POSSIBLE EFFECTS OF A COST-OF-SERVICE TRANSPORTATION RATE STRUCTURE ON THE UNITED STATES GRAIN MARKETING SYSTEM

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PREFACE

The purpose of this study was to analyze the effects of a cost-of-service transportation rate structure on the United States grain marketing system. Cost of transportation services for trucks, rails, and barges were developed and used as input data in a mathematical model of the system using linear programming procedures which determined simultaneously the geographical flows of wheat, feed grain, soybeans, and wheat flour such that the total cost of storage, assembly, milling, and distribution, for the system was minimized. These results were compared with the results from use of existing transportation rates.

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CHAPTER I

INTRODUCTION

The 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. The transportation system and transportation rates have had and continue to have an important role in determining the location of facilities and the competitive position of firms in the grain marketing system.

At the turn of the twentieth century, grain was grown on comparatively small farms. Horses were the main source of farm power, including the source of power for the prime mover of grain, the wagon, to the market. Farmers had little choice as to the point of first sale of their grain because of the transportation situation. Small grain elevators dotted the farmland along railroads, providing convenient points of first collection. Most corn was picked by hand and stored on the farm to be fed to livestock on the farm. Soybeans were not grown commercially and combine type grain sorghums had not yet been developed. Wheat, oats, and barley were cut and stacked or shocked and later threshed, usually by a custom operated threshing machine in the fall or winter. Under these conditions, grain entered the commercial market channels over an extended period of time at a leisurely pace.

Flour mills had come westward before the turn of the century with the development of the railroads. The Western railroads enticed the mills westward with choice sites and favorable freight rates. The latter inducement developed into a general practice of hauling flour and wheat at the same rate. Such a parity rate policy amounted to a 27 percent freight charge advantage for the Western mills shipping flour to the East since the millfeed portion of milling operations was discarded as a waste product in those days.

Transportation charge advantages and technological break-throughs in milling hard wheat gave the newer mid-continent mills superiority in economies of size and firmly established the flour milling industry in mid-America near the production of wheat before the turn of the century, limiting the milling industry of eastern and southeastern states to local markets. The transit rate system which permitted interim stops to unload, inspect, mill and store grain, and provided prosperity for the mid-America mills, lasted until the 1950's, nearly a half century.

With increased utilization of machine power in agricultural production, farms became larger, production increased, and harvesting periods were greatly reduced. These factors called for changes in the storage and handling of grain. Likewise, the development of a road network and trucking industry, and the rebirth of inland water transportation presented competition for the first time to the railroads for transportation of grain and mill products.

Historical Development of Grain Rate Structure After Regulation

Before 1887, the railroads had notoriously abused their monopoly power. Rebates, special privileges, and favoritism were the order of the day. In 1887, the Act to Regulate Commerce was enacted, or as it is now known, the Interstate Commerce Act. This act was a formulation of the common law aimed at monopoly abuses. There were six principle sections, each dealing with a different phase or abuse of monopoly power.

The Interstate Commerce Commission established by the act was to hear complaints of alleged violations and could issue cease and desist orders based on its findings. Investigative powers into business operations were also vested in this commission. The commission was to prescribe a uniform system of accounts and make annual reports to Congress as well as require annual reports of the carriers.

In 1903, the act was strengthened by the Elkins Act. In 1906, the Hepburn Act gave the Commission power to prescribe maximum rates.

The Hoch-Smith resolution of 1925 directed the Commission (ICC) to investigate and revise the carriers' (railroads) rate structures to promote freedom of movement of agricultural products. This investigation resulted in a rate structure for grain unlike any other rate structure. A rate break plan of proportional rates was instigated to equalize gateways, thus permitting grain to move through one of several rate break points or gateways on equal rates to a given final destination.[1]

The the 1930's the trucking industry was developing and had begun to give the railroads competition for movements of grain. This resulted in a see-saw rate-cutting battle for traffic, which ended up with the passage of the Motor Carrier Act of 1935, or Part II of the Interstate Commerce Act to regulate motor carriers. Up to this time motor carriers had been unregulated. This act made certain classes of motor transportation exempt from regulation. More specifically, truck-hauled unmanufactured agricultural commodities were exempted from regulation.

This meant that wheat could be hauled exempt by trucks, but flour now came under regulation.

With the passing of time, the development of bigger trucks, extended and improved highways, and improved inland waterways, the stable transportation situation of the millers began to erode.

With the financial crisis of the railroads becoming more evident by early 1938, the government became more active in the "transportation problem." And by September, 1940, the Congress had passed and the President signed the Transportation Act of 1940, or Part III of the Interstate Commerce Act. Part III of the Interstate Commerce Act provided for regulation of common and contract water carriers on the inland waterways, coasts, intercoastal and Greak Lakes. As with the motor carriers, Congress exempted certain classes of traffic from regulation--this time bulk commodities, as long as not more than three bulk commodities were hauled in one vessel. A single vessel was defined to be "two or more vessels while navigated as a unit."[2]

With the addition of water carriers to the jurisdiction of ICC regulation, grain became a commodity which came under regulation if transported by rails, exempt if by trucks, and either exempt or regulated if transported by water, depending upon the cargo of the vessel.

After World War II, the railroads were in a state of disrepair and needed much capital for improvements of the system. Between January 1, 1947, and February 1, 1958, railway freight rates received six permanent increases. This doubled the pre-war, March 1938, level of rail rates on grain and grain products.[3] In many instances these rates surpassed truck and water rates. Consequently, the rails lost traffic. By 1952, 76 amendments and amendatory acts affecting the Interstate Commerce Act had been enacted.

In 1955, a Presidential Advisory Committee appraised Federal transportation policies and their administration in an attempt to redesign regulatory policies to make them more effective. This committee proposed that the Declaration of Policy in the Interstate Commerce Act be revised to put emphasis on transportation developments "under the free enterprise system of dynamic competition." Further, regarding rate making, the committee stated ". . .increased reliance on competitive forces in rate making constitutes the cornerstone of a modernized regulatory program."[4]

Export rail grain rate reductions began in September, 1957, from Oklahoma and Kansas origins and in May, 1958, from Oregon, Washington, and North Idaho origins.

In 1958, Congress drafted and passed the Transportation Act of 1958, using the 1955 Presidential Advisory Committee report as a guide. This act amended the Rule of Ratemaking, Section 15a (3) of the Interstate Commerce Act to read:

> In a proceeding involving competition between carriers of different modes of transportation subject to this act, the Commission, in determining whether a rate is lower than a reasonable minimum rate, shall consider the facts and circumstances attending the movement of the traffic by the carrier or carriers to which the rate is applicable. Rates of a carrier shall not be held up to a particular level to protect the traffic of any other mode of transportation, giving due consideration to the objectives of the national transportation policy declared by this act.

In June, 1961, the Southern Railway System announced its intention to make effective in August, 1961, drastically reduced rates on grain in multiple car lots (90 tons per car, 5 car minimum) from certain Mississippi and Ohio River crossings to 37 specified destinations in the southeast, using its new "Big John" covered aluminum hopper cars. In addition rates for 900 tons (10 cars) and 1800 tons (20 cars) would be published to be 10 and 20 cents lower per ton respectively than the 450 ton (5 car) shipments. These rates which did not allow transit were generally 60 percent below those on individual box car movements. The railroad argued that the larger equipment would lower their unit costs. This case was appealed to the Supreme Court, returned to the district court, and reconsidered by the ICC.

On October 22, 1965, the proceeding came to an end with Southern's 450 ton (5 car) rate being determined "just and reasonable." In the meantime, Southern withdrew its other multiple-car rate proposals. Single car rates, minimum 90 tons per car, were also found "just and reasonable" at 120 percent of the 450-ton rate per hundredweight.

With these new rates, the grain industry had a new technology for a new service including a new method of operation and a new concept of pricing that was related to the greatly lowered costs of the new technology.

This was only the beginning of changes in grain rate making. In December, 1963, announcement and publication of a "Unit-Train Wheat Tariff" by the Soo Line Railroad was made--the first tariff of its kind in America railway transportation of grain. This tariff was for a minimum shipment of 4950 tons with 55 tons per car minimum from Duluth-Superior or the Twin Cities to Buffalo (via Chicago) provided that tender be on one bill of loading, one day, from one consignor at one location or origin, to a single consignee at one location at one destination, where all cars must be completely unloaded. Twenty-four hours free time were provided for loading or unloading. A charge of $475 would be assessed for each 24-hour period or fraction thereof if the cars were not tendered within the free-time period. Other railroads followed the Soo Line and published identical tariffs. These tariffs were opposed by special interest groups, but were affirmed with only minor modifications in May, 1965.

Another significant modification of the grain-rate structure occured when the so-called inverse rate structure on export wheat at North Pacific ports from the hard red spring wheat production area became effective in June, 1965.

Further innovation in grain transportation was inaugurated in November, 1968, when Cargill, Inc. launched "Rent-A-Train" or RAT. With this arrangement, the railroad supplies the power unit, caboose, and crew for a specified period of time for a contracted price. The shipper or carrier may supply the cars, depending upon the contract. Once the train is rented, the shipper moves the train any place on the carrier's line for an agreed upon price per train-mile or price per ton-mile.

The Problem Setting

The current rail financial crisis has created much concern in our government as to actions which should be taken to prevent deterioration of our transportation system. One alternative which has been suggested is deregulation.

The President's Council of Economic Advisors in its annual report sent to Congress February 1, 1971, in a section entitled "Transportation," said:[5]

> The development of the transportation industry under regulation suggests that the public as well as large sections of the industry would be well served by relying more on the forces of competition. . . .By frustrating this potential for competition, regulation appears to have promoted high freight rates and number inefficiences, and in the long run to have weakened firms financially.

The grain transportation rate structure revolution which started in the 1960's will continue in accordance with technological advancements if all rates charged by each mode are based on the cost of providing the particular transportation service required and each mode provides the service where it has a particular advantage.

Such an evolution of rates will 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 due to lags in adjustments by carriers operating in other geographical areas. Others will be longer lasting.

Changes in transportation rates affect not only the short-run flow pattern, but more importantly the long-run structural pattern of markets. Changes in direction of grain flow can be dictated on short notice, but once capital is sunk in a plant at a given location, it is difficult, if not impossible to recoup losses when there is an unfavorable transportation rate change.

Uncertainty concerning future rate structures will have a dampening effect upon investments in new facilities having high fixed costs, and upon relocation of existing facilities.

Objectives of the Study

The purpose of this study is to evaluate the interregional aspects and competitive structure of the grain marketing industry under a cost-of-service transportation rate structure. This study will provide information for decision-making and planning to firms marketing, transporting, and processing grains and flour, and to policymakers.

A study of the U. S. grain marketing system recently completed by Leath,[6] employing existing transportation rates, ascertained the optimum flows of feed grains and wheat and the optimum regional storage requirements. Further, by including the flour milling industry under competitive conditions, optimum milling capacities and flour flows were also determined.

A need exists to further these efforts by employing cost-of-service transportation charges to study the possible changes in the optimum regional storage requirements and optimum regional flour milling capacities as a result of such a rate structure.

Costs incurred by rail, truck, and barge carriers for providing grain and flour transportation services have been developed in this study in an attempt to depict resulting spatial relationships associated with such a rate structure. An attempt has been made to include the regional differences in costs to rail and truck carriers. Also, for barge operations, differences in costs of operation on different waterways and segments of these waterways have been included.

The specific objectives of the study were to:

(1) Develop regional costs of transportation service to the carrier by mode, i.e., rail, barge, and truck for grains and for flour.

(2) Determine distribution patterns of grains and flour which will minimize the total cost of storage, acquisition, processing, and distribution for the U. S. grain marketing system, with existing market

structure, competitive conditions, and transportation costs from (1).

(3) Compare the distribution patterns of (2) with those resulting when existing transportation rates were used.

(4) Determine intermarket and shipping point price relationships for grain by computing equilibrium price differentials between major markets and shipping points and evaluating the competitive position of various production and consumption regions under the conditions of (2).

(5) Determine the competitive position of flour mills in various regions and estimate the savings that would result from a reallocation of milling capacity among the regions consistent with cost-of-service transportation charges.

(6) Estimate the social cost of the existing grain transportation rate structure.

FOOTNOTES

[1]To define terms, rate-break points or markets were designated as Minneapolis and Duluth, Minnesota, and the Missouri River markets from Sioux City, Iowa south to Kansas City, Missouri. A gateway is a point at which freight moving from one rail territory to another is interchanged between transportation lines.

[2]See Section 303, Paragraph B, Part III of the Interstate Commerce Act for a more detailed specification of the exemption.

[3]Edmund A. Nightingale, "Some Effects of Recent Changes in the Railway Grain-Rate Structure on Interregional Competition and Regional Development" in Transportation Problems and Policies in the Trans-Missouri West, edited by Jack R. Davidson and Howard W. Ottoson, University of Nebraska Press, Lincoln, 1967.

[4]See "Transportation in Agricultural Marketing" In Agricultural Markets in Change, U. S. Department of Agriculture, Agricultural Economics Report No. 95, Washington, D.C., July, 1966, p. 91.

[5]See American Waterway Operators, Inc., Weekly Letter (Washington, February 6, 1971), pp. 2-3.

[6]Mack N. Leath, An Interregional Analysis of the United States Grain Marketing Industry (Unpublished Ph.D. dissertation, Oklahoma State University, May, 1970). (Note: A publication is soon to be released.)

CHAPTER II

THEORETICAL CONSIDERATIONS

In spite of the obvious importance of the economics of transportation in relation to the transportation rate-making process and the consequent effects upon the results of locational analysis in which those rates are a major ingredient, there has been inadequate and negligible consideration of these aspects in the literature which deals with location economics and theory. The practice has been to accept uncritically the structure of transportation rates as given data. The consequence is unfortunate, for such practice permits the creation of a formidable structure of locational organization upon a transportation rate foundation that may be irrational, arbitrary, insecure, and temporary. The merging of location and transportation economics would permit evaluations of locational consequences to pay a vital role in the rate-making processes, and should thereby reinforce the economic validity both of the transportation rate structure and of the locational determinations. As in other applications of theoretical analysis, the discrepancy between reality and the theoretical ideals and conveniences is recognized, but it is believed that a sufficiently close approximation to reality would be achieved to make efforts to merge location and transportation economics of probable practical value.

The problem considered in this study is embodied in location theory and marginal pricing of transportation services. This chapter will review the more important contributions to location theory and give a brief review of marginal pricing of transportation services. The purpose of this presentation is to provide a theoretical framework for formulation and analysis of the problem. It will also aid in understanding the general nature of and the importance of the transportation rate structure to the location problem.

Location Theory

The problem of location analysis usually comes under one of two categories. Been has called these "Category I -- Adaptation of the Location," and "Category II -- Adaptation to the Location."[1] In the first category, location of an enterprise itself is variable and the optimum location is desired in order to maximize profits with respect to fixed markets. A more descriptive term then might be the "fixed market" approach. The second category is a situation involving a fixed location of the economic decision unit. To maximize profits the firm or industry must make decisions considering the relative location of economic units with which it must trade, or perhaps more definitive, the "market area" problem.

A practical German farm owner and operator, Johann Heinrich von Thunen, is the undisputed founder of the economic theory of location.[2] His first publication, "The Isolated State," appeared in 1826.[3] The setting of his problem in an English paraphrase by Been is:[4]

> Suppose there is a very large city located at the center of a fertile plain, traversed by a navigable stream or canal. The plain itself consists of uniform soil, capable of cultivation everywhere. At a considerable distance from the city, the plain ends in an uncultivated wilderness which completely separates this city from the rest of the world.

Then continuing, a statement of the problem:[5]

> Now, the following question occurs: How would agricultural activities be organized in relation to these assumed circumstances, and, in particular, how would the agricultural production be affected by its greater or smaller distance from the city?

The last phrase of the above statement points out that tranportation costs were the key variable in von Thunen's analysis. It is interesting to note that von Thunen used two grains, corn and rye, as referents to gauge the effects of transportation cost.[6] Further, he used a non-linear cost function in terms of distance in computing his transportation costs.[7] Von Thunen also demonstrated an understanding of the concept of minimizing combined land-water transportation costs plus transfer charges.[8]

The net farm price of a product was the gross city price minus transportation costs. Combining the price gradients with known production costs the choice of production was determined, resulting in a series of concentric rings.

Although von Thunen's theory in itself is not adequate for this study, it has provided the foundation on which the economic theory of location has been developed.

Launhardt, a German professor of engineering, in his two contributions to location theory in 1882[9] and 1885,[10] recognized the work of von Thunen. These writings went unnoticed by economists until 1910. Possible explanations for the delay in recognition by economists are that Launhardt was an engineer and his works may not have been noticed or recognized among economists.[11] Another partial explanation is that his analyses were quite rigorous in mathematics and geometry at a time when these methods were not so well accepted in economic applications.[12]

The first paper which may be translated in title to mean "The Determination of the Optimum Location of a Business Enterprise"[13] was devoted to the point location of a plant or enterprise. Launhardt identifies a number of factors other than transportation costs which would influence given fixed point location. These factors were different prices for site acquisition, availability of source of power, inequalities in living conditions and worker's wages, the availability of a trained work force, and others.

Launhardt developed the three-point "classical theorem" of location theory, which many associate with Weber, but which Weber independently rediscovered 27 years later.[14] The method developed by Launhardt was entirely different and much more rigorous than that of Weber. Launhardt attempted to extend his method to more than three fixed points by successive application of his polar construction to groups of more than three points. This procedure was shown to be invalid by Weber[15] when the combined number of locations of raw materials and markets is greater than three.

A location related problem which is of particular interest in this study is a method of mathematical analysis pertaining to combined modes of transportation developed by Launhardt. This analysis is illustrated in Figure 1.

Assume that grain to be hauled to market is located at point A, the market at point C, and the main line, low-cost transportation route, is represented by the line BC=b distance. Let "a" represent the distance on the most direct connecting route from A to the lower cost route, BC. Let "h" represent the direct distance from A to C. Let " " be the transportation rate per mile from A to any point on BC and

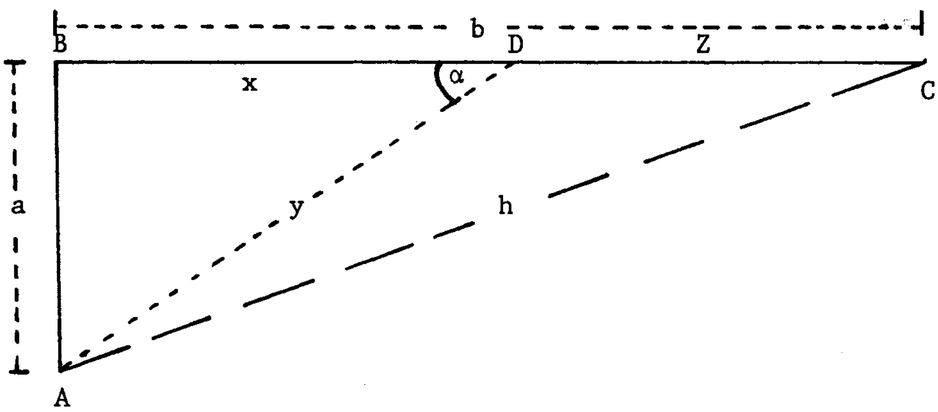

Figure 1. Launhardt's Cost Minimizing Formulation For A Combination of Transportation Modes

r_2 be the rate along BC, then the total cost of shipping directly from A to C may be represented by Equation (2.1).

$$TC_s = r_1\, h = r_1 \sqrt{a^2 + b^2} \qquad (2.1)$$

However, since $r_1 > r_2$, it is clear that this particular shipment would minimize the transportation costs of moving grain from A to C. In answering the question of how to ship, three factors must be considered: (1) the respective rates r_1 and r_2; (2) a reloading cost, R; and (3) minimum cost. Let the cost of moving using a combination of modes be represented by Equation (2.2).

$$TC_c = r_1\, y + r_2\, Z + R \qquad (2.2)$$

where Z - b - X distance.

In Equation (2.2), we may substitute for y and Z to yield Equation (2.3).

$$TC_c = r_1 \sqrt{a^2 + X^2} + r_2\, (b - X) + R \qquad (2.3)$$

or Equation (2.4).

$$TC_c = r_1 (a^2 + \chi^2)^{1/2} + r_2 b - r_2\chi + R. \qquad (2.4)$$

Since all terms are fixed in Equation (2.4) except χ , the value of χ that will minimize total cost can be found by setting the first derivative of that expression with respect to χ equal to zero. Then testing by setting the second derivative with respect to χ equal to zero. The result must be positive.

$$\frac{dTC}{d} = \frac{1}{2} r_1 (a^2 + \chi^2)^{-1/2} (2\chi) - r_2 = 0$$

$$= r_1 \frac{\chi}{\sqrt{a^2 + \chi^2}} - r_2 = 0$$

$$r_2 = \frac{r_1\chi}{\sqrt{a^2 + \quad 2}}$$

$$\frac{r_2}{r_1} = \frac{\chi}{\sqrt{a^2 + \quad 2}}$$

$$\frac{r_2}{r_1} = \cos \alpha \qquad (2.5)$$

Thus, the cost minimizing location for changing transport modes is that point D, where the cosine of angle   is equal to the ratio of the transportation rates. If we define

$$\frac{x}{y} = \frac{r_2}{r_1} \quad \text{or} \quad \chi = \frac{r_2}{r_1} y, \qquad (2.6)$$

$$\sin \alpha = \frac{a}{y} \quad \text{or} \quad y = \frac{a}{\sin \alpha}, \qquad (2.7)$$

Equation (2.2) may be rewritten by using the relationships (2.6) and (2.7) as

$$TC_c = r_1 \left(\frac{a}{\sin \alpha}\right) + r_2 \left[b - \frac{r_2}{r_1} y \right] + R \qquad (2.8)$$

By using Equations (2.1) and (2.8), the equation for the curve representing locations where the cost of the combined modes is equal to the cost of the single mode may be written as

$$TC_c = r_1 \left(\frac{a}{\sin \alpha}\right) + r_2 \quad b - \frac{r_2}{r_1} \left(\frac{a}{\sin \alpha}\right) \quad + R = r_1 \sqrt{a^2 + b^2}. \quad (2.9)$$

To find the point on line BC, where single and combined modes are equally costly (isocost), let a = 0 and rewrite Equation (2.9) as

$$r_1 b = r_2 b + R$$

$$b = \frac{R}{r_1 - r_2} . \qquad (2.10)$$

Equation (2.10) states that the distance from point C is equal to the reload cost divided by the difference of the two rates. If R = 0, the boundary described by Equation (2.9) will be a straight line through point C. If R ≠ 0, this boundary will not be a straight line, but arcs of circles as shown in Equation (2.1).

Launhardt also treated the transportation of commodities in one section of his book on mathematical principles of economies which appeared in 1885.[16] In one subsection, he establishes the sales areas of competing product sources. Initially, Launhardt's formulation of market competition involved two competitors, offering two different products which were made equivalent on the basis of utility, thus simulating the case of two competitors selling one product. Figure 2 depicts the Launhardt model. Let A and B denote the two supply points and P_A and P_B, the respective prices of the products at the two locations. Let f_A and f_B equal the respective freight rates per unit of weight per unit of distance. Then let point E be defined such that at distance χ from A and distance y from B, the local delivered prices

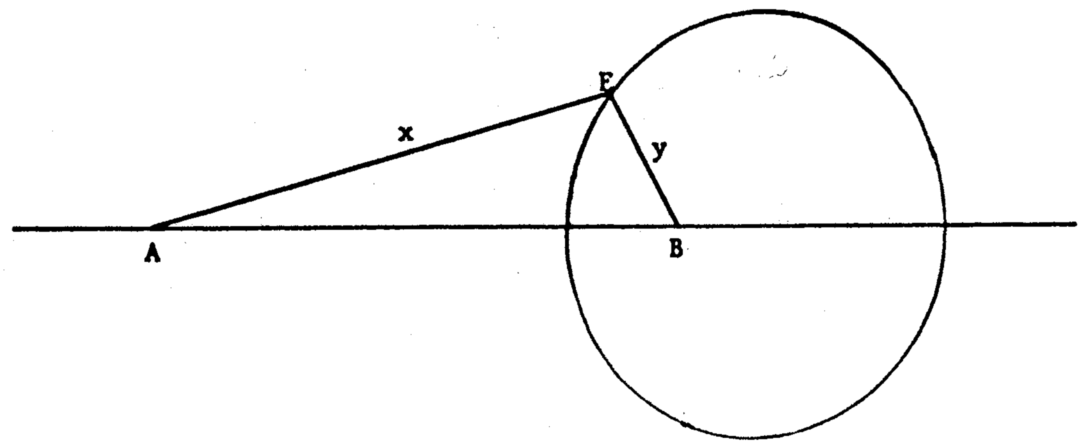

Figure 2. Launhardt's Closed Oval Boundary Between Market-Supply Areas of Two Competing Markets or Supply Areas

at E are the same, that is,

$$P_A + f_A \quad = P_B + f_B\, y. \tag{2.11}$$

The closed oval in Figure 2 then is the locus of all such points satisfying Equation (2.11). According to Launhardt, the oval encloses the market sales region of the "inferior" product, or in other words the product with the lower value to weight ratio and a steeper transportation cost gradient.[17] The diameter of the contour through points A and B was calculated in terms of freight rates, the product prices at the respective product sources, and the distance AB. That diameter was called the "minor axis" of the "ellipse," but did not demonstrate that that axis would necessarily be the minor axis.

Launhardt pointed out three special cases. One, when two supply prices, P_A and P_B, were equal at their source that the curved boundary would become a circle. Two, when the freight rates f_A and f_B were equal, that a closed curve market boundary would no longer be defined, but a hyperbola, with its concave side toward the higher-priced source. For supply regions the concave side would be toward the lower priced market. The third case, a combination of the above two, that is, when both the respective prices and freight rates were equal the market boundary would become a perpendicular bisector of the line joining the two sources, A and B.[18]

In the case of many sellers having equal production costs, Launhardt proved mathematically that hexagonal economic regions would develop with the seller located at the center.[19]

The influence of transportation costs upon exports and imports of a market and its supply region were also treated by Launhardt. Figure 3 illustrates Launhardt's development. The horizontal axis is the yield per unit of land, let us say, an acre. In Section A of the figure, the vertical axis represents the unit price of the product, X. The vertical axis in Section B represents the revenue per acre. Thus, Section A is the price-yield relationship and Section B is the total revenue function of yield. For the yield range OE, the product yield is not sufficient to meet the demand of the market, thus the market is satisfied by importing at the price of EP_1. But, as yield increases from OE to OA, the region can supply total market requirements. As the market supply increases, the price declines from EP_1 until it reaches the export price of AP_2, at yields of OA or more. For yields greater than OA, the region can export at price AP_2. Launhardt concluded from this analysis that more efficient and thus lower-cost transportation facilities would narrow the export-import price spread, and would shorten the yield range of self sufficiency, EA, as the region would

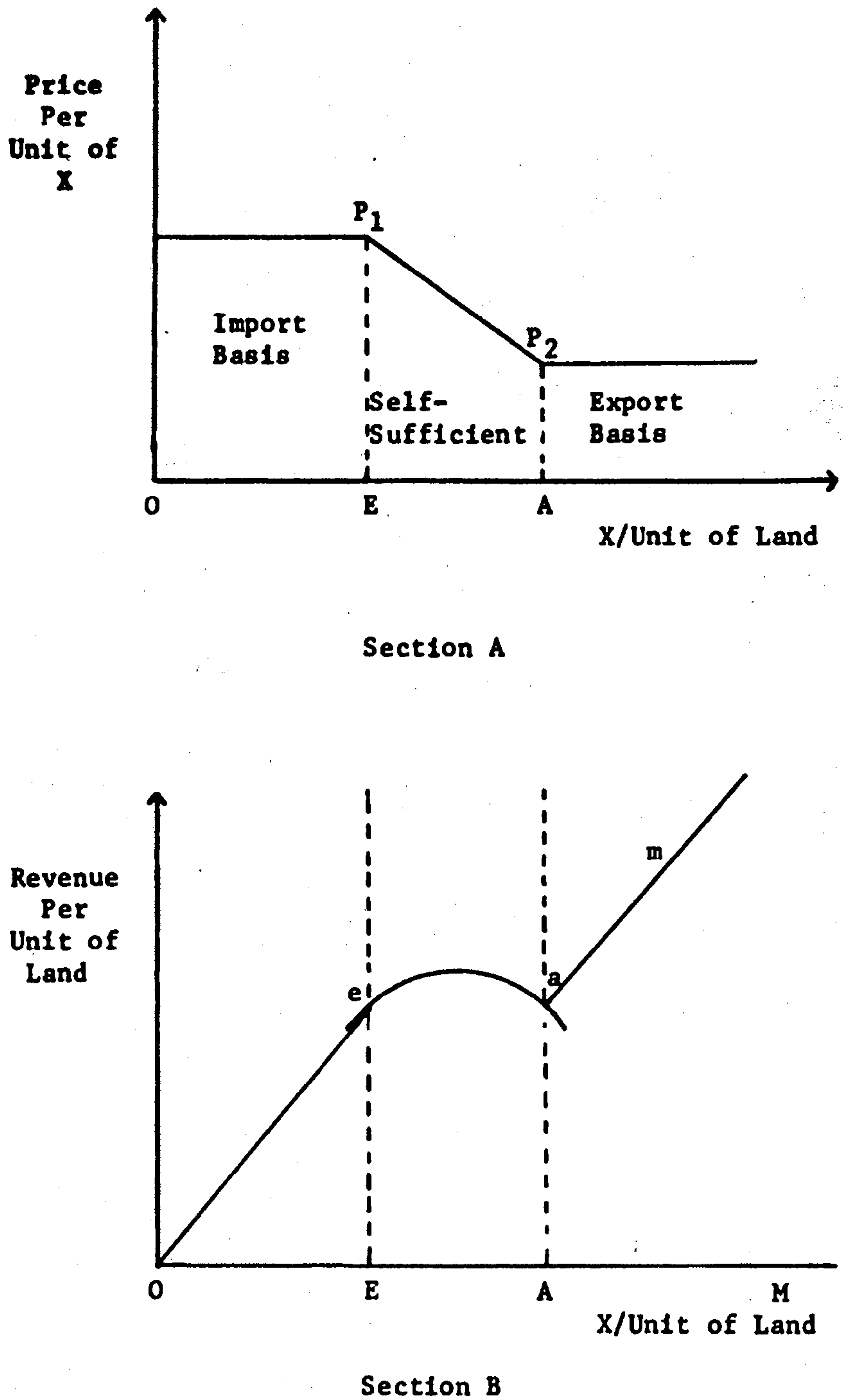

Figure 3. Launhardt's Yield Variations Related to Imports and Exports

come under the influence of interregional markets. Another consequence would be an increased variability of total revenue and net revenue of the landowner when the range of comparatively stable yield, EA in the lower diagram, is narrowed.

Launhardt can be credited with speaking to both the fixed market and market area problems of location theory, but he did not bring the two together.

Weber wrote about many of the same subjects in the "fixed markets" theory as did Launhardt. Weber's was the first attempt, though, of a systematic and comprehensive treatment of economic location as it affected the point location of a plant or industry. Weber extended the analysis of Launhardt beyond the transportation orientation to include the effects of labor costs and "agglomeration."[20] He assumed that labor was geographically fixed and the supply at a particular location was perfectly elastic. Thus, with fixed supply points and market locations, Weber sought to determine the location of processing enterprises such that the total transportation costs of materials and finished materials plus labor costs of processing would be minimized.

The analyses of von Thunen, Launhardt, and Weber never extended beyond that of a partial equilibrium approach. It is Losch who is generally recognized as the first writer to present a general equilibrium system incorporating the interrelationships of all locations. His formulation is an interesting intellectual exercise. He was quite creative, but his creativity was often in the form of abstract theoretical concepts which were not always adaptable to applied analysis.

Losch is critical of Weber's analysis, criticizing the emphasis on costs and the neglect of demand and price. Much of Losch's work concerns patterns of grouping and clustering of population and other aggregations, using numerous illustrations which rely on the data of economic geography.

Perhaps the greatest contribution of the above mentioned writers and others such as Palander,[21] Fetter,[22] and Hoover[23] was in calling attention to the influence of transportation costs upon the location of economic activity even though many of the so-called real world transportation factors were not considered in their analyses.

Of the more recent writers on location theory, Isard is the single writer who has attempted to bring all the theories together as he has stated about his work, Location and Space Economy:[24]

> It derives a general location principle through rederiving to common simple terms the basic elements of the diverse location theories embodied in the works of von Thunen, Launhardt, Weber, Predohl, Ohlin, Palander, Losch, Dunn, and others. Thereby it seeks to synthesize the separate location theories into one general doctrine, and, where possible, to fuse the resulting doctrine with existing production, price, and trade theory.

This general theory is not too useful in handling real-world problems as admitted by Isard, but neither was this his objective.[25] However, Isard's analysis incorporates terminal and loading charges and allows incorporation of different transportation rates for raw materials and finished products. This is a very important consideration for industries such as the flour milling industry where the rate structure is evolving toward a cost-of-service basis.

This study does not use location theory which may be attributed to any single author discussed in this Chapter, but uses concepts from several authors to provide a theoretical framework. Perhaps like many of the writers after von Thunen, Launhardt, and Weber, the analyses of this study rely most heavily on their early developments of the theory.

Transportation Pricing

Inefficient allocation within the transportation sector of the economy encourages misallocation in other producer sectors as can be analyzed applying the principles of location theory developed by the writers discussed above. Actually, the costs of misallocation in transportation itself may be only a small part of the total costs of misallocation. Viewing this allocation overall, it can result in wrong commodities, produced in wrong places, by wrong firms, being hauled by wrong carriers, over wrong routes, to wrong destinations.

The importance of the transportation system to the grain industry can be illustrated by considering transportation's contribution to the value of grain. Transportation charges accounted for an average of 10 percent of the value of wheat received by rail at Minneapolis, Kansas City, Portland, and St. Louis during 1959.[26] The comparable figure for corn received by rail at Chicago was 12 percent. The magnitude of these data make it apparent that inefficiences in the transportation system which could produce a non-optimal shipment pattern for the U.S. grain marketing system can result in a sizable increase in the total costs of marketing grain. Thus, it becomes evident that transportation costs are an important consideration in location. Further, the theory of transportation pricing is important to this study because it provides a theoretical framework for developing the underlying transportation costs which are used in applying location theory.

Chapter I discussed the historical development of the grain rate structure. During the period of development of the grain rate structure, the goals of the country were settling in the West, building an industrial economy, and exploiting our abundant natural resources. The need then was not so much for low-cost transportation, but for abundant, low-priced transportation. The policy was such that the goals and needs were met.

The remainder of this chapter will discuss the concept of "value-of-service" or demand - oriented transportation pricing compared with cost-of-service pricing. The former was justified as a developmental tool in the "Pioneer Days" of the West while cost-of-service pricing more nearly meets the need of today's environment.

The value-of-service of a movement is quite different from, and not necessarily related to, the cost of performing the service. There are two aspects of value-of-service pricing. One, it implies that if the transportation service value is high to the user, the price can and will be high. But, (2) it likewise implies that if the evaluation of the service by the user is low, the price must necessarily also be low. Carried to its conclusion, illogical at that, value-of-service rate-making would mean that movements of zero value could occur at negative rates.

Many unmeasurable and changing factors affect the actual value of service of a movement, even to a particular shipper. Under a system of "pure" value-of-service ratemaking, different rates might be required for every shipper of every given commodity between given points, and perhaps even different rates for successive shipments of the same commodity by the same shipper. Thus, administratively, such a system is impossible. In economic terms, such a system is nonsensical since a rate, which must be set by some averaging process for some estimated volume of traffic, apparently determines whether any given movement occurs.

Value-of-service pricing implies that judgments must be made regarding the value of a particular service. A system of pricing based on the value of service, then, may be discriminatory due to the very nature of value determination, leading to regulation to prevent unreasonable preferences or advantages to particular carriers, shippers, regions, or commodity groups.

The Interstate Commerce Act prohibits carriers from giving undue or unreasonable preference or advantage, subjecting others to undue or unreasonable prejudice or disadvantage.[27] Not only is preference and prejudice prohibited as to persons and corporations, but also as to associations, localities, ports or port districts, gateways, transit points, regions, territories or any particular description of traffic. Dissimilar competitive conditions may be considered to justify a difference in rates as well as might different services provided such as transit or higher minimum weights. Explanation of the Interstate Commerce Commission's[28] restriction to competitive situations is to be found in the ICC's view that discrimination among commodities is beneficial, not merely to the shipper in whose favor the discrimination is practiced, but also to the shipper against whom it is directed, provided merely that the shippers do not compete with one another. This was the doctrine that served to justify the ICC's active support of discriminatory rate structures in the past.

In reality, value of service establishes a ceiling for rates and cost of service establishes a rate floor. Between the floor and the ceiling is the "Zone of Reasonableness" within which actual rates are set.[29] The Zone of Reasonableness leads to indeterminate results rather than toward purposeful goals. It is a legal concept and has no meaning in economic theory.

Wilson makes a concise statement to justify discriminatory pricing of transportation services among commodities.[30]

> In the case of railway pricing. . .the shippers paying the relatively higher rates are not, in reality, injured because if lower rates were not charged on some commodities their contributions to the overhead costs would disappear and an even greater proportion of the fixed costs would have to be recovered from the now higher rated commodities. Value-of-service pricing. . .therefore, leads to lower rates on all commodities than would be the case if some form of discrimination were not practiced.

Locklin states rather explicity:[31]

> . . .the implication that the low rates on some traffic means that other traffic must be charged more than it otherwise would have been is entirely erroneous. If the distinction between constant and variable expenses has been fully grasped, it will be apparent that preferential rates relieve rather than increase the burden on other traffic if two conditions are fulfilled. These are (1) that the rate must more than cover the direct costs and (2) that the traffic will not move at higher rates. When these conditions are fulfilled, preferential rates are of benefit to all concerned.

The Wilson-Locklin justification can be depicted by a simple model. First, make the following simplifying assumptions: (1) there is a single railroad (or if more than one railroad, they are in overt or tacit collusion) operating between two terminals; (2) two commodities, wheat and coal, are transported; (3) wheat and coal have different elasticities of demand for transport and their cross-elasticities are zero; (4) the marginal cost of transportation within the relevant region is constant and marginal cost equals average variable cost; (5) the marginal costs of transporting wheat and coal are identical; and (6) "reasonable" earnings (determined by the regulatory authority), are less than the returns which could be earned by a discriminating monopolist. Graphically the model is shown in Figure 4.

In Figure 4, AR_w and AR_c represent the respective average revenue curves for wheat and coal. MR_w and MR_c are the marginal revenue curves derived from the average revenue curves. The MC curve represents the marginal cost curve.

The profit maximizing rates for transportation of wheat and coal are represented by WO and CO, respectively. With no regulation to limit net earnings, wheat shippers would benefit from a rule against discriminatory pricing, since the non-discriminatory monopoly price (equating MC with the summation of MR_w and MR_c) would be somewhere between WO and CO. Now assume that the regulatory authority determines that total revenue, GHMJ, provides reasonable earnings for the carriers (equating total revenue with total costs). Total costs, TC, equals total variable cost, TVC = NHML, plus total fixed cost, TFC = GNLJ. Even though a nondiscriminatory rate of 10 would result in revenues covering total costs, 10 is too high to maximize the quasi-rent

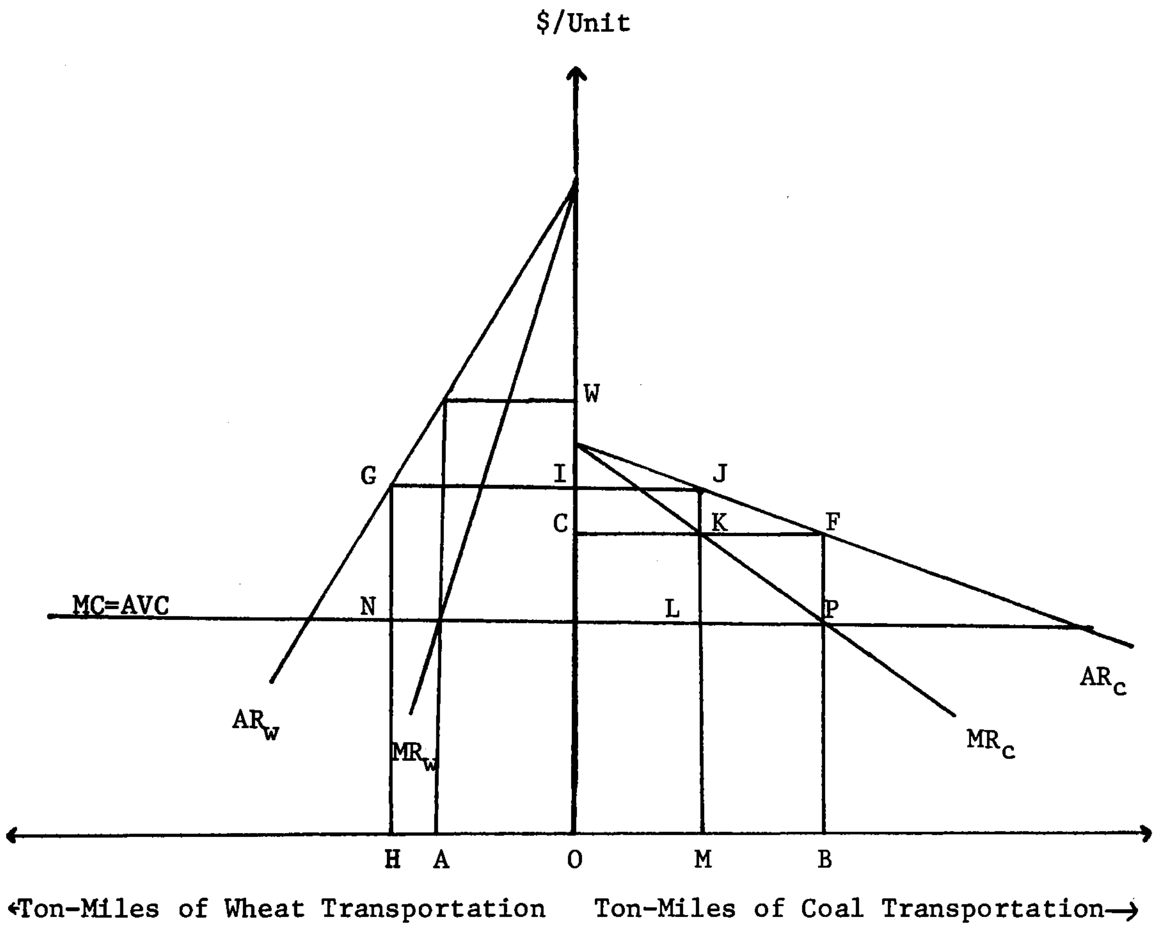

Figure 4. The Traditional Rationale for Commodity Discrimination

from the transportation of coal. Thus, decreasing the coal rate from IO to CO will reduce the net revenue which must be obtained from wheat transportation by KLPF minus ICKJ.

Assuming that the Interstate Commerce Commission is effective in controlling the general level of freight rates, it would seem that the above rationale would be valid only in either of two cases. The one case would be that railroads have assets which are infinitely durable, thus never allowing excess capacity to cease, with short-run marginal cost lying continuously below short-run average cost. The second case would depend on rate flexibility, so that preferred rates existing with excess capacity would rise to equal long-run marginal cost once excess capacity disappeared.

As excess capacity is eliminated, short-run marginal cost will approach long-run marginal cost. A rate structure in which the least profitable rates cover little more than short-run marginal costs when considerable excess capacity exists, would be incapable of benefitting those paying discriminatory rates, once the excess capacity disappeared. And as for flexibility of rates to validate the traditional rationale, rate structures have never exhibited this flexibility.[32]

Economic theory tells us that for such a practice to be successful, monopoly elements must exist to enable subsidication of low-valued commodities by high-valued commodities. But, the pricing mechanism does not recognize restraints which permit such signals. Rather than monopolistic elements contributing to the success of this practice, one must only recall the objective of Congress and the Interstate Commerce Commission "to encourage the largest practicable exchange of products between different sections of our country. . . by placing upon the higher classes of freight some shares of the burden that. . .if service alone were considered, would fall upon those of less value."[33]

We have established that supply-oriented pricing of transportation services, or cost-of-service, is more compatible with goals of efficient resource allocation. The question is raised, "What is cost-of-service?" There has been much debate on this question since the railroads' profit squeeze following World War II. This debate was stirred when Hotelling published his argument for marginal cost pricing.[34] Prior to that time (1938-1939), the Interstate Commerce Commission only gave "lip service" to cost-of-service pricing[35] and professional economists as a group had not really become concerned about railroad pricing. As a result many definitions of cost-of-service transportation were espoused by commentators on transportation pricing. Such terms as "fully distributed cost,"[36] "out-of-pocket-cost,"[37] "fully allocated cost," "average cost," "average variable cost," "long-run marginal cost," "short-run marginal cost," and others have appeared. Not all of these terms are fully clear and mutually understood.

Judging the differences in definition of terms in light of economic theory, there are economists who advocate short-run marginal cost pricing[38] and those who support long-run marginal cost pricing.[39]

By definition, in the long run all fixed costs disappear and all costs become variable. Therefore, this means that long-run efficiency must be measured by "full" costs rather than "less-than-full" costs.

Sampson reviews three principal arguments which are advanced against long-run marginal cost pricing.[40] They are (1) the traffic and production disruption argument, (2) the deficit pricing contribution argument, and (3) the impossibility argument.

The traffic and production disruption argument contends that long-run marginal cost pricing would lead to some total reduction in traffic volume, which may or may not be true, and would favor modes and locations. But, economic theory says that if the traffic cannot pay its way, it should not move. Also, those carriers who cannot move particular traffic profitably should not attempt to move it, and producers who require subsidies in the form of less-than-cost rates should change their location or occupation. There is no such thing as a neutral freight rate, rate structure, or rate change in economic theory. The process by which resources are efficiently allocated under competition sometimes is harsh to individuals. Thus, for certain goals of society to be accomplished, for example, national defense, economic theory may not be the appropriate guide.

The deficit pricing[41] contribution argument simply points out that in some situations, short-run considerations will improve utilization and increase net revenue. Marginal cost theory is not in disagreement with this, but proponents of long-run marginal cost pricing argue that when capacity is adjusted to demand for transportation services, short-run marginal cost will be equal to long-run marginal cost. If output fluctuates around the least-cost combination, short-run marginal cost is subject to rather wide variations, thus it would appear that long-run marginal costs would provide the more stable rates.

Finally, the impossibility argument is concerned with the impossibility of determining long-run marginal costs because of the common or joint costs of the service. This would appear to be an accounting or cost finding problem and not one of economics.

The ultimate result of long-run marginal cost pricing would be a more efficient economy, and more efficient and more profitable carriers within all modes of transportation.

FOOTNOTES

[1]Richard O. Been, _A Reconstruction of the Classical Theory of Location_, (Unpublished Ph.D. dissertation, University of California, 1965), pp. 5-6.

[2]Been, page 19.

[3]Ibid.

[4]Ibid, p. 22.

[5]Ibid.

[6]Ibid, p. 26.

[7]The function was of the general form, t(r) = A r/(1+Br), where t(r) is the rate, t, as a function of distance, r,; and A and B are positive constants. See Been, pp. 20, 137.

[8]Been, p. 24.

[9]Cf. Been, p. 40. "Die Bestimmung des wackmassigsten Standortes einer gewerblichen Anlage," _Zeitschrift des Vereines Deutscher Ingenieure_, Band 26, Heft 3 (March, 1882), pp. 105 - 116.

[10]Cf. Been, p. 40: _Mathematische Begrundung der Volkwirtschaftslchre_.

[11]Been, p. 39.

[12]Ibid.

[13]Ibid, p. 40.

[14]Ibid, p. 44.

[15]Alfred Weber, _Theory of the Location of Industries_, tr. Carl J. Frederick (Chicago, 1929), pp. 238 - 239.

[16]See Been, p. 41, for a discussion.

[17]See Been, pp. 58 - 71, for his thorough discussion of Launhardt's market area developments.

[18]These points are similar in approach to the development by August A. Losch in The Economics of Location, tr. William H. Woglom. (New Haven, 1954), p. 105.

[19]Also see Losch, p. 110.

[20]Weber, p. 21, defined agglomeration to mean "to contract industry at certain points within" regions.

[21]Torde Palander, Beitrage zur Standortstheorie (Uppsala, 1935).

[22]Frank A. Fetter, "The Economic Law of Market Areas," Quarterly Journal of Economics, XXXVIII (1924).

[23]E. M. Hoover, The Location of Economics Activity (New York, (New York, 1948).

[24]Walter Isard, and associates, Methods of Regional Analysis: An Introduction to Regional Science (New York, 1960), p.i., pertaining to the volume by Walter Isard Location and Space-Economy (New York, 1956).

[25]Walter Isard, Location and Space Economy (New York, 1956), p. viii.

[26]Bruce H. Wright, "Transportation and the Grain Industry," Marketing Grain, Proceedings of the NCM-30 Grain Marketing Symposium, North Central Regional Research Publication No. 176 (Lafayette, January, 1968), p. 109.

[27]Interstate Commerce Act, Part I, Section 3(1), Part II, Section 216(d), Part III, Section 305(C), and Part IV, Section 404(b)(c), respectively, for railroads, motor carriers, barge lines, and freight forwarders.

[28]Further references in this study to the Interstate Commerce Commission will be referred to as the ICC.

[29]D. Philip Locklin, Economics of Transportation (6th ed., Homewood, 1966), Chapters 19, 20.

[30]George W. Wilson, Essays on Some Unsettled Questions in the Economics of Transportation (Foundation for Economic and Business Studies, Bloomington, Indiana, 1962), p. 161.

[31]Locklin, p. 150.

[32]John Richard Felton, "Commodity Rate Discrimination in Railroad Transport," Transportation Problems and Policies in the Trans-Missouri West, ed. Jack R. Davidson and Howard W. Ottoson (Lincoln, 1967), p. 59.

[33]Interstate Commerce Commission, Annual Report, 1887 (Washington, 1888), p. 36.

[34] Harold Hotelling, "The General Welfare in Relation to Problems of Taxation and of Railway and Utility Rates," Econometrica, VI (1938), and "The Relation of Prices to Marginal Costs in an Optimum System," Econometrica, VII (1939).

[35] Roy J. Sampson, "Transportation Pricing in the 1970's: A Move Toward Present Realities," in Conference Proceedings on Transportation: The 1970's. Upper Great Plains Transportation Institute Report No. 1 (Fargo, 1968), p. 20.

[36] See Interstate Commerce Commission, Bureau of Accounts, Railroad Carload Unit Costs of Territories for the Year 1962 (Washington, 1964), p. 4.

[37] Ibid.

[38] For a concise statement supporting short-run marginal cost pricing see William J. Baumol, et. al., "The Role of Cost in the Minimum Pricing of Railroad Services," The Journal of Business, XXXV (October, 1962), pp. 357-366.

[39] For a concise statement supporting long-run marginal cost pricing see Ray J. Sampson, "The Case for Full Cost Rate Making," I.C.C. Practitioner's Journal, XXXIII (March, 1966), pp. 490-495.

[40] Ibid.

[41] This is Sampson's definition of pricing which is less than long-run marginal cost, or by his definition, "full" cost.

CHAPTER III

THE MODEL

The geographical distribution of production and consumption of food and feed grains in the United States creates a complex interregional flow of grain and flour. This flow is not simply a physical movement of grain from surplus regions to deficit regions. Between the production and consumption activities, is the involvement of handling, storage, and processing activities. One of the analytical tools which allows study of the efficiency of these interregional flows is the transhipment model. The purpose of this chapter is to present the development of the transhipment model and its application in this study. Since the transhipment model may be formulated as a transportation problem or a linear programming problem, both problems will be discussed. Linear programming will be discussed first since the transportation model is a special case of the general linear programming model.

The Linear Programming Model

Linear programming was developed in the field of military logistics, particularly during World War II to minimize resource use and time in military efforts. Linear programming is entirely a mathematical technique to analyze problems in which a linear function of a number of variables is to be maximized (or minimized), subject to a number of restraints in the form of linear inequalities on those variables. Dantzig was the inventor of the simplex method, the first successful computational technique for solving problems stated in linear terms.[1] The simplex method was extended and varied by Dantzig,[2] Dorfman,[3] and Charnes, Cooper, and Henderson.[4] Economists and mathematicians have investigated many aspects of linear programming and made numerous applications of the technique.[5] Many applications of linear programming have been made in agriculture because of its flexibility and adaptability to different problem situations.[6]

Mathematically, we may define a linear programming maximization problem as:

$$\text{Maximize } Z = \sum C_j X_j, \qquad j = 1, 2, \ldots, n, \tag{3.1}$$

subject to the constraints,

$$\sum_{j=1}^{n} a_{2j} X_j \{\geq , = , \leq\} b_i, \qquad i = 1, 2 \ldots, m, \tag{3.2}$$

$$X_j \geq 0, \qquad j = 1, 2, \ldots, n, \tag{3.3}$$

where a_{ij}, b_i, and C_j are all assumed to be known constants. For each constraint, one and only one of the signs, $\geq$, = , $\leq$ holds, but may vary from one constraint to the next.

The basic assumptions associated with this model may be stated as follows:

(1) There is an objective to be maximized or minimized (Equation (3.1).

(2) All variables and constraints must be of linear form (Equations (3.1) and (3.2).

(3) The activities must be additive, Equation (3.2).

(4) The variables are nonnegative, Equation (3.3)

(5) The factors to be used are divisible, that is fractional units are possible.

Any set of X_j which satisfies the constraints is called a solution and any solution which satisfies the non-negative restriction is called a feasible solution. A feasible solution which maximizes (minimizes) the objective function is called an optimal feasible solution, the goal of solving a problem with the linear programming technique.

The General Transportation Model

The first application of linear programming in wide use was the transportation problem which has been widely discussed and thoroughly investigated.[7]

A mathematical definition of this model with an objective to minimize a linear function subject to certain linear restraints may be stated as follows:

$$\text{Minimize} \qquad C = \sum_i \sum_j C_{ij} \cdot X_{ij}, \qquad \begin{array}{l} i = 1, 2, \ldots, m, \\ j = 1, 2, \ldots, n, \end{array} \qquad (3.4)$$

subject to the constraints,

$$\sum_j X_{ij} = S_i \qquad (3.5)$$

$$\sum_i X_{ij} = R_j \qquad (3.6)$$

$$X_{ij} \geq 0 \tag{3.7}$$

$$\sum_i S_i = \sum_j R_j \tag{3.8}$$

where:

C is the cost of the operation,

m is the number of supply points,

n is the number of demand points,

S_i is the supply of a commodity at the i^{th} location,

R_j is the demand for the commodity at the j^{th} location,

C_{jj} is the transfer cost of the commodity from location i to location j,

X_{ij} is the quantity of the commodity shipped from S_i to R_j such that the cost of the operation is minimized.

A convenient representation of Equations (3.5), 3.6), and (3.8) is presented in Figure 5.

		Destinations				
		1	2	...	n	S_i
Origins	1	C_{11}	C_{12}	...	C_{1n}	S_1
	2	C_{21}	C_{22}	...	C_{2n}	S_2
	⋮	⋮	⋮	...	⋮	⋮
	m	C_{m1}	C_{m2}	...	C_{mn}	S_m
	R_i	R_1	R_2	...	R_n	

Figure 5. The Transportation Array

In discussions of transportation models, the terms "demand" and "supply" refer to quantities of a particular product that a region must obtain or bring forth respectively, in the marketing system to satisfy the requirements of the region. Throughout the study, reference to these two terms will bear this connotation rather than the theoretical reference to schedules depicting price-quantity relationships. There are "m" supplies shipping to "n" demands as the array is read by rows from left to right. Likewise there are "n" demands receiving from "m" supplies when the system is read by columns from top to bottom. Thus, there are "m" x "n" elements in this array, each of which has a corresponding cost element, C_{ij}. Equation (3.8) is satisfied when the R_j row total and the S_i row total are equal. If the total real supply exceeds total real demand, a dummy demand must be included which represents inventories at the shipping points incurring no costs for transfer. Likewise, if real demand exceeds total real supply, a dummy supply must be included which represents unfilled demand incurring no transfer cost.

The four basic assumptions of this model are:

(1) There is an objective function such as Equation (3.4) to satisfy.

(2) The supplies and demands are known by their origins and destinations, respectively.

(3) The per unit cost of supplying each destination from each origin, C_{ij}, is known and independent of the quantity transferred.

(4) There is homogeneity of the commodity.

The problem posed by Equations (3.5) - (3.8) was originally formulated and solved by Hitchcock, but similar ideas were developed earlier by Kantorovich.[8] This problem was also considered independently by Koopmans[9] and by Koopmans and Reiter.[10] Because of these early investigations, the problem is sometimes called the "Hitchcock-Koopmans transportation problem."[11]

Samuelson designed a model extending the Hitchcock-Koopmans formulation which determined equilibrium prices as well as the inter-regional commodity flows.[12]

Many applications to agricultural problems have been made since the initial works by Hitchcock and Koopmans. Briefly, only a few of the many studies which have determined interregional shipping patterns under varying conditions and assumptions for different commodities will be mentioned: Henry and Bishop in 1957 for national broiler markets;[13] Koch and Snodgrass in 1959 for tomatoes;[14] Stemberger in 1959 for eggs;[15] Hertsgaard in 1961 for dressed turkey;[16] Hertsgaard and Phillippi in 1961 for live cattle and dressed beef;[17] Judge and Hieronymus in 1962 for the corn sector;[18] and Nichols, Mathia, and King in 1964 for fresh snap beans.[19]

The Transhipment Model

The transhipment model had its origin from the transportation model in 1956 when Orden[20] allowed any origin or destination to act as an intermediate point for transhipment. Thus the problem became one of minimizing shipments over a transportation network of links and nodes.

In the 1960's a series of modifications to this original work by Orden were made. In 1961, Kriebel introduced transhipment of a product with seasonal demand thus necessitating storage activities. King and Logan in 1964 made the first major application of transhipment in agricultural economics when they accounted for economies of size in California cattle slaughtering operations in determining optimum location of plants and the shipping patterns of raw and finished products.[21] In 1965, Hurt and Tramel modified and extended the King-Logan formulation to include multiple products with actual levels of shipments determined by the model.[22] The next year, 1966, Leath and Martin modified and extended the work of Hurt and Tramel.[23] The Leath-Martin formulation was a more general model which introduced multiproduct storage, allowing all products to compete for the limited storage space of each region. In their paper Leath and Martin also presented methods of imposing minimum and maximum restraints on supplies, demands and transportation modes within the model. In 1967, Leath and Martin again, extended their 1966 work when they introduced time periods in their model to study flows of seasonally produced and uniformly consumed commodities.[24]

A recent application of the Leath and Martin 1967 formulation has been further modified by Leath.[25] This formulation used the revised simplex procedure of linear programming rather than the transportation algorithm to generate solutions. The transportation formulation necessitated predetermined allocation of processing capacity among commodities. In the linear programming procedure, all commodities compete for the total regional processing capacity and the model determines the commodities processed by the region. Another problem encountered by Leath with the transportation algorithm was that regional storage capacity restraints were violated in the time-staged models. With the linear programming procedure, such a violation is not possible.

Leath found that when using the time-staged linear programming model, difficulty in obtaining solutions to large problems may occur.[26] This problem is a result of the extremely long time required by the computer central processing unit in inverting large problem matrices. Perhaps with faster computer hardware in the future, this difficulty in solving such large problems will be overcome.

The Model of This Study Illustrated[27]

This study is an extension of the 1970 study of the U.S. grain marketing system by Leath referred to earlier.[28] In this study the possible effects of an alternative transportation rate structure are investigated by developing cost-of-service transportation charges which are discussed in Appendices A, B, and C, and comparing the resultant solutions with those of Leath.[29] Thus, the model illustrated here is the model developed and used by Leath in his study.

The model of this study includes the following:

(1) five primary commodities -- hard wheat, soft wheat, durum wheat, feed grain, and soybeans,

(2) forty-two domestic regions with associated production, commercial storage, and flour milling activities,

(3) thirteen export regions, and

(4) flour and grain demands associated with each domestic and export region.

The following assumptions were made to reduce the model to a manageable size.

(1) Points of origin and destination and the associated supply and demand quantities are preassigned.

(2) Transfer charges between regions include loading costs and receiving costs for the respective origin and destination and there is independence of the per unit transfer cost and the quantity moved.

(3) No quantity of wheat in excess of total flour demands moves through the processing sector.

(4) Feed grains are assumed to be perfect substitutes, and regional requirements are suppled by the "least-cost" grain.

(5) Feed milling is decentralized occuring at points of consumption, thus simplifying the model by elimination of a feed milling sector.

(6) Soybean crushing plants represent the final domestic soybean demands.

(7) The demand for processed durum wheat is specified as the location of durum product mills, and the distribution of semolina flour is excluded from the model due to insufficient data.

The mathematical definition of the linear programming formulation of the transhipment model used in this study may be stated as follows:

$$\text{Minimize } Z = \sum_k \sum_i \sum_j C_{kij}\ XG_{kij} \tag{3.9}$$

$$+ \sum_k \sum_i \sum_j C_{kij}\ XM_{kij} + \sum_k \sum_i \sum_j C_{kij}\ XF_{kij}$$

$$+ \sum_k \sum_j C_{k.j}\ QM_{k.j} + \sum_k \sum_i C_{ki}\ I_{ki}.$$

subject to the constraints,

$$S_{ki} + I_{ki} = \sum_j XG_{kij} + \sum_j XM_{kij} + I_{ki} \tag{3.10}$$

$$DG_{kj} = \sum_i XG_{kij} \tag{3.11}$$

$$SCAP_i \geq \sum_k I_{ki}. \tag{3.12}$$

$$MCAP_j \geq \sum_k QM_{k.j} \tag{3.13}$$

$$QM_{k.j} \equiv \sum_i XM_{kij} \equiv \sum_i XF_{kji} \tag{3.14}$$

$$DF_{ki} = \sum_j XF_{kji} \tag{3.15}$$

where:

Z is the cost of the industry,

C_{kij} is the unit transfer cost of product k from region i to region j,

$C_{k.j}$ is the unit cost of milling prduct k in region j,

$C_{ki.}$ is the unit cost of storing product k in region i,

XG_{kij} is the quantity of product k shipped from supply region i to statisfy grain demands in region j,

XM_{kij} is the quantity of product k shipped from supply region i to milling facilities in region j,

XF_{kji} is the quantity of type k flour shipped from milling facilities of region j to satisfy flour demands in region i,

$QM_{k.j}$ is the quantity of type k flour milled in region j,

I_{ki} is the quantity of product k stored in region i,

S_{ki} is the off-farm sales of product k in region i,

DG_{kj} is the demand for grain commodity k in region j,

$SCAP_i$ is the storage capacity in region i,

$MCAP_j$ is the milling capacity in region j, and

DF_{ki} is the demand for type k flour in region i.

Equation (3.9) is the total cost function for the grain marketing system with the objective to minimize the total cost of marketing. Equation (3.10) states the equality of off-farm sales in a given period for a particular commodity plus carryover equals all shipments from that region plus the ending inventory. Equation (3.11) is the statement of the constraint which equates shipments of a particular commodity into a specific region with the requirements for that commodity in that region. Equations (3.12) and (3.13) are constraints on regional storage capacity and milling capacity, respectively equal to their availabilities. Equation (3.14) states that the quantity of a particular flour milled in a given region is identical to the receipts of the corresponding wheat to that region and to the shipments of that flour from the region since flour storage is not considered in the model. Equation (3.15) is the statement of constraint requiring receipts of a particular flour in a region to be equal to the demand for that particular flour in that region.

The matrix format for a hypothetical example involving two regions, two wheats, and two types of flour is presented in Table I. From the matrix

$STKH_i$ and $STKS_i$ = the respective quantities of hard wheat and soft wheat stored in region i,

$HW_{i,j}$ and $SW_{i,j}$ = the respective quantities of hard wheat and soft wheat shipped from region i to region j,

QMH_i and QMS_i = the respective quantities of hard wheat and soft wheat milled in region i,

$FH_{i,j}$ and $FS_{i,j}$ = the respective quantities of hard wheat soft wheat flour shipped from mills located in region i to the consumption point in region j,

$C_{ki\cdot}$ = the cost per unit for storing type k wheat, hard wheat, soft wheat, in facilities in region i,

C_{kij} = the transfer cost per unit for transferring product k, hard wheat, soft wheat, hard wheat flour or soft wheat flour, from region i to region j,

$C_{k\cdot j}$ = the per unit cost of milling hard wheat and soft wheat, respectively, in region j,

SHW_i and SSW_i = the respective supplies of hard and soft wheat in region i,

DHW_i and DSW_i = the respective demands for hard wheat and soft soft wheat in region i,

TABLE 1

LINEAR PROGRAMMING TRANSHIPMENT MATRIX: TWO REGIONS, TWO GRAINS, STORAGE, PROCESSING, AND TWO PROCESSED PRODUCTS

Right Hand Side	Restriction	Activities																							
		STKH1	STKH2	STKS1	STKS2	HW1,1	HW1,2	HW2,1	HW2,2	SW1,1	SW1,2	SW2,1	SW2,2	QMH1	QMH2	QMS1	QMS2	FH1,1	FH1,2	FH2,1	FH2,2	FS1,1	FS1,2	FS2,1	FS2,2
OBJ	N	$C_{ki\cdot}$				C_{kij}								$C_{k\cdot j}$				C_{kij}							
SHW1	=	1				1	1																		
SHW2	=		1					1	1																
SSW1	=			1						1	1														
SSW2	=				1							1	1												
DHW1	=					1		1																	
DHW2	=						1		1																
DSW1	=									1		1													
DSW2	=										1		1												
SCAP1	≤	1		1																					
SCAP2	≤		1		1																				
MRH1	=					-1		-1						1											
MRH2	=						-1		-1						1										
MRS1	=									-1		-1				1									
MRS2	=										-1		-1				1								
MCAP1	≤													1		1									
MCAP2	≤														1		1								
MSH1	=													-1				1	1						
MSH2	=														-1					1	1				
MSS1	=															-1						1	1		
MSS2	=																-1							1	1
DHF1	=																	1		1					
DFH2	=																		1		1				
DSF1	=																					1		1	
DSF2	=																						1		1

$SCAP_i$ = the available storage capacity in region i,

MRH_i and MRS_i = the respective receipts of hard and soft wheat at mills in region i,

$MCAP_i$ = the available milling capacity in region i,

MSH_i and MSS_i = the respective shipments of hard wheat flour and soft wheat flour from mills in region i in bushels of wheat equivalents,

DHF_i and DSF_i = the respective demands for hard wheat flour and soft wheat flour in region i expressed in bushels of wheat equivalents.

More than one optimal solution may exist for a given transportation problem. The frequency of this occurrence generally increases as the number of stages considered in the problem increases. Loomba has discussed the number of alternate solutions that may be derived once two or more optimal solutions to a problem have been found to exist.[30]

FOOTNOTES

[1] William J. Baumol, Economic Theory and Operations Analysis (Englewood Cliffs, 1965), p. 70.

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[11] Garvin, p. 86.

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[20]Alex Orden, "The Transhipment Problem," Management Science, II (April, 1956).

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[25]Mack N. Leath, An Interregional Analysis of the United States Grain Marketing Industry, (Unpublished Ph.D. dissertation, Oklahoma State University, May, 1970).

[26]Leath, 1970, p. 183.

[27]For a comprehensive discussion of the model used in this study, see Leath, 1970, pp. 39-49, 59-63.

[28]Leath, 1970.

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[30]N. Paul Loomba, Linear Programming, An Introductory Analysis (New York, 1964), pp. 210-213.

CHAPTER IV

REGIONAL DEMARCATION AND BASIC DATA

Spatial studies of the scope of this study require concerted efforts in data collection. The validity of conclusions of such a study depend in part on the accuracy of the data used. The tremendous data requirements of this study prohibited generation of data specifically for model requirements due to budget and time constraints, thus secondary data are used in many instances. The purpose of this chapter is to briefly discuss the data used, more specifically, regional demarcation; basic data pertaining to supplies, demands, capacities of storage and processing facilities; and marketing charges and costs pertaining to grain handling costs, flour milling costs, and transportation costs. The transportation charge data are the only data of this study which differ from the data in the study by Leath.[1]

Regional Demarcation

The geographical area of consideration is that of the forty-eight adjacent United States. Demarcation of boundaries for this area involves subjective judgments and data availability. In this case, much of the data were not available for geographical areas smaller than states. Another consideration is that of data processing limitations when the number of regions is expanded. Thus, as can be seen in Figure 6, only twelve of forty-two domestic regions are composed of an

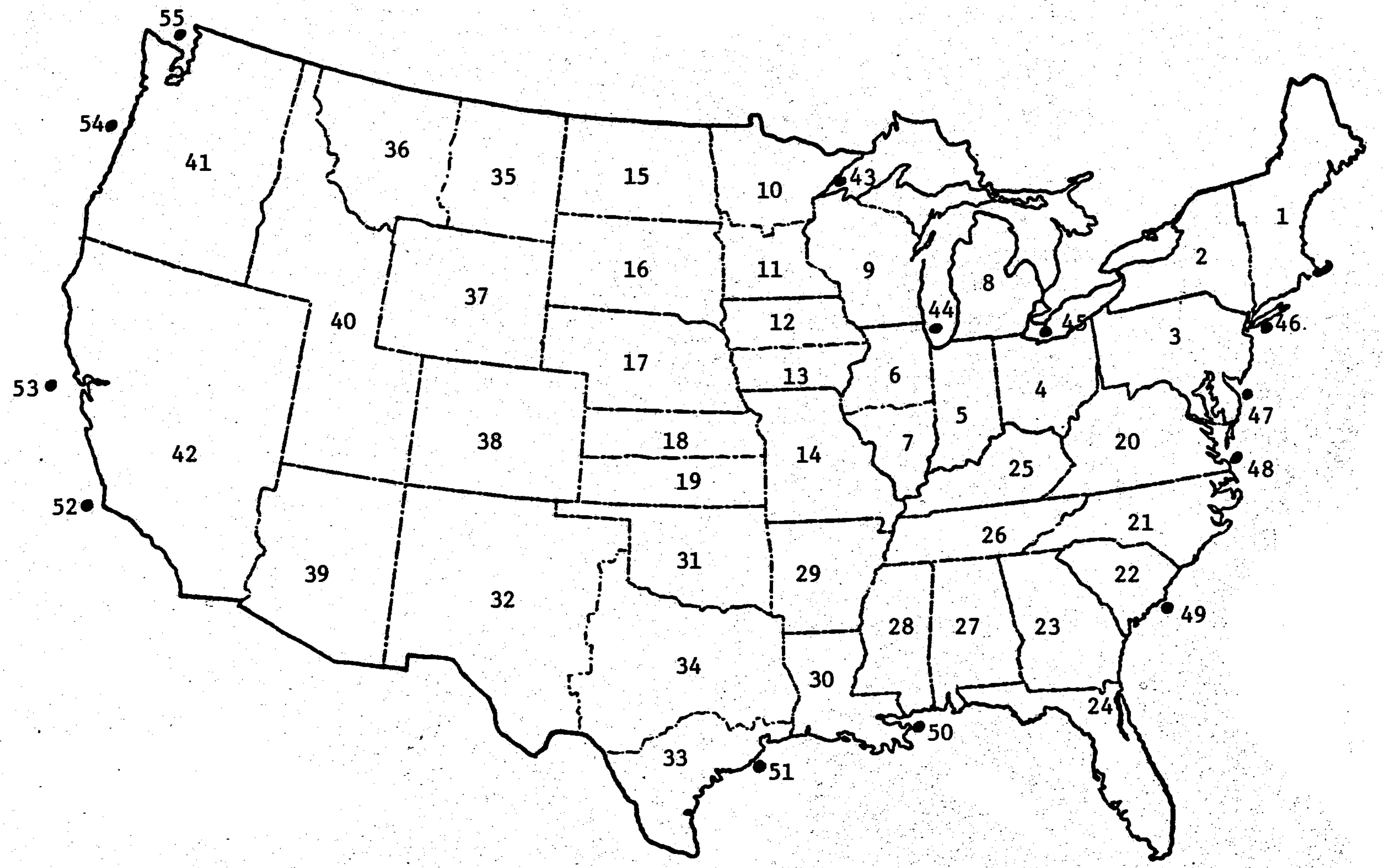


Figure 6. Regional Demarcation of the United States Grain Marketing System

area smaller than one state. In those instances, where states were sub-divided, either rail rates or Interstate Commerce Commission rail cost territories necessitated demarcation. Specification of the thirteen ports of export were also guided by available rail rates and the need for data consolidation.

Points of grain origin and destination in this study are distinctly different locations. The points of origin were selected to approximate (1) centers of major regional grain production and (2) location in relation to major rail lines, thus approaching reality with respect to specification of grain rates and of grain storage at these points. The grain destination (points of consumption) of a region was selected with reference to major population centers of that region and represents location of grain processing facilities. These grain origins and destinations for which basic data on supplies and demands were developed are specified by region in Table II.

Destinations for ports of export are given in Table III.

Basic Data

The basic data which are considered in this section are the "supplies" and "demands" of the thirteen export port destinations discussed in the previous section. These data also include processing and storage capacities for which marketing charges are incurred when these facilities are utilized in the model. The marketing charges and transportation costs will be discussed in a later section of the chapter. "Supplies" and "demands" as used in this chapter and throughout this study are simply the respective quantities available and quantities required by the regions under consideration in the study and are not to

TABLE II

REGIONAL BASING POINTS FOR UNITED STATES DOMESTIC GRAIN ORIGINS AND DESTINATIONS

Code		State	Grain Origin	Grain Destination
1	NE	New England	Northampton	Boston
2	NY	New York	Canadaigua	New York
3	Pa	Delaware, Md, Penn, and New Jersey	Altoona	Philadelphia
4	Oh	Ohio	Marysville	Mansfield
5	In	Indiana	Kokoma	Indianapolis
6	Il	Illinois, North	Peoria	Chicago
7	Il	Illinois, South	Mt. Vernon	East St. Louis
8	Mi	Michigan	Albion	Detroit
9	Wi	Wisconsin	Madison	Fondulac
10	Mn	Minnesota, North	Fergus Fall	Duluth
11	Mn	Minnesota, South	New Elm	Minneapolis
12	Ia	Iowa, North	Algona	Mason City
13	Ia	Iowa, South	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, North	Russell	Topeka
19	Ks	Kansas, South	Pratt	Wichita
20	Va	Virginia and West Va.	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 Mex., Texas, West	Littlefield	Amarillo
33	Tx	Texas, South	Beeville	Houston
34	Tx	Texas, East	Cisco	Ft. Worth
35	Mt	Montana, East	Wolfe Point	Miles City
36	Mt	Montana, West	Conrad	Great Falls
37	Wy	Wyoming	Wheatland	Casper
38	Co	Colorado	Limon	Denver
39	Az	Arizona	Tucson	Phoenix
40	Id	Utah, Idaho	Pocatello	Ogden
41	Wa	Washington, Oregon	Othello	Portland
42	Ca	Nevada, California	Modesto	Fresno

TABLE III

BASING POINTS FOR UNITED STATES EXPORT PORT DESTINATIONS

Region	Code		Port
Lake Ports	43	Su	Superior, Wisconsin
		Du	Duluth, Minnesota
	44	Ch	Chicago, Illinois
		Mw	Milwaukee, Wisconsin
	45	To	Toledo, Ohio
		Sg	Saginaw, Michigan
		Ca	Carrollton, Michigan
		Zi	Silwaukee, Michigan
		Bu	Buffalo, New York
Atlantic Ports	46	Al	Albany, New York
		Bo	Boston, Massachusetts
		Pr	Portland, Maine
	47	Ba	Baltimore, Maryland
		Pa	Philadelphia, Pennsylvania
		NY	New York, New York
	48	Nf	Norfolk, Virginia
	49	Cs	North Charleston, S.C.
Gulf Ports	50	NO	New Orleans, Louisiana
		Mb	Mobile, Alabama
		Pc	Pascagoula, Mississippi
		Pl	Port Allen, Louisiana
		De	Destrehan, Louisiana
	51	Ho	Houston, Texas
		Pr	Port Arthur, Texas
		Be	Beaumont, Texas
		Gr	Galveston, Texas
		CC	Corpus Christi, Texas
Pacific Ports	52	LB	Long Beach, California
	53	Sk	Stockton, California
		SF	San Francisco, California
		Oa	Oakland, California

TABLE III (Continued)

Region	Code		Port
Pacific Ports (cont'd)	54	Po	Portland, Oregon
		As	Astoria, Oregon
		Vn	Vancouver, Washington
		Lo	Longview, Washington
		Ka	Kalama, Washington
	55	Se	Seattle, Washington
		Ta	Tacoma, Washington

to be confused with these terms as used in economic theory. Since grain storage capacity is incorporated in the model, all grains were aggregated on a bushel basis. This aggregation was necessary since an expansion of the model to eight grains would have greatly exceeded the available data processing capacity.

Regional Supplies

Supplies of hard wheat, soft wheat, durum wheat, feed grain, and soybeans in this study are 1966 off-farm crop sales[2] pluss off-farm (commercial) stocks.[3] Hard wheat is defined to include the hard red winter and hard red spring wheats. Soft wheat includes soft red winter and white wheats. Durum wheat is self-explanatory, but is included separately since it is milled in specialized mills and does not compete for the same milling capacity as the two other wheats as defined in this study. Feed grain includes corn, oats, barley, and grain sorghum, or those grains grown primarily for livestock feed. Again, soybeans is a self-explanatory term. Soybeans are included in this study since they are a major competitor for storage space in many grain producing areas.

Since aggregate supply data were not available for the wheats as defined in the model, regional supplies of each type of wheat were estimated by taking the acreage of the type of wheat in the region relative to the total acreage in the region.[4]

Estimated regional supplies of grain by type of grain are presented in Table IV.

Regional Demands

In general, we may classify demands for the five grains considered in this study as (1) livestock feed, (2) industrial demands, including

TABLE IV

ESTIMATED REGIONAL SUPPLIES OF GRAIN BY TYPE OF GRAIN, 1966

Region		Hard Wheat	Soft Wheat	Durum Wheat	Feed Grain	Soybeans
				10,000 Bu.		
1	Ne	0	0	0	213	0
2	NY	367	2,140	0	1,618	5
3	Pa	565	1,943	0	4,669	537
4	Oh	42	4,325	0	17,437	6,325
5	In	157	3,804	0	26,373	7,741
6	Il	1,697	642	0	46,771	8,993
7	Il	2,473	1,302	0	17,887	9,630
8	Mi	28	3,080	0	5,899	1,119
9	Wi	1,253	474	0	7,547	329
10	Mn	2,422	260	1,727	10,018	2,016
11	Mn	1,770	0	1,600	11,430	6,681
12	Ia	325	0	0	17,960	6,659
13	Ia	423	0	0	38,229	9,810
14	Mo	2,629	2,198	0	10,633	8,847
15	ND	13,188	0	6,349	13,050	533
16	SD	6,095	0	416	11,691	695
17	Ne	11,724	0	0	47,899	2,367
18	Ks	13,937	0	0	12,219	1,353
19	Ks	13,936	0	0	7,952	954
20	Va	55	486	0	1,125	630
21	NC	0	438	0	3,935	2,191
22	SC	0	174	0	971	1,966
23	Ga	0	185	0	3,533	666
24	Fl	0	61	0	693	213
25	Ky	0	533	0	2,957	960
26	Tn	0	420	0	1,782	2,821
27	Al	0	158	0	1,136	784
28	Ms	0	744	0	608	4,591
29	Ar	131	987	0	740	9,591
30	La	85	195	0	844	2,485
31	Ok	10,863	0	0	3,041	280
32	Tx	6,307	0	0	34,900	334
33	Tx	571	0	0	8,728	3
34	Tx	3,446	0	0	15,057	23
35	Mt	4,249	369	297	1,888	0
36	Mt	5,718	110	231	3,611	0
37	Wy	459	13	0	272	0
38	Co	4,560	0	0	3,082	0
39	Az	24	85	0	2,487	0
40	Id	2,487	2,119	0	2,194	0
41	Wa	3,208	12,517	0	4,559	0
42	Ca	70	1,085	30	11,476	0

food, (3) seed, and (4) exports. For the two types of flour, hard-wheat and soft-wheat, there are domestic demands and export demands.

Wheat. Since regional data for quantities of wheat used in livestock feeding above that fed on farms where grown were not available for 1966-67, these data were not included for consideration. As a result, domestic wheat disappearance is underestimated by approximately 60 million bushels, but is compensated for in regional estimates of feed grain for livestock feeding. As a result ending wheat inventories are slightly increased and ending feed grain inventories are correspondingly slightly decreased.

The majority (approximately 74 percent) of the domestic disappearance of wheat for the July 1966-June 1967[5] year was from food, most of which was in the form of flours.[6] Thus, food demand for wheat is accounted for by regional demands for hard-wheat and soft-wheat flows excepting durum wheat which was not accounted for beyond mill demands due to lack of data. Flour demands by type were estimated from a 1963 study by Bitting and Rogers[7] using 1960 data and adjusted to 1966-67 per capita consumption estimates[8] and for 1966 regional population estimates.[9] The estimated regional flour demands used in this study are presented in Table V. The flour estimates for the two Kansas regions (Regions 18 and 19) include 558,915 hundredweights of flour (divided equally between the two regions) used for alcohol distillation in that state.[10] Regional export flour demands are also included in Table V. These demands exclude relief flour shipments because of inavailability of necessary data.

Regional requirements of wheat for seed are presented in Table VI. These quantities are those required in excess of on-farm produced seed.

TABLE V

ESTIMATED DOMESTIC AND EXPORT FLOUR REQUIREMENTS[a] IN WHEAT EQUIVALENTS, BY REGION AND TYPE OF FLOUR, 1966-67

Region		Hard-Wheat Flour	Soft-Wheat Flour	Region		Hard-Wheat Flour	Soft-Wheat Flour
		10,000 Bu.				10,000 Bu.	
1	NE	1,696	560	29	Ar	363	224
2	NY	2,789	920	30	La	657	384
3	Pa	3,777	1,448	31	Ok	453	264
4	Oh	1,869	696	32	Tx	397	204
5	In	893	340	33	Tx	753	432
6	Il	1,528	564	34	Tx	989	568
7	Il	439	160	35	Mt	41	16
8	Mi	1,555	576	36	Mt	83	36
9	Wi	768	296	37	Wy	53	24
10	Mn	147	56	38	Co	320	136
11	Mn	500	192	39	Az	258	108
12	Ia	195	80	40	Id	291	128
13	Ia	319	128	41	Wa	847	364
14	Mo	814	312	42	Ca	3,038	1,284
15	ND	120	48	43	Du	27	0
16	SD	126	52	44	Ch	34	18
17	Ne	271	104	45	To	0	23
18	Ks	267[b]	80	46	Al	0	0
19	Ks	267[b]	80	47	Ba	181	79
20	Va	1,200	708	48	Nf	0	0
21	NC	936	568	49	Cs	39	13
22	SC	495	296	50	NO	1,367	87
23	Ga	811	480	51	Ho	3,196	0
24	Fl	1,044	584	52	LB	12	0
25	Ky	618	376	53	Sk	22	0
26	Tn	715	428	54	Po	123	82
27	Al	648	392	55	Se	87	38
28	Ms	451	288				

[a]Export requirements exclude flour exports designated for relief.

[b]Kansas requirements include 558,915 cwts. of flour used in the manufacture of distilled spirits.

TABLE VI

ESTIMATED REGIONAL SEED DEMANDS FOR WHEAT AND SOYBEANS, 1967 CROP

Region		Hard Wheat	Soft Wheat	Durum Wheat	Soybeans
			10,000 Bu.		
1	NE	0	0	0	0
2	NY	0	30	0	1
3	Pa	0	74	0	20
4	Oh	0	148	0	109
5	In	0	90	0	133
6	Il	26	14	0	118
7	Il	52	28	0	144
8	Mi	0	136	0	39
9	Wi	4	0	0	15
10	Mn	73	0	11	33
11	Mn	36	0	0	133
12	Ia	5	0	0	140
13	Ia	1	0	0	211
14	Mo	89	73	0	217
15	ND	147	0	325	18
16	SD	92	0	20	21
17	Ne	159	0	0	58
18	Ks	166	0	0	26
19	Ks	166	0	0	17
20	Va	0	19	0	17
21	NC	0	26	0	64
22	SC	0	11	0	44
23	Ga	0	10	0	27
24	Fl	0	5	0	8
25	Ky	0	22	0	41
26	Tn	0	24	0	96
27	Al	0	12	0	42
28	Ms	0	80	0	178
29	Ar	10	76	0	244
30	La	0	15	0	126
31	Ok	189	0	0	92
32	Tx	136	0	0	19
33	Tx	0	0	0	0
34	Tx	84	0	0	1
35	Mt	62	0	12	0
36	Mt	90	0	8	0
37	Wy	16	0	0	0
38	Co	15	0	0	0
39	Az	3	8	0	0
40	Id	71	61	0	0
41	Wa	51	233	0	0
42	Ca	0	37	0	0

Data on the distribution of semolina flour milled from durum wheat were not sufficient for determination beyond the mills. Thus, the total demand[11] for durum wheat was computed by allocating the U. S. demand for durum wheat flour among the few specialized mills which mill durum wheat according to each mill's proportion of total durum milling capacity. The allocation of durum wheat is presented in Table VII.

Wheat export demands by type of wheat were determined from published data on inspections for export by port and are presented in Table VIII.

Feed Grain. Regional feed grain requirements for livestock feed were allocated among the domestic regions in proportion to the total number of grain-consuming animal units fed during the 1966 feeding year, then reduced by the quantities of wheat and feed grain fed on farms where grown. Thus, feed processing was assumed to take place at the point of consumption and feed grains enter the model as whole grain demands.

Industrial uses of feed grains include dry corn milling, wet processing, cereal manufacturing, malting, and distilling and brewing. Regional data for these various feed grain demands were available only for distilling and brewing.[12] Regional data for the other industrial uses were derived. Dry corn milling was proportioned according to milling capacity of such mills reported by *The Northwestern Miller*. Where millers wished to keep their capacity confidential, regional average capacity was assumed for those mills. Regional requirements for wet corn milling, barley malting, and cereal processing were determined by allocating the aggregate demands proportional to individual

TABLE VII

DOMESTIC DURUM WHEAT REQUIREMENTS AND MILLING CAPACITY BY REGION OF MILLING, 1966-67

Milling Region		Daily Capacity	Annual Capacity (Wheat Equiv.)	Annual Mill Capacity (Wheat Equiv.)
		cwt.	10,000 Bu.	10,000 Bu.
2	NY	4,600	27	239
9	Wi	9,700	57	505
11	Mn	18,000	106	936
15	ND	4,000	24	209
41	Wa	7,000	41	364

plant employment statistics for the appropriate industry as reported by the Bureau of The Census.[14] Total industrial feed grain requirements are presented in Table IX.

Planted crop acreages for 1967 crops were used to allocate feed grain disappearance for seed requirements.[15] In regions where the quantities of wheat and feed grain fed on farms where grown exceeded the estimated livestock feed requirements, the excess was taken from the seed requirements. In regions 10, 11, and 15 the net seed demand was zero. Table IX presents the regional feed grain seed requirements.

As for the wheats, export demands for feed grain were determined from published data and inspections for export by port. These data are also presented in Table VIII.

Soybeans. The two major domestic requirements for soybeans are for processing and seed. Allocation of soybeans for processing (crushing)

TABLE VIII

EXPORT DEMANDS FOR HARD WHEAT, SOFT WHEAT, DURUM WHEAT, FEED GRAIN, AND SOYBEANS BY PORT, 1966-67

Port		Hard Wheat	Soft Wheat	Durum Wheat	Feed Grain	Soybeans
				10,000 Bu.		
43	Du	1,354	0	2,749	6,568	873
44	Ch	39	97	0	5,656	1,885
45	To	0	1,308	0	2,146	2,494
46	Al	815	364	83	396	0
47	Ba	3,628	1,123	289	2,649	571
48	Nf	1,325	747	816	2,018	428
49	Cs	151	15	0	40	872
50	NO	8,185	4,040	729	37,831	~~17,~~643
51	Ho	20,815	0	70	19,190	146
52	LB	34	8	0	4,184	0
53	Sk	17	12	0	0	0
54	Po	5,810	9,305	52	1,540	0
55	Se	1,289	2,354	0	278	0

Source: U. S. Department of Agriculture, Grain Market News, Consumer and Marketing Service, Grain Division, Vols. 14 and 15 (Hyattsville, 1966, 1967), selected issues.

TABLE IX

DOMESTIC FEED GRAIN REQUIREMENTS BY REGION, 1966-67

Region		Seed	Livestock Feed	Industrial Uses	Total
			10,000 Bu.		
1	NE	24	8,579	457	9,060
2	NY	144	6,551	1,698	8,393
3	Pa	240	16,869	1,522	18,631
4	Oh	232	1,874	396	2,502
5	In	209	3,590	3,823	7,622
6	Il	187	1,723	9,211	11,121
7	Il	292	1,772	5,707	7,771
8	Mi	184	732	2,556	3,472
9	Wi	546	1,050	4,453	6,049
10	Mn	0	0	0	0
11	Mn	0	0	2,065	2,065
12	Ia	258	2,469	224	2,751
13	Ia	571	5,504	6,055	12,130
14	Mo	162	10,514	2,530	13,206
15	ND	0	0	17	17
16	SD	776	301	0	1,077
17	Ne	279	6,763	655	7,697
18	Ks	131	1,645	137	1,913
19	Ks	80	641	222	943
20	Va	71	5,745	854	6,670
21	NC	98	12,501	882	13,481
22	SC	65	2,672	209	2,946
23	Ga	81	17,653	460	18,194
24	Fl	14	3,660	176	3,850
25	Ky	44	3,042	2,475	5,561
26	Tn	59	5,237	2,922	8,218
27	Al	53	12,183	346	12,582
28	Ms	48	8,314	91	8,453
29	Ar	39	14,087	0	14,126
30	La	21	2,583	5	2,609
31	Ok	152	3,081	445	3,678
32	Tx	264	2,400	13	2,677
33	Tx	87	4,092	969	5,148
34	Tx	131	7,282	426	7,839
35	Mt	127	0	18	145
36	Mt	257	37	0	294
37	Wy	52	123	0	175
38	Co	109	3,251	51	3,411
39	Az	28	1,327	0	1,355
40	Id	150	2,073	24,247	2,470
41	Wa	219	5,068	42,429	5,716
42	Ca	361	18,955	1,428	20,744

among the regions was accomplished by proportioning the aggregate crush[16] according to regional crushing capacity. Crushing capacities will not be published here to avoid identity of firms in those regions with as few as two firms. However, these data are used as inputs for this study.

Published data on regional soybeans seed requirements[17] were adjusted downward to reflect the amount of seed supplied by farms where produced. These data are presented in Table VI.

Published data on inspections were used for the export demands of soybeans. These data are presented in Table VIII.

Regional Capacities and Charges

Ideally, a researcher would like to include a separate specification of capacity for each plant in a study of the type we are concerned with here. Since this was impractical, capacities of plants have been combined in the 42 regions of this study. This applies to both storage capacity and processing capacity.

Grain Storage. Two types of facilities, county elevators and terminal elevators, were combined to comprise the handling and storage capacity used in this study. Since location and capacity data on Commodity Credit Corporation (CCC) were not available, these data could not be included. The estimates of off-farm storage by region are presented in Table X.

Flour Milling. Regional flour milling capacities were obtained from The Northwestern Miller.[18] Individual mill capacities for each of the 37 regions having milling capacity were aggregated to arrive at the mill capacities which are presented in Table XI.

TABLE X

ESTIMATED REGIONAL GRAIN STORAGE CAPACITY, 1967

Region	Storage Capacity	Region	Storage Capacity
	10,000 Bu.		10,000 Bu.
1	427	29	10,545
2	5,492	30	2,628
3	4,408	31	23,600
4	13,371	32	57,226
5	16,805	33	9,722
6	38,287	34	21,066
7	11,204	35	3,082
8	5,882	36	2,823
9	6,209	37	644
10	9,096	38	8,333
11	28,716	39	1,600
12	20,479	40	5,950
13	38,231	41	17,015
14	20,178	42	9,732
15	17,327	43	5,203
16	15,388	44	5,822
17	57,153	45	1,909
18	50,415	46	1,382
19	37,322	47	1,746
20	928	48	711
21	2,730	49	64
22	1,465	50	2,487
23	1,900	51	4,544
24	293	52	327
25	2,334	53	1,085
26	3,852	54	2,855
27	1,121	55	1,271
28	2,568		

Source: U. S. Department of Agriculture, Economic Research Service, Marketing Economics Division, Fibers and Grains Branch (Washington).

TABLE XI

REGIONAL FLOUR MILLING CAPACITY, 1967

Region		Active Daily Capacity	Inactive Daily Capacity	Total Daily Capacity	Yearly Capacity[a] (Wheat Equiv.)
		cwt.	cwt.	cwt.	10,000 Bu.
2	NY	94,666	-	94,666	5,596
3	Pa	33,862	100	33,962	2,008
4	Oh	60,270	1,000	61,270	3,624
5	In	28,070	-	28,070	1,660
6	Il	21,590	-	21,590	1,276
7	Il	3,450	-	31,450	1,860
8	Mi	29,950	-	29,950	1,772
9	Wi	160	-	160	8
10	Mn	2,175	-	2,175	128
11	Mn	69,615	-	69,615	4,116
13	Ia	20,700	-	20,700	1,224
14	Mo	84,190	-	84,190	4,980
15	ND	7,000	-	7,000	412
16	SD	2,700	300	3,000	176
17	Ne	28,430	-	28,430	1,680
18	Ks	60,050	-	60,050	3,552
19	Ks	75,940	2,400	78,340	4,632
20	Va	11,396	-	11,396	672
21	NC	22,256	-	22,256	1,316
22	SC	3,430	1,200	4,630	272
23	Ga	3,830	-	3,830	228
24	Fl	2,500	-	2,500	148
25	Ky	4,519	-	4,519	268
26	Tn	29,474	-	29,474	1,744
27	Al	6,500	-	6,500	384
28	Ms	400	-	400	24
31	Ok	25,700	3,600	29,300	1,732
32	Tx	1,060	-	1,060	64
33	Tx	7,100	7,300	14,400	852
34	Tx	37,880	2,600	40,480	2,392
36	Mt	10,180	-	10,180	600
37	Wy	2,700	-	22,700	160
38	Ca	11,880	-	11,880	704
39	Az	840	-	840	48
40	Id	27,047	-	27,047	1,600
41	Wa	52,600	-	52,600	3,112
43	Ca	35,220	-	35,220	2,084

[a]Assumes a year of 254 operating days.

Source: The Northwestern Miller (Minneapolis, September, 1967), p. 9.

Marketing Charges

Four types of marketing charges are required inputs for the model of this study. These are (1) storage charges, (2) milling costs for wheat, (3) handling costs for receiving and shipping grain, and (4) transportation costs between origins and destinations. Since the model assumes a homogenous product, grain cleaning and drying costs are not included.

Storage Charges. The standard storage charges of the Commodity Credit Corporation (CCC) were used for the costs of storage in this study since there are indications that elevator operators' charges for storing commercial stocks of grain are closely related to the negotiated charges paid by the CCC.[19] This solved the problem of specifying regional storage costs based upon capacity utilization with decreasing average costs and multiple-firm storage within a region. The rate for the 1966-67 year was $.00036 per bushel per day for commingled grain or 13.14 cents per bushel on an annual basis.

Flour Milling Costs. The costs of milling flour used for this model were derived from data reported by the National Commission on Food Marketing.[20] Since this study does not include millfeed (because it is not possible to consider joint-product processing in this transhipment model) the aforementioned data were adjusted to cost per unit of flour on a bushel of wheat equivalent basis by proportioning the milling cost per unit of product sold by the number of pounds of flour in the final product mix from milling wheat. These costs are presented in Table XII.

Handling Costs. The costs of in-handling and out-handling, or receiving and shipping, of grain vary by mode of transportation and by

TABLE XII

ESTIMATED MILLING COST PER BUSHEL
BY REGION, 1966-67

Region	Cost/Bushel Wheat Equivalent
	(Dollars)
Middle Atlantic[a]	.3237
South Atlantic[b]	.4093
North Central[c]	.2702
South Central[d]	.2793
Mountain[e]	.3067
Pacific[f]	.3019

[a]N.E., N.Y., Pa., Dl., Md., N.J.

[b]W.V., Va., N.C., S.C., Ga., Fl.

[c]Oh., In., Il., Mi., Wi., Mn., Ia., Mo., N.D., S.D., Ne., Ks.

[d]Tn., Ky., Al., Ms., La., Ar., Ok., Tx.

[e]Mt., Id., Ut., Wy., Co., Az., N.M., Ne.

[f]Wa., Ca., Or.

types of grain receiving facility, whether country elevator or terminal elevator. Since no distinction of storage facilities was made in the model, regional handling costs developed by the Economic Research Service[21] were weighted for type of facility by the proportion of total capacity represented by each type of facility in each region. The handling costs used in this study by type of facility and mode of transportation are presented in Table XIII. Data from this table were combined with the cost-of-service transportation charges discussed in the following section to develop the charges for movements of grain in this study.

Transportation Costs. The overall objective of this study, which has been mentioned earlier, is to determine the possible effects of a cost-of-service transportation rate structure on the U. S. grain marketing system. The model used which portrays the grain marketing system was discussed in Chapter III. Of necessity, then, this study requires transportation charges which estimate the cost to the carrier(s) of providing transportation services to the grain industry. This study, with its scope, required a major effort to develop such costs since grain is moved by any one of the three surface modes of transportation or combinations of the three modes.

A basic assumption made in developing these costs was that grain is a homogeneous commodity for purposes of transportation, thus there would be no discrimination in costs among the grains. Thus, separate costs were developed for grain and for flour. Costs of flour transportation by barge were not considered since it is doubtful any bakery in the world could "accomodate a whole barge load of flour."[22]

Before proceeding further, the appropriate term selected to refer to the charges used for transportation of grain and flour between origins and destinations of this study is "transfer costs". Transfer costs is a more inclusive term than transportation costs as it includes the handling charges mentioned in the preceding section. The Swedish

TABLE XIII

ESTIMATED COSTS OF HANDLING GRAIN IN COMMERCIAL ELEVATORS BY GEOGRAPHICAL AREA, TYPE OF FACILITY AND MODE OF TRANSPORTATION, 1967-68

Facility	Received by --			Shipped by --		
	Truck	Rail	Water	Truck	Rail	Water
			(Cents/Bu.)			
North Plains[a]						
Inland elevators	1.95	4.81	1.50[g]	3.50	2.71	1.00
Port elevators	--	--	--	--	--	--
Mid Plains[b]						
Inland elevators	2.28	2.87	1.50[g]	2.36	3.56	2.50[g]
Port elevators	--	--	--	--	--	--
South Plains[c]						
Inland elevators	3.07	10.50	1.50[g]	3.38	4.19	2.50[g]
Port elevators	1.60	1.20	1.20	2.30	3.10	0.80
West[d]						
Inland elevators	2.64	7.55	1.50[g]	3.45	3.15	2.50[g]
Port elevators	2.00	2.30	1.20	2.00	4.20	1.50
Great Lakes[e]						
Inland elevators	2.47	6.75	1.50[g]	2.49	3.08	2.50[g]
Port elevators	1.30	3.00	1.10	4.30	2.60	1.40
South and East[f]						
Inland elevtors	1.95	3.86	2.00	3.20	2.18	2.50[g]
Port elevators	1.30	1.80	4.00	3.90	2.40	1.00

[a]N.D., S.D., and Mn. (excluding port facilities).

[b]Ne., Ks., Co., Wy., Ia., and Mo.

[c]Ok., N.M., and Tx. plus all gulf port facilities.

[d]Wa., Or., Id., Mt., Ca., Az., Ne., and Ut.

[e]Wi., Il., In., Oh., Mi., and Mn., port facilities

[f]Ar., Ms., S.C., Tn., Ky., N.Y., Va., Pa., N.J., Md., Dl., La., Al., Ga., Fl., N.C., W.V., and N.E. (excluding port facilities).

[g]From U. S. Army Corps of Engineers, "Reevaluation of Project Economics," Supplement to the General Design Memorandum, Tennessee-Tombigbee Waterway, Alabama and Mississippi, Mobile District (Mobile, 1966), p. B-18.

economist Bertil Ohlin is credited with adopting this distinction.[23] The discussion from this point will not concern inclusion of handling costs, but will deal exclusively with the development of the costs of providing transportation services.

Previous research on cost-of-service transportation for a national study of this nature has not been attempted. In a recent study, Wright[24] 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. But, his method does not allow for elements other than distance to affect the cost of service.

The costs of transportation used in this study are a synthesis of costs for conditions which existed for trucks, rails, and barges in 1966, accounting for regional variations. Mileages used for the various point-to-point movements by trucks were taken from Household Goods Carriers Bureau, Mileage Guide No. 9.[25] Rail distance data are available in tablular form in a number of publications.[26, 27, 28] The number of origins and destinations listed as well as the specific points included varies considerably among these publications. There is also significant variation in the mileages listed. An alternative means of obtaining short-line rail distance[29] is to use a procedure called PICADAD[30] developed by the U. S. Department of Commerce which allows one to convert highway mileage data. PICADAD is based on data for 3,100 rail movements which were divided into mileage blocks. these mileage blocks, ratios of rail short-line miles to straight-line miles and highway miles to straight-line miles were computed. By employing these two ratios, ratios of rail short-line miles to highway miles can be derived for the various mileage blocks. These data which were used to compute rail mileages for this study are presented in Table XIV.

The mileages used for barge portions of movements were taken from <u>Light List, Volume V</u> - United States Coast Guard,[31] and <u>The Intercoastal Waterway</u>, "Gulf Section"[32] and "Atlantic Section"[33] by the United States Army Corps of Engineers.

The regions used for trucking cost specification are shown in Figure 7. The trucking costs of transportation services for grain and flour used in this study are presented in Table XV. These costs are developed in Appendix A.

The regions used for rail cost specifications are shown in Figure 8. The rail costs-of-transportation services for grain and flour used in this study are presented in Table XVI. These costs are developed in Appendix B.

Barging costs were derived for point to point movements and as such took account of the rivers and segments of rivers on which grain moved. The equation representing barging costs is a function of the time required to deliver grain from origin to destination. The equation may be expressed as

$$T = V + O \qquad (4.1)$$

where T = total barging cost per loaded barge,

V = voyage time cost per loaded barge, and

O = other operating-time cost per loaded barge

Voyage time may be defined as

$$V = (1 + \alpha) \frac{D}{S} Bn \div (1 + \quad) n \qquad (4.2)$$

where D = distance between two points,

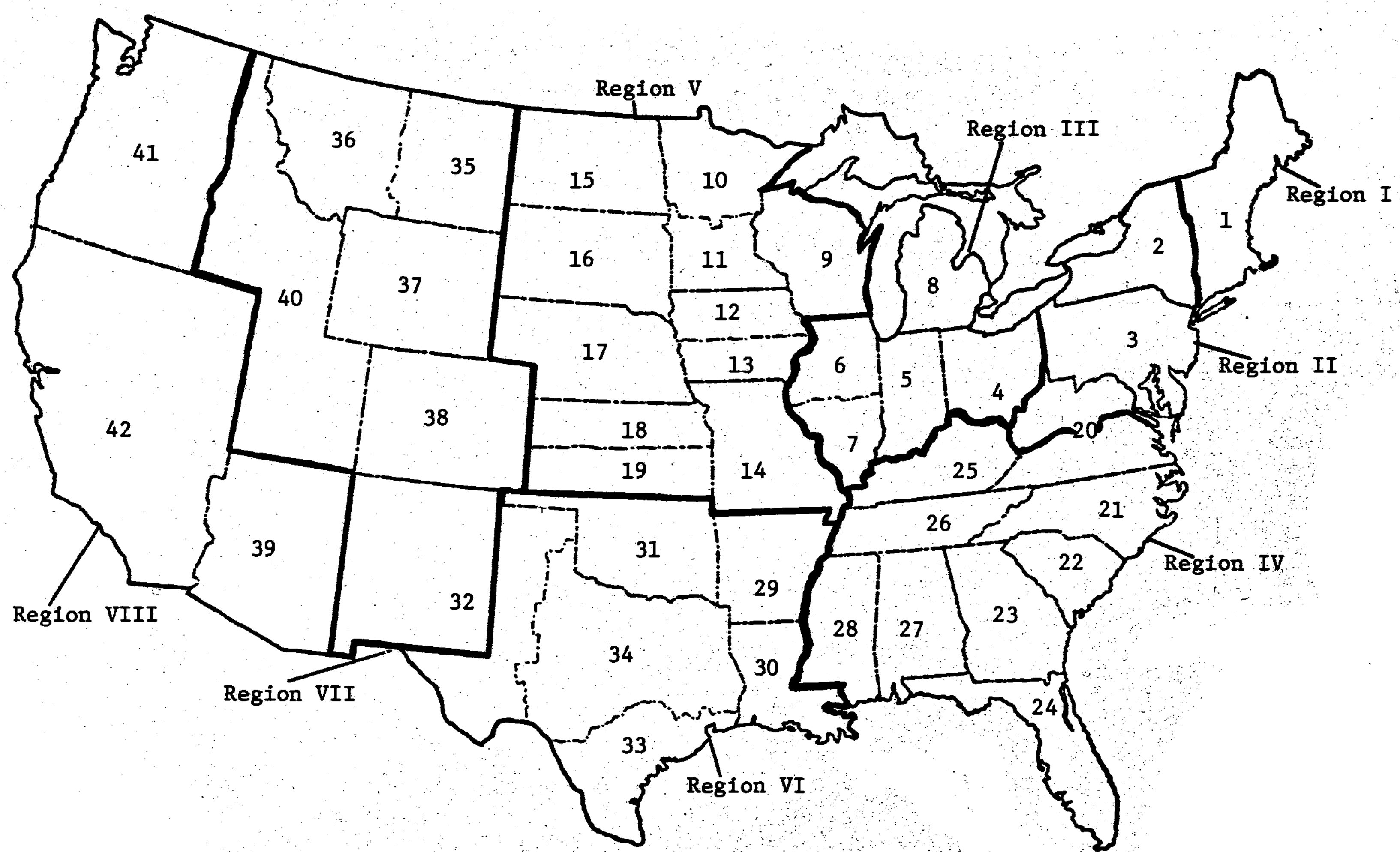


Figure 7. Regional Delineation of Truck-Cost Regions

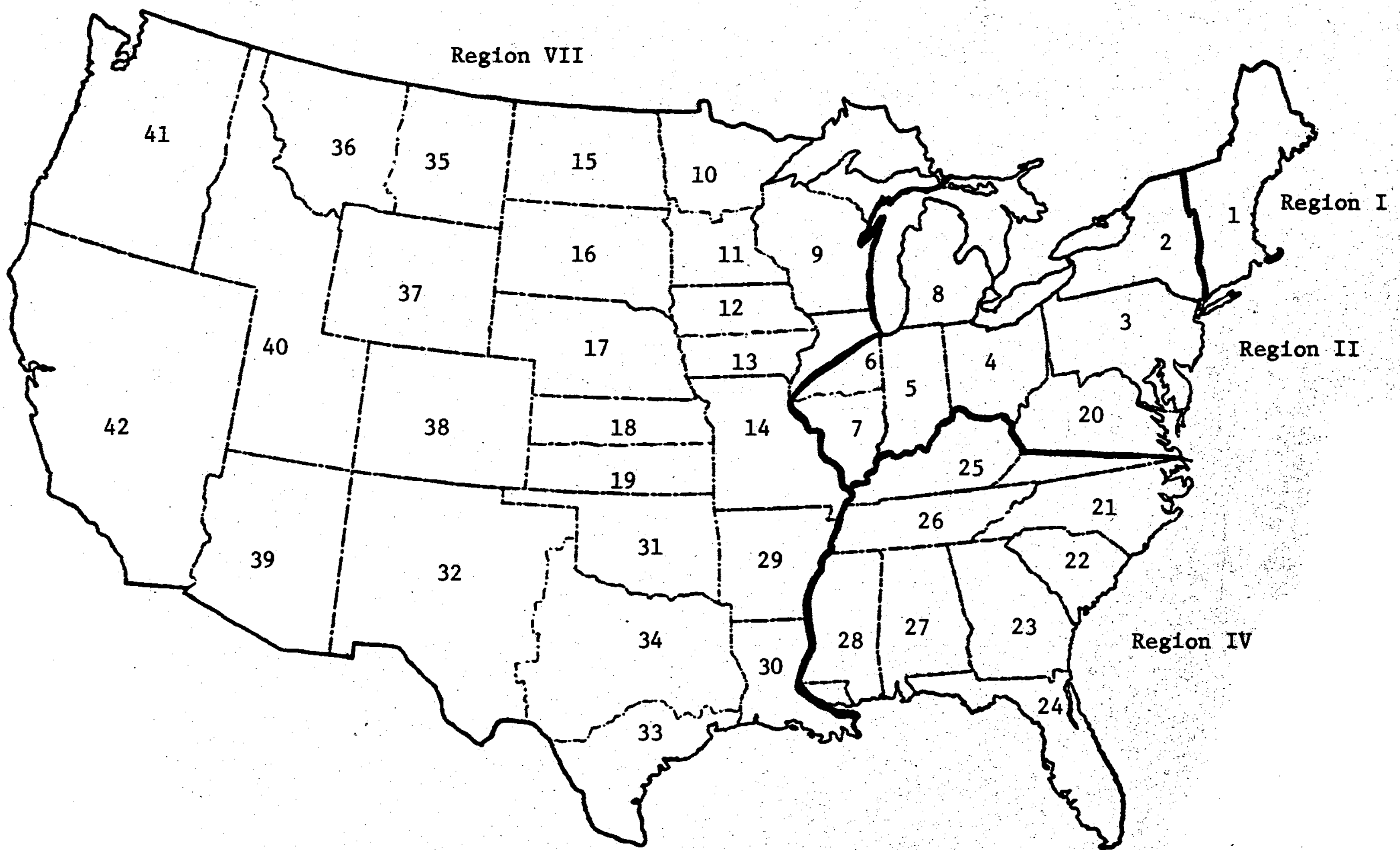


Figure 8. Regional Delineation of Rail-Cost Regions

TABLE XIV

RAIL, HIGHWAY, AND STRAIGHT-LINE MILEAGE RATIOS

Straight-Line Mileage Block[a]	Ratio of Rail Short-Line to Straight-Line Miles[a]	Ratio of Highway Miles Straight-Line Miles[a]	Ratio of Rail Short-Line to Highway Miles
50- 99 Miles	1.32	1.26	1.05
100- 199 Miles	1.27	1.27	1.00
200- 299 Miles	1.26	1.26	1.00
300- 499 Miles	1.24	1.23	1.01
500- 699 Miles	1.24	1.21	1.02
700- 999 Miles	1.22	1.20	1.02
1,000-1,299 Miles	1.20	1.19	1.01
1,300-1,499 Miles	1.25	1.16	1.08
1,500-1,799 Miles	1.26	1.20	1.05
1,800-1,999 Miles	1.24	1.20	1.03
2,000- Miles	1.23	1.20	1.03

[a]Source: Donald E. Church, PICADAD, A System for Machine Processing of Geographic and Distance Factors in Transportation and Marketing Data, U.S. Department of Commerce Mimeograph (Washington, February 1, 1965), p. 6.

TABLE XV

REGIONAL AND INTERREGIONAL COST-OF-SERVICE TRUCK TRANSPORTATION CHARGES FOR GRAIN AND FLOUR, 1966

Region of Origin	Region of Destination	Transportation Cost Grain	Transportation Cost Flour
		Cents/Bu.-Mile (Wheat Equiv.)	
I	I	.06220	.055308
II	II	.058575	.053807
II	I	.059713	.054277
III	III	.047563	.044662
III	II	.052950	.047863
III	I	.052130	.047894
III	IV	.051538	.047649
III	VI	.044000	.039787
IV	IV	.046138	.049685
V	V	.055525	.051775
V	III	.051950	.048582
V	IV	.055617	.050912
V	VI	.047550	.043091
V	VII	.047850	.045508
VI	VI	.041963	.037004
VI	VII	.042638	.039451
VI	IV	.046650	.041192
VII	VII	.043213	.041560
VIII	VIII	.040063	.035246
VIII	VI	.041075	.036182
VIII	VII	.041850	.038838

TABLE XVI

REGIONAL AND INTERREGIONAL COST-OF-SERVICE RAIL TRANSPORTATION EQUATIONS FOR GRAIN AND FLOUR, 1966

Rail Regions		Total Cost (Wheat Equiv.)	Mileage	Commodity
Origin	Destination			
		Cents/Bu.-Mi.		
I	I	Y = 4.91579 + .04213 X		Grain
		Y = 5.22368 + .03006 X		Flour
II	II	Y = 3.96739 + .024403 X		Grain
		Y = 4.55889 + .01764 X		Flour
II	I	Y = 4.44160 + .02710 X		Grain
		Y = 4.89128 + .02046 X		Flour
II	IV	Y = 3.45284 + .02433 X		Grain
		Y = 4.09197 + .01627 X		Flour
IV	IV	Y = 2.99743 + .02128 X		Grain
		Y = 3.62506 + .01538 X		Flour
VII	VII	Y = 4.20006 + .02373 X		Grain
		Y = 4.80425 + .01748 X		Flour
VII	II	Y = 4.08157 + .02391 X		Grain
		Y = 4.68157 + .01758 X		Flour
VII	IV	Y = 3.59940 + .02252 X		Grain
		Y = 4.21466 + .01673 X		Flour

S = speed in miles per hour downstream,

u = speed in miles per hour upstream,

$= \frac{\xi}{u}$,

B = cost per hour of operation per barge,

λ = backhaul percentage,

n = number of barges in flotilla.

Other operating time cost per loaded barge may be defined as

$$O = K_1 + K_2 + K_3 + K_4 \qquad (4.3)$$

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

$$K_1 = \frac{(n \cdot w \cdot k_1)\ B,}{(1 + \lambda)\ n} \qquad (4.4)$$

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

k_1 = a constant, 96 hours;

K_2 is the make-up and break-up charge per loaded barge equivalent or

$$K_2 = \frac{(n \cdot m \cdot k_2)}{(1 + \lambda)\ n}\ B, \qquad (4.5)$$

where m = number of make-up and break-up operations,

k_2 = a constant of 1.5 hours per barge per operation;

K_3 is the loading and unloading charge per loaded barge equivalent or

$$K_3 = k_3 B,$$

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

K_4 is the fleeting charge[34] per round trip per loaded barge equivalent on movements utilizing the Mississippi River of

$$K_4 = \frac{k_4}{(1 + \lambda) n} , \tag{4.6}$$

where k_4 = the constant, \$480.

Barging costs are developed in Appendix C.

In all instances, the least-cost mode or combination of modes was used as the input for the model.

FOOTNOTES

[1]Mack N. Leath, *An Interregional Analysis of the United States Grain Marketing Industry* (unpublished Ph.D. dissertation, Oklahoma State University, May, 1970).

[2]U. S. Department of Agriculture, *Field and Seed Crops, Production, Farm Use, Sales, Value, By States*, 1965-1966, Statistical Reporting Service Pub. No. CrPr 1 (67) (Washington, May, 1967), pp. 5, 7, 9, 11, 15, and 19.

[3]U. S. Department of Agriculture, *Stocks of Grain in All Positions*, Statistical Reporting Service Pub. No. GrLg 11-1 (1-67) (Washington, January 24, 1967), pp. 4, 6, 8, 10, 14, and 16.

[4]U. S. Department of Agriculture, *Distribution of the Varieties and Classes of Wheat in the United States, Statistical Reporting Service*, Stat. Bul. 369 (Washington, 1964), pp. 55-65.

[5]Throughout the remainder of this study, 1966-67 year will be used to refer to the year July 1, 1966 through June 30, 1967.

[6]See Mack N. Leath, p. 77, for a thorough discussion of the procedure of this paragraph.

[7]H. Wayne Bitting and Robert O. Rogers, "Utilization of Wheat for Food," Agricultural Economics Research, XV (Washington, April, 1963), p. 66-67.

[8]U. S. Department of Agriculture, *National Food Situation, Economic Research Service*, Pub. No. NFS-123 (Washington, February, 1968), p. 16.

[9]U. S. Bureau of the Census, *Current Population Reports, Population Estimates*, Series P-25, Pub. No. 380 (Washington, November 24, 1967), p. 12.

[10]U. S. Treasury Department, *Alcohol and Tobacco Summary Statistics, Fiscal Year 1967*, Internal Revenue Service, Pub. No. 67 (1967) (Washington, 1967), p. 6.

[11]Total durum wheat flour demand was based on a 1966 estimate of 4.98 pounds derived from p. 67 of Bitting and Rogers' article (footnote 7).

[12]U. S. Treasury Department, Pub. 67 (1967), pp. 7, 41.

[13]U. S. Department of Agriculture, Feed Situation, Economic Research Service Pub. Fds-222 (Washington, February, 1968), pp. 8-9.

[14]U. S. Bureau of the Census, Location of Manufacturing Plants by Industry, County and Employment Size: Part 1, Food and Kindred Products, Special Report No. MC63(S)-3.1 (Washington, 1963), pp. 75-76.

[15]U. S. Department of Agriculture, Crop Production, 1967 Annual Summary, Acreage, Yield, Production, By States, Statistical Reporting Service, Pub. No. CrPr2-1 (67) (Washington, December 19, 1967), p. 48.

[16]U. S. Department of Agriculture, Fats and Oils Situation, Economic Research Pub. No. FOS-243 (Washington, June, 1968), p. 24.

[17]U. S. Department of Agriculture, Statistical Reporting Service Pub. No. CrPr 1 (67), p. 18.

[18]The Northwestern Miller (Minneapolis, September, 1967), pp. 20-71.

[19]Mack N. Leath

[20]National Commission of Food Marketing, Organization and Competition in the Milling and Baking Industries, Technical Study No. 5 (Washington, 1966), pp. 37, 117.

[21]U. S. Department of Agriculture, Costs of Storing and Handling Grain in Commercial Elevators, 196-6, Economic Research Service Pub. No. 288 (Washington, April, 1966).

[22]Jeff Maillie and Dale Solum, An Analysis and Evaluation of Factors Which are Deleterious to the Competitive Interests of the Mid-America Wheat Flour Milling Industry (Kansas City, 1968), p. 16.

[23]Interregional and International Trade, Harvard University Press, (Cambridge, 1933), p. 142.

[24]Bruce H. Wright, Regional and Sectoral Analysis of the Wheat-Flour Economy, A Transportation Study, U. S. Department of Agriculture, Economic Research Service, Marketing Research Report No. 858 (Washington, October, 1969).

[25]Household Goods Carriers Bureau, Household Goods Carrier's Bureau, Mileage Guide No. 9, (Washington, December, 1967).

[26]Chicago and Eastern Illinois Railroad, The Fast Freighter (Chicago, 1955).

[27]Rand, McNally and Company, Rand McNally Handy Railroad Atlas of the United States (Chicago, 1965).

[28]St. Louis Southwestern Railway Lines Traffic Department, Southwestern Traffic Manual (St. Louis, 1932).

[29]Short-line mileage may be thought of as the most direct route between two rail points.

[30]Donald E. Church, PICADAD, A System For Machine Processing of Geographic and Distance Factors in Transportation and Marketing Data, U. S. Department of Commerce, Mimeograph, (Washington, February 1, 1965).

[31]U. S. Department of Transportation, Light List, Vol. 5, U. S. Coast Guard, (Washington, 1969).

[32]U. S. Army Corps of Engineers, The Intra-Coastal Waterway-Gulf Section, (Washington, 1961).

[33]U. S. Army Corps of Engineers, The Intra-Coastal Waterway-Atlantic Section, (Washington, 1961).

[34]Feeting as the process of joining barges from the Missouri, Illinois, and Ohio Rivers at points such as St. Louis, Missouri, and Cairo, Illinois into a fleet or flotilla of barges to go down the Mississippi River.

CHAPTER V

ANALYSES

Information on optimum geographical grain flows, regional flour milling activities, and optimum flour distribution patterns are provided by the solution of the model of Chapter III depicting the United States grain marketing system. Additional information which can be derived from the solution pertain to regional price differentials and locational advantage of various production regions, consumption regions, and marketing firms in those regions.

This chapter will present the results of Model I-C, a model utilizing the data of Chapter IV with particular emphasis on cost-of-service transportation charges. This model will then be compared with a similar model by Leath,[1] except that existing transportation rates were used. Let us call Leath's model, Model I-R. Then Model II-C will be presented which differs from Model I-C in that regional milling and storage capacities were not restricted. Finally, Model II-C will be compared with Model I-R.

Model I-C

This section will present the least-cost distribution patterns for grain and flour of the forty-two domestic regions and thirteen export regions delineated in Figure 6, using the supplies, demands, capacities and marketing charges of Chapter IV. Inter-market price differentials for each grain and grain product, which were determined simultaneously will also be presented. The optimum utilization of milling capacity by region and the optimum ending inventories of each grain by region will also be presented in this section.

Optimum Geographical Flows

The optimum geographical flows presented in this section are those flows which should result in the minimum cost of supplying the various regional demands for grain and flour given the supply, demand, estimated cost-of-service transportation charges, and the competitive conditions of 1966-67. Given these data as presented in Chapter IV and assuming they are accurate, no other flow pattern(s) exists which would result in a lower total cost for the United States grain marketing system. In the tables on the optimum geographical flows of grains and flows that follow in this section, Model I-C data are presented in the "Cost" rows. Model I-R data are presented in the "Rate" rows, but will be discussed in a later section of this chapter.

Hard Wheat. Wheat was used for flour milling, export, and seed in this study. Since the optimum source of seed wheat in all regions was from local supplies, no interregional movement of this wheat occurred. Handling costs at the origin were the only costs incurred to satisfy this demand.

The optimum hard wheat shipments to domestic flour mills and to ports of export of Model I-C are presented in the "Cost" rows of Tables XVII and XVIII respectively. The shipments shown in these two

TABLE XVII

OPTIMUM DOMESTIC HARD WHEAT SHIPMENTS FROM SUPPLY REGIONS TO MILLING REGIONS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination												
		2 NY	3 Pa	4 Oh	6 Il	7 Il	8 Mi	10 Mn	11 Mn	13 Ia	14 Mo	15 ND	16 SD	17 Ne
		10,000 Bu.												
3 Pa	Rate		560											
	Cost		560											
	Δ		0											
4 Oh	Rate			42										
	Cost			42										
	Δ			0										
5 In	Rate			157										
	Cost			0										
	Δ			-157										
6 Il	Rate				802									
	Cost				0									
	Δ				-802									
7 Il	Rate					1,860								
	Cost					586								
	Δ					-1,274								
8 Mi	Rate						28							
	Cost						0							
	Δ						-28							
9 Wi	Rate			1,210	0									
	Cost			804	406									
	Δ			-406	406									
10 Mn	Rate	1,767		0			582							
	Cost	0		794			1,555							
	Δ	-1,767		794			973							
11 Mn	Rate								175					
	Cost								0					
	Δ								-175					
12 Ia	Rate								228	92				
	Cost								0	320				
	Δ								-228	228				
13 Ia	Rate									422				
	Cost									422				
	Δ									0				
14 Mo	Rate										1,981			
	Cost										0			
	Δ										-1,981			
15 ND	Rate	0						72	0	0		364		
	Cost	3,800						128	3,924	113		0		
	Δ	3,800						56	3,924	113		-364		
16 SD	Rate								3,521				124	
	Cost								0				126	
	Δ								-3,521				2	
17 Ne	Rate													1,576
	Cost													1,662
	Δ													86
18 Ks	Rate	2,672									0			
	Cost	0									4,353			
	Δ	-2,672									4,353			
19 Ks	Rate													
	Cost													
	Δ													
31 Ok	Rate													
	Cost													
	Δ													
35 Mt	Rate											0		
	Cost											290		
	Δ											290		

TABLE XVII (Continued)

Origin	Transportation Tariff	18 Ks	19 Ks	20 Va	21 NC	22 SC	23 Ga	24 Fl	25 Ky	26 Tn	27 Al	28 Ms	31 Ok
		10,000 Bu.											
3 Pa	Rate												
	Cost												
	Δ												
4 Oh	Rate												
	Cost												
	Δ												
5 In	Rate												
	Cost												
	Δ												
6 Il	Rate							0	0				
	Cost							38	268				
	Δ							38	268				
7 Il	Rate								0				
	Cost								151				
	Δ								151				
8 Mi	Rate												
	Cost												
	Δ												
9 Wi	Rate												
	Cost												
	Δ												
10 Mn	Rate												
	Cost												
	Δ												
11 Mn	Rate							92		1,316			
	Cost							0		0			
	Δ							-92		-1,316			
12 Ia	Rate												
	Cost												
	Δ												
13 Ia	Rate												
	Cost												
	Δ												
14 Mo	Rate						53		268		238		
	Cost						0		0		0		
	Δ						-53		-268		-238		
15 ND	Rate												
	Cost												
	Δ												
16 SD	Rate										0		
	Cost										384		
	Δ										384		
18 Ks	Rate	3,432		205	943	85							
	Cost	3,472		0	0	0							
	Δ	40		-205	-943	-85							
19 Ks	Rate		4,552							0			
	Cost		4,632							371			
	Δ		80							371			
31 Ok	Rate												1,086
	Cost												1,732
	Δ												646

TABLE XVII (Continued)

Origin	Transportation Tariff	Destination								
		32 Tx	33 Tx	34 Tx	36 Mt	37 Wy	38 Co	40 Id	41 Wa	42 Ca
		10,000 Bu.								
16 SD	Rate									
	Cost									
	Δ									
17 Ne	Rate									
	Cost									
	Δ									
18 Ks	Rate		0							
	Cost		852							
	Δ		852							
19 Ks	Rate		182							
	Cost		0							
	Δ		-182							
30 La	Rate									
	Cost									
	Δ									
31 Ok	Rate									
	Cost									
	Δ									
32 Tx	Rate	64								
	Cost	64								
	Δ	0								
33 Tx	Rate		571							
	Cost		0							
	Δ		-571							
34 Tx	Rate			2,392						
	Cost			2,212						
	Δ			-180						
35 Mt	Rate								117	
	Cost								0	
	Δ								-117	
36 Mt	Rate				124					
	Cost				564					
	Δ				440					
37 Wy	Rate					53				
	Cost					126				
	Δ					73				
38 Co	Rate						578			
	Cost						578			
	Δ						0			
40 Id	Rate							1,399		966
	Cost							1,412		945
	Δ							13		-21
41 Wa	Rate								1,868	
	Cost								1,439	
	Δ								-429	
42 Ca	Rate									70
	Cost									70
	Δ									0

TABLE XVIII

OPTIMUM EXPORT HARD WHEAT SHIPMENTS FROM SUPPLY REGIONS TO PORT REGIONS, MODEL I-C AND MODEL I-R, 1966-67

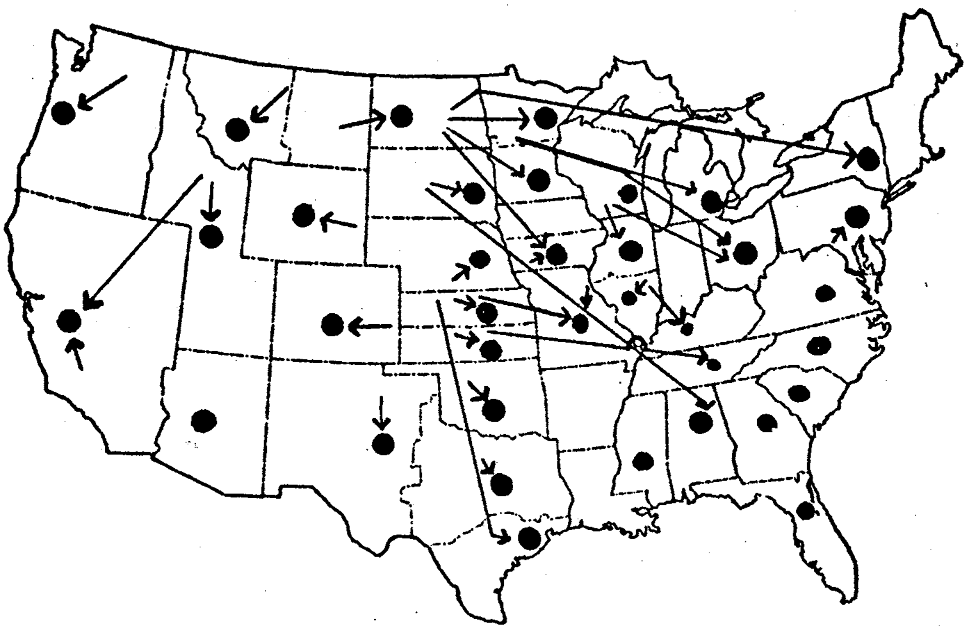
Origin	Transportation Tariff	Destination											
		43 Du	44 Mw	46 Ab	47 Ba	48 Nf	49 Cs	50 NO	51 Ho	52 LB	53 Sk	54 Po	55 Ta
		10,000 Bu.											
2 NY	Rate			0	367								
	Cost			367	0								
	Δ			367	-367								
3 Pa	Rate			0	5								
	Cost			5	0								
	Δ			5	-5								
4 Oh	Rate												
	Cost												
	Δ												
5 In	Rate				0								
	Cost				157								
	Δ				157								
6 Il	Rate				869			0					
	Cost				0			1,671					
	Δ				-869			1,671					
7 Il	Rate			561	0	0	0						
	Cost			0	384	1,270	30						
	Δ			-561	384	1,270	30						
8 Mi	Rate				0								
	Cost				28								
	Δ				28								
9 Wi	Rate		39										
	Cost		39										
	Δ		0										
11 Mn	Rate						151	0					
	Cost						0	1,734					
	Δ						-151	1,734					
14 Mo	Rate							0					
	Cost							2,540					
	Δ							2,540					
15 ND	Rate	1,354		0								37	
	Cost	1,354		443								0	
	Δ	0		443								-37	
17 Ne	Rate			254	2,387	1,270		6,078					
	Cost			0	3,059	0		2,155					
	Δ			-254	672	-1,270		-3,923					

TABLE XVIII (Continued)

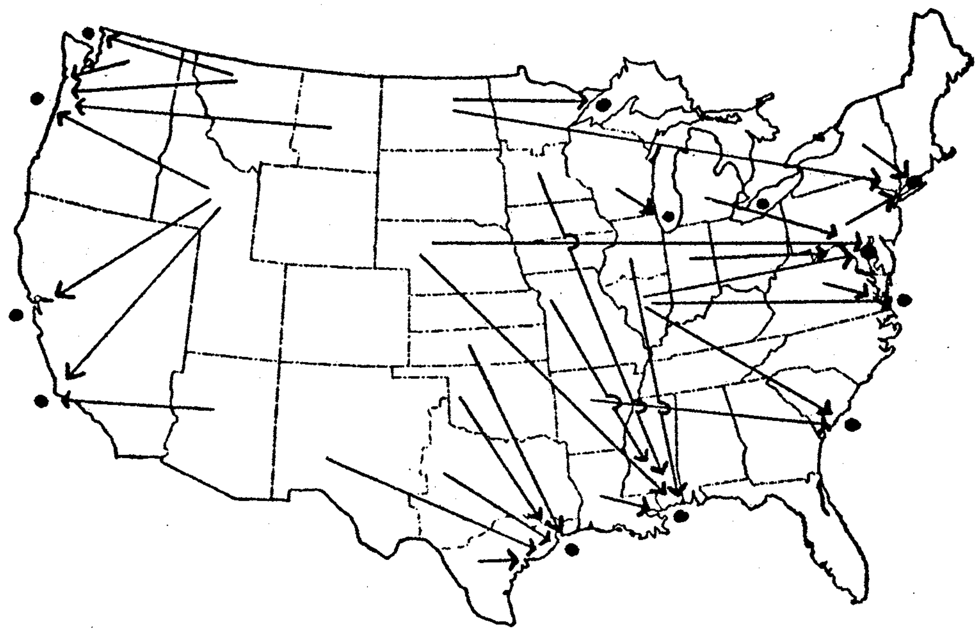
Origin	Transportation Tariff	Destination											
		43 Du	44 Mw	46 Ab	47 Ba	48 Nf	49 Cs	50 NO	51 Ho	52 LB	53 Sk	54 Po	55 Ta
		10,000 Bu.											
19 Ks	Rate							1,901	4,150				
	Cost							0	4,045				
	Δ							-1,901	-105				
20 Va	Rate					55							
	Cost					55							
	Δ					0							
29 Ar	Rate						0	121					
	Cost						121	0					
	Δ						121	-121					
30 La	Rate							85					
	Cost							85					
	Δ							0					
31 Ok	Rate								9,588				
	Cost								8,942				
	Δ								-646				
32 Tx	Rate								6,107				
	Cost								6,107				
	Δ								0				
33 Tx	Rate								0				
	Cost								571				
	Δ								571				
34 Tx	Rate								970				
	Cost								1,150				
	Δ								180				
35 Mt	Rate											1,352	
	Cost											915	
	Δ											-437	
36 Mt	Rate											4,421	0
	Cost											3,148	1,289
	Δ											-1,273	1,289
39 Az	Rate									0			
	Cost									21			
	Δ									21			
40 Id	Rate									34	17	0	
	Cost									13	17	29	
	Δ									-21	0	29	
41 Wa	Rate											0	1,289
	Cost											1,718	0
	Δ											1,718	-1,289

tables were determined simultaneously since domestic millers and exporters compete for the available hard wheat. The domestic movements of Table XVII are presented as flows in Section A of Figure 9. Examination of this figure reveals that the majority of the movements were within the West North Central states.[2] Other major movements were from the West North Central states to the East North Central states, Ohio and Michigan. There were only three interregional movements to states east of the Mississippi River and south of the Ohio River. These movements were from North Central states to Kentucky, Tennessee, and Alabama. Of particular note is the single movement to the Atlantic Coastal states, the movement from North Dakota to New York mills of 38 million bushels. One other long-distant movement is quite noticeable, a movement by rail-barge combination from northern Kansas to southern Texas. The only interregional movement with a westerly direction was from Utah-Idaho to California mills. Northern Minnesota was the only region that transhipped hard wheat.

The export shipments of hard wheat presented in Table XVIII are shown as flows in Figure 9, Section B. In general, the export demands for hard wheat were satisfied from a relatively few supply points. North Dakota was the sole supplier to Duluth-Superior and Wisconsin was the only shipper to Chicago-Milwaukee. Albany received hard wheat from three regions, North Dakota, New York, and Pennsylvania, in that order of magnitude of shipments. Baltimore received in excess of 30 million bushels of its approximately 36 million bushels requirement from Nebraska with the remainder coming from southern Illinois, Indiana, and Michigan in that order of magnitudes shipped. Southern Illinois shipped approximately 96 percent of the requirement of



Section A. Domestic Flows



Section B. Export Flows

Figure 9. Optimum Flow Patterns for Hard Wheat, Model I-C, 1966-67

Norfolk, with nearby Virginia supplying the remaining 4 percent. North Charleston received about 80 percent of its requirements from Southern Illinois and the remaining 20 percent from Arkansas. The two Gulf ports, New Orleans and Houston, received greater numbers of shipments than the other ports. Missouri, Nebraska, southern Minnesota, and northern Illinois were the major shippers to New Orleans with that respective order of volumes shipped. Of the five shippers to Houston, Oklahoma, western Texas, and southern Kansas were the major suppliers. The Pacific ports shipped less volume than the Gulf ports and also received fewer shipments. Long Beach received from Arizona and Utah-Idaho, Stockton from Utah-Idaho, Portland from Washington-Oregon, eastern and western Montana and Utah-Idaho. Tacoma received from western Montana. The three major movements to Pacific ports in order of volume shipped were from western Montana to Portland, Washington-Oregon to Portland, and western Montana to Tacoma.

Hard-Wheat Flour. Flour storage was not included in the model, thus the volume of flour shipped from particular mills was equivalent to the volume of wheat received at those mills.

The optimum domestic hard-wheat flour shipments of Model I-C are presented in Table XIX and are presented as flows in Section A of Figure 10. The predominant flows were to the East and South. Most noticeable were the movements from the two Kansas regions and Missouri to states in the South and also from Missouri and northern Kansas to Pennsylvania and Indiana. Other noticeable flows were from southern Minnesota to nearby Wisconsin and northern Illinois, and more-distant New York. The major interregional movements of hard-wheat flour in the Western states were from mills in Washington-Oregon, Utah-Idaho,

TABLE XIX

OPTIMUM DOMESTIC HARD-WHEAT FLOUR SHIPMENTS FROM MILLING REGIONS TO DEMAND REGIONS, MODEL I-C AND MODEL I-R, 1966-67

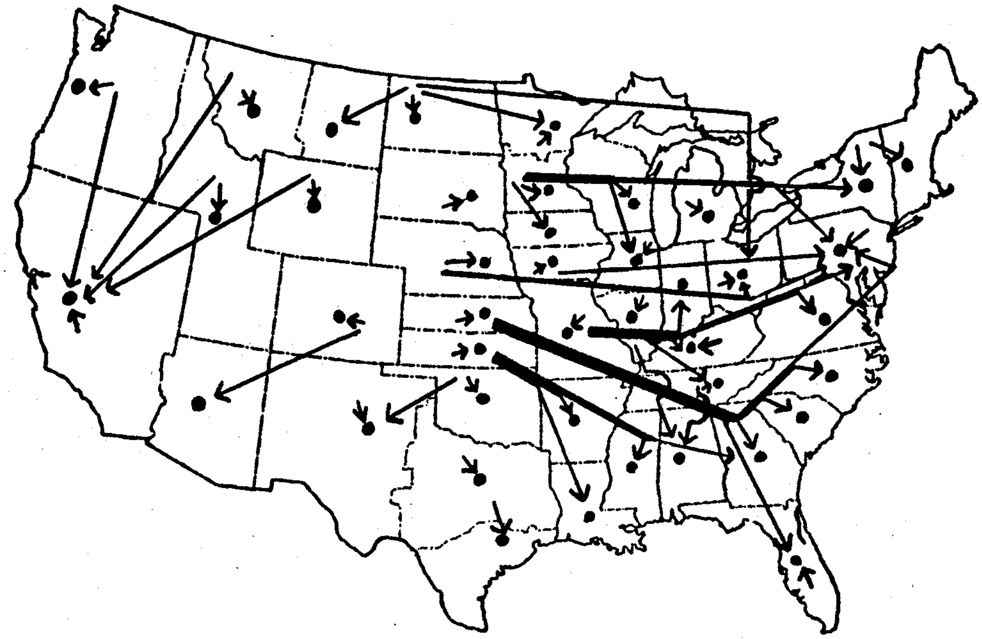
Origin	Transportation Tariff	1 NE	2 NY	3 Pa	4 Oh	5 In	6 Il	7 Il	8 Mi	9 Wi	10 Mn	11 Mn	12 Ia	13 Ia	14 Mo	15 ND	16 SD	17 Ne	18 Ks	19 Ks
		Destination (10,000 Bu.)																		
2 NY	Rate	1,696	2,743																	
	Cost	1,696	2,104																	
	Δ	0	-639																	
3 Pa	Rate			560																
	Cost			560																
	Δ			0																
4 Oh	Rate				1,409															
	Cost				1,640															
	Δ				231															
6 Il	Rate						768													
	Cost						406													
	Δ						-362													
7 Il	Rates			1,510				0												
	Cost			0				439												
	Δ			-1,510				439												
8 Mi	Rate			58					552											
	Cost			0					1,555											
	Δ			-58					1,003											
10 Mn	Rate										72									
	Cost										128									
	Δ										56									
11 Mn	Rate		0	0		893	760		1,003	768		500	0							
	Cost		685	620		0	1,122		0	768		500	195							
	Δ		685	620		-893	362		-1,003	0		0	195							
13 Ia	Rate			0									195	319						
	Cost			536									0	319						
	Δ			536									-195	0						
14 Mo	Rate			0	460	0		439							814					
	Cost			298	0	893		0							814					
	Δ			298	-460	893		-439							0					
15 ND	Rate			140	0						75					120	2			
	Cost			0	83						19					120	0			
	Δ			-140	83						-56					0	-2			
16 SD	Rate																124			
	Cost																126			
	Δ																2			
17 Ne	Rate			1,124	0													271		
	Cost			1,245	146													271		
	Δ			121	146													0		
18 Ks	Rate			385															267	
	Cost			518															267	
	Δ			133															0	
19 Ks	Rate		46																	267
	Cost		0																	267
	Δ		-46																	0

TABLE XIX (Continued)

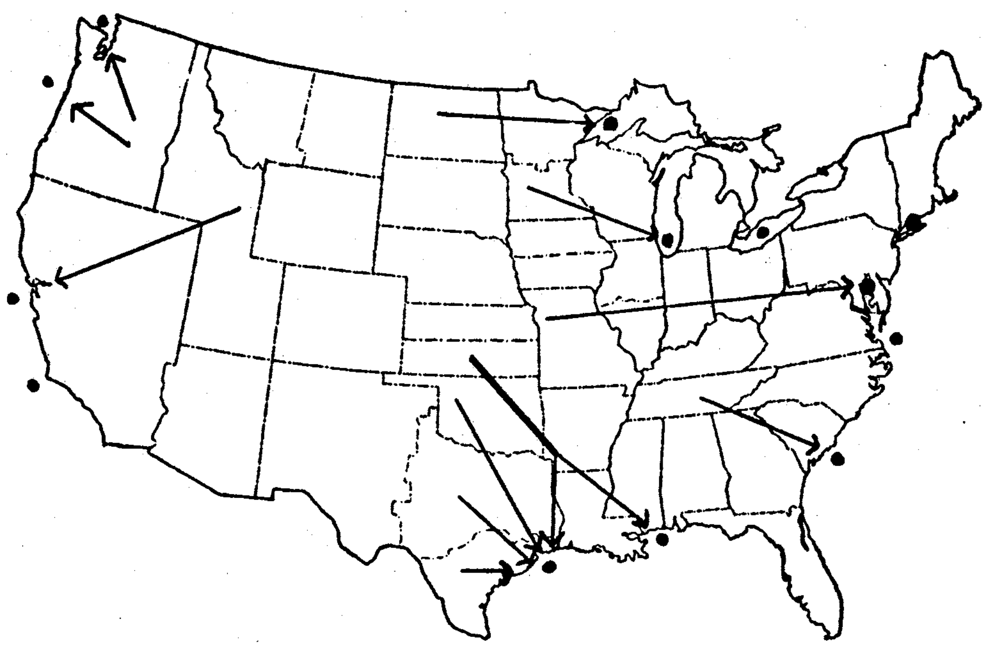
Origin	Transportation Tariff	20 Va	21 NC	22 SC	23 Ga	24 Fl	25 Ky	26 Tn	27 Al	28 Ms	29 Ar	30 La	31 Ok	32 Tx	33 Tx	34 Tx	35 Mt	36 Mt	37 Wy
		Destination (10,000 Bu.)																	
7 Il	Rate						350		0										
	Cost						0		147										
	Δ						-350		147										
14 Mo	Rate	0					0	0		268									
	Cost	1,200					467	500		0									
	Δ	1,200					467	500		-268									
15 ND	Rate																0		
	Cost																41		
	Δ																41		
18 Ks	Rate		32	410	0	952					363	657							
	Cost		936	495	212	1,044					0	0							
	Δ		904	85	212	92					-363	-657							
19 Ks	Rate	995			450					0	0	0							
	Cost	0			599					451	363	657							
	Δ	-995			149					451	363	657							
20 Va	Rate	205																	
	Cost	0																	
	Δ	-205																	
21 NC	Rate		904																
	Cost		0																
	Δ		-904																
22 SC	Rate			85															
	Cost			0															
	Δ			-85															
23 Ga	Rate				53														
	Cost				0														
	Δ				-53														
24 Fl	Rate					92													
	Cost					38													
	Δ					-54													
25 Ky	Rate						268												
	Cost						151												
	Δ						-117												
26 Tn	Rate				191			715	410										
	Cost				0			215	117										
	Δ				-191			-500	-293										
27 Al	Rate								238										
	Cost								384										
	Δ								146										
31 Ok	Rate				117					183			453	333					
	Cost				0					0			453	333					
	Δ				-117					-183			0	0					
32 Tx	Rate													64					
	Cost													64					
	Δ													0					
33 Tx	Rate														753				
	Cost														0				
	Δ														-753				
34 Tx	Rate														0	989			
	Cost														753	989			
	Δ														753	0			
36 Mt	Rate																41	83	
	Cost																0	83	
	Δ																-41	0	
37 Wy	Rate																		53
	Cost																		53
	Δ																		0

TABLE XIX (Continued)

Origin	Transportation Tariff	Destination				
		38 Co	39 Az	40 Ut	41 Wa	42 Ca
		10,000 Bu.				
36 Mt	Rate					0
	Cost					481
	Δ					481
37 Wy	Rate					0
	Cost					73
	Δ					73
38 Co	Rate	320	258			
	Cost	320	258			
	Δ	0	0			
40 Ut	Rate			291		1,074
	Cost			291		1,087
	Δ			0		13
41 Wa	Rate				847	928
	Cost				847	382
	Δ				0	-546
42 Ca	Rate					1,036
	Cost					1,015
	Δ					-21



Section A. Domestic Flows



Section B. Export Flows

Figure 10. Optimum Flow Patterns for Hard-Wheat Flour, Model I-C, 1966-67

western Montana, and Wyoming to California. Movement also occurred between Colorado mills and Arizona population centers, both Mountain states. The only other westerly-interregional movements were from North Dakota mills to neighboring eastern Montana and from Oklahoma mills to neighboring western Texas. It is interesting to note that Tennessee and New York transhipped hard-wheat flour. New York shipped more flour to New England than it received from southern Minnesota and Tennessee shipped less flour to Alabama than it received from Missouri.

The optimum export shipments of hard-wheat flour of Table XX are presented as flows in Figure 10, Section B. The major demands for hard-wheat flour were the Gulf Ports, New Orleans and Houston. Houston was the only port receiving hard-wheat flour from more than one milling region. Oklahoma and southern Kansas supplied nearly equal amounts to Houston, with southern Texas slightly less, and eastern Texas supplying slightly more than half the quantity of either Oklahoma or southern Kansas. Missouri mills were the most distant export shippers of hard-wheat flour, shipping to Baltimore. The Pacific ports of Portland and Tacoma were the only ports receiving their entire requirements from adjacent-state mills.

Soft Wheat. Soft wheat seed requirements, like hard wheat seed requirements were satisfied from local supplies. The major volume-movements of soft wheat were intraregional movements. The shipments of domestic soft wheat are presented in Table XXI. The corresponding flows are presented in Figure 11, Section A. Examination of this figure reveals that the majority of the interregional soft-wheat movements were in a westerly or southerly direction. There were only two exceptions to this generalization, a movement from eastern

TABLE XX

OPTIMUM EXPORT HARD-WHEAT FLOUR SHIPMENTS FROM MILLING REGIONS TO DEMAND PORTS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination								
		43 Du	44 Ch	47 Ba	49 Cs	50 NO	51 Ho	53 Sk	54 Po	55 Ta
		10,000 Bu.								
6 Il	Rate		34							
	Cost		0							
	Δ		-34							
11 Mn	Rate		0							
	Cost		34							
	Δ		34							
14 Mo	Rate			0						
	Cost			181						
	Δ			181						
15 ND	Rate	27								
	Cost	27								
	Δ	0								
17 Ne	Rate			181						
	Cost			0						
	Δ			-181						
18 Ks	Rate					366				
	Cost					0				
	Δ					-366				
19 Ks	Rate					1,301	1,793			
	Cost					1,367	928			
	Δ					366	-865			
21 NC	Rate				39					
	Cost				0					
	Δ				-39					
26 Tn	Rate				0					
	Cost				39					
	Δ				39					
31 Ok	Rate						0			
	Cost						946			
	Δ						946			
33 Tx	Rate						0			
	Cost						852			
	Δ						852			
34 Tx	Rate						1,403			
	Cost						470			
	Δ						-933			
40 Ut	Rate							34		
	Cost							34		
	Δ							0		
41 Wa	Rate								123	87
	Cost								123	87
	Δ								0	0

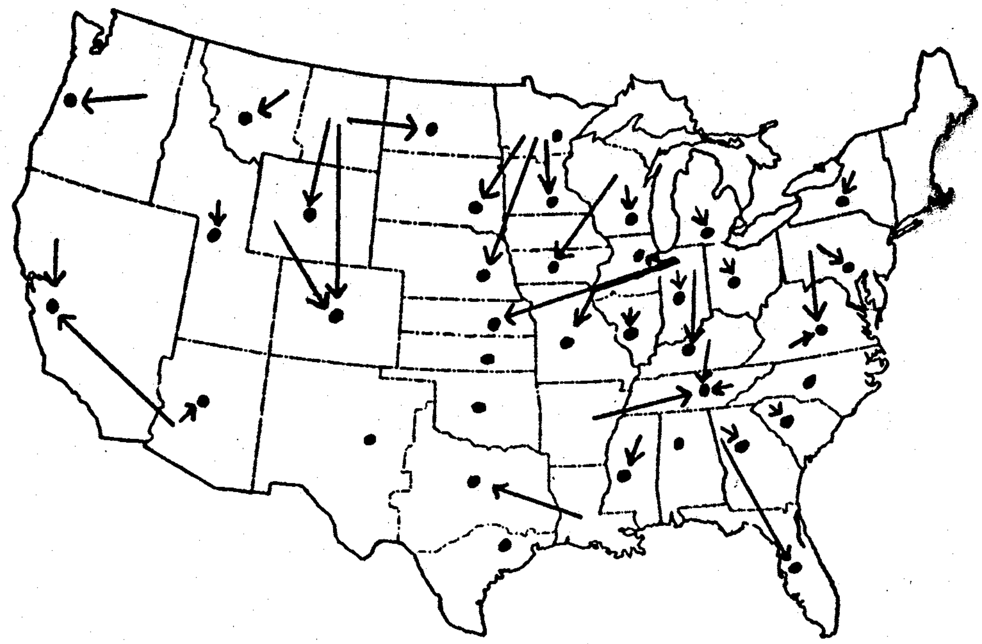
TABLE XXI

OPTIMUM DOMESTIC SOFT WHEAT SHIPMENTS FROM SUPPLY REGIONS TO MILLING REGIONS, MODEL I-C AND MODEL I-R, 1966-67

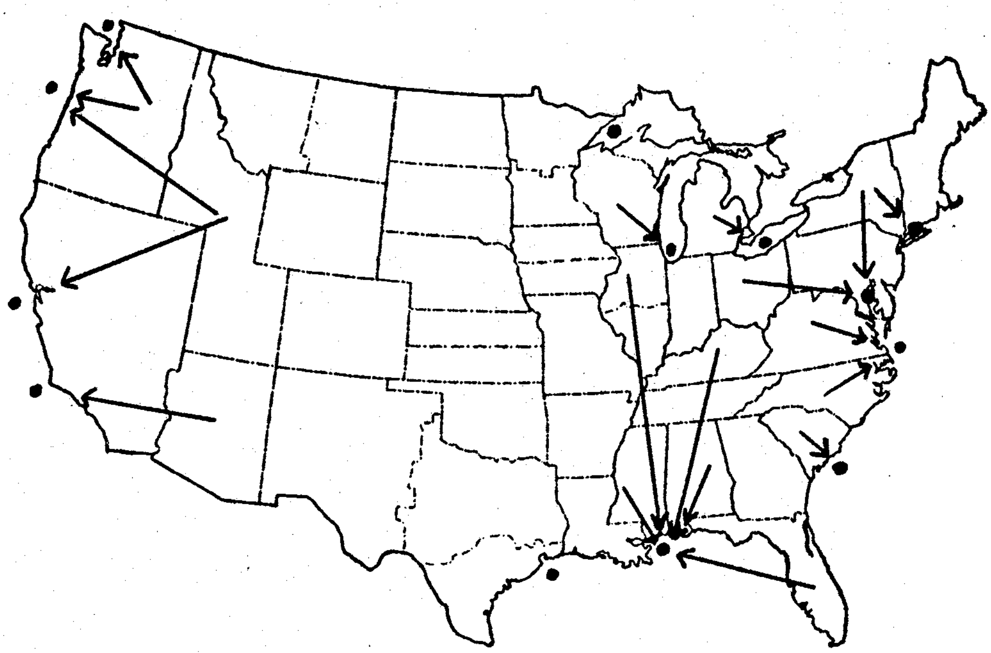
Origin	Transportation Tariff	Destination																	
		2 NY	3 Pa	4 Oh	5 In	6 Il	7 Il	8 Mi	9 Wi	10 Mn	11 Mn	13 Ia	14 Mo	15 ND	16 SD	17 Ne	18 Ks	19 Ks	20 Va
		10,000 Bu.																	
2 NY	Rate Cost Δ	1,157 1,635 478																	
3 Pa	Rate Cost Δ		1,448 1,448 0																0 421 421
4 Oh	Rate Cost Δ			2,215 1,984 -231															
5 In	Rate Cost Δ				1,660 1,660 0	0 870 870				36 0 -36		128 0 -128	0 627 627			104 0 -104	120 80 -40	80 0 -80	
6 Il	Rate Cost Δ																		
7 Il	Rate Cost Δ						0 1,274 1,274												
8 Mi	Rate Cost Δ					474 0 -474		1,162 217 -945											
9 Wi	Rate Cost Δ								8 8 0			0 369 369							
10 Mn	Rate Cost Δ									20 0 -20	192 192 0			48 0 -48	0 50 50	0 18 18			
14 Mo	Rate Cost Δ												2,125 0 -2,125						
20 Va	Rate Cost Δ																		467 132 -335
35 Mt	Rate Cost Δ													0 122 122	52 0 -52				

TABLE XXI (Continued)

Origin	Transportation Tariff	Destination																	
		21 NC	22 SC	23 Ga	24 Fl	25 Ky	26 Tn	27 Al	28 Ms	31 Ok	33 Tx	34 Tx	36 Mt	37 Wy	38 Co	39 Az	40 Id	41 Wa	42 Ca
		10,000 Bu.																	
5 In	Rate					0													
	Cost					117													
	Δ					117													
6 Il	Rate						32		24	164									
	Cost						0		0	0									
	Δ						-32		-24	-164									
21 NC	Rate	373	24																
	Cost	0	0																
	Δ	-373	-24																
22 SC	Rate		163																
	Cost		148																
	Δ		-15																
23 Ga	Rate			175	0														
	Cost			27	148														
	Δ			-148	148														
24 Fl	Rate				56														
	Cost				0														
	Δ				-56														
25 Ky	Rate						0												
	Cost						66												
	Δ						66												
26 Tn	Rate						396												
	Cost						396												
	Δ						0												
27 Al	Rate							146											
	Cost							0											
	Δ							-146											
28 Ms	Rate								0										
	Cost								24										
	Δ								24										
29 Ar	Rate						0												
	Cost						911												
	Δ						911												
30 La	Rate										99	0							
	Cost										0	180							
	Δ										-99	180							
35 Mt	Rate													107	0				
	Cost													34	113				
	Δ													-73	113				
36 Mt	Rate												52						
	Cost												36						
	Δ												-16						
37 Wy	Rate														13				
	Cost														13				
	Δ														0				
39 Az	Rate															48			0
	Cost															48			21
	Δ															0			21
40 Id	Rate																201		
	Cost																188		
	Δ																-13		
41 Wa	Rate																	707	
	Cost																	699	
	Δ																	-8	
42 Ca	Rate																		1,048
	Cost																		1,048
	Δ																		0



Section A. Domestic Flows



Section B. Export Flows

Figure 11. Optimum Flow Patterns for Soft Wheat, Model I-C, 1966-67

Montana to North Dakota, and a movement from Arkansas to Tennessee.

The export shipments of soft wheat are presented in Table XXII with the corresponding flows presented in Figure 11, Section B. Seven of the eleven ports with soft-wheat requirements received shipments from a single adjacent state, with the exception of Long Beach which received its 80,000 bushels requirement from neighboring Arizona. The soft wheat received at New Orleans was shipped from three major sources, nearby-Mississippi, northern Illinois, and Kentucky, in that order of importance. The shipments from Mississippi and Kentucky were truck-barge combination movements while the shipments from northern Illinois were by barge alone. Lesser quantities came by rail from Oklahoma and Florida. Portland received over 99 percent of its approximately 93 million bushels requirement from adjacent Washington-Oregon, with the remainder shipped from Utah-Idaho. Baltimore was the only port receiving the major portion of its requirements from a single distant origin. Ohio shipped in excess of 90 percent of the over 11 million bushels required at Baltimore. New York shipped the remaining requirements.

Soft-Wheat Flour. The domestic shipments of soft-wheat flour are presented in Table XXIV. The flows of domestic soft-wheat flour are given in Figure 12, Section A. The number of interregional shipments of soft-wheat flour originating from mills in Indiana and Ohio are quite noticeable in Figure 12, Section A. Ohio and Indiana, in that order, were the largest volume millers of soft-wheat flour in Model I-C. Interregional shipments from Ohio were to the South Atlantic states with the exception of a movement to Michigan. Interregional movements from Indiana mills were to states in the South,

TABLE XXII

OPTIMUM EXPORT SOFT WHEAT SHIPMENTS FROM SUPPLY REGIONS TO PORT REGIONS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination										
		44 Mw	45 To	46 Ab	47 Ba	48 Nf	49 Cs	50 NO	52 LB	53 Sk	54 Po	55 Ta
		10,000 Bu.										
2 NY	Rate			0	953							
	Cost			364	111							
	Δ			364	-842							
3 Pa	Rate				170							
	Cost				0							
	Δ				-170							
4 Oh	Rate			364	0	747						
	Cost			0	1,012	0						
	Δ			-364	1,012	-747						
5 In	Rate							191				
	Cost							0				
	Δ							-191				
6 Il	Rate							408				
	Cost							628				
	Δ							220				
7 Il	Rate							1,274				
	Cost							0				
	Δ							-1,274				
8 Mi	Rate		1,308									
	Cost		1,308									
	Δ		0									
9 Wi	Rate	97										
	Cost	97										
	Δ	0										
14 Mo	Rate							0				
	Cost							2,125				
	Δ							2,125				
20 Va	Rate					0						
	Cost					335						
	Δ					335						
21 NC	Rate					0	15					
	Cost					412	0					
	Δ					412	-15					
22 SC	Rate						0					
	Cost						15					
	Δ						15					
23 Ga	Rate											
	Cost											
	Δ											
24 Fl	Rate							0				
	Cost							56				
	Δ							56				
25 Ky	Rate							511				
	Cost							445				
	Δ							-66				
26 Tn	Rate											
	Cost											
	Δ											
27 Al	Rate							0				
	Cost							146				
	Δ							146				
28 Ms	Rate							664				
	Cost							640				
	Δ							-24				
29 Ar	Rate							911				
	Cost							0				
	Δ							-911				
30 La	Rate							81				
	Cost							0				
	Δ							-81				
39 Az	Rate								0			
	Cost								8			
	Δ								8			
40 Id	Rate								8	12	82	
	Cost								0	12	74	
	Δ								-8	0	-8	
41 Wa	Rate										9,223	2,354
	Cost										9,231	2,354
	Δ										8	0

TABLE XXIII

OPTIMUM DOMESTIC SOFT-WHEAT FLOUR SHIPMENTS FROM MILLING REGIONS TO DEMAND REGIONS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination																	
		1 NE	2 NY	3 Pa	4 Oh	5 In	6 Il	7 Il	8 Mi	9 Wi	10 Mn	11 Mn	12 Ia	13 Ia	14 Mo	15 ND	16 SD	17 Ne	18 Ks
		10,000 Bu.																	
2 NY	Rate	560	597																
	Cost	560	920																
	Δ	0	323																
3 Pa	Rate			1,448															
	Cost			1,448															
	Δ			0															
4 Oh	Rate		323		696				0										
	Cost		0		696				359										
	Δ		-323		0				359										
5 In	Rate					340	354	160											
	Cost					340	0	0											
	Δ					0	-354	-160											
6 Il	Rate						210			0									
	Cost						564			288									
	Δ						354			288									
7 Il	Rate							0											
	Cost							160											
	Δ							160											
8 Mi	Rate								576	288			80						
	Cost								217	0			0						
	Δ								-359	-288			-80						
9 Wi	Rate									8									
	Cost									8									
	Δ									0									
10 Mn	Rate										56								
	Cost										0								
	Δ										-56								
11 Mn	Rate											192							
	Cost											192							
	Δ											0							
13 Ia	Rate												0	128				0	
	Cost												80	128				86	
	Δ												80	0				86	
14 Mo	Rate														312				
	Cost														312				
	Δ														0				
15 ND	Rate										0					48	0		
	Cost										56					48	2		
	Δ										56					0	2		
16 SD	Rate																52		
	Cost																50		
	Δ																-2		
17 Ne	Rate																	104	
	Cost																	18	
	Δ																	-86	
18 Ks	Rate																		80
	Cost																		80
	Δ																		0

TABLE XXIII (Continued)

Origin	Transportation Tariff	19 Ks	20 Va	21 NC	22 SC	23 Ga	24 Fl	25 Ky	26 Tn	27 Al	28 Ms	29 Ar	30 La	31 Ok	32 Tx	33 Tx	34 Tx	35 Mt	36 Mt
		Destination 10,000 Bu.																	
2 NY	Rate		0																
	Cost		155																
	Δ		155																
4 Oh	Rate		241		109	305	528												
	Cost		0		148	230	436												
	Δ		-241		39	-75	-92												
5 In	Rate					0		376		246	0		0						
	Cost					223		259		392	264		95						
	Δ					223		-117		146	264		95						
6 Il	Rate										264								
	Cost										0								
	Δ										-264								
7 Il	Rate			0											0		0		
	Cost			568											204		342		
	Δ			568											204		342		
8 Mi	Rate			195															
	Cost			0															
	Δ			-195															
13 Ia	Rate	0																	
	Cost	75																	
	Δ	75																	
14 Mo	Rate	0										224	384	100	204	333	568		
	Cost	5										0	0	264	0	0	46		
	Δ	5										-224	-384	164	-204	-333	-522		
15 ND	Rate																	0	
	Cost																	16	
	Δ																	16	
19 Ks	Rate	80																	
	Cost	0																	
	Δ	-80																	
20 Va	Rate		467																
	Cost		553																
	Δ		86																
21 NC	Rate			373															
	Cost			0															
	Δ			-373															
22 SC	Rate				187														
	Cost				148														
	Δ				-39														
23 Ga	Rate					175													
	Cost					27													
	Δ					-148													
24 Fl	Rate						56												
	Cost						148												
	Δ						-92												
25 Ky	Rate							0											
	Cost							117											
	Δ							117											
26 Tn	Rate								428			0	0			0			
	Cost								428			224	289			432			
	Δ								0			224	289			432			
27 Al	Rate									146									
	Cost									0									
	Δ									-146									
28 Ms	Rate										24								
	Cost										24								
	Δ										0								
31 Ok	Rate													164					
	Cost													0					
	Δ													-164					
33 Tx	Rate															99			
	Cost															0			
	Δ															-99			
34 Tx	Rate																0		
	Cost																180		
	Δ																180		
36 Mt	Rate																	16	36
	Cost																	0	36
	Δ																	-16	0

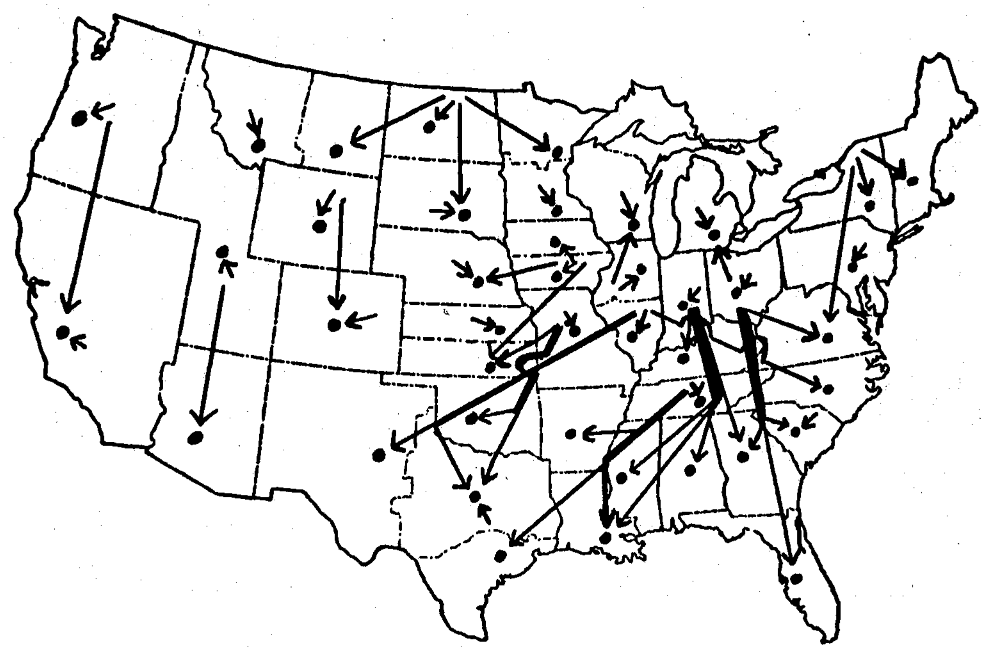
TABLE XXIII (Continued)

Origin	Transportation Tariff	Destination					
		37 Wy	38 Co	39 Az	40 Ut	41 Wa	42 Ca
		10,000 Bu.					
18 Ks	Rate		40				
	Cost		0				
	Δ		-40				
37 Wy	Rate	24	83				
	Cost	24	10				
	Δ	0	-73				
38 Co	Rate		13				
	Cost		126				
	Δ		113				
39 Az	Rate			48			
	Cost			48			
	Δ			0			
40 Ut	Rate			60	128		13
	Cost			60	128		0
	Δ			0	0		-13
41 Wa	Rate					364	223
	Cost					364	215
	Δ					0	-8
42 Ca	Rate						1,048
	Cost						1,069
	Δ						21

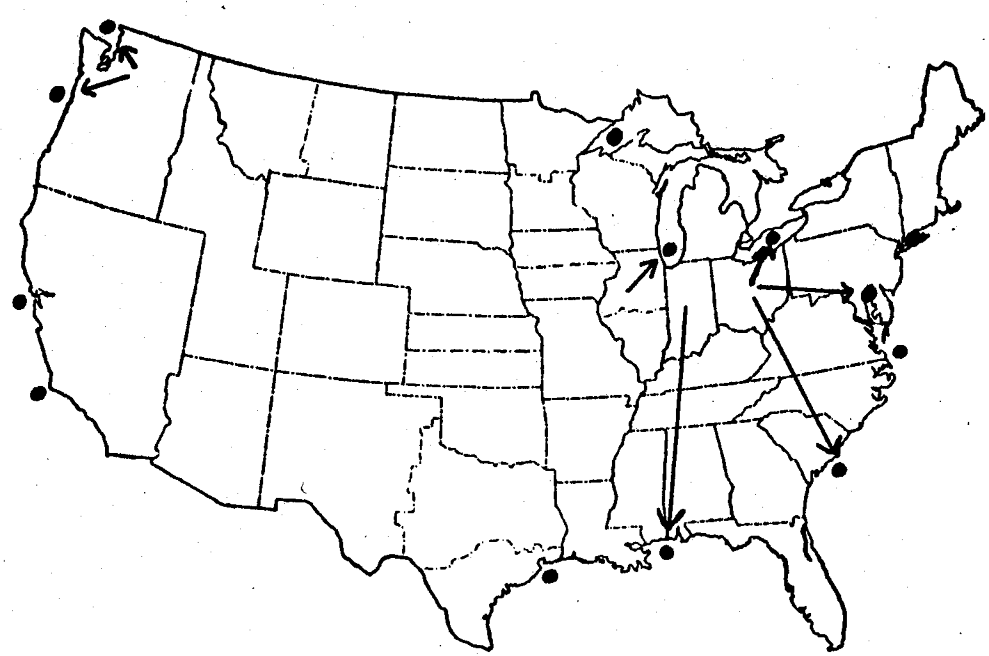
TABLE XXIV

OPTIMUM EXPORT SOFT-WHEAT FLOUR SHIPMENTS FROM MILLING REGIONS TO DEMAND PORTS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination						
		44 Ch	45 To	47 Ba	49 Cs	50 NO	54 Po	55 Ta
		10,000 Bu.						
4 Oh	Rate		0	0	13			
	Cost		23	79	13			
	Δ		23	79	0			
5 In	Rate	18		79		87		
	Cost	0		0		87		
	Δ	-18		-79		0		
6 Il	Rate	0						
	Cost	18						
	Δ	18						
8 Mi	Rate		23					
	Cost		0					
	Δ		-23					
41 Wa	Rate							82 38
	Cost							82 38
	Δ							0 0



Section A. Domestic Flows



Section B. Export Flows

Figure 12. Optimum Flow Patterns for Soft-Wheat Flour, Model I-C, 1966-67

primarily to the East South Central States. Tennessee was the only milling region in the South with interregional shipments of soft-wheat flour. Tennessee was the fifth largest volume miller of soft wheat after third-and fourth-volume millers, New York and Pennsylvania. Tennessee's interregional shipments were exclusively to the West South Central states. The interregional movements from southern Illinois, the sixth largest volume miller of soft wheat, are also quite noticeable in Figure 12, Section A, going southwesterly to the state of Texas and southeasterly to North Carolina. The only interregional movements of soft-wheat flour in a northerly direction were from southern Iowa to northern Iowa, northern Illinois to Wisconsin, and from Ohio to Michigan. There were no transhipments of soft-wheat flour. Figure 12, Section A, and Table XXIII show that soft-wheat flour was milled primarily in areas of soft-wheat production.

The export shipments of soft-wheat flour are presented in Table XXIV. Figure 12, Section B, presents the flows. Only 3.4 million bushels' grind of soft-wheat flour were exported in 1966-67. Requirements at Chicago-Milwaukee were supplied by northern Illinois and Toledo was supplied by Ohio. The only Atlantic ports having soft-wheat flour demands, Baltimore and North Charleston, were also supplied by Ohio mills. Indiana mills satisfied the demands at New Orleans and Washington-Oregon mills supplied the Pacific ports, Portland and Tacoma.

Durum Wheat. The number of durum-wheat movements was quite limited compared with soft-wheat and hard-wheat movements. This is due in part to the limited production area of durum wheat and to the limited number of specialized durum-wheat mills. The domestic shipments of durum wheat represent movements to satisfy requirements of both processing and seed. These shipments are presented in Table XXV and further shown as flows in Figure 13, Section A. The interregional movements which occurred were from north Minnesota to southern Minnesota, from North Dakota to New York and Wisconsin, from eastern Montana to North Dakota and Washington-Oregon, and from western Montana and California to Washington-Oregon. Figure 13, Section A, shows that North Dakota transhipped durum wheat.

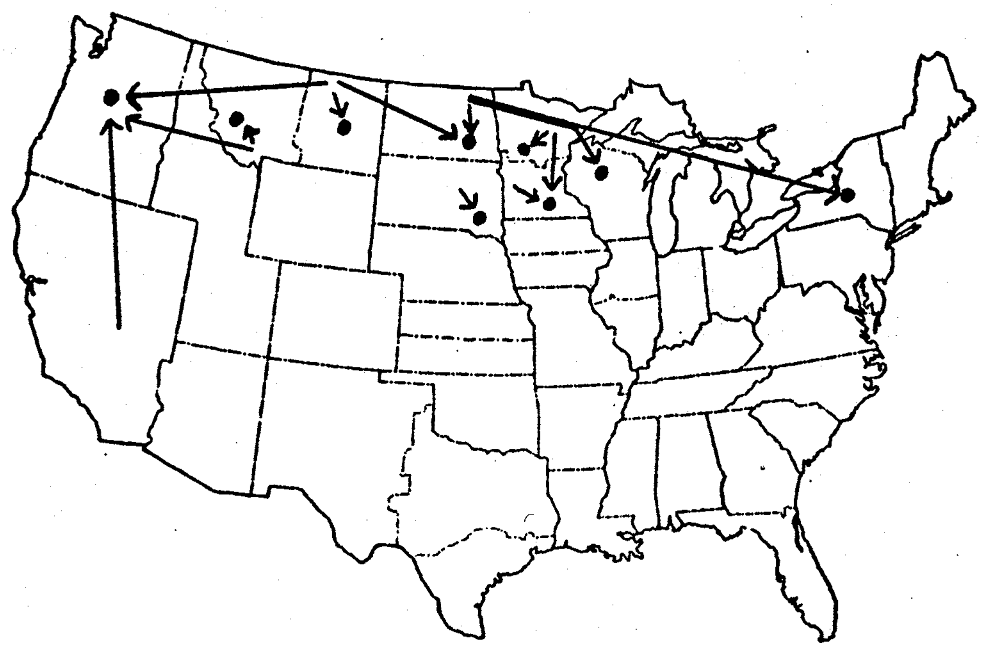
Table XXVI shows that North Dakota was the major exporter of durum wheat. Figure 13, Section B, shows the flows of durum wheat to ports of export. North Dakota was the sole supplier to Duluth-Superior, the major demand of export durum wheat, and to Albany and Norfolk. Southern Minnesota was the primary shipper to Baltimore with North Dakota shipping a minor quantity in comparison. Southern Minnesota was the sole supplier to the Gulf ports, New Orleans and Houston. Eastern Montana supplied Portland, the only Pacific port-demand for durum wheat.

Feed Grain. Examination of Table XXVII will reveal the optimum domestic feed grain shipments to satisfy the demands of the various regions. Figure 14 presents these shipments as flows. A study of Figure 14 gives the image of a flow to the southeast corner of the diagram. Of the many interregional shipments represented, the predominant flow of domestic feed grain is from the North Central states to the South. Deficits in the Northeastern states were satisfied by shipments from Ohio, Indiana, Michigan, and northern Iowa. Ohio also shipped to Virginia-West Virginia.

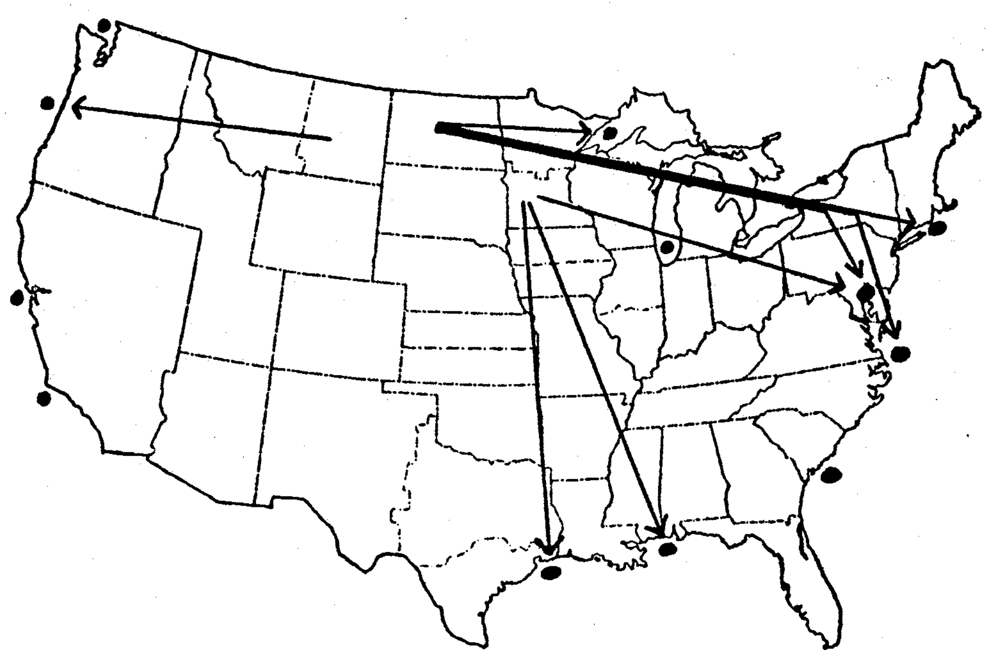
TABLE XXV

OPTIMUM DOMESTIC DURUM WHEAT SHIPMENTS FROM SUPPLY REGIONS TO MILLING REGIONS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination								
		2 NY	9 Wi	10 Mn	11 Mn	15 ND	16 SD	35 Mt	36 Mt	41 Wa
		10,000 Bu.								
10 Mn	Rate	240	508	11	927					
	Cost	0	0	11	379					
	Δ	-240	-508	0	-548					
11 Mn	Rate				9					
	Cost				557					
	Δ				548					
15 ND	Rate	0	0			534				
	Cost	240	508			412				
	Δ	240	508			-122				
16 SD	Rate						20			
	Cost						20			
	Δ						0			
35 Mt	Rate					0		12		141
	Cost					122		12		111
	Δ					122		0		-30
36 Mt	Rate								8	223
	Cost								8	223
	Δ								0	0
42 Ca	Rate									0
	Cost									30
	Δ									30



Section A. Domestic Flows



Section B. Export Flows

Figure 13. Optimum Flow Patterns for Durum Wheat, Model I-C, 1966-67

TABLE XXVI

OPTIMUM EXPORT DURUM WHEAT SHIPMENTS FROM SUPPLY REGIONS TO PORT REGIONS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination						
		43 Du	46 Ab	47 Ba	48 Nf	50 NO	51 Ho	54 Po
		10,000 Bu.						
11 Mn	Rate		83	0	709	729	70	
	Cost		0	244	0	729	70	
	Δ		-83	244	-709	0	0	
15 ND	Rate	2,749	0	0	0			
	Cost	2,749	83	45	816			
	Δ	0	83	45	816			
16 SD	Rate			289	107			
	Cost			0	0			
	Δ			-289	-107			
35 Mt	Rate							22
	Cost							52
	Δ							30
42 Ca	Rate							30
	Cost							0
	Δ							-30

TABLE XXVII

OPTIMUM DOMESTIC FEED GRAIN SHIPMENTS FROM SUPPLY REGIONS TO DEMAND REGIONS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination																
		1 NE	2 NY	3 Pa	4 Oh	5 In	6 Il	7 Il	8 Mi	9 Wi	11 Mn	12 Ia	13 Ia	14 Mo	15 ND	16 SD	17 Ne	18 Ks
		10,000 Bu.																
1 NE	Rate Cost Δ	213 0 -213																
2 NY	Rate Cost Δ		1,618 0 -1,618	0 1,435 1,435														
3 Pa	Rate Cost Δ			4,669 4,669 0														
4 Oh	Rate Cost Δ	0 9,033 9,033		10,526 363 -10,163	2,498 2,498 0													
5 In	Rate Cost Δ	8,820 0 -8,820	6,777 4,642 -2,135	3,153 9,441 6,288		7,623 7,623 0												
6 Il	Rate Cost Δ						0 11,123 11,123											
7 Il	Rate Cost Δ							0 7,772 7,772										
8 Mi	Rate Cost Δ		0 3,753 3,753	281 0 -281					3,472 0 -3,472									
9 Wi	Rate Cost Δ									6,052 6,052 0								
10 Mn	Rate Cost Δ								0 3,472 3,472									
11 Mn	Rate Cost Δ										0 2,068 2,068					0 582 582		
12 Ia	Rate Cost Δ			0 2,721 2,721			8,775 0 -8,775					2,751 2,751 0						
13 Ia	Rate Cost Δ						2,348 0 -2,348	7,772 0 -7,772					12,127 12,127 0	13,204 13,204 0				
14 Mo	Rate Cost Δ																	
15 ND	Rate Cost Δ										2,068 0 -2,068				16 0 -16	0 495 495		
16 SD	Rate Cost Δ															1,077 0 -1,077		
17 Ne	Rate Cost Δ																7,698 7,698 0	0 1,916 1,916
18 Ks	Rate Cost Δ																	1,916 0 -1,916
35 Mt	Rate Cost Δ														0 16 16			

TABLE XXVII (Continued)

Origin	Transportation Tariff	Destination															
		19 Ks	20 Va	21 NC	22 SC	23 Ga	24 Fl	25 Ky	26 Tn	27 Al	28 Ms	29 Ar	30 La	31 Ok	32 Tx	33 Tx	34 Tx
		10,000 Bu.															
4 Oh	Rate		4,413														
	Cost		5,543														
	Δ		1,130														
5 In	Rate																
	Cost																
	Δ																
6 Il	Rate					14,657	379	0		6,105	626						
	Cost					0	3,850	5,558		0	0						
	Δ					-14,657	3,471	5,558		-6,105	-626						
7 Il	Rate		1,130	9,544	2,014				0	5,199	0						
	Cost		0	0	0				8,216	0	1,899						
	Δ		-1,130	-9,544	-2,014				8,216	-5,199	1,899						
11 Mn	Rate										0		1,791				
	Cost										1,026		0				
	Δ										1,026		-1,791				
12 Ia	Rate			0	0				6,434								
	Cost			9,544	1,974				0								
	Δ			9,544	1,974				-6,434								
13 Ia	Rate					0	2,778					0					
	Cost					9,225	0					3,672					
	Δ					9,225	-2,778					3,672					
14 Mo	Rate							2,601		140		7,892	0				
	Cost							0		0		0	2,635				
	Δ							-2,601		-140		-7,892	2,635				
16 SD	Rate									0							
	Cost									11,691							
	Δ									11,691							
18 Ks	Rate															0	
	Cost															5,147	
	Δ															5,147	
19 Ks	Rate	941										2,453		3,677			
	Cost	941										6,375		636			
	Δ	0										3,922		-3,041			
20 Va	Rate		1,125														
	Cost		1,125														
	Δ		0														
21 NC	Rate			3,935													
	Cost			3,935													
	Δ			0													
22 SC	Rate				931												
	Cost				971												
	Δ				40												
23 Ga	Rate					3,533											
	Cost					3,533											
	Δ					0											
24 Fl	Rate					0	693										
	Cost					693	0										
	Δ					693	-693										
25 Ky	Rate					0		2,957									
	Cost					2,957		0									
	Δ					2,957		-2,957									
26 Tn	Rate					0			1,782								
	Cost					1,782			0								
	Δ					1,782			-1,782								
27 Al	Rate									1,136	0						
	Cost									889	247						
	Δ									-247	247						
28 Ms	Rate										608						
	Cost										608						
	Δ										0						
29 Ar	Rate											740					
	Cost											700					
	Δ											-40					
30 La	Rate										0		844				
	Cost										844		0				
	Δ										844		-844				
31 Ok	Rate											3,041		0			
	Cost											0		3,041			
	Δ											-3,041		3,041			
32 Tx	Rate											0			2,676	0	
	Cost											3,379			2,676	632	
	Δ											3,379			0	632	
33 Tx	Rate															5,147	
	Cost															0	
	Δ															-5,147	
34 Tx	Rate										7,220						7,837
	Cost										3,830						7,837
	Δ										-3,390						0

TABLE XXVII (Continued)

Origin	Transportation Tariff	Destination							
		35 Mt	36 Mt	37 Wy	38 Co	39 Az	40 Ut	41 Wa	42 Ca
		10,000 Bu.							
17 Ne	Rate				58				9,268
	Cost				58				0
	Δ				0				-9,268
32 Tx	Rate								0
	Cost								9,268
	Δ								9,268
35 Mt	Rate	143	294	175			0	1,156	
	Cost	143	0	175			273	0	
	Δ	0	-294	0			273	-1,156	
36 Mt	Rate		0				273	0	
	Cost		294				0	1,156	
	Δ		294				-273	1,156	
37 Wy	Rate				272				
	Cost				272				
	Δ				0				
38 Co	Rate				3,082				
	Cost				3,082				
	Δ				0				
39 Az	Rate					1,355			
	Cost					1,355			
	Δ					0			
40 Ut	Rate						2,194		
	Cost						2,194		
	Δ						0		
41 Wa	Rate							4,559	
	Cost							4,559	
	Δ							0	
42 Ca	Rate								11,476
	Cost								11,476
	Δ								0

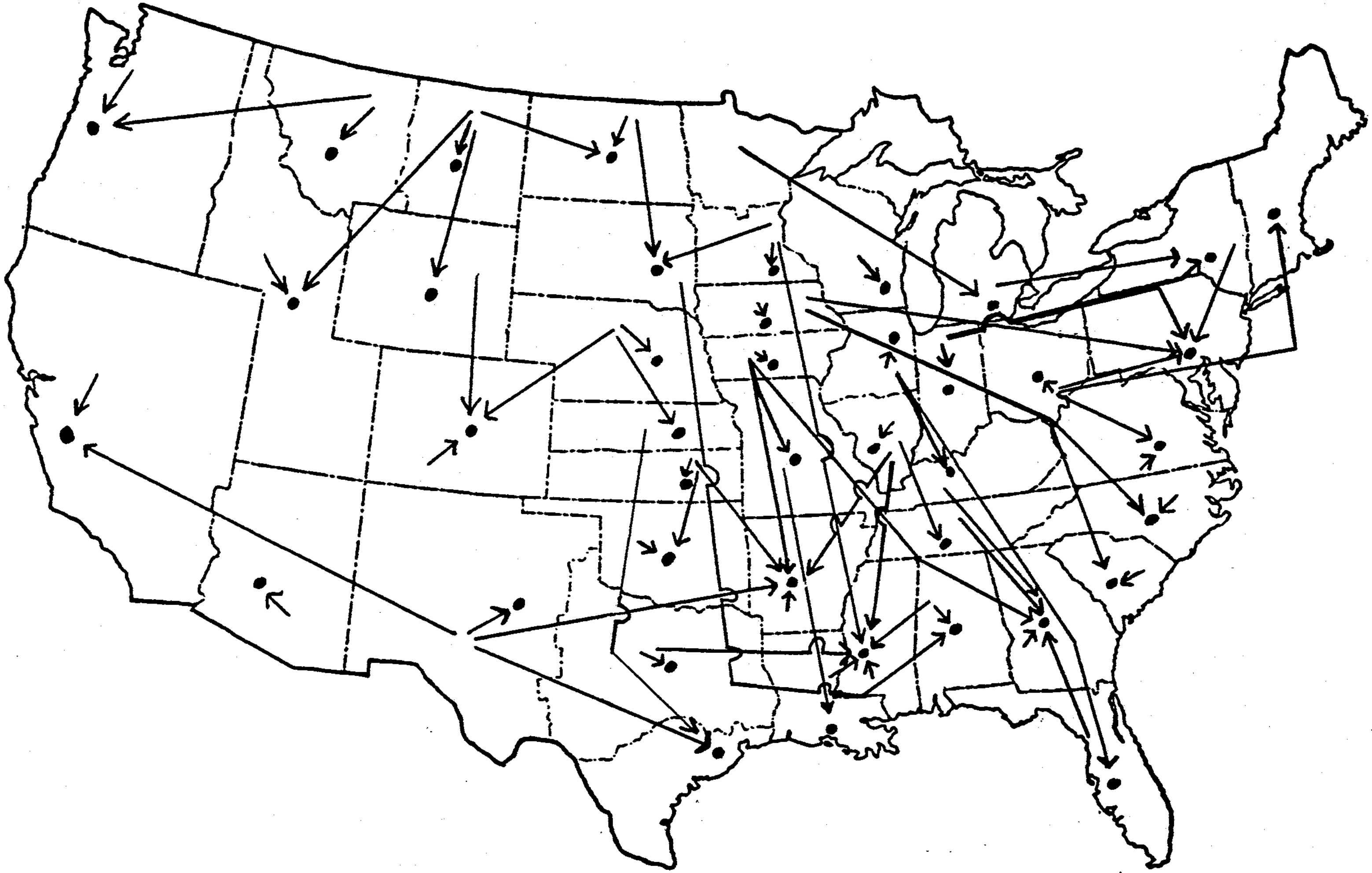


Figure 14. Optimum Domestic Flow Patterns for Feed Grain, Model I-C, 1966-67

Observing the flows to the East South Central states, one notices the major difference between a transhipment model and a surplus-deficit transportation model. Mississippi was the only state of the four East South Central states which was not involved with both receipts and shipments of feed grain. Eastern Texas was the only major shipper to these states that was not in the North Central states. Other examples of transhipment are Missouri, northern Kansas, North Dakota, Wyoming, Michigan, and Florida.

The states west of the Missouri-Mississippi River system show few interregional movements compared with those discussed above. The major movements were over 92.6 million bushels from western Texas to California, over 63.7 million bushels from southern Kansas to Arkansas, over 51.4 million bushels from northern Kansas to southern Texas, over 36.7 million bushels from southern Iowa to Arkansas, and over 33.7 million bushels from western Texas to Arkansas.

Table XXVIII presents the least-cost shipments of export feed grain. The Lake ports with the exception of Duluth-Superior received their entire requirements from adjacent regions. Duluth-Superior received approximately 0.3 percent of its requirements from northern Iowa. The major requirements of the Atlantic ports were at Baltimore and Norfolk which were supplied by Indiana. Albany received shipments from nearby New York and New England while Charleston was supplied by Arkansas. The optimum shipments to New Orleans were shipments involving barge transportation from southern Minnesota, northern Illinois, and Missouri. Houston was supplied by two Texas regions and northern Kansas, with the largest volume shipped from southern Texas and the smallest volume shipped from eastern Texas. The least-cost

TABLE XXVIII

OPTIMUM EXPORT FEED GRAIN SHIPMENTS FROM SUPPLY REGIONS TO PORT REGIONS, MODEL I-C AND MODEL I-R, 1966-67

Origin	Transportation Tariff	Destination												
		43 Du	44 Mw	45 To	46 Ab	47 Ba	48 Nf	49 Cs	50 NO	51 Ho	52 LB	53 Sk	54 Po	55 Ta
		10,000 Bu.												
1 NE	Rate				0									
	Cost				213									
	Δ				213									
2 NY	Rate				0									
	Cost				183									
	Δ				183									
5 In	Rate					0	0							
	Cost					2,649	2,018							
	Δ					2,649	2,018							
6 Il	Rate		0		396	2,649	2,018		19,941					
	Cost		4,161		0	0	0		22,079					
	Δ		4,161		-396	-2,649	-2,018		2,138					
8 Mi	Rate			2,146										
	Cost			2,146										
	Δ			0										
9 Wi	Rate		1,495											
	Cost		1,495											
	Δ		0											
10 Mn	Rate	6,568												
	Cost	6,546												
	Δ	-22												
11 Mn	Rate								17,890					
	Cost								7,754					
	Δ								10,136					
12 Ia	Rate	0												
	Cost	22												
	Δ	22												
14 Mo	Rate								0					
	Cost								7,998					
	Δ								7,998					
16 SD	Rate		4,161											
	Cost		0											
	Δ		-4,161											
18 Ks	Rate									0				
	Cost									7,072				
	Δ									7,072				
22 SC	Rate							40						
	Cost							0						
	Δ							-40						
29 Ar	Rate							0						
	Cost							40						
	Δ							40						
32 Tx	Rate									15,609	3,052	924		
	Cost									0	3,052	0		
	Δ									-15,609	0	-924		
33 Tx	Rate									3,581				
	Cost									8,728				
	Δ									5,147				
34 Tx	Rate									0				
	Cost									3,390				
	Δ									3,390				
35 Mt	Rate												120	
	Cost												1,281	
	Δ												1,161	
36 Mt	Rate											0	1,420	278
	Cost											924	259	278
	Δ											924	-1,161	0
39 Az	Rate										1,132			
	Cost										1,132			
	Δ										0			

supplies for Long Beach were from western Texas and Arizona. Stockton was supplied by western Montana, Portland from the Montana regions, and Tacoma from western Montana.

Soybeans. Domestic soybean shipments are reported in Table XXIX according to regions defined by the Bureau of the Census which have been noted in the footnotes of this chapter. Since regional soybean crushing capacities and volumes crushed were confidential, domestic shipments will not be presented as they have been for grains and flours. The only interregional shipments of soybeans according to Bureau of Census regions were shipments from the East North Central and West South Central states to East South Central states.

The optimum export shipments of soybeans are presented in Table XXX and illustrated as flows in Figure 15, Section B. The requirements of the Lake ports were supplied by the adjoining regions. The Atlantic ports were also supplied by adjoining regions with the exception of Baltimore, which had its major shipment from South Carolina and a very small quantity from North Carolina as well as shipments from nearby Virginia. New Orleans received shipments from 10 regions, but the major shipments were received from Missouri, Mississippi, Tennessee, and Louisiana in that order of magnitude. The requirements of Houston were satisfied by southern Illinois, Louisiana, southern Texas, and eastern Texas. Regions shipping the largest volume of soybeans to the Gulf ports, Missouri, Mississippi, and southern Illinois, all utilized barge transportation.

TABLE XXIX

OPTIMUM SOYBEAN SHIPMENTS FROM SUPPLY REGIONS TO DOMESTIC DEMAND REGIONS, MODEL I-C

	Destination[a]				
Origin[a]	South Atlantic	East North Central	West North Central	East South Central	West South Central
			10,000 Bu.		
South Atlantic	3,468	0	0	0	0
East North Central	0	23,942	0	1,097	0
West North Central	0	0	18,849	0	0
East South Central	0	0	0	877	0
West South Central	0	0	0	5,028	3,794

[a]Individual shipments were aggregated to standard regions used by the Bureau of the Census to avoid disclosure of individual firm capacities.

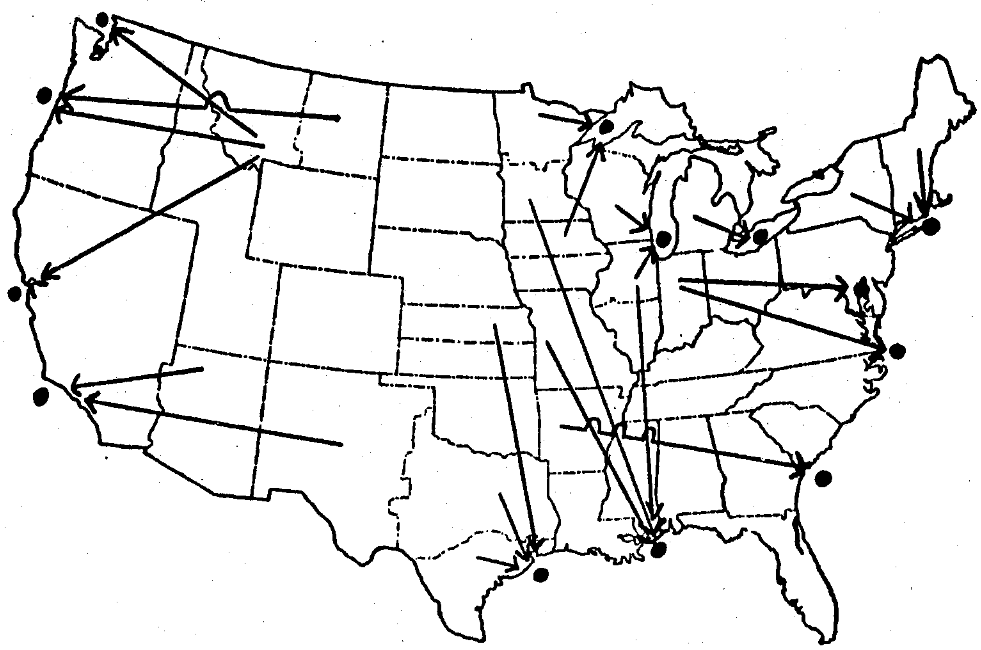
TABLE XXX

OPTIMUM EXPORT SOYBEAN SHIPMENTS FROM SUPPLY REGIONS TO PORT REGIONS, MODEL I-C AND MODEL I-R, 1966-67

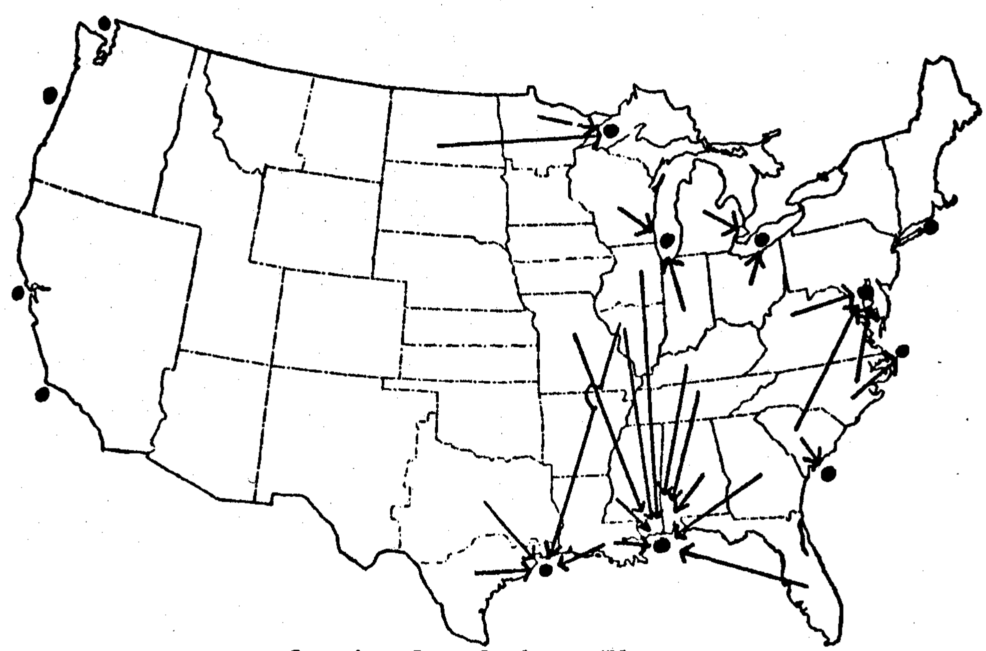
Origin	Transportation Tariff	Destination							
		43 Du	44 Ch	45 To	47 Ba	48 Nf	49 Cs	50 NO	51 Ho
		10,000 Bu.							
2 NY	Rate			3					
	Cost			0					
	Δ			-3					
3 Pa	Rate				537				
	Cost				0				
	Δ				-537				
4 Oh	Rate			1,420	40				
	Cost			1,453	0				
	Δ			33	-40				
5 In	Rate		1,571						
	Cost		1,571						
	Δ		0						
6 Il	Rate							37	
	Cost							37	
	Δ							0	
7 Il	Rate							5,175	
	Cost							107	
	Δ							-5,068	
8 Mi	Rate			1,041					
	Cost			1,041					
	Δ			0					
9 Wi	Rate		314						
	Cost		314						
	Δ		0						
10 Mn	Rate	0							
	Cost	376							
	Δ	376							
11 Mn	Rate	873							
	Cost	0							
	Δ	-873							
14 Mo	Rate							0	
	Cost							6,190	
	Δ							6,190	
15 ND	Rate	0							
	Cost	497							
	Δ	497							
20 Va	Rate				0				
	Cost				202				
	Δ				202				

TABLE XXX (Continued)

Origin	Transportation Tariff	43 Du	44 Ch	45 To	47 Ba	48 Nf	49 Cs	50 NO	51 Ho
		10,000 Bu.							
21 NC	Rate				0	428			
	Cost				6	428			
	Δ				6	0			
22 SC	Rate				0		872		
	Cost				369		872		
	Δ				369		0		
23 Ga	Rate							592	
	Cost							596	
	Δ							4	
24 Fl	Rate							197	
	Cost							197	
	Δ							0	
25 Ky	Rate							0	
	Cost							83	
	Δ							83	
26 Tn	Rate							0	
	Cost							2,821	
	Δ							2,821	
27 Al	Rate							0	
	Cost							784	
	Δ							784	
28 Ms	Rate							3,555	
	Cost							4,591	
	Δ							1,036	
29 Ar	Rate							5,739	
	Cost							0	
	Δ							-5,739	
30 La	Rate							2,348	11
	Cost							2,237	122
	Δ							-111	111
31 Ok	Rate								111
	Cost								0
	Δ								-111
33 Tx	Rate								3
	Cost								3
	Δ								0
34 Tx	Rate								21
	Cost								21
	Δ								0



Section A. Feed Grain Flows



Section B. Soybean Flows

Figure 15. Optimum Export Flow Patterns for Feed Grain and Soybeans to Port Destinations, Model I-C, 1966-67

Optimum Utilization of Milling Capacity

The information determined about optimum utilization of milling capacity was determined simultaneously with the optimum geographical flows of wheat and flour. The "optimum" refers to specification of the volume and type of flour to be milled in each region such that the total marketing cost of the system is minimized.

The quantity and type of flour milled in each of the regions, the unused milling capacity, and the value of additional capacity are presented in Table XXXI. The value of additional capacity is a marginal value and represents the value per 10,000 bushels, given that all other milling capacities remain at their current levels. Thus, the relative level of these data estimate relative profitability of flour milling in the various regions.

Six of the 37 milling regions had excess capacity. Of these six regions, one region, North Carolina, was 100 percent idle, while Georgia utilized only 8.4 percent of its capacity. In total, unused capacity is over-estimated, since relief-flour exports were not included in flour-export data due to their inavailability. In general, the data of Table XXXI suggest that flour milling would be more profitable in the East North Central states than in other sections given that the transportation rate structure approached cost of service. This group of states milled the greatest proportion of the soft wheat. Likewise milling in the South Atlantic states would be least profitable due to the excess capacity in those states.

TABLE XXXI

OPTIMUM UTILIZATION OF EXISTING FLOUR MILLING CAPACITY, UNUSED MILLING CAPACITY, AND VALUE OF ADDITIONAL CAPACITY, MODEL I-C, 1966-67

Milling Region		Quantity of Wheat Milled		Unused Milling Capacity	Value of Additional Capacity
		Hard	Soft		
		----------10,000 Bu./Yr.----------			$/10,000 Bu.
2	NY	3,800	1,635	161	0
3	Pa	560	1,448	0	652
4	Oh	1,640	1,984	0	1,120
5	In	0	1,660	0	1,458
6	Il	406	870	0	1,668
7	Il	586	1,274	0	1,023
8	Mi	1,555	217	0	1,567
9	Wi	0	8	0	2,384
10	Mn	128	0	0	1,556
11	Mn	3,924	192	0	1,158
13	Ia	855	369	0	910
14	Mo	4,353	627	0	873
15	ND	290	122	0	736
16	SD	126	50	0	1,279
17	Ne	1,662	18	0	1,388
18	Ks	3,472	80	0	1,157
19	Ks	4,632	0	0	1,645
20	Va	0	553	119	0
21	NC	0	0	1,316	0
22	SC	0	148	124	0
23	Ga	0	27	201	0
24	Fl	0	148	0	111
25	Ky	151	117	0	1,260
26	Tn	371	1,373	0	1,170
27	Al	384	0	0	2,212
28	Ms	0	24	0	908
31	Ok	1,732	0	0	1,330
32	Tx	64	0	0	2,041
33	Tx	852	0	0	2,518
34	Tx	2,212	180	0	1,285
36	Mt	564	36	0	1,141
37	Wy	126	34	0	1,134
38	Co	578	126	0	1,456
39	Az	0	48	0	2,703
40	Ut	1,412	188	0	1,325
41	Wa	1,439	699	974	0
42	Ca	1,015	1,069	0	939

Optimum Ending Inventories of Grain

Ending inventories or stocks as determined by the model represent the supplies in excess of domestic and export demands. These are the quantities for which storage charges are incurred in the model. Table XXXII presents the optimum regional inventories by type of grain. Optimum hard-wheat stocks were located in the West North Central states and the Mountain states. The East North Central states and the Mountain states were the locations for soft-wheat stocks. Durum wheat inventories were located in the Dakotas and northern Minnesota. Feed-grain stocks were located primarily in the West North Central states with quantities also stored in western Texas-New Mexico and western Montana. Soybeans were also stored primarily in the West North Central states, with the exceptions being southern Illinois, Ohio, the West South Central States, and Virginia-West Virginia.

Regional Price Differentials

Regional price differential information can be used to compare the relative advantage or disadvantage of various origins in supplying grain based on marketing costs excluding production costs. Also, the relative advantage or disadvantage of milling regions in procuring supplies, or ports of export in competing for supplies may be compared. The data determined by the model are the dual variables of linear programming theory. Since there are $m + n-1$ elements in a basis and $m+n$ dual variables, the value of one of the variables is arbitrary. Thus, relative equilibrium prices, and not absolute equilibrium prices are determined. The assumption underlying such

TABLE XXXII

OPTIMUM REGIONAL ENDING INVENTORIES OF GRAIN, MODEL I-C

Storage Region		Hard Wheat	Soft Wheat	Durum Wheat	Feed Grain	Soy-beans
			10,000 Bu.			
1	NE	0	0	0	0	0
2	NY	0	0	0	0	0
3	Pa	0	0	0	0	0
4	Oh	0	1,181	0	0	1,225
5	In	0	360	0	0	0
6	Il	0	0	0	0	0
7	Il	0	0	0	0	3,257
8	Mi	0	1,419	0	0	0
9	Wi	0	0	0	0	0
10	Mn	0	0	1,337	0	893
11	Mn	0	0	0	0	3,691
12	Ia	0	0	0	948	3,589
13	Ia	0	0	0	0	2,757
14	Mo	0	0	0	0	0
15	ND	3,279	0	1,171	12,555	0
16	SD	5,493	0	396	0	653
17	Ne	4,689	0	0	38,227	2,051
18	Ks	5,094	0	0	0	291
19	Ks	4,722	0	0	0	0
20	Va	0	0	0	0	0
21	NC	0	0	0	0	52
22	SC	0	0	0	0	0
23	Ga	0	0	0	0	0
24	Fl	0	0	0	0	0
25	Ky	0	0	0	0	0
26	Tn	0	0	0	0	0
27	Al	0	0	0	0	0
28	Ms	0	0	0	0	0
29	Ar	0	0	0	0	922
30	La	0	0	0	0	0
31	Ok	0	0	0	0	127
32	Tx	0	0	0	16,525	296
33	Tx	0	0	0	0	0
34	Tx	0	0	0	0	0
35	Mt	2,982	100	0	0	0
36	Mt	627	74	0	700	0
37	Wy	317	0	0	0	0
38	Co	3,967	0	0	0	0
39	Az	0	0	0	0	0
40	Id	0	1,784	0	0	0
41	Wa	0	0	0	0	0
42	Ca	0	0	0	0	0

price differentials is that the value of a commodity at a particular destination should differ from its value at the origin(s) supplying that destination by the transfer cost between the two points.

The regional price differentials of Model I-C are presented in Table XXXIII. As an example of the information given there, the two Kansas regions had the same price differential of 5.8 cents per bushel for hard wheat. Thus, there was no advantage by either region, but when compared with Oklahoma with a price differential of 7.9 cents per bushel, the two Kansas regions had a locational advantage of 2.1 cents per bushel.

Table XXXIV presents the estimated regional price differentials for grain and flour at destinations. The wheat-destination differentials are prices at flour mills and reflect the relative disadvantage of mills in obtaining wheat supplies. For instance, comparing Oklahoma with a hard-wheat price differential of 19.6 cents per bushel and southern Kansas (Region 19) with a price differential of 14.4 cents per bushel means that the miller in southern Kansas will be able to pay 5.2 cents less per bushel for hard wheat than Oklahoma millers. In other terms, the Oklahoma miller has to overcome a 5.2 cents per bushel disadvantage to compete with the southern Kansas millers in various flour markets.

Likewise, examination reveals that the Lake ports of Duluth-Superior and Chicago-Milwaukee have an advantage in terms of marketing costs over the other ports in exporting hard wheat. And in turn, the Gulf ports, New Orleans and Houston, have an advantage over the Atlantic and Pacific ports with the exception that Tacoma has 0.1 cent advantage over Houston.

TABLE XXXIII

ESTIMATED REGIONAL DOMESTIC PRICE DIFFERENTIALS AT GRAIN ORIGINS BY TYPE OF GRAIN, MODEL I-C

Supply Region		Hard Wheat	Soft Wheat	Durum Wheat	Feed Grain	Soy-beans
		Cents per Bushel				
1	NE	a	a	a	31.9	a
2	NY	34.1	9.3	a	27.7	7.3
3	Pa	29.9	7.6	a	29.3	9.0
4	Oh	28.9	5.8	a	22.0	2.1
5	In	23.5	5.8	a	17.5	3.3
6	Il	22.9	17.1	a	18.6	9.1
7	Il	17.7	12.4	a	18.1	2.1
8	Mi	23.4	5.8	a	18.7	27.8
9	Wi	16.4	6.8	a	17.6	7.3
10	Mn	6.0	6.6	4.5	5.8	2.1
11	Mn	12.2	a	8.5	7.8	2.1
12	Ia	12.7	a	a	5.8	2.1
13	Ia	16.4	a	a	9.2	2.1
14	Mo	20.9	15.1	a	16.5	7.1
15	ND	1.3	a	0.0	1.7	0.0
16	SD	5.8	a	4.5	15.2	2.1
17	Ne	5.8	a	a	32.0	2.1
18	Ks	5.8	a	a	14.4	2.1
19	Ks	5.8	a	a	8.8	6.3
20	Va	35.8	13.7	a	34.0	7.1
21	NC	a	14.3	a	36.3	2.1
22	SC	a	15.2	a	31.5	2.5
23	Ga	a	15.1	a	28.5	5.2
24	Fl	a	17.1	a	25.8	9.0
25	Ky	a	10.6	a	23.1	2.6
26	Tn	a	13.8	a	24.3	4.4
27	Al	a	15.2	a	21.2	7.2
28	Ms	a	15.3	a	25.5	7.3
29	Ar	28.1	11.6	a	22.7	2.1
30	La	23.3	17.5	a	22.6	9.4
31	Ok	7.9	a	a	13.2	2.1

TABLE XXXIII (Continued)

Supply Region		Hard Wheat	Soft Wheat	Durum Wheat	Feed Grain	Soy-beans
				Cents per Bushel		
32	Tx	8.0	a	a	5.8	2.1
33	Tx	22.3	a	a	21.4	13.6
34	Tx	14.2	a	a	11.2	3.4
35	Mt	0.0	0.0	2.4	0.0	a
36	Mt	5.8	5.8	8.6	5.8	a
37	Wy	5.8	17.2	a	15.9	a
38	Co	5.8	a	a	18.9	a
39	Az	16.8	9.5	a	20.8	a
40	Id	7.9	5.8	a	21.8	a
41	Wa	19.4	17.3	a	23.9	a
42	Ca	33.6	31.5	11.6	40.4	a

[a]Price differential was not computed, respective grains not produced.

TABLE XXXIV

ESTIMATED REGIONAL PRICE DIFFERENTIALS AT GRAIN DESTINATIONS BY TYPE OF GRAIN AND FLOUR (WHEAT EQUIVALENT), MODEL I-C

Demand Region		Hard Wheat	Hard Flour	Soft Wheat	Soft Flour	Durum Wheat	Feed Grain	Soy-beans
					Cents Per Bushel			
1	NE	a	81.9	a	67.9	a	41.6	a
2	NY	41.7	85.3	21.4	65.0	18.9	38.9	a
3	Pa	45.1	84.0	22.8	61.7	a	44.5	24.3
4	Oh	38.1	76.3	15.0	53.2	a	31.2	11.3
5	In	31.1	72.6	13.4	55.0	a	25.2	10.9
6	Il	29.3	71.0	18.9	60.6	a	25.8	16.4
7	Il	27.2	64.5	21.9	59.1	a	27.6	11.6
8	Mi	29.1	71.8	16.0	58.7	a	28.8	a
9	Wi	25.0	68.8	15.4	66.2	28.1	26.2	a
10	Mn	21.0	63.6	23.0	63.6	a	21.0	18.5
11	Mn	20.5	59.1	21.2	59.8	19.1	18.4	12.7
12	Ia	a	64.4	a	64.3	a	14.0	10.3
13	Ia	24.5	60.6	23.5	59.6	a	17.4	10.3
14	Mo	25.7	61.5	24.6	60.4	a	25.5	16.9
15	ND	15.9	50.3	15.9	50.3	18.3	15.9	a
16	SD	17.5	57.3	23.8	63.6	a	21.1	a
17	Ne	16.4	57.3	26.3	67.2	a	16.4	12.7
18	Ks	19.8	58.4	29.2	67.8	a	23.1	16.2
19	Ks	14.4	57.9	32.4	71.4	a	17.0	15.0
20	Va	45.7	83.3	23.6	64.5	a	43.9	17.0
21	NC	47.7	67.2	22.6	62.7	a	44.6	10.3
22	SC	41.6	79.5	25.8	66.7	a	42.1	13.1
23	Ga	39.2	77.5	26.6	67.5	a	40.0	16.7
24	Fl	36.7	84.3	26.3	74.6	a	32.3	a
25	Ky	31.8	72.3	18.2	58.7	a	28.4	15.7
26	Tn	32.0	71.6	22.9	62.6	a	33.0	13.5
27	Al	23.5	76.3	24.1	66.9	a	32.9	16.1
28	Ms	29.5	74.2	25.1	69.8	a	35.4	16.7
29	Ar	a	70.7	a	69.0	a	33.3	12.7
30	La	a	76.0	a	74.0	a	28.7	a
31	Ok	19.6	60.8	31.5	72.7	a	25.0	13.8
32	Tx	19.8	68.1	29.0	77.3	a	17.6	a
33	Tx	20.5	73.2	29.4	77.8	a	29.2	a
34	Tx	25.1	65.9	34.8	75.6	a	22.1	a
35	Mt	a	60.4	a	60.4	a	12.8	a
36	Mt	14.2	56.7	14.6	56.7	a	14.6	a
37	Wy	15.2	57.2	22.9	64.9	a	22.9	a
38	Co	13.4	58.6	27.9	73.1	a	26.6	a
39	Az	28.0	77.5	20.7	78.4	a	32.1	a
40	Ut	19.6	63.5	17.4	61.3	a	33.5	a
41	Wa	35.2	65.4	33.0	63.2	42.5	39.7	a
42	Ca	43.9	83.5	41.7	81.3	a	50.6	a

TABLE XXXIV (Continued)

Demand Region		Hard Wheat	Hard Flour	Soft Wheat	Soft Flour	Durum Wheat	Feed Grain	Soy-beans
					Cents per Bushel			
43	Du	19.2	63.6	a	a	17.9	18.9	17.9
44	Ch	24.1	69.7	14.5	59.5	a	25.3	15.0
45	To	a	a	14.9	55.0	a	27.9	11.8
46	Ab	47.9	a	23.1	a	46.6	41.5	a
47	Ba	45.1	82.7	24.2	62.6	44.2	39.2	19.9
48	Nf	47.2	a	25.2	a	47.6	43.9	12.9
49	Cs	44.8	85.2	24.3	67.1	a	39.3	11.6
50	NO	32.8	76.0	27.0	69.5	31.9	28.4	19.0
51	Ho	31.4	73.6	a	a	30.8	28.4	20.6
52	LB	38.6	a	31.3	a	a	42.6	a
53	Sk	35.8	81.4	33.7	a	a	43.4	a
54	Po	34.9	65.4	32.7	63.2	37.3	34.9	a
55	Ta	32.7	69.6	30.6	67.5	a	32.7	a

[a]Price differential was not computed.

Model I-C and Model I-R Compared

As discussed at the beginning of this chapter, Model I-C and Model I-R differed only by the charges used for transportation, Model I-C using estimated costs of service for 1966 and Model I-R using the lowest existing rates for 1966. A comparison of the optimum geographical flows, optimum utilization of milling capacity, and optimum regional ending inventories of these two models should provide information to the grain trade about the possible changes which might occur in the industry if transportation rates become more and more closely structured about costs of service. This section will make those comparisons and end with an estimation of the social cost of the transportation rate structure as it was in 1966.

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

The optimum geographical flows of the various grains and flours for Models I-C and I-R are presented in Tables XVII through XXX with the exception of domestic soybean shipments in Table XXIX. The net changes in the volumes shipped between the various origins and destinations are denoted by the delta symbol. These differences reflect the changes resulting from the impact of different transportation charges on the United States grain marketing system.

Hard Wheat. The optimum domestic shipments of hard wheat for Model I-R are given by the "Rate" rows of Table XVII and the optimum shipments for Model I-C are given by the "Cost" rows of that table.

Of the point-to-point domestic movements made in Model I-R, only 6 shipments remained unchanged when cost-of-service transfer charges were substituted for the existing rates. Twenty-one of the movements by rates were deleted and 11 new ones entered the solution. There were 16 movements which had changes in the volume shipped when cost-of-service transfer charges were substituted. Eleven of these movements were increases in volume and five were decreases.

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

There were more regions shipping hard wheat to export with cost-of-service transfer charges than with rates, indicating that the average quantity shipped to export by region decreased. Eleven movements made by rates were deleted while 17 new movements were initiated. Of those point-to-point movements which occurred in both models, six had decreased volume and two had increased volume in Model I-C, while six other movements had no change in volume shipped.

When aggregate domestic and export hard wheat are considered, four regions (Regions 16, 17, 19, and 35) had net-volume losses in hard wheat shipped. Regions 17, 16, and 19 had far greater losses than Region 35. Likewise, five regions (Regions 15, 18, 36, 37, and 39) had net-volume gains. Region 15 gained more than the combined losses of Regions 16 and 17. Ten regions (Regions 5, 6, 7, 8, 11, 14, 33, 34, 40, and 41) had volume losses in domestic shipments offset by gains in volume exported. Region 14 had the greatest shift from domestic shipments (by rail) to export shipments (by barge). Region 31 (Oklahoma) had domestic gains offset by export losses. Three regions (Regions 3, 9, and 32) had no change in volume shipped to domestic or export demands. The remaining ten regions which shipped hard wheat (Regions 2, 4, 10, 12, 13, 20, 29, 30, 38, and 42) shipped either solely to domestic demands or to export demands in both Models I-C and I-R and experienced no changes in volume shipped in Model I-C.

A significant change in the volume of hard wheat (from 32 million bushels to just greater than 9 million bushels) shipped from the North Central states to the South Atlantic and East South Central states in Model I-C can be seen on the second page of Table XVII.

There were significant shifts among regions in volume shipped intraregionally in the North Central states. Of considerable notice is the shift in shipments made from South Dakota, southern Minnesota, and northern Iowa to North Dakota in Model I-R to intraregional shipments made by North Dakota in Model I-C. Also, note that within the North Central states are decreased shipments to southern Illinois mills, increased shipments to Michigan mills, and a shift and increase in shipments to Missouri mills. It might be added that while North Dakota deleted shipments to southern Minnesota, shipments from North Dakota to New York were significant, but were not as great as the combined decrease in shipments to New York from northern Minnesota and northern Kansas.

Other increases in domestic shipments of over 5 million bushels' volume were from northern Minnesota to Ohio mills and to northern Minnesota mills, from Oklahoma to local mills, and from northern Kansas to southern Texas mills. Other decreases in domestic shipments of over 5 million bushels' volume were from northern Illinois to local mills and from southern Texas to local mills.

The most significant shifts in satisfying export hard-wheat requirements were among the North Central states in supplying New Orleans. Nebraska lost over 39 million bushels, most of which went to storage. Although southern Kansas deleted shipments in excess of 19 million bushels, this loss was offset by its domestic gains. The loss of shipments of hard wheat from Nebraska and southern Kansas to New Orleans were gained by northern Illinois, southern Minnesota, and Missouri, all of which had offsetting increased domestic shipments. Nebraska had truck-barge combination transportation and southern Kansas had all-rail transportation to New Orleans in Model I-C while Missouri and southern Illinois had all-water movements and southern Minnesota truck-barge combination movements to New Orleans. The fact that northern Illinois-and Missouri-all-water movements entered in Model I-C may be a result of the reduced handling costs accompanying the low-cost all-water movements from these two regions.

Significant shifts also occurred in meeting the export requirements at Portland and Tacoma. Decreases in shipments by the Montana regions to Portland in Model I-C were offset by new shipments from Washington-Oregon, which in turn deleted shipments to Tacoma. Further, western Montana replaced Washington-Oregon in supplying Tacoma.

Hard-Wheat Flour. As to be expected if the domestic hard-wheat shipments of Model I-C differed from Model I-R, likewise the hard-wheat flour shipments would be different. The hard-wheat flour shipments of Model I-R and Model I-C can be compared by examining Table XIX.

The shift in shipments received by the South Atlantic and East South Central states is quite noticeable. The requirements of these states were met primarily by shipments from Missouri and Kansas mills in Model I-C. North Carolina and Tennessee mills were the largest volume hard-wheat millers in the South Atlantic and East South Central states in Model I-R and naturally experienced the greatest absolute decreases in hard wheat flour shipments in Model I-C.

Mills in southern Minnesota shifted hard-wheat flour away from Indiana and Michigan in Model I-C and shipped to northern Illinois, northern Iowa, Pennsylvania and New York.

The largest volume shift of domestic flour was 15. 1 million bushels' grind shipped from southern Illinois to Pennsylvania in Model I-R which was shipped by Missouri, Iowa and southern Minnesota mills in Model I-C. Another major change from Model I-R in the North Central states was Michigan becoming self-sufficient in hard-wheat flour production in Model I-C.

In the West South Central states, the major change from Model I-R in hard-wheat flour shipments, was eastern Texas replacing southern Texas in meeting the requirements of southern Texas. In the Western states, decreased shipments to California by Washington-Oregon mills were replaced primarily by shipments from western Montana.

Export hard-wheat flour shipments for Model I-R and Model I-C are presented in Table XX. The greatest changes from Model I-R in the volumes shipped, occurred in shipments to the Gulf ports, New Orleans and Houston. In Model I-C southern Kansas supplied the entire requirements of over 13.6 million bushels' grind at New Orleans, whereas in Model I-R northern Kansas had shipped in excess of 3.6 million bushels' grind. At Houston, receipts from southern Kansas and eastern Texas were reduced in Model I-C, but were increased from Oklahoma and southern Texas.

Nebraska mills lost their flour exports at Baltimore of Model I-R to Missouri mills in Model I-C. Also, southern Minnesota replaced northern Illinois in supplying Chicago and Tennessee replaced North Carolina in meeting the requirements at North Charleston in Model I-C.

Soft Wheat. Comparison of soft-wheat shipments of Model I-R and Model I-C can be made by examining Tables XXI and XXII.

Of the various point-to-point movements made in Model I-R, 8 domestic and 4 export movements remained in Model I-C with the same volumes as in Model I-R. There were 11 domestic and 6 export movements of Model I-R which remained in Model I-C, but with changes in the volumes shipped. Ten of the 11 domestic movements were increased volumes, while only 2 of the 6 export movements had increased volumes. There were 16 domestic movements and 9 export movements of Model I-R deleted in Model I-C while 17 domestic and 8 export movements were added.

There was no region in Model I-C which had no change in volumes of both domestic and export soft wheat shipped when compared with Model I-R. However, there were 6 regions (Regions 3, 10, 23, 26, 37, and 42) which shipped the same domestic volume and 2 regions (Regions 8 and 9) which shipped the same export volume in Model I-C as in Model I-R. There were 11 regions (Regions 2, 3, 5, 7, 9, 25, 28, 29, 30, 35, and 39) with domestic volume gains and 9 regions (Regions 6, 20, 21, 23, 27, 39, 41, 14, and 24) with export volume gains in Model I-C, while there was no region which had gains in both domestic volume and export volume shipped. There were 12 regions (Regions 4, 6, 8, 14, 20, 21, 22, 24, 27, 36, 40, and 41) which had net losses in domestic volume shipped and 10 regions (Regions 2, 3, 4, 5, 7, 25, 28, 29, 30, and 40) which had net export volume losses in Model I-C. However, only 2 regions (Regions 4 and 40) had net losses in both domestic and export volumes shipped.

A comparison of aggregate volumes shipped (domestic plus export) reveals that 5 regions (Regions 3, 5, 9, 35, and 39) had net gains in volume of soft-wheat shipped, 4 regions (Regions 4, 8, 36, and 40) had net losses, and the remaining 17 regions had no change in net volumes shipped in Model I-C.

The major shifts in domestic volume of soft wheat shipped occurred in the North Central States. The most significant change was deletion of approximately 21.2 million bushels to local mills by Missouri shippers. Table XXII reveals that Missouri shifted its local shipments to export at New Orleans. This was an all-barge movement on the Missouri-Mississippi River system. Another large volume change from Model I-R was the shipment of over 12.7 million bushels to local mills by southern Illinois. Table XXII reveals that southern Illinois, unlike Missouri, diverted its exports to local mills. Southern Illinois had truck-barge combination movement possibility to export at New Orleans while Missouri had all-water movement to New Orleans with reduced handling costs of the single mode. Likewise, Arkansas in the West South Central states diverted over 9.1 million bushels from export at New Orleans to mills in Tennessee. Indiana, one of the net gainers of soft wheat shipments in Model I-C, shipped 8.7 million and approximately 6.3 million bushels, respectively, to northern Illinois and Missouri mills. Michigan deleted shipments to northern Illinois and local mills.

Ohio which supplied the export requirements of Norfolk (over 7.4 million bushels) in Model I-R, deleted those shipments in Model I-C and added shipments of over 10.1 million bushels to Baltimore, replacing New York and Pennsylvania as the suppliers in Model I-R. Virginia-West Virginia and North Carolina met the requirements of Norfolk in Model I-C.

All export shipments from Pennsylvania, Indiana, southern Illinois, and Arkansas were delted in Model I-C.

Soft-Wheat Flour. Tables XXIII and XXIV, respectively, present the domestic and export shipments of soft-wheat flour for Model I-C and Model I-R. There are two regions (Mo and Tn) which had noticeable changes in domestic shipments in Model I-C. Missouri had decreases in the number and the volume of shipments. Tennessee had a noticeable increase in number and volume of shipments. Three of the deleted shipments by Missouri mills were made by Tennessee.

The change in shipments to particular regions can easily be seen in Tables XXIII and XXIV 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 Milling Industry Organization

The effects of cost-of-service transfer charges on regional milling capacity utilization for the 1966-67 year are presented in Table XXXV. One must remember that any adjustments in flour milling activities shown by comparisons in this table were such that a lower

TABLE XXXV

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	
		Model I-R	Model I-C	Change	Model I-R	Model I-C	Change	Model I-R	Model I-C
				10,000 Bu.					
2	NY	4,439	3,800	- 639	1,157	1,635	478	0	161
3	Pa	560	560	0	1,448	1,448	0	0	0
4	Oh	1,409	1,640	231	2,215	1,984	- 231	0	0
5	In	0	0	0	1,660	1,660	0	0	0
6	Il	802	406	- 396	474	870	396	0	0
7	Il	1,860	586	-1,274	0	1,274	1,274	0	0
8	Mi	610	1,555	945	1,162	217	- 945	0	0
9	Wi	0	0	0	8	8	0	0	0
10	Mn	72	128	56	56	0	- 56	0	0
11	Mn	3,924	3,924	0	192	192	0	0	0
13	Ia	514	855	341	128	369	241	582	0
14	Mo	1,981	4,353	2,372	2,125	627	-1,498	874	0
15	ND	364	290	- 74	48	122	74	0	0
16	SD	124	126	2	52	50	- 2	0	0
17	Ne	1,576	1,662	86	104	18	- 86	0	0
18	Ks	3,432	3,472	40	120	80	- 40	0	0
19	Ks	4,552	4,632	80	80	0	- 80	0	0
20	Va	205	0	- 205	467	553	86	0	119
21	NC	943	0	- 943	373	0	- 373	0	1,316
22	SC	85	0	- 85	187	148	- 39	0	124
23	Ga	53	0	- 53	175	27	- 148	0	201
24	Fl	92	0	- 92	56	148	92	0	0
25	Ky	268	151	- 117	0	117	117	0	0
26	Tn	1,316	371	- 945	428	1,373	945	0	0
27	Al	238	384	146	146	0	- 146	0	0
28	Ms	0	0	0	24	24	0	0	0
31	Ok	1,086	1,732	646	164	0	- 164	482	0
32	Tx	64	64	0	0	0	0	0	0
33	Tx	753	852	99	99	0	- 99	0	0
34	Tx	2,392	2,212	- 180	0	180	180	0	0
36	Mt	124	564	440	52	36	- 16	424	0
37	Wy	53	126	73	107	34	- 73	0	0
38	Co	578	578	0	13	126	113	113	0
39	Az	0	0	0	48	48	0	0	0
40	Ut	1,399	1,412	13	201	188	- 13	0	0
41	Wa	1,985	1,439	- 546	707	699	- 8	420	974
42	Ca	1,036	1,015	- 21	1,048	1,069	21	0	0

total cost to the grain marketing system in supplying the 1967 flour requirements, given the regional wheat distribution, would have resulted. These results are quite sensitive to the basic data used. Particularly, the sensitivity to transfer charges is shown by this table. The results cannot be said to be a predictor of the optimum organization of the milling industry in the future, but only that these adjustments would have resulted in a lower marketing bill for the U.S. grain marketing system in 1966-67.

Of the 37 flour-milling regions, 8 regions (Regions 3, 5, 9, 11, 28, 32, 38, and 39) had no changes in the volume of hard wheat milled in Model I-C. Seven regions (Regions 3, 5, 9, 11, 28, 32, and 39) had no changes in the volume of soft wheat milled when compared with Model I-R. It is easy to see that Colorado (Region 38) did not have a change in hard-wheat volume milled but, did have a change in soft-wheat volume milled. Eleven regions (Regions 2, 13, 14, 20, 21, 22, 23, 31, 36, 38, and 41) had changes in utilization. There is a noticeable clustering of these regions when Census Bureau state groupings are considered. In particular, the South Atlantic states as a group experienced net reductions in milling capacity utilization. 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. Virginia and South Carolina's utilization decreased to 74 percent and 54 percent respectively. Florida was the only South Atlantic state that did not experience a decrease in milling capacity utilization in Model I-C. None of the South Atlantic states that milled in Model I-C milled hard-wheat. There was also a decrease in hard-wheat milled in the East South

Central states with increased hard-wheat milling. Thus, hard-wheat milling corresponded more closely with hard-wheat production areas. New York and Washington-Oregon mills were the only other mills experiencing decreased capacity utilization in Model I-C. New York decreased hard-wheat milling volume, with utilization dropping to 97.1 percent. Washington-Oregon mills decreased both hard-wheat and soft-wheat milling volumes, with a total capacity reduction from 86.5 percent in Model I-R to 69 percent in Model I-C. Milling regions with capacity utilization increases were Colorado, from 84 percent to 100 percent, western Montana from 40 percent to 100 percent, Missouri from 82.5 percent to 100 percent, Iowa from 52.5 percent to 100 percent, and Oklahoma from 72 percent to 100 percent. Oklahoma, Montana, and Missouri's increased utilization came from a reduction in soft-wheat milling which was more than offset by increased hard-wheat milling. Iowa's increased utilization came from an increase in milling of both hard-wheat and soft-wheat while Colorado's increase came solely from increased soft-wheat milling.

Optimum Geographical Flows: Durum Wheat, Feed Grain, Soybeans

Durum Wheat. Optimum domestic and export durum wheat shipments of Model I-R and Model I-C may be compared by examining Tables XXV and XXVI. Since the volume of durum wheat milled is very low compared to the other wheats, and due to the limited number of production regions and milling regions, the number of shifts in durum wheat shipments should not be expected to be significant. There were three major shifts in domestic durum wheat shipments. North Dakota replaced northern Minnesota in supplying New York and Wisconsin durum wheat mills. The other major shift was in the supply to southern Minnesota mills where southern Minnesota replaced northern Minnesota as the major supplier. The only other shifts were western Montana shipping a part of North Dakota requirements and California shipping part of Washington's requirements which had been shipped in Model I-R by eastern Montana.

The largest single shift in durum wheat shipments occurred in export movements to Norfolk. Southern Minnesota and South Dakota combined, decreased shipments to Norfolk in excess of 8.1 million bushels which were shipped by North Dakota in Model I-C whereas in Model I-R, South Dakota was the sole supplier. North Dakota replaced southern Minnesota supplying Albany in Model I-C and western Montana became the sole supplier to Portland replacing the shipments made by California in Model I-R.

Feed Grains. Domestic and export shipments of feed grain in Model I-C and Model I-R may be compared by examining Tables XXVII and XXVIII respectively.

Looking at 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 of the source of supply was less. In those cases which are exceptions, usually transhipment was taking place. For example, deficits in Arkansas in Model I-R were supplied by Missouri and Oklahoma, whereas in Model I-C, Arkansas's 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 transhipped to Arkansas as was the case in Model I-R. This is not to say there was no transhipment of feed grain in Model I-C as Louisiana is a case in point. Louisiana shipped its own production to Mississippi and received its entire supply from Missouri.

Four regions (Regions 12, 15, 17, and 32) had net losses in volume of feed grain shipped when compared with Model I-R and five regions (Regions 10, 16, 18, 19, and 36) had net gains. Northern Iowa had net losses in both domestic and export shipments. North Dakota and Nebraska had net losses attributable to loss of domestic shipments while the losses of western Texas were in exports. Domestic gains allowed northern Minnesota, South Dakota, southern Kansas and western Montana to experience net gains in feed grain shipments compared with Model I-R, while northern Kansas had net gains in both domestic and export shipments.

Soybeans. As mentioned earlier in this chapter, domestic interregional soybean shipments cannot be reported here to avoid disclosing the identity of individual firms. Thus, comparative data for Model I-R and Model I-C will be presented for Bureau of the Census regions which are defined in the footnotes of this chapter. The domestic shipments of soybeans for Model I-C are reported in Table XXIX. Due to aggregation, these data differ only slightly from those of Model I-R. In both Models I-C and I-R[3], the South Atlantic area met its own requirements. The East North Central states met their own requirements in Model I-C, whereas in Model I-R, 18.11 million bushels of the total requirements, 239.42 million bushels, were shipped from the West North Central states.[4] 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.[5] The West South Central states increased shipments by 48.17 million bushels in Model I-C while the East South Central states decreased shipments by 47.24 million bushels. The South Atlantic states deleted 930 thousand bushels to the East South Central states and the West North Central states deleted 10.97 million bushels, while the only other change was the addition of 10.97 million bushels by the East North Central states.

Export soybean shipments of Models I-C and I-R may be compared by examining Table XXX. The largest volume shifts occurred in shipments to New Orleans which had the greatest volume of soybean requirements. Missouri became the largest-volume soybean shipper to New Orleans in Model I-C, utilizing all-water transportation, replacing Arkansas of Model I-R. Mississippi, utilizing truck-barge transportation, and Tennessee became the second and third largest-volume shippers to New Orleans in Model I-C replacing southern Illinois which had truck-barge transportation available in Model I-C and Louisiana of Model I-R, although Louisiana was 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 XXXVI. Absolute volumes of ending inventories may be made by comparing the data of Table XXXVI with that of Table XXXII. Table XXXVI reveals some major shifts in regional ending inventories, which is a reflection of total shipments from a given origin since ending inventories are the residuals after shipments have been made from supplies.

Hard Wheat. Major shifts in ending inventories of hard-wheat were the reduction of over 79.3 million bushels in North Dakota, the

TABLE XXXVI

NET CHANGE FROM MODEL I-R IN OPTIMUM ENDING INVENTORIES OF GRAIN BY REGION, MODEL I-C

Storage Region		Hard Wheat	Soft Wheat	Durum Wheat	Feed Grain	Soy-beans
				10,000 Bu.		
1	NE	a	a	a	a	a
2	NY	a	a	a	a	a
3	Pa	a	-251	a	a	a
4	Oh	a	330	a	a	7
5	In	a	-1,035	a	a	a
6	Il	a	a	a	a	a
7	Il	a	a	a	a	3,257
8	Mi	a	1,419	a	a	a
9	Wi	a	-369	a	a	a
10	Mn	a	a	1,296	-3,450	-1,123
11	Mn	a	a	a	a	1,620
12	Ia	a	a	a	948	0
13	Ia	a	a	a	a	0
14	Mo	a	a	a	a	-4,379
15	ND	-7,935	a	-1,570	9,840	-497
16	SD	3,135	a	396	-6,453	0
17	Ne	4,689	a	a	7,326	0
18	Ks	-1,340	a	a	-10,303	0
19	Ks	1,737	a	a	-854	21
20	Va	a	a	a	a	a
21	NC	a	a	a	a	52
22	SC	a	a	a	a	a
23	Ga	a	a	a	a	a
24	Fl	a	a	a	a	a
25	Ky	a	a	a	a	a
26	Tn	a	a	a	a	a
27	Al	a	a	a	a	a
28	Ms	a	a	a	a	a
29	Ar	a	a	a	a	922
30	La	a	a	a	a	a
31	Ok	a	a	a	a	114
32	Tx	a	a	a	3,886	0
33	Tx	a	a	a	a	a
34	Tx	a	a	a	a	a
35	Mt	264	-110	-122	a	a
36	Mt	-456	16	a	-940	a

TABLE XXXVI (Continued)

Storage Region	Hard Wheat	Soft Wheat	Durum Wheat	Feed Grain	Soy-beans
37 Wy	-73	a	a	a	a
38 Co	0	a	a	a	a
39 Az	-21	-29	a	a	a
40 Id	a	29	a	a	a
41 Wa	a	a	a	a	a
42 Ca	a	a	a	a	a

[a]No ending inventory in either model.

reduction of 13.4 million bushels in northern Kansas, and additions of over 46.8 million bushels, 31.3 million bushels, and 17.3 million bushels, respectively, in Nebraska, South Dakota and southern Kansas. Changes occurring in ending inventories outside the North Central states were in the Mountain states where western Montana inventories were decreased over 4.5 million bushels, and Wyoming and Arizona inventories were decreased by less than one million bushels. On the other hand eastern Montana inventories increased slightly more than one-quarter million bushels.

Soft Wheat. There were only six regions with soft-wheat ending inventories in Model I-C while there were eight such regions in Model I-R. Pennsylvania, Wisconsin, and Arizona had soft-wheat ending inventories in Model I-R, but did not have any in Model I-C, while Michigan had soft-wheat ending inventories in Model I-C, but not in Model I-R. The major shift in soft wheat inventories occurred with an approximate 10 million-bushel decrease in inventory in Indiana and the addition of an approximate 14 million-bushel inventory in Michigan. The other changes which occurred amounted to less than 10 million bushels in all cases.

Durum Wheat. The major portion of ending inventories of durum wheat was located in northern Minnesota and North Dakota in Model I-C, while North Dakota alone was the major inventory holder in Model I-R. The shift amounted to approximately 13 million bushels to northern Minnesota storage sites in Model I-C when compared with Model I-R. The only other region with durum-wheat ending inventories in Model I-C was South Dakota, with approximately 4 million bushels.

Feed Grain. The concentration of feed-grain ending inventories remained in the North Central states in Model I-C with 3 fewer regions having ending inventories. Both Kansas regions and South Dakota were devoid of ending inventories. The combined deletions in Kansas were approximately 111.6 million bushels and the deletion in South Dakota was over 64.5 million bushels. Northern Iowa added ending inventories of more than 9.4 million bushels while North Dakota increased its volume in excess of 98.4 million bushels. Nebraska increased its ending inventories by approximately 73.3 million bushels to over 382 million bushels. Ending inventories in western Texas-New Mexico increased over 38.8 million bushels to approximately 165.2 bushels. Feed-grain ending inventories were decreased 9.4 million bushels in western Montana making Model I-C ending inventories in that region 7 million bushels.

Soybeans. As with feed grains, optimum ending inventories of soybeans remained concentrated in the North Central states. The major shift occurred with 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 shift in the North Central states was the decrease of over 11.2 million bushels in northern Minnesota and an increase of 16.2 million bushels in southern Minnesota. North Dakota had deletion of approximately 5 million bushels, southern Kansas added 210 thousand bushels, and Ohio increased 70 thousand bushels. In the South, North Carolina added 520 thousand bushels, Arkansas added over 9.2 million bushels, and Oklahoma increased over 1.1 million bushels.

Comparative Cost Analysis

Cost incurred for domestic transportation and associated handling costs, transportation costs and associated handling costs to ports of export, and costs of milling are presented in Table XXXVII for Model I-C and Model I-R. Social costs of the existing transportation rate structure are estimated by subtracting corresponding costs of Model I-C from Model I-R. Storage costs are not presented in this analysis since only ending inventories incur storage costs in these models, thus under-estimating the actual cost of storage. Data are presented for each grain and grain flour.

As stated in Chapter III, 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. The latter case is demonstrated for soft-wheat milling and for transportation of durum wheat for export, when cost-of-service transportation costