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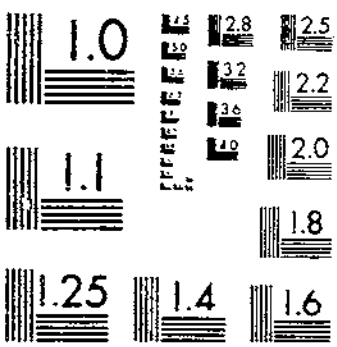

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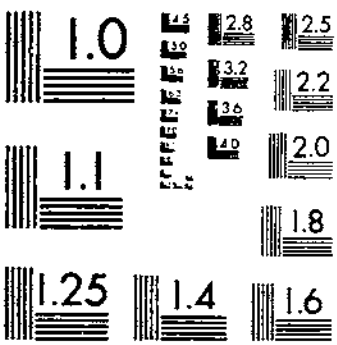

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Analysis of the Effects of Cost-of-Service Transportation Rates on the U.S. Grain Marketing System

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PREFACE

The purpose of the study was to analyze effects of a cost-of-service transportation rate structure on the U. S. grain marketing system. This report supplements An Interregional Analysis of the U.S. Grain Marketing Industry, 1966/67, issued by the Economic Research Service (ERS), U.S. Department of Agriculture (USDA), in November 1971, as Technical Bulletin 1444. Cost-of-service transportation charges for transporting grain via truck, rail, and barge were developed and used as input data in alternative formulations of a mathematical model of the grain marketing system. In this model, linear programming procedures were used which determined simultaneously the geographical flows of wheat, feed grain, soybeans, and wheat flour in such a way that total cost of storage, assembly, milling, and distribution for the system was minimized. Results of alternative formulations were compared with each other as well as with results of model formulations which used existing transportation rates.

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Washington, D.C. 20250 October 1973

SUMMARY

Costs of transportation services to carriers (truck, rail, and barge) for transporting grain and flour were developed by synthesis for specified U.S. regions from secondary data for marketing year 1966/67. These costs served as input data for an operational mathematical transshipment model used to analyze effects of a cost-of-service transportation rate structure on the U.S. grain marketing system.

Two formulations of the basic transshipment model were involved in studying utilization of flour milling capacity and the associated least-cost interregional flows of hard, soft, and durum wheats; feed grains; soybeans; and hard wheat and soft wheat flours. Cost-of-service transportation rates were considered effective. The first formulation, model I-C, determined the least-cost flows and optimum milling capacity utilization, given 1966/67 regional demands, supplies, marketing costs, milling capacities, and estimated cost-of-service transportation rates. Comparing model I-C results with similar results from model I-R, which used existing transportation rates for 1966/67, provided an estimate of potential savings over the existing grain transportation rate structure. Model II-C, the second formulation, determined the optimum regional location of flour milling activities, given 1966/67 regional wheat supplies and flour requirements and cost-of-service transportation charges.

The cost of marketing grain and flour in model I-C was about $1,115 million, or a reduction attributable to a cost-of-service rate structure of about $262 million (19 percent) compared with model I-R. Domestic transportation cost, export transportation costs, and flour milling costs were approximately $661, $299, and $155 million, respectively, in model I-C, or reductions of about $136, $126, and $0.1 million, respectively. Combined costs of shipping wheat to mills, milling, and distributing flour were reduced over $41 million with cost-of-service transportation charges rather than existing rates. The most significant reduction was over $90 million in domestic transportation of feed grain. Export transportation costs were $50 million lower.

Eight regions had no change in hard wheat milling activities in model I-C compared with model I-R; seven of them experienced no change in soft wheat milling activities. Eleven regions shifted in utilization of milling capacity. The South Atlantic States experienced a net reduction in milling activities in model I-C because no hard wheat was milled. A decrease in hard wheat milling also occurred in the East South Central States. Five regions experienced greater capacity utilization. Three of them had increased hard wheat milling activities which more than offset their decreased soft wheat milling activities. One region gained milling capacity utilization solely from a rise in soft wheat milling; and one region increased milling capacity utilization when the volume rose of both hard wheat and soft wheat milled.

Model II-C differed from model I-C in that regional milling and storage capacities were not restricted but allowed to seek an optimum level. Total marketing costs of model II-C were about $1,090 million. Compared with the total for model I-R, the reduction was over $287 million. Savings in domestic transportation costs for shipping wheat and flour amounted to more than $47 million; costs of milling decreased less than $4 million. No hard wheat was milled in 15 of the 42 regions in model II-C. Seven of these regions were in the East South Central and South Atlantic States, although there was a net increase of hard wheat shipments to those States because hard wheat milling expanded greatly in Alabama.

ANALYSIS OF THE EFFECTS OF COST-OF-SERVICE TRANSPORTATION RATES ON THE U.S GRAIN MARKETING SYSTEM

By

L. D. Schnake and John R. Franzmann 1/

INTRODUCTION

The U.S. transportation system takes grain from where it is produced to where it will be used, and delivers it in the form and at the time needed. This system and its rates continue to be important in determining the location of facilities and the competitive position of participants in the U.S. grain marketing system.

Changes in transportation rates affect not only the shortrun flow pattern, but, more importantly, the longrun structural pattern of the industries involved. Uncertainty concerning future rate structures may have a restrictive effect on investments in new facilities with high fixed costs and on relocation of existing facilities.

Knowledge of possible effects of alternative transportation rates on the U.S. grain marketing system is of utmost importance to Government policymakers and in decisionmaking and planning by firms marketing, transporting, and processing grains and flour. Such information may be useful in determining location or expansion, or both, of facilities to transport, store, or process grain and grain products.

The Problem

Generally, the structure of transportation rates has been accepted as given data in studies of interregional competition. The consequence is unfortunate, as this practice supports a structure of locational organization based on transportation rates that may be arbitrary and temporary.

The costs of misallocation of resources in transportation may be only a small part of the total costs of resource misallocation in industries served by the transportation system. Overall, misallocation can mean that the commodities produced will be the wrong ones, as will be the places of production, processors, carriers, routes, and destinations.

1/ L. D. Schnake is an Agricultural Economist in the Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture, and is stationed at Manhattan, Kans. John R. Franzmann is an Associate Professor with the Department of Agricultural Economics, Oklahoma State University, Stillwater, Okla.

Concepts of value of service and public utility are reflected to some extent in existing rate structures. These concepts carry over from the period when national goals involved settling the West and building an industrial economy, when the need was not so much for low-cost transportation, but for abundant, low-priced transportation.

Considerable changes in ratemaking started in the late 1950's and gained impetus in the early 1960's when the Southern Railroad stated that larger equipment would lower its unit costs in support of its "Big John" rates. The case "Grain in Multiple-Car Shipments--River Crossings to the South" is now a landmark (13). 2/ Since that time, "Unit-Train" and "Rent-A-Train" rates have developed and cost of service has been the underlying element.

This bulletin supplements the study of the U.S. grain marketing system recently completed by Leath (21). He employed existing transportation rates to ascertain optimum flows of feed grain and wheat, optimum regional storage requirements, and optimum flour milling location under alternative capacity restraints with resultant flour flows. This supplemental study was needed to provide information on locational adjustment and optimum flows of grain and flour, given cost-of-service transportation rates.

In the study, costs of providing transportation services (to the carrier) were synthesized from secondary data for trucks, rails, and barges to reflect regional differences in costs. All other input data and the basic model were the same as those discussed by Leath (21, pp. 3-28).

Objectives

The prime objective was to evaluate the interregional aspects and competitive structure of the grain marketing system through use of an operational transshipment model that incorporated cost-of-service transportation rates. Achievement of the objective will provide information about possible effects of such a rate structure on the marketing system which would need consideration by decisionmakers and planners in firms marketing, transporting, and processing grains and flour, and by Government policymakers.

Specific objectives were to:

(1) Develop a methodology to determine costs to carriers (rail, truck, and barge) for transporting grain and flour;
(2) Estimate the per unit cost of transporting grain and flour between selected origins and destinations in the continental United States; and
(3) Evaluate the effects on optimum grain and flour flows, optimum processing locations, and grain marketing costs of cost-of-service transportation rates for grain and flour.

2/ Underscored numbers in parentheses refer to entries in Literature Cited.

ANALYTICAL PROCEDURES

The purpose of this section is to (1) explain briefly the general model used in this study, (2) give sources of the input data which were used in alternative formulations of the general model, and (3) present the alternative formulations of the model used to accomplish study objectives.

The General Model

The general model used in the study is discussed in detail by Leath (21, pp. 3-8) and is usually referred to as the transshipment model. Basically, this model, used in a linear programming format, represents a reformulation of the Leath and Martin transshipment model (22, 23). The transshipment model used here contained:

(1) Five primary products--hard, soft, and durum wheats, feed grains, and soybeans;
(2) Two processed products--hard wheat flour and soft wheat flour;
(3) Forty-two domestic regions with associated production, commercial storage, and flour milling activities;
(4) Thirteen export regions; and
(5) Flour grain demands associated with each region.

The simplifying assumptions made to reduce the model to a manageable size were (21, p. 4):

(1) Regional production and consumption take place at particular points in each region, and quantities supplied and demanded are preassigned.
(2) Transfer charges between regions include loading costs at origin and receiving costs at destination; the per unit charge between two regions is independent of the number of units moved; and the supply of transportation facilities at any origin is perfectly elastic.
(3) Only that quantity of wheat required to meet the domestic and export demands for flour moves through the processing sector.
(4) Feed grains are perfect substitutes, and domestic and export requirements are met by the "least-cost" type of grain. 3/
(5) Feed milling is decentralized and occurs at points of consumption, thus eliminating the need for a feed milling sector in the model.
(6) Soybean crushing plants represent the final domestic demand for soybeans.
(7) The domestic demand for durum wheat for processing is specified at the durum wheat mill locations, and the distribution of the semolina flour involved is excluded from the model.

3/ Because feed grains are assumed to be perfect substitutes and feed milling is assumed to be decentralized (assumption 5), "least-cost" feed grain in this case is determined by the least cost of transportation from origin to destination. This assumption is necessary to satisfy objective 3 of the study. Also, see (21, pp. 4 and 24).

The scope of the study required concerted efforts in data collection. The validity of its conclusions depend in part on the accuracy of the data used. The tremendous data requirements prohibited generating statistics specifically for the model because of budget and time constraints; thus, secondary data were used. The general model discussed briefly earlier required four types of data: (1) regional supplies of each grain, (2) regional demands (consumption) of each grain, (3) regional capacities in storage and processing, and (4) regional marketing costs or charges, or both, for performing various functions.

"Supplies" and "demands" as used in the study are simply the respective quantities available and quantities required by the regions under consideration in the study and are not to be confused with these terms as used in economic theory.

Supplies of hard, soft, and durum wheats, feed grains, and soybeans were 1966 crop off-farm sales (43, pp. 5-19) plus off-farm (commercial) stocks (47, pp. 4-16) of previous crops on hand July 1, 1966. Hard wheat was defined to include the Hard Red Winter and Hard Red Spring classes. Soft wheat included Soft Red Winter and White. Durum wheat was considered a separate type, as it is milled in specialized mills and does not compete for the same milling capacity as do the two other types. The product, feed grain, included those grains grown primarily for livestock feed (corn, oats, barley, and grain sorghum). Soybeans were studied because they are a major competitor for storage space in many grain-producing areas.

As aggregate supply data were not available for the wheats in the model, regional supplies for each type were estimated by taking the acreage of the type of wheat in the region relative to the total acreage in the region (41, pp. 55-65).

In general, demands for the five grains considered in the study may be classified as (1) livestock feed, (2) industrial uses, including food processing, (3) seed, and (4) exports. For the two types of flour, domestic and export demands were estimated.

Wheat Demands

As noted, regional data for quantities of wheat used in livestock feeding, in addition to wheat fed on farms where grown, were not available. Thus, wheat procurements from off-farm sources for livestock feeding were not considered. As a result, domestic wheat disappearance was underestimated by approximately 60 million bushels, but was compensated for in regional estimates of feed grain for livestock feeding. Therefore, ending wheat inventories were slightly increased and ending feed grain inventories were correspondingly lowered somewhat.

The majority (approximately 74 percent) of the domestic disappearance of wheat was for food, mostly as flour. Thus, food demand for wheat was accounted for by regional demands for hard wheat flour and soft wheat flour and mill demands for durum wheat. Flour demands by type were estimated (21, p. 16) from a 1963 study (1, pp. 66-67) and adjusted to 1966-67 per capita consumption estimates (46, p. 16) and for 1966 regional population estimates (48, p. 12).

The flour requirements in Kansas included 558,915 hundredweights of flour (divided equally between the two regions of Kansas) used for alcohol distillation in that State (62, p. 6). Flour demands did not include relief flour shipments because data were not available.

Data on the distribution of semolina flour milled from durum wheat were insufficient. Thus, the regional demands for durum wheat were computed by allocating the quantity of durum wheat milled in the United States among the regions having durum mills based on the proportion of total durum milling capacity located in each region (21, pp. 16 and 17).

Requirements of wheat for seed were specified as quantities required in excess of seed used on farms where produced.

Export demands (21, p. 18) by type of wheat were determined from published data on inspections for export by port (44).

Feed Grain

Regional feed grain requirements for livestock feed were estimated by allocating the total quantity of feed grain fed in the United States among the domestic regions in proportion to the total number of grain-consuming animal units fed during the feeding year. These regional estimates were reduced by the quantities of wheat and feed grain fed on farms where grown (21, pp.17 and 18).

Industrial uses of feed grains include dry-corn milling, wet processing, cereal manufacturing, malting, and distilling and brewing. However, regional data were available only for distilling and brewing (62, pp. 7 and 41). Regional data for other industrial uses were derived (21, pp. 19-21). Dry-corn milling was proportioned according to milling capacity of such mills reported in a corn milling industry directory (28). When millers wished to keep their capacity confidential, regional average capacity was assigned to their mills. Regional requirements for wet-corn milling, barley malting, and cereal processing were determined by allocating the aggregate demands proportional to individual plant employment statistics for the appropriate industry as reported by the Bureau of Census (50, pp. 75 and 76).

Annual planted crop acreages were used to allocate feed grain disappearance for seed requirements (40, p. 48). In some regions, quantities of wheat and feed grain fed on farms where grown exceeded the estimated livestock feed requirements. In these cases, the excess was deducted from the seed requirements (21, pp. 18 and 20).

As with wheat, export demands for feed grain were also determined from published data on inspections for export. Feed grains in each port region were aggregated (62, vols. 14 and 15, 1966 and 1967, selected issues; and 21, p.21).

Soybean Demands

The two major domestic requirements for soybeans are processing and seed. Soybeans for processing (crushing) were allocated among the regions by proportioning the aggregate crush according to regional crushing capacity (42, p. 24). Published data on regional soybean seed requirements (43, p. 18) were adjusted downward to reflect the amount of seed used on farms where produced (21, p. 20). Published data on inspections were used to determine the export demand for soybeans (44).

Regional Capacities and Associated Charges

Grain Storage

Two types of facilities, country and terminal elevators, were combined to comprise the handling and storage capacity studied. Because location and capacity data on Commodity Credit Corporation (CCC) bin sites were not available, these data could not be included (21, p. 22). Estimates of off-farm storage by region were those used by Leath (21, p. 23).

The standard storage charges of CCC's Uniform Grain Storage Agreement were used for the costs of storage because elevator operators' charges for storing commercial stocks of grain seemed to be closely related to the negotiated charges paid by CCC (21, p. 27). The prevailing rate was $0.00036 per bushel per day for commingled grain, or 13.14 cents per bushel annually.

Flour Milling

Regional flour milling capacities were obtained from a directory of the flour milling industry (28, Sept. issue, p. 9). Individual mill capacities for each appropriate region were aggregated to arrive at total regional milling capacities (21, p. 26).

The costs of milling flour used for this model were derived (21, pp. 27 and 28) from data reported in (26, pp. 37 and 117). As millfeed was not included in the study, these data were adjusted to cost per unit of flour on a bushel of wheat equivalent basis. The milling cost per unit of product sold was proportioned by the number of pounds of flour in the final product mix from milling wheat.

Transportation Costs

Transportation costs used for trucks, rails, and barges were synthesized from secondary data. Regional cost estimates were synthesized for trucks and rails, and weighted regional costs were used to estimate interregional cost-of-service transportation charges for grain and flour. Barge cost-of-service transportation charges were developed for specified origins and destinations which account for navigational factors that affect barging costs significantly.

Model Formulations

Two formulations of the general model were used to generate optimum solutions employed in conjunction with the solution formulated by Leath as model I (21, p. 9). 4/ The purpose of this section is to specify these models and show how various comparisons of them were used to accomplish the objectives.

Basic to the model formulations discussed below is a unit of measure. The unit used throughout was 10,000 bushels with flour demands, milling capacity, and milling cost converted to wheat equivalents.

Model I-C

Model I-C was designed to be compared with model I-R to provide information relative to study objective 3. The supply and demand conditions and cost relationships mentioned earlier were assumed to hold. The regional flour milling capacity assigned was annual capacity based on daily capacity of mills existing as of July 1967 and operating 254 days. The only difference between models I-C and I-R was the transportation cost input data. Whereas existing (1966/67) transportation rates for grain and flour were used in model I-R, model I-C contained estimated costs of transportation services to carriers. The development of these costs is detailed later in this study.

An optimum solution of model I-C yielding a distribution pattern which minimizes total cost of storage, acquisition, processing, and distribution to the grain marketing system was compared with an optimum solution of model I-R. This comparison allowed analyses of changes in shipping flows, milling capacity utilization, ending grain inventories, and potential savings from a cost-of-service transportation rate structure for the 1966/67 marketing year.

Model II-C

Model II-C was designed, in part, to examine the possible effects of cost-of-service transportation rates on the location of flour mills to partially fulfill objective 3. This analysis was made by relaxing the regional milling and storage capacity restraints of model I-C and allowing each region to seek an optimum, or equilibrium level of capacity. In turn, the optimum solution obtained from this model, compared with the solution of model I-R, provided an estimate of longrun changes in flow patterns, milling capacity location, and costs to the grain marketing system with cost-of-service transportation rates effective.

4/ Future reference to Leath's model I will be model I-R.

DEVELOPMENT OF COST-OF-SERVICE TRANSPORTATION CHARGES

The overall objective, as mentioned, was to evaluate the effects of a cost-of-service transportation rate structure on the U.S. grain marketing system. Fulfilling this objective required development of transportation charges which estimated the cost to the carrier(s) of providing transportation services to the grain industry. A major effort was required to develop such costs because grain is moved by any one or combinations of the three surface modes of transportation.

A basic assumption made in developing costs of services to the carrier(s) was that grain is a homogeneous commodity for purposes of transportation. Thus, there would be no discrimination in costs among the grains. However, for several reasons, separate transportation costs were developed for grain and flour to reflect industry practice and experience. These reasons included different loading weights on vehicles for grains and flour as reported by industry sources, legal weight limits on highways, industry experience with "average" car sizes, health regulations regarding food items, and economic factors associated with specified equipment for grain and for flour.

Previous research on cost-of-service transportation for a national study has not been attempted. In a recent study, Wright (65) referred to a cost-of-service rate structure by using a simple linear relationship of mileage and cost: 1 mile equal to 0.1 cent, 10 miles to 1 cent, and so forth. The costs of transportation used in the study are a synthesis of costs for conditions which existed for trucks, rails, and barges in 1966, accounting for regional variations.

Trucking Costs

When hauled by truck, grain is exempt from Interstate Commerce Commission (ICC) rate regulation. Data on costs of hauling grain by truck are virtually nonexistent. A study by Cassavant and Nelson (2) for North Dakota revealed much information on grain trucking costs for that area; however similar studies for other States or regions have not been made. Data on costs of trucking flour also are not readily available. Thus, the basic data for flour transportation by truck in the study assumed a truck-tractor which could haul either grain or flour.

The cost of transportation by truck was divided into categories:

1. Investment costs
   - a. Capital outlays
     - 1) Truck-tractors and trailers
     - 2) Garaging facility
   - b. Depreciation
   - c. Returns to management
   - d. Interest on investment
   - e. Real estate taxes
2. Operating costs
   - a. Insurance
     - 1) Public liability and collision

2) Cargo loss and damage
3) Fire insurance

b. Licenses and road-user taxes
c. Driver-mechanic wages
d. Fuel
e. Tires
f. Maintenance
g. Administrative and utilities

Functionally, these costs were expressed as:

$$T_{ij} = \frac{\alpha}{\rho} \frac{x}{\lambda} \qquad (1)$$

where T_{ij} = truck cost-of-service transportation charges per bushel-mile for hauling grain (flour) from origin i to destination j;

α = the cost per running mile for operating tractor-trailer trucks;

ρ = the percentage of total mileage which is laden;

x = the point-to-point mileage between origin and destination; and

λ = the load of the truck expressed in bushels.

α was defined as:

$$\alpha = I + O \qquad (2)$$

where I = investment costs per running mile, and

O = operating costs per running mile.

Further investment costs were defined as:

$$I = \sum_i D_i + R + I + t \qquad (3)$$

where D_i = depreciation per running mile on garaging facilities, truck-tractors, and trailers;

R = returns to management per running mile;

I = interest cost on investment minus salvage value of garaging facilities, truck-tractors, and trailers; and

t = real estate taxes per running mile.

Operating costs were defined as:

$$O = \sum_i P_i + \sum_i L_i + W + F + S + M + A \qquad (4)$$

where P_i = insurance costs per running mile for public liability and collision, cargo loss and damage, and fire;

L_i = license fees and road-user taxes per running mile;

W = drivers' wages per running mile;

F = fuel costs per running mile;

S = tire and tube cost per running mile;

M = maintenance and repair costs of truck-tractor and trailer units per running mile; and

A = administrative expenses and utility costs per running mile.

Each of the costs listed above will be discussed. First, a brief word should be mentioned about the firm. Cassavant and Nelson found that no noticeable economies of size were realized by increasing the firm's size beyond three tractors and four trailers (2, p.33). In a 1966 study by Milikus, the median size was a five-tractor firm (25, p. 6). For the current study, firms hauling grain and firms hauling flour were assumed to have three tractors and four trailers. Another consideration was the number of miles the vehicle was driven annually. Since appropriate trucking cost curves were not available, assumptions about annual mileage were imperative. Data from the U.S. Department of Commerce indicated 70,000 miles per year for all types of tractor-trailer vehicles (53, p. 9). DeWolfe reported mileages by regions for carriers hauling exempt agricultural commodities in 1961 (6, p. 39). These data are presented in appendix table 1 and were adjusted to 1966 mileages using ICC data for regulated motor carriers (19, pp. 32-33). The assumption was that the mileage traveled by grain haulers would follow the same pattern as that of the regulated carriers. The procedure used was to correct the ICC data on the mileage for North Dakota firms which were operating at nearly optimum efficiency at the 45-percent level of capacity or 67,500 miles annually (2, p. 42). These adjusted data are presented in appendix table 1.

Another important consideration in grain transportation is backhaul. Backhaul data were estimated using statistics from DeWolfe on laden miles per vehicle by region (6, p. 12). The percentages of laden miles by region used in the study are presented in appendix table 1.

Investment Costs

For clarity and brevity of presentation of the various items of investment costs, descriptive information will be included in the discussion of each item. Capital items necessary for the trucking firms considered were truck-tractors, grain trailers, or pneumatic bulk flour trailers. Since grain trucking firms are rather specialized and are not usually located near large specialized maintenance facilities, a capital outlay for a maintenance garaging facility was considered necessary.

Truck-Tractors and Trailers.--New equipment was specified in the study, as it is most difficult to define a "used" truck or trailer and arrive at regional investment costs as well as depreciation and operating costs. The tractor specified for the study was a diesel with tandem axle, capable of pulling 72,000 pounds gross vehicle weight. This particular vehicle can handle a maximum load for most regions specified in the model. The grain trailer specified was a tandem axle, aluminum, exterior post trailer capable of hauling a payload equivalent to 800 bushels of wheat averaging 60 pounds per bushel, or a load of 24 tons. The pneumatic flour trailer was also specified to be a tandem axle trailer with an auxiliary electric motor to provide power for unloading. Because the flour trailer is a heavier vehicle, the payload was 45,000 pounds of flour, or 22.5 tons.

Initial costs for tractors and trailers as specified above were supplied by major truck manufacturers, trailer manufacturers, and industry people using the equipment. The costs were assumed to vary by region only by the State sales taxes imposed on the new vehicles. The base prices used which were averages of prices received from the sources mentioned above are:

Tandem axle tractors	$21,040
Tandem axle grain trailers	6,850
Tandem axle pneumatic flour trailer	22,896

The State sales tax rates used for adjustment are given in appendix table 1 (55, p. 11).

Garaging Facility.--The assumption was made that the trucking firm would need to repair only one tractor-trailer unit at any one time; thus, the garaging facility specified was of a size to accommodate one tractor and one trailer. The cost of such a facility was based on the cost of $4,800 found by Cassavant and Nelson (2, p. 16). This figure was adjusted for each State through a construction cost index.

The "total" index of a representative company (32, p. 95) was regressed on Standard Metropolitan Area (SMSA) populations (49) for the points listed in the index and also dummy variables for regions. The equation was:

$$Y_j = B_0 + B_1 X_{1j} + \sum_{k=1}^{8} d_k D_{kj} + e_t$$

where Y_j = the representative company cost index for city j;

X_{1j} = the SMSA population in city j and

D_{kj} = dummy variables associated with the nine regions. 5/

5/ The regional delineation was determined on the basis of statistical considerations. The regions (numbered) and States included in each are: (1) Wash., Oreg., Calif.; (2) Mont., Idaho, Utah, Ariz., Wyo., Colo., N. Mex.; (3) Minn., Iowa, Mo., N. Dak., S. Dak., Nebr. Kans.; (4) Ark., La., Tex., Okla.; (5) Ohio, Ind., Ill., Mich., Wisc.; (6) Ga., Fla., Ala., Miss.; (7) Ky., Va., W. Va., Md., N.C., S.C.; (8) Pa., N.J.; and (9) Conn., Me., Mass., N.H., N.Y., R.I., and Vt.

The resulting regression equation was:

$$Y_j = 103.17493 - 3.08121X_{1j} - 7.90527D_1 - 6.25732D_2 - 13.59441D_3 - 4.47440D_4 - 15.20495D_5 - 14.07675D_6 + 1.24344D_7 + 1.31051D_8. \quad (5)$$

The computed R^2 statistic was 0.89. If States were not represented by cities in the SMSA population data, indexes were estimated by averaging those of the surrounding States. The regions were chosen so that the total number of observations (city populations reported) would be as nearly equal as possible. The resulting garaging facility cost estimates are presented by State in appendix table 2.

Depreciation.--The services of garaging facilities are used over a period of time and may be considered as flow resources. The annual cost of such services may be computed by amortizing the investment over a suitable period of time. The services of trucking equipment are usually considered a function of time, but may be a function of use if the utilization rate is high. "If annual utilization rates exceed 100,000 miles, it is likely that depreciation is a function of use and not time" (30, p. 167). Since the utilization rate was less than 100,000 miles per year in the study, depreciation of trucks was considered a function of time.

The Internal Revenue Service establishes guidelines for depreciating various types of property (63). For garaging facilities, the estimated useful life is 45 years (63, p. 4) and was used in this report. For transportation equipment, "tractor units (over-the-road)," 4 years are allowed and for "trailers," 6 years are allowed (63, p. 3). Because the range of service for equipment which hauls grain and flour is light to medium, use is not considered extensive enough to warrant such a short amortization period. Cassavant and Nelson used a 10-year life expectancy for truck grain transportation equipment (2, p. 18). A similar life expectancy seemed reasonable for the study because new equipment was specified. A salvage value of 10 percent of the purchase price was assumed; thus, depreciation was on 90 percent of the purchase price of the equipment. These data are presented by States in appendix table 2.

Returns to Management.--Without a detailed study of management, it is difficult to state what returns to management are or should be. In the study, the managers of trucking firms were assumed to be drivers also. Cassavant and Nelson estimated the returns to management by asking various commercial trucking firms what they paid to persons holding a management-driver job in a grain trucking firm (2, p. 20). Their estimate was $6,500 per year, and that figure was used in the study.

Interest on Investment.--Interest on investment must be considered a cost, as such investment could earn income in other areas. The effective rate of return used in the study was 6 percent on the nondepreciating value of the garaging facility and transportation equipment (20, p. 4).

Real Estate Taxes.--Real estate taxes on garaging facilities were estimated by converting the market value or construction cost to an assessed value. Ratios of assessed value to market value as reported by the U.S. Bureau of the Census were computed (51, pp. 42-47). Each State's ratio was applied to estimated construction costs for that State. The tax rate came from the Statistical Abstract (56, p. 428). This rate was multiplied by assessed value to determine the tax. Real estate taxes are presented in appendix table 2. Taxes on truck equipment are discussed later.

Operating Costs

In addition to the investment in garaging facilities and transportation equipment, the actual operation of the grain trucking firm requires expenditures for insurance, licenses and taxes, driver-mechanic wages, fuel, tires, maintenance, administrative expenses, and utilities. Some of these operating costs are fixed and some are variable. Considered variable are fuel, tires, and maintenance which are a function of equipment use. The remainder can be considered fixed.

Insurance.--Insurance expenses to the grain trucking firm are incurred for public liability, cargo loss and damage, and fire insurance. Coverage for public liability was assumed to be the same as that used in (2, p. 18)--$50,000 to $100,000 and $10,000 property damage. The cost per vehicle was adjusted regionally by using the Class II Motor Carrier public liability insurance costs per mile as an index (19, pp. 24 and 25). These data are presented in appendix table 2 by State.

Cargo loss and damage insurance was estimated using the same data sources and procedures as for public liability insurance (app. table 2).

Fire, theft, and collision insurance cost was computed as a percentage of public liability insurance, again with the Class II Motor Carrier data mentioned above (app. table 2).

Garaging facility insurance was specified to be a standard insurance policy. The rates were furnished by D. B. Jeffrey of the Agricultural Economics Department, Oklahoma State University, and are presented in appendix table 2.

Licenses and Road-User Taxes.--Costs included under this heading were registration fees, property tax, mileage or ton-mile tax, and other taxes and fees paid by private carriers reported in (54, p. 62) for a diesel-powered, five-axle, tractor-semitrailer, 72,000 pounds gross vehicle weight. As these data did not include Federal annual vehicle use taxes, these taxes were added: $3 per 1,000 pounds gross combination weight or $216 for 72,000 pounds gross combination weight (60, p. 61). The data are contained in appendix table 2.

Driver-Mechanic Wages.--The drivers were assumed to perform vehicle maintenance, which will be discussed under maintenance costs. Cassavant and Nelson used a figure of 5 cents per mile for driver's wages (2, p. 21). This figure was adjusted to regional levels by using Bureau of Labor Statistics (BLS) hourly union wages for truck drivers (58, table 7) divided by ICC line-haul miles per

hour of regulated truckers (10, p. vi) to derive a wage per mile. This wage was indexed with the North Dakota derived wage per mile as the base. The derived wages were adjusted to include the employers' social security costs of 4.2 percent of the wages (57). These data are presented in appendix table 1.

Fuel Costs.--No data are published on wholesale or retail prices of diesel fuel for motor trucks as verified by correspondence with a petroleum industry pricing service. 6/ Thus, prices of diesel fuel No. 2 were obtained for the study from a major oil company. Also, transportation costs of fuel were furnished. Most truckers contract their fuel and receive it in tanker lots. On the road, they buy fuel from the contracting company at the price using the contract number. 7/ State fuel taxes as well as the Federal fuel tax came from published data (60, p. 8). To convert these data to a cost per mile, a fuel efficiency factor of 4.9 miles per gallon was used (60, p. 54). Fuel tax rates per gallon are in appendix table 1, and fuel costs per laden mile, in appendix table 2.

Tire and Tube Costs.--Tire wear is a function of several variables, none of which should vary to a great degree by type of trucking operation; that is, whether regulated or exempt from regulation. According to a transportation consultant, ICC data should be quite accurate in reflecting regional tire and tube costs for grain trucking firms. 8/ Thus, tire and tube costsper running mile were derived from ICC data presented in appendix table 1 (10, pp. 24 and 25).

Maintenance Costs.--In the study at North Dakota, Cassavant and Nelson used a figure of 0.9 cent per mile for maintenance (2, p. 23). This figure is only for engine maintenance and does not include other costs for transmissions, differentials, brakes, general chassis maintenance, or trailer maintenance. A more realistic figure reported by Kerchner was 3.19 cents per mile including 0.92 cent per mile for maintenance labor which was considered performed by the driver in the study (20, p. 6).

Administrative Expenses and Utilities.--Recordkeeping and general business management represent another cost for the grain trucking operation and are grouped here under the title of administrative expenses and utilities. Administrative salaries were not included but were considered to be part of the returns to management. Estimation of these expenses was made with data from (2, p. 20), (8, p. 13), and (20, p. 4). Variables were telephone costs, utility costs, and general administrative expenses. An average figure of $135 per month, or $1,620 per year, was used.

6/ Correspondence with Thomas Marshall, Assistant Editor of Platt's Oilgram and Oil Price Handbook.

7/ Information from Hoy A. Richards, Texas Transportation Institute, consultant to ERS, USDA.

8/ Information from Hoy A. Richards, Texas Transportation Institute, consultant to ERS, USDA.

Trucking Cost Summary

Grain and flour trucking costs are summarized by region in table 1. State data are reported in summary form in appendix table 2. Costs of grain handling and many transportation cost items are given regionally only. Thus, any attempt to specify trucking costs for grain and flour on a State-to-State basis for the model in the study means computing a host of interregional costs which would be an aggregate of various regional data. Therefore, to reduce the task involved in specifying trucking cost regions, the ICC regions of figure 1 were specified (10, cover page). 9/

To derive regional trucking costs for grain and bulk flour, weighted State data were used. State costs within the ICC regions of figure 1 were weighted by the proportional miles driven by for-hire trucks in each State (52, "Truck Inventory and Use Survey"--table 11). Mileages driven by for-hire trucks are given in appendix table 3, and proportional weights and State costs are presented in appendix table 2. To derive interregional trucking costs, regional cost data were weighted by the proportional average length of haul of Class I common carriers of freight for the regions delineated in figure 1. These trip mileages are presented in appendix table 3; costs per laden mile for transporting grain and bulk flour are in appendix table 4.

Costs per laden mile must be converted to a unit basis to be used in the model specified in part II. To maintain identity throughout the model, a common unit of expression was chosen--the bushel; flour was expressed as bushel equivalents of wheat. Further, since transfer costs between any two points had to be predetermined for the model, the mode of expression used was cost per bushel-mile.

Following the assumption that the grain trailer would haul 800 bushels, the costs per laden mile were divided by 800 bushels to derive a cost per bushel-mile for grain transportation. Regional and interregional truck transportation costs of service for grain and flour are presented in table 2. Since flour is transported both in bags and in bulk, it would not be realistic to use data on bulk flour cost-of-service transportation only. Data from the National Commission on Food Marketing were used to derive the percentages of flour shipped in bulk and in bags. Commercial, Government, and export flour were assumed to be transported 54.42 percent bagged (26, pp. 42 and 43). Commercial soft flour was assumed to move 35.36 percent bulk (26, p. 43), and family flour was assumed to move only in bags (100 percent). These percentages were applied to the appropriate proportion of the total flour considered to derive the ratio of 58 percent bagged to 42 percent bulk. Data are presented by type of flour in appendix table 5 for bagged flour and by subtraction from 100 percent, the remainder was assumed to be bulk flour. Costs per hundredweight-mile of transporting bulk flour are given in appendix table 6. This table presents the estimated costs per hundredweight-mile of hauling flour, 58 percent bagged and 42 percent bulk by region and interregionally. These data were computed by

9/ These regions are indicated here by Roman numerals for simplicity, whereas ICC uses geographical titles.

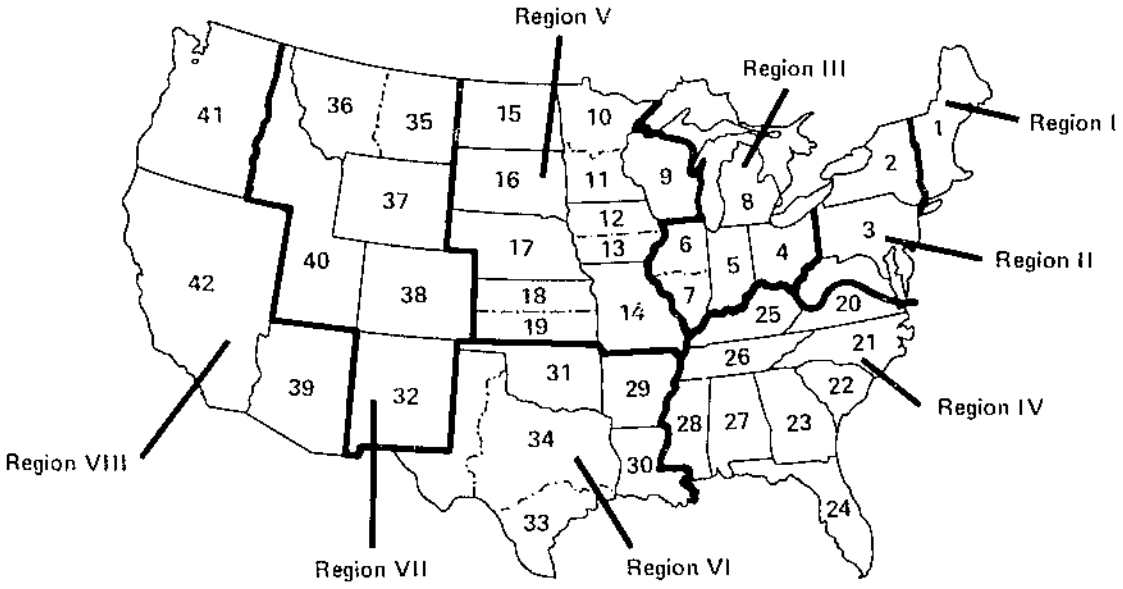
Table 1--Summary of grain and flour trucking costs by region, 1966 1/

Item	I New England	II Middle Atlantic	III Southern	IV Central	V Midwest	VI Southwest	VII Rocky Mountain	VIII Pacific
				Dollars				
Fixed costs:								
Investments in--								
Garage	5,700	5,241	4,918	4,977	4,860	4,461	4,292	4,990
Tractor	65,362	61,[illegible]	63,314	65,383	64,526	64,343	65,230	65,462
Grain trailer	28,243	28,252	28,226	28,257	27,876	27,971	28,182	28,237
Flour trailer	94,486	94,448	94,317	94,450	93,132	93,494	94,199	94,382
Total investment in--								
Grain trucking firms	98,905	95,[illegible]90	[illegible]1,[illegible]40	98,817	97,866	97,176	98,210	98,589
Flour trucking firms	165,088	163,220	164,048	164,810	162,537	162,694	164,228	164,739
Ownership costs:								
Annual depreciation of--								
Garage	115	117	98	111	108	99	106	111
Tractors	5,882	5,890	5,878	5,884	5,807	5,817	5,871	5,882
Grain trailers	2,542	2,543	2,539	2,543	2,509	2,516	2,531	2,541
Flour trailers	8,497	8,505	8,489	8,500	8,386	8,414	8,478	8,495
Total depreciation of--								
Grain trucking firms	8,542	8,553	8,515	8,538	8,424	8,432	8,514	8,535
Flour trucking firms	14,497	14,513	14,466	14,495	14,301	14,348	14,456	14,488
Annual interest on--								
Grain trucking firms	5,934	5,940	5,872	5,917	5,835	5,831	5,893	5,915
Flour trucking firms	9,884	9,914	9,869	9,889	9,751	9,782	9,854	9,885
Real estate taxes	101	145	71	82	93	48	52	68
Total ownership costs of--								
Grain trucking firms	14,617	14,637	14,484	14,527	14,352	14,320	14,048	10,188
Flour trucking firms	24,482	24,572	24,336	24,386	24,145	24,150	24,362	24,441
Operating costs:								
Returns to management	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Insurance:								
Public liability	298	286	342	226	180	162	117	156
Cargo loss and damage	20	19	17	17	21	21	18	18
Fire	43	49	46	39	34	18	30	67
Fire insurance-garage	53	51	50	51	51	46	50	52
Licenses and road-user taxes on vehicles	2,336	1,[illegible]55	1,780	2,445	2,374	2,035	3,389	2,174
Licenses and road-user taxes on farm	8,707	8,[illegible]43	5,330	7,134	7,122	6,106	10,194	6,303
Administrative expenses and utilities	1,620	1,[illegible]27	1,620	1,620	1,620	1,620	1,620	1,620
Total fixed operating costs	19,243	18,[illegible]77	13,755	15,967	15,526	14,473	18,528	14,755
				Cents				
Per laden mile-grain	12.67	[illegible].78	8.88	11.93	12.07	7.11	8.96	7.07
Per laden mile-flour	16.07	12.72	13.13	13.98	17.39	10.17	13.55	10.52
				Cents				
Variable costs:								
Operating-grain trucking:								
Driver-mechanic wages per laden mile	11.12	10.44	7.96	9.34	8.03	7.06	6.94	8.65
Fuel cost per laden mile	5.19	5.62	4.73	5.20	4.70	4.14	4.11	4.35
Maintenance cost per laden mile	5.03	5.08	4.57	5.02	4.68	4.47	4.24	4.37
Tire cost per laden mile	3.62	4.18	4.02	4.40	3.78	3.73	3.21	2.83
Total variable operating costs per laden mile-grain trucking	24.96	25.38	20.29	24.74	21.19	19.41	18.32	20.20
Operating-flour trucking:								
Driver-mechanic wages per laden mile	14.11	13.17	11.15	11.87	10.95	10.09	10.45	12.66
Fuel cost per laden mile	6.46	7.23	6.59	6.60	6.40	5.91	6.18	6.37
Maintenance cost per laden mile	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38
Tire cost per laden mile	5.60	5.72	4.59	5.50	5.19	5.37	4.87	4.14
Total variable operating costs per laden mile-flour trucking	32.55	32.50	28.69	30.17	28.92	27.75	27.36	29.56
				Percent				
Laden mile-percentage for--								
Grain trucks	64.29	64.64	70.71	64.63	68.31	71.55	76.14	73.54
Flour trucks	50.50	50.10	50.08	50.07	50.30	50.00	50.60	50.09
				Miles				
Annual mileage per vehicle	84,228	91,142	75,298	75,302	84,205	94,906	91,167	94,984
Total annual laden miles								
Grain-trucking firms	122,131	122,[illegible]00	160,019	141,342	119,485	204,280	208,238	209,060
Flour-trucking firms	94,857	93,788	112,943	112,954	96,158	142,359	136,752	142,476
				Cents				
Total costs-grain trucking firms:								
Ownership costs per laden mile	12.17	11.98	9.18	10.21	11.14	7.04	7.28	4.86
Operating costs per laden mile	37.59	34.98	28.87	34.80	33.24	26.53	27.29	27.27
Total	49.76	46.96	38.05	44.91	44.42	33.57	34.57	32.05
Total costs-flour trucking firms								
Ownership costs per laden mile	25.80	26.42	21.62	21.69	25.01	16.96	17.81	17.19
Operating costs per laden mile	47.14	47.[illegible]	40.[illegible]	44.14	46.[illegible]	37.87	41.11	40.10
Total	72.94	73.38	62.05	65.80	71.65	54.83	58.92	57.31

1/ Regional estimates of [illegible] of item represent weighted averages of State cost data [illegible]

Note: See fig. 1 for a delineation of trucking cost regions.

DELINEATION OF REGIONS USED IN STUDY OF TRUCKING COSTS IN GRAIN MARKETING SYSTEM



Source: Interstate Commerce Commision. Cost of Transporting Freight by Class I and Class II Motor Carriers of General Commodities by Regions of Territories for the Year 1966. Bur. of Accts., Stmt. 8-67, Wash., D.C. 1967, cover page.

Figure 1

assuming the trailer truck which hauls grain would transport a 480-hundredweight payload to be within legal highway weight limits. Weighting the cost figures for grain trucking by 0.58 and dividing by 480 hundredweights, and weighting the cost figures for flour trucking by 0.42 and dividing by 450 hundredweights resulted in a composite cost per hundredweight mile for transporting flour.

To solve the product identity problem mentioned, the data of appendix table 6 were converted to bushels of wheat-equivalent basis. A hundredweight of flour is milled from 139.697 pounds of wheat, or 2.328 bushels of wheat. Thus, the costs per hundredweight mile were multiplied by 0.4295 (1 ÷ 2.328) to obtain a cost per bushel-mile in wheat equivalents. These data are presented for regional and interregional movements in table 2.

Rail Costs

Unlike grain transported by truck, grain shipped by rail is a regulated commodity. Flour is regulated in both instances. Data on costs of rail transportation of commodities are virtually limited to data required to be reported to the ICC and data reported in various rate hearings before the ICC.

Table 2--Estimated regional and interregional truck transportation costs of service for grain and flour (wheat equivalents) 1966 1/

Origin region	Destination region							
	I	II	III	IV	V	VI	VII	VIII
	Cents per bushel-mile							
Grain:								
I	0.062200	0.059713	0.052130	0.058175	2/	2/	2/	2/
II	.059713	.058575	.052950	.057418	.058635	.047825	2/	2/
III	.052130	.052950	.047563	.051538	.051950	.044000	2/	2/
IV	.058175	.057418	.051538	.046138	.055617	.046650	2/	2/
V	2/	.058635	.051950	.055617	.055525	.047550	.047850	2/
VI	2/	.047825	.044000	.046650	.047550	.041963	.042638	.041075
VII	2/	2/	2/	2/	.047850	.042638	.043213	.041850
VIII	2/	2/	2/	2/	2/	.041075	.041850	.040063
Flour:								
I	.055308	.054277	.047894	.051570	2/	2/	2/	2/
II	.054277	.053807	.047863	.051850	.048211	.042554	2/	2/
III	.047894	.047863	.044662	.047649	.048582	.039787	2/	2/
IV	.051570	.051850	.047649	.049685	.050912	.041192	2/	2/
V	2/	.048211	.048582	.050912	.051775	.043091	.045508	2/
VI	2/	.042554	.039787	.041192	.043091	.037004	.039451	.038214
VII	2/	2/	2/	2/	.045508	.039451	.041560	.040715
VIII	2/	2/	2/	2/	2/	.038214	.040715	.039599

1/ 58-percent bagged.
2/ Not considered a feasible shipment, thus not computed.

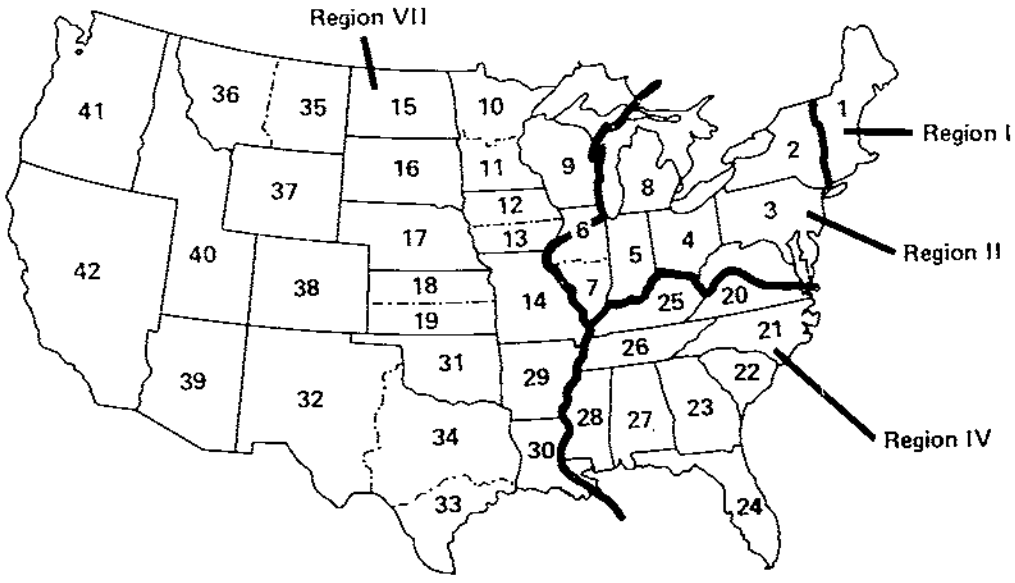
For the study; the prime source of rail-cost data was Rail Carload Cost Scales By Territories for the Year 1966 (16). Table III of (16) is a detailed tabular presentation of rail carload unit costs by territory and type of train (average-weight, way, and through) for 13 types of equipment, discussed later. The cost coefficients of table III were obtained from summary 1 of the rail cost formula known as Rail Form A (12) and are based on 1966 operations.

The purpose of this section is to explain how ICC costs (16) were adjusted to estimate rail costs of service for transporting grain and flour.

Cost Territories

The cost factors developed from ICC's Rail Form A are classified according to "territories" or regions and presented in appendix table 7. These classifications consist of groups of carriers operating in the same general geographical area (figure 2). It should be noted that these "territories" are actually groupings of entire railroad lines, rather than the portions of lines lying within rigid geographical boundaries. Hence, some geographical overlapping is involved. To avoid as much overlapping as possible, regions shown in figure 2 were the ones used in the study.

DELINEATION OF REGIONS USED IN STUDY OF RAIL COSTS IN GRAIN MARKETING SYSTEM



Source: Interstate Commerce Commission. Cost of Transporting Freight by Class I and Class II Motor Carriers of General Commodities by Regions or Territories for the Year 1966. Bur. of Accts., Stmt. 8-67, Wash., D.C. 1967, cover page.

Figure 2

In developing rail costs, fully distributed costs reported by ICC were used. These costs, which in economic theory are termed longrun average costs, are averages for the region. For the study, adjustments were made to reflect more closely costs associated with grain and flour movements.

Some rail transportation authorities contend that carrier pricing should not in all cases be based on fully allocated costs. Their arguments are that: (1) the large unallocable costs, characteristic of the railroad industry, make it unnecessary for the various items of traffic to bear equal proportions or percentages of these costs; (2) the important costs, particularly for many grain movements, are the variable or marginal costs; these should be borne by the individual commodities, considering the competitive situation, seasonality of traffic, possible growth trends in traffic, and flow imbalance characteristics; (3) if traffic increases, the variable or marginal costs rise and if the traffic is not handled, they can be avoided; and (4) the variable costs, which are approximately 80 percent of fully distributed costs, should be considered as a floor on railroad cost pricing.

Types of Costs

The cost coefficients presented in ICC table III may be used to compute what ICC terms "out-of-pocket" costs, "constant expenses," and "fully distributed" costs (app. table 8). 10/

Type of Train

Cost coefficients for each type of equipment for average-weight, way, and through trains are found in table 3 of ICC's statement 2-68 (16). Coefficients for the average-weight train reflect the average of all trains over the total train miles in each region (16, p. 185). Way-train coefficients represent movements between major rail terminals and way stations (local rail stations); through-train coefficients constitute movements between major rail terminals or distribution points (15, pp. 589, 646, and 647).

Using data for both way and through trains necessitates two mileage computations per region for interregional movements. For simplicity of calculation, average-weight trains were specified. 11/

10/ These items are defined in (11, pp. 2, 3, and 25, respectively). Out-of-pocket-costs are "the expenses which can be directly assigned to any given product of service"; constant costs "represent the difference between the out-of-pocket, or variable costs, and the total costs"; fully distributed costs comprise "the out-of-pocket costs plus a statistical apportionment of the constant expenses. . ."

11/ For use of way-train and through-train coefficients, consult (16, p. 6).

Type of Equipment

Of the 13 types of equipment listed in table III of ICC's statement 2-68 (16), two types are used to haul flour and grain by railroad--covered hopper cars and general service boxcars. 12/

Adjustments of ICC Table III Coefficients

Car Ownership Cost Adjustments.--The covered hopper cars used to haul grain and flour are somewhat different from the "average" covered hopper car represented in ICC table III. The car specified in the study has 3,000 bushels' capacity and is classified as a jumbo. Such a car has a higher purchase price than smaller, older hopper cars. Likewise, the covered hopper car which hauls flour is also specialized and limited as to the types of other commodities it can haul because of health regulations and construction restrictions.

For these reasons, covered hopper cars which haul grain and those which haul flour have ownership costs different from the "average" car (app. table 9). Boxcar ownership costs for hauling grain and flour were assumed to be the same as those reported by the ICC (16). The procedure for adjusting the "average" ownership costs of ICC table III was specified by M. Paolo, Director of the Bureau of Accounts, ICC. These costs are presented in tables 3 and 4 for grain and flour hopper cars, respectively. The initial purchase price of a jumbo covered hopper car for hauling grain in 1966 was $16,000. 13/ The price for a 100-ton covered hopper car equipped to haul flour was $24,000. 13/

Entries for line-haul and terminal car ownership costs in tables 3 and 4, minus respective entries for covered hopper cars in columns (4) and (6) of appendix table 9, yield the car ownership cost adjustments for grain hopper and flour hopper cars, respectively, given in table 5.

The adjustment factors by region for grain and flour covered hopper cars are also shown in table 5. Car ownership costs for grain and flour increase the coefficients published in ICC table III.

Passenger-train Deficits.--The ICC table III data include passenger train deficits distributed over all regions. Since we are concerned with costs of service for hauling grain and flour by rail, these commodities should not bear losses from carrying any other commodities. Therefore, passenger train deficits expressed as percentages were subtracted in table 5. 14/ The adjustment percentages are given in appendix table 10 (16, p. 6, item 5).

Floating Equipment Costs.--Costs for floating equipment services are diffused over all traffic rather than being distributed over the actual traffic receiving the service. However, these costs have been subtracted from the costs

12/ For a specific description of any type of railcar, see (29), which is issued quarterly.

13/ Prices were received from James McClellan of the Policy Division, Federal Railroad Administration, U.S. Department of Transportation, by telephone conversation in June 1969.

14/ Social costs to society were not considered.

Table 3--Adaptation of ICC average hopper car ownership costs to grain hopper cars

Item	Average hopper car	Grain hopper car	Adjustment factor: Depreciation	Adjustment factor: Return on investment
	--------Dollars--------		---------Units---------	
Original cost	7,775	16,000	1/2.06	--
Net investment (original cost minus accrued depreciation, 2/ $480 for 1 year)	5,061	15,520	--	3/3.06
	---------Cents---------			
Line-haul car ownership cost per car mile (statement 2-68, p. 176, line 44, col. (4))	6.31	10.93	--	--
Car depreciation	1.58	3.26	--	--
Return on investment	1.43	4.37	--	--
Remainder (repairs and overhead)	3.30	3.30	--	--
	--------Dollars--------			
Terminal car ownership cost per carload (statement 2-68, p. 176, line 44, col. (6))	2,031.18	4,640.24	--	--
Car depreciation	435.46	897.05	--	--
Return on investment	1,042.46	3,189.93	--	--
Remainder (repairs and overhead)	553.26	553.26	--	--

1/ $16,000 ÷ $7,775 = 2.06.
2/ At the rate of 3 percent.
3/ $15,520 ÷ $5,061 = 3.06.

Source: (16), adjusted as directed by M. Paolo, Director, Bur. Accts., Interstate Commerce Commission.

Table 4--Adaptation of ICC average hopper car ownership costs to flour hopper cars

Item	Average hopper car	Grain hopper car	Adjustment factor: Depreciation	Adjustment factor: Return on investment
	--------Dollars--------		---------Units---------	
Original cost	7,775	24,000	1/3.09	--
Net investment (original cost minus accrued depreciation, 2/ $720 for 1 year)	5,061	23,280	--	3/4.60
	---------Cents---------			
Line-haul car ownership cost per car mile (statement 2-68, p. 176, line 44, col. (4))	6.31	14.75	--	--
Car depreciation	1.58	4.89	--	--
Return on investment	1.43	6.56	--	--
Remainder (repairs and overhead)	3.30	3.30	--	--
	--------Dollars--------			
Terminal car ownership cost per carload (statement 2-68, p. 176, line 44, col. (6))	2,031.18	6,694.14	--	--
Car depreciation	435.46	1,345.57	--	--
Return on investment	1,042.46	4,795.31	--	--
Remainder (repairs and overhead)	553.26	553.26	--	--

1/ $24,000 ÷ $7,775 = 3.09.
2/ At the rate of 3 percent.
3/ $23,280 ÷ $5,061 = 4.60.

Source: Correspondence with M. Paolo, Director, Bur. Accts., Interstate Commerce Commission.

Table [illegible] Per car mile, per train mile, per carload, per cent, per car mile/mile, per cent, for freight cars and locomotives

Region	(1) Per car mile	(2) Per train mile	(3) Per carload	(4) Per cent	(5) Per car mile/mile	(6) Per cent
			Cents/unit			
NEW ENGLAND REGION						
Type of equipment and adjustment						
Box car, general service	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Floating equipment costs	[illegible]	[illegible]	+ 26,424	--	[illegible]	- .308
Platform handling costs	--	--	--	[illegible]	[illegible]	- .006
Loss and damage	--	--	+ 882,000	--	--	--
Special services						
Grain car doors	--	--	+ 396,000	--	--	--
Floor car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	[illegible]	--	--	--
Station clerical cost adjustment	--	--	[illegible]	--	--	--
Coefficients before elasticity adjustment 2/	[illegible]	[illegible]	[illegible]	[illegible]	.02326	3.533
Adjustments with elasticity	[illegible]	[illegible]	--	--	.02628	--
Hopper car, general	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Car ownership costs	+ [illegible]	[illegible]	[illegible]	[illegible]	.02553	3.847
Passenger train deficits	[illegible]	[illegible]	[illegible]	--	--	--
Floating equipment costs	[illegible]	[illegible]	- 26,424	[illegible]	[illegible]	- .308
Platform handling costs	--	--	--	[illegible]	[illegible]	- .006
Loss and damage	--	--	--	--	--	--
Special services						
Grain car doors	--	--	--	--	--	--
Floor car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	[illegible]	--	--	--
Station clerical cost adjustment	--	--	[illegible]	--	--	--
Coefficients before elasticity adjustment 2/	[illegible]	[illegible]	[illegible]	[illegible]	.02326	3.533
Adjustments with elasticity	[illegible]	[illegible]	--	--	.02628	--
REGION 2: EASTERN						
Type of equipment and adjustment						
Box car, general service	[illegible]	[illegible]	3,827,138	.017300	.02553	3.847
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	[illegible]	[illegible]	- 646,174	[illegible]	[illegible]	- .308
Floating equipment costs	[illegible]	[illegible]	- 36,924	--	[illegible]	- .006
Platform handling costs	--	--	--	[illegible]	--	--
Loss and damage	--	--	+ 882,000	--	--	--
Special services						
Grain car doors	--	--	--	--	--	--
Floor car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	--	--	--	--
Station clerical cost adjustment	--	--	--	--	--	--
Coefficients before elasticity adjustment 2/	[illegible]	[illegible]	[illegible]	[illegible]	.02326	3.533
Adjustments with elasticity	[illegible]	[illegible]	--	--	.02628	--
Hopper car, general	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Car ownership costs	+ [illegible]	[illegible]	[illegible]	[illegible]	.02553	3.847
Passenger train deficits	[illegible]	[illegible]	[illegible]	--	--	--
Floating equipment costs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- .308
Platform handling costs	--	--	--	[illegible]	[illegible]	- .006
Loss and damage	--	--	--	--	--	--
Special services						
Grain car doors	--	--	--	--	--	--
Floor car cleaning costs	--	--	[illegible]	--	--	--
Switching cost adjustment	--	--	--	--	--	--
Station clerical cost adjustment	--	--	--	--	--	--
Coefficients before elasticity adjustment 2/	[illegible]	[illegible]	[illegible]	.05900	.02326	3.533
Adjustments with elasticity	[illegible]	[illegible]	--	--	.02628	--
REGION 3: NORTH						
Type of equipment and adjustment						
Box car, general service	[illegible]	[illegible]	[illegible]	[illegible]	.01182	2.323
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	[illegible]	[illegible]	- 283,509	[illegible]	[illegible]	- .093
Floating equipment costs	[illegible]	[illegible]	- 125,112	--	[illegible]	- .015
Platform handling costs	--	--	--	[illegible]	--	--
Loss and damage	--	--	+ 582,800	--	--	--
Special services						
Grain car doors	--	--	+ 335,000	--	--	--
Floor car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	[illegible]	--	--	--
Station clerical cost adjustment	--	--	+ 927,000	--	--	--
Coefficients before elasticity adjustment 2/	[illegible]	[illegible]	[illegible]	[illegible]	.01224	2.215
Adjustments with elasticity	[illegible]	[illegible]	--	--	.01272	--
Hopper car, general	[illegible]	[illegible]	[illegible]	[illegible]	.01182	2.323
Car ownership costs	+ [illegible]	[illegible]	[illegible]	--	--	--
Passenger train deficits	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- .093

See footnotes at end of table.

--Continued

Table 5--Adjustments to the territorial cost scales, by rail region and type of equipment, 1[illegible]--Continued

Region	(4) Per car mile 1/	(5) Per car-hour 2/	(6) Per carload 1/	(7) Per car 3/	(8) Per car-mile 1/	(9) Per car 1/
			CENTS UNIT			
REGION II--[illegible]						
Hopper car, covered--continued:						
Floating equipment costs	+ .[illegible]	-2.[illegible]	+[illegible]	--	-0.[illegible]1	-0.01
Platform handling costs	--	--	--	--	--	--
Loss and damage	--	--	--	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	-1,516,000	--	--	--
Station vertical cost adjustment	--	--	- 427,000	--	--	--
Coefficients before territory adjustment 4/	26,88838	.[illegible]47	7,481,121	.04500	.01124	2.215
Adjustments with territory	42,61838	.[illegible]79	--	--	.01270	--
REGION III--FLOUR						
Type of equipment and adjustment:						
Box car, general service	$8,3421	+ .[illegible]4	7,678,215	.12300	.01182	2.323
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	4[illegible]	[illegible]	2[illegible]	-.00700	-.00047	- .093
Floating equipment costs	+ .[illegible]61	[illegible]	+ 129,132	--	-.00011	- .015
Platform handling costs	--	--	--	-.12625	--	--
Loss and damage	--	--	+ 8[illegible],000	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	--	--	--	--
Station vertical cost adjustment	--	--	--	--	--	--
Coefficients before territory adjustment 4/	[illegible]7,[illegible]6[illegible]	[illegible]	7,561,07[illegible]	.03975	.01124	2.215
Adjustments with territory	[illegible]4 .98[illegible]9	[illegible]	--	--	.01270	--
Hopper car, covered	+[illegible]6,[illegible]48	[illegible]	7,999,[illegible]58	.04700	.01182	2.323
Car ownership costs	+ [illegible]	--	+[illegible],8[illegible],694	--	--	--
Passenger train deficits	+ [illegible],[illegible]6[illegible]	[illegible]	- 306,934	-.00200	-.00047	- .093
Floating equipment costs	- [illegible]2[illegible]4	[illegible]	- 134,035	--	-.00011	- .015
Platform handling costs	--	--	--	--	--	--
Loss and damage	--	--	--	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	[illegible]	--	--	--
Station vertical cost adjustment	--	--	--	--	--	--
Coefficients before territory adjustment 4/	32,[illegible]186	.[illegible]43	21,736,023	.04500	.01124	2.215
Adjustments with territory	48,[illegible]4[illegible]	.[illegible]79	--	--	.01270	--
REGION IV--[illegible]						
Type of equipment and adjustment:						
Box car, general service	$4,[illegible]82[illegible]	.[illegible]42	-,831,630	.13200	.01145	1.694
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	+ 1,[illegible]0828	-.[illegible]463	- 642,[illegible]4[illegible]	-.01000	-.00080	- .119
Floating equipment costs	+ .[illegible]0176	--	- 1,364	--	--	--
Platform handling costs	--	--	--	-.11816	--	--
Loss and damage	--	--	+ 562,800	--	--	--
Special services:						
Grain car doors	--	--	+ [illegible],[illegible]000	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	- 505,000	--	--	--
Station vertical cost adjustment	--	--	- 748,000	--	--	--
Coefficients before territory adjustment 4/	33,[illegible]7[illegible]	.[illegible]6[illegible]	+,032,692	.01384	.01065	1.575
Adjustments with territory	35,[illegible]126[illegible]	.[illegible]92[illegible]	--	--	.01203	--
Hopper car, covered	2[illegible],[illegible]4[illegible]2	.[illegible]42	5,20[illegible],931	.02400	.01145	1.694
Car ownership costs	+ [illegible],[illegible]8[illegible]9	--	+2,9[illegible],[illegible]86	--	--	--
Passenger train deficits	+ 1,[illegible]871[illegible]	-.[illegible]0[illegible]	- [illegible],[illegible]45	-.00200	-.00080	- .119
Floating equipment costs	+ .[illegible]002[illegible]6	--	- 1,516	--	--	--
Platform handling costs	--	--	--	--	--	--
Loss and damage	--	--	--	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	-	--	- 8[illegible],000	--	--	--
Station vertical cost adjustment	--	--	- 748,000	--	--	--
Coefficients before territory adjustment 4/	21,[illegible]82[illegible]	.[illegible]086[illegible]	6,186,[illegible]43	.02200	.01665	1.575
Adjustments with car mile	[illegible]4,[illegible]4[illegible]9	.[illegible]0[illegible]72	--	--	.01203	--
REGION IV--FLOUR						
Type of equipment and adjustment:						
Box car, general service	1[illegible],[illegible]82[illegible]	.[illegible]0425	+,891,63[illegible]	.13200	.01145	1.694
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	+ 1,[illegible]0828	-.[illegible]463	- 342,[illegible]4[illegible]	-.01000	-.00080	- .119
Floating equipment costs	+ .[illegible]0176	--	- 1,364	--	--	--

See footnotes at end of table.

--Continued

Table 5--Adjustments to ICC rail territorial cost scales, by rail region and type of equipment, 1966--Continued

Region	(4) Per car mile 1/	(5) Per cwt./mile 1/	(6) Per carload 1/	(7) Per cwt. 1/	(8) Per cwt./mile 1/	(9) Per cwt. 1/
			Cents/unit			
REGION IV--FLOUR(Continued)						
Boxcar, general service(continued)						
Platform handling costs	--	--	--	-0.11816	--	--
Loss and damage	--	--	+ 872.000	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	--	--	--	--
Station clerical cost adjustment	--	--	--	--	--	--
Coefficients before circuity adjustment 2/	11.37403	.00860	5,419.852	.01384	.01065	1.575
Adjustments with circuity	15.11265	.00972	--	--	.01203	--
Hopper car, covered	20.53052	.00925	5,204.931	.02400	.01145	1.694
Car ownership costs	+ 8.21912	--	+4,981.262	--	--	--
Passenger train deficits	- 1.43314	-.00065	- 364.345	-.00780	-.00080	- .119
Floating equipment costs	- .00266	--	+ 1.516	--	--	--
Platform handling costs	--	--	--	--	--	--
Loss and damage	--	--	--	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	+9,821.000	--	--	--
Switching cost adjustment	--	--	--	--	--	--
Station clerical cost adjustment	--	--	--	--	--	--
Coefficients before circuity adjustment 2/	27.31084	.00860	19,641.332	.02200	.01065	1.575
Adjustments with circuity	30.86035	.00972	--	--	.01203	--
REGION VII--GRAIN						
Type of equipment and adjustment:						
Boxcar, general service	15.31047	.01067	7,463.086	.43700	.01281	2.706
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	- .76552	-.00053	- 373.154	-.02200	-.00064	- .135
Floating equipment costs	- .01000	--	- 2.894	--	-.00001	--
Platform handling costs	--	--	--	-.34342	--	--
Loss and damage	--	--	+ 562.800	--	--	--
Special services:						
Grain car doors	--	--	+ 221.800	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	-1,174.000	--	--	--
Station clerical cost adjustment	--	--	-1,397.000	--	--	--
Coefficients before circuity adjustment 2/	14.53495	.01014	5,299.838	.07158	.01216	2.571
Adjustments with circuity	16.42449	.01146	--	--	.01374	--
Hopper car, covered	23.22384	.01067	7,921.483	.09400	.01281	2.706
Car ownership costs	+ 4.61781	--	+2,609.065	--	--	--
Passenger train deficits	- 1.16369	-.00053	- 396.074	-.00500	-.00064	- .135
Floating equipment costs	- .01505	--	- 3.216	--	-.00001	--
Platform handling costs	--	--	--	--	--	--
Loss and damage	--	--	--	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	-1,308.000	--	--	--
Station clerical cost adjustment	--	--	-1,397.000	--	--	--
Coefficients before circuity adjustment 2/	26.71291	.01014	7,426.258	.08900	.01216	2.571
Adjustments with circuity	30.18559	.01146	--	--	.01374	--
REGION VII--FLOUR						
Type of equipment and adjustment:						
Boxcar, general service	15.31047	.01067	7,463.086	.43700	.01281	2.706
Car ownership costs	--	--	--	--	--	--
Passenger train deficits	- .76552	-.00053	- 373.154	-.02200	-.00064	- .135
Floating equipment costs	- .01000	--	- 2.894	--	-.00001	--
Platform handling costs	--	--	--	-.34342	--	--
Loss and damage	--	--	+ 872.000	--	--	--
Special services:						
Grain car doors	--	--	--	--	--	--
Flour car cleaning costs	--	--	--	--	--	--
Switching cost adjustment	--	--	--	--	--	--
Station clerical cost adjustment	--	--	--	--	--	--
Coefficients before circuity adjustment 2/	14.53495	.01014	7,959.038	.07158	.01216	2.571
Adjustments with circuity	16.42449	.01146	--	--	.01374	--
Hopper car, covered	23.22384	.01067	7,921.483	.09400	.01281	2.706
Car ownership costs	+ 8.44683	--	+4,462.967	--	--	--
Passenger train deficits	- 1.16369	-.00053	- 396.074	-.00500	-.00064	- .135
Floating equipment costs	- .01505	--	+ 3.216	--	-.00001	--
Platform handling costs	--	--	--	--	--	--
Loss and damage	--	--	--	--	--	--
Special services						
Grain car doors	--	--	--	--	--	--

See footnotes at end of table.

--Continued

Table 5--Adjustments to ICC rail territorial cost scales, by rail region and type of equipment, 1966--Continued

Region	(4) Per car mile 1/	(5) Per cwt.-mile 2/	(6) Per carload 1/	(7) Per cwt. 1/	(8) Per cwt./mile 1/	(9) Per cwt. 1/
			Cents/mile			
REGION VII--FLOUR(Continued)						
Hopper car, covered(continued)						
Special services:						
Flour car cleaning costs	--	--	49,618.000	--	--	--
Switching cost adjustment	--	--	--	--	--	--
Station clerical cost adjustment	--	--	--	--	--	--
Coefficients before circuity adjustments 2/	30.54093	.01014	21,603.160	.08900	.01216	2.571
Adjustments with circuity	34.51125	.01146	--	--	.01374	--

1/ The column number represents the identical column in (16).
2/ Circuity is discussed in the section "Rail Cost-of-Service Equation Development."

in appendix table 8 (table 5). Floating equipment costs should be included for specific movements involving line-haul service across Lake Michigan or floating service at terminal harbors. Corrections for such costs are also shown in table 5. For a detailed explanation of these costs, see (16, pp. 202, 218, and 219).

Platform Handling Costs.--ICC table III includes an average terminal cost for platform handling of carload traffic for general service boxcars of 0.10926 cent per hundredweight for region I, 0.12625 cent for region II, 0.11816 cent for region IV, and 0.34342 cent for region VII (16, p. 201). As explained earlier, only regions in figure 2 were considered in the study. Since neither grain nor flour received such services, terminal cost was subtracted from data in appendix table 8 (table 5). For futher detail on platform handling costs, see (16, pp. 201-202).

Loss and Damage.--Loss and damage claims were excluded from ICC table III. Therefore, they had to be added to the data presented in appendix table 8. For movements of both grain and flour in covered hopper cars (bulk shipments), no cost was included for loss and damage. For shipments in boxcars, a figure of $5.628 per carload was added to column 6 of table 5 for grain and $8.720 per carload for flour (16, p. 204).

Special Services.--Special services include such items as expense for cleaning cars, furnishing grain doors, and closing doors on hopper cars. A per carload amount was entered in ICC table III by region for these services. These amounts were included in column 6 of appendix table 8 and are also in appendix table 10.

According to testimony given in (14, Investigation and Suspension Docket Number 8364), costs to one railroad for furnishing grain car doors were $6.03 per load. The difference in this figure and the special services cost data of appendix table 10 was used as an adjustment for special services for boxcars in each region. The assumption was that these special services should cost at least as much as grain doors. For boxcars used to haul flour, the assumption was that the special service cost would be the average ICC cost included in column 6 of appendix table 8 and in appendix table 10.

The special services cost adjustment for hopper cars hauling flour was computed to be the difference of 5 cents per hundredweight (24, p. 80) for 100 tons per car, or $100 per car; and the data are presented in appendix table 10. These adjustments are found in table 5. No adjustments for special services were made for jumbo covered hopper cars hauling grain. 15/

Origin-Destination Switching Cost Adjustment.--A basic assumption made pertaining to the movement of grain and flour was that grain would move in multiples of five cars and flour would move in single cars. A study showed that

15/ Because of the construction of jumbo covered hopper cars, some railroads pay no claims for loss and damage of grain or flour hauled in these cars unless such loss or damage can be proved. See (14, Exhibit No. 2 Schedule, DJL-4 of the Chicago, Rock Island, and Pacific Railroad).

for a single-car cut, the average time required for classification switching was 3.16646 minutes. For a five-car cut, the average time was 0.8650 minute per car, or a total of 4.32486 minutes (66, pp. 23-25). The switching cost per car was included in column 6 of table 8. Appendix table 1 presents the switching times associated with specific switching costs for each region.

The times and costs (app. table 11) were adjusted using Coffin's procedure (3, pp. 24 and 25). The switch engine time per car in minutes at destination is represented as:

$$T_S = \frac{a_0}{N} + a_1 \qquad (6)$$

where T_S = switch engine minutes per car,

N = number of cars in shipment, and

a_0, a_1 = time in minutes for a single-car cut and marginal time per car for additional cars, respectively.

These two constants are determined by assuming proportionality between them and the respective coefficients of equation (7) below.

$$T_S = \frac{3.16646}{N} + 0.28960 \qquad (7)$$

where 3.16646 = time in minutes for switching a single car in a five-car cut,

0.28960 = average time for each of remaining four cars in a five-car cut, and

N = number of cars in a cut.

$$\text{Thus, } \frac{3.16646}{a_0} = \frac{0.28960}{a_1} . \qquad (8)$$

Rearranging (8) and substituting average time per car for the appropriate region, a system of equations was developed for each region and type of car:

$$a_0 + a_1 = T_{ICC} \qquad (9)$$

$$\frac{3.16646}{a_0} - \frac{0.28960}{a_1} = 0 \qquad (10)$$

where T_{ICC} = average time in minutes per car (app. table 11).

Solving the above system of equations for each region and type of car--box and hopper--the switching times per car in minutes were derived (table 6).

Table 6--Derived regional average destination switching times and cost, by type of car and rail region, 1966

Type of car	I	II	IV	VII
		Minutes/car		
Boxcar	5.63346	6.86282	4.80665	6.45086
Hopper car	6.24870	7.61052	5.34072	7.12986
		Dollars/car		
Boxcar	4.82	5.04	2.73	4.32
Hopper car	5.36	5.59	3.04	4.76

Switching costs in table 6 were computed by multipling the derived destination switching time per car in the table by costs per minute for destination switching derived from ICC data (16, p. 189).

The destination switching cost adjustment factors were computed by subtracting the costs computed in table 6 from those in appendix table 11. The switching cost factors were subtracted in column 6 of table 5.

Station Clerical Cost Adjustment.--Station clerical costs represent a portion of salaries and wages of employees who prepare waybills, freight bills, interline settlements, and so on. These costs are sometimes regarded as constant for each shipment because one waybill can be made to cover any number of cars.

The assumption made in the study was that 10 percent of the station clerical cost shown in (16, table XV of ICC Statement No. 2-68) was fixed for each car and that the remainder was distributable over all cars in the shipment (3, p. 26). This adjustment would apply to grain shipments only. The adjustment factors are computed in table 7 and were included in table 5.

Developing a Rail Cost-of-Service Equation

The preceding section explained the adjustments made to ICC rail territorial cost scales for 1966 and showed results in summary form (table 5), plus the adjusted territorial coefficients for two basic types of equipment to haul two different commodities, grain and flour.

Table 7--Station clerical cost adjustment factors, by rail region, 1966

Item number	I	II	IV	VII
	Dollars			
1. ICC carload cost	16.12	12.88	10.37	19.40
2. Fixed cost per car	-1.61	-1.29	-1.04	-1.94
3. Remainder (five cars)	14.15	11.59	9.33	17.46
4. Item 3 : 5	2.90	2.32	1.87	3.49
5. Item 2	1.61	1.29	1.04	1.94
6. Item 4 plus item 5	4.51	3.61	2.91	5.43
7. Adjustment (negative) (Item 1 minus item 6)	-11.61	-9.27	-7.46	-13.97

This section explains the procedure for using coefficients to determine the cost to the rail carrier for transporting grain and flour. 16/ ICC reports rail costs in three denominators, cents per car-mile, cents per hundredweight-mile, and cents per carload. To be meaningful for a commodity, these costs must be expressed in a common unit.

In appendix table 8 and table 5, "Terminal Costs" in columns (6), (7), and (9) can be expressed on a per unit of weight basis by specifying the weight per carload for column (6). For the study, a boxcar hauls 2,000 bushels, or 1,200 hundredweights, of grain (11). The same boxcar can haul 1,154 hundredweights of bagged flour (space is lost between bags). A hopper car that hauls grain carries 3,000 bushels, or 1,800 hundredweights (11); a hopper car equipped to haul flour carries 2,000 hundredweight (100 tons). Further, grains were assumed to move in five-car shipments. The proportions of grain moving in box and hopper cars were developed from (18). The percentages of grain moving by type of car by regions in 1966 are presented in appendix table 12. Flour was assumed to move in single cars (27, p. 156). Fifty-eight percent of the flour was assumed to be hauled in bags in boxcars and 42 percent bulk in "airslide" (pneumatic-like) covered hopper cars (app. table 5).

The "line-haul costs," columns (4), (5), and (8) of table 5 and appendix table 8, can be expressed as per bushel-mile or per hundredweight-mile cost when the weight per car is specified for column (4). When territorial costs are expressed as a function of weight and weight-mileage, total cost can be readily computed.

16/ (11) is devoted entirely to discussing the use of ICC rail territorial costs.

Table 8--Intraregional rail terminal cost analysis for grain, 1966

Region and type of equipment		Out-of-pocket expenses				Constant expense		Total
		(6)		(7)		(9)		
		Cents/carload	Cents/bu.	Cents/cwt.	Cents/bu.	Cents/cwt.	Cents/bu.	Cents/bu.
I	Box	5,638.843	2.81900	0.04974	0.02984	3.533	2.11980	4.96864
	Hopper	7,319.758	2.43992	.05900	.03540	3.533	2.11980	4.59512
	Composite	--	2.76536	--	.03063	--	2.11980	4.91579
II	Box	5,267.874	2.63394	.03975	.02385	2.215	1.32900	3.98679
	Hopper	7,481.121	2.49371	.04500	.02700	2.215	1.32900	3.84971
	Composite	--	2.61410	--	.02430	--	1.32900	3.96739
IV	Box	4,037.652	2.01883	.01384	.00830	1.575	.94500	2.97213
	Hopper	6,186.430	2.06214	.02200	.01320	1.575	.94500	3.02034
	Composite	--	2.04156	--	.01087	--	.94500	2.99743
VII	Box	5,299.838	2.64991	.07158	.04295	2.571	1.54260	4.23546
	Hopper	7,426.258	2.47542	.08900	.05340	2.571	1.54260	4.07142
	Composite	--	2.61226	--	.04521	--	1.54260	4.20006

Source: Computed from table 5 and app. table 8.

Tables 8 and 9, computed from table 5 and appendix table 8, give that portion of total cost per bushel including circuity for grain and cost per hundredweight for flour, which can be expressed as a function of weight (9, p.1). 17/ Tables 10 and 11, also computed from table 5, present the portion of total cost for intraregional movements expressed as a per weight-mile basis for hauling grain and flour.

Rail Cost-of-Service Equations.--Equations for intraregional movements of grain and flour as a function of mileage (X) can be obtained using the necessary coefficients from tables 8-11. Figures for "composite" are a weighted average of the "box" and "hopper" data, weighted by the percentage of the appropriate commodity moving in each type of equipment (app. table 12). The resulting intraregional equations for the rail regions considered in the study (fig. 2) are given in table 12. Interregional equations were developed using the data of tables 8-11 and appendix table 12.

To develop the terminal cost coefficient for an interregional equation, the simple average of the terminal costs of the two regions is weighted by the car ratio for the appropriate interregional movement. The coefficients for miles traveled in each region (line-haul costs) were developed using the car ratios of appendix table 12 and the "line-haul cost" coefficients of tables 10 and 11 for each likely interregional movement. These equations are presented in table 13.

The functional representation of interregional rail costs of service for grain and flour when mileages traveled in each rail region between origin and destination are known may be expressed as:

$$Y = \tfrac{1}{2}\sum_i a_i + \sum_i b_i x_i, \qquad (11)$$

Where Y = total cost per unit for shipping from a given origin to a given destination 18/

a_i = costs specified per unit of commodity and are not affected by mileage, referred to as "terminal costs" (43),

X = Total mileage between the origin and destination,

b_i = costs per unit-weight mile, or "line-haul" costs (11), for mileage traveled in rail region i from a particular origin to a particular destination, and

x_i = mileage traveled in rail region i from a particular origin to a particular destination.

17/ Adjustment for circuity allows for the actual miles traveled by a shipment rather than the short-line or most direct mileage upon which rail rates are based.

18/ Total cost here represents "fully distributed" costs as discussed in (11).

Table 9--Intraregional rail terminal cost analysis for flour, 1966

Region and type of equipment		Out-of-pocket expenses (6)		Out-of-pocket expenses (7)		Constant expense (9)		Total
		Cents/carload		Cents/cwt.		Cents/cwt.		
I	Box	8,036.043	6.96268	0.04974	--	3.533	--	--
	Hopper	21,608.660	10.80433	.05900	--	3.533	--	--
	Composite	--	8.57617	--	.05363	--	3.533	12.16280
II	Box	7,551.074	6.54248	.03975	--	2.215	--	--
	Hopper	21,730.023	10.86501	.04500	--	2.215	--	--
	Composite	--	8.35794	--	.04196	--	2.215	10.61490
IV	Box	5,419.852	4.69593	.01384	--	1.575	--	--
	Hopper	19,641.332	9.82067	.02200	--	1.575	--	--
	Composite	--	6.84832	--	.01727	--	1.575	8.44059
VII	Box	7,959.038	6.89596	.07158	--	2.571	--	--
	Hopper	21,603.160	10.80158	.08900	--	2.571	--	--
	Composite	--	8.53632	--	.07890	--	2.571	11.18622

Source: Computed from table 5 and app. table 8.

Table 10--Intraregional rail line-haul cost analysis for grain, 1966

Region and type of equipment		Out-of-pocket expense				Constant expense		Total
		(4)		(5)		(8)		
		Cents/ car-mile	Cents/ bu.-mile	Cents/ cwt.-mile	Cents/ bu.-mile	Cents/ cwt.-mile	Cents/ bu.-mile	Cents/ bu.-mile
I	Box	31.66142	0.01583	0.01791	--	0.02628	--	0.04235
	Hopper	42.77401	.01427	.01791	--	.02628	--	.04078
	Composite	--	.01561	--	.01075	--	.01577	.04213
II	Box	19.55609	.00978	.01079	--	.01270	--	.02387
	Hopper	32.63874	.01088	.01079	--	.01270	--	.02497
	Composite	--	.00994	--	.00647	--	.00762	.02403
IV	Box	15.11265	.00756	.00972	--	.01203	--	.02061
	Hopper	26.53468	.00884	.00972	--	.01203	--	.02189
	Composite	--	.00823	--	.00583	--	.00722	.02128
VII	Box	16.42449	.00821	.01146	--	.01374	--	.02333
	Hopper	30.18559	.01006	.01146	--	.01374	--	.02518
	Composite	--	.00861	--	.00688	--	.00824	.02373

Source: Computed from table 5 and app. table 8.

Table 11--Intraregional rail line-haul cost analysis for flour, 1966

Region and type of equipment		Out-of-pocket expense			Constant expense			Total
		(4)	(5)		(8)			
		Cents/ car-mile	Cents/cwt.-mile					
I	Box	31.66142	0.02743	0.01791	--	0.02628	--	--
	Hopper	47.09968	.02355	.01791	--	.02628	--	--
	Composite	--	.02580	--	.01791	--	.02628	.06999
II	Box	19.55609	.01694	.01079	--	.01270	--	--
	Hopper	36.96440	.01848	.01079	--	.01270	--	--
	Composite	--	.01759	--	.01079	--	.01270	.04108
IV	Box	15.11265	.01309	.00972	--	.01203	--	--
	Hopper	30.86035	.01543	.00972	--	.01203	--	--
	Composite	--	.01407	--	.00972	--	.01203	.03582
VII	Box	16.42449	.01423	.01146	--	.01374	--	--
	Hopper	34.51125	.01726	.01146	--	.01374	--	--
	Composite	--	.01550	--	.01146	--	.01374	.04070

Source: Computed from table 5 and app. table 8.

Table 12-- Estimated intraregional rail cost-of-service equations for grain and flour, 1966

Region and commodity		Total cost		Terminal cost		Line-haul cost	Cost easure
I	Grain	Y	=	4.91579	+	0.04213X	Cents/bu.
	Grain	Y	=	8.19298	+	.07022X	Cents/cwt.
	Flour	Y	=	12.16280	+	.06999X	Cents/cwt.
	Flour	Y	=	5.22368	+	.03006X	1/Cents/bu.
II	Grain	Y	=	3.96739	+	.02403X	Cents/bu.
	Grain	Y	=	6.61232	+	.04005X	Cents/cwt.
	Flour	Y	=	10.61490	+	.04108X	Cents/cwt.
	Flour	Y	=	4.55889	+	.01764X	1/Cents/bu.
IV	Grain	Y	=	2.99743	+	.02128X	Cents/bu.
	Grain	Y	=	4.99572	+	.03547X	Cents/cwt.
	Flour	Y	=	8.44059	+	.03582X	Cents/cwt.
	Flour	Y	=	3.62506	+	.01538X	1/Cents/bu.
VII	Grain	Y	=	4.20006	+	.02373X	Cents/bu.
	Grain	Y	=	7.00010	+	.03955X	Cents/cwt.
	Flour	Y	=	11.18622	+	.04070X	Cents/cwt.
	Flour	Y	=	4.80425	+	.01748X	1/Cents/bu.

1/ Cents per bushel (wheat equivalents), using the procedure described in the section on trucking costs of service.

Table 13--Selected interregional rail cost-of-service equations for grain and flour, when mileages are known for each region, 1966

Region and commodity			Total cost		Terminal cost	Line-haul cost 1/		Cost measure
Origin	Destination							
II	I	Grain	Y	=	4.44160	+ 0.02403X	+ 0.04213Z	Cents/bushel
		Grain	Y	=	7.40267	+ .04005X	+ .07022Z	Cents/hundredweight
		Flour	Y	=	11.38885	+ .04108X	+ .06999Z	Cents/hundredweight
II	IV	Grain	Y	=	3.45284	+ .02932X	+ .02138Z	Cents/bushel
		Grain	Y	=	5.75473	+ .04887X	+ .03563Z	Cents/hundredweight
		Flour	Y	=	9.52774	+ .04108X	+ .03582Z	Cents/hundredweight
VII	II	Grain	Y	=	4.08157	+ .02369X	+ .02409Z	Cents/bushel
		Grain	Y	=	6.80262	+ .03948X	+ .04015Z	Cents/hundredweight
		Flour	Y	=	10.90056	+ .04070X	+ .04108Z	Cents/hundredweight
VII	IV	Grain	Y	=	3.59940	+ .02347X	+ .02071Z	Cents/bushel
		Grain	Y	=	5.99900	+ .03912X	+ .03452Z	Cents/hundredweight
		Flour	Y	=	9.81341	+ .04070X	+ .03582Z	Cents/hundredweight

1/ X represents the miles traveled in the origin rail region and Z represents the miles traveled in rail region of the destination.

For the mathematical model of the study with specified supply and demand points, costs for transportation services for grain and flour must be specific for origins and destinations. To minimize mileage computations, an equation as a function of a single mileage between origin and destination is desirable. Single-mileage equations for interregional movements of grain and flour can be developed from the equations in table 13 when the movements are known, thus eliminating half the mileage computations required for the equations in table 13.

ICC data give a 1-percent sample of carload grain movements and flour movement by State (17). The origin and destination for each movement listed were classified by rail regions shown in figure 2. The ton-mileages moved in each rail region were derived assuming that the mileages moved in each rail region were proportional to the actual mileages which would have been traveled if the origins and destinations in (18) were the same as those used in the study (tables 21 and 22). These ton-mileage data are presented as decimal fractions in table 14.

Equations resulting from this weighted averaging procedure are a simple linear function of mileage, such as:

$$Y = a + bX \qquad (12)$$

where Y = total cost per unit for a shipment of X miles.

The "a" term for interregional equations of the form of (12) can be taken from table 13. Likewise, data from tables 10, 11, and 14, and appendix table 12 can be combined to yield the "b" term (line-haul costs/unit-mile). These data are presented in table 15. Selected single-mileage interregional equations are presented in table 16.

Table 14--Ton mileages for grain and flour in selected interregional movements, by rail region, 1966

Commodity	Origin		Destination	
	Region	Weighting factor	Region	Weighting factor
Grain	II	0.8305	I	0.1695
Flour		.7244		.2556
Grain	II	.3712	IV	.6288
Flour		.3960		.6040
Grain	VII	.4529	II	.5471
Flour		.3847		.6153
Grain	VII	.6575	IV	.3425
Flour		.6443		.3557

Source: Derived from (52).

Table 15--Estimated single-mileage line-haul cost coefficients for interregional rail shipments of grain and flour, 1966

Commodity	Origin			Destination			Single-mileage coefficient	Unit of cost
	Region	Weight	Coefficient	Region	Weight	Coefficient		
Grain	II	0.8305	0.02403	I	0.1695	0.04213	0.02710	Per bu.-mile
Grain		.8305	.04005		.1695	.07022	.04517	Per cwt.-mile
Flour		.7244	.04108		.2556	.06999	.04765	Per cwt.-mile
Grain	II	.3712	.02932	IV	.6288	.02138	.02533	Per bu.-mile
Grain		.3712	.04887		.6288	.03563	.04055	Per cwt.-mile
Flour		.3960	.04108		.6040	.03582	.03790	Per cwt.-mile
Grain	VII	.4529	.02369	II	.5471	.02409	.02396	Per bu.-mile
Grain		.4529	.03948		.5471	.04015	.03985	Per cwt.-mile
Flour		.3847	.04070		.6153	.04108	.04093	Per cwt.-mile
Grain	VII	.6575	.02347	IV	.3425	.02071	.02252	Per bu.-mile
Grain		.6575	.03912		.3425	.03452	.03753	Per cwt.-mile
Flour		.6443	.04070		.3557	.03582	.03896	Per cwt.-mile

Table 16--Selected single-mileage estimated interregional rail cost-of-service equations for grain and flour, 1966

Region		Total cost		Terminal cost		Line-haul cost	Unit of cost	Commodity
							Cents	
Origin:	Destination:							
II	I	Y	=	4.44160	+	0.02710X	Per bu.	Grain
		Y	=	7.40267	+	.04517X	Per cwt.	Grain
		Y	=	11.38885	+	.04765X	Per cwt.	Flour
		Y	=	4.89128	+	.02046X	1/Per bu.	Flour
II	IV	Y	=	3.45284	+	.02433X	Per bu.	Grain
		Y	=	5.75473	+	.04055X	Per cwt.	Grain
		Y	=	9.52774	+	.03790X	Per cwt.	Flour
		Y	=	4.09197	+	.01627X	1/Per bu.	Flour
VII	II	Y	=	4.08157	+	.02391X	Per bu.	Grain
		Y	=	6.80262	+	.03985X	Per cwt.	Grain
		Y	=	10.90056	+	.04093X	Per cwt.	Flour
		Y	=	4.68157	+	.01758X	1/Per bu.	Flour
VII	IV	Y	=	3.59940	+	.02252X	Per bu.	Grain
		Y	=	5.99900	+	.03753X	Per cwt.	Grain
		Y	=	9.81341	+	.03896X	Per cwt.	Flour
		Y	=	4.21466	+	.01673X	1/Per bu.	Flour

1/ In "wheat equivalents," using the procedure discussed in the section on trucking costs-of-service. These equations were used in the study to maintain product identity.

Barging Costs

Grain which is barged is regulated by the ICC only if more than three commodities are present in the tow. With modern fleeting operations, it is quite easy to have a flotilla of 22 or more barges carrying three or fewer commodities on the Mississippi River (36 p. B-3). Thus, we can generally say that barge movements of grain are unregulated and move at charges which may differ from those published. 19/

As with truck transportation of grain, published data on costs of service for barge transportation of grain are virtually nonexistent. Although ICC requires reports on operations of regulated carriers, these data are aggregated and, therefore, difficult to utilize in estimating costs for a particular bulk commodity such as grain.

Some authorities contend that published barge tariffs for grain are highly correlated with distance. This generality was not confirmed when the published tariffs were analyzed. Navigation factors--controlling channel depth and width, and locks and dams--affect barging operation time. The time element has an important influence on the costs of barge movements.

The purpose of this section is to explain the data used to derive barging costs of service for grain transportation available to regions studied which had feasible access to the Mississippi River system, the Columbia-Snake Rivers, or the Gulf Intracoastal Waterway. These regions are denoted in figure 3 with black dots. Specific points of river origin and destination for grain were taken from (64, p. 3) for the Mississippi River system and from information supplied by a grain association 20/ and a grower company 21/ for the Columbia-Snake Rivers. To and from the river loading and unloading points, grain was transported by the least-cost mode, truck or rail.

Navigational Factors

Waterway characteristics, lockage conditions, tow size, and horsepower of the towboat in relation to the size of tow all influence the origin-to-destination time of barge movements.

The sizes of lock chambers have dictated standardization of vessel dimensions on the inland waterways. In the study, the industry-standard barge,

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19/ Data of the U.S. Army Corps of Engineers (37, part 5, p. 122) reveal that 84.34 percent of the total grain tonnage moved in 1966 on inland waterways went exempt or by private carrier. Thus, much of the barged grain moved at rates which were not necessarily the same as published rates.

20/ Correspondence with Richard Crabtree of the Pacific Northwest Grain and Grain Products Assoc., in June 1970.

21/ Correspondence with W. E. Balsiger of North Pacific Grain Growers, Inc., in June 1970.

REGIONS WITH BARGING FEASIBILITY IN STUDY OF GRAIN MARKETING SYSTEM

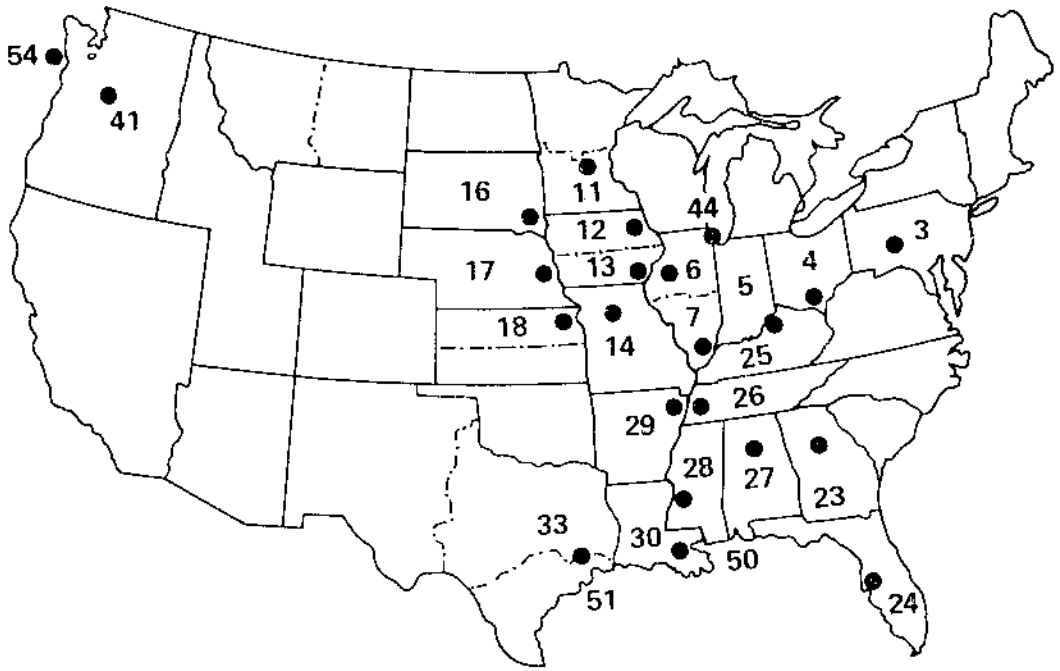


Figure 3

known as the jumbo covered hopper barge, which is 195 feet by 35 feet, was specified for the Mississippi River system. 22/ Covered barges 250 feet by 42 feet were specified for tows on the Columbia River because technology differs on that river. 23/

Adequate-sized lock chambers on waterways requiring locks are necessary for typical tows operating on these waterways. Efficient lock operation is important to the economics of barge transportation. When a tow is too large to pass through a lock in a single operation, the tow must be broken and double-locked. Breakup and reassembly of the tow, plus any time if other tows are waiting for lockage (35), imposes added costs to operators. Towboat operating costs (1966) were $66 per hour up to $105 per hour for 3,200 to 6,500 horse-power towboats, respectively (36).

22/ Confirmed by correspondence with D. R. Brandenborg, Vice President of Cargo Carriers Inc., Minneapolis, Minn., in Sept. 1969. The rivers of the Mississippi River system included here are the Missouri River, the Illinois Waterway, the Ohio River, and the Tennessee River.

23/ Supplied by Paul W. Light, Traffic Coordinator of Pacific Inland Navigation Company, Inc., Vancouver, Wash., in May 1970.

Channel depth also affects the costs of barging operations. Considering that payload must be lightened 17 tons for every inch reduction of draft, the cost per unit barged increases rapidly when channel depth is reduced. 24/

Speed of barge tows differs for movements upstream and downstream since movements with the stream require less towboat power.

Data used in the study for channel depth, towboat speeds, tow sizes, towboat horsepower, and number of barges per tow are presented in appendix table 13.

Cost Data

The only barging cost data found during the study were not readily accessible. But with the cooperation of the Mobile District, Army Corps of Engineers, these data were loaned to us (36). At the suggestion of Tennessee Valley Authority (TVA) officials, costs for cleaning barges were added. This section presents resulting costs for towboats and barges.

Towboat Costs.--Costs of service for towboats developed by the Corps of Engineers include ownership cost--depreciation, interest, return on investment, administration, insurance and taxes; and variable costs--wages, maintenance and repairs, supplies, subsistence, and miscellaneous costs (36, p. B-7).

Towboats were depreciated over a 20-year period and were assumed to have a 5-percent salvage value. Thus, annual depreciation is computed on 95 percent of the new cost of the equipment.

The firm operating towboats has been assumed to obtain half its investment capital from the market and half from internal sources. Thus, an interest cost is incurred on half the investment at a rate of 5 1/2 percent (36, p. B-8).

A return on investment must be charged for the portion of towboat investment borne by internal capital. A rate of 8 percent on half the investment has been used because the risk involved in carrying a mortgage equal to the investment supported by internal capital may be considered a cost. 25/

Administrative and supervisory expenses were also grouped with ownership costs. These costs were taken from (36, p. B-8). Insurance costs for towboats were not separated as to type (36, p. B-8). Taxes for towboats were found to be 0.5 percent of the initial investment cost (36, p. B-8). All costs discussed in this section are shown in table 17.

24/ Furnished by D. R. Branderborg, Vice President of Cargo Carriers, Inc., Minneapolis, Minn.

25/ In (36), a return on investment of 10 percent was used, but an 8-percent figure was used in revised data furnished by the U.S. Army Corps of Engineers, Tulsa District.

The variable costs considered are those related to operating towboats. Costs for wages and fringe benefits, fuel, maintenance and repairs, supplies, subsistence, and miscellaneous expenses appear in table 17.

Total annual operating costs are the sum of ownership and variable costs. Because a barging firm has a large investment in a towboat, operation of a towboat is as close to 24 hours a day as possible. The only downtime considered is for major repairs. Thus, for the Mississippi River system operations, towboats are considered to operate 345 days per year, or 8,280 hours (36, p. B-11). For towboats operating on the Columbia-Snake Rivers, annual operation is 330 days, or 7,920 hours annually. 26/ Thus, hourly operating costs in table 17 were derived by allocating total annual costs of operation over total annual hours of operation. Later in this section, an explanation of allocating hourly total costs to bushels of grain is given.

Barge Costs.--Total costs of operation for barges considered by the Corps of Engineers (36, p. B-8) include ownership costs, depreciation, interest, return on investment, administration, insurance and taxes, and variable costs associated with operations, maintenance, and repairs. Hourly costs are presented for the jumbo barge (195 feet by 35 feet) as developed in (36), with the exception of the revision for return on investment made by the Tulsa District and the development of barge cleaning costs suggested by the TVA.

Costs presented for the 250- by 42-foot super jumbo covered barge used on the Columbia River were synthesized from relationships found in (36, p. B-8). The investment cost was derived by assuming that the relationship of the costs of a 42- by 250-foot dry cargo covered (jumbo) barge to a similar 195- by 35-foot barge was the same as the relationship of a 195- by 35-foot cylindrical pressure barge and a similar barge 240 by 50 feet (36, p. B-10). Administrative expenses were found to be 6.26 percent of depreciation and interest expenses; maintenance and insurance were 3.13 percent of the investment, proportioned as 0.36 and 0.64, respectively, as found for the 195- by 35-foot barge; and taxes were found to be 10 percent of the return on investment (table 18).

Cleaning cost data were not readily available. The cost associated with cleaning grain barges came from data presented before the ICC on barge-cleaning costs (13, unpublished exhibit number 393 of Schedules Band C). Total cleaning costs in 1963 for barges were presented for a major barging firm. The total number of barges was also given. Thus, costs were derived for single barges by simple division. These data were adjusted to the 1966 level by using "Average (Median) General Wage Changes in Major Collective Bargaining Situations" (59, table II). The total annual cleaning costs per barge are presented in table 18.

Total costs per hour of operation by type of barge are also in this table. Costs for barges on the Mississippi River system and the Columbia-Snake Rivers

26/ This information was supplied by Paul W. Light, Traffic Coordinator of the Pacific Inland Navigation Company, Inc., Vancouver, Wash., May 1970.

Table 17--Total hourly costs for owning and operating towboats, by horsepower rating, 1966

Item	Horsepower rating							
	800	1,200	1,800	2,000	2,200	2,400	3,200	5,600
	Dollars							
Fixed costs:								
Investment	250,000	350,000	500,000	5 ,500	587,000	630,000	800,000	1,310,000
Ownership costs:								
Depreciation	11,875	16,625	23,750	25,815	27,880	29,925	38,000	62,225
Interest	6,875	9,625	13,750	14,950	16,140	17,325	22,000	36,025
Return on investment	10,000	14,000	20,000	21,740	23,480	25,200	32,000	52,400
Administration	28,445	33,825	41,360	45,555	47,115	48,675	57,265	77,260
Insurance	5,000	7,000	10,000	10,870	11,740	12,600	16,000	26,200
Taxes	1,250	1,750	2,500	2,720	2,940	3,140	4,000	6,550
Total ownership costs	63,445	82,825	111,360	121,650	129,295	136,875	169,265	260,660
Variable costs:								
Wages and fringe benefits	129,420	141,570	158,360	175,100	175,100	175,100	191,130	207,600
Fuel	27,315	41,695	62,120	68,535	75,530	82,520	198,430	183,530
Maintenance and repairs	12,500	17,500	25,000	27,175	20,350	31,500	40,000	65,500
Supplies	5,750	6,500	7,625	8,000	8,375	8,750	10,250	14,750
Subsistence	7,245	8,280	9,315	10,350	10,350	10,350	11,385	12,420
Miscellaneous	2,415	2,955	10,000	10,870	11,740	3,670	4,380	5,050
Total variable costs	184,645	218,500	265,730	292,830	302,375	311,890	365,575	488,850
Total annual costs of operation	248,090	301,325	377,090	414,480	431,670	448,765	534,840	749,510
Total hourly costs of operation	30	36	46	50	52	57	65	91

Table 18--Total hourly costs of service for barges, by barge size, 1966

Item	Barge dimensions	
	195' x 35'	250' x 42'
	Dollars	
Fixed costs:		
Investment	76,000	109,615
Ownership costs:		
Depreciation	3,610	5,207
Interest	2,090	3,014
Return on investment	3,040	4,385
Administration	357	515
Insurance	1,520	2,196
Taxes	380	438
Total ownership costs	10,997	15,755
Variable costs:		
Maintenance and repairs	859	1,236
Cleaning costs	643	643
Total variable costs	1,502	1,879
Total annual costs of operation	12,499	17,634
Total hourly costs of operation	1/1.47 2/1.51	2/2.13 3/

1/ Mississippi River system--using 355 days, or 8,520 hours, of annual operation.
2/ Columbia-Snake Rivers--using 345 days, or 8,280 hours, of annual operation.
3/ Not considered to be used on the Mississippi River system.

differ because of the number of days of the year the barges are considered to be in use. On the Mississippi River system, barges are considered to be in active use 355 days, 24 hours a day or 8,520 hours per year. On the Columbia-Snake Rivers, the year of operation is 345 days, or 8,280 hours.

Costs for loss and damage were not considered in (36). These data were constructed from data on tons of grain lost from barging (45, p. 19) and average 1966 prices (38). The cost derived per ton was 20 cents, or 0.6 cent per bushel.

Time Factors and Backhaul

Time Factors.--Since costs have been developed on a time basis, other cost factors not yet mentioned which depend on time must be considered. These may be categorized by the part of the tow which incurs the time: the barge, the towboat, and both the barge and towboat (36).

The two factors accounting for barge time only are loading and unloading time and layover time at river interchanges. The average total time for loading and unloading a grain barge was assumed to be 96 hours (36, p. B-4). The associated cost was 96 hours multiplied by the applicable cost per hour from table 18.

When grain movements involve routing over two or more connecting waterways, the size of the tow will vary with the respective channel characteristics. The change in tow size occurs at waterway junctions or interchange points, and involves some loss of time or layover until the barges are picked up by the new tow. The estimated time required for such interchanges was an average of 48 hours at each interchange (36, p. B-3). Thus, for each barge movement of grain in the study, the number of interchanges or total layover time was computed by considering the number of hours per interchange and the total hourly barge cost of operation.

When tows consist of 20 or more barges, specified in the study for movements which both originate and terminate on the Mississippi River, the assistance of an extra towboat is required to assemble or disassemble the barge tow. This operation is known as fleeting in the industry (36, p. B-3). The fleeting cost used for the study, which is applicable to towboat costs only, was assumed to be $480 for a round trip for movements using the Mississippi River.

The costs for time which involve both towboat and barges are for makeup, breakup, turn-around time, and mileage. These costs are for time needed to makeup at origin or point of interchange and for travel between these points (36, p. B-3). In the study, for each barge movement, 1 1/2 hours were charged to barges and towboats for each makeup and breakup operation. Travel time for individual movements was computed by dividing distances traveled on each waterway by the corresponding waterway speed (app. table 13).

Backhaul.--The discussion up to this point has presented total hourly costs of operation and time for movements of grain by barge. These costs must be specified further for the unit being transported; in this case, the bushel. To reflect costs of service, accurately, backhaul must be considered.

Specific data on backhaul of barges hauling grain were not found. Thus, these data were estimated from Corps of Engineers figures reported by rivers for the number of trips of vessels (barges) by draft going upstream and going downstream. The estimating method used was that of Federal Barge Lines before the ICC (13, unpublished exhibit No. 393, pp. 5, 5a, and 6). Assuming that any draft 3 feet and under was an empty barge and any draft over 3 feet was a loaded one, the number of empty and loaded barges going upstream and going downstream was estimated. 27/

A measure of backhaul that includes direction of movement was developed. The ratio of empty barges upstream to loaded barges downstream was determined for downstream grain shipments; and the ratio of empty barges downstream to loaded barges upstream was determined for upstream grain shipments.

Consequently, the costs for all barges in a tow can be allocated to the loaded barges and in turn to a unit of product hauled; in this case, the bushel. The empty:loaded ratios by river are presented in appendix table 14.

Barging costs of service were derived for point-to-point movements and thus took account of the rivers and segments of rivers on which grain moved. The equation representing barging costs of service is a function of the time required to deliver grain from origin to destination, plus a fixed cost of 20 cents per ton for grain loss and damage expense. The equation may be expressed as:

$$T = V + O + L \qquad (13)$$

where T = total barging cost per loaded barge,

V = voyage time cost per loaded barge,

O = other operating-time cost per loaded barge, and

L = loss and damage expense of 20 cents per ton delivered.

Voyage time may be defined as:

$$V = \left[\frac{D}{S} + \frac{D}{U}\right] Bn \div (1 + \lambda)\, n \qquad (14)$$

Or, dividing both sides of the equation by n and simplifying this relationship may be expressed as:

27/ This information was obtained by telephone conversation with the U.S. Army Corps of Engineers, U.S. Engineer Division, Lower Mississippi Valley, Office of the Division Engineer, Vicksburg, Miss., May 1969.

$$V = \left(\frac{1}{S} + \frac{1}{U} \right) \left(\frac{BD}{1 + \lambda} \right) \qquad (15)$$

where D = distance between two points,

S = speed in miles per hour downstream,

U = speed in miles per hour upstream,

B = cost per hour of operation per barge,

λ = backhaul percentage, and

n = number of barges in flotilla.

Other operating time cost per loaded barge may be defined as:

$$O = K_1 + K_2 + K_3 + K_4 \qquad (16)$$

where K_1 is the layover time charge per loaded barge equivalent or:

$$K_1 = \frac{(n \cdot w \cdot k_1)\ B,}{(1 + \lambda)\ n} \qquad (17)$$

where w = the number of waterway junctions where layover time is experienced:

k_1= a constant, 96 hours;

K_2= makeup and breakup charge per loaded barge equivalent, or:

$$K_2 = \frac{(n \cdot m \cdot k_2)\ B,}{(1 + \lambda)\ n} \qquad (18)$$

where m = number of makeup and breakup operations:

k_2= a constant of 1.5 hours per barge per makeup, breakup operation, or both;

K_3= loading and unloading charge per loaded barge equivalent or:

$$K_3 = k_3 B, \qquad (19)$$

where k_3= loading and unloading time per barge for loaded barges;

K_4= fleeting charge per round trip per loaded barge equivalent on movements utilizing the Mississippi River; and:

$$K_4 = \frac{k_4}{(1 + \lambda)n}, \qquad (20)$$

where k_4= the constant, $480.

The procedure for deriving transportation costs of service for trucks, rails, and barges was determined using the equations and methods defined thus far. Appropriate handling costs (table 19) were combined with service costs associated with each mode of transportation to arrive at transfer costs. These were used in the study to describe more accurately the costs of the grain marketing system.

Transfer costs associated with each mode of transportation were computed for each possible movement between points of origin and destination defined for the study (tables 20 and 21).

Mileages used for the various point-to-point movements by truck were taken from (7). Rail distance data were available in tabular form in several publications (4, 31, and 33). The number of origins and destinations listed, as well as the specific points included, varied considerably among these publications. There was also significant variation in the mileage listed. An alternative means of obtaining short-line rail distance was to use a procedure called PICADAD, developed by the U.S. Department of Commerce (5). This method allows one to convert highway mileage data and is based on data for 3,100 rail movements divided into mileage blocks. Ratios of rail short-line miles to straight-line miles and of highway miles to straight-line miles were computed for the blocks. Through the two ratios, ratios of rail short-line miles to highway miles can be derived for the mileage blocks. These data were used to compute rail mileages for the study (app. table 15). The mileages used for barge portions of movements came from data published by the U.S. Corps of Engineers (34) and the U.S. Department of Transportation (61).

Thus, the basic difference in input data in Leath's model I (21), defined as model I-R here, and model I-C of the study, was the difference in Leath's 1966 transportation rates and the estimated transportation costs of service developed here.

ANALYSES

Two basic models were formulated to evaluate the effects on optimum grain and flour flows, optimum locations, capacities of processing facilities, and costs of marketing grain. Model I-C was composed of data from the analytical procedure section plus cost-of-service transportation charges. This model was compared with Leath's model I-R, using the same supply, demand, and marketing facilities, and published transportation rates. The result was an estimate of the shortrun costs of the existing transportation rate structure. Model II-C differed from model I-C in that regional milling and storage capacities

Table 19--Estimated costs of handling grain in commercial elevators by geographical area, type of facility, and mode of transportation, 1964-65

Area and facility	Received by--			Shipped by--		
	Truck	Rail	Water	Truck	Rail	Water
	Cents/bushel					
North Plains: 1/						
Inland elevators	1.95	4.81	2/1.50	3.50	2.71	1.00
Port elevators	--	--	--	--	--	--
Midplains: 3/						
Inland elevators	2.28	2.87	2/1.50	2.36	3.56	2/2.50
Port elevators	--	--	--	--	--	--
South Plains: 4/						
Inland elevators	3.07	10.50	2/1.50	3.38	4.19	2/2.50
Port elevators	1.60	1.20	1.20	2.30	3.10	0.80
West: 5/						
Inland elevators	2.64	7.55	2/1.50	3.45	3.15	2/2.50
Port elevators	2.00	2.30	1.20	2.00	4.20	1.50
Great Lakes: 6/						
Inland elevators	2.47	6.75	2/1.50	2.49	3.08	2/2.50
Port elevators	1.30	3.00	1.10	4.30	2.60	1.40
South and East: 7/						
Inland elevators	1.95	3.86	2.00	3.20	2.18	2/2.50
Port elevators	1.30	1.80	4.00	3.90	2.40	1.00

1/ N. Dak., S. Dak., and Minn. (excluding port facilities).
2/ From (36, p. B-18).
3/ Nebr., Kans., Colo., Wyo., Iowa, and Mo.
4/ Okla., N. Mex., and Tex., plus all gulf port facilities.
5/ Wash., Oreg., Idaho, Mont., Calif., Ariz., Nev., and Utah.
6/ Wisc., Ill., Ind., Ohio, Mich., Minn., and port facilities.
7/ Ark., Miss., S.C., Tenn., Ky., N.Y., Va., Pa., N.J., Md., Del., La., Ala., Ga., Fla., N.C., W. Va., and New England (excluding port facilities).

Source: (39, 1966), unless otherwise noted.

Table 20--Regional basing points for U.S. domestic grain origins and destinations

Code		State	Grain origin	Grain destination
1	NE	New Lngland	Northampton	Boston
2	NY	New York	Canandaigua	New York
3	Pa	Delaware, Maryland, Pennsylvania and New Jersey	Altoona	Philadelphia
4	Oh	Ohio	Marysville	Mansfield
5	In	Indiana	Kokomo	Indianapolis
6	Il	Illinois, northern	Peoria	Chicago
7	Il	Illinois, southern	Mt. Vernon	East St Louis
8	Mi	Michigan	Albion	Detroit
9	Wi	Wisconsin	Madison	Fon du Lac
10	Mn	Minnesota, northern	Fergus Falls	Duluth
11	Mn	Minnesota, southern	New Ulm	Minneapolis
12	Ia	Iowa, northern	Algona	Mason City
13	Ia	Iowa, southern	Chariton	Des Moines
14	Mo	Missouri	Brunswick	Jefferson City
15	ND	North Dakota	Finley	Minot
16	SD	South Dakota	Huron	Sioux Falls
17	Ne	Nebraska	Central City	Lincoln
18	Ks	Kansas, northern	Russell	Topeka
19	Ks	Kansas, southern	Pratt	Wichita
20	Va	Virginia and West Virginia	Farmville	Richmond
21	NC	North Carolina	Dunn	Rocky Mount
22	SC	South Carolina	Sumter	Laurens
23	Ga	Georgia	Fitzgerald	Atlanta
24	Fl	Florida	Cottondale	Tampa
25	Ky	Kentucky	Eddyville	Louisville
26	Tn	Tennessee	Waverly	Jackson
27	Al	Alabama	Clanton	Birmingham
28	Ms	Mississippi	Greenwood	Jackson
29	Ar	Arkansas	Wynne	Little Rock
30	La	Louisiana	Pineville	Baton Rouge
31	Ok	Oklahoma	Waynoka	Oklahoma City
32	Tx	New Mexico; Texas, western	Littlefield	Amarillo
33	Tx	Texas, southern	Beeville	Houston
34	Tx	Texas, eastern	Cisco	Ft. Worth
35	Mt	Montana, eastern	Wolf Point	Miles City
36	Mt	Montana, western	Conrad	Great Falls
37	Wy	Wyoming	Wheatland	Casper
38	Co	Colorado	Limon	Denver
39	Az	Arizona	Tucson	Phoenix
40	Id	Utah and Idaho	Pocatello	Ogden
41	Wa	Washington and Oregon	Othello	Portland
42	Ca	Nevada and California	Modesto	Fresno

Table 21--Basing points for U.S. export port destinations

Region	Code	Port
Lake ports	43 Su	Superior, Wisc.
	Du	Duluth, Minn.
	44 Ch	Chicago, Ill.
	Mw	Milwaukee, Wisc.
	45 To	Toledo, Ohio
	Sg	Saginaw, Mich.
	Ca	Carrollton, Mich.
	Zi	Zilwaukee, Mich.
	Bu	Buffalo, N.Y.
Atlantic ports	46 Al	Albany, N.Y.
	Bo	Boston, Mass.
	Pr	Portland, Maine
	47 Ba	Baltimore, Md.
	Pa	Philadephia, Pa.
	NY	New York, New York
	48 Nf	Norfolk, Va.
	49 Cs	North Charleston, S.C.
Gulf ports	50 NO	New Orleans, La.
	Mb	Mobile, Ala.
	Pc	Pascagoula, Miss.
	Pl	Port Allen, La.
	De	Destrehan, La.
	51 Ho	Houston, Tex.
	Pr	Port Arthur, Tex.
	Be	Beaumont, Tex.
	Ga	Galveston, Tex.
	CC	Corpus Christi, Tex.
Pacific ports	52 LB	Long Beach, Calif.
	53 Sk	Stockton, Calif.
	SF	San Francisco, Calif.
	Oa	Oakland, Calif.
	54 Po	Portland, Oreg.
	As	Astoria, Oreg.
	Vn	Vancouver, Wash.
	Lo	Longview, Wash.
	Ka	Kalama, Wash.
	55 Se	Seattle, Wash.
	Ta	Tacoma, Wash.

were unrestrained. Comparing model II-C with model I-R provided data on longrun changes in flows of grain and flour, and optimum location of flour milling capacity. These two comparisons satisfied objective 3 of the study.

Model I-C and Model I-R Compared

Comparing optimum geographical flows, utilization of milling capacity, and regional ending inventories of models I-C and I-R provides information about changes which might occur in the industry if transportation rates became more and more closely related to service costs.

Optimum Georgraphical Flows: Hard Wheat, Soft Wheat, and Associated Flours

The absolute volumes shipped in model I-C and net changes in optimum geographical flows of grains and flours and soybeans in models I-C and I-R are presented below. Volumes shipped in model I-C are given in the "quantity shipped" columns of the accompanying tables, and the net changes in volumes shipped between origins and destinations are shown in the "change in quantity" columns. These differences reflect the shifts resulting from the impact of different transportation charges on the grain marketing system.

Hard Wheat.--Of the point-to-point domestic movements made in model I-R, only six shipments remained unchanged when cost-of-service transfer charges were substituted for the existing rates (table 22). Twenty-one of the movements which were optimum under existing rates were deleted and 11 new ones entered the solution. 28/ There were 16 movements which had changes in the volume shipped when cost-of-service transfer charges were substituted. Eleven of these movements were increased in volume and five were decreases.

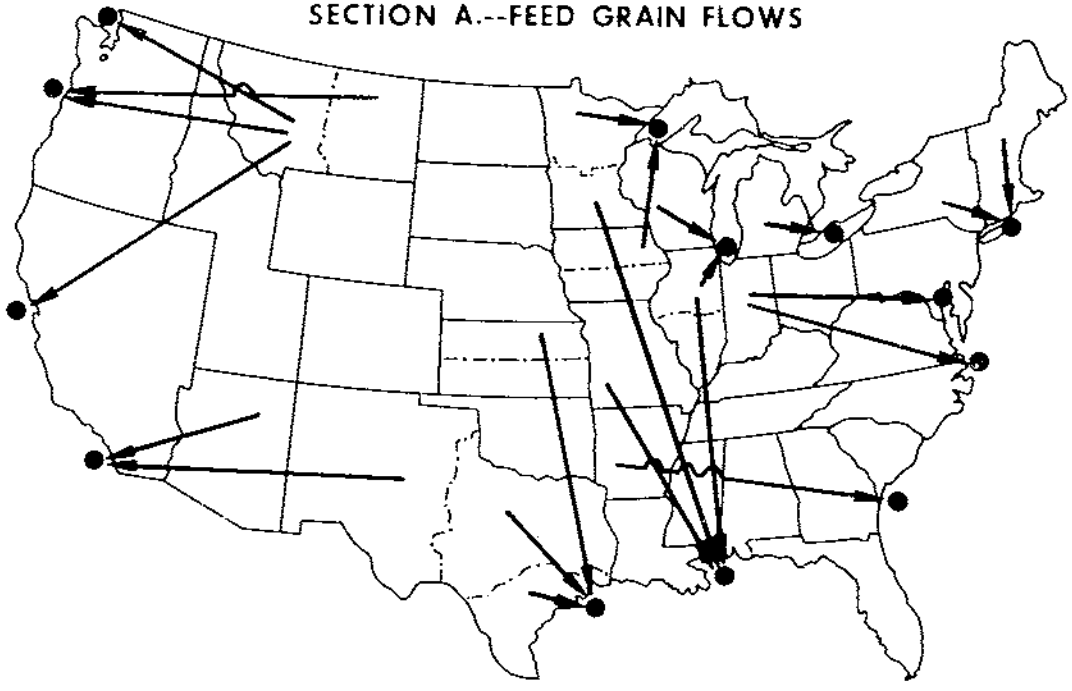
Nine regions (3, 4, 9, 10, 12, 13, 32, 38, and 42) had no changes in volume of hard wheat shipped to domestic destinations. Eight (15, 17, 18, 19, 31, 35, 36, and 37) had net gains and 11 had net losses (5, 6, 7, 8, 11, 14, 16, 33, 34, 40, and 41). Of regions with net losses, three had no domestic shipments in model I-C (regions 8, 11, and 14), and sent their entire available supplies to export.

More regions shipped hard wheat to export with cost-of-service transfer charges than with existing rates, indicating that the average quantity shipped to export decreased. Eleven shipments made by rates were deleted while 17 new movements were initiated. Of point-to-point movements occurring in both models, six had decreased volume and two had increased volume in model I-C; six other movements had no change in volume shipped.

28/ Throughout the discussion comparing grain flows of the models, the term "deleted" means that a movement from a particular origin to a particular destination in one model did not occur in the other model. The term "decreased" means that the quantity shipped from a particular origin to a particular destination went down, and "increased" means the quantity went up.

OPTIMUM EXPORT FLOW PATTERNS FOR FEED GRAIN AND SOYBEANS TO PORT DESTINATIONS, MODEL I-C, 1966/67

SECTION A.--FEED GRAIN FLOWS



SECTION B.--SOYBEAN FLOWS

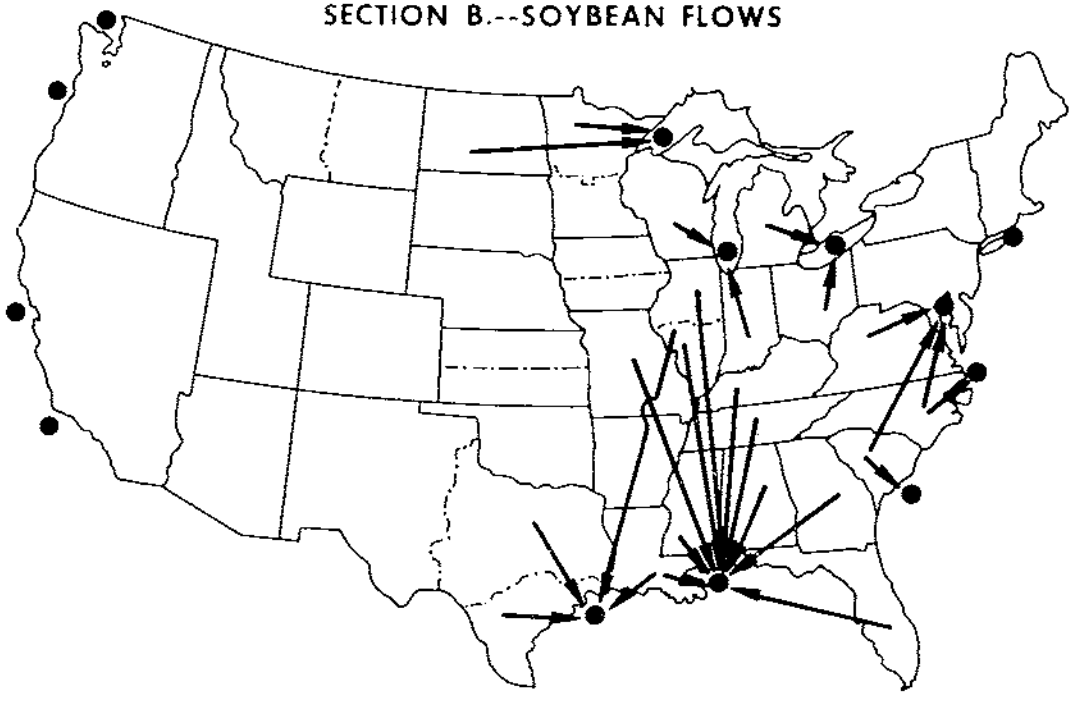


Figure 4

Table 22--Optimum hard wheat shipments to domestic and export demand regions from supply regions and net changes from model I-R, model I-C

Demand region	Supply region	Quantity shipped	Change in quantity	Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
2 N.Y.	10 Minn.	0	-1,767	38 Colo.	38 Colo.	578	0
	15 N. Dak.	3,800	3,800	40 Utah	40 Idaho	1,412	13
	18 Kans.	0	-2,672	41 Wash.	35 Mont.	0	-117
3 Pa.	3 Pa.	560	0		41 Wash.	1,439	-429
4 Ohio	4 Ohio	42	0	42 Calif.	40 Idaho	[illegible]	-21
	5 Ind.	0	-157		42 Calif.	70	0
	9 Wisc.	840	-406	43 Duluth	15 N. Dak.	1,354	0
	10 Minn.	794	794	44 Milwaukee	9 Wisc.	39	0
6 Ill.	6 Ill.	0	-802	46 Albany	2 N.Y.	367	367
	9 Wisc.	406	406		3 Pa.	5	5
7 Do.	7 Ill.	586	-1,274		7 Ill.	0	-561
8 Mich.	8 [illegible]	0	-28		15 N. Dak.	443	443
	10 Minn.	1,555	973		17 New England	0	-254
10 Minn.	15 N. Dak.	128	56	47 Baltimore	2 N.Y.	0	-367
11 Do.	11 Minn.	0	-17[illegible]		3 Pa.	0	-5
	12 Iowa	0	-228		5 Ind.	157	157
	15 N. Dak.	4,924	4,924		6 Ill.	0	-869
	16 S. Dak.	0	-1,321		7 Do.	384	384
13 Iowa	12 Iowa	320	228		8 Mich.	28	28
	13 Do.	22	0		17 Nebr.	3,059	672
	15 N. Dak.	113	113	48 Norfolk	7 Ill.	1,270	1,270
14 Mo.	14 Mo.	0	-1,981		17 Nebr.	0	-1,270
	18 Kans.	4,353	4,353		20 Va.	55	0
15 N. Dak.	15 N. Dak.	0	-364	49 North			
	35 Mont.	290	290	Charleston	7 Ill.	30	30
16 S. Dak.	16 S. Dak.	126	2		11 Minn.	0	-151
17 Nebr.	17 Nebr.	1,662	86		29 Ark.	121	121
18 Kans.	18 Kans.	3,472	40	50 New Orleans	6 Ill.	1,671	1,671
19 Do.	19 Do.	4,642	80		11 Minn.	1,734	1,734
20 Va.	18 Kans.	0	-205		14 Mo.	2,540	2,540
21 [illegible]	[illegible] Do.	0	-[illegible]41		17 Nebr.	2,155	-3,923
22 S.C.	[illegible] Do.	0	-85		19 Kans.	0	-1,901
23 Md.	14 Mo.	[illegible]	-53		29 Ark.	0	-121
26 Fla.	6 Ill.	38	38		30 La.	85	0
25 Ky.	11 Minn.	0	-92	51 Houston	19 Kans.	4,045	-105
	6 Ill.	268	268		31 Okla.	8,942	-646
	7 Do.	151	151		32 Tex.	6,107	0
	14 Mo.	0	-268		33 Do.	571	571
26 Tenn.	11 Minn.	0	-1,316		34 Do.	1,150	180
	19 Kans.	371	371	52 Long Beach	39 Ariz.	21	21
27 Ala.	14 Mo.	0	-238		40 Idaho	13	-21
	16 S. Dak.	384	384	53 Stockton	Do.	17	0
31 Okla.	31 Okla.	1,732	646	54 Portland	15 N. Dak.	0	-37
32 Tex.	32 Tex.	64	0		35 Mont.	915	-437
33 Do.	18 Kans.	852	852		36 Do.	3,148	-1,273
	19 Do.	0	-182		40 Idaho	29	29
	33 Tex.	0	-571		41 Wash.	1,718	1,718
34 Do.	34 Do.	2,212	-180	55 Tacoma	36 Mont.	1,289	1,289
36 Mont.	36 Mont.	564	440		41 Wash.	0	-1,289
37 Wyo.	37 Wyo.	126	73				

When aggregate domestic and export hard wheat are considered, four regions (16, 17, 19, and 35) had net volume losses in hard wheat shipped. Five regions (15, 18, 36, 37, and 39) had net volume gains. Ten (5, 6, 7, 8, 11, 14, 33, 34, 40, and 41) had volume losses in domestic shipments offset by gains in volume exported. Region 31 (Oklahoma) had domestic gains offset by export losses. Three regions (3, 9, and 32) had no change in volume shipped to domestic or export demands. The remaining 10 regions shipping hard wheat (2, 4, 10, 12, 13, 20, 29, 30, 38, and 42) met either domestic or export demands solely in both models I-C and I-R. These regions also experienced no changes in volume shipped in model I-C.

A significant change occurred in the volume of hard wheat shipped from North Central States to the South Atlantic and East South Central States in model I-C--from 32 million to just above 9 million bushels (table 22).

Significant shifts took place among regions in volume shipped intra-regionally in the North Central States. Of considerable notice is the shift in mill receipts of southern Minnesota mills. Shipments from North Dakota to New York were significant, but not as great as the combined decrease in shipments to New York from northern Minnesota and northern Kansas.

The most significant shifts in satisfying export hard wheat requirements were among the North Central States in supplying New Orleans. Nebraska deleted over 39 million bushels to New Orleans, and most of them were stored. The loss of shipments of hard wheat from Nebraska and southern Kansas to New Orleans was gained by other North Central States, all of which had offsetting increased domestic shipments.

Significant shifts occurred in meeting the export requirements at Portland and Tacoma, where Washington and Montana regions essentially offset each other's shifts. The flows of hard wheat in model I-C are presented in figure 4.

Hard Wheat Flour.--As to be expected, if the domestic hard wheat shipments of model I-C differed from model I-R the hard wheat flour shipments would also differ. These are compared in table 23. The flows of model I-C are presented in figure 5.

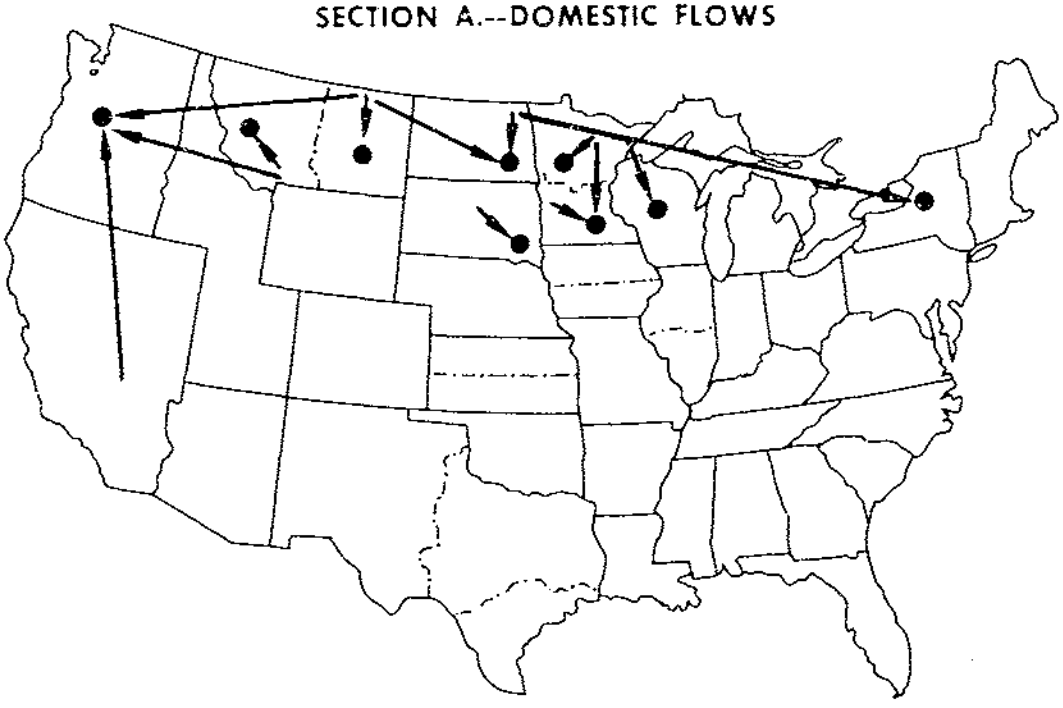
The shift in shipments received by the South Atlantic and East South Central States to more reliance on mills in the North Central States is noticeable. Flour was relatively cheaper to ship than wheat to those areas when cost-of-service transportation charges were assumed effective.

A major change in shipments from mills within the North Central States to the Middle Atlantic States occurred in model I-C. Southern Illinois lost shipments to Pennsylvania of 15.1 million bushels grind, which were gained by other mills in the North Central States. Another significant change in model I-C occurred in hard wheat flour shipments within the North Central States; Michigan became self-sufficient in hard wheat milling.

The most significant shift in volume of export shipments of hard wheat flour in model I-C was to the Gulf ports. Changes involving over 21.6 million bushels occurred among Kansas regions of the North Central States and Oklahoma and Texas regions of the West South Central States.

OPTIMUM FLOW PATTERNS FOR DURUM WHEAT, MODEL I-C, 1966/67

SECTION A.--DOMESTIC FLOWS



SECTION B.--EXPORT FLOWS

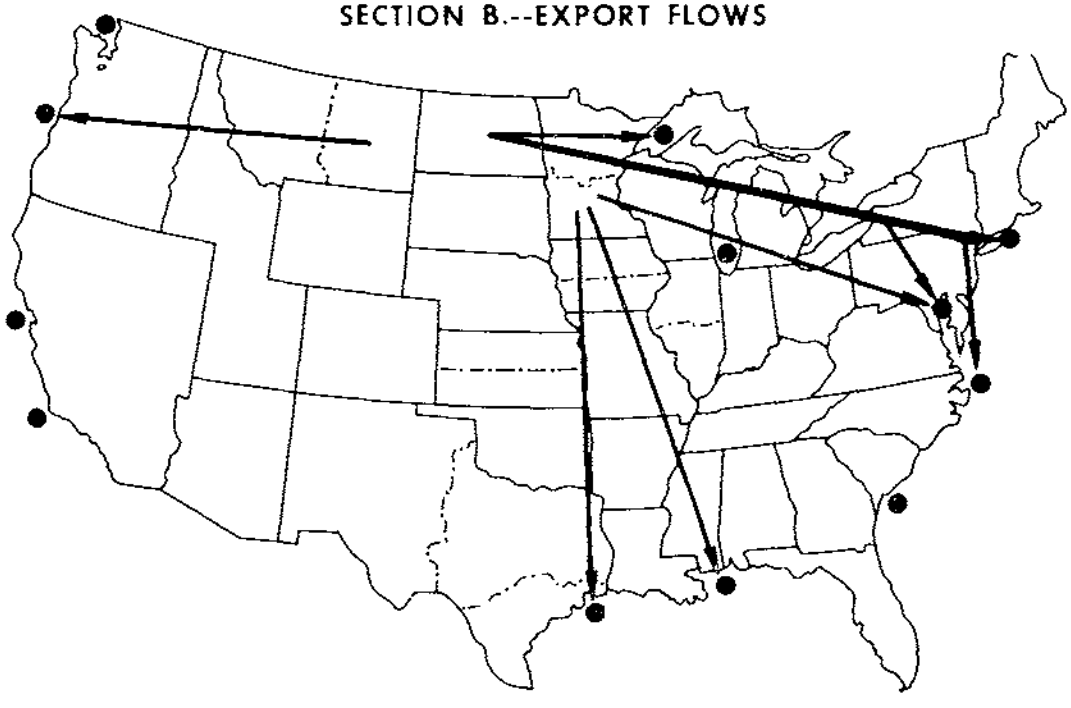


Figure 5

Table 23--Optimum hard wheat flour shipments to domestic and export demand regions from milling regions (wheat equivalents) and net changes from model I-F, model I-[illegible]

Demand region	Supply region	Quantity shipped	Change in quantity	Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
1 New England	2 N.Y.	1,696	0	[illegible]	24 Fla.	0	-82
2 N.Y.	Do.	2,104	-639	[illegible]	7 Ill.	0	-459
	11 Minn.	685	685		14 [illegible]	467	467
	19 Kans.	0	-46		23 Wy.	151	-117
3 Pa.	3 Pa.	560	0	26 Tenn.	24 Mo.	500	500
	7 Ill.	0	-1,910		26 Tenn.	215	-500
	8 Mich.	0	-56	27 Ala.	7 Ill.	147	147
	11 Minn.	620	620		26 Tenn.	117	-293
	13 Iowa	536	536		27 Ala.	384	146
	14 Mo.	298	298	28 Miss.	14 Mo.	0	-268
	15 N. Dak.	0	-246		19 Kans.	451	451
	17 Nebr.	1,245	121		31 Okla.	0	-183
	18 Kans.	518	133	29 Ark.	18 Kans.	0	-363
4 Ohio	4 Ohio	1,040	231		19 Do.	363	363
	14 Mo.	0	-460	30 La.	18 Do.	0	-657
	15 N. Dak.	83	83		19 Do.	657	657
	17 Nebr.	146	146	31 Okla.	31 Okla.	453	0
5 Ind.	11 Minn.	0	-893	32 Tex.	Do.	333	0
	14 Mo.	893	893		32 Tex.	64	0
6 Ill.	6 Ill.	406	-362	33 Do.	33 Do.	0	-753
	11 Minn.	1,122	362		34 Do.	753	753
[illegible]	7 Ill.	439	439	34 Do.	Do.	989	0
	14 Mo.	0	-439	35 Mont.	15 N. Dak.	41	41
8 Mich.	8 Mich.	1,355	1,003		36 Mont.	0	-41
	11 Minn.	0	-1,003	36 Do.	Do.	83	0
9 Wisc.	Do.	768	0	37 Wyo.	37 Wyo.	53	0
10 Minn.	10 Do.	128	56	38 Colo.	38 Colo.	320	0
	15 N. Dak.	29	-56	39 Ariz.	Do.	258	0
11 [illegible]	11 Minn.	503	0	40 Utah	40 Utah	291	0
12 Iowa	Do.	195	195	41 Wash.	41 Wash.	847	0
	13 Iowa	0	-195	42 Calif.	36 Mont.	481	481
13 Do.	Do.	319	0		37 Wyo.	73	73
14 Mo.	14 Mo.	814	0		40 Utah	1,087	13
15 N. Dak.	15 N. Dak.	120	0		41 Wash.	382	-546
16 S. Dak.	Do.	0	-2		42 Calif.	1,015	-21
	16 S. Dak.	126	2	43 Duluth	15 N. Dak.	27	0
17 Nebr.	17 Nebr.	271	0	44 Chicago	6 Ill.	0	-34
18 Kans.	18 Kans.	267	0		11 Minn.	34	34
19 Do.	19 Do.	267	0	47 Baltimore	14 Mo.	181	181
20 Va.	14 Mo.	1,200	1,200		17 Nebr.	0	-181
	19 Kans.	0	-995	49 North Charleston	21 N.C.	0	-39
	20 Va.	0	-205		26 Tenn.	39	39
21 N.C.	18 Kans.	904	904	50 New Orleans	18 Kans.	0	-366
	21 N. Caro.	0	-904		19 Do.	1,367	366
22 S.C.	18 Kans.	495	85	51 Houston	Do.	928	-865
	22 S.C.	0	-85		31 Okla.	946	946
23 Ga.	18 Kans.	212	212		33 Tex.	852	852
	19 Do.	500	149		34 Do.	470	-933
	23 Ga.	0	-63	53 Stockton	40 Utah	34	0
	26 Tenn.	0	-191	54 Portland	41 Wash.	123	0
	31 Okla.	0	-117	55 Tacoma	Do.	87	0
24 Fla.	18 Kans.	1,044	92				

Table 24--Optimum soft wheat shipments to domestic and export demand regions from supply regions and net changes from model I-R, model I-C

Demand region	Supply region	Quantity shipped	Change in quantity	Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
2 N.Y.	2 N.Y.	1,635	+78	33 Tex.	30 La.	0	-99
3 Pa.	3 Pa.	1,448	0	34 Do.	Do.	180	180
4 Ohio	4 Ohio	1,984	-231	36 Mont.	36 Mont.	36	-16
5 Ind.	5 Ind.	1,660	0	37 Wyo.	35 Do.	34	-73
6 Ill.	Do.	870	870	38 Colo.	Do.	113	113
	8 Mich.	0	-474		37 Wyo.	13	0
7 Do.	7 Ill.	1,274	1,274	39 Ariz.	39 Ariz.	48	0
8 Mich.	8 Mich.	217	-945	40 Utah	40 Idaho	188	-13
9 Wisc.	9 Wisc.	8	0	41 Wash.	41 Wash.	699	-8
10 Minn.	5 Ind.	0	-36	42 Calif.	39 Ariz.	21	21
11 Do.	10 Minn.	[illegible]	-20		42 Calif.	1,048	0
	Do.	152	0	44 Chicago	9 Wisc.	97	0
14 Iowa	5 Ind.	[illegible]	-128	45 Toledo	8 Mich.	1,308	0
	9 Wisc.	369	369	46 Albany	2 N.Y.	364	364
14 Mo.	5 Ind.	627	627		4 Ohio	0	-364
	14 Mo.	[illegible]	-2,125	47 Baltimore	2 N.Y.	111	-842
15 N. Dak.	10 Minn.	0	-48		3 Pa.	0	-170
	35 Mont.	122	122		4 Ohio	1,012	1,012
16 S. Dak.	10 Minn.	50	50	48 Norfolk	Do.	0	-747
	35 Mont.	[illegible]	-52		20 Va.	335	335
17 Nebr.	5 Ind.	0	-106		21 N.C.	412	412
	10 Minn.	18	18	49 North Charleston	Do.	0	-15
18 Kans.	5 Ind.	80	-40		22 S.C.	15	15
19 Do.	Do.	0	-80	50 New Orleans	5 Ind.	0	-191
20 Va.	4 Pa.	+21	421		6 Ill.	628	220
	20 Va.	132	-335		7 Do.	0	-1,274
21 N.C.	21 N.C.	0	-373		14 Mo.	2,125	2,125
22 S.C.	Do.	0	-24		24 Fla.	56	56
	22 S.C.	148	-15		25 Ky.	445	-66
23 Ga.	23 Ga.	27	-1.3		27 Ala.	146	146
24 Fla.	Do.	148	148		28 Miss.	640	-24
	24 Fla.	0	-56		29 Ark.	0	-911
25 Ky.	5 Ind.	117	117		30 La.	0	-81
26 Tenn.	6 Ill.	0	-32	52 Long Beach	39 Ariz.	8	8
	25 Ky.	66	66		40 Idaho	0	-8
	26 Tenn.	396	0	53 Stockton	Do.	12	0
	29 Ark.	911	911	54 Portland	Do.	74	-8
27 Ala.	27 Ala.	0	-146		41 Wash.	9,231	8
28 Miss.	6 Ill.	0	-24	55 Tacoma	Do.	2,354	0
	28 Miss.	24	24				
31 Okla.	6 Ill.	0	-164				

Soft Wheat.--Comparison of soft wheat shipments of model I-R and model I-C are shown in table 24. Soft wheat flows for model I-C are presented in figure 6.

Of the point-to-point movements made in model I-R, eight domestic and four export movements had the same volumes in model I-C as in model I-R. There were 11 domestic and six export movements of model I-R which remained in model I-C, but volumes shipped changed. Ten of the 11 domestic movements increased in volume, while only two of the six export movements gained. Sixteen domestic and nine export movements of model I-R were deleted in model I-C while 17 domestic and eight movements were added.

All regions in model I-C experienced a change in volumes of both domestic and export soft wheat shipped compared with model I-R. However, six regions (3, 10, 23, 26, 37, and 42) shipped the same domestic volume and two regions (8 and 9) shipped the same export volume in model I-C as in model I-R. There were 11 regions (2, 3, 5, 7, 9, 25, 28, 29, 30, 35, and 39) with domestic volume gains and nine (6, 20, 21, 23, 27, 39, 41, 14, and 24) with export volume gains in model I-C. But no region had gains in both domestic and export volumes shipped. Twelve regions (4, 6, 8, 14, 20, 21, 22, 24, 27, 36, 40, and 41) experienced net losses in domestic volume shipped and 10 regions (2, 3, 4, 5, 7, 25, 28, 29, 30, and 40) had net export losses in model I-C. However, only two regions (4 and 40) had net losses in both domestic and export volumes shipped.

A comparison of aggregate volumes shipped (domestic plus export) revealed that five regions (3, 5, 9, 35, and 39) had net gains in volume of soft wheat shipped, four (4, 8, 36, and 40) experienced net losses, and the remaining 17 regions did not change net volumes shipped in model I-C.

The major shifts in domestic volumes of soft wheat shipped occurred in the North Central States and probably resulted from the comparative advantage of low-cost all-water transportation from Missouri to the Gulf.

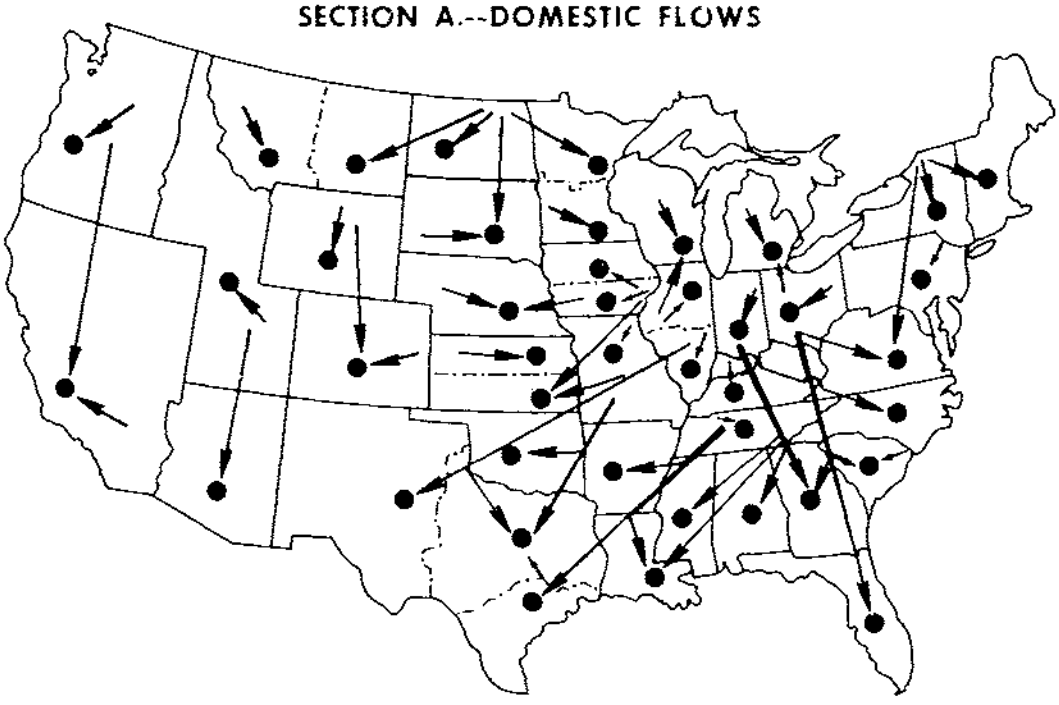
Major changes took place in export shipments to Baltimore and Norfolk, involving approximately 17.6 million bushels. All shipments for export from Pennsylvania, Indiana, southern Illinois, and Arkansas were deleted in model I-C.

Soft Wheat Flour.--Table 25 presents shipments of soft wheat flour for model I-C and net changes in shipments from model I-R. The flows of soft wheat flour for model I-C are contained in figure 7. There were two regions (Missouri and Tennessee) which changed noticeably in domestic shipments in model I-C. Missouri decreased in number and volume of shipments. Tennessee had a rise in both number and volume of shipments and made three of the shipments deleted by Missouri mills.

The change in shipments to particular regions can be seen in table 25, by comparing the "minus" and "plus" movements to those regions. In most instances, decreases in shipments to particular regions were assumed by bordering region mills.

OPTIMUM FLOW PATTERNS FOR SOFT WHEAT FLOUR, MODEL I-C, 1966/67

SECTION A.--DOMESTIC FLOWS



SECTION B.--EXPORT FLOWS

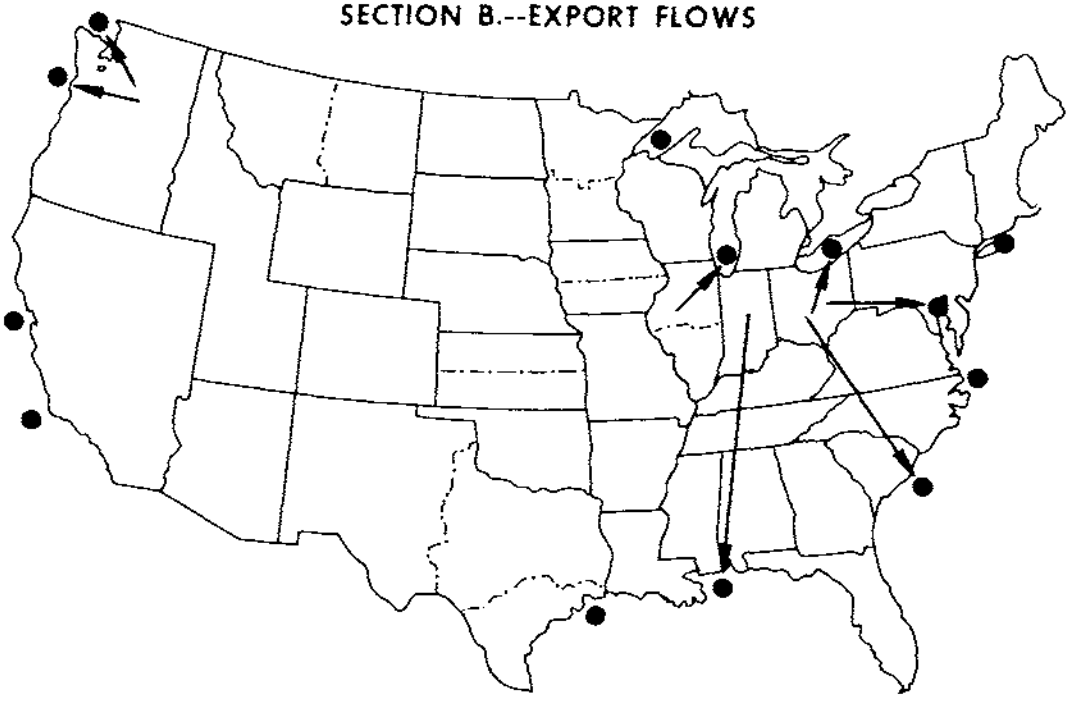


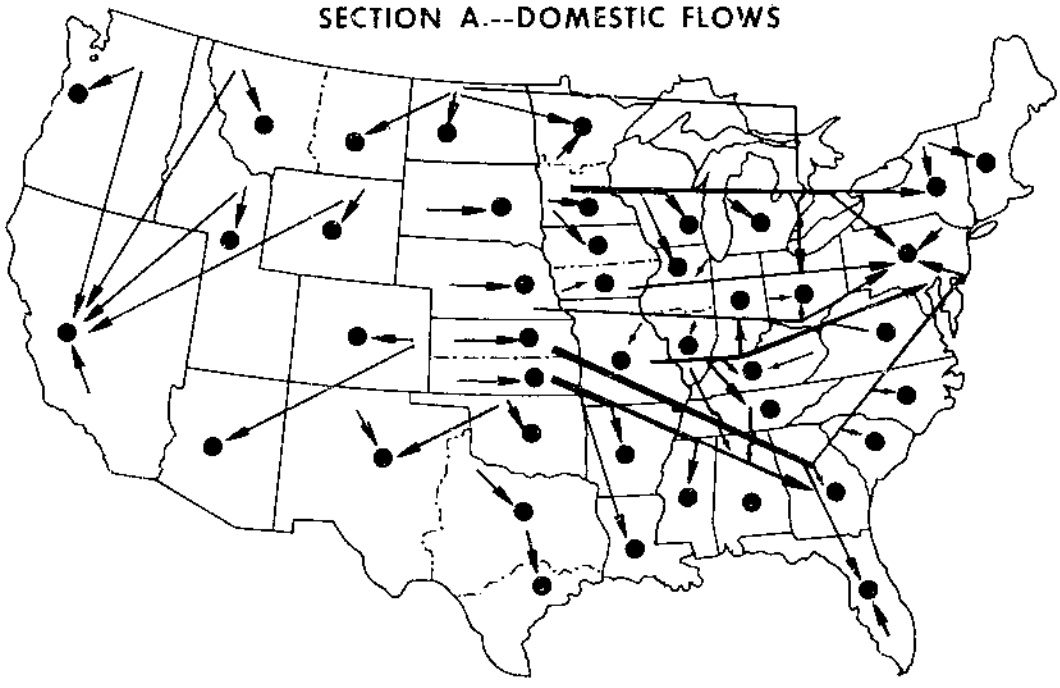
Figure 6

Table 25--Optimum soft wheat flour shipments to domestic and export demand regions from milling regions (wheat equivalents) net changes from model I-R, model I-C

Demand region	Supply region	Quantity shipped	Change in quantity	Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
1 New England	2 N.Y.	560	0	26 Tenn.	26 Tenn.	428	0
2 N.Y.	Do.	920	323	27 Ala.	5 Ind.	392	146
	4 Ohio	0	-323		27 Ala.	0	-146
3 Pa.	3 Pa.	1,448	0	28 Mass.	5 Ind.	264	264
4 Ohio	4 Ohio	696	0		6 Ill.	0	-264
5 Ind.	5 Ind.	340	0		28 Miss.	24	0
6 Ill.	Do.	0	-354	29 Ark.	14 Mo.	0	-224
	6 Ill.	564	354		26 Tenn.	224	224
7 Do.	5 Ind.	0	-160	30 La.	5 Ind.	95	95
	7 Ill.	160	160		14 Mo.	0	-384
8 Mich.	4 Ohio	359	359		26 Tenn.	289	289
	8 Mich.	217	-359	31 Okla.	14 Mo.	264	164
9 Wisc.	6 Ill.	288	288		31 Okla.	0	-164
	8 Mich.	0	-288	32 Tex.	7 Ill.	204	204
	9 Wisc.	8	0		14 Mo.	0	-204
10 Minn.	10 Minn.	0	-56	33 Do.	Do.	0	-333
	15 N. Dak.	56	56		26 Tenn.	432	432
11 Do.	11 Minn.	192	0		33 Tex.	0	-99
12 Iowa	8 Mich.	0	-80	34 Do.	7 Ill.	342	342
	13 Iowa	80	80		14 Mo.	46	-522
13 Do.	Do.	128	0		34 Tex.	180	180
14 Mo.	14 Mo.	312	0	35 Mont.	15 N. Dak.	16	16
15 N. Dak.	15 N. Dak.	48	0		36 Mont.	0	-16
16 S. Dak.	Do.	2	2	36 Do.	Do.	36	0
	16 S. Dak.	50	-2	37 Wyo.	37 Wyo.	24	0
17 Nebr.	13 Iowa	86	86	38 Colo.	18 Kans.	0	-40
	17 Nebr.	18	-86		37 Wyo.	10	-73
18 Kans.	16 Kans.	80	0		38 Colo.	126	113
19 Do.	13 Iowa	75	75	39 Ariz.	39 Ariz.	48	0
	14 Mo.	5	5		40 Utah	60	0
	19 Kans.	0	-80	40 Utah	Do.	128	0
20 Va.	2 N.Y.	155	155	41 Wash.	41 Wash.	364	0
	4 Ohio	0	-241	42 Calif.	40 Utah	0	-13
	20 Va.	553	86		41 Wash.	215	-8
21 N.C.	7 Ill.	568	568		42 Calif.	1,069	21
	8 Mich.	0	-195	44 Chicago	4 Ohio	0	-18
	21 N.C.	0	-373		6 Ill.	18	18
22 S.C.	4 Ohio	148	39	45 Toledo	4 Ohio	23	23
	22 S.C.	148	-39		8 Mich.	0	-23
23 Ga.	4 Ohio	230	-75	47 Baltimore	4 Ohio	79	79
	5 Ind.	223	223		5 Ind.	0	-79
	23 Ga.	27	-148	49 North Charleston	4 Ohio	13	0
24 Fla.	4 Ohio	436	-92	50 New Orleans	5 Ind.	87	0
	24 Fla.	148	92	54 Portland	41 Wash.	82	0
25 Ky.	5 Ind.	259	-117	55 Tacoma	Do.	38	0
	25 Ky.	117	117				

OPTIMUM FLOW PATTERNS FOR HARD WHEAT FLOUR, MODEL I-C, 1966/67

SECTION A.--DOMESTIC FLOWS



SECTION B.--EXPORT FLOWS

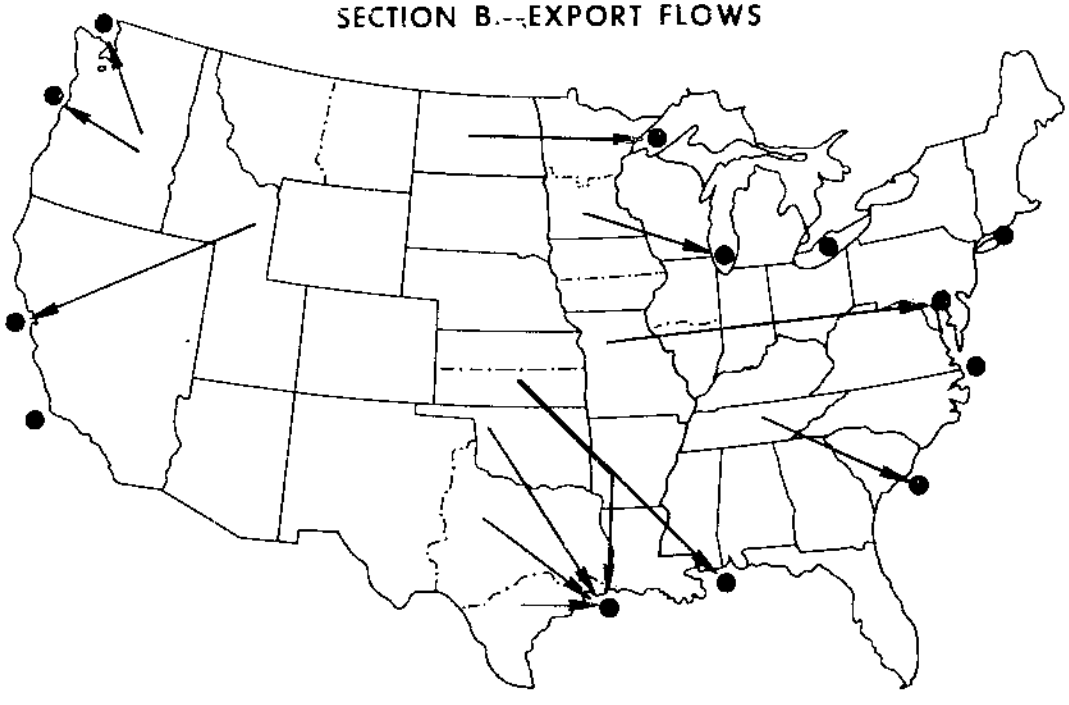


Figure 7

Optimum Milling Industry Organization

Possible effects of cost-of-service transfer charges on regional milling capacity utilization are presented in table 26. The adjustments in flour milling activities shown in this table were such that the total cost to the grain marketing system in supplying flour requirements would have been lower, given the regional wheat distribution. Thus, these adjustments should not be considered as a prediction of the optimum organization of the milling industry. The model's sensitivity to the basic data is shown by the results in the table; the transfer charges were the only difference in data of the two models.

Eleven regions had changes in milling capacity utilization. Considering Census Bureau State groups, most of the regions with net reduction in milling capacity were clustered in the South Atlantic States. North Carolina and Georgia experienced the greatest decreases, from 100-percent utilization in model I-R to zero and 12-percent capacity utilization, respectively, in model I-C. None of the South Atlantic States that milled in model I-C milled hard wheat. Also, hard wheat milled decreased in the East South Central States and soft wheat milled increased. Thus, hard wheat milling corresponded more closely with hard wheat production areas in model I-C than in model I-R. Capacity utilization increases occurred in the North Central, Mountain, and West South Central States.

Optimum Geographical Flows: Durum Wheat, Feed Grains, and Soybeans

Durum Wheat.--Optimum durum wheat shipments of models I-R and I-C are compared in table 27. The flows of durum wheat for model I-C are presented in figure 8. As the volume of durum wheat milled is very low compared with the other wheats, and the number of production and milling regions is limited, the number of shifts in durum wheat shipments was not expected to be significant. The major changes in durum shipments occurred among the durum wheat-producing areas of the North Central States.

Feed Grains.--Shipments of feed grains in models I-C and I-R are compared in table 28. The flows (domestic and export) of feed grains in model I-C are presented in figure 9 and section A of figure 10, respectively.

Of the shifts made in model I-C, most changes in the source of supply for a given destination were from one origin to a nearby origin(s). Thus, in most instances, distance from the source of supply was less. For example, deficits in Arkansas in model I-R were supplied by Missouri and Oklahoma, whereas in model I-C, Arkansas' deficits were supplied by southern Iowa, southern Kansas, and western Texas. Thus, southern Kansas shipped to Arkansas in model I-C, rather than to Oklahoma, and Oklahoma shipped to Arkansas as was true in model I-R. However, some shipment of feed grain in model I-C came from deficit supply regions. For example, Louisiana shipped its own production to Mississippi and received its entire supply from Missouri.

Four regions (12, 15, 17, and 32) had net losses in volume of feed grains shipped compared with model I-R, and five (10, 16, 18, 19, and 36) had net gains.

Table 26--Optimum utilization of existing flour milling capacity and unused milling capacity, model I-R and model I-C

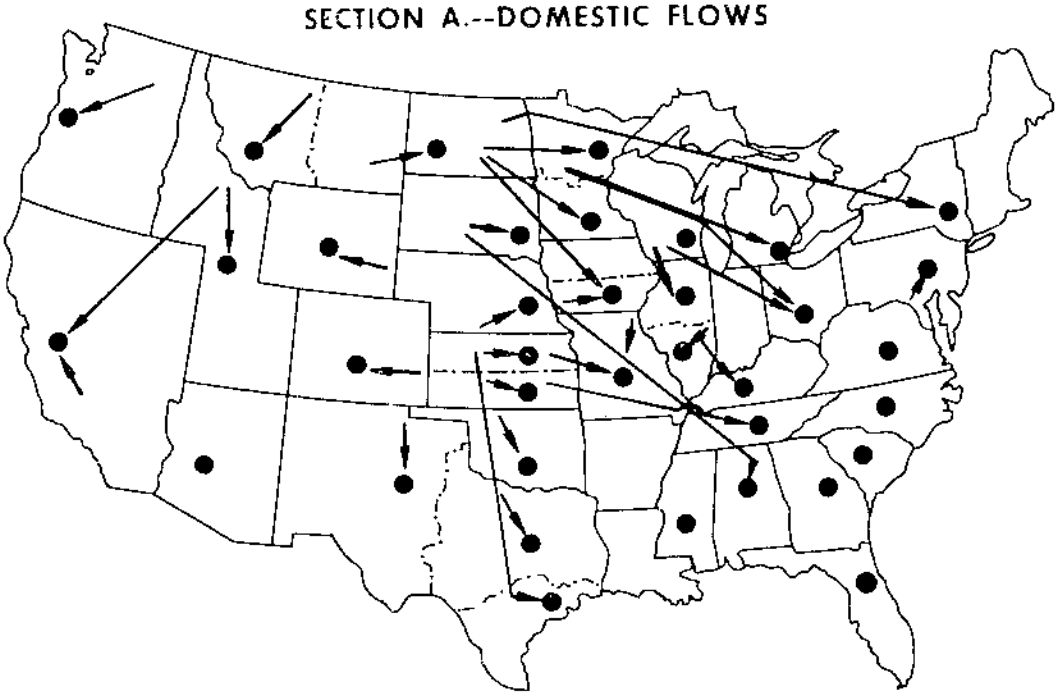
	Milling region	Hard wheat milled			Soft wheat milled			Unused capacity		Value of additional capacity
		Model I-R	Model I-C	Change	Model I-R	Model I-C	Change	Model I-R	Model I-C	
		10,000 bushels								Dollars per 10,000 bushels
2	N.Y.	4,459	3,800	- 659	1,157	1,635	478	0	161	0
3	Pa.	560	560	0	1,448	1,448	0	0	0	652
4	Ohio	1,409	1,640	231	2,215	1,984	- 231	0	0	1,120
5	Ind.	0	0	0	1,660	1,660	0	0	0	1,458
6	Ill.	802	406	- 396	474	870	396	0	0	1,668
7	do.	1,860	586	-1,274	0	1,274	1,274	0	0	1,023
8	Mich.	610	1,555	945	1,162	217	- 945	0	0	1,567
9	Wisc.	0	0	0	8	8	0	0	0	2,384
10	Minn.	72	128	56	56	0	- 56	0	0	1,556
11	do.	3,924	3,924	0	192	192	0	0	0	1,158
13	Iowa	514	855	341	128	369	241	582	0	910
14	Mo.	1,981	4,353	2,372	2,125	627	-1,498	874	0	873
15	N. Dak.	364	290	- 74	48	122	74	0	0	736
16	S. Dak.	124	126	2	52	50	- 2	0	0	1,279
17	Nebr.	1,576	1,662	86	104	18	- 86	0	0	1,388
18	Kans.	3,432	3,472	40	120	80	- 40	0	0	1,157
19	do.	4,552	4,632	80	80	0	- 80	0	0	1,645
20	Va.	205	0	- 205	467	553	86	0	119	0
21	N.C.	943	0	- 943	373	0	- 373	0	1,316	0
22	S.C.	85	0	- 85	187	148	- 39	0	124	0
23	Ga.	53	0	- 53	175	27	- 148	0	201	0
24	Fla.	92	0	- 92	56	148	92	0	0	111
25	Ky.	268	151	- 117	0	117	117	0	0	1,260
26	Tenn.	1,316	371	- 945	428	1,373	945	0	0	1,170
27	Ala.	238	384	146	146	0	- 146	0	0	2,212
28	Miss.	0	0	0	24	24	0	0	0	908
31	Okla.	1,086	1,732	646	164	0	- 164	482	0	1,330
32	Tex.	64	64	0	0	0	0	0	0	2,041
33	do.	753	852	99	99	0	- 99	0	0	2,518
34	do.	2,392	2,212	- 180	0	180	180	0	0	1,285
36	Mont.	124	564	440	52	36	- 16	424	0	1,141
37	Wyo.	53	126	73	107	34	- 73	0	0	1,134
38	Colo.	578	578	0	13	126	113	113	0	1,456
39	Ariz.	0	0	0	48	48	0	0	0	2,703
40	Utah	1,399	1,412	13	201	188	- 13	0	0	1,325
41	Wash.	1,985	1,439	- 546	707	699	- 8	420	974	0
42	Calif.	1,036	1,015	- 21	1,048	1,069	21	0	0	939

Table 27--Optimum durum wheat shipments to domestic and export demand regions from supply regions and net changes from model I-R, model I-C

Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels	
2 N.Y.	10 Minn.	0	-240
	15 N. Dak.	240	240
9 Wisc.	10 Minn.	0	-508
	15 N. Dak.	508	508
10 Minn.	10 Minn.	11	0
11 Do.	Do.	379	-548
	11 Do.	557	548
15 N. Dak.	15 N. Dak.	412	-122
	35 Mont.	122	122
16 S. Dak.	16 S. Dak.	20	0
35 Mont.	35 Mont.	12	0
36 Do.	36 Do.	8	0
42 Calif.	35 Do.	111	-30
	36 Do.	223	0
42 Do.	42 Calif.	30	30
43 Duluth	15 N. Dak.	2,749	0
46 Albany	11 Minn.	0	-83
	15 N. Dak.	83	83
47 Baltimore	11 Minn.	244	244
	15 N. Dak.	45	45
	16 S. Dak.	0	-289
48 Norfolk	11 Minn.	0	-709
	15 N. Dak.	816	816
	16 S. Dak.	0	-107
50 New Orleans	11 Minn.	729	0
51 Houston	Do.	70	0
54 Portland	35 Mont.	52	30
	42 Calif.	0	-30

OPTIMUM FLOW PATTERNS FOR HARD WHEAT, MODEL I-C, 1966/67

SECTION A.--DOMESTIC FLOWS



SECTION B.--EXPORT FLOWS

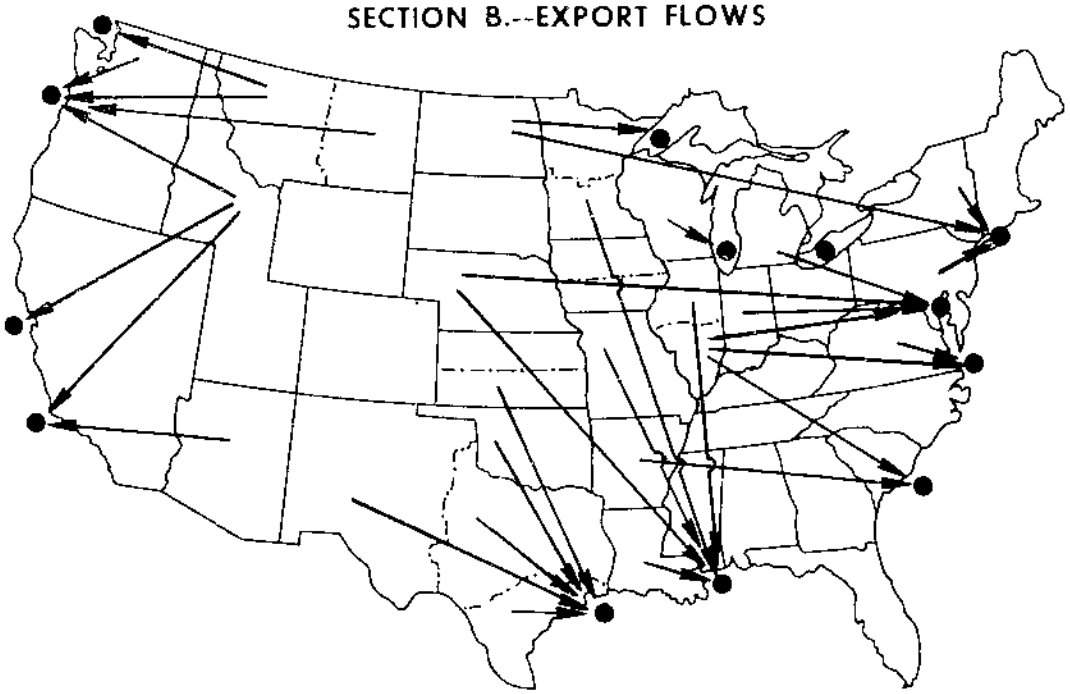


Figure 8

OPTIMUM DOMESTIC FLOW PATTERNS FOR FEED GRAIN, MODEL I-C, 1966/67

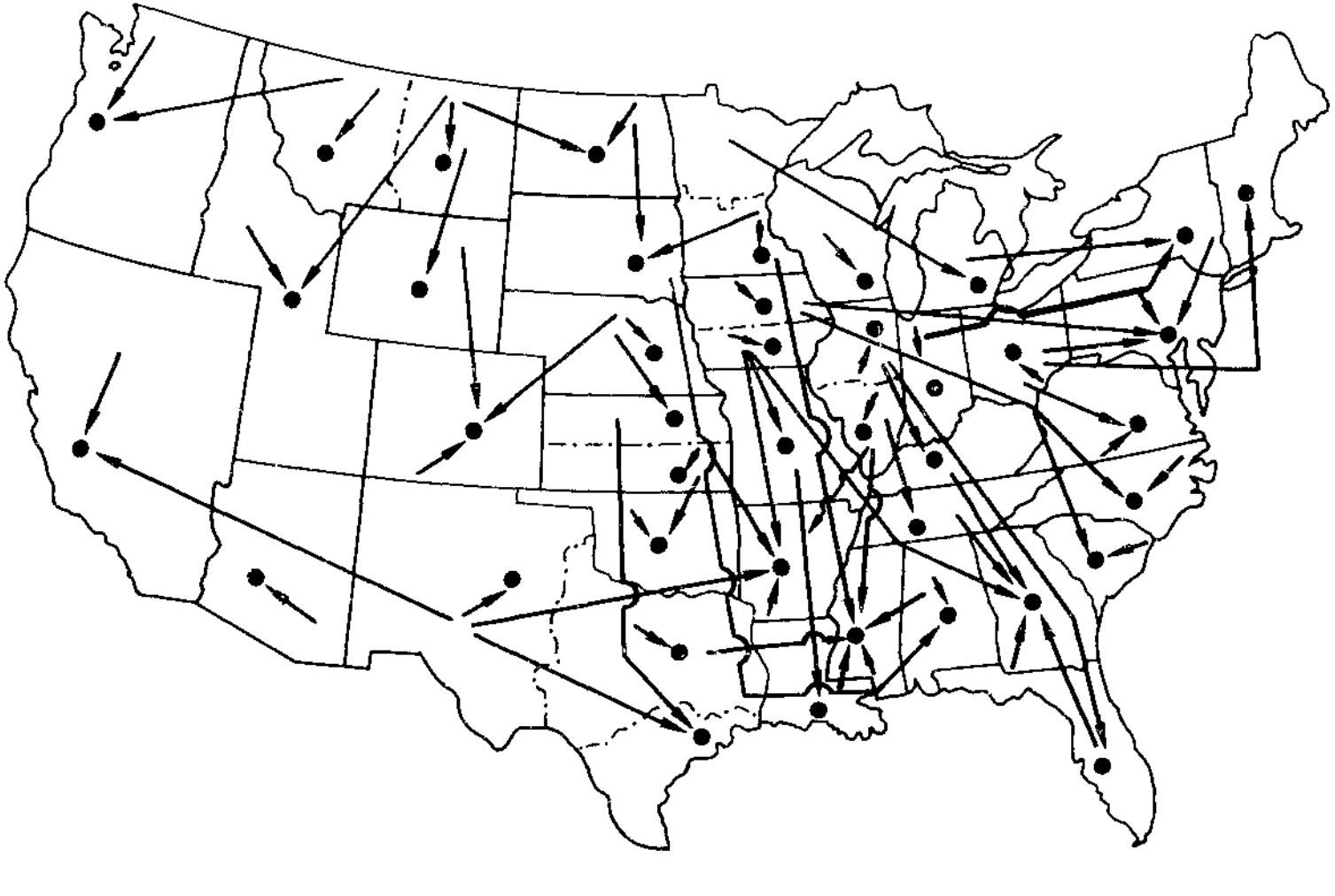


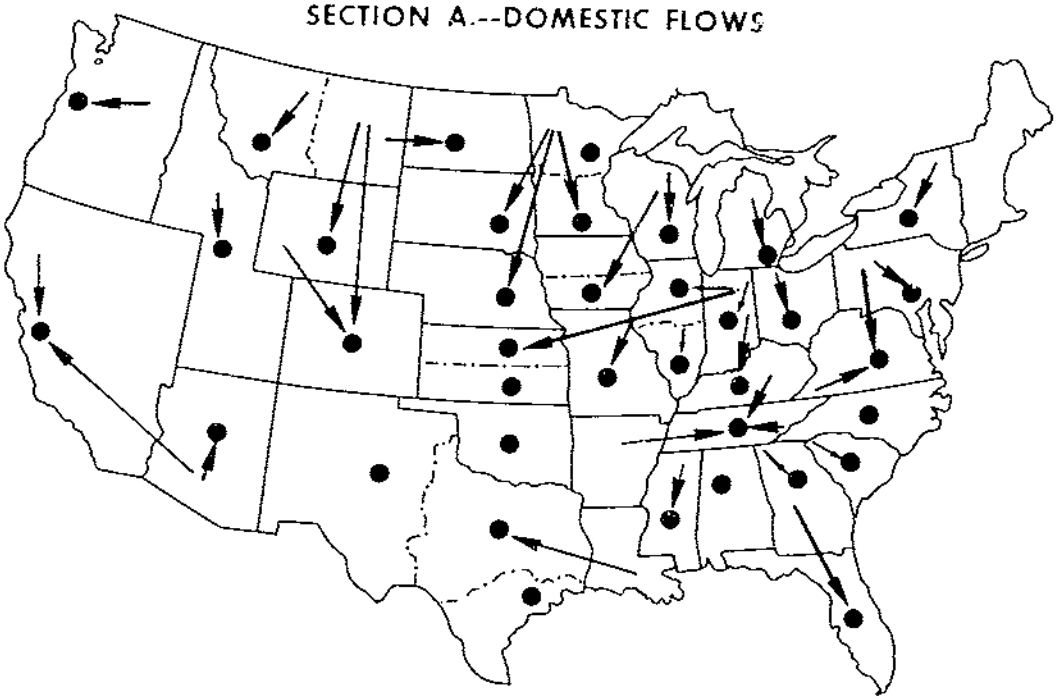
Figure 9

Table 28--Optimum feed grain shipments to domestic and export demand regions from supply regions and net changes from model I-R, model I-C

