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A REVIEW OF SPATIAL EQUILIBRIUM MODELS OF THE CROP SECTOR

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The purpose of this paper is to: 1) identify previously constructed spatial equilibrium models of the crop sector, and 2) provide sufficient detail of each model to permit researchers to evaluate their merits.

All reviewed models, except a model by Taylor, Blokland and Swanson, were formulated as cost minimizing linear programming models. [5] The Taylor, Blokland and Swanson model maximized producers plus consumers surplus and was formulated in a maximizing linear programming framework.

The following ordering of discussed models is arbitrary and implies no preferences.

THE IOWA STATE UNIVERSITY MODEL

The first comprehensive spatial equilibrium model of the crop sector was developed by Egbert and Heady at Iowa State University in the 1950's. The Iowa State model determines the least-cost production location of each crop, grain shipments between regions and utilized transportation mode. [1] Since its development, the model has been updated and modified to answer numerous questions. Recently, Fedeler, Heady and Koo [3] employed the model to answer questions regarding the effect of alternative transportation systems on least-cost locations of grain production and interregional grain flows. Because the Fedeler, Heady and Koo study represents one of the most recent uses of the Iowa State model, the following discussion of model characteristics is taken from publications describing their work.

Producing Regions

One hundred and fifty-two production regions are delineated for the forty-eight contiguous states. A town or city near the geographical center of the region represented the origin of the grain produced in the region. (Figure 1) For each region, all costs, except land, are calculated for crops which may be produced in the region. Grains included are wheat, soybeans, corn, oats, barley and grain sorghum; the last four are aggregated into one commodity, feedgrain, on the basis of their feed values. Cotton is included because it competes with grain for cropland and cottonseed is a major substitute for soybeans. Acreage bounds for each region are specified as a substitute for other constraints that discourage crop production specialization. These bounds permit crop acreages to range from 20% below to 20% above 1969 actual acreages, except upper limits on soybean acreages are restricted to 50% of the available land or 1969 acreage, whichever is larger. The amount of crop shipped from a region is constrained to be no more than regional production.

Consuming Regions

The forty-eight contiguous states are partitioned into 73 regions of domestic demand. (Figure 2) All regions have a demand for feedgrains and wheat, but only 42 have soybean demands. Fourteen regions are identified as regions of export demand for grain. Nine of the fourteen regions are specified as domestic consuming regions; therefore, 78 domestic and export demand regions result. A center of transportation and commerce was identified in each region and represented the location of that region's demands.

Figure 1. Delineation of Iowa State Model's Producing Regions.

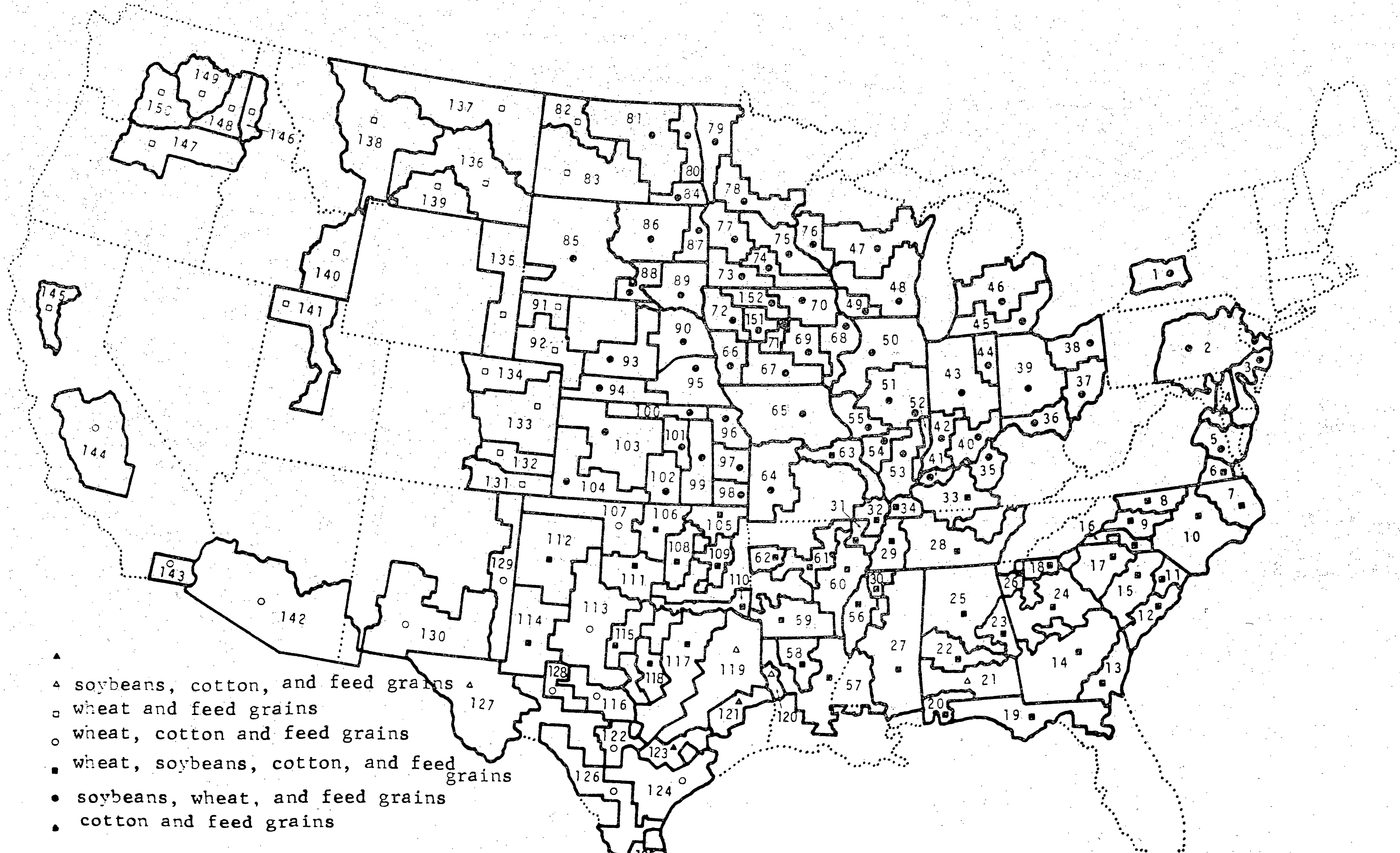
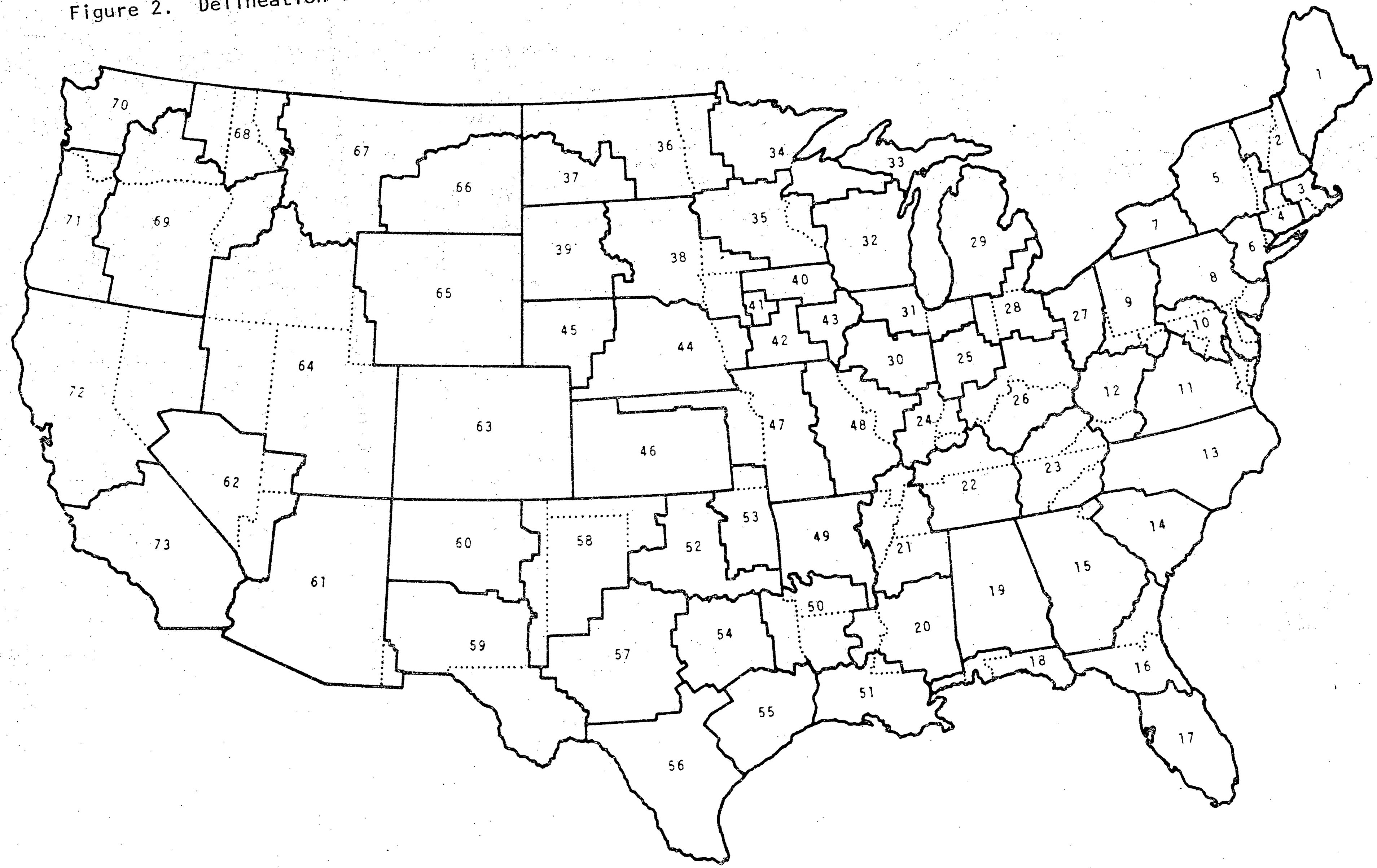


Figure 2. Delineation of Iowa State Model's Consuming Regions.



Total national demands are projected to 1980. Demands for livestock feed are derived from projected per capita demand for livestock products adjusted for net foreign trade and direct grain demands for horses, mules and other livestock. Demand projections include industrial uses of grain such as cereal, dry processing, wet processing, flour, alcohol, malt, etc. Per capita demands are based on commodity price indexes, real per capita income and time. Two levels of grain exports are considered. Annual demands for feedgrains and soybeans are allocated to two periods, December-March and April-November because the Missouri River, Upper Mississippi River and Great Lakes are not navigable in winter. Regional wheat demands were on an annual basis.

Transportation Costs

The model requires knowledge of transportation costs between each production region and consuming region by crop and time period. The costs of moving grain by rail, water, truck and combinations of the three are estimated. The transportation costs are those encountered by the transportation industry, i.e. costs rather than rates are employed. No transportation costs are applied to movements of grain from a producing region to a consuming region if part or all of the producing region lies within the consuming region.

Grain loading and unloading costs at grain elevators are added to transportation costs since these handling costs are effected by utilized transportation mode. Whenever grain is transferred from one transportation mode to another while enroute, the elevator handling costs for unloading and reloading are added to transportation costs.

The Fedeler, Heady and Koo study focused on transportation activities and investigated ten alternative model specifications. They were:

1. The base model which included a 1972 interregional cost structure with demands and yields projected for normal or average conditions for 1980 based on past trends.
2. A rail system with shipments in 50 car units.
3. A 10% increase in all rail costs.
4. A 20% increase in all rail costs.
5. A 10% increase in all barge costs.
6. A 20% increase in all barge costs.
7. An alternative single car rail transport system which reduced the variable and increased the fixed cost of rail transportation.
8. A reassignment of 10% of the Gulf export demands to Seattle.
9. A reassignment of 25% of the Gulf export demands to Seattle.
10. A 25% increase in all grain exports.

Model specifications 2-10 are identical to specification 1 above, except for the above indicated changes.

The Linear Programming Model

The linear programming model minimizes national crop production and transportation costs. The objective function includes the following cost coefficients:

1. All costs, except land, of producing one acre of each crop type in each of the 152 producing regions.

2. The cost of transporting (total transfer costs) one ton of each crop type from each of the 152 producing regions to the 78 consuming locations. In the case of feedgrains and soybeans, transportation costs for two time periods are entered into the objective function to reflect the impossibility of using barge in northern areas during the winter months. Rail, barge and truck costs are considered.

