05915	0.85501	1.61141	1.62651	3.54232
	0.11555	(0.10766)	(0.54378)	(0.14256)	6.67719
CL2	0.02200	0.55801	0.31081	0.91871	0.0
	0.02861	(0.15456)	(0.43862)	(0.18246)	1.37831
CL3	0.0	0.0	0.0	0.0	0.0
	0.00951	0.13831	0.11831	0.21411	0.25621
CTNL	0.0	0.0	0.0	0.0	0.0
	0.17301	0.74501	0.82401	0.70701	7.00101
WHL	0.0	0.21301	0.84601	0.01501	0.0
	0.00001	(1.10551)	(1.24720)	(0.62907)	0.00001
PASTA	12.29139	15.42280	19.57400	14.26035	8.17895
	(0.10755)	(0.18158)	(0.17575)	(0.19595)	(0.14827)
LBCS	0.97846	7.27572	9.11696	8.37315	8.38602
	(0.90000)	(0.09944)	(0.10265)	(0.13803)	(0.78286)
LBNCS	0.0	0.75668	1.22620	0.58454	0.0
	0.00001	0.06340	0.09134	0.05861	0.00001
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(2.36277)	(1.80754)	(1.80764)	(1.89000)	(1.46536)
RUFAG	-0.33458	-0.01822	-0.08396	-0.09127	-0.03876
	(2.36277)	(1.80754)	(1.80764)	(1.89000)	(1.44505)

TABLE A-13. (CONTINUED)

AREA NO.	131(TN)	132(TN)	133(AL)	134(AL)	135(TN)
CHL1	1.91721	3.34821	3.71151	2.41141	0.97041
	(0.05224)	(0.53174)	(0.41739)	(0.49618)	(0.92483)
CHL2	0.0	0.0	2.01551	2.23851	0.90111
	1.47571	1.91601	(0.00984)	(0.02195)	(0.16712)
CHL3	0.0	0.66046	0.0	0.0	0.0
	1.10611	0.78235	0.40671	0.67431	0.74011
CL1	0.63802	1.30920	0.32013	1.99506	0.03203
	1.11879	1.76781	3.11938	0.41635	0.47718
CL2	0.0	0.0	0.0	0.0	0.02884
	1.27291	1.70601	1.56611	1.87391	0.33287
CL3	0.0	0.02576	0.0	0.0	0.0
	0.66581	0.85215	0.27291	0.42261	0.25461
CTNL	0.53430	1.22645	0.06094	1.96801	0.00101
	0.44371	0.64456	3.19507	(0.16803)	(1.36936)
WHL	0.0	0.0	0.0	0.0	0.0
	0.00001	0.00001	0.00001	0.00001	0.00001
PASTA	8.63655	15.01766	12.74035	11.57692	4.77299
	0.37457	(0.02742)	(0.16614)	(0.16614)	2.65802
LBCS	8.92132	17.25847	9.86131	17.98436	7.25953
	(0.25646)	(0.17972)	(0.06685)	(0.02815)	1.57668
LBNCS	0.89590	1.38038	1.29503	1.16898	2.54779
	1.96982	3.18122	0.49995	2.09180	0.22845
HAYAR	0.00001	0.00001	0.00001	0.00001	0.00001
	(1.50582)	(1.77246)	(1.64941)	(1.67370)	(2.10475)
RUFAG	-0.14486	-0.25978	-0.14294	-0.12577	-0.11990
	(1.50582)	(1.77246)	(1.64941)	(1.67370)	(2.10475)

TABLE A-13. (CONTINUED)

AREA NO.	136(TN)	137(TN)	138(NC)
CHL1	3.28031	4.13931	0.64831
	(0.70050)	(0.49466)	(0.85047)
CHL2	0.0	0.0	0.0
	3.62171	1.29041	0.93031
CHL3	0.0	0.0	0.0
	3.09631	0.93271	1.23751
CL1	0.32731	0.63962	0.0
	1.34490	1.99659	0.45361
CL2	0.0	0.0	0.0
	1.43121	0.66091	0.55431
CL3	0.0	0.0	0.0
	1.03391	0.38481	0.45591
CTNL	0.07401	0.43201	0.0
	(0.65385)	(0.75766)	0.00001
WHL	0.0	0.0	0.0
	0.00001	0.00001	0.00001
PASTA	9.12432	23.53125	3.18258
	21.20300	(0.03183)	4.21605
LBCS	14.74742	17.15023	2.80708
	14.95860	(0.13956)	13.09040
LBNCS	4.88205	4.24045	0.88021
	4.42669	0.93763	3.81469
HAYAR	0.00001	0.00001	0.00001
	(2.02488)	(1.80765)	(2.00022)
RUFAG	-0.54339	-0.24656	-0.12347
	(2.02488)	(1.80765)	(2.00022)

Table A-14. Consuming region transfer activities, Solution II

Code	Descriptions	Unit ($x10^5$)
FMMGMK	From Fluid Milk to Manufactured Milk	1000 lbs.
CFSLAU	Calf Slaughter (to other Beef)	Head
YLSLAU	Yearling Slaughter (to other Beef)	Head
WHETP1	Wheat to TDN-Protein Type 1	1000 lbs TDN
WHETP2	Wheat to TDN-Protein Type 2	1000 lbs TDN
WHETP3	Wheat to TDN-Protein Type 3	1000 lbs TDN
FGTP1	Feed Grain to TDN-Protein Type 1	1000 lbs TDN
FGTP2	Feed Grain to TDN-Protein Type 2	1000 lbs TDN
FGTP3	Feed Grain to TDN-Protein Type 3	1000 lbs TDN
SBTP1	Soybean to TDN-Protein Type 1	CWT TDN
SBTP2	Soybean to TDN-Protein Type 2	CWT TDN
SBTP3	Soybean to TDN-Protein Type 3	CWT TDN
CSTP1	Cotton Seed to TDN-Protein Type 1	CWT TDN
CSTP2	Cotton Seed to TDN-Protein Type 2	CWT TDN
CSTP3	Cotton Seed to TDN-Protein Type 3	CWT TDN
XF1TP1	Exogenous Feed Type 1 to TDN-Protein Type 1	1000 lbs TDN
XF1TP2	Exogenous Feed Type 1 to TDN-Protein Type 2	1000 lbs TDN
XF1TP3	Exogenous Feed Type 1 to TDN-Protein Type 3	1000 lbs TDN
XF2TP1	Exogenous Feed Type 2 to TDN-Protein Type 1	1000 lbs TDN
XF2TP2	Exogenous Feed Type 2 to TDN-Protein Type 2	1000 lbs TDN
XF2TP3	Exogenous Feed Type 2 to TDN-Protein Type 3	1000 lbs TDN
XF3TP1	Exogenous Feed Type 3 to TDN-Protein Type 1	1000 lbs TDN
XF3TP2	Exogenous Feed Type 3 to TDN-Protein Type 2	1000 lbs TDN
XF3TP3	Exogenous Feed Type 3 to TDN-Protein Type 3	1000 lbs TDN
XF4TP1	Exogenous Feed Type 4 to TDN-Protein Type 1	1000 lbs TDN
XF4TP2	Exogenous Feed Type 4 to TDN-Protein Type 2	1000 lbs TDN
XF4TP3	Exogenous Feed Type 4 to TDN-Protein Type 3	1000 lbs TDN
BFGBFO	Grain-Fed Beef to Other Beef	CWT

TABLE A-14. (CONTINUED)

REGION NO.	1	2	3	4	5
FMMGMK		200.29003			
CFSLAU					
YLSLAU	0.19894	5.02606	0.00001	0.00003	4.09631
WHETP1	119.15138			0.99060	
WHETP2					
WHETP3					
FGTP1	18.87302	116.44246		27.85793	12.66776
FGTP2	0.03696	0.92397			0.31859
FGTP3	7.85628	145.07163	7.09921	9.24164	0.02261
SBTP1		190.28561			
SBTP2					
SBTP3					
CSTP1	0.00001	8.15301			0.00001
CSTP2					
CSTP3		108.83599			
XF1TP1					
XF1TP2					
XF1TP3					
XF2TP1	17.35280		5.45668	4.99468	2.41667
XF2TP2					
XF2TP3	0.34230		0.44116	0.57430	0.00150
XF3TP1					
XF3TP2					
XF3TP3					
XF4TP1					
XF4TP2					
XF4TP3					
BFGBFC					

TABLE A-14. (CONTINUED)

REGION NO.	6	7	8	9	10
FMMGMK			4.83052	324.31032	64.50361
CFSLAU					
YLSLAU	3.11783	1.42919	8.66168	0.00001	6.85400
WHETP1					
WHETP2					
WHETP3					
FGTP1	9.41551	16.18467	11.38820	70.26746	93.36237
FGTP2	0.40625	0.18622	1.51407		1.46771
FGTP3	31.06114	19.26544	13.25608	44.59701	328.73790
SBTP1	0.00001	0.24969			179.81537
SBTP2					
SBTP3		18.39215			258.92614
CSTP1	26.23652	28.52515			15.31992
CSTP2					
CSTP3	30.79642			0.00001	
XF1TP1				4.36940	
XF1TP2					
XF1TP3				3.28985	
XF2TP1		0.83367			
XF2TP2					
XF2TP3					
XF3TP1					
XF3TP2					
XF3TP3					
XF4TP1			23.36179	59.39282	
XF4TP2			0.66446		
XF4TP3			4.51894		
BFG8FO					

TABLE A-14. (CONTINUED)

REGION NO.	11	12	13	14	15
FMMGMK	36.44169	31.85260	12.99965	13.00682	
CFSLAU					
YLSLAU	16.08479	2.63471	4.02686	4.59432	13.31202
WHETP1			34.56134		
WHETP2					
WHETP3			27.17482	1.85864	
FGTP1	48.90302	12.89337		14.65662	31.59971
FGTP2	2.23909	0.30338	0.68740	0.49645	1.15639
FGTP3	169.55993	64.08675	22.12868	18.29301	
SBTP1					
SBTP2					
SBTP3	78.82226		0.00001	0.00001	0.00001
CSTP1			5.34998	34.39504	
CSTP2					
CSTP3	0.00001		19.26395	12.30262	
XF1TP1					
XF1TP2					
XF1TP3					
XF2TP1	4.09492				
XF2TP2					
XF2TP3	1.22292				
XF3TP1	1.68236		12.83720		14.70965
XF3TP2					
XF3TP3					
XF4TP1		62.63691			
XF4TP2					
XF4TP3	2.05041	7.24443			
BFGBFO					

Table A-15. Producing area activities (crops, livestock, transfer). Solution II

Code	Descriptions	Unit ($x10^5$)
COTN1	Cotton, Land Class 1	Acre
COTN2	Cotton, Land Class 2	Acre
COTN3	Cotton, Land Class 3	Acre
WHEA1	Wheat, Land Class 1	Acre
WHEA2	Wheat, Land Class 2	Acre
WHEA3	Wheat, Land Class 3	Acre
FDGR1	Feed Grain, Land Class 1	Acre
FDGR2	Feed Grain, Land Class 2	Acre
FDGR3	Feed Grain, Land Class 3	Acre
HAYY1	Hay, Land Class 1	Acre
HAYY2	Hay, Land Class 2	Acre
HAYY3	Hay, Land Class 3	Acre
WHAY	Wild Hay	Acre
FGSB1	Feed Grain-Soybean Rotation, Land Class 1	Acre
FGSB2	Feed Grain-Soybean Rotation, Land Class 2	Acre
FGSB3	Feed Grain-Soybean Rotation, Land Class 3	Acre
FGSG1	Feed Grain-Silage Rotation, Land Class 1	Acre
FGSG2	Feed Grain-Silage Rotation, Land Class 2	Acre
FGSG3	Feed Grain-Silage Rotation, Land Class 3	Acre
HASG1	Hay-Silage Rotation, Land Class 1	Acre
HASG2	Hay-Silage Rotation, Land Class 2	Acre
HASG3	Hay-Silage Rotation, Land Class 3	Acre
FGSS1	Feed Grain-Soybean-Silage Rotation, Land Class 1	Acre
FGSS2	Feed Grain-Soybean-Silage Rotation, Land Class 2	Acre
FGSS3	Feed Grain-Soybean-Silage Rotation, Land Class 3	Acre
BROLR	Broiler	CWT
DYCOW	Dairy Cow	Head
BFCOW	Beef Cow	Head
YLCAF	Calf-Yearling	Head
HOGGG	Hog	CWT
DEFRD	Feeder Calf, Deferred Feeding	Head
EXTSG	Feeder Calf, Extended Silage	Head
CFOSG	Feeder Calf, On Silage	Head
CFNSG	Feeder Calf, No Silage	Head
SFYRL	Feeder Yearling, Short-Fed	Head
YLOSG	Feeder Yearling, On Silage	Head
YLNSG	Feeder Yearling, No Silage	Head
CHPS1	Crop Hay Land Class 1 Converted Pasture	Acre
CHPS2	Crop Hay Land Class 2 Converted Pasture	Acre
CHPS3	Crop Hay Land Class 3 Converted Pasture	Acre
PASRA	Pasture, Region to Area	10 AUMs
HARUF	Hay to Roughage	Ton
HAYAG	Hay, Area to Region	Ton
HAYRA	Hay, Region to Area	Ton
LBCSH	Labor Hired, Crop Season	10 hrs.
LBNH	Labor Hired, Non-Crop Season	10 hrs.

TABLE A-15. (CONTINUED)

AREA NO.	001(NY)	002(PA)	003(WV)	004(MD)	005(NE)
CCTN1					
COTN2					
COTN3					
WHEA1	2.21831				
WHEA2					
WHEA3					
FDGR1		14.39304			
FDGR2					
FDGR3					
HAYY1	4.92239	4.50976			
HAYY2					
HAYY3					
WHAY					
FGSB1				5.69689	
FGSB2					
FGSB3					
FGSG1					0.26509
FGSG2					
FGSG3					
HASG1			0.31711		9.64882
HASG2			0.19491		
HASG3					
FGSS1				1.32761	
FGSS2					
FGSS3					
BROLR				164.98981	
DYCOW	2.02254	1.70358	0.29194		3.74915
BFCCW					
YLCAF					
HOGGG					
DEFRD					
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA	0.18141		0.07275		
HARUF	11.07540	10.01169	0.80295	0.00001	15.72758
HAYAG					
HAYRA			0.30340		
LBCSH					
LBNH			0.32839		

TABLE A-15. (CONTINUED)

AREA NC.	006(VA)	007(NC)	008(NC)	009(NC)	010(VA)
CCTN1					0.13601
COTN2					
COTN3					
WHEA1					
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			0.22604		
HAYY2					
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	1.23442	0.39764		0.04115	10.56340
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCOW	0.59111				2.82617
BFCOW					
YLCAF					
HOGGG					
DEFRD					5.42864
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA	0.16531				
HARUF	1.93805	0.47321	0.37072	0.05968	15.95074
HAYAG					
HAYRA					0.10573
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	011(SC)	012(GA)	013(GA)	014(SC)	015(SC)
CCTN1					
CCTN2					
COTN3					
WHEA1					
WHEA2					
WHEA3					
FDGR1					
FCGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	0.15253	0.03682	0.11616	0.07C95	1.85021
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR			30.73301	33.63861	
DYCOW					1.29965
BFCOW					
YLCAF					
HOGGG					
CEFRD					
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARLF	0.21661	0.05193	0.15798		3.23787
HAYAG				0.10572	
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	016(FL)	017(FL)	018(AL)	019(AL)	020(AL)
COTN1			0.14179	1.88352	2.56624
COTN2					
COTN3					
WHEA1				2.52669	
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1	0.11871		0.04410		
HAYY2	0.11842				
HAYY3					
WHAY					
FGSB1			0.88382		
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1					0.78177
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR		18.56871			
DYCOW		1.38413			
BFCOW	6.82480		0.31480	1.29697	2.35543
YLCAF	4.13768				
HOGGG					
DEFRD		0.01737		0.09526	0.71221
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					0.77190
CHPS2					
CHPS3					
PASRA	0.69501				
HARUF	0.70792		0.07365	0.00001	1.32330
HAYAG		0.00001			0.03699
HAYRA	0.00002				
LBCSH	0.14958				
LBNH	1.32566				

TABLE A-15. (CONTINUED)

AREA NO.	021(MS)	022(KY)	023(TN)	024(MS)	025(AR)
COTN1	9.17055	0.00401	4.61464	2.00251	5.51201
COTN2					
COTN3					
WHEA1			4.13075		2.30496
WHEA2					6.36051
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1		9.98370		0.05020	0.00814
HAYY2				0.53720	0.07130
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	0.31556		0.29345		
HASG2	0.72254				
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR	24.77091	15.09961			
DYCOW					
BFCOW	5.45659			4.23180	
YLCAF		3.14931			
HOGGG					
DEFRD		13.72550			
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA				4.07983	
HARUF	1.81925	17.67116	0.50181	1.08277	0.05820
HAYAG					0.14399
HAYRA		3.21515			
LBCSH					0.05809
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	026(MO)	027(KY)	028(ID)	029(KY)	030(OH)
CCTN1	3.36931				
COTN2					
CCTN3					
WHEA1		1.13294	2.09022		
WHEA2			2.70311		
WHEA3			1.75171		
FDGR1					
FDGR2					
FDGR3					
HAYY1	0.09650				
HAYY2			5.89150	0.72800	
HAYY3					
WHAY	0.01401		2.33501		
FGSB1					
FGSB2	10.06201				
FGSB3					
FGSG1			1.16735		
FGSG2					
FGSG3					
HASG1		7.62167	3.05584	3.13321	6.53271
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR	21.59795		25.38511		
DYCOW		1.69357	0.46220		4.60401
BFCCW			5.01307		
YLCAF					
HOGGG					
DEFRD		4.87066		5.98324	
EXTSG			12.74775		
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA				0.48711	0.09724
HARUF	0.07514	11.99584	27.83540	7.28912	13.91468
HAYAG	0.20203	2.33291			
HAYRA					5.98132
LBCSH					
LBNH					4.99294

TABLE A-15. (CONTINUED)

AREA NO.	031(NY)	032(OH)	033(OH)	034(IN)	035(IN)
COTN1					
COTN2					
COTN3					
WHEA1		2.78847			
WHEA2		5.98397			
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1	22.72601				
HAYY2	22.41395				
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					2.19821
FGSG2					
FGSG3					
HASG1		3.25044		19.93171	0.45110
HASG2		1.24450			
HASG3					
FGSS1			51.36961		
FGSS2					
FGSS3					
BROLR				30.73221	
DYCOW	14.37966	2.67282	8.09825	2.58683	0.05099
BFCOW					
YLCAF	0.20094				
HOGGG					
DEFRD	5.90252			3.88311	
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1			5.58479		
CHPS2					
CHPS3					
PASRA	0.30485	0.55422			
HARUF	87.62010	9.53075	0.00001	10.60875	
HAYAG	0.68939			40.81506	0.91123
HAYRA		0.67822	32.86553		
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	036(IL)	C37(CA)	038(IN)	039(NV)	040(MI)
COTN1					
COTN2					
COTN3					
WHEA1	14.21478				6.96219
WHEA2	12.02828		7.02884		
WHEA3					
FDGR1			25.65330		
FDGR2					
FDGR3					
HAYY1			1.99661		29.15442
HAYY2					
HAYY3					
WHAY	0.04701	0.73801		1.90928	
FGSB1			39.15210		
FGSB2			3.12657		
FGSB3					
FGSG1		6.42656		0.98696	
FGSG2		4.34843			
FGSG3					
HASG1	4.59153	3.85985		1.47365	
HASG2	2.37543	0.13400			
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR			34.53720		
DYCOW	2.90892	3.15833		0.68824	11.49832
BFCOW					
YLCAF		6.22343	5.07682	3.27296	
HOGGG		0.00002	398.64480		
DEFRD	3.66160				
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					8.31899
CHPS3					
PASRA					0.60295
HARUF	14.33402	16.53700	4.71201	6.71479	66.18054
HAYAG	0.93596				
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	041(MI)	042(WI)	043(WI)	044(CO)	045(IL)
CCTN1				0.02401	
COTN2					
CCTN3					
WHEA1			21.89720		
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			10.16581		
HAYY2	4.66465		11.00492		4.45670
HAYY3					
WHAY			0.13301		
FGSB1					141.18767
FGSB2					14.51951
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	3.41291	10.56360		0.76650	8.42013
HASG2				0.14295	
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR		20.84931			
DYCOW	2.80362	4.16988	10.30045		3.28569
BFCOW		7.37504	10.08231	6.82627	6.02947
YLCAF					
HCGGG					311.48785
DEFRD	0.19619				5.97561
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1		1.43731			
CHPS2		4.97311	1.05879	0.93706	
CHPS3		6.48051	10.68591	1.55431	
PASRA		0.40051		3.93229	
HARUF	15.00148	19.85957	67.59553	3.01078	33.94535
HAYAG					
HAYRA					
LBCSH					
LBNH				0.19256	

TABLE A-15. (CONTINUED)

AREA NO.	046(MO)	047(IL)	048(CA)	049(AZ)	050(MO)
CCTN1	1.25035			5.82862	
COTN2					
CCTN3					
WHEA1		5.67013	0.47621		
WHEA2		9.44181	0.49771		
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			0.01772		
HAYY2					
HAYY3					
WHAY	0.17240				1.25201
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1		2.89728		0.31389	7.87481
HASG2		0.76670			
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR	26.76441				0.06845
DYCCW		1.27677			2.80388
BFCCW				3.39136	
YLCAF			0.58920		
HCGGG					
DEFRD		1.73495			8.01444
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1				1.26270	
CHPS2				1.97581	
CHPS3					
PASRA			0.42223		
HARUF	0.26378	7.19254	0.10600		17.33207
HAYAG					
HAYRA					
LBCSH				28.72191	
LBNH					

TABLE A-15. (CONTINUED)

AREA NC.	051(MO)	052(IA)	053(IA)	054(MN)	055(NM)
CCTN1					
CCTN2					
CCTN3					
WHEA1					2.35275
WHEA2	5.20534				
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			5.01780		0.32255
HAYY2			3.57987	0.91594	
HAYY3					
WHAY	0.17801				
FGSB1			104.93821	30.87554	
FGSB2			25.52331		
FGSB3					
FGSG1				25.26217	
FGSG2					
FGSG3					
HASG1	2.58064			5.21969	
HASG2	16.95096	5.32223			
HASG3					
FGSS1	35.39427	22.75211			
FGSS2	14.20401	21.72827		9.98791	
FGSS3					
BRCLR					
DYCCW	7.54934	0.20201		4.56889	
BFCOW		10.11996	15.26587		4.08658
YLCAF	6.92322				
HCGGG			507.06523	10.41455	
DEFRD	1.C1610			1.54413	
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					2.11172
CHPS2			5.20283		1.06341
CHPS3			7.66411		0.86491
PASRA		1.57191			
HARUF	37.30240	12.40081	24.99899	12.34554	1.90625
HAYAG					
HAYRA					
LBCSH					1.65283
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	056(MN)	057(MN)	058(MN)	059(MN)	060(MN)
COTN1					
COTN2					
COTN3					
WHEA1					13.96236
WHEA2	4.58951	7.70191			8.87165
WHEA3	0.95081				
FDGR1	17.79701				
FDGR2					
FDGR3					
HAYY1	1.62810	20.74567	0.66590	8.28722	
HAYY2	0.97940				
HAYY3					
WHAY	0.19101	0.59001			
FGSB1		6.12454			
FGSB2					
FGSB3					
FGSG1			1.92861		
FGSG2			1.32091		
FGSG3					
HASG1					2.48405
HASG2					1.29406
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW	1.03297	11.65595	3.38771	1.99399	1.45220
BFCOW					
YLCAF					
HOGGG	66.66905				
DEFRD	1.78822	0.18120		8.23308	0.75284
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1			0.94579	1.19779	
CHPS2		3.68510		6.06621	
CHPS3					
PASRA					
HARUF	8.11168	64.31367	1.42503	21.79990	
HAYAG				0.32699	
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	061(ND)	062(ND)	063(ND)	064(SD)	065(ND)
COTN1					
CCTN2					
CCTN3					
WHEA1	19.59531	52.27321	11.82680		
WHEA2	2.60691	12.32961			
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1	0.79197	2.72110	9.49071		0.38417
HAYY2					
HAYY3					
WHAY	0.50801	6.17201		0.09001	1.33701
FGSB1					1.58951
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1					
HASG2					
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCOW					
BFCOW				0.02276	
YLCAF					
HCGGG				1.80540	
DEFRD	1.48774	8.40839	11.69101		1.28550
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1	0.47733				
CHPS2	0.65390	3.21590			
CHPS3		3.65051			
PASRA		0.45923	0.96018		
HARUF	2.03756	11.42041	15.84950	0.06752	1.77205
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	066(SD)	067(SD)	068(SD)	069(SD)	070(SD)
COTN1					
COTN2					
COTN3					
WHEA1				5.06821	
WHEA2	2.05665				
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1				0.59960	0.27274
HAYY2					
HAYY3					
WHAY	6.32901	8.35901	0.35154	2.86601	1.80801
FGSB1					26.72301
FGSB2					4.25781
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	2.60231	2.92803			
HASG2	7.41436				
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCCW					
BFCOW	7.62694	5.29571	0.09272	0.74378	1.06879
YLCAF					
HCGGG		59.11209	70.60376	28.96200	158.59809
DEFRC					
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1		21.19558			
CHPS2					
CHPS3					
PASRA					
HARUF	15.32784	9.10946	0.37616	1.78920	2.66935
HAYAG				1.39295	
HAYRA					
LBCSH					
LBNH	0.92081				