Demand region	Supply region	Quantity shipped	Change in quantity	Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
1 New England	[illegible]	0	-213		28 Miss.	608	0
	[illegible]	9,033	9,033		30 La.	844	844
	[illegible]	0	-8,820		34 Tex.	1,830	-1,390
2 [illegible]	[illegible]	0	-1,618	29 Ark.	13 Iowa	1,672	1,672
	Ind.	4,642	-2,135		14 Mo.	0	-7,892
	[illegible]	3,753	3,753		19 Kans.	6,375	3,922
3 [illegible]	[illegible]	1,435	1,435		29 Ark.	700	-40
	[illegible]	4,669	0		31 Okla.	0	-1,041
	[illegible]	364	-10,164		32 Tex.	3,379	3,379
	[illegible]	9,441	6,288	30 La.	11 Minn.	0	-1,791
	[illegible]	0	-281		14 Mo.	2,635	2,635
	[illegible]	2,721	2,721		30 La.	0	-844
4 [illegible]	Ohio	2,498	0	31 Okla.	19 Kans.	636	-3,041
5 Ind.	Ind.	7,623	0		31 Okla.	3,041	3,041
6 Ill.	Ill.	11,123	11,123	32 Tex.	32 Tex.	2,676	0
	Iowa	0	-8,775	33 Do.	18 Kans.	5,147	5,147
	Do.	0	-2,348		33 Tex.	0	-5,147
7 Do.	Ill.	7,772	7,772	34 Do.	34 Do.	7,837	0
	Iowa	0	-7,772	35 Mont.	35 Mont.	143	0
8 Mich.	Mich.	0	-[illegible]	36 Do.	Do.	0	-294
	Minn.	3,472	3,472		36 Do.	294	294
9 Wisc.	Wisc.	6,052	0	37 Wyo.	35 Do.	175	0
11 Minn.	Minn.	2,068	2,068	38 Colo.	17 Nebr.	58	0
	S. Dak.	0	-2,068		37 Wyo.	272	0
12 Iowa	Iowa	2,751	0		38 Colo.	3,082	0
13 Do.	Do.	12,127	0	39 Ariz.	39 Ariz.	1,355	0
14 Mo.	Mo.	13,204	0	40 Utah	35 Mont.	273	273
15 N. Dak.	N. Dak.	0	-16		36 Do.	0	-273
	Mont.	16	16		40 Utah	2,194	0
16 S. Dak.	Minn.	582	582	41 Wash.	35 Mont.	0	-1,156
	N. Dak.	495	495		36 Do.	1,156	1,156
	S. Dak.	0	-1,077		41 Wash.	4,559	0
17 Nebr.	Nebr.	9,098	0	42 Calif.	17 Nebr.	0	-9,268
18 Kans.	Do.	1,916	1,916		32 Tex.	9,268	9,268
	Kans.	0	-1,916		42 Calif.	11,476	0
19 Do.	Do.	941	0	43 Duluth	10 Minn.	6,546	-22
20 Va.	[illegible]	5,513	1,130		12 Iowa	22	22
	Ill.	0	-1,130	44 Chicago	6 Ill.	4,161	4,161
	Va.	1,125	0		9 Wisc.	1,495	0
21 N.C.	Ill.	0	-9,544		16 S. Dak.	0	-4,161
	Iowa	9,544	9,544	45 Toledo	8 Mich.	2,146	0
	S.C.	3,935	0	46 Albany	1 New England	213	213
22 S.C.	Ill.	0	-2,014		2 N.Y.	183	183
	Iowa	1,974	1,974		6 Ill.	0	-396
	S.C.	971	40	47 Baltimore	5 Ind.	2,649	2,649
23 Ga.	Ill.	0	-14,657		6 Ill.	0	-2,649
	Iowa	9,225	9,225	48 Norfolk	5 Ind.	2,018	2,018
	Ga.	3,533	0		6 Ill.	0	-2,018
	Fla.	693	693	49 North			
	Ky.	2,957	2,957	Charleston	22 S.C.	0	-40
	Tenn.	1,782	1,782		29 Ark.	40	40
24 Fla.	Ill.	3,850	3,471	50 New Orleans	6 Ill.	22,079	2,138
	Iowa	0	-2,778		11 Minn.	7,754	-10,136
	Fla.	0	-693		14 Mo.	7,998	7,998
25 Ky.	Ill.	5,558	5,558	51 Houston	18 Kans.	7,072	7,072
	Mo.	0	-2,601		32 Tex.	0	-15,609
	Ky.	0	-2,957		33 Do.	8,728	5,147
26 Tenn.	Ill.	8,216	8,216		35 Do.	3,390	3,390
	Iowa	0	-6,434	52 Long Beach	32 Tex.	3,052	0
	Tenn.	0	-1,782		39 Ariz.	1,132	0
27 Ala.	Ill.	0	-8,105	53 Stockton	32 Tex.	0	-924
	Ky.	0	-5,199		36 Mont.	924	924
	Mo.	0	-140	54 Portland	35 Do.	1,281	1,161
	S. Dak.	11,691	11,691		36 Do.	259	-1,161
	Tenn.	889	-247	55 Tacoma	Do.	278	0
28 Miss.	Ill.	0	-626				
	Ky.	1,899	1,899				
	Miss.	1,026	1,026				
	Ala.	247	247				

OPTIMUM FLOW PATTERNS FOR SOFT WHEAT, MODEL I-C, 1966/67

SECTION A.--DOMESTIC FLOWS



SECTION B.--EXPORT FLOWS

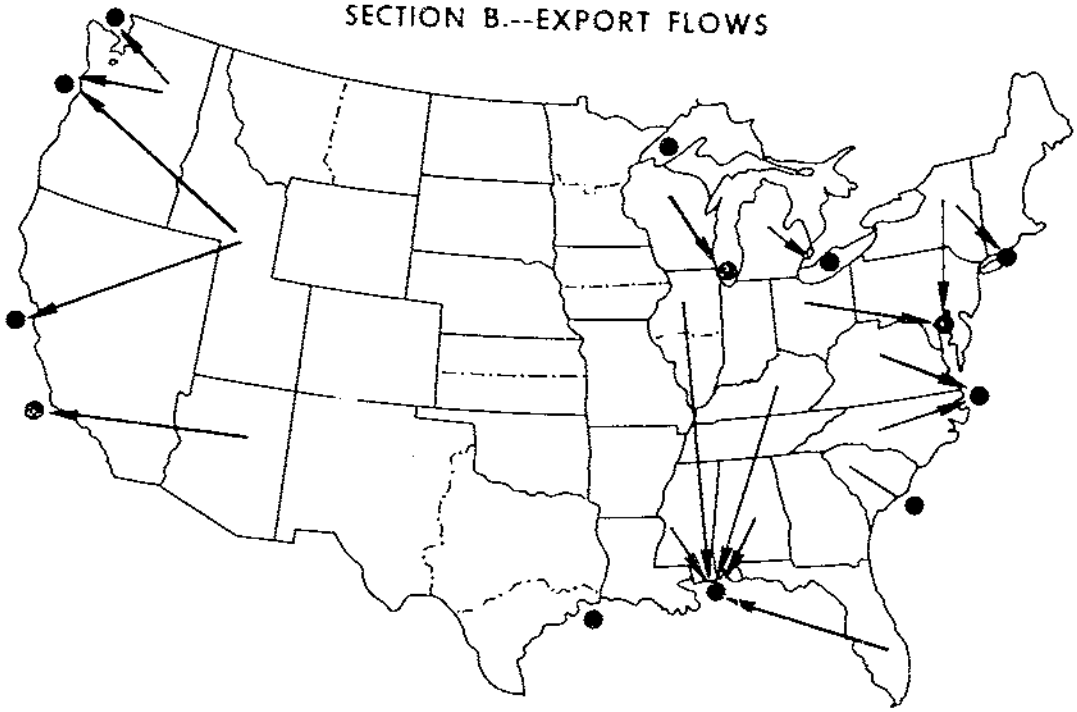


Figure 10

Soybeans.--The domestic shipments of soybeans for model I-C and changes from model I-R are reported in table 29. Because of aggregation, these data differ only slightly. In both models I-C and I-R, the South Atlantic area met its own requirements. The East North Central States met their demands in model I-C, whereas in model I-R, 18.1 million bushels of their total 239.4-million bushel requirement were shipped from the West North Central States. In both models, the West North Central and West South Central States supplied their own requirements. The major shift in domestic soybean shipments was to the East South Central States. The West South Central States increased shipments 48.2 million bushels in model I-C; the East South Central States decreased shipments 47.2 million bushels. The South Atlantic States deleted 930,000 bushels to the East South Central States and the West North Central States deleted 11.0 million bushels. The only other change was the addition of 11.0 million bushels by the East North Central States.

Export soybean shipments of models I-C and I-R are compared in table 30. Export soybean flows are presented in figure 10, section B. The largest volume shifts occurred in shipments to New Orleans, which had the greatest soybean requirements. Missouri became the largest volume soybean shipper to New Orleans in model I-C, utilizing all-water transportation and replacing Arkansas. Mississippi, utilizing truck-barge transportation, and Tennessee became the second and third largest volume shippers to New Orleans in model I-C. They replaced southern Illinois, which had truck-barge transportation capability in model I-C, and Louisiana in model I-R. However, Louisiana remained the fourth largest volume export shipper of soybeans in model I-C.

Optimum Ending Inventories of Grain

The net changes from model I-R in optimum regional ending inventories of grain are presented in table 31. Absolute volumes of ending inventories in model I-C are also given by type of grain. Major shifts took place in regional ending inventories, reflecting changes in total shipments from the regions. Ending inventories represent the residuals after shipments have been made from supplies.

Hard Wheat.--The greatest changes in ending inventories of hard wheat were the reduction of over 79.3 million bushels in North Dakota and 13.4 million bushels in northern Kansas; and additions of over 46.8 million bushels, 31.3 million bushels, and 17.3 million bushels in Nebraska, South Dakota, and southern Kansas, respectively. Outside the North Central States, western Montana inventories lost over 4.5 million bushels, and Wyoming and Arizona combined inventories fell about 1 million bushels. On the other hand, eastern Montana inventories increased slightly, more than one-quarter million bushels.

Soft Wheat.--Only six regions had soft wheat ending inventories in model I-C, but eight did in model I-R. The major shift in soft wheat inventories occurred in Indiana--a loss of about 10 million bushels--and in Michigan--a gain of approximately 14 million bushels. The other changes totaled less than 10 million bushels.

Table 29--Optimum soybean shipments to domestic demand regions from supply regions and net changes from model I-R, model I-C

Demand region 1/	Supply region 1/	Quantity shipped	Change in quantity
		10,000 bushels	
South Atlantic	South Atlantic	3,468	0
East North Central	East North Central	23,942	1,811
	West North Central	0	-1,811
West North Central	West North Central	18,849	0
East South Central	East North Central	1,097	0
	East South Central	877	-4,724
	West South Central	5,028	4,817
	South Atlantic	0	-93
West South Central	West South Central	3,794	0

1/ Individual shipments were aggregated to standard regions used by the Bureau of the Census to avoid disclosure of individual firms' capacities.

Table 30--Optimum soybean shipments to export demand regions from supply regions and net changes from model I-R, model I-C

Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels	
43 Duluth	10 Minn.	376	376
	11 Do.	0	-873
	15 N. Dak.	497	497
44 Chicago	5 Ind.	1,571	0
	9 Wisc.	314	0
45 Toledo	2 N.Y.	0	-3
	4 Ohio	1,423	3
	8 Mich.	1,041	0
47 Baltimore	3 Pa.	0	-537
	4 Ohio	0	-40
	20 Va.	202	202
	21 N.C.	6	6
	22 S.C.	369	369
48 Norfolk	21 N.C.	428	0
49 North Charleston	22 S.C.	872	0
50 New Orleans	6 Ill.	37	0
	7 Do.	107	-5,068
	14 Mo.	6,190	6,190
	23 Ga.	596	4
	24 Fla.	197	0
	25 Ky.	83	83
	26 Tenn.	2,821	2,821
	27 Ala.	784	784
	28 Miss.	4,591	1,036
	29 Ark.	0	-5,739
	30 La.	2,237	-111
51 Houston	Do.	122	111
	31 Okla.	0	-111
	33 Tex.	3	0
	34 Do.	21	0

Table 31--Optimum regional ending inventories of grain and net changes from model I-R, model I-C

	Storage region	Hard wheat		Soft wheat		Durum wheat		Feed grain		Soy-beans	
		10,000 bushels									
1	New England	0		0		0		0		0	
2	N.Y.	0		0		0		0		0	
3	Pa.	0		0	-251	0		0		0	
4	Ohio	0		1,181	330	0		0		1,225	7
5	Ind.	0		360	-1,035	0		0		0	
6	Ill.	0		0		0		0		0	
7	Do.	0		0		0		0		3,257	3,257
8	Mich.	0		1,419	1,419	0		0		0	
9	Wisc.	0		0	-369	0		0		0	
10	Minn.	0		0		1,337	1,296	0	-3,450	893	-1,123
11	Do.	0		0		0		0		3,691	1,620
12	Iowa	0		0		0		948	948	3,589	0
13	Do.	0		0		0		0		2,757	0
14	Mo.	0		0		0		0		0	-4,379
15	N. Dak.	3,279	-7,935	0		1,171	-1,270	12,555	9,840	0	-497
16	S. Dak.	5,493	3,135	0		396	396	0	-6,453	653	0
17	Nebr.	4,689	4,689	0		0		38,227	7,326	2,051	0
18	Kans.	5,094	-1,340	0		0		0	-10,303	291	0
19	Do.	4,722	1,737	0		0		0	-854	0	21
20	Va.	0		0		0		0		0	
21	N.C.	0		0		0		0		52	52
22	S.C.	0		0		0		0		0	
23	Ga.	0		0		0		0		0	
24	Fla.	0		0		0		0		0	
25	Ky.	0		0		0		0		0	
26	Tenn.	0		0		0		0		0	
27	Ala.	0		0		0		0		0	
28	Miss.	0		0		0		0		0	
29	Ark.	0		0		0		0		922	922
30	La.	0		0		0		0		0	
31	Okla.	0		0		0		0		127	114
32	Tex.	0		0		0		16,525	3,886	296	0
33	Do.	0		0		0		0		0	
34	Do.	0		0		0		0		0	
35	Mont.	2,982	264	100	-110	0	-122	0		0	
36	Do.	627	-456	74	16	0		700	-940	0	
37	Wyo.	317	-73	0		0		0		0	
38	Colo.	3,967	0	0		0		0		0	
39	Ariz.	0	-21	0	-29	0		0		0	
40	Idaho	0		1,784	29	0		0		0	
41	Wash.	0		0		0		0		0	
42	Calif.	0		0		0		0		0	

Note: Blank space means no ending inventory in either model.

Durum Wheat.--Most of the ending inventories of durum wheat were located in northern Minnesota and North Dakota in model I-C; North Dakota alone held the greatest portion in model I-R. The shift amounted to approximately 13 million bushels to northern Minnesota storage sites in model I-C compared with I-R. The only other region with durum wheat ending inventories in model I-C was South Dakota, which had approximately 4 million bushels.

Feed Grains.--Feed grain ending inventories remained concentrated in the North Central States in model I-C though three fewer regions had ending inventories--both Kansas regions and South Dakota. The combined deletions in Kansas were approximately 111.6 million bushels; the deletion in South Dakota was over 64.5 million bushels. Northern Iowa added ending inventories of more than 9.4 million bushels; North Dakota increased its volume in excess of 98.4 million bushels. Nebraska raised its ending inventories approximately 73.3 million bushels to over 382 million bushels. Ending inventories in western Texas went up over 38.8 million bushels to approximately 165.2 million bushels. Feed grain ending inventories fell 9.4 million bushels in western Montana, making the region's ending inventories in model I-C , 7 million bushels.

Soybeans.--As with feed grains, optimum ending inventories of soybeans remained concentrated in the North Central States. The major shifts were the addition of inventories in southern Illinois in model I-C of over 32.5 million bushels and the deletion of over 43.7 million bushels in Missouri. The other major shifts in the North Central States were the decrease of over 11.2 million bushels in northern Minnesota and the increase of 16.2 million bushels in southern Minnesota. North Dakota lost approximately 5 million bushels. In the South, Arkansas added over 9.2 million bushels, and Oklahoma gained over 1.1 million.

Comparative Cost Analysis

Table 32 presents costs of domestic and export transportation and associated handling, plus costs of milling in models I-C and I-R. Storage charges are not shown because total ending inventories were the same in both models. Further, because uniform storage costs were used in both models, as discussed earlier, the same total storage charges existed in both models.

The optimum flows of grain and grain flour which minimize the total cost of distributing supplies from origins to demand destinations do not necessarily minimize the cost to every region or every sector of the system. Minimizing cost to the sector is demonstrated for soft wheat milling and transportation of durum wheat for export. Cost-of-service transportation costs resulted in increased costs of both these operations. But further examination revealed a substantial overall reduction in total marketing costs of over $261 million to the grain marketing system. These changes occurred when cost-of-service transportation charges were substituted for existing transportation rates to determine the optimum flows and the resulting minimum total marketing costs.

Total cost to the system in model I-C was only 81 percent of that in model I-R. Thus, if cost-of-service transportation charges had been effective throughout the system in 1966/67, the resulting savings over total costs with a system of optimum flows and existing transportation rates would have been 19 percent.

Table 32--Selected costs of marketing grain and flour, model I-R and model I-C

Product and activity	Model I-R	Model I-C	Change in cost
		1,000 dollars	
Hard wheat:			
Domestic transportation	80,091	70,061	10,030
Export transportation	149,012	103,544	45,468
Hard wheat flour:			
Domestic transportation	49,985	36,527	13,458
Export transportation	11,223	6,111	5,112
Milling	109,594	109,092	502
Soft wheat:			
Domestic transportation	23,251	18,515	4,736
Export transportation	39,179	27,129	12,050
Soft wheat flour:			
Domestic transportation	16,064	8,711	7,293
Export transportation	561	279	282
Milling	45,336	45,745	-409
Durum wheat:			
Domestic transportation	13,343	4,682	8,661
Export transportation	6,211	12,307	-6,096
Feed grains:			
Domestic transportation	557,807	467,698	90,109
Export transportation	170,921	120,226	50,695
Soybeans:			
Domestic transportation	56,180	54,752	1,428
Export transportation	48,001	29,549	18,452
Summary:			
Domestic transportation	796,721	660,998	135,723
Export transportation	425,108	299,145	125,963
Milling	154,930	154,836	94
Total	1,376,759	1,114,979	261,780

Hard wheat milling costs went down only slightly in model I-C (just over half a million dollars). However, as hard wheat was milled closer to points of production, a reduction of more than $10 million resulted from transportation of hard wheat to mills. Further cost reduction for hard wheat milling came from a savings of approximately $13.3 million in distribution of domestic hard wheat flour. Savings of over $5.1 million occurred from transporting hard wheat flour to ports of export.

Although the cost of milling hard wheat flour decreased $502,000, that of milling soft wheat flour increased $409,000. However, the savings in transporting soft wheat to mills was approximately $4.7 million.

Considering the milling industry alone, the estimated savings over existing transportation rates was over $41 million.

The most significant reduction in costs in model I-C was over $90.1 million in the domestic transportation of feed grains. Transportation costs of exported grain were reduced over $50 million, resulting in a total marketing cost reduction for feed grains of approximately $140.7 million. This figure underestimated the savings over the existing transportation rate structure, since feed grains were not carried beyond milling locations in these models.

Savings also occurred in the marketing of durum wheat and soybeans. The estimated savings in domestic transportation of durum wheat of over $8.6 million more than compensated for the increased cost of $6.1 million for transporting durum to ports of export. The difference was approximately $2.6 million. The reduced cost of marketing soybeans came principally in their transportation for export--over $18.4 million. Domestic transportation cost reductions were only $1.4 million.

Model II-C and Model I-R Compared

The relationship of wheat and flour transportation rates (parity and transit rates) was the major factor considered when most existing flour mills were built. The stability of the rate relationship is an important factor in the competitive position of these mills.

Model II-C was designed in part to examine the possible effects of cost-of-service transportation charges on the location of flour mills. As discussed in part II, model II-C is a variant of model I-C. The milling and storage capacity restraints of model I-C were relaxed in model II-C, making it a model estimating longrun conditions with cost-of-service transportation charges assumed. Results of the solution to this so-called longrun model were compared with the solution of model I-R, a model which represented the existing grain marketing system under optimum conditions and existing transportation rates. This comparison made possible an examination of the likely effects of cost-of-service transportation charges on flour milling locations--a partial fulfillment of objective 3. Savings from such relocation could also be estimated.

Optimum Geographical Flows

Hard Wheat.--Optimum volumes in model II-C and net changes in hard wheat shipments from model I-R are presented in table 33.

No hard wheat was milled in 15 of the 42 milling regions in model II-C. Seven of the 15 were in East South Central and South Atlantic States. However, there was a net gain in hard wheat shipments to the East South Central and South Atlantic States because hard wheat milling expanded decidedly in Alabama. The entire hard wheat requirements (31.2 million bushels) of Alabama in model II-C were met by shipments from South Dakota.

In the West South Central States, the most significant change in flows of hard wheat was the diversion to export of local shipments (34.8 million bushels) in Oklahoma and eastern Texas, where mills were idle in model II-C. Shifts were made in flows to accommodate new milling capacity in the West South Central States (table 33).

In the North Central States, major shifts occurred in the flow of wheat among States in the region as well as to other States (New York, Alabama, and Texas). The reasons were a net gain in hard wheat milling of over 10 million bushels in the North Central States, a deletion of hard wheat milling in New York, and an increase of hard wheat milling in Alabama and southern Texas.

Increased milling of hard wheat in the Mountain States was accomplished by shifting shipments from export at Pacific ports to area mills; consequent requirements at the Pacific ports were supplied by adjacent States.

Hard Wheat Flour.--The changes in model II-C from model I-R in flows of hard wheat to mills had associated changes in hard wheat flour flows (table 34). Many shifts took place in quantities shipped from mills to consumption centers. Only 13 of the many point-to-point movements did not change.

New England, with no milling capacity restraints in model II-C, continued to mill no hard wheat. Its hard wheat flour requirements were met by new milling capacity in northern Iowa, replacing shipments from New York mills. These mills also decreased local shipments, which were met by southern Kansas mills. Nebraska replaced North Dakota, northern Kansas, southern Illinois, Michigan, and Pennsylvania in shipments of hard wheat flour to Pennsylvania consumption centers. Because southern Kansas had such an increase in hard wheat milling, many shipments of model I-R were replaced in model II-C by southern Kansas shipments. Southern Kansas and northern Kansas deleted shipments to New Orleans, which were made by Louisiana and southern Texas mills in model II-C. Southern Texas mills also replaced requirements at Houston; these were supplied by southern Kansas and eastern Texas in model I-R. Alabama shipped hard wheat flour to Georgia, Florida, and Kentucky, replacing quantities from their respective local mills and mills in both Kansas regions, Tennessee, and Oklahoma. Michigan supplied local requirements, replacing southern Minnesota.

In the West, western Montana utilized additional capacity to replace Washington's local shipments, and Colorado and Utah mills replaced shipments to California made by California and Washington mills.

Table 13--Optimum hard wheat shipments to domestic and export demand regions from supply regions and net changes from model I-R, model II-C

Demand region	Supply region	Quantity shipped	Change in quantity	Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
3 N.Y.	:10 Minn.	0	-1,767	:35 Mont.	:35 Mont.	41	41
	:18 Kans.	0	-2,672	:36 Do.	:36 Do.	1,140	1,016
3 Pa.	: 3 Pa.	0	-560	:37 Wyo.	:37 Wyo.	53	0
4 Ohio	: 4 Ohio	0	-42	:38 Colo.	:38 Colo.	1,485	1,485
	: 5 Ind.	0	-157	:39 Ariz.	:39 Ariz.	21	21
	: 9 Wisc.	0	-1,210	:40 Utah	:40 Idaho	2,365	966
5 Ind.	: 5 Ind.	157	157	:41 Wash.	:35 Mont.	0	-117
6 Ill.	: 6 Ill.	1,120	318	:41 Do.	:41 Wash.	0	-1,868
	: 9 Wisc.	408	408	:42 Calif.	:40 Idaho	0	-966
7 Do.	: 7 Ill.	439	-1,421	:	:42 Calif.	70	0
8 Mich.	: 8 Mich.	0	-28	:43 Duluth	:15 N. Dak.	1,354	0
	:10 Minn.	1,555	973	:44 Chicago	: 9 Wisc.	39	0
9 Wisc.	: 9 Wisc.	802	802	:46 Albany	: 2 N.Y.	250	250
10 Minn.	:15 N. Dak.	147	75	:	: 3 Pa.	565	565
11 Do.	:11 Minn.	527	352	:	: 7 Ill.	0	-561
	:12 Iowa	0	-228	:	:17 Nebr.	0	-254
	:16 S. Dak.	0	-3,521	:47 Baltimore	: 2 N.Y.	362	-5
12 Iowa	:12 Iowa	320	320	:	: 3 Pa.	0	-5
	:16 S. Dak.	1,571	1,571	:	: 4 Ohio	42	42
13 Do.	:12 Iowa	0	-92	:	: 6 Ill.	0	-869
	:13 Do.	422	0	:	: 7 Do.	682	682
14 Mo.	:14 Mo.	0	-1,981	:	: 8 Mich.	28	28
15 N. Dak.	:15 N. Dak.	0	-364	:	:17 Nebr.	2,759	378
	:35 Mont.	120	120	:48 Norfolk	: 7 Ill.	1,270	1,270
16 S. Dak.	:16 S. Dak.	126	?	:	:17 Nebr.	0	-1,270
17 Nebr.	:17 Nebr.	4,229	2,651	:	:20 Va.	55	0
18 Kans.	:18 Kans.	495	-2,937	:49 North Charleston	: 7 Ill.	30	30
19 Do.	:19 Do	11,031	6,479	:	:11 Minn.	0	-151
20 Va.	:18 Do.	0	-205	:50 New Orleans	: 6 Ill.	318	318
21 N.C.	: Do.	0	-943	:	:14 Mo.	2,540	2,540
22 S.C.	: Do.	0	-85	:	:17 Nebr.	3,802	-2,276
23 Ga.	:14 Mo.	0	-53	:	:18 Kans	8,100	8,100
24 Fla.	:11 Minn.	0	-92	:	:19 Do.	0	-1,901
25 Ky.	:14 Mo.	0	-268	:	:29 Ark.	0	-121
26 Tenn.	:11 Minn.	0	-1,316	:	:30 La.	85	0
	:19 Kans.	715	715	:51 Houston	:18 Kans.	5,671	5,671
27 Ala.	:14 Mo.	0	-238	:	:19 Do.	434	-3,716
	:16 S. Dak.	3,121	3,121	:	:31 Okla.	10,674	1,086
29 Ark.	:19 Kans.	39	39	:	:32 Tex.	5,774	-333
	:29 Ark.	121	121	:	:33 Do.	571	571
30 La.	:10 Minn.	794	794	:	:34 Do.	3,362	2,392
31 Okla.	:31 Okla.	0	-1,086	:52 Long Beach	:40 Idaho	34	0
32 Tex.	:32 Tex.	397	333	:53 Stockton	: Do.	17	0
33 Do.	:18 Kans.	5,179	5,179	:54 Portland	:15 N. Dak.	0	-37
	:19 Do.	0	-182	:	:35 Mont.	0	1,352
	:33 Tex.	0	-571	:	:36 Do.	1,140	1,016
34 Do.	:34 Do.	0	-2,392	:	:41 Wash.	3,157	3,157
				:55 Tacoma	:36 Mont.	1,289	1,289

Table 34--Optimum hard wheat flour shipments to domestic and export demand regions from milling regions (wheat equivalents) and net changes from model I-R, model II-C

Demand region		Milling region	Quantity shipped	Change in quantity	Demand region		Milling region	Quantity shipped	Change in quantity
			10,000 bushels					10,000 bushels	
1 New England	2	N.Y.	0	-1,696	25 Ky.	7	Ill.	0	-350
	12	Iowa	1,696	1,696		25	Ky.	0	-268
2 N.Y.	2	N.Y.	0	-2,743		27	Ala.	618	618
	13	Iowa	103	103	26 Tenn.	26	Tenn.	715	0
	19	Kans.	2,686	2,640	27 Ala.		Do.	0	-410
3 Pa.	3	Pa.	0	-560		27	Ala.	648	410
	7	Ill.	0	-1,510	28 Mass.	14	Mo.	0	-268
	8	Mich.	0	-58		19	Kans.	451	451
	15	N. Dak.	0	-140		31	Okla.	0	-183
	17	Nebr.	3,777	2,653	29 Ark.	18	Kans.	0	-363
	18	Kans.	0	-385		19	Do.	363	363
4 Ohio	4	Ohio	0	-1,409	30 La.	18	Do.	0	-657
	14	Mo.	0	-460		33	Tex.	657	657
	19	Kans.	1,869	1,869	31 Okla.	19	Kans.	453	453
5 Ind.	5	Ind.	157	157		31	Okla.	0	-453
	11	Minn.	0	-893	32 Tex.		Do.	0	-333
	19	Kans.	736	736		32	Tex.	397	333
6 Ill.	6	Ill.	1,528	760	33 Do	33	Do.	753	0
	11	Minn.	0	-760	34 Do.	19	Kans.	989	989
7 Do.	7	Ill.	439			34	Tex.	0	-989
	14	Mo.	0	-493	35 Mont.	35	Mont.	41	41
8 Mich.	8	Mich.	1,555	1,003		36	Do.	0	-41
	11	Minn.	0	-1,003	36 Do.		Do.	83	0
9 Wisc.	9	Wisc.	768	768	37 Wyo.	37	Wyo.	53	0
	11	Minn.	0	-768	38 Colo.	38	Colo.	320	0
10 Minn.	10	Do.	147	75	39 Ariz.		Do.	237	-21
	15	N. Dak.	0	-75		39	Ariz.	21	21
11 Do.	11	Minn.	500	0	40 Utah.	40	Idaho	291	0
12 Iowa	12	Iowa	195	195	41 Wash.	36	Mont.	847	847
	13	Do.	0	-195		41	Wash.	0	-847
13 Do.		Do.	319	0	42 Calif.	38	Colo.	928	928
14 Mo.	14	Mo.	0	-814		40	Utah	2,040	966
	19	Kans.	814	814		41	Wash.	0	-928
15 N. Dak.	15	N. Dak.	120	0		42	Calif.	70	-966
16 S. Dak.		Do.	0	-2	43 Duluth	11	Minn.	27	27
	16	S. Dak.	126	2		15	N. Dak.	0	-27
17 Nebr.	17	Nebr.	271	0	44 Chicago	6	Ill.	0	-34
18 Kans.	19	Kans.	0	-267		9	Wisc.	34	34
	19	Do.	267	267	47 Baltimore	17	Nebr.	181	0
19 Do.		Do.	267	0	49 North				
20 Va.		Do.	1,200	205	Charleston	21	N.C.	0	-39
	20	Va.	0	-205		29	Ark.	39	39
21 N.C.	18	Kans.	0	-32	50 New Orleans	18	Kans.	0	-366
	19	Do.	936	936		19	Do.	0	-1,001
	21	N.C.	0	-904		29	Ark.	0	794
22 S.C.	18	Kans.	495	85		33	Tex.	573	573
	22	S.C.	0	-85	51 Houston	19	Kans.	0	-1,793
23 Ga.	19	Kans.	0	-450		33	Tex.	3,196	3,196
	23	Ga.	0	-53		34	Do.	0	-1,403
	26	Tenn.	0	-191	53 Stockton	40	Utah	34	0
	27	Ala.	811	811	54 Portland	36	Mont.	123	123
	31	Okla.	0	-117		41	Wash.	0	-123
24 Fla.	18	Kans.	0	-952	55 Tacoma	36	Mont.	87	87
	24	Fla.	0	-92		41	Wash.	0	-87
	27	Ala.	1,044	1,044					

Soft Wheat.--The changes in model II-C from model I-R in shipments of soft wheat are presented in table 35. In general, the mills of the East North Central States received more soft wheat in model II-C, but shipments from other areas did not increase as much as mill receipts since no soft wheat was imported from other areas. Thus, the greater soft wheat milling in the East North Central States was supported by States in the area. The major source of soft wheat came from reduced stocks held by Indiana. Southern Illinois also diverted a major quantity from export at New Orleans to local mills. Wisconsin, like Indiana, also diverted inventories to local mills.

In the West North Central States, there was no change in the volume of soft wheat shipped, but there was a major shift in movements. Missouri diverted over 21.2 million bushels from local mills to export at New Orleans. The West North Central States also experienced a reduction of over 21.6 million bushels in soft wheat milling, the greatest proportion as a result of the shift of Missouri soft wheat.

The Middle Atlantic States experienced a net decrease in soft wheat shipments. The major decrease was from less soft wheat milling in New York and greater inventory in that State.

The South Atlantic States experienced a net loss of over 1.4 million bushels in soft wheat shipments and over 12.5 million bushels in soft wheat milling. The difference is explained by the fact that the South Atlantic States except South Carolina diverted all of their soft wheat from local mills to export. South Carolina did ship exports to North Charleston, but had a net loss, and thus, increased ending inventories.

The East South Central States had no change in volume shipped, but did increase soft wheat milled more than 1.1 million bushels. The deficits were supplied by shipments from Arkansas and exports diverted from New Orleans by Mississippi.

Soft wheat volume shipped in the West South Central States did not change, but the volume of soft wheat milled in those States increased over 12.5 million bushels. There were shifts in shipments, however. The higher soft wheat requirements were met by northern Illinois, Idaho, and Missouri. Although there was a net increase in soft wheat milled in the West South Central States, Oklahoma had a total loss of soft wheat milling.

Idaho was primarily responsible for the greater shipments of the Mountain States. The net gain in soft wheat milling in the area was not as great as the net gain in soft wheat shipments.

Washington had a net loss of soft wheat shipments while California had no changes, thus leaving the Pacific States with a net loss. The decline in shipments to local mills by Washington equaled the drop in soft wheat flour milled in Washington and California.