The above costs are included in the objective function and are minimized subject to the following constraints:

1. Total amount of land producing crops in the producing region must be less than or equal to land available for grain production in that region. The use of land is constrained from exceeding the quantity available in the producing region.

2. In addition to the regional land availabilities, the level of production of the individual crops is constrained by upper and lower limits which are arbitrarily specified to permit some choice in the location of production, but prevents total regional specialization.

3. Constraints require each consuming region's grain demands be met, that is, the quantities of grain crops shipped into a consuming region must be at least as large as that region's demands, (some demands are export demands). The annual demands for feedgrains and soybeans are based on two time periods.

4. A constraint requires the production of cotton lint be at least as large as the national demand.

5. A set of constraints requires the quantity of grain crops exported from a producing region to be less than or equal to that region's production of the particular grain crop. The level of production is a function of yields and number of acres produced.

Solutions to the model reveal the cost of crop production, the location of production, location of consumption, mode of transportation utilized to transport grain from production to consumption regions, and transportation cost. The transportation costs in the model include the cost of loading and unloading transportation vehicles, since these handling costs depend on mode of transportation employed. The quantity of each grain carried by each transportation mode, the number of ton-miles of traffic for each mode and grain, and the handling costs for each grain are derived from the models. General flow of data for analysis are shown in Figure 3.

In general, there are two methods whereby the researcher can effect changes in a linear programming model in order to evaluate various transportation system proposals or modifications--either the objective function's cost coefficients or right-hand-side constraints may be altered. For example, if the impact of changing transportation mode cost relationships were to be evaluated, objective function costs could be altered for each mode to reflect the change in these cost relationships. Then, by comparing a base model solution with the solution including altered cost relationships, the impacts on location of production, costs, modal splits and grain flows between regions could be resolved. In a similar manner, the impact of altering transportation cost relationships between regions could be evaluated. The impact of adding a new transportation activity to a region (barge) may be determined by adding this activity into the model's objective function, likewise, removing the availability of a transportation mode to a region could be evaluated by removing this activity from the objective function. Any impacts involving changes in transportation costs or availability of a transportation mode can be incorporated into the model by changing transportation costs in the objective function or by simply adding or deleting available transportation activities. In general, all of the models discussed in this paper can be manipulated in an analogous manner.

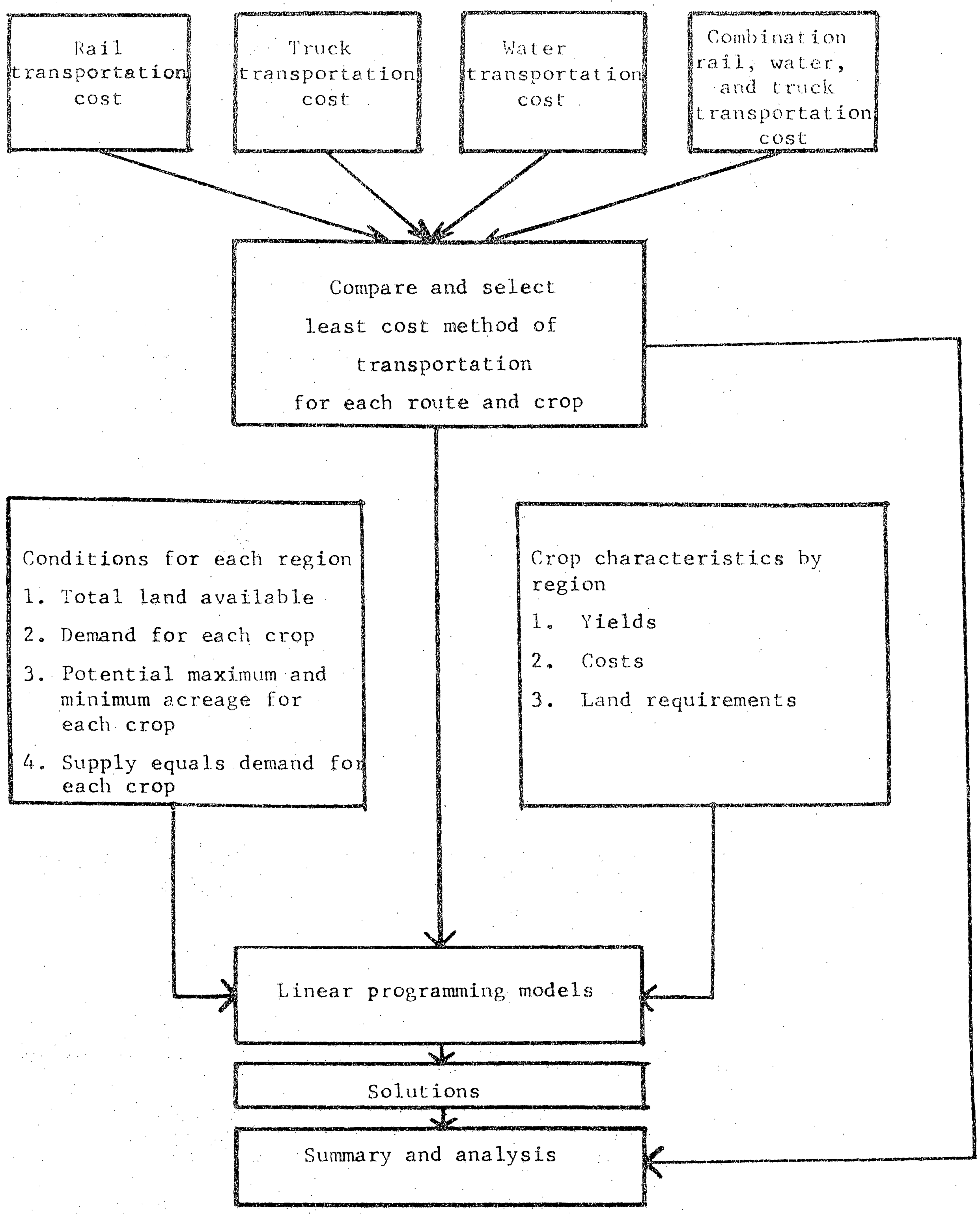


Figure 3. Flow of Analysis Surrounding Iowa State's Linear Programming Model.