TABLE A-15. (CONTINUED)

AREA NO.	071(NB)	072(NB)	073(NB)	074(CC)	075(NB)
COTN1					
COTN2					
COTN3					
WHEA1		0.48433	4.34744		5.91721
WHEA2		0.89614	6.74441		4.20461
WHEA3		0.99897	3.64441		
FDGR1				1.97711	
FDGR2				1.53251	
FDGR3				4.62021	
HAYY1					5.02720
HAYY2	9.09984		0.48590	0.25770	
HAYY3				2.49810	
WHAY	2.44401	1.43901	2.09701	0.23201	6.83901
FGSB1	43.44781				
FGSB2	20.48647				
FGSB3					
FGSG1				1.38270	
FGSG2					
FGSG3					
HASG1		0.64667	1.44967		
HASG2		0.34087			
HASG3		0.82043			
FGSS1					
FGSS2					
FGSS3					
BROLR			13.65671	3.99246	
DYCOW	7.28205		0.27372	0.57442	0.35562
BFCOW	1.13573	0.49561	3.06952	1.26969	
YLCAF		3.92136			
HOGGG			1.10653		
DEFRD					14.57874
EXTSG				2.33375	
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					1.79510
CHPS3					5.86351
PASRA					
HARUF		4.09553	6.56656	8.02527	20.57909
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	076(NB)	077(NB)	078(KS)	079(KS)	080(KS)
COTN1					
COTN2					
COTN3					
WHEA1	9.13894			0.40480	0.60991
WHEA2	3.70661				
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1			3.54352	3.17481	
HAYY2					
HAYY3					
WHAY	0.37701	10.59001			
FGSB1			2.48799		
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	2.91727	0.89671			2.19688
HASG2		0.59245			
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCOW	0.48054		0.25562	0.14487	
BFCCW		3.15286	5.27012	4.94641	2.59997
YLCAF		3.58987			3.82594
HOGGG					
DEFRD	7.33029				
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					3.01521
CHPS2	0.45920		7.44901	7.06351	7.97931
CHPS3	3.97301		3.56691	2.16231	1.36331
PASRA					
HARUF	7.84145	10.36975	11.87079	10.73087	3.82258
HAYAG					
HAYRA					
LBCSH					
LBNH		1.24277			

TABLE A-15. (CONTINUED)

AREA NO.	081(KS)	082(KS)	083(TX)	084(KS)	C85(OK)
CCTN1					
CCTN2					
COTN3					
WHEA1	1.40060			32.02833	1.83341
WHEA2					0.68326
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1	4.82221	7.78798			
HAYY2					
HAYY3					
WHAY				0.84701	0.87301
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1				12.53188	1.10690
HASG2					0.78525
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW					0.38779
BFCOW	7.87158	12.53756	13.59646	23.24591	3.26932
YLCAF			1.17615		
HOGGG					20.35790
DEFRD					
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1		7.27483			
CHPS2	5.92671	12.76551			
CHPS3	2.88251	8.21071		18.64611	
PASRA					
HARUF		25.38881	0.00001	18.39256	4.17883
HAYAG				5.37104	
HAYRA			6.39878		
LBCSH			17.01176		
LBNH	1.22374	1.59934		3.39861	

TABLE A-15. (CONTINUED)

AREA NO.	086(KS)	087(OK)	088(OK)	089(OK)	090(OK)
COTN1				0.19527	
COTN2					
COTN3					
WHEA1	3.29092	3.46451	24.08391	0.10790	2.70531
WHEA2	17.47041	0.55201	13.53596	11.25581	0.87723
WHEA3			6.78291	4.20201	
FDGR1					
FDGR2					
FDGR3					
HAYY1	2.43839	0.61060			
HAYY2					
HAYY3					
WHAY	0.16001	1.43001	0.44801	0.28601	0.53801
FGSB1	2.69540				
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1				3.41414	0.71180
HASG2			2.08945		0.09179
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCOW		0.34108	0.43017		0.28072
BFCOW	4.35491	1.99825	3.57203	2.42982	1.51368
YLCAF	4.91009				
HOGGG			67.70790		20.74006
DEFRD		0.24300		5.04703	
EXTSG				1.94929	
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2		0.29150			
CHPS3	6.07811		3.02450	0.81030	
PASRA					
HARUF	11.12607	3.50714	4.24042	2.99771	2.39482
HAYAG				3.24107	
HAYRA					
LBCSH					
LBNH	0.28151				

TABLE A-15. (CONTINUED)

AREA NO.	091(TX)	092(TX)	093(TX)	094(TX)	095(TX)
CCTN1		7.56401	16.16095	7.89561	
COTN2				8.07440	
COTN3					
WHEA1	0.61191				3.20727
WHEA2	2.47734		13.67531		0.86311
WHEA3					
FDGR1		6.47408			
FDGR2		22.93981			
FDGR3					
HAYY1		0.36462			
HAYY2		0.19040			
HAYY3					
WHAY	0.43801	0.10201			
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	2.97690		1.45526		0.70054
HASG2	1.31847			1.46730	
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW	1.16924				
BFCOW	6.62657	6.23403	7.07498	13.14936	2.73642
YLCAF					
HCGGG					
DEFRD					
EXTSG					
CFCSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2				8.44461	
CHPS3		2.10711		8.52931	
PASRA					1.93792
HARUF	5.38222	2.88561		2.78788	0.70055
HAYAG					
HAYRA					
LBCSH		23.20168	11.35080	23.32374	
LBNH					

TABLE A-15. (CONTINUED)

AREA NC.	096(TX)	097(TX)	098(TX)	099(TX)	100(TX)
COTN1				2.20701	
COTN2					
COTN3					
WHEA1		20.58769	1.18523		
WHEA2		8.25977			
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY		0.37601			0.19201
FGSB1					
FGSB2					
FGSB3					
FGSG1				0.42553	13.17112
FGSG2					3.44603
FGSG3					0.43049
HASG1	1.58681	2.48582	1.55318	1.87837	0.55708
HASG2	0.73511	3.06352			1.14768
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR		54.02991			
DYCOW		2.49580		1.09490	0.60632
BFCOW	1.54535	3.11766	6.42892	0.92505	9.06761
YLCAF					
HOGGG					
DEFRD					
EXTSG	1.76697				
CFCSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					5.04899
HARUF	1.12141	7.35945	1.77064	2.68607	2.17647
HAYAG	1.73537				
HAYRA					
LBCSH			0.46289		
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	101(MT)	102(MT)	103(WY)	104(MT)	105(WY)
COTN1					
COTN2					
COTN3					
WHEA1		4.96244		1.01701	1.37961
WHEA2		12.28845	2.45277	1.82181	2.40151
WHEA3		3.38421	4.13731	1.21881	4.53691
FDGR1					
FDGR2					
FDGR3					
HAYY1				0.34840	1.61340
HAYY2				1.12310	3.29550
HAYY3					4.12773
WHAY		1.18501	1.38501	0.07101	4.74501
FGSB1					
FGSB2					
FGSB3					
FGSG1	7.00451				
FGSG2	21.22887				
FGSG3	8.59221				
HASG1		0.71787	2.37171		
HASG2	2.55624	3.26566	1.50617		
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW					
BFCOW	5.23446	3.55814	3.64574	1.13505	11.41752
YLCAF					
HOGGG		18.05952	18.05217	10.29753	
DEFRD					
EXTSG		1.13633		0.60209	
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3		1.08840		0.51260	
PASRA	3.11046	0.45969			5.53039
HARUF	1.49651	8.80870	6.46745	3.21481	22.82308
HAYAG	1.97999				
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	106(CO)	107(CO)	108(CO)	109(NM)	110(ID)
COTN1					
COTN2					
COTN3					
WHEA1					5.13116
WHEA2	8.91091				5.70288
WHEA3	1.78862				1.46191
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY		0.01701	0.04901		0.50301
FGSB1					
FGSB2					
FGSB3					
FGSG1		0.59916		0.52731	
FGSG2				3.71911	
FGSG3		1.20783		2.70721	
HASG1	5.05891	1.11085	0.14471		0.67505
HASG2					2.56253
HASG3			0.83125		
FGSS1					
FGSS2					
FGSS3					
BROLR			3.26403		
DYCOW					1.26089
BFCOW	1.78598	2.10800	0.87646	7.14627	
YLCAF	1.36776				
HCGGG					23.14130
DEFRD					
EXTSG	10.84058				
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2		0.50730			
CHPS3		2.30248		0.37450	
PASRA				5.95492	0.16936
HARUF		2.73173	1.43302	0.00001	9.55718
HAYAG	0.45999				
HAYRA					
LBCSH				4.90106	
LBNH	2.15631			0.00971	

TABLE A-15. (CONTINUED)

AREA NO.	111(UT)	112(ID)	113(OR)	114(WA)	115(WA)
COTN1					
COTN2					
COTN3					
WHEA1		1.19501	7.49310	6.24871	2.39343
WHEA2		1.54031	10.94043	6.92781	2.44439
WHEA3		0.47511	4.08771	0.25655	1.97581
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2	0.76837	0.60350		0.76040	
HAYY3			0.48640		
WHAY	0.22001	0.02201	0.15301	0.08901	3.00201
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	3.70091	0.12470	2.24671	2.30660	5.70488
HASG2			1.54248		3.82692
HASG3					
FGSS1					
FGSS2					
FGSS3					
BROLR	4.09142				
DYCOW	2.00075	0.15652	1.38252	2.12303	4.85992
BFCCW					
YLCAF			4.06753		
HOGGG		5.36532			
DEFRD					
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2	0.84714				
CHPS3	0.54901				
PASRA					
HARUF	14.35936	1.21121	12.13592	11.28369	27.82861
HAYAG					
HAYRA					
LBCSH					
LBNH				1.35675	

TABLE A-15. (CONTINUED)

AREA NO.	116(CA)	117(CA)	118(GA)	119(AL)	120(LA)
CCTN1		5.34234			
CCTN2					
COTN3					
WHEA1	1.27443	2.93336		1.97705	3.66931
WHEA2	1.64551				
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1		0.68047			6.77480
HAYY2					
HAYY3					
WHAY	0.08701	0.05301			
FGSB1					
FGSB2					
FGSB3					
FGSG1		1.56470			
FGSG2					
FGSG3					
HASG1	0.51458		6.08821	0.48655	
HASG2	0.43453				
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR					
DYCOW	0.59370		1.58628		
BFCOW			2.15904	4.12360	3.77800
YLCAF	1.96286	4.67098	0.00002		
HOGGG					
DEFRD			6.25944		8.66440
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLCSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA	0.86108			0.79871	2.24848
HARUF	4.44164	1.29513	12.11554	0.82227	12.60113
HAYAG		3.22899			
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	121(AR)	122(AR)	123(AR)	124(LA)	125(TX)
COTN1		1.28741			
COTN2					
COTN3					
WHEA1	2.52973	5.18127			
WHEA2		2.16426			
WHEA3		2.41454			
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY	0.10601	1.62001	0.30201		0.47201
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	1.37903	0.74383	1.79863	0.02350	5.89291
HASG2	1.51194	1.01485			
HASG3		4.60457			
FGSS1	19.94805				
FGSS2	17.23627				
FGSS3					
BRCLR					
DYCOW		3.12461	0.91006		2.35637
BFCOW	0.33850		0.91358	0.25182	5.65179
YLCAF		8.74916			
HOGGG					
DEFRD	4.13259				
EXTSG					1.56422
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARUF	4.07370	10.87548	3.02822	0.03596	9.71473
HAYAG					
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	126(TX)	127(OK)	128(OK)	129(TX)	130(TX)
COTN1					
COTN2					
COTN3					
WHEA1		0.85010	1.57583	1.61944	
WHEA2		0.54947	0.31081	0.89383	
WHEA3					
FDGR1					0.64296
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY		0.21301	0.84601	0.01501	
FGSB1					
FGSB2					
FGSB3					
FGSG1					2.89936
FGSG2					
FGSG3					
HASG1	0.18371	0.20461	0.37448	0.11787	
HASG2	0.06831	0.35594		0.41457	
HASG3					
FGSS1					
FGSS2					
FGSS3					
BRCLR				42.15401	
DYCOW		0.07123	0.20796	0.02797	
BFCOW	0.03579	1.12084	1.37640	1.11365	0.73610
YLCAF	1.48516				
HOGGG		12.12985	12.14629		
DEFRD					
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2					
CHPS3					
PASRA					
HARUF	0.28189	1.17485	1.98926	0.44746	
HAYAG					0.00001
HAYRA					
LBCSH	0.18713				
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	131(TN)	132(TN)	133(AL)	134(AL)	135(TN)
COTN1	0.53430	1.22645	0.06094	1.96801	0.00101
COTN2					
COTN3					
WHEA1					
WHEA2					
WHEA3					
FDGR1					
FDGR2					
FDGR3					
HAYY1					
HAYY2					
HAYY3					
WHAY					
FGSB1					
FGSB2					
FGSB3					
FGSG1					
FGSG2					
FGSG3					
HASG1	1.38291	2.12176	3.65057	0.44340	0.96940
HASG2					0.90111
HASG3		0.66046			
FGSS1					
FGSS2					
FGSS3					
BROLR					
DYCOW					0.82694
BFCOW				1.92079	
YLCAF					
HOGGG				2.68672	
DEFRD	2.19584	3.83440	5.46428	0.31364	
EXTSG					
CFOSG					
CFNSG					
SFYRL					
YLOSG					
YLNSG					
CHPS1					
CHPS2			2.01551	2.23851	
CHPS3					
PASRA			0.08745	0.40576	
HARUF	2.42676	4.72499	6.35200	0.78483	2.87281
HAYAG	0.02099				
HAYRA					
LBCSH					
LBNH					

TABLE A-15. (CONTINUED)

AREA NO.	136(TN)	137(TN)	138(NC)
COTN1	0.07401	0.43201	
COTN2			
COTN3			
WHEA1			
WHEA2			
WHEA3			
FDGR1			
FDGR2			
FDGR3			
HAYY1			0.64831
HAYY2			
HAYY3			
WHAY			
FGSB1			
FGSB2			
FGSB3			
FGSG1			
FGSG2			
FGSG3			
HASG1	3.20630	3.70730	
HASG2			
HASG3			
FGSS1			
FGSS2			
FGSS3			
BROLR			11.71481
DYCOW	1.54544	1.04353	0.09455
BFCOW			
YLCAF		1.44362	
HOGGG			
DEFRD		2.01275	0.65755
EXTSG			
CFOSG			
CFNSG			
SFYRL			
YLOSG			
YLNSG			
CHPS1			
CHPS2			
CHPS3			
PASRA			
HARUF	5.32247	6.11705	1.37442
HAYAG			
HAYRA			
LBCSH			
LBNH			

Table A-16. Consuming regions and producing areas

Region No.	Area No.	Sequential No. of Area Within a Region
1	1	1
	2	2
	3	3
	4	4
	5	5
	31	6
2	30	1
	32	2
	33	3
	34	4
	38	5
	40	6
	41	7
3	6	1
	7	2
	8	3
	9	4
	10	5
	14	6
4	11	1
	12	2
	13	3
	15	4
	18	5
	19	6
	20	7
	118	8
	119	9
5	16	1
	17	2
6	22	1
	27	2
	29	3
	35	4
7	131	1
	132	2
	133	3
	134	4
	135	5
	136	6
	137	7
	138	8
8	21	1
	23	2
	24	3
	25	4
	120	5
	121	6
	122	7
	123	8
	124	9
9	42	1
	43	2
	54	3
	56	4
	57	5
	58	6
	59	7
	60	8
10	26	1
	36	2
	45	3
	46	4
	47	5
	50	6
	51	7
	52	8
	53	9

Table A-16. (Continued)

Region No.	Area No.	Sequential No. of Area Within a Region	Region No.	Area No.	Sequential No. of Area Within a Region
11	61	1	13	28	1
	62	2		101	2
	63	3		102	3
	64	4		103	4
	65	5		104	5
	66	6		105	6
	67	7		110	7
	68	8		112	8
	69	9		113	9
	70	10		114	10
	71	11		115	11
	72	12			
	73	13	14	39	1
	75	14		44	2
	76	15		49	3
	77	16		55	4
	78	17		74	5
	79	18		106	6
	80	19		107	7
	81	20		108	8
	82	21		109	9
	84	22		111	10
	86	23			
			15	37	1
12	83	1		48	2
	85	2		116	3
	87	3		117	4
	88	4			
	89	5			
	90	6			
	91	7			
	92	8			
	93	9			
	94	10			
	95	11			
	96	12			
	97	13			
	98	14			
	99	15			
	100	16			
	125	17			
	126	18			
	127	19			
	128	20			
	129	21			
	130	22			

Table A-17. Regional origins and destinations of transportation activities, and mileage

Region No.	To population center → / From production center ↓	1 Newburgh, NY	2 Findley, OH	3 Lynchburg, VA	4 Atlanta, GA	5 Orlando, FL
1	Philadelphia, PA	152	566	400	771	1036
2	Fort Wayne, IN	821	103	626	640	1137
3	Lynchburg, VA	551	591	0	465	741
4	Atlanta, GA	922	673	465	0	497
5	Lakeland, FL	1242	1223	794	550	53
6	Bowling Green, KY	1030	395	635	374	870
7	Chattanooga, TN	902	519	445	137	634
8	Greenville, MS	1363	825	906	530	948
9	St. Paul, MN	1364	629	1153	1130	1626
10	Burlington, IA	1219	484	1008	832	1284
11	Grand Island, NB	1576	841	1348	1145	1597
12	Fort Worth, TX	1727	1188	1269	857	1275
13	Walla Walla, WA	2922	2187	2711	2637	3089
14	Grand Junction, CO	2269	1534	2003	1801	2233
15	Fresno, CA	3250	2567	2804	2219	2832

Table A-17. (continued)

6	7	8	9	10	11	12	13	14	15
Elizabeth-town, KY	Chatta-nooga, TN	Vicksburg, MS	La Crosse, WI	Peoria, IL	Lincoln, NB	Dallas, TX	Yakima, WA	Grand Junc-tion, CO	Hayward, CA
843	750	1283	1082	936	1359	1543	2893	2117	3063
330	488	856	424	280	703	1041	2237	1461	2434
671	445	880	1021	877	1300	1238	2834	2003	2770
409	137	459	998	776	1080	825	2760	1801	2357
958	687	930	1547	1281	1585	1296	3265	2286	2850
34	237	546	659	538	842	806	2522	1563	2339
271	0	435	817	639	944	801	2624	1664	2328
508	506	71	943	619	884	436	2524	1545	2030
757	993	1100	132	450	403	997	1681	1161	2221
560	695	746	400	131	417	717	2097	1175	2243
873	1009	1020	450	500	65	832	1616	715	1877
872	833	397	975	928	799	32	2298	1016	1500
2369	2614	2472	1690	2074	1558	2207	150	1068	1011
1529	1664	1380	1100	1191	758	1048	1112	0	1143
2408	2363	1994	2388	2303	1823	1567	1061	1185	35

Table A-18. Producing areas and states

Area No.	State	Area No.	State	Area No.	State
1	NY	47	IL	93	TX
2	PA	48	CA	94	TX
3	WV	49	AZ	95	TX
4	MD	50	MO	96	TX
5	NE[a]	51	MO	97	TX
6	VA	52	IA	98	TX
7	NC	53	IA	99	TX
8	NC	54	MN	100	TX
9	NC	55	NM	101	MT
10	VA	56	MN	102	MT
11	SC	57	MN	103	WY
12	GA	58	MN	104	MT
13	GA	59	MN	105	WY
14	SC	60	MN	106	CO
15	SC	61	ND	107	CO
16	FL	62	ND	108	CO
17	FL	63	ND	109	NM
18	AL	64	SD	110	ID
19	AL	65	ND	111	UT
20	AL	66	SD	112	ID
21	MS	67	SD	113	OR
22	KY	68	SD	114	WA
23	TN	69	SD	115	WA
24	MS	70	SD	116	CA
25	AR	71	NB	117	CA
26	MO	72	NB	118	GA
27	KY	73	NB	119	AL
28	ID	74	CO	120	LA
29	KY	75	NB	121	AR
30	OH	76	NB	122	AR
31	NY	77	NB	123	AR
32	OH	78	KS	124	LA
33	OH	79	KS	125	TX
34	IN	80	KS	126	TX
35	IN	81	KS	127	OK
36	IL	82	KS	128	OK
37	CA	83	TX	129	TX
38	IN	84	KS	130	TX
39	NV	85	OK	131	TN
40	MI	86	KS	132	TN
41	MI	87	OK	133	AL
42	WI	88	OK	134	AL
43	WI	89	OK	135	TN
44	CO	90	OK	136	TN
45	IL	91	TX	137	TN
46	MO	92	TX	138	NC

[a]New England.

Table A-19. 138 producing areas corresponding to Eyvindson's 157 producing areas

Area No.	Eyvindson's Area No.
1	1
2	2
3	3
4	4,5[a]
5	138
6	6
7	7,10
8	8
9	9
10	140A[b]
11	11
12	12
13	13
14	14
15	15,16B[c]
16	142
17	17
18	18
19	19
20	20A
21	21A
22	143A
23	23,22B,28B
24	24
25	25
26	26
27	27A
28	152
29	29
30	30,31
31	139
32	32
33	33
34	34,37
35	35
36	36,48,49
37	157

[a]Two or more of Eyvindson's areas are combined into one area.

[b]"A" denotes a part of the area.

[c]"B" denotes a part of the area to be combined with other areas or parts of other areas.

Table A-19. (continued)

Area No.	Eyvindson's Area No.
38	38,39
39	155
40	40,41
41	144
42	42
43	43,44
44	154
45	45,46
46	146
47	47
48	136
49	135
50	50
51	51
52	52
53	53,55
54	54,58
55	134
56	56
57	57
58	145
59	59
60	60
61	61
62	62
63	63,64
64	151
65	65
66	66
67	67
68	68
69	69
70	70
71	71,77
72	72
73	73
74	74
75	75
76	76
77	150
78	78
79	79
80	80
81	81
82	82,83

Table A-19. (continued)

Area No.	Eyvindson's Area No.
83	133
84	84,85
85	148
86	86
87	87
88	88,91
89	89
90	90
91	149
92	92
93	93
94	94
95	95
96	96
97	97
98	98,131
99	99
100	100
101	101
102	102
103	103,105
104	104
105	153
106	106
107	107
108	108
109	109
110	110
111	111
112	112
113	113
114	114,115
115	156
116	116
117	117
118	118,141B
119	119
120	120
121	121
122	122,137,147
123	123
124	124
125	125,126
126	132
127	127

Table A-19. (continued)

Area No.	Eyvindson's Area No.
128	128
129	129
130	130
131	22B,28B
132	21B,22B,27B
133	20A
134	20B,141B
135	22B,140B,143B
136	140B,141B,143B
137	22A
138	16B,140B,143B

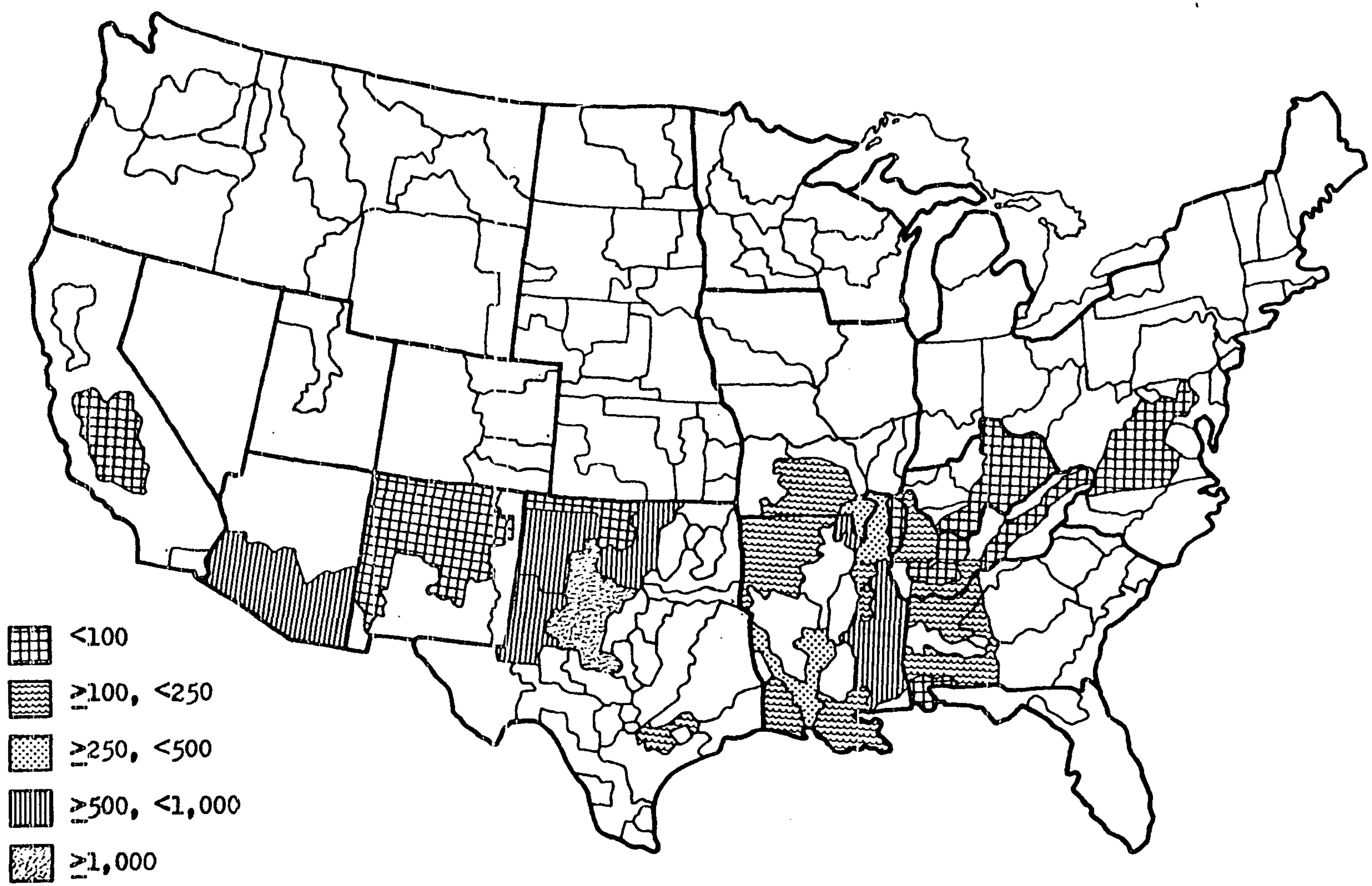

Figure A-1. Cotton production (unit: 1,000 acres)

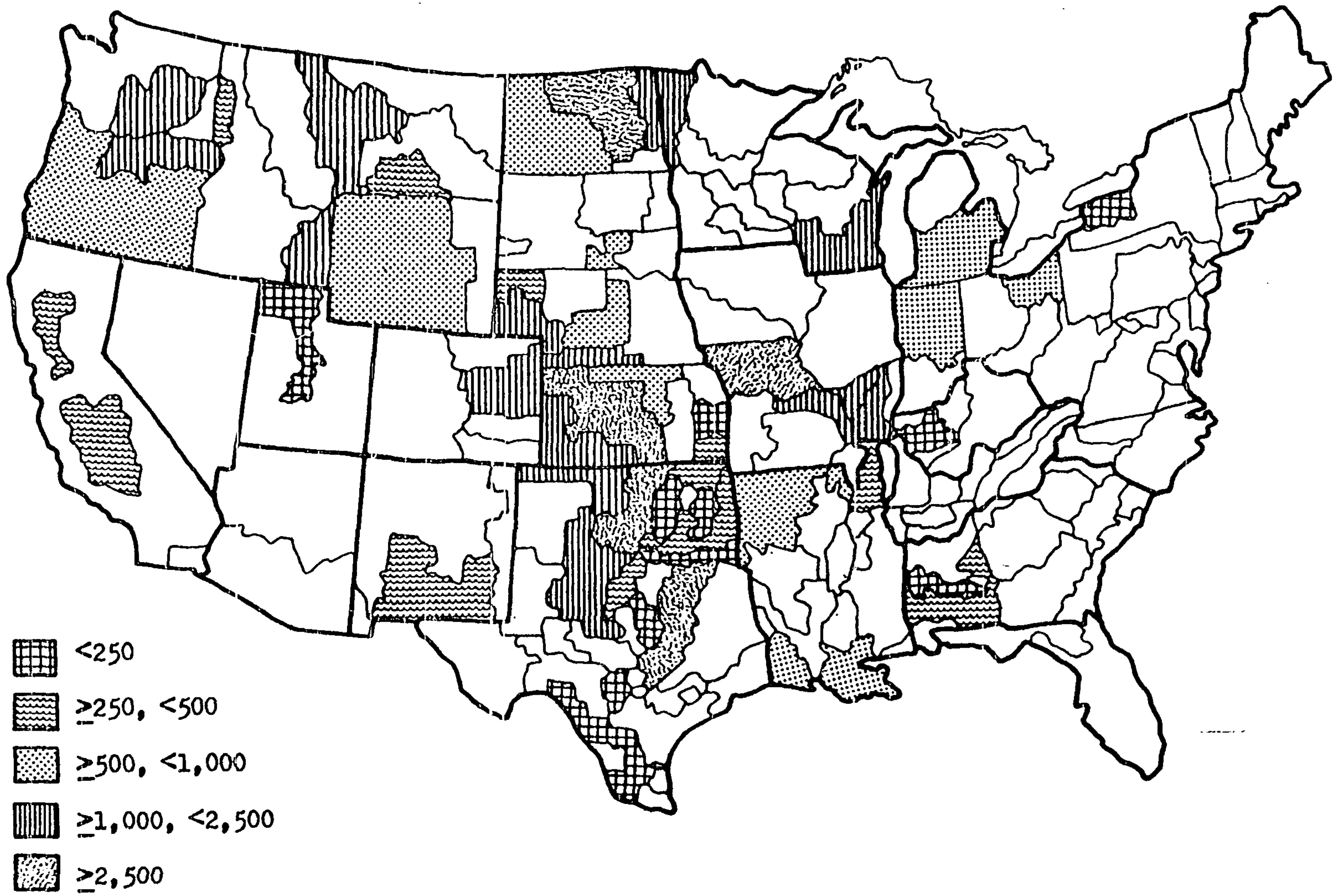

Figure A-2. Wheat production (unit: 1,000 acres)

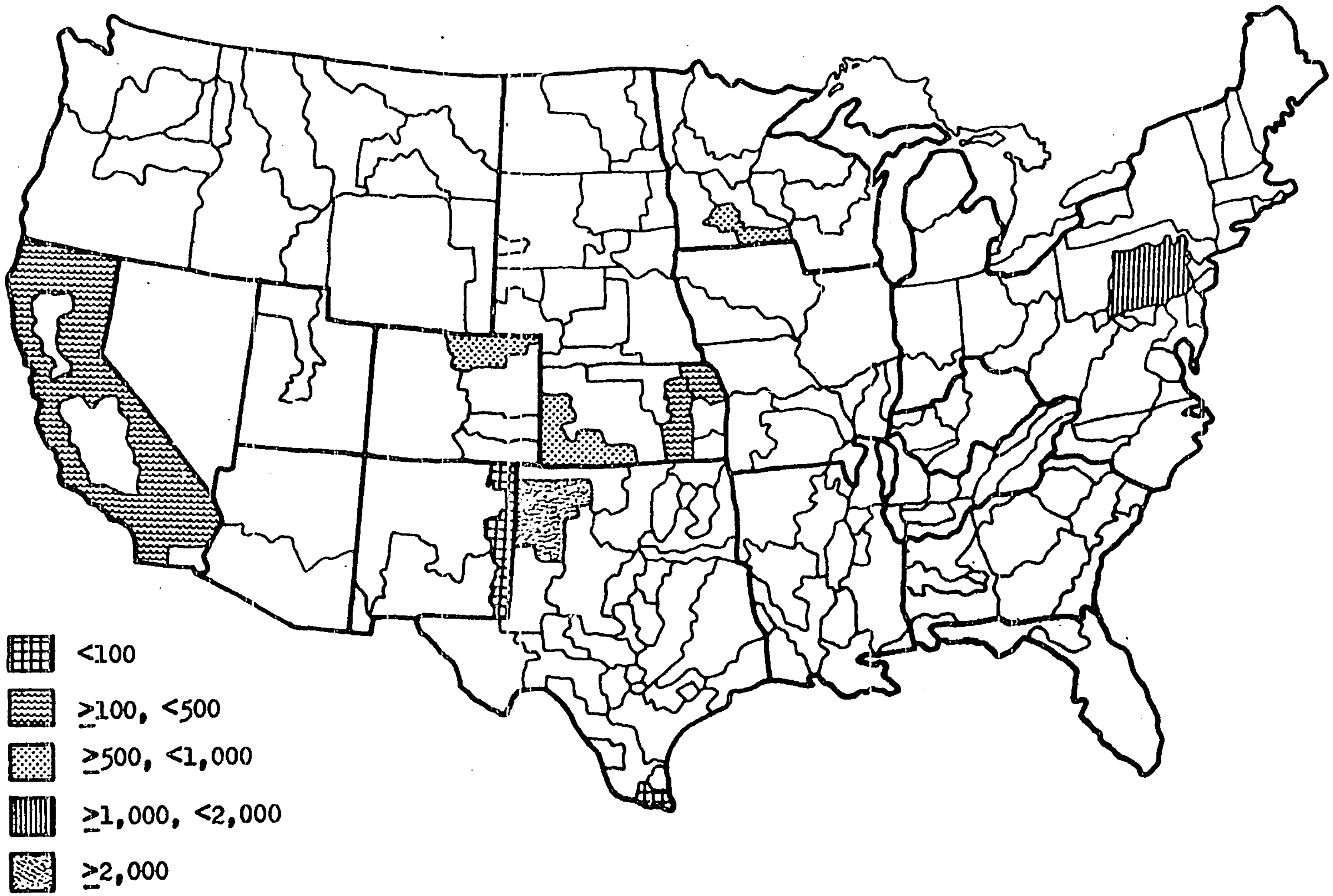

Figure A-3. Feed grain production (unit: 1,000 acres)

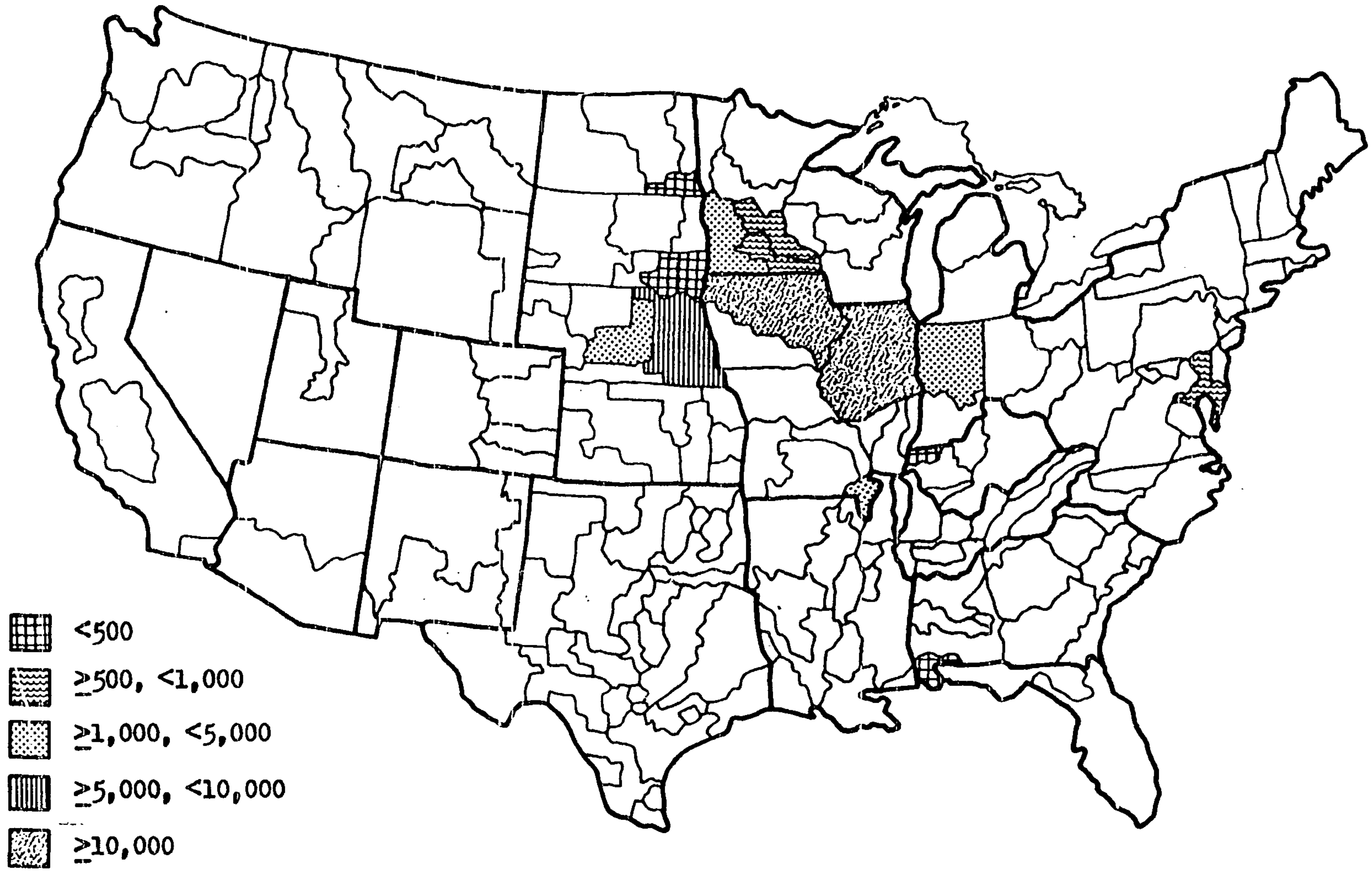

Figure A-4. Feed grain-soybean rotation production (unit: 1,000 acres)

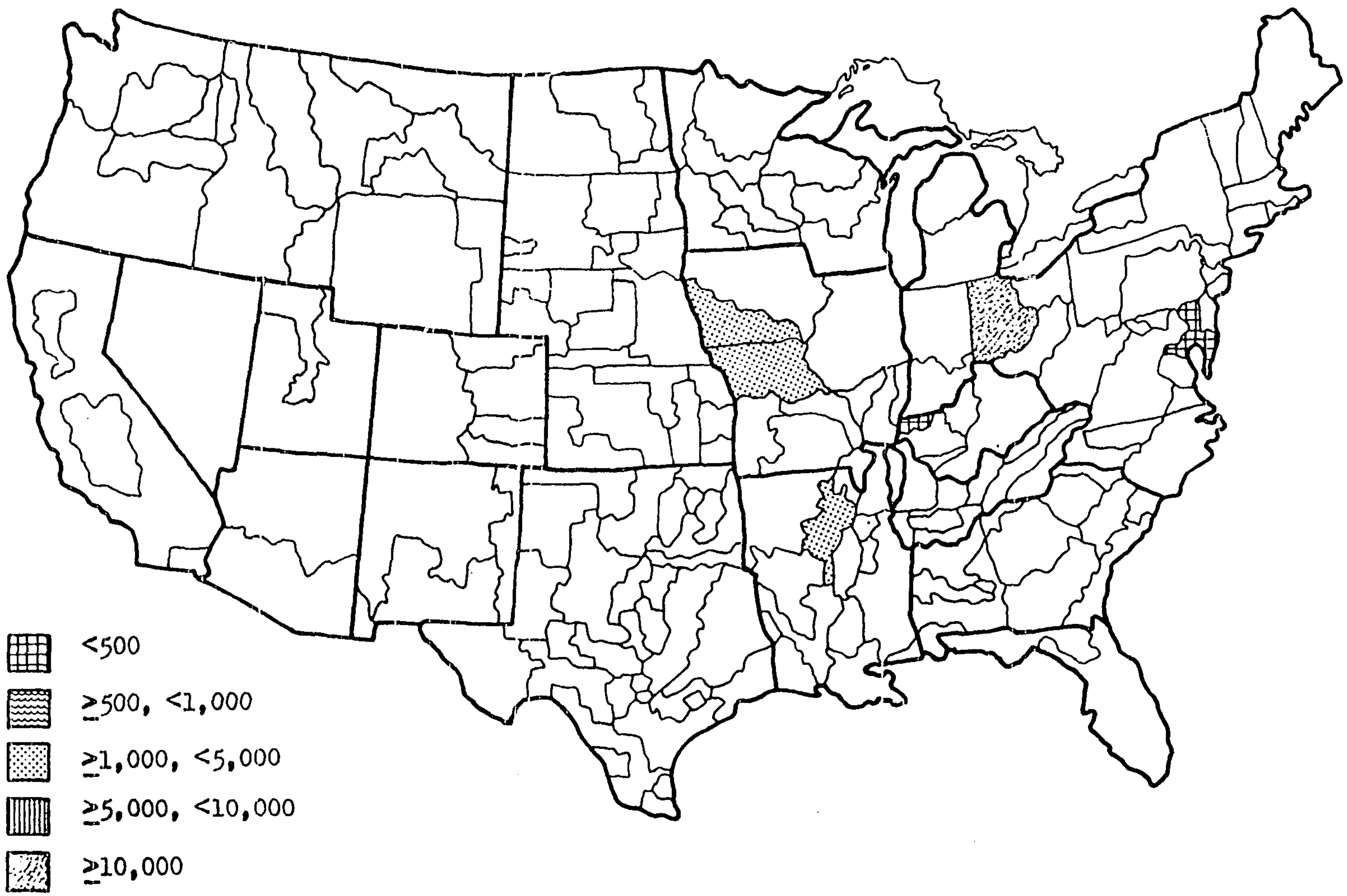

Figure A-5. Feed grain-soybean-silage rotation production (unit: 1,000 acres)

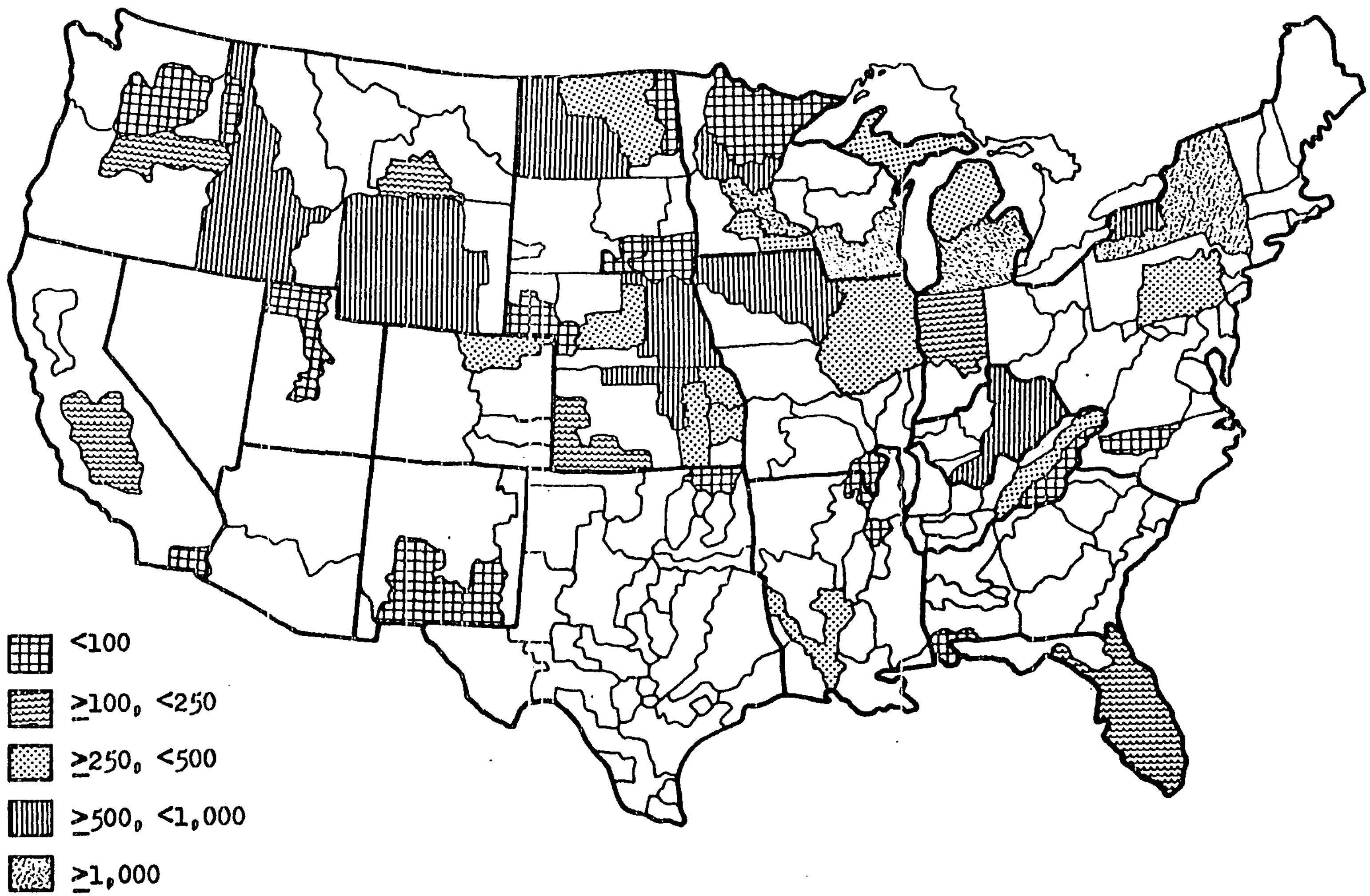

Figure A-6. Hay production (unit: 1,000 acres)

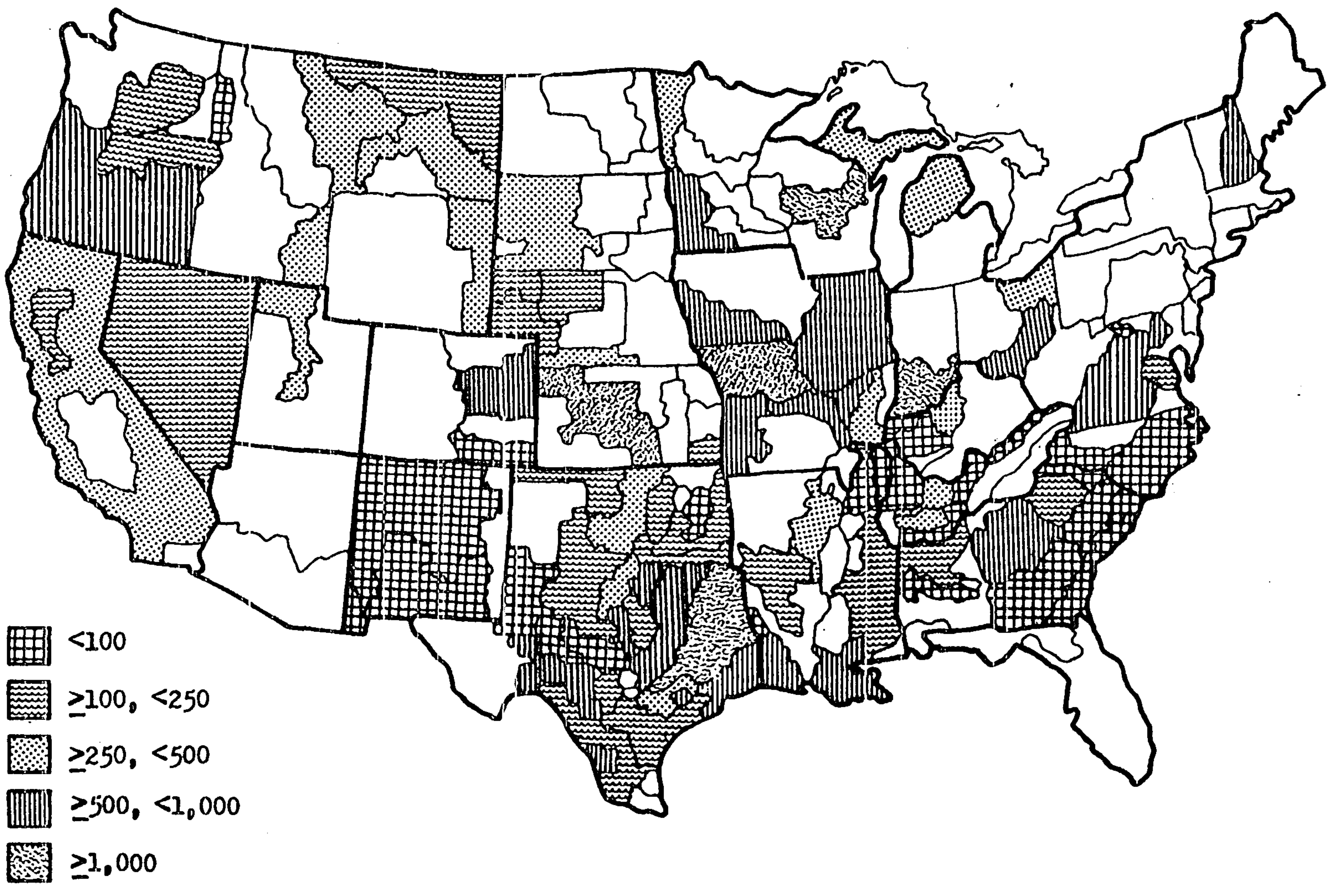

Figure A-7. Hay-silage rotation production (unit: 1,000 acres)

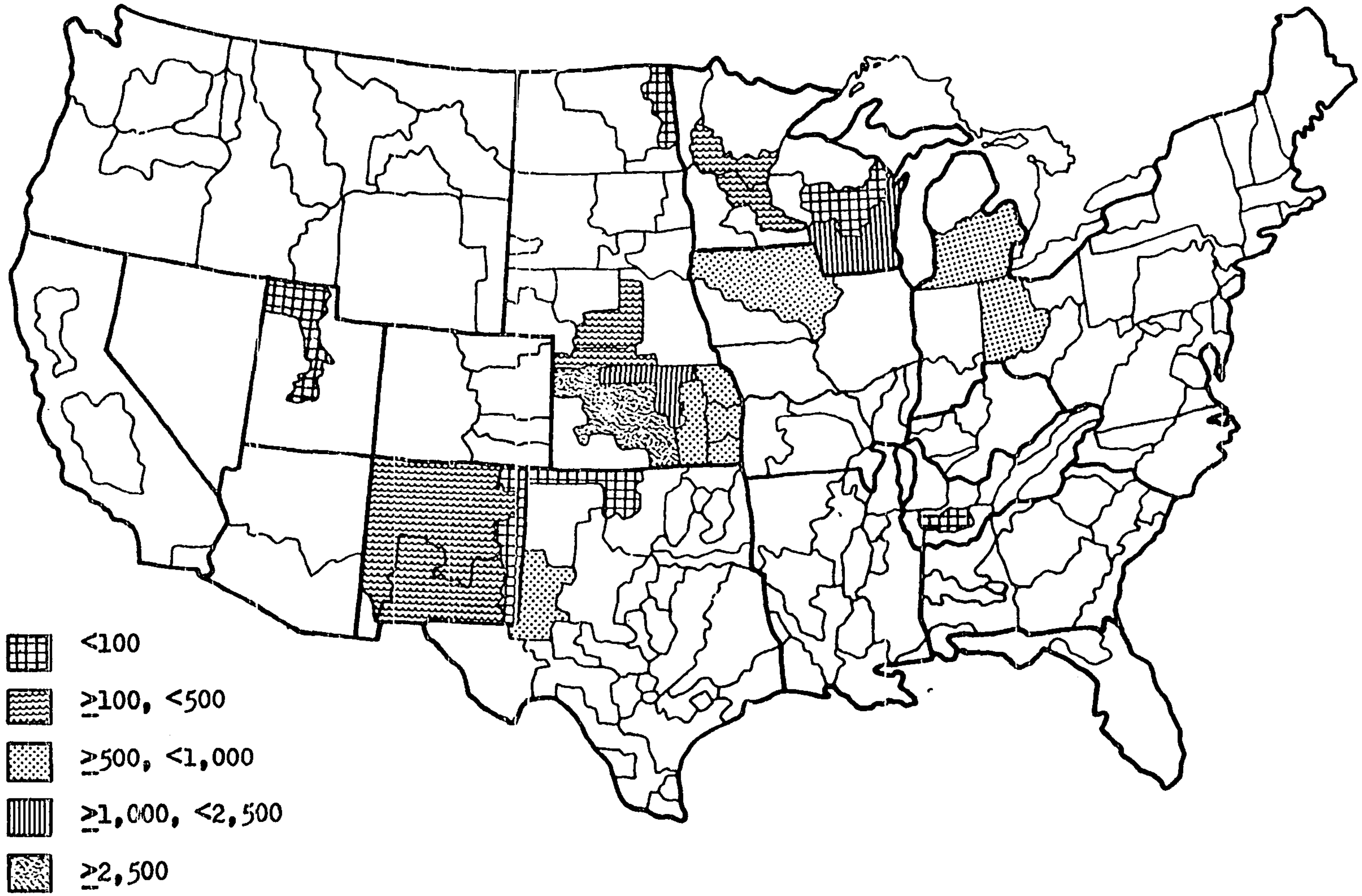

Figure A-8. Crop-hay land converted into pasture (unit: 1,000 acres)

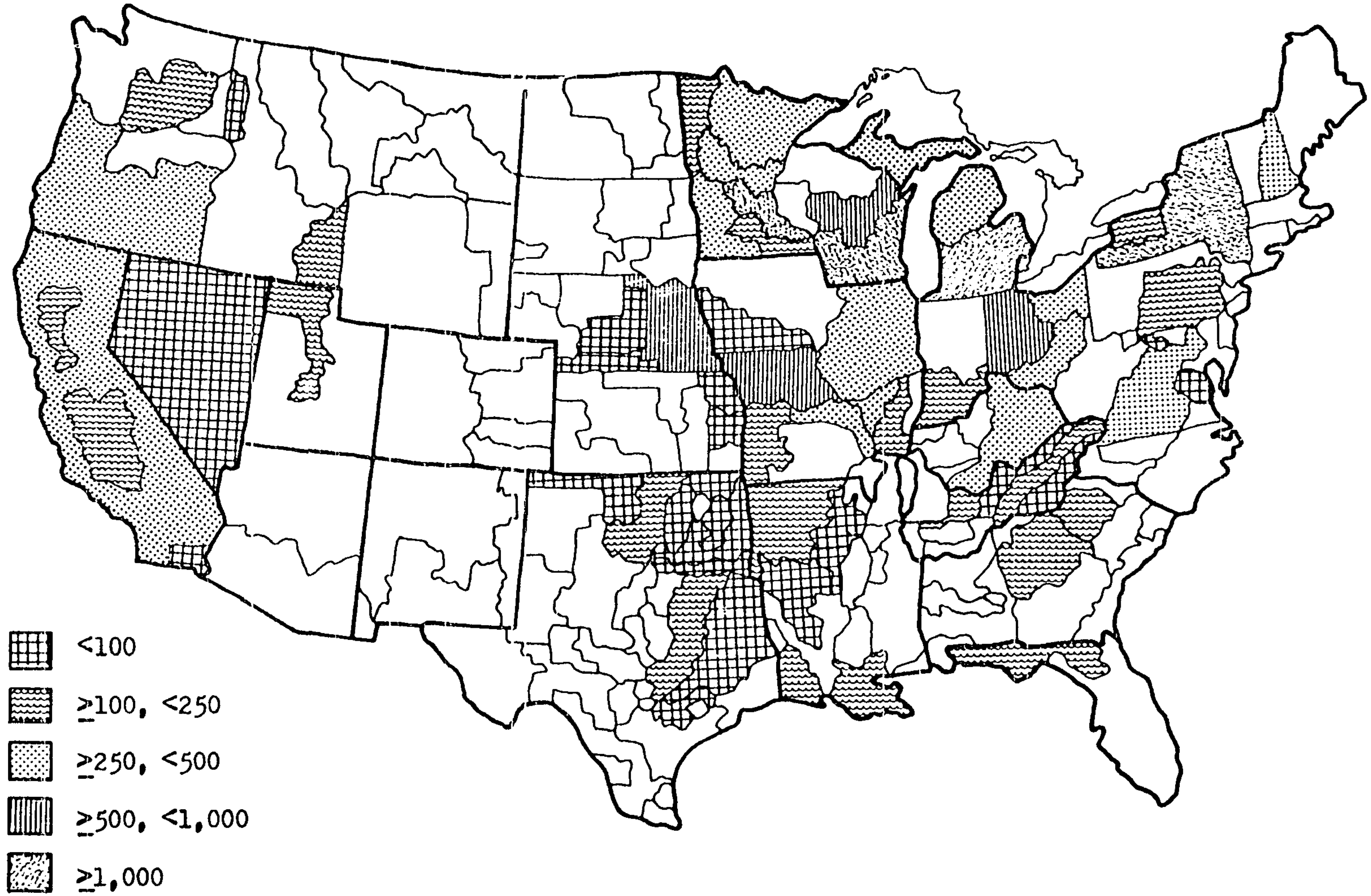

Figure A-9. Dairy cow production (unit: 1,000 head)

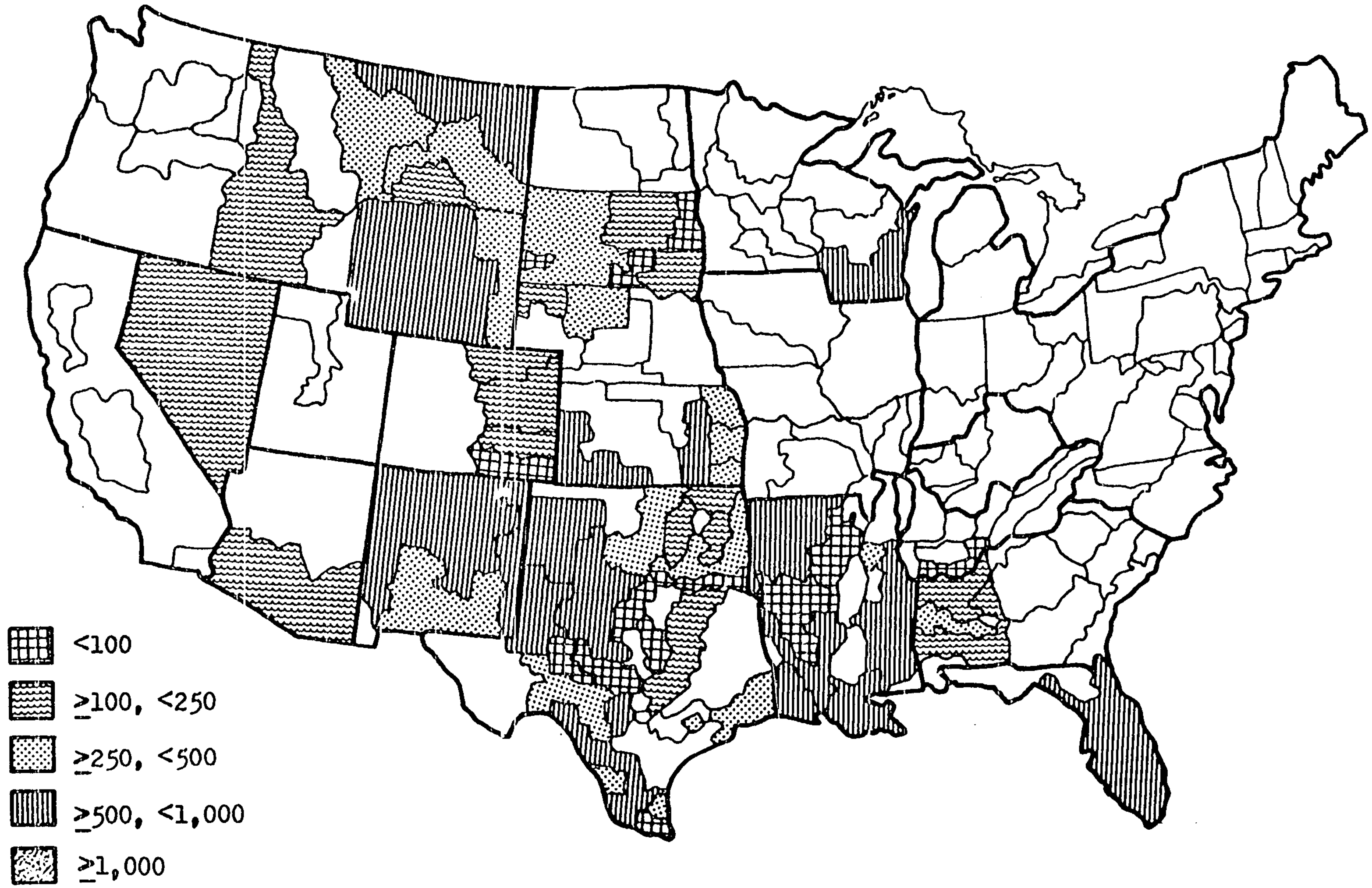

Figure A-10. Beef cow production (unit: 1,000 head)

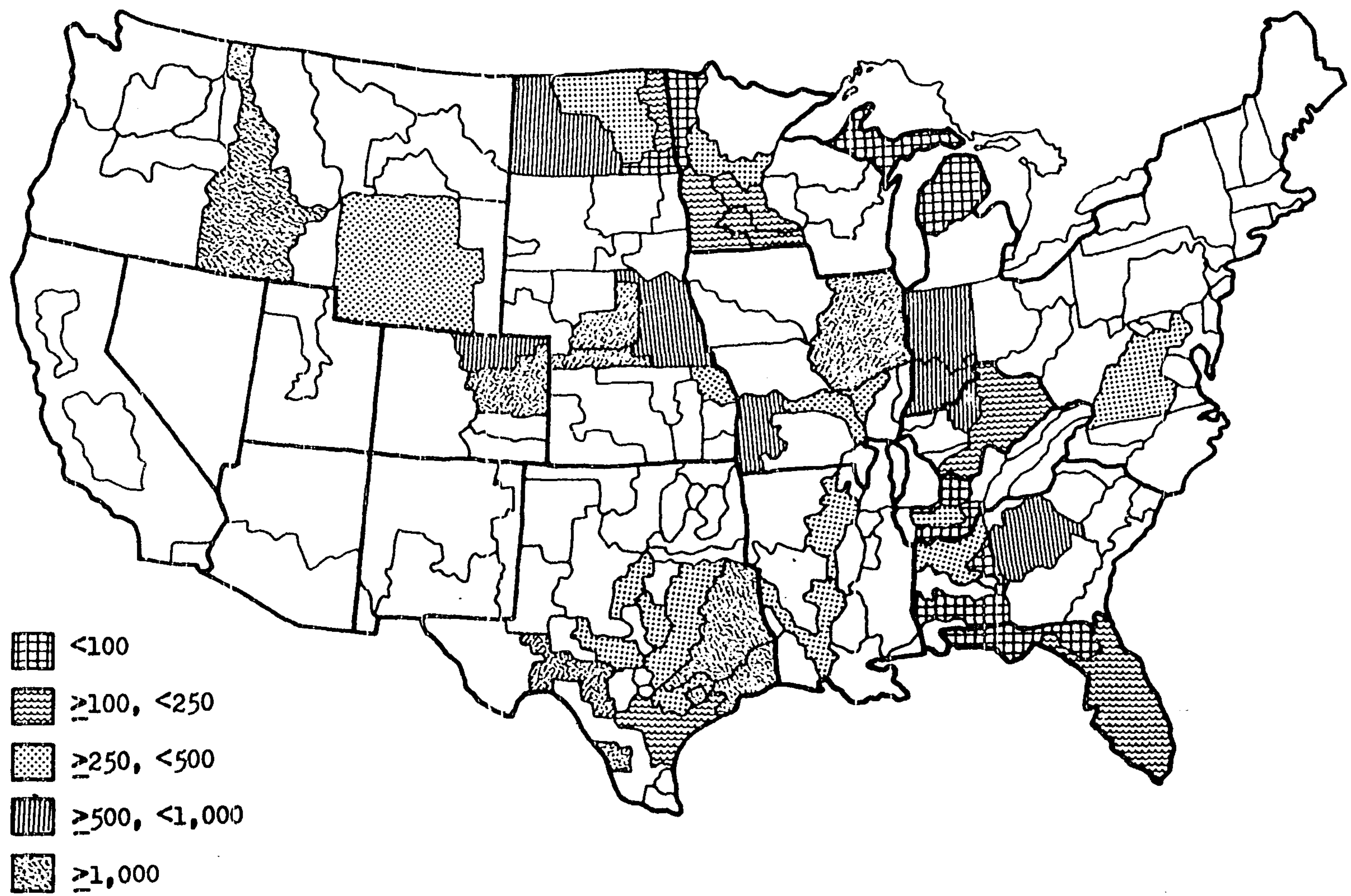

Figure A-11. Feeder cattle production (unit: 1,000 head)

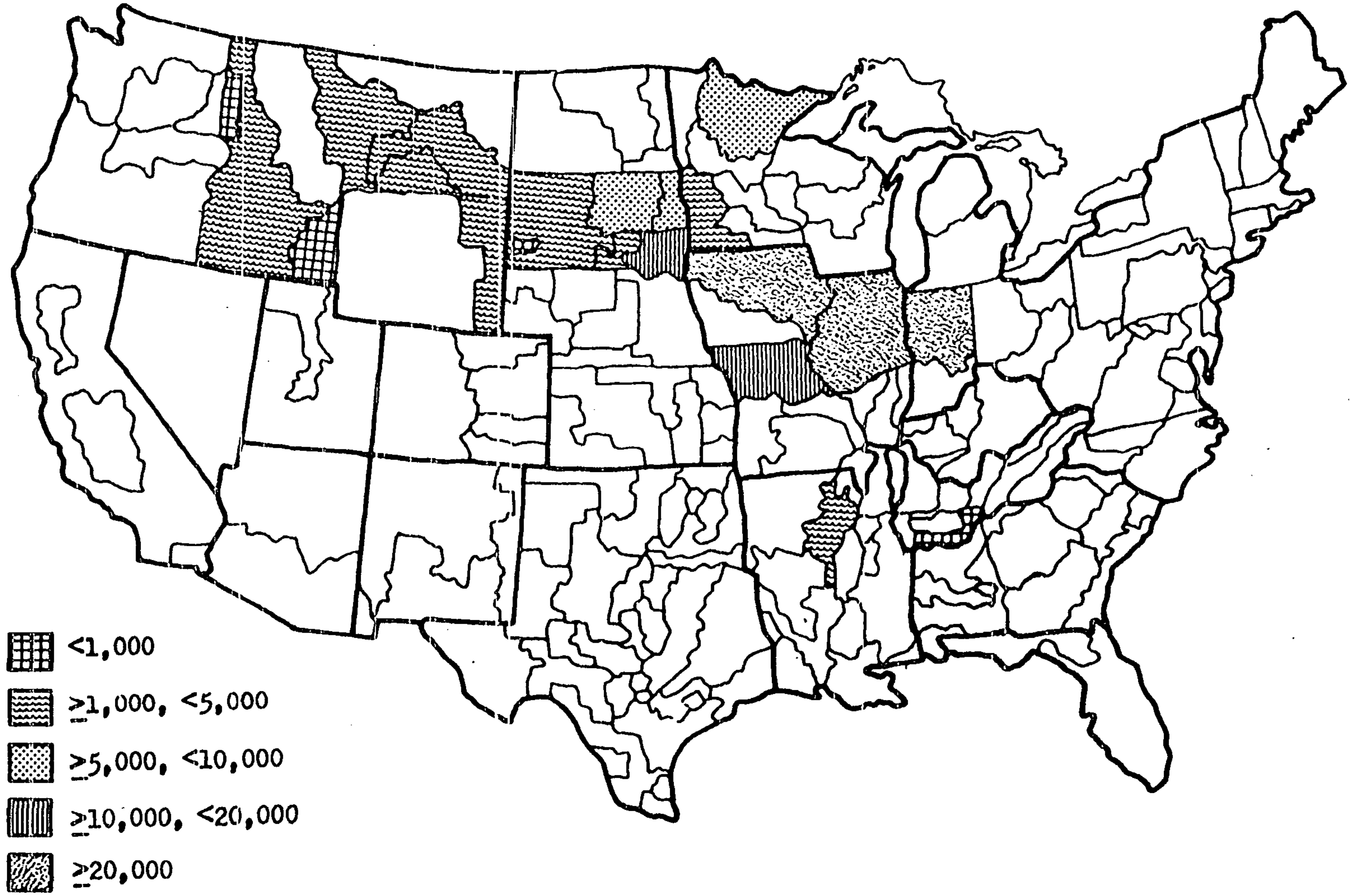

Figure A-12. Hog production (unit: 1,000 CWT live weight)

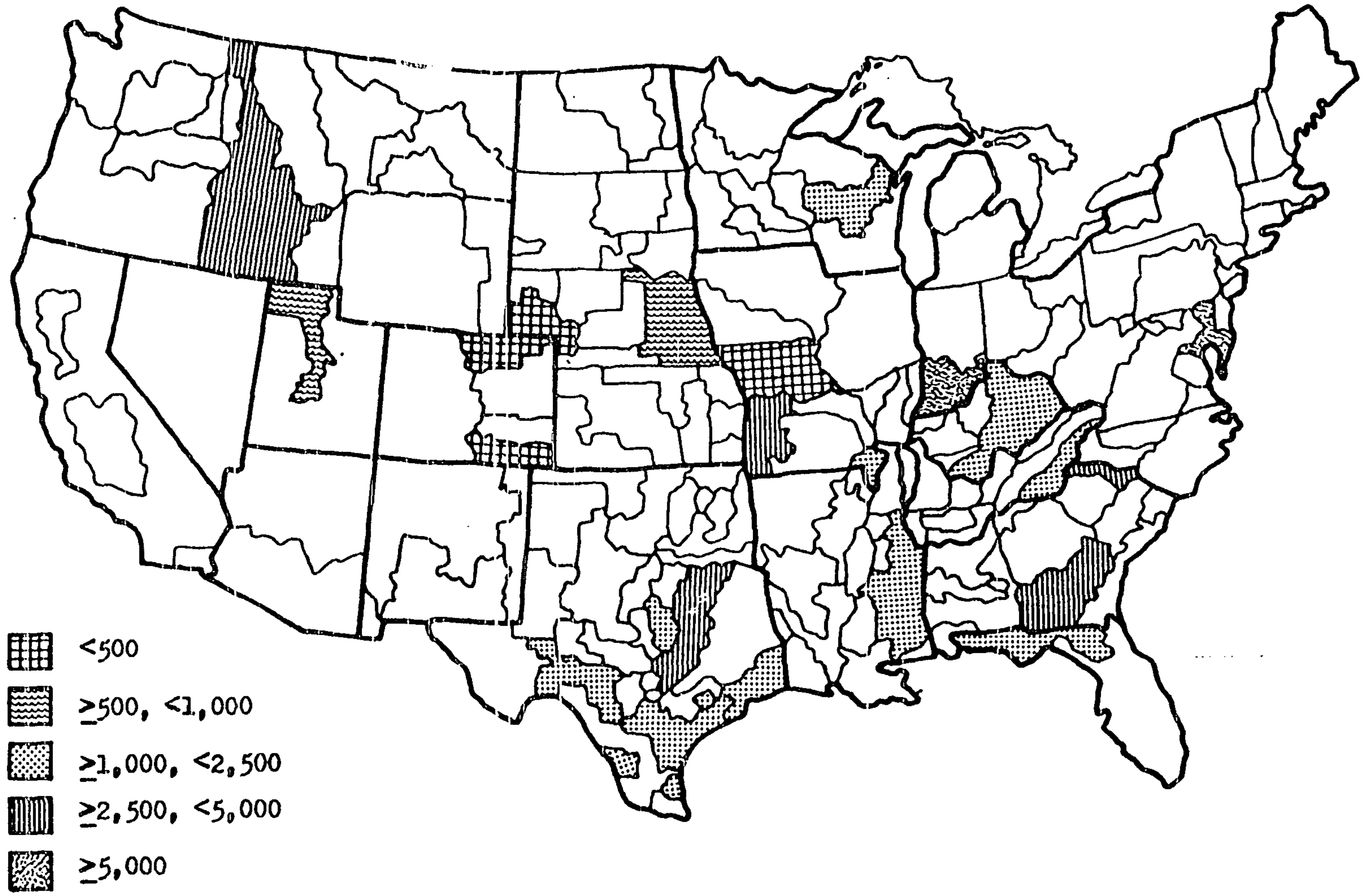

Figure A-13. Broiler production (unit: 1,000 CWT)