Soft Wheat Flour.--The changes in model II-C from model I-R in soft wheat flour shipments are presented in table 36. The major shift was from Missouri mills mainly to local shipments in the areas affected. A marked increase in

Table 35--Optimum soft wheat shipments to domestic and export demand regions from supply regions and net changes from model I-R, model II-C

Demand region	Supply region	Quantity shipped	Change in quantity	Demand region	Supply region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
2 N.Y.	2 N.Y.	0	-1,157	33 Do.	6 Ill.	0	-164
3 Pa.	3 Pa.	1,448	0		30 Ia.	0	-99
4 Ohio	4 Ohio	3,206	986	35 Mont.	35 Mont.	16	16
5 Ind.	5 Ind.	2,972	1,412	36 Do.	36 Do.	36	-16
6 Ill.	Do.	582	582	37 Wyo.	35 Do.	0	-107
	8 Mich.	0	-474		40 Idaho	24	24
7 Do.	7 Ill.	999	999	38 Colo.	37 Wyo.	13	0
8 Mich.	8 Mich.	599	-563	39 Ariz.	39 Ariz.	77	29
9 Wisc.	9 Wisc.	336	328	40 Utah	40 Idaho	395	194
10 Minn.	5 Ind.	0	-36	41 Wash.	41 Wash.	484	-223
	10 Minn.	16	-4	42 Calif.	42 Calif.	1,048	0
11 Do.	Do.	192	0	44 Chicago	5 Ind.	39	39
12 Iowa	9 Wisc.	80	80	45 Toledo	9 Wisc.	58	-39
13 Do.	5 Ind.	0	-128		8 Mich.	1,308	0
	8 Mich.	128	128	46 Albany	2 N.Y.	364	364
14 Mo.	5 Ind.	41	41		4 Ohio	0	-364
	14 Mo.	0	-2,125	47 Baltimore	2 N.Y.	991	38
15 N. Dak.	10 Minn.	0	-48		3 Pa.	0	-170
	35 Mont.	48	48		20 Va.	132	132
16 S. Dak.	10 Minn.	52	52	48 Norfolk	4 Ohio	0	-747
	35 Mont.	0	-52		20 Va.	335	335
17 Neor.	5 Ind.	0	-104		21 N.C.	412	412
	8 Mich.	104	104	49 North			
18 Kans.	5 Ind.	80	-40	Charleston	Do.	0	-15
19 Do.	Do.	0	-80		22 S.C.	15	15
20 Va.	20 Va.	0	-467	50 New Orleans	5 Ind.	0	-191
21 N.C.	21 N.C.	0	-373		6 Ill.	196	-212
22 S.C.	Do.	0	-24		7 Do.	275	-999
	22 S.C.	0	-163		14 Mo.	2,038	2,038
23 Ga.	23 Ga.	0	-175		23 Ga.	175	175
24 Fla.	24 Fla.	0	-56		24 Fla.	56	56
26 Tenn.	6 Ill.	0	-32		25 Ky.	511	0
	26 Tenn.	396	0		27 Ala.	146	146
	29 Ark.	32	32		28 Miss.	463	-201
27 Ala.	27 Ala.	0	-146		29 Ark.	0	-911
28 Mass.	6 Ill.	0	-24		30 La.	180	99
	28 Mass.	201	201	52 Long Beach	40 Idaho	8	0
	29 Ark.	87	87	53 Stockton	Do.	12	0
29 Ark.	29 Do.	792	792	54 Portland	Do.	0	-82
30 La.	14 Mo.	87	87		41 Wash.	9,305	82
31 Okla.	6 Ill.	0	-164	53 Tacoma	Do.	2,354	0
32 Tex.	40 Idaho	204	204				

Table 3b--Optimum soft wheat flour shipments to domestic and export demand regions from milling regions (wheat equivalents) and net changes from model I-B, model II-C

Demand region	Milling region	Quantity shipped	Change in quantity	Demand region	Milling region	Quantity shipped	Change in quantity
		10,000 bushels				10,000 bushels	
1 New England	2 N.Y.	0	-960	26 Tenn.	26 Tenn.	428	0
	4 Ohio	960	960	27 Ala.	5 Ind.	392	146
2 N.Y.	2 N.Y.	0	-997		27 Ala.	0	-146
	4 Ohio	920	507	28 Miss.	6 Ill.	0	-264
3 Pa.	3 Pa.	1,448	0		28 Miss.	288	264
4 Ohio	4 Ohio	696	0	29 Ark.	14 Mo.	0	-224
5 Ind.	5 Ind.	340	0		29 Ark.	224	224
6 Ill.	5 Ind.	0	-384	30 La.	5 Ind.	384	384
	6 Ill.	384	384		14 Mo.	0	-384
7 Mich.	5 Ind.	0	-260	31 Okla.	5 Ind.	264	264
	7 Ill.	260	260		14 Mo.	0	-100
8 Wisc.	8 Mich.	576	0		31 Okla.	0	-164
9 Minn.	9 Wisc.	0	-288	32 Tex.	14 Mo.	0	-204
	9 Wisc.	288	288		32 Tex.	204	204
10 Minn.	9 Wisc.	0	-0	33 Do.	14 Mo.	0	-333
	10 Minn.	10	-0		33 Tex.	333	333
11 Do.	11 Do.	192	0	34 Do.	14 Mo.	0	-568
12 Iowa	8 Mich.	0	-580		29 Ark.	568	568
	12 Iowa	580	580	35 Mont.	35 Mont.	16	16
13 Do.	13 Do.	128	0	36 Do.	36 Do.	0	-16
14 Mo.	7 Ill.	271	271		36 Do.	36	0
	14 Mo.	41	-271	37 Wyo.	37 Wyo.	24	0
15 N. Dak.	15 N. Dak.	48	0	38 Colo.	18 Kans.	0	-40
16 S. Dak.	16 S. Dak.	92	0		37 Wyo.	0	-83
17 Nebr.	17 Nebr.	124	0		38 Colo.	136	123
18 Kans.	18 Kans.	80	0	39 Ariz.	39 Ariz.	77	29
19 Do.	5 Ind.	80	80	40 Utah	40 Utah	0	-29
	19 Kans.	0	-80	40 Utah	40 Do.	128	0
20 Va.	4 Ohio	508	467	41 Wash.	41 Wash.	364	0
	20 Va.	0	-467	42 Calif.	40 Utah	236	223
21 N.C.	7 Ill.	568	568		41 Wash.	0	-223
	8 Mich.	0	-195		42 Calif.	1,048	0
	21 N.C.	0	-373	44 Chicago	5 Ind.	0	-18
22 S.C.	4 Ohio	224	115		6 Ill.	18	18
	5 Ind.	72	72	45 Toledo	8 Mich.	23	0
	22 S.C.	0	-187	47 Baltimore	4 Ohio	79	79
23 Ga.	4 Ohio	0	-305		5 Ind.	0	-79
	5 Ind.	480	480	49 North Charleston	4 Ohio	13	0
	23 Ga.	0	-175	50 New Orleans	5 Ind.	0	-87
24 Fla.	4 Ohio	0	-528		29 Ark.	87	87
	5 Ind.	584	584	54 Portland	41 Wash.	82	0
	24 Fla.	0	-56	55 Tacoma	Do.	38	0
25 Ky.	5 Ind.	176	0				

soft wheat milling in Ohio and Indiana shifted shipments of soft wheat flour in States east and south of the East North Central States. Shipments of soft wheat flour in the West did not change significantly in model II-C from model II-R.

Durum Wheat, Feed Grain, and Soybeans.--Optimum flows of durum wheat, feed grain, and soybeans in model II-C did not differ surficiently from those of model I-C to warrant tabular presentation here.

Shifts in domestic and export durum wheat shipments involved over 14.5 million bushels. Northern Minnesota gained more than 10.6 million bushels in shipments to Wisconsin and southern Minnesota; North Dakota added over 3.8 million bushels in shipments to export at Superior, Baltimore, and Norfolk. These gains were offset by losses in South Dakota.

Net shifts in domestic and export feed grain shipments involved over 22.2 million bushels. South Dakota had a net loss in shipments of approximately 5.0 million bushels; eastern Montana lost more than 17.2 million bushels. Offsetting gains occurred in northern Iowa, Nebraska, western Texas, and western Montana of over 4.9, 1.7, 8.5, and 7.0 million bushels, respectively. All shifts in movements were among bordering regions.

The only change in soybean shipments from model I-C was the shipment of more than 4.9 million bushels to export at Superior, where northern Minnesota replaced North Dakota.

The shifts in durum wheat, feed grain, and soybean shipments were brought about when storage capacity in only one region, eastern Montana, was 100-percent utilized in model I-C; in model II-C, storage capacity restraints were relaxed. Ending inventories for model II-C are not discussed because the regions with net gains and losses in shipments mentioned above were also the regions with ending inventory adjustments.

Optimum Milling-Industry Organization

The volume of each type of wheat milled by region in models I-R and II-C and the net change from model I-R in the volume of each type of wheat milled in model II-C are presented in table 37. Table 38 shows the capacity utilized in models I-R and II-C and the optimum milling capacity requirements by region in relation to existing milling capacity when milling capacity restraints are relaxed. Given the incentives suggested by model I-C, the adjustments would have resulted in a lower total cost to the industry in satisfying the regional flour requirements with 1967 wheat supplies. The most significant increases and decreases in milling volume occurred for hard wheat. New York, Washington, Ohio, Missouri, Oklahoma, and eastern Texas milled no hard wheat and southern Minnesota, northern Kansas, and southern Illinois had significant reductions. Notable increases occurred in southern Kansas, southern Texas, Alabama, Nebraska, northern Iowa, and western Montana. The level of concentration of hard wheat milling was higher in model II-C, particularly in southern Kansas, Nebraska northern Iowa, northern Illinois, Michigan, southern Texas, Alabama, Colorado, western Montana, and Utah (table 37). A void of hard wheat milling was especially marked in the South Atlantic and Northeastern States.

Table 37--Volume of hard and soft wheat milled by region, model I-R and model II-C

	Milling region	Hard wheat milled			Soft wheat milled		
		Model I-R	Model II-C	Change	Model I-R	Model II-C	Change
		10,000 bushels					
1	New England	1/	0	0	1/	0	0
2	N.Y.	4,439	0	-4,439	1,157	0	-1,157
3	Pa.	560	0	-560	1,448	1,448	0
4	Ohio	1,409	0	-1,409	2,215	3,200	985
5	Ind.	0	157	157	1,660	2,972	1,312
6	Ill.	802	1,528	726	474	582	108
7	Do.	1,860	439	-1,421	0	999	999
8	Mich.	610	1,555	945	1,162	599	-563
9	Wisc.	0	802	802	8	336	328
10	Minn.	72	147	75	56	16	-40
11	Do.	3,924	527	-3,397	192	192	0
12	Iowa	1/	1,891	1,891		80	80
13	Do.	514	422	-92	128	128	0
14	Mo.	1,981	0	-1,981	2,125	41	-2,084
15	N. Dak.	364	120	-244	48	48	0
16	S. Dak.	124	126	2	52	52	0
17	Nebr.	1,576	4,229	2,653	104	104	0
18	Kans.	3,432	495	-2,937	120	80	-40
19	Do.	4,552	11,031	6,479	80	0	-80
20	Va.	205	0	-205	467	0	-467
21	N.C.	943	0	-943	373	0	-373
22	S.C.	85	0	-85	187	0	-187
23	Ga.	53	0	-53	175	0	-175
24	Fla.	92	0	-92	56	0	-56
25	Ky.	268	0	-268	0	0	0
26	Tenn.	1,316	715	-601	428	428	0
27	Ala.	238	3,121	2,883	146	0	-146
28	Miss.	0	0	0	24	288	264
29	Ark.	1/	39	39	1/	792	792
30	La.	1/	794	794	1/	87	87
31	Okla.	1,086	0	-1,086	164	0	-164
32	Tex.	64	397	333	0	204	204
33	Do.	753	5,179	4,426	99	432	333
34	Do.	2,392	0	-2,392	0	0	0
35	Mont.	1/	41	41	1/	16	16
36	Do.	124	1,140	1,016	52	36	-16
37	Wyo.	53	53	0	107	24	-83
38	Colo.	578	1,485	907	13	136	123
39	Ariz.	0	21	21	48	77	29
40	Utah	1,399	2,365	966	201	395	194
41	Wash.	1,985	0	-1,985	707	484	-223
42	Calif.	1,036	70	-966	1,048	1,048	0

1/ No capacity in model I-R.

Table 38--Milling capacity utilization, model I-R and model II-C

	Milling region	Existing capacity	Capacity utilized: Model I-R	Capacity utilized: Model II-C	Model II-C capacity utilization specified: Under	Model II-C capacity utilization specified: Over
			10,000 bushels			
1	New England	1/	1/	0		
2	N.Y.	5,596	5,596	0	5,596	
3	Pa.	2,008	2,008	1,448	560	
4	Ohio	3,624	3,624	3,200	424	
5	Ind.	1,660	1,660	3,129		1,469
6	Ill.	1,276	1,276	2,110		834
7	Do.	1,860	1,860	1,438	422	
8	Mich.	1,772	1,772	2,154		382
9	Wisc.	8	8	1,138		1,130
10	Minn.	128	128	163		35
11	Do.	4,116	4,116	719	3,397	
12	Iowa	1/	1/	1,971		1,971
13	Do.	1,224	642	550	674	
14	Mo.	4,980	1,107	41	4,939	
15	N. Dak.	412	412	168	244	
16	S. Dak.	176	176	178		2
17	Nebr.	1,680	1,680	4,333		2,653
18	Kans.	3,552	3,552	575	2,977	
19	Do.	4,632	4,632	11,031		6,399
20	Va.	672	672	0	672	
21	N.C.	1,316	1,316	0	1,316	
22	S.C.	272	272	0	272	
23	Ga.	228	228	0	228	
24	Fla.	148	148	0	148	
25	Ky.	268	268	0	268	
26	Tenn.	1,744	1,744	1,143	601	
27	Ala.	384	384	3,121		2,737
28	Miss.	24	24	288		264
29	Ark.	1/	1/	831		831
30	La.	1/	1/	881		881
31	Okla.	1,732	1,250	0	1,732	
32	Tex.	64	64	601		537
33	Do.	852	852	5,611		4,759
34	Do.	2,392	2,392	0	2,392	
35	Mont.	1/	1/	57		57
36	Do.	600	600	1,176		576
37	Wyo.	160	47	77	83	
38	Colo.	704	704	1,621		917
39	Ariz.	48	48	98		50
40	Utah	1,600	1,600	2,760		1,160
41	Wash.	3,112	2,692	484	2,628	
42	Calif.	2,084	2,084	1,118	966	

1/ No milling capacity in 1966/67.

The changes in soft wheat milling activity were much less significant compared with hard wheat. The most significant shifts were the reduction of soft wheat milling in Missouri of 20.84 million bushels, the deletion of 11.57 million bushels in New York, and increases of approximately 10 million bushels or more in Indiana, Ohio, and southern Illinois.

No milling activity took place in the South Atlantic States, Kentucky, Oklahoma, eastern Texas, and New York (tables 37-38). Also, New England was the only region without capacity in model II-C, when milling capacities were not restricted. Only one region, South Dakota, maintained a capacity in model II-C which was not significantly different from existing capacity, although northern Minnesota differed only slightly. Eight regions had reduced capacity and eight added over 10 million bushels each. The largest reduction in milling activities were in New York and Missouri; the greatest need for additional capacity was in southern Kansas.

The East North Central States had demands over four times their idle capacity, when comparing milling capacity distribution of models II-C and I-R. The West North Central States had demands which were less than their idle capacity, suggesting redistribution of capacity would be needed.

In the East South Central States, the situation was similar to the East North Central States. Oklahoma and Texas had capacity needs of more than 1.3 times their combined needs, again suggesting a redistribution would be necessary. In the West, the capacity situation was just the reverse. Colorado, Utah, Arizona, and Montana had need for additional capacity equal to approximately 75 percent of the combined idle capacity of Washington and California.

Comparative Cost Analysis

Questions arise pertaining to possible reductions in marketing costs when discussing relocation of an industry. Table 39 presents selected marketing costs for models I-R, II-C, and I-C. As in table 32, storage costs were not considered because they do not affect the net differences in total marketing costs of the system.

With relocation of facilities and implementation of an effective cost-of-service transportation rate structure, total net cost reduction in grain marketing would be approximately $287 million. Of this amount, approximately $126 million was associated with the wheat-flour complex. The shift in the location of hard wheat milling activities decreased the cost of milling approximately $1.7 million, but lowered costs of acquiring hard wheat over $32 million and decreased costs of shipping domestic hard wheat flour less than $1 million. Soft wheat flour milling costs went down over $2 million. Cost of acquiring soft wheat by mills was lowered over $6 million and transportation costs for shipping domestic soft wheat flour were reduced more than $7 million. The savings in transportation costs of hard and soft wheat flours to ports was over $9.2 million. Costs of transporting hard and soft wheats to ports were reduced approximately $62 million.

Savings in transportation costs of durum wheat, feed grain, and soybeans when models II-C and I-C were compared amounted to just over $3.9 million. New

Table 39--Selected costs of marketing grain and flour models I-R, I-C, and II-C

Product and activity	Model I-R	Model II-C	Model I-C
		1,000 dollars	
Hard wheat:			
Domestic transportation	80,091	47,615	70,061
Export transportation	149,012	99,518	103,544
Hard wheat flour:			
Domestic transportation	49,985	49,082	36,527
Export transportation	11,223	1,417	6,111
Milling	109,594	107,896	109,092
Soft wheat:			
Domestic transportation	23,251	17,145	18,515
Export transportation	39,179	26,929	27,129
Soft wheat flour:			
Domestic transportation	16,064	8,906	8,771
Export transportation	561	130	279
Milling	45,336	43,118	45,745
Durum wheat:			
Domestic transportation	13,343	4,727	4,682
Export transportation	6,211	11,780	12,307
Feed grains:			
Domestic transportation	557,807	470,155	467,698
Export transportation	170,921	116,936	120,226
Soybeans:			
Domestic transportation	56,180	54,752	54,752
Export transportation	48,001	29,444	29,549
Summary:			
Domestic transportation	796,721	652,383	660,998
Export transportation	425,108	286,161	299,145
Milling	154,930	151,014	154,836
Total	1,376,759	1,089,558	1,114,979

storage capacity entering in model II-C in eastern Montana was responsible for the shifts in flows of durum wheat, feed grain, and export soybeans which resulted in the reduced transportation costs.

Comparing the two models also revealed that relocation of milling activity would reduce total costs over $15.9 million (table 38). This difference reflects the opportunity cost of 1966/67 milling capacity distribution, given cost-of-service transportation charges. Leath derived a figure of $11.3 million for the opportunity cost associated with the milling capacity distribution when he compared optimum organization using rates (21, p. 57). A cost reduction of $15.9 million would not justify relocating milling capacity to the extent suggested in table 39, but data in table 26 on value of additional capacity suggest that expansion in several regions might be desirable, particularly in the East North Central, East South Central, and Mountain States. This finding was somewhat contrary to Leath's, which suggested expansion of capacity in the Southeast (21, p. 49). Thus, transportation rates indicated a locational pattern of milling activities somewhat different from that using carriers' costs of providing transportation services.

CONCLUSIONS

Inferences

Changes in direction of grain flow can be dictated on short notice. Once capital is sunk in a plant at a given location, however, it is difficult if not impossible to recoup losses when an unfavorable transportation rate change occurs.

The grain rate revolution may be said to have started with the now famous "Big John" case. The revolution is expected to continue in accordance with technological advancements if all rates charged by each mode are based on the cost of providing the service and if each mode provides service where it has a particular advantage. This revolution in rates should foster intense competition among the railroads, trucks, and barges for grain and grain products traffic. Long-established geographical flows have been and will continue to be altered. Some alterations may be temporary because of lags in adjustments by carriers operating in other geographical areas. Others will be longer lasting. Uncertainty concerning future rate structures will have a dampening effect on investments in new grain marketing facilities with high fixed costs, and on relocation of facilities.

Comparison of models I-C and I-R demonstrated clearly how changes in transportation rates affect shortrun flow patterns in the grain industry. Change to a cost-of-service transportation rate structure in model I-C from the existing rate structure of model I-R and resulting alterations in flow patterns of wheats, feed grains, soybeans, and wheat flours reduced total marketing costs 19 percent, or over $261 million, in model I-C compared with model I-R. Although milling costs of hard and soft wheat went down $93,000, savings accrued in transportation associated with wheat acquisition amounted to approximately $14.7 million and savings in flour distribution costs exceeded $26.0 million.

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Model II-C showed how the longrun structural pattern of markets may be affected by changes in rate structure. Leath's analysis (2, pp. 47-50) indicated relocation of milling capacity in the Southeast (21, pp. 47-50). Model II-C suggested reduction of capacity for that area in general. The implication was that the current transportation rate structure would indicate a locational pattern of milling activities somewhat different from the pattern suggested by a cost-of-service transportation rate structure. Leath's study may have indicated the Southeast as a relocation area for milling capacity because the Southeast obtained grain rates which tended to be relatively low. The sensitivity of the transshipment model to transportation charges reflects favorable rate relationships indicated by Leath's analysis. Hypothesizing that Southeastern rates are nearly representative of costs of service and all areas have rates closely approximating costs of services, shifts in milling capacity due to rate changes would not be expected to differ from shifts under conditions assuming costs of service to be effective (model II-C). Leath's reorganization of milling capacity and model II-C's reorganization were not the same. Thus, one might conclude that not all areas have rates closely related to the costs of service, assuming the costs used in the study were accurate. Further, the basis for establishing transportation rates and their relationship among regions and between commodities (for example, wheat and flour rates) will be important in the future location of milling facilities in the United States.

Total cost for a particular region, industry, or other segment of a multistaged problem such as the one in the study might change in alternate solutions, although total cost to the system remained the same. This fact is attested to by the small (insignificant) difference in total costs of solutions to models I-C and II-C. A single decisionmaking unit would be required for the system to achieve such solutions in reality, because each economic unit or firm in the system would seek to minimize its cost. Minimizing cost to the system does not imply minimum cost for each segment of the system.

Limitations

Researchers of practical problems of economics are usually faced with making certain assumptions, which may be more or less limiting, to accomplish their mission. Some assumptions of this type were made for the study. Thus, the results are not put forth as predictive information on the future of the U.S. grain marketing system. Instead, they suggest how the system should operate, given 1966/67 data on supply, demand, location of facilities, estimated cost-of-service transportation charges, and the goal of minimizing total costs.

There were three basic limitations: First, flour was the only wheat milling product considered. Thus, 28 percent of the product, millfeed, which is 10 percent of product value, was considered to be used at flour consumption centers by the mixed feed industry with no further processing or transportation costs. Second, feed grain was assumed to be a homogeneous commodity, whereas specific grains are required for most industrial uses. Third, the supply of transportation facilities was assumed to be perfectly elastic for all points. In particular seasons, certain modes might be limited or unavailable to certain points, as with barges during winter months. Thus, timeliness of flows was not a consideration.

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Appendix table 1--Selected data to develop trucking cost, by State, 1966

State	General sales tax rate 1/	Mileage per vehicle/1961 2/	Percentage of 1961 mileage laden 3/	Estimated vehicle mileage, 1966	Driver-mechanic wages/mile 4/	Diesel fuel tax rate 5/	Fuel price	Estimated tire and tube cost
	Cents/dollar	Miles	Percent	Miles	Cents/mile	Cents/gallon	Cents/gallon	Cents/mile
Ala.	4	79,977	72.0	76,782	5.622	7	16.52	2.114
Ariz.	3	82,815	75.3	94,766	5.224	7	15.90	2.068
Ark.	3	79,977	72.0	94,906	5.044	8.5	14.60	2.665
Calif.	3	82,815	75.3	94,766	6.372	7	15.40	2.068
Colo.	3	82,815	75.3	91,168	5.224	7	15.00	2.433
Conn.	3.5	56,363	65.8	63,238	7.080	6	15.74	2.293
Del.	0	68,852	71.4	63,192	5.402	7	15.93	2.624
Fla.	3	68,852	71.4	76,782	5.622	7	15.91	2.114
Ga.	3	68,852	71.4	76,782	5.622	6.5	17.06	2.114
Idaho	3	82,815	75.3	91,168	5.224	6	16.20	2.433
Ill.	3.5	61,543	64.0	75,302	5.936	5	15.32	2.796
Ind.	2	61,543	64.0	75,302	5.936	6	15.84	2.796
Iowa	2	56,018	68.3	56,102	5.210	8	15.75	3.227
Kans.	3	56,018	68.3	56,102	5.210	7	15.61	3.227
Kans.	3	79,977	72.0	76,782	5.402	9	16.87	2.114
La.	2	79,977	72.0	94,906	5.044	7	15.06	2.665
Maine	4	56,363	65.8	63,238	7.080	7	16.27	2.293
Md.	3	68,852	71.4	63,192	5.402	7	15.93	2.624
Mass.	3	56,363	65.8	63,238	7.080	6.5	15.76	2.293
Mich.	4	61,543	64.0	75,302	5.936	6	15.94	2.796
Minn.	0	56,018	68.3	74,732	5.936	6	15.80	1.907
Miss.	3.5	79,977	72.0	76,782	5.622	8	15.26	2.114
Mo.	3	56,018	68.3	56,102	5.210	5	15.25	3.227
Mont.	0	82,815	75.3	91,168	5.224	9	16.50	2.433
Nebr.	0	56,018	68.3	56,102	5.210	7.5	15.50	3.227
Nev.	2	82,815	75.3	94,766	6.372	6	16.40	2.068
N.H.	0	56,363	65.8	63,238	7.080	7	16.01	2.293
N.J.	3	56,363	65.8	63,192	6.852	6	16.54	2.624
N. Mex.	3	82,815	75.3	91,168	5.224	6	14.72	2.433
N.Y.	2	56,363	65.8	63,192	6.852	9	16.54	2.624
N.C.	3	68,852	71.4	76,782	5.622	7	15.83	2.114
N. Dak.	2.25	56,018	68.3	74,732	5.210	6	16.40	1.907
Ohio	4	61,543	64.0	75,302	5.936	7	17.39	2.796
Okla.	2	79,977	72.0	94,906	5.044	6.5	15.26	2.665
Oreg.	0	82,815	75.3	94,766	6.372	6	16.50	2.068
Pa.	6	56,363	65.8	63,192	6.852	7	16.81	2.624
R.I.	4	56,363	65.8	63,238	7.080	7	15.86	2.293
S.C.	3	68,852	71.4	76,782	5.622	7	15.83	2.114
S. Dak.	3	56,018	68.3	74,732	5.210	7	16.09	1.907
Tenn.	3	79,977	72.0	76,782	5.622	8	15.60	2.114
Tex.	2	79,977	72.0	94,906	5.044	6.5	14.10	2.665
Utah	3	82,815	75.3	91,163	5.224	6	14.50	2.433
Vt.	0	56,363	65.8	63,238	7.080	0	16.01	2.293
Va.	2	68,852	71.4	76,782	5.402	9	15.88	2.114
Wash.	4.2	82,815	75.3	94,766	6.372	7.5	16.80	2.068
W. Va.	3	68,852	71.4	63,192	5.402	7	16.32	2.624
Wisc.	3	61,543	64.0	74,732	5.936	6	16.06	1.907
Wyo.	2.5	82,815	75.3	91,168	5.224	7	16.62	2.433

1/ Source: (55, p. 11).
2/ Source: (6, p. 39).
3/ Derived from (6, p. 39).
4/ Running mile.
5/ Source: (60, p. 8).

Appendix table 2--Summary of estimated trucking costs to carriers, by type of motor carrier, 1977

Item	Units	I. New England region					II. Middle Atlantic region				
		Conn.	Maine	Mass.	N. H.	R.I.	Vt.	Del.	Md.	N. J.	N. Y.	Pa.	W. Va.
Fixed costs:													
Investments:													
Garage	Dollars	4,500	4,300	5,500	4,400	4,300	5,300	4,502	4,702	5,458	4,329	5,458	4,429
Tractors	Do.	65,350	65,250	65,325	65,325	65,250	65,325	65,325	65,325	65,325	66,869	66,994	65,325
Grain trailers	Do.	28,500	28,500	28,220	27,400	28,596	27,400	27,400	28,220	28,220	27,948	28,778	28,220
Flour trailers	Do.	94,783	93,747	94,432	91,584	94,846	91,584	91,584	94,432	94,432	94,817	95,436	94,432
Total investment in--													
Grain trucking firms	Do.	99,350	97,050	99,045	96,125	98,146	96,125	96,227	98,247	99,003	98,016	100,122	97,974
Flour trucking firms	Do.	164,633	163,047	164,932	160,307	164,096	160,307	159,209	164,379	165,135	164,486	166,215	164,086
Ownership costs:													
Annual depreciation--													
Garage	Do.	218	218	218	218	218	218	104	104	121	120	121	98
Tractors	Do.	5,936	5,936	5,879	5,708	5,930	5,708	5,708	5,879	5,879	5,822	5,994	5,879
Grain trailers	Do.	2,565	2,565	2,540	2,466	2,563	2,466	2,466	2,540	2,540	2,514	2,589	2,540
Flour trailers	Do.	8,531	8,433	8,498	8,244	8,522	8,244	8,244	8,498	8,498	8,497	8,655	8,498
Taxes:													
Grain trucking firms	Do.	8,704	8,617	8,697	8,297	8,684	8,228	8,228	8,723	8,723	8,681	8,704	8,517
Flour trucking firms	Do.	14,549	14,020	14,487	14,389	14,626	14,067	14,055	14,473	14,498	14,154	14,770	14,467
Annual interest on--													
Grain trucking firms	Do.	5,844	5,785	5,931	5,565	5,984	5,767	5,732	5,895	5,941	5,881	6,059	5,878
Flour trucking firms	Do.	9,919	9,820	9,963	9,618	9,980	9,618	9,584	9,963	9,963	9,899	10,093	9,845
Real estate taxes	Do.	34	33	206	122	214	189	67	83	248	132	187	36
Total ownership costs:													
Grain trucking firms	Do.	14,067	14,173	14,672	14,181	14,729	14,269	14,035	14,481	14,778	14,481	14,880	14,431
Flour trucking firms	Do.	24,198	24,087	24,888	23,809	24,771	23,847	23,683	24,399	24,795	24,302	24,970	24,346
Operating costs:													
Return to management	Do.	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Vehicle--													
Public liability	Do.	298	298	298	298	298	298	318	318	182	318	318	182
Cargo loss and damage	Do.	20	20	20	20	20	20	20	20	12	20	20	20
Fire	Do.	43	43	43	43	43	43	52	52	30	52	52	52
Fire and damage-garage	Do.	55	55	55	55	55	55	49	49	46	56	57	46
Insurance for nonowner trips carried	Do.	2,332	2,242	2,336	1,855	2,335	1,855	1,599	1,556	1,550	216	1,641	216
Licenses and registration fees	Do.	5,114	4,924	6,208	5,564	7,005	5,625	4,792	4,668	4,650	648	4,923	648
Administrative expenses not allocated	Do.	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Total fixed operating costs	Do.	16,182	15,955	17,273	16,148	18,991	16,161	15,150	15,283	14,590	9,410	15,490	9,808
Fixed operating costs laden mile grain	Cents	12.17	12.17	13.17	12.31	14.48	12.32	11.55	11.65	11.12	7.17	11.81	7.48
Fixed operating costs laden mile--flour	Do.	17.19	17.07	18.07	17.11	19.38	17.13	16.09	16.23	15.47	9.98	16.45	10.41
Variable costs:													
Operating cost per trucking:													
Driver's and helper's wages laden mile	Cents	11.04	11.03	10.34	10.11	13.36	14.15	10.83	8.86	10.46	11.45	9.97	9.68
Fuel cost laden mile	Do.	4.80	4.83	4.69	4.67	6.11	6.53	6.50	5.13	5.15	5.63	4.99	5.97
Maintenance cost laden mile	Do.	4.82	4.74	4.68	4.56	6.02	6.38	6.38	4.24	4.87	5.13	4.64	5.72
Tire cost laden mile	Do.	3.67	3.57	3.35	3.20	4.13	4.59	5.25	4.30	4.01	4.39	3.82	4.70
Total variable operating costs													
laden mile--grain trucking	Do.	24.33	24.18	23.06	22.62	29.81	31.66	28.96	23.72	24.49	26.83	23.43	26.07
Operating cost in trucking:													
Driver's wages laden mile	Cents	14.13	14.13	14.13	14.13	18.35	14.16	10.80	10.80	13.70	13.70	13.70	10.80
Fuel cost laden mile	Do.	6.42	6.64	6.43	6.53	6.62	6.51	6.50	6.50	7.75	7.75	6.86	6.66
Maintenance cost laden mile	Do.	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38
Tire cost laden mile	Do.	4.58	4.59	5.59	4.49	5.59	4.59	5.24	5.24	5.24	5.25	5.24	5.25
Total variable operating costs													
laden mile--flour trucking	Do.	31.51	31.76	31.53	31.53	31.94	31.66	28.93	28.93	32.08	32.08	32.19	29.09
Laden mile percentage:													
Grain trucks	Percent	70.00	60.84	68.50	70.00	51.00	50.00	69.50	61.00	65.50	59.80	68.70	55.80
Flour trucks	Do.	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Annual mileage vehicle	Miles	63,238	63,238	63,238	63,238	63,238	63,238	63,192	63,192	63,192	63,192	63,192	63,192
Total annual laden miles per--													
Grain trucking firms	Do.	133,748	115,348	129,954	132,280	100,548	95,857	131,755	115,641	124,172	111,366	130,239	105,783
Flour trucking firms	Do.	94,857	94,857	94,857	94,857	94,857	94,857	94,788	94,788	94,788	94,788	94,788	94,788
Total costs grain trucking firms:													
Ownership costs laden mile	Cents	10.96	12.80	11.24	10.72	14.62	14.97	10.66	12.52	11.90	12.77	11.40	13.64
Operating costs laden mile	Do.	34.05	39.05	34.74	33.27	45.26	46.59	39.07	35.16	35.00	34.98	33.79	34.64
Grand total	Do.	45.04	51.85	45.98	43.99	59.88	61.56	49.73	47.68	46.90	47.75	45.19	48.28
Total costs flour trucking firms:													
Ownership costs laden mile	Do.	25.91	26.13	25.95	25.09	26.06	25.13	24.98	25.74	26.05	25.64	26.34	25.68
Operating costs laden mile	Do.	48.04	47.53	47.62	46.52	47.97	46.69	43.82	42.88	45.85	41.80	56.42	38.66
Grand total	Do.	73.93	73.66	73.56	71.61	74.03	71.82	68.80	68.62	71.90	67.44	82.76	64.34
Regional weighting factor	--	.1587	.0817	.0899	.0289	.1832	.0595	.0717	.0820	.2031	.2774	.3371	.0285
Regional cost laden mile for--													
Grain trucking	Do.	9.76									46.86		
Flour trucking	Do.	71.55									73.56		

--Continued

Appendix table [illegible] estimated trucking costs to carriers, by region and State, 1986--Continued

Item	Unit	III. Southern region								
		Ala.	Fla.	Ga.	Ky.	Miss.	N.C.	S.C.	Tenn.	Va.
Fixed costs:										
Investments in--										
Garage	Dollars	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trucks	Do.	65,498	65,325	65,325	65,325	65,550	65,325	65,325	65,325	64,689
Semi trailers	Do.	28,498	28,220	28,220	28,220	28,339	28,220	28,220	28,220	27,928
Pupf trailers	Do.	93,247	93,545	93,545	93,545	93,889	93,545	93,545	93,545	93,616
Total investment in--										
Urban trucking firms	Do.	98,745	[illegible]	97,960	97,960	98,260	97,959	97,959	97,905	97,866
Rural trucking firms	Do.	165,743	164,[illegible]	164,[illegible]	164,[illegible]	164,[illegible]	164,071	164,071	164,017	162,544
Ownership ratio:										
Annual depreciation rate--										
Garage	Pct.	99	98	98	98	97	98	98	97	98
Trucks	Do.	5,499	5,879	5,879	5,879	5,850	5,879	5,879	5,879	5,822
Semi trailers	Do.	2,565	2,540	2,540	2,540	2,550	2,540	2,540	2,540	2,514
Pupf trailers	Do.	8,552	8,490	8,490	8,490	8,542	8,490	8,490	8,490	8,402
Debt:										
Urban trucking firms	Do.	8,399	8,517	8,517	8,517	8,569	8,517	8,517	8,516	8,434
Rural trucking firms	Do.	14,[illegible]	14,[illegible]	14,[illegible]	14,[illegible]	14,[illegible]	14,[illegible]	14,[illegible]	14,[illegible]	14,327
Value of interest:										
Urban trucking firms	Pct.	5,[illegible]	5,878	5,878	5,878	5,898	5,878	5,878	5,874	5,824
Rural trucking firms	Do.	9,[illegible]	9,[illegible]	9,[illegible]	9,[illegible]	9,982	9,844	9,844	9,241	9,752
Business taxes	Do.	[illegible]	85	84	87	22	49	22	46	160
Total overhead costs:										
Urban trucking firms	Do.	[illegible]	[illegible]	[illegible]	[illegible]	14,517	[illegible]	[illegible]	[illegible]	14,418
Rural trucking firms	Do.	24,[illegible]	[illegible]	[illegible]	[illegible]	24,[illegible]	24,360	24,[illegible]	[illegible]	24,239
Operating ratio:										
Reduction in engagement	Pct.	[illegible]	[illegible]	[illegible]	6,500	6,500	6,500	6,500	6,500	6,500
Insurance:										
Public liability	Do.	182	182	182	182	182	182	182	182	318
Cargo & fire and damage	Do.	17	17	17	17	17	17	17	17	17
Life	Do.	36	36	36	36	36	36	36	36	36
Bond premium equivalent	Do.	46	46	46	46	45	46	46	46	46
Licenses and tax/asset ratio urban	Do.	1,941	[illegible]	[illegible]	[illegible]	[illegible]	2,021	1,992	2,236	216
Licenses and tax/asset ratio rural	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,215	5,976	6,705	648
Administrative expenses ratio (1,[illegible])	Pct.	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Total fixed operating costs	Do.	[illegible]	[illegible]	[illegible]	15,[illegible]	16,263	14,[illegible]	14,377	15,105	9,185
Urban operating ratio (adjusted to gross)	Ratio	[illegible]	[illegible]	8,[illegible]	10,[illegible]	10,19	9,01	9,84	11,40	7,42
Rural operating ratio (adjusted to gross)	Do.	[illegible]	[illegible]	[illegible]	14,78	14,12	12,69	12,48	13,12	9,64
Variable costs:										
Depreciation/maintenance rate:										
Straight-line miles (adjusted)	Pct.	[illegible]	[illegible]	[illegible]	5,31	8,11	7,99	8,87	9,78	8,27
Fuel, oil, grease, tires	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,59	5,10	5,34	[illegible]
Maintenance, repairs (adjusted)	Do.	[illegible]	[illegible]	[illegible]	[illegible]	4,60	4,53	5,03	5,55	4,89
Tires, tubes (adjusted)	Do.	[illegible]	[illegible]	2,86	[illegible]	3,05	3,09	3,33	3,68	3,24
Total variable operating costs										
Ldgo - average trucking	Pct.	[illegible]	[illegible]	[illegible]	22,35	20,26	20,11	22,31	24,54	21,30
Operating costs of trucking:										
Fuel-gasoline, wages (adjusted)	Pct.	[illegible]	[illegible]	11,24	10,80	11,24	11,24	11,24	11,24	10,80
Fuel, oil, lube, tires	Do.	[illegible]	[illegible]	[illegible]	6,89	6,23	6,46	6,46	6,37	6,48
Maintenance, repair (adjusted)	Do.	[illegible]	[illegible]	[illegible]	6,38	6,38	6,38	6,38	6,37	6,38
Tires, tubes (adjusted)	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total variable operating costs										
Labor (adjusted for productivity)	Pct.	[illegible]	[illegible]	[illegible]	28,69	28,08	28,31	28,31	28,22	27,99
Labor factor productivity:										
Urban firms	Percent	[illegible]	[illegible]	70,40	63,50	69,30	70,40	63,40	57,50	65,30
Rural firms	Do.	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00
Annual average vehicle	Miles	76,782	76,782	76,782	76,782	76,782	76,782	76,782	76,782	63,192
Total annual fixed costs:										
Urban trucking firms	Pct.	[illegible]	[illegible]	[illegible]	146,270	159,630	162,164	146,039	132,469	123,793
Rural trucking firms	Do.	[illegible]	[illegible]	[illegible]	115,173	115,173	115,173	115,173	115,173	94,788
Total annual variable operating costs										
Ownership costs (adjusted)	Cents	[illegible]	[illegible]	8,48	9,90	9,80	8,90	9,87	10,89	11,64
Operating costs (adjusted)	Do.	24,[illegible]	26,30	[illegible]	33,13	[illegible]	29,12	32,17	35,94	28,78
Grand total	Do.	[illegible]	[illegible]	[illegible]	43,03	39,54	38,02	42,04	46,83	40,42
Total costs (fixed trucking ratio):										
Ownership costs (adjusted)	Do.	[illegible]	[illegible]	21,16	21,19	21,21	21,15	21,12	20,84	25,57
Operating costs (adjusted)	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand total	Do.	[illegible]	[illegible]	61,50	64,26	63,41	62,15	61,91	61,98	63,25
Regional weighting factor	--	.[illegible]	.[illegible]	.1186	.0916	.0167	.2929	.0464	.0669	.1092
Regional cost index (urban firms)--										
Urban firms	Do.	[illegible]					38.05			
Rural firms	Do.	[illegible]					62.05			

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Appendix table --Summary of estimated trucking costs to carriers, by region and State, 1966--Continued

Item	Unit	E. North Central region				W. North Central region							
		Ill.	Ind.	Ohio	Mich.	Iowa	Kans.	Minn.	Mo.	Nebr.	N. Dak.	S. Dak.	Wisc.
Fixed costs:													
Investments in--													
Garage	Dollars	4,935	4,937	4,926	5,133	4,805	4,804	4,882	4,860	4,815	4,800	4,800	4,957
Tractor	Do.	65,550	64,689	63,325	65,958	66,689	65,325	63,423	65,325	63,423	64,848	65,325	65,325
Grain trailers	Do.	28,359	27,948	28,220	28,496	27,948	28,220	27,400	28,220	27,400	28,016	28,220	28,220
Flour trailers	Do.	94,789	93,416	94,332	95,347	93,416	94,332	91,658	94,332	91,658	93,665	94,332	94,332
Total investment in--													
Grain trucking firms	Do.	98,844	97,574	98,470		97,442	98,351	96,701	98,405	95,638	97,664	98,345	98,502
Flour trucking firms	Do.	164,274	163,042	164,582	166,138	164,910	164,465	159,768	164,517	159,696	163,291	164,457	164,614
Ownership costs:													
Annual depreciation on--													
Garage	Do.	110	110	109	114	107	107	109	108	107	107	107	110
Tractors	Do.	5,900	5,822	5,694	5,936	5,822	5,879	5,708	5,879	5,708	5,836	5,879	5,879
Grain trailers	Do.	2,552	2,516	2,540	2,565	2,515	2,540	2,466	2,540	2,466	2,521	2,540	2,540
Flour trailers	Do.	8,531	8,407	8,490	8,581	8,407	8,490	8,249	8,490	8,249	8,429	8,490	8,490
Total:													
Grain trucking firms	Do.	8,562	8,448	8,528	8,615	8,444	8,526	8,283	8,527	8,281	8,464	8,526	8,529
Flour trucking firms	Do.	14,541	14,339	14,473	14,622	14,336	14,476	14,058	14,477	14,058	14,371	14,476	14,479
Annual interest													
Grain trucking firms	Do.	5,911	5,826	5,868	5,935	5,842	5,901	5,734	5,902	5,738	5,860	5,901	5,910
Flour trucking firms	Do.	9,846	9,711	9,805	9,900	9,775	9,868	9,586	9,871	9,582	9,798	9,867	9,877
Real estate taxes	Do.	109	83	91	92	92	75	141	61	55	79	91	123
Total ownership costs:													
Grain trucking firms	Do.	14,582	14,357	14,487	14,642	14,382	14,502	14,166	14,492	14,074	14,403	14,518	14,562
Flour trucking firms	Do.	24,504	24,207	24,418	24,654	24,203	24,419	23,911	24,460	23,695	24,248	24,434	24,479
Operating costs:													
Returns to management	Do.	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Insurance:													
Public liability	Do.	226	226	226	226	176	176	185	176	176	185	185	185
Cargo loss and damage	Do.	17	17	17	17	21	21	20	21	21	20	20	20
Fire	Do.	49	49	49	49	34	34	33	34	34	33	33	33
Fire insurance-garage	Do.	51	51	51	51	50	50	51	51	50	50	50	52
Licenses and road-user taxes vehicle	Do.	2,534	2,052	3,143	1,782	2,254	2,996	2,279	2,278	2,774	2,035	2,630	2,178
Vacation and sick-leave allowance	Do.	7,723	6,150	9,424	5,346	6,762	8,988	6,837	6,834	8,322	6,105	7,890	6,534
Administrative expenses and utilities	Do.	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Total fixed operating costs	Do.	18,171	14,609	17,552	13,601	15,163	17,389	15,245	15,256	16,723	14,513	16,298	14,944
Fixed operating costs laden mile grain	Cents	11.10	8.93	10.73	9.17	13.27	15.21	9.82	12.08	14.68	10.54	11.45	10.15
Fixed operating costs laden mile flour	Do.	14.42	12.34	15.45	12.22	18.02	20.66	18.12	18.11	19.87	12.95	14.54	13.33
Variable costs:													
Operating-grain trucking:													
Driver-mechanic wages laden mile	Dol.	9.20	9.38	9.25	8.91	7.67	8.28	8.62	7.41	7.29	8.49	8.20	9.03
Fuel cost laden mile	Do.	4.84	5.12	5.04	4.88	4.73	5.07	4.68	4.43	4.42	5.45	5.17	4.99
Maintenance cost laden mile	Do.	4.95	5.05	5.24	4.79	4.70	5.07	4.61	4.54	4.46	5.20	5.02	4.86
Tire cost laden mile	Do.	2.55	2.47	2.54	2.53	2.32	2.53	2.27	2.59	2.51	3.11	3.00	2.90
Total variable operating costs laden mile-grain trucking	Do.	22.44	22.42	22.07	21.78	21.22	23.55	20.69	20.96	20.69	22.23	21.40	21.78
Operating-flour trucking:													
Driver-mechanic wages laden mile	Dol.	11.87	11.87	11.87	11.87	10.42	10.42	11.87	10.42	10.42	10.42	10.42	11.87
Fuel cost laden mile	Do.	6.25	6.47	7.09	6.51	6.43	6.37	6.45	6.22	6.32	6.69	6.57	6.55
Maintenance cost laden mile	Do.	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38
Tire cost laden mile	Do.	5.59	5.59	5.59	5.59	5.59	6.45	3.81	6.45	6.45	3.81	3.81	3.81
Total variable operating costs laden mile-flour trucking	Do.	30.01	30.31	30.94	30.35	28.82	29.63	28.51	29.47	29.58	27.31	27.18	28.62
Laden miles: percentage													
Grain trucks	Percent	64.50	63.20	62.50	66.80	67.90	62.90	68.90	70.80	71.50	61.40	63.50	65.70
Flour trucks	Do.	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Actual average vehicle	Miles	75,302	75,302	75,302	75,302	58,102	58,102	74,732	58,102	58,102	74,732	74,732	74,732
Total annual laden miles													
Grain trucking firms	Do.	143,771	142,771	137,444	150,453	114,280	105,864	154,471	118,119	120,339	137,656	142,364	147,297
Flour trucking firms	Do.	112,953	112,953	112,953	114,953	84,153	84,153	112,098	84,153	84,153	112,098	112,098	112,098
Total cost-grain trucking firms:													
Ownership costs laden mile	Cents	10.14	10.07	10.58	9.73	12.58	13.69	9.17	12.27	11.69	10.46	10.19	9.89
Operating costs laden mile	Do.	33.54	33.21	33.51	31.97	34.49	38.98	30.56	33.84	34.59	32.77	33.85	31.93
Grand total	Do.	43.68	43.28	44.09	41.70	47.07	52.67	39.73	46.08	46.28	43.23	44.04	41.81
Total cost-flour trucking firms:													
Ownership costs laden mile	Do.	21.70	21.42	21.62	21.86	28.76	29.01	21.21	29.30	28.15	21.63	21.79	21.83
Operating costs laden mile	Do.	43.63	43.24	46.72	42.57	46.84	50.29	46.63	47.58	49.45	38.26	41.72	41.95
Grand total	Do.	65.33	64.66	68.34	64.43	75.60	79.30	67.84	76.88	77.60	59.89	63.51	63.78
Regression weighting factor		.2178	.2240	.2492	.2294	.1471	.0367	.1931	.2184	.1678	.0271	.0388	.1709
Regression: Laden mile													
Grain trucking	Cents	41.81								71.65			
Flour trucking	Do.	65.81											

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Appendix table 2--Summary of estimated trucking costs to carriers, by region and State, 1986--Continued

Item	Unit	VII. Southwest region				VIII. Rocky Mountain region					
		Kans.	Okla.	Texas	Total	Colo.	Idaho	Mont.	N. Mex.	Utah	Wyo.
Fixed costs:											
Investments in--											
Garage	Dollars	4,441	4,482	4,443	4,462	4,721	4,921	4,900	4,724	4,735	4,844
Tractors	Do.	65,325	64,689	64,689	64,689	65,325	65,325	63,423	65,325	65,325	65,047
Grain trailers	Do.	28,220	27,948	27,948	27,948	28,220	28,220	27,400	28,220	28,220	28,085
Flour trailers	Do.	94,332	93,416	93,416	93,416	94,332	94,332	91,458	94,332	94,332	93,874
Total investment in--											
Grain trucking firms	Do.	97,986	97,124	97,096	97,099	98,316	98,468	95,723	98,269	98,280	97,936
Flour trucking firms	Do.	164,098	162,592	162,564	162,567	164,428	164,578	159,781	164,381	164,392	163,725
Ownership costs:											
Annual depreciation on--											
Garage	Do.	94	98	94	96	106	104	109	105	105	108
Tractors	Do.	5,884	5,822	5,822	5,822	5,879	5,879	5,708	5,879	5,879	5,851
Grain trailers	Do.	2,540	2,514	2,514	2,514	2,540	2,540	2,466	2,540	2,540	2,528
Flour trailers	Do.	8,490	8,407	8,407	8,407	8,490	8,490	8,243	8,490	8,490	8,449
Total											
Grain trucking firms	Do.	8,518	8,434	8,431	8,431	8,525	8,523	8,283	8,524	8,524	8,487
Flour trucking firms	Do.	14,468	14,327	14,328	14,328	14,475	14,478	14,060	14,474	14,474	14,406
Annual interest:											
Grain trucking firms	Do.	5,826	5,827	5,826	5,826	5,899	5,908	5,743	5,896	5,897	5,876
Flour trucking firms	Do.	9,446	9,356	9,356	9,356	9,866	9,875	9,587	9,863	9,864	9,824
Real estate taxes	Do.	34	34	36	36	41	47	26	30	43	29
Total ownership costs:											
Grain trucking firms	Do.	14,478	14,295	14,293	14,293	14,465	14,485	14,102	14,450	14,464	14,392
Flour trucking firms	Do.	24,348	24,117	24,118	24,118	24,404	24,402	23,721	24,368	24,381	24,261
Operating costs:											
Returns to management	Do.	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Insurance											
Public liability	Do.	162	162	162	162	117	117	117	117	117	117
Cargo loss and damage	Do.	21	21	21	21	18	18	18	18	18	18
Fire	Do.	18	18	18	18	30	30	30	30	30	30
Fire insurance-garage	Do.	46	47	46	46	50	51	51	49	49	50
Licenses and road-user taxes vehicle	Do.	2,487	1,536	1,734	2,106	4,416	3,472	2,813	1,538	2,109	1,083
Licenses and road-user taxes firm	Do.	7,495	6,118	6,117	6,118	13,248	10,416	8,439	4,614	6,327	9,249
Administrative expenses and utilities	Do.	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Total fixed operating costs	Do.	13,822	13,486	13,258	14,685	21,581	18,752	16,775	12,948	14,661	17,584
Fixed operating costs laden mile-grain	Cents	8.97	8.83	8.61	7.16	9.93	9.40	9.41	8.27	6.60	11.51
Fixed operating costs laden mile-flour	Do.	13.11	9.47	9.47	10.32	15.78	13.71	12.27	9.47	10.72	12.86
Variable costs:											
Operating-grain trucking											
Driver-mechanic wages laden mile	Do.	6.11	6.33	5.54	7.00	6.57	7.17	8.01	8.05	6.43	9.51
Fuel cost laden mile	Do.	4.74	3.87	4.38	4.00	3.85	4.54	5.16	4.63	3.64	5.81
Maintenance cost laden mile	Do.	4.00	3.81	4.84	4.43	4.01	4.38	4.89	4.92	3.93	5.81
Tire cost laden mile	Do.	3.34	3.18	4.09	3.70	3.06	3.34	3.73	3.75	3.00	4.43
Total variable operating costs laden mile-grain trucking	Do.	17.42	16.67	21.69	19.14	17.49	19.41	21.80	21.34	16.26	25.56
Operating-flour trucking:											
Driver-mechanic wages laden mile	Do.	9.33	9.53	10.00	10.09	10.45	10.45	10.45	10.45	10.45	10.45
Fuel cost laden mile	Do.	5.96	6.21	6.21	5.75	6.12	6.61	6.73	6.01	5.91	6.37
Maintenance cost laden mile	Do.	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38
Tire cost laden mile	Do.	5.33	5.33	5.33	5.33	4.87	4.87	4.87	4.87	4.87	4.87
Total variable operating costs laden mile flour trucking	Do.	27.00	27.45	28.03	27.55	27.81	28.31	28.43	27.70	26.41	28.07
Laden mileage per average:											
Grain trucks	Percent	84.50	83.80	83.20	82.00	79.50	72.90	65.20	84.90	81.20	54.90
Flour trucks	Do.	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Annual mileage per truck	Miles	94,906	94,906	94,906	94,906	91,168	91,168	91,168	91,168	91,168	91,168
Total annual laden miles:											
Grain trucking firms	Do.	226,920	238,994	185,036	204,397	212,036	199,384	128,125	177,504	222,095	150,154
Flour trucking firms	Do.	142,359	142,359	142,359	142,359	136,752	136,752	136,752	136,752	136,752	136,752
Unit costs per laden mile:											
Ownership costs laden mile	Cents	6.35	6.09	7.20	6.98	7.22	7.26	7.90	8.14	6.51	9.58
Operating costs laden mile	Do.	24.19	22.32	28.93	26.30	27.42	28.81	31.20	28.63	22.86	32.27
Grand total	Do.	30.54	28.41	36.83	33.28	34.69	36.07	39.11	36.77	29.37	46.85
Total costs-all trucking firms											
Ownership costs laden mile	Do.	17.21	16.94	16.94	16.95	17.84	17.84	17.14	17.81	17.82	17.74
Operating costs laden mile	Do.	38.26	37.42	37.70	37.87	43.59	42.02	40.70	37.17	37.13	40.93
Grand total	Do.	55.46	54.36	54.64	54.82	61.43	59.86	58.04	54.98	54.95	58.67
Regional average cost per ton-mile		.0369	.0346	.0349	.0388	.0390	.1565	.0358	.0451	.2586	.0650
Regional cost per ton-mile											
Grain hauling	Cents	----------			34.57	----------					
Flour hauling	Do.	----------			58.92	----------					

--Continued

Appendix table 2--Summary of estimated trucking costs to carriers, by region and State, 1966--Continued

Item	Unit	VIII. Pacific region				
		Ariz.	Calif.	Nev.	Oreg.	Wash.
Fixed costs:						
Investments in--						
Garage	Dollars	4,986	4,988	4,986	4,989	4,999
Tractor	Do.	65,625	65,325	64,689	63,423	66,069
Grain trailers	Do.	28,220	29,220	27,948	27,400	28,551
Flour trailers	Do.	94,132	94,314	93,416	91,584	95,431
Total investment in--						
Grain trucking firms	Do.	98,301	98,533	97,603	95,822	99,619
Flour trucking firms	Do.	166,417	166,645	165,073	160,006	166,499
Ownership costs:						
Annual depreciation of--						
Garage	Do.	142	111	110	110	111
Tractors	Do.	5,874	5,879	5,822	5,708	5,946
Grain trailers	Do.	2,540	2,944	2,514	2,466	2,570
Flour trailers	Do.	8,498	8,498	8,407	8,233	8,589
Total:						
Grain trucking firms	Do.	8,556	8,940	8,446	8,285	8,627
Flour trucking firms	Do.	14,914	14,980	14,339	14,062	14,646
Annual interest						
Grain trucking firms	Do.	9,846	9,872	9,856	9,749	9,972
Flour trucking firms	Do.	9,804	9,879	9,784	9,600	9,990
Real estate taxes	Do.	33	21	35	63	47
Total ownership costs:						
Grain trucking firms	Do.	14,487	9,142	14,337	14,097	14,651
Flour trucking firms	Do.	24,184	24,440	24,158	23,725	24,683
Operating costs						
Returns to management	Do.	6,500	6,500	6,500	6,500	6,500
Insurance:						
Public liability	Do.	156	156	156	156	156
Cargo loss and damage	Do.	18	18	18	18	18
Fire	Do.	67	67	67	67	67
Fire maintenance garage	Do.	52	52	52	52	52
Taxes and road user taxes vehicle	Do.	1,849	1,952	1,830	4,256	2,589
Licenses and road user taxes fuel	Do.	9,487	9,486	9,490	12,768	7,767
Administrative expenses and miscellaneous	Do.	1,620	1,620	1,620	1,620	1,620
Total fixed operating costs:		17,997	19,999	19,903	21,181	16,180
Fixed operating costs laden mile grain	Cents	6.07	6.80	7.50	10.28	6.87
Fixed operating costs laden miles flour	Do.	9.71	10.06	9.78	13.90	11.35
Variable costs						
Operating grain trucking						
Driver-mechanic wages laden mile	Do.	8.47	8.80	9.22	8.79	7.69
Fuel cost laden mile	Do.	4.02	4.34	5.13	4.64	4.14
Maintenance cost laden mile	Do.	3.95	4.41	4.89	4.46	3.85
Tire cost laden mile	Do.	2.39	2.86	2.17	2.85	2.49
Total variable operating costs						
laden mile-grain trucking	Do.	17.83	20.40	22.97	20.69	18.17
Operating-flour trucking:						
Driver-mechanic wages laden mile	Do.	12.74	12.74	12.74	12.74	12.74
Fuel cost laden mile	Do.	6.48	6.28	6.69	6.73	6.85
Maintenance cost laden mile	Do.	6.38	6.38	6.38	6.38	6.38
Tire cost laden mile	Do.	4.13	4.13	4.13	4.13	4.13
Total variable operating costs						
laden mile-flour trucking	Do.	29.73	29.93	29.95	29.99	30.11
Laden mileage percentage						
Grain trucks	Percent	80.70	72.40	66.20	72.50	82.90
Flour trucks	Do.	50.00	50.00	50.00	50.00	50.00
Annual mileage vehicle	Miles	94,766	94,766	94,766	94,766	94,766
Total annual laden miles:						
Grain trucking firms	Do.	229,628	205,832	185,362	206,116	235,683
Flour trucking firms	Do.	142,149	142,149	142,149	142,149	142,149
Total costs grain trucking firms						
Ownership costs laden mile	Cents	6.30	4.46	7.73	6.83	6.21
Operating costs/laden mile	Do.	23.08	27.20	30.47	30.97	25.03
Grand total	Do.	29.38	31.66	38.20	37.80	31.22
Total costs flour trucking firms:						
Ownership costs laden mile	Do.	17.15	17.18	16.99	16.69	17.36
Operating costs/laden mile	Do.	37.23	39.58	39.73	44.89	41.46
Grand total	Do.	54.39	56.76	56.72	61.58	58.82
Regional weighing factor		.0458	.8137	.0039	.0809	.0380
Regional cost laden mile:						
Grain trucking	Do.	32.05				
Flour trucking	Do.	57.31				

Appendix table 3--Mileages driven by for-hire trucks and miles per trip of Class I motor carriers, by region and State, 1966

Region and State	Million miles 1/	Miles per trip 2/	Region and State	Million miles 1/	Miles per trip 2/
Pacific	2,534	385	Central	4,539	216
Ariz.	116		Ill.	1,170	
Calif.	2,056		Ind.	1,019	
Nev.	10		Mich.	1,023	
Oreg.	205		Ohio	1,327	
Wash.	147				
Rocky Mountain	754	508	Southern	4,486	250
Colo.	331		Ala.	380	
Idaho	118		Fla.	785	
Mont.	27		Ga.	523	
N. Mex.	34		Ky.	411	
Utah	195		Miss.	75	
Wyo.	49		N.C.	1,314	
			S.C.	208	
			Tenn.	300	
Midwest	3,344	307	Va.	490	
Iowa	489				
Kans.	122		Middle Atlantic	4,452	239
Minn.	642		Del.	319	
Mo.	726		Md.	365	
Nebr.	558		N.J.	905	
N. Dak.	90		N.Y.	1,235	
S. Dak.	129		Pa.	1,501	
Wisc.	568		W. Va.	127	
Southwestern	2,934	438	New England	857	109
Ark.	251		Conn.	136	
La.	195		Maine	70	
Okla.	731		Mass.	419	
Tex.	1,757		N.H.	24	
			R.I.	157	
			Vt.	51	

1/ Source: (52, table 11).
2/ Source: (10, pp. 41, 54, 67, 80, 106, 119, 132, and 171).

Appendix table 4--Selected regional and interregional estimated costs per laden mile for grain and flour, 1966

Commodity and origin region	Destination region							
	I	II	III	IV	V	VI	VII	VIII
	Cents/laden mile							
Grain:								
I	49.76	47.77	41.61	46.54				
II	47.77	46.86	42.36	45.93	45.49	38.26		
III	41.61	42.36	38.05	41.23	41.56	35.20		
IV	46.54	45.93	41.23	44.91	44.62	37.32		
V		45.49	41.56	44.62	44.42	38.04	38.28	
VI		38.26	35.20	37.32	38.04	33.57	34.11	32.86
VII					38.28	34.11	34.57	33.48
VIII						32.86	33.48	32.05
Flour:								
I	73.55	73.56	65.55	68.40				
II	73.56	73.56	67.68	59.96	72.49	57.57		
III	65.55	67.68	62.04	63.87	67.34	53.65		
IV	68.40	59.96	63.87	65.80	69.23	47.55		
V		72.49	67.34	69.23	71.65	58.25	63.72	
VI		57.57	53.65	47.55	58.25	48.85	54.26	53.74
VII					63.72	54.26	58.92	59.09
VIII						52.36	58.23	57.31

Note: Blank means not considered to be a feasible shipment, thus not computed.

Appendix table 5--Estimated percentage of flour transported in bags, 1966

Type of flour	As percentage of all flour 1/	Percentage in bags 2/
	Percent	
Bakers' white bread-type:		
Commercial	66.48	2/54.42
Government	6.44	2/54.42
Export	8.67	2/54.42
Commercial soft:		
White	7.49	35.36
Family	10.92	100.00
All flour	100.00	57.97

1/ Derived from (26, p. 42).
2/ Source: (26, p. 43).

Appendix table 6--Selected regional and interregional costs of service per cwt.-mile for transporting flour by truck, 1966

Form and origin region	Destination region							
	I	II	III	IV	V	VI	VII	VIII
	Cents/cwt.-mile							
Bulk:								
I	0.163444	0.163461	0.145667	0.152000				
II	.163461	.163467	.150400	.133244	.161089	.123489		
III	.145667	.150400	.138113	.141871	.149644	.119222		
IV	.152000	.133244	.141871	.146222	.153844	.105667		
V		.161089	.149644	.153844	.159222	.129444	.141600	
VI		.123489	.119222	.105667	.129444	.108556	.120578	.117340
VII					.141600	.120578	.130933	.129391
VIII						.117340	.129391	.127356
Bagged (58 percent):								
I	.128773	.126373	.111511	.120722				
II	.126373	.125279	.111439	.120480	.112250	.099078		
III	.111511	.111439	.103985	.110941	.113113	.092635		
IV	.120722	.120480	.110941	.115680	.118537	.095908		
V		.112250	.113113	.118537	.120547	.100328	.105723	
VI		.099078	.092635	.095908	.100328	.086157	.091853	.088975
VII					.105723	.091853	.096764	.094796
VIII						.088975	.094796	.092199

Note: Blank means not considered to be a feasible shipment, thus not computed.

Appendix table 7--ICC rail region classification, 1966

Region number	Territory or region
I	New England region
II	Official territory excluding New England region
III	Official territory (Eastern district plus Pochontas region)
IV	Southern region
V	Western district excluding Mountain Pacific and Transterritory
VI	Mountain Pacific and Transterritory
VII	Western district

Source: (16, p. 1).

Appendix table 8--Regional carload unit costs for average-weight train, by type of equipment, 1966

Type of equipment (2)	Empty return ratio (3)	Out-of-pocket expenses: Line-haul: Per car-mile (4)	Out-of-pocket expenses: Line-haul: Per cwt.-mile (5)	Out-of-pocket expenses: Terminal: Per carload (6)	Out-of-pocket expenses: Terminal: Per cwt. (7)	Constant expenses: Line-haul: Per cwt.-mile (8)	Constant expenses: Terminal: Per cwt. (9)
		Cents/unit					
Region I:							
Box-general service	0.59	31.07205	0.01746	7827.138	0.173	0.02553	3.847
Box-general service	.69	37.09761	.01746	8344.552	.173	.02553	3.847
Gondola	.74	33.69962	.01746	8344.552	.064	.02553	3.847
Hopper, open	1.13	41.40172	.01746	8344.552	.064	.02553	3.847
Hopper, covered	1.04	40.79195	.01746	8344.552	.064	.02553	3.847
Flat, except TOFC	.68	35.53472	.01746	8344.552	.173	.02553	3.847
Flat, TOFC	.21	30.83090	.01746	9184.491	.045	.02553	3.847
Stock	.74	31.63410	.01746	8344.552	.173	.02553	3.847
Refrigerator	.90	46.90604	.01746	6019.106	.173	.02553	3.847
Rack, except auto	.92	38.99574	.01746	8344.552	.173	.02553	3.847
Tank	1.02	53.28442	.01746	6019.106	.064	.02553	3.847
Tank, 20,000 gals.	1.00	63.51043	.01746	6019.106	.064	.02553	3.847
Tank, 30,000 gals.	1.00	70.07430	.01746	6019.106	.064	.02553	3.847
Region II:							
Box-general service	.46	18.33217	.01004	7087.715	.173	.01182	2.323
Box-special service	.83	25.51309	.01004	7599.338	.173	.01182	2.323
Gondola	.79	22.29605	.01004	7599.338	.047	.01182	2.323
Hopper, open	.88	23.49257	.01004	7599.338	.047	.01182	2.323
Hopper, covered	1.08	26.65993	.01004	7599.338	.047	.01182	2.323
Flat, except TOFC	.65	21.11538	.01004	7599.338	.173	.01182	2.323
Flat, TOFC	.19	21.07444	.01004	9656.436	.027	.01182	2.323
Stock	1.05	24.13523	.01004	7599.338	.173	.01182	2.323
Refrigerator	.78	31.24201	.01004	5746.887	.173	.01182	2.323
Rack, except auto	1.01	26.12591	.01004	7599.338	.173	.01182	2.323
Tank	1.03	41.74853	.01004	5746.887	.047	.01182	2.323
Tank, 20,000 gals.	1.00	47.31521	.01004	5746.887	.047	.01182	2.323
Tank, 30,000 gals.	1.00	51.08965	.01004	5746.887	.047	.01182	2.323
Region IV:							
Box-general service	.42	14.38257	.00925	4891.620	.142	.01145	1.694
Box-special service	.79	20.41383	.00925	5204.931	.142	.01145	1.694
Gondola	.89	18.96827	.00925	5204.931	.024	.01145	1.694
Hopper, open	.86	18.73597	.00925	5204.931	.024	.01145	1.694
Hopper, covered	.98	20.53052	.00925	5204.931	.024	.01145	1.694
Flat, except TOFC	.71	17.69929	.00925	5204.931	.142	.01145	1.694
Flat, TOFC	.36	20.72659	.00925	9969.340	.023	.01145	1.694
Stock	.97	18.53265	.00925	5204.931	.142	.01145	1.694
Refrigerator	.82	29.13935	.00925	3492.048	.142	.01145	1.694
Rack, except auto	.97	20.75467	.00925	5204.931	.142	.01145	1.694
Tank	1.03	37.48296	.00925	3492.048	.024	.01145	1.694
Tank, 20,000 gals.	1.00	42.62415	.00925	3492.048	.024	.01145	1.694
Tank, 30,000 gals.	1.00	46.10040	.00925	3492.048	.024	.01145	1.694
Region VII:							
Box-general service	.41	15.31047	.01067	7463.086	.437	.01281	2.706
Box-special service	.66	20.46848	.01067	7921.483	.437	.01281	2.706
Gondola	.89	20.32096	.01067	7921.483	.094	.01281	2.706
Hopper, open	.99	21.48105	.01067	7921.483	.094	.01281	2.706
Hopper, covered	1.09	23.27384	.01067	7921.483	.094	.01281	2.706
Flat, except TOFC	.69	18.78347	.01067	7921.483	.437	.01281	2.706
Flat, TOFC	.29	21.38858	.01067	9358.637	.075	.01281	2.706
Stock	.81	18.14804	.01067	7921.483	.437	.01281	2.706
Refrigerator	.53	25.02114	.01067	5890.305	.437	.01281	2.706
Rack, except auto	1.04	23.10871	.01067	7921.483	.437	.01281	2.706
Tank	1.02	39.38212	.01067	5890.305	.094	.01281	2.706
Tank, 20,000 gals.	1.00	45.56249	.01067	5890.305	.094	.01281	2.706
Tank, 30,000 gals.	1.00	49.57293	.01067	5890.305	.094	.01281	2.706

Source: Excerpted from (1n, pp. 163, 165, 169, and 175).

Note: Only these regions considered to avoid geographical overlapping.

Appendix table 9--Car ownership costs included in ICC Statement 2-68, by region, 1966

Region	Type of equipment	Empty return ratio	Out-of-pocket expenses				Constant expenses	
			Line-haul		Terminal		Line-haul	Terminal
			Per car-mile	Per cwt.-mile	Per carload	Per cwt.	Per cwt.-mile	Per cwt.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Cents/unit					
I	Box-general service	xxx	7.68631	xxx	2209.173	xxx	0.00175	0.446
	Hopper, covered	xxx	9.86169	xxx	2325.446	xxx	.00175	.446
II	Box-general service	xxx	5.06303	xxx	1759.829	xxx	.00115	.250
	Hopper, covered	xxx	7.21309	xxx	1852.451	xxx	.00115	.250
IV	Box-general service	xxx	4.68610	xxx	1627.239	xxx	.00107	.187
	Hopper, covered	xxx	6.53414	xxx	1712.883	xxx	.00107	.187
VII	Box-general service	xxx	4.25525	xxx	1929.619	xxx	.00100	.211
	Hopper, covered	xxx	6.30743	xxx	2031.178	xxx	.00100	.211

Source: Excerpted from (16, pp. 164, 166, 170, and 176).

Appendix table 10--Passenger train deficits and special service charges, by region, 1966

Item	Rail region			
	I	II	IV	VII
	Percent 1/			
Deficits	8	4	7	5
	Dollars per carload 2/			
Special services	3.96	2.68	1.79	3.82

1/ Deficits are given as percentages of fully distributed costs.
2/ Source: (16, p. 188).
Note: Only these regions were considered to avoid geographical overlapping.

Appendix table 11--Switching time and cost per car, 1966

Type of car	Region I		Region II		Region IV		Region VII	
	Cost	Time	Cost	Time	Cost	Time	Cost	Time
	Dol.	Min.	Dol.	Min.	Dol.	Min.	Dol.	Min.
Box	18.05	21.1	18.86	24.7	10.24	18.0	16.06	24.0
All other	20.06	23.4	20.95	28.5	11.38	20.0	17.84	26.7

Source: (16, p. 189).
Note: Only these regions were considered to avoid geographical overlapping.

Appendix table 12--Grain movements proportioned by type of car, by rail region, 1966

Region number		Grain moved by--	
Origin	Destination	Boxcar	Hopper car
I	I	0.8585	0.1415
II	I	.8585	.1415
II	II	.8585	.1415
II	IV	.4010	.5990
IV	IV	.4752	.5248
VII	II	.8037	.1963
VII	IV	.9240	.0760
VII	VII	.7842	.2158

Derived from (18).

Appendix table 13--Selected navigational characteristics, by waterway, 1966

River or waterway	Draft	Towboat horsepower	Barges per tow	Load per barge	Towboat speed	
					Upstream	Downstream
	Feet	Horsepower rating	Number	Bushels	Miles/hour	
Columbia River	8.5	2,400	3	45,000	6.2	6.2
Intracoastal Waterway	8.5	1,200	4	31,400	6.0	6.0
Illinois Waterway:						
Above Joliet	8.5	800	3	45,000	3.0	3.0
Below Joliet	8.5	2,200	10	45,000	3.3	4.0
Mississippi River:						
Above St. Louis	8.5	2,200	10	45,000	4.6	6.3
Below St. Louis	6.5	5,600	22	45,000	4.0	10.0
Missouri River:						
Above Omaha	6.5	3,200	8	31,400	3.5	10.0
Omaha to Kansas City	7.0	3,200	8	35,200	3.5	10.0
Below Kansas City	7.5	3,200	8	38,200	3.5	10.0
Ohio River	8.5	3,200	12	45,000	5.3	7.4
Tennessee River						
Above Chattanooga	8.5	800	3	45,000	1/5.3	1/7.4
Below Chattanooga	8.5	2,000	8	45,000	5.3	7.4

1/ Data not available, thus assumed to be the same as "below Chattanooga."

Source: (36).

Appendix table 14--Ratio of barges loaded or empty to stream flow, by river, 1966

River 1/	Empty upstream--Loaded downstream	Empty downstream--Loaded upstream
Columbia 2/	1.00	1.00
Illinois	.69	.74
Mississippi:		
Above the Missouri River mouth	.65	.53
Missouri River mouth to Ohio River mouth	.67	.48
Ohio River mouth to Gulf	.68	.41
Missouri:		
Above Omaha	.92	.91
Omaha to Kansas City	.93	.85
Kansas City to Mississippi River	.95	.92
Ohio	.91	.88
Tennessee	.97	.97

1/ The Gulf Intracoastal Waterway ratios were assumed to be the same as for the section of the Mississippi River at the Gulf, as adequate data were not published to compute ratios.

2/ Information to compute the ratios for the Columbia River was furnished by Paul Light of Pacific Inland Navigation Company, Incorporated.

Appendix table 15--Rail, highway, and straight-line mileage ratios

Straight-line mileage block	Ratio of rail short-line to straight-line miles	Ratio of highway miles to straight-line miles	Ratio of rail short-line to highway miles
50-99	1.32	1.26	1.05
100-199	1.27	1.27	1.00
200-299	1.26	1.26	1.00
300-499	1.24	1.23	1.01
500-699	1.24	1.21	1.02
700-999	1.22	1.20	1.02
1,000-1,299	1.20	1.19	1.01
1,300-1,499	1.25	1.16	1.08
1,500-1,799	1.26	1.20	1.05
1,800-1,999	1.24	1.20	1.03
2,000 or more	1.23	1.20	1.03

Source: (5, p. 6).

END