The Iowa State Model includes transportation costs rather than rates; accordingly, to evaluate changes in rate structures, it would be necessary to substitute rates for costs in the objective function. The Iowa State model includes two time periods for soybeans and feedgrains and one time period for wheat; therefore, the present formulation is probably not adequate to evaluate the impact of peak pricing of transportation services.

Currently, the Iowa State model does not include transportation capacity constraints, that is, an unbounded horizontal supply function is assumed. As the model is currently formulated, the researcher can alter the magnitude and location of regional and export demands in addition to regional land availabilities. The effects of these modifications on the transportation system could be determined by parametrically altering grain demands (export, domestic, regional) and changing land availabilities.

THE OKLAHOMA STATE UNIVERSITY MODELS

Oklahoma State University cooperated with the U.S.D.A. (Economic Research Service) in two grain spatial equilibrium studies. The initial study, by Leath and Blakely, resulted in a publication entitled, An Interregional Analysis of the U.S. Grain-Marketing Industry, 1966-67, Technical Bulletin No. 1444. The second study, by Schnake and Franzmann [4] utilized the model developed in the initial study but substituted transportation costs for the transportation rates which had been used in the Leath and Blakely formulation. The cost-minimizing linear programming model required the following types of data: 1) regional supplies of each grain by time period, 2) regional consumption of each grain by time period, 3) regional capacities in grain storage and wheat processing, and 4) regional marketing costs (includes transportation cost between regions) or charges or both for performing various functions.

The linear programming transshipment model determined the following:

1. efficient distribution patterns which would minimize total cost of storage, acquisition, processing and distribution for the grain-marketing system, given existing structure and competitive conditions;

2. intermarket and shipping-point price relationships for grain and the competitive position of the production and consumption regions;

3. the competitive position of flour mills in the regions and the estimated savings that would result from a relocation of mills that would be consistent with the low bulk rates on wheat to many destinations, and

4. optimum utilization of storage capacity and quarterly interregional grain flows that would be consistent with the available regional storage capacity.

Regional Demarcation

The continental United States was divided into 42 regions. The same regional demarcation applied to production, storage, processing and consumption of each grain and grain product. (Figure 4) In addition, 13 demand points were designated as export points. The export points are shown in Figure 5.

Regional production and consumption were assumed to take place at particular origin and destination points in each region; and quantities available and requirements were preassigned. Separate points for production and consumption were specified for each region. Generally, regional production and consumption points did not coincide. Grain storage facilities were assumed to be located at the origin points. Grain consumption points were selected with reference to major population centers within a particular region; and grain processing facilities were assumed to be located at these points.

Regional Supplies

Quantities of grain supplies are preassigned to a region and are not price responsive. The model includes five primary products--hard wheat, soft wheat, durum wheat, feedgrain and soybeans.

Since the study was concerned with the marketing system for grain and the optimum use of the facilities, only the proportion of total supply that moved through commercial marketing channels and competed for the limited capacities was considered. The relevant components of supply were off-farm sales of 1966 stocks and off-farm (commercial) stocks of previous crops on hand July 1, 1966.

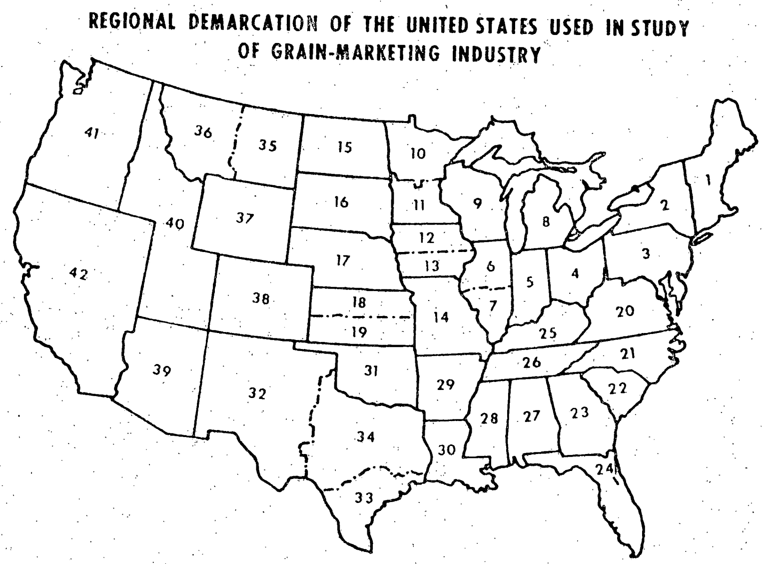
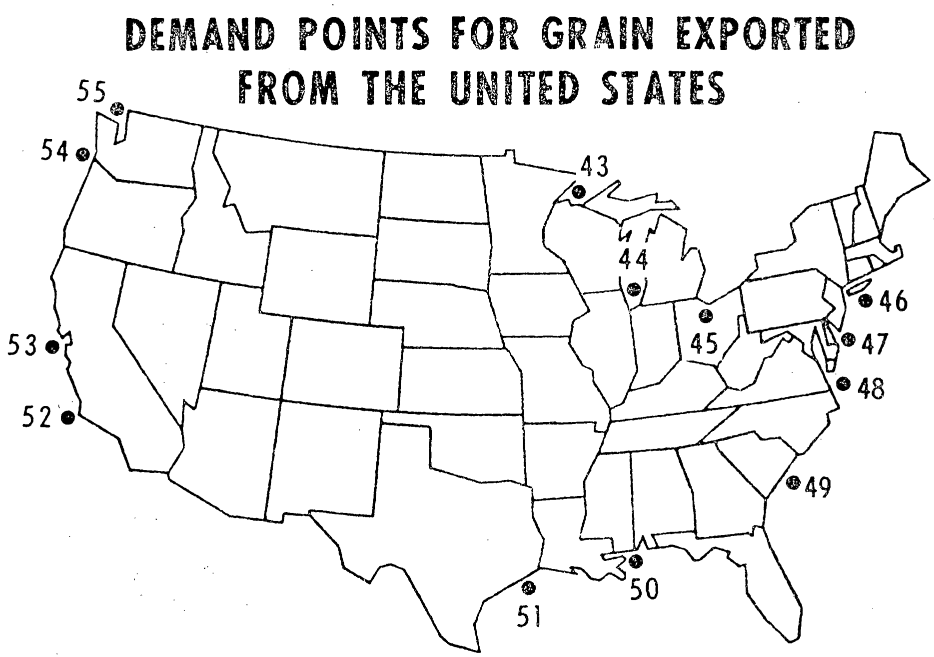


Figure 4. Delineation of Oklahoma State Model's Regions.



LAKE PORTS

43 – Superior, Wis.
Duluth, Minn.

44 – Chicago, Ill.
Milwaukee, Wis.

45 – Toledo, Ohio
Saginaw, Mich.
Carrollton, Mich.
Zilwaukee, Mich.
Buffalo, N.Y.

GULF PORTS

50 – New Orleans, La.
Mobile, Ala.
Pascagoula, Miss.
Port Allen, La.
Destrehan, La.

51 – Houston, Tex.
Port Arthur, Tex.
Beaumont, Tex.
Galveston, Tex.
Corpus Christi, Tex.

ATLANTIC PORTS

46 – Albany, N.Y.
Boston, Mass.
Portland, Me.

47 – Baltimore, Md.
Philadelphia, Pa.
New York, N.Y.

48 – Norfolk, Va.

49 – N. Charleston, S.C.

PACIFIC PORTS

52 – Long Beach, Calif.

53 – Stockton, Calif.
San Francisco, Calif.
Oakland, Calif.

54 – Portland, Ore.
Astoria, Ore.
Vancouver, Wash.
Longview, Wash.
Kalama, Wash.

55 – Seattle, Wash.
Tacoma, Wash.

Figure 5. Identification of the Oklahoma State Model's Export Demand Points.

Since the time staged model included four time periods; allocation of off-farm sales among quarters was necessary. It was assumed that grain sold off-farm moved into commercial marketing channels during the quarter(s) in which harvest takes place.

Feedgrains considered by the study were corn, oats, barley and grain sorghum. These grains were assumed to be perfect substitutes, accordingly, they were treated as a single grain in the model.

Regional Demands

Demands were predetermined and represented the quantity of a particular product that a region must obtain through the marketing system to satisfy its requirements during the period under consideration. The model included 42 domestic consuming regions and 13 export regions.

Domestic disappearance of wheat in the United States involved the following uses: 1) processed for food, 2) seed, 3) industrial, and 4) livestock feed. Processing of wheat into flour was wheat's most important domestic use. Results of previous research were used as a basis for estimating the amount of hard- and soft-wheat flour consumed in each of the 42 consuming regions. Per capita consumption of flour multiplied by population yielded, estimated regional flour demands. The volume of each type of wheat exported was determined from data on inspections for export, by type of grain and port.

Feedgrain had four major uses: 1) livestock feed, 2) seed, 3) industrial, and 4) exports. The livestock industry and the mixed-feed industry were the largest users of feedgrain. Feed processing activities were assumed to take place at points of consumption and regional grain requirements for feeding were expressed as whole-grain demands. The total quantity of each feedgrain used for livestock feed was determined. These totals were combined and allocated among States in proportion to total number of grain-consuming animal units fed in each State during the 1966 feeding year. Industrial uses of feedgrain considered were dry-corn milling, wet processing, cereal manufacturing, malting and brewing, and distilling. Data on monthly grain exports by port were collected from reports published by the U.S.D.A.

Soybeans' major uses were for processing, seed and exports.

Regional Capacities

The model required estimates of grain storage and flour milling capacities for the 42 regions. The capacities of all plants in a region were aggregated.

The grain storage and handling industry storage capacity included country elevators, terminal elevators and CCC binsites. The location and capacity of each region's individual flour mills were aggregated to obtain regional totals.

Marketing Charges and Costs

The model required the following cost data: 1) transportation rates between grain origins and destinations, 2) handling costs for receiving and shipping grain, 3) storage charges, and 4) costs of milling wheat into flour.

The use of the multiproduct spatial model necessitated the collection of a very large number of transportation rates between the various regions. Truck rates were collected from various sources to develop predictive regression equations. Actual point-to-point rail rates for domestic and export shipments were compiled. Rent-a-train and unit-train rates were not used in the study. Barge rates were provided by barge transportation companies. Point-to-point barge-truck and barge-rail combination rates were computed where appropriate for interregional movements.

Once point-to-point or combination rates were compiled, loading and receiving costs were combined with the rates for each mode of transportation. The total costs associated with shipments by each mode of transportation were compared for each possible movement; and the coefficient for the least-cost mode was used as an input to the model.

The Linear Programming Model

The objective function includes the following cost coefficients:

1. The least-cost means of transporting a unit of product (whole grain, wheat flour) on an intra- and interregional basis in each of the four time periods. These costs include the costs of loading-out and receiving the product.

2. The cost of milling a unit of wheat product in each region in each of the four time periods.

3. The cost of storing a unit of product in each region in each of the four time periods.

The above listed costs are included in the objective function and are minimized subject to the following constraints:

1. For a particular product, off-farm sales in a given region, plus carryover from the previous time period, plus any transshipments into that region must equal all outshipments from that region, plus the ending inventory in a specified quarter.

2. Constraints require that shipments into a particular region to satisfy grain demands must be equal to requirements in that region.

3. Capacity constraints limit storage and processing in a particular region to available capacity.

4. Constraints require that the quantity of wheat milled of a particular product in a given region be identical with inshipments of wheat to that region and outshipments of flour from that region.

5. Flour receipts in a region must equal flour demand in that region.

Solution of the model reveals the flow of grain and grain products between regions to minimize cost of transportation (includes total transfer costs), storage and flour milling activities. In particular, it specifies by region and time period, the quantity of grain or flour received from another region, quantity of grain stored, quantity of wheat milled, quantity of grain or flour shipped to any region and transportation modes used in all grain and flour receipts or shipments.

Changes can be effected in the model by: 1) altering objective function cost coefficients (transportation, milling, storage), and 2) altering quantities supplied and demanded, and the storage processing capacities in each region. Changes in quantity constraints are implemented by altering the right-hand-side column.

UNIVERSITY OF ILLINOIS MODELS
(Taylor, Blokland and Swanson)

Recently, two linear programming spatial-equilibrium models have been developed at the University of Illinois. These models have been used to evaluate a wide variety of policy instruments and economic situations, including; hail suppression technologies, shifts in the export demand for agricultural commodities, non-point pollution control methods, domestic and export transportation rate changes and alternative pest control methods.

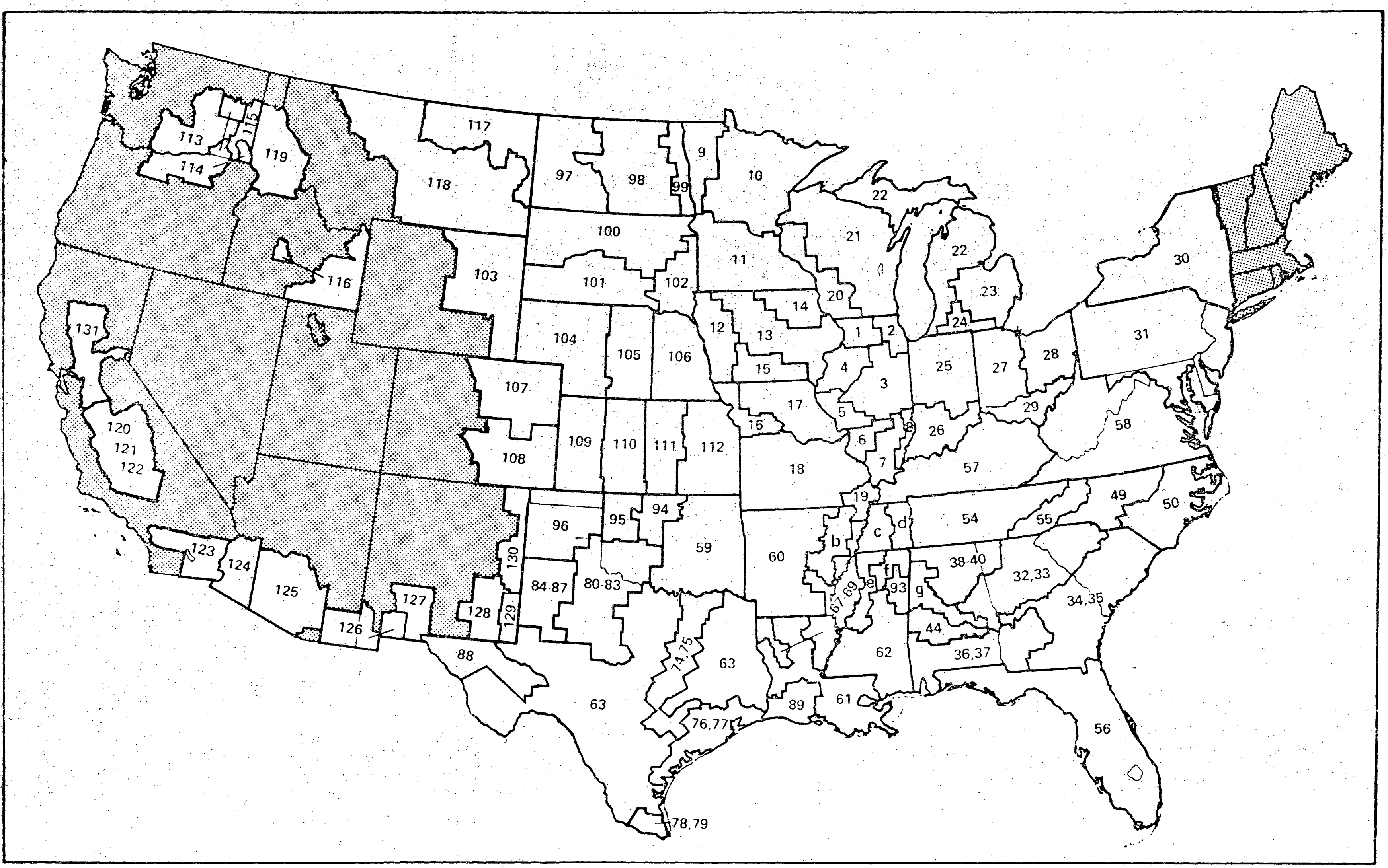
One model is a linear programming cost-minimizing model (Cost model), which is similar in structure and purpose to the Iowa State model. The second formulation is also a linear programming model; however, its objective is to maximize consumers' plus producers' surplus. (Surplus model) For a discussion of the Surplus model methodology, see an article by J.H. Duloy and R.D. Norton in the November 1975 issue of the AJAE entitled, "Prices and Incomes in Linear Programming Models". If it were not for differences in model specification, the two models would have yielded exactly the same acreage and transportation solutions. The data input for both models were analogous, except for demand information required by the Surplus model. The domestic and export farm level price elasticities used for the Surplus model were obtained from P.S. George's and G.A. King's publication entitled, Consumer Demand for Food Commodities in the United States with Projections for 1980, Giannini Foundation Monograph No. 26, March 1971 and personal communication with T.A. Hieronymous and S.C. Schmidt at the University of Illinois.

Producing Regions

The contiguous United States was divided into 137 producing regions. (Figure 6) The variable costs of producing corn, soybeans, wheat, oats, barley, rye, grain sorghum and cotton in applicable regions was obtained from the Economic Research Service. Yield data was provided by the ERS's Aggregate Production Analysis System (APAS). Data from many state and regional research publications were also used. Cost data was adjusted to reflect 1973 costs. Production activities for at least two crops were included in the model for each producing region. Where appropriate, both dryland and irrigated crop production activities were defined. Land flexibility constraints were specified at 50 and 150 percent of the 1973 acreages of a region's crops. The total cropland constraint for each producing region was the sum of: 1) planted acreages of all crops whose production was endogenous to the model, 2) acreages in fallow, if production activities for sequences of small grain and fallow were defined for that region, and 3) total acreage of land in government diversion and set aside programs. Production region data requirements are identical for the Surplus and Cost models.

Consuming Regions

Twenty-one consuming region delineations were made. (Figure 7) In the Cost model, commodity demand for each consuming region was separated into: 1) domestic demand for specified commodities for human consumption, 2) export demand for specified commodities, 3) domestic seed demand, 4) domestic demand for specified grains by all livestock except cattle, sheep and swine, and 5) domestic nutrient



[a]Crop production in the shaded areas is exogenous to the model.

[b]70-73 [e]64-66

[c]45-48 [f]90-92

[d]51-53 [g]41-43

Figure 6. Delineation of University of Illinois' models Producing Regions.

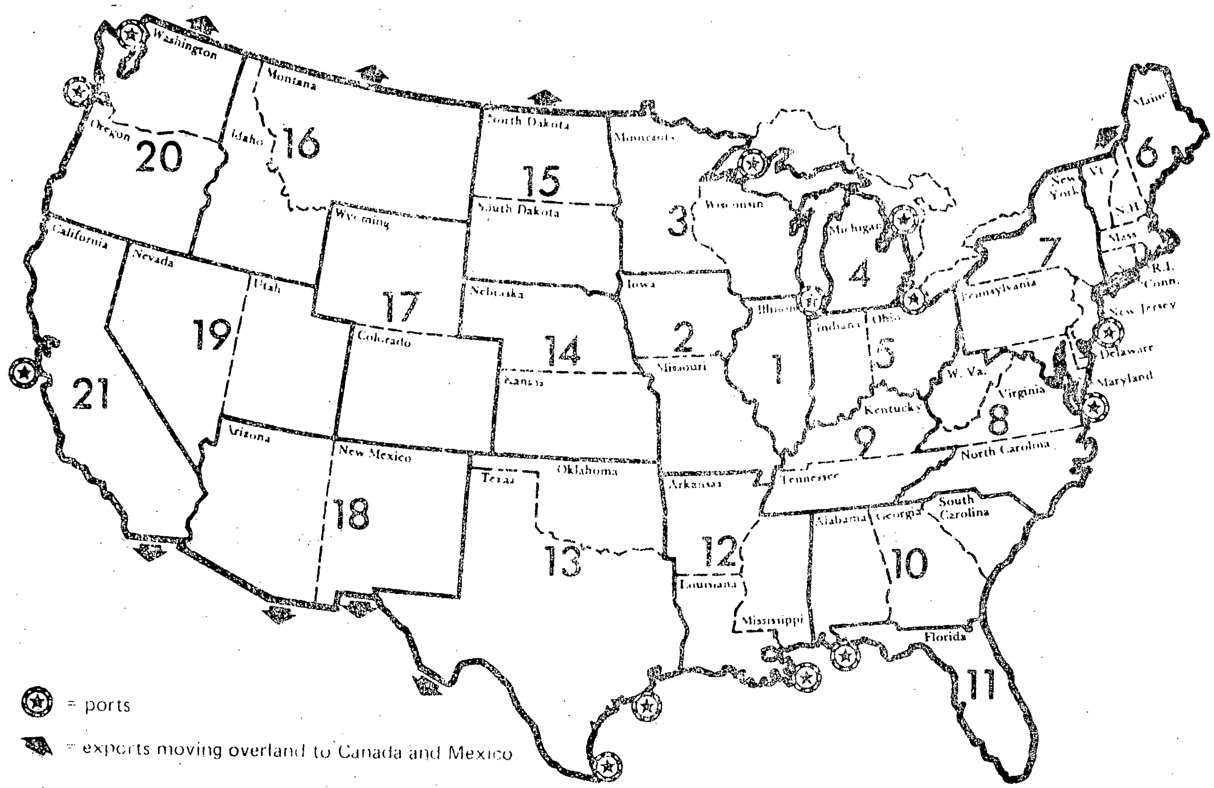


Figure 7. Delineation of University of Illinois Models Consuming Regions.

demand, specifically total digestible nutrients (TDN) and digestible protein (DP) by cattle, sheep and swine. Export demand for each crop was specified by port and added to domestic demand in the consuming region corresponding to that port. Exports of corn and soybeans moving overland to Mexico and Canada were added to domestic demand in consuming regions bordering these countries. Livestock nutrient demand was separated into demand by livestock type, because the nutritional value of feeds depends upon animal type. Demand for feed for cattle, sheep and swine was divided into demand for total digestible nutrients and demand for digestible protein. Total digestible nutrients and digestible protein requirements were allocated to the consuming region by the number of grain-consuming animal units of each livestock type. A constraint was placed on the total weight of the feed so that the nutrient requirements would be satisfied without excessive bulk. Livestock nutrient demand was incorporated into the model in this manner to gain added precision and make feed composition endogenous to the model. Demand for food was determined by multiplying human population in each consuming region by average per capita consumption. Similarly, the poultry demand and "other" livestock feed demand was the product of animal numbers and average per capita use.

With the Surplus model, regional demand functions for three commodity groups were specified--foodgrains, feedgrains and oilmeals. It was assumed that the demand function for a particular use was of the form:

$$Q = a - bP$$

where Q = quantity demanded
P = price
a, b = nonnegative parameters

The parameters of the function were computed by first specifying the demand elasticity, e, and then applying the following formula:

$$b = \frac{\overline{Q}e}{\overline{P}}$$

$$a = \overline{Q} + b\overline{P}$$

where $\overline{Q}$ = approximate quantity demanded in 1975

$\overline{P}$ = shadow price (marginal cost) associated with $\overline{Q}$ in the benchmark, cost model. The benchmark solution is a solution using 1973 demand and export levels.

The total demand function for a commodity group in a specified consuming region was obtained by summing domestic and export demand.

Transportation Costs

The rail transportation cost functions used in estimating the cost of transporting commodities between regions were taken from the work of Eyvindson. [2] In addition to rail transportation activities, barge transportation activities were included for those regions which had access to this mode. Barge transportation activities were constrained at their high level in recent years. Trucking activities were not included in either model.

Linear Programming Model

The linear programming Cost model minimizes national crop production and transportation costs. The objective function includes the following cost coefficients:

1. All variable costs of producing one acre of each crop type in each of the producing regions for dryland and irrigated acreages.

2. The cost of transporting one unit of a crop type among regions by rail.

3. The cost of transporting one unit of a crop type among applicable regions by barge.

The above costs are minimized subject to the following constraints:

1. Total amount of land (dryland and irrigated) in the producing region must be less than or equal to land available for grain production in that region.

2. In addition to regional land availabilities, the level of production of the individual crops is constrained by upper and lower bounds.

3. Constraints require that all regional grain demands (food, poultry, "other") be met. That is, regional grain production, plus grain inflow, minus grain outflow must be at least equal to that region's grain demands.

4. Constraints require the production of cotton lint be at least as large as the national demand.

5. Constraints require that regional cattle, sheep, and swine nutrient demands be met.

6. Constraints require that pea demand in the pea area of the Northwest be met.

7. Constraints restrict the level of available barge transportation.

All columns of the Surplus model matrix are analogous to those of the cost model; except for the last columns which represent stepwise approximations to the area under demand functions for the three commodity groups--foodgrains, feedgrains and oilmeals. Consumers', plus producers' surplus is maximized subject to the following row constraints: cropland, supply-demand balances for each commodity group in each region, cotton lint production, pea production in the Northwest, barge transportation flexibility constraints on land and convex combination constraints for incorporating the stepped demand functions into the model.

The solution to the Cost model gives the acreages of eight commodities (corn, soybeans, wheat, oats, barley, rye, grain sorghum and cotton) in 137 producing regions that minimize the cost of producing and transporting commodities given resource availability, technology and the quantities of various commodities that must be available for consumption in 21 consuming areas.

The Surplus model solution gives the acreages of the eight commodities which maximize consumers, plus producers surplus given resource availability and technology.

As previously discussed, parametric analysis on either model can be accomplished by effecting objective function coefficients or constraints.

UNIVERSITY OF ILLINOIS MODELS
(Judge, etc.)

During the 1960's, George Judge collaborated with several individuals on commodity interregional models. In 1962, Judge and Hieronymous published, Interregional Analysis of the Corn Sector, AERR-55, and in 1965 Guedry and Judge collaborated on The Spatial Structure of the Feed Grain Economy, AERR-78. As indicated by the titles, the Judge and Hieronymous study focused on corn, while the Guedry and Judge study delt with all feedgrain. The methodologies employed in each study was analogous. The following discussion will elaborate on the Guedry and Judge work.

Supply Region

The area under investigation in this study was the continental limits of the United States. A state was taken as the regional unit, with the exception of several New England States which were aggregated--a total of 42 regions resulted. One city within each region, located near its center of producing, consuming or exporting area was selected as the basing point.

Total available supply of feedgrain was determined on the basis of the following information: 1) production of feedgrain for the year, 2) beginning stocks of feedgrain as of October 1, and 3) ending stocks of feed grains as of September 31. The study included corn, oats, barley and grain sorghum.

Regional Demands

The demands were annual demands, which were obtained from secondary sources. Demands for feed grain included commercial, export and feed uses. Because grains can substitute for each other to meet feed demand, all demands were placed on a corn equivalent per hundred-weight basis, based on protein content. Export demands were taken from published data on shipments from port areas. The number of animal units in each region formed the basis for determining regional feed demands.

Transportation Costs

An estimated transport cost function, based on published rail freight rates, the ICC carload waybill statistics and truck and water transport rates relevant to private grain companies, provided the basis for most rates utilized in the analysis. Only minimum truck barge or rail rates between regions were included in the model.

Linear Programming Model

To derive minimum cost flows of feed grain among the region, the following cost coefficient was entered in the objective function:

1. the cost of transporting a specified feedgrain among regions to meet alternative types of demand.

Cost of transportation is minimized subject to the following constraints:

1. total amount of grain flowing out of a region must be less than or equal to that available, and

2. grain demands in all regions must be met.

The model determines the magnitude and direction of feedgrain flows between each possible pair of regions that minimizes total transport cost. Parametric analysis can be applied to the objective function or right-hand-side constraints to resolve sensitivity of solution.

SUMMARY

Table 1 summarizes some of the relevant characteristics of the discussed models.

The Iowa State model and the University of Illinois cost model (Taylor, Blokland, and Swanson) are similar with respect to intent and included variables. Solutions to these models specify the least-cost location of grain production and magnitude of grain flows from alternative production regions to consuming regions via each mode. The principal endogenous inputs to the model include; crop budgets for each region, regional land constraints, transportation costs between regions, regional domestic demands and export demands. Neither summary indicated if the model selected the transportation mode on interregional shipments or whether the mode was resolved endogenously. The Iowa State model included two time periods, whereas, the Illinois model included one time period. Both were cost minimizing linear programming models. The product of the University of Illinois surplus model is analogous to the above producers', plus consumers' surplus.

The focus of the Oklahoma State models were somewhat different from the Iowa State and University of Illinois models (Taylor, Blokland and Swanson). The Oklahoma State models determined grain distribution patterns which minimized total cost of storage, acquisition, processing and transportation for the grain marketing system, given existing structure and competitive conditions. This model was not constructed to optimize location of crop production, as were the above models. The principal endogenous data inputs to the model were; level of regional grain production, transportation rates (costs) between grain origin and consumption regions, grain storage capacity and costs in each region, flour millling capacity and costs in each region, grain handling costs in each region, level of regional grain and flour demand, and export demands. The Oklahoma State model was a cost minimizing linear programming model, which included four time periods.

The University of Illinois models (Judge, etc.) included less detail and fewer variables than the above models. These models resolved the flow of grain between regions which minimized total transportation rates. Endogenous data inputs to the model include grain supply in each region, grain demand (domestic, foreign) in each region and transportation rates between regions. The cost-minimizing linear programming model included one time period.

Table 1. Model Characteristics.

Model	Grain Types Included				Time Periods	Model Type		Transportation		Models Research Product				
	Wheat	Feedgrain	Soybeans	Rice		Cost Minimization	Surplus Maximization	Rates	Costs	Optimum Location, Level and Cost of Regional Crop Production	Optimum Flow of Grain Between Regions and Associated Transportation Cost	Optimum Choice of Transportation Mode a/	Optimum Level of Region Grain Storage	Optimum Levels of Grain Processing Capacity and Product Distribution Costs
IOWA STATE	X	X	X		2 b/	X			X	X	X	X		
OKLAHOMA STATE														
Leath, Blakely	X	X	X		4	X		X			X	X	X	c/
Schnake, Franzmann	X	X	X		4	X			X		X	X	X	c/
ILLINOIS														
Taylor, Blokland, Swanson														
Cost Model	X	X	X		1	X			X	X	X	X		
Surplus Model	X	X	X		1		X		X	X	X	X		
Judge														
Guedry, Judge		X			1	X		X			X	X		
Hieronymous, Judge		d/			1	X		X			X	X		

a/ For most models all feasible transportation cost alternatives were enumerated and the least-cost selection entered in the model. This was necessary to reduce matrix size and computation cost.

b/ Wheat is on an annual basis, while soybeans and feedgrain involve two time periods.

c/ Flour milling.

d/ Corn.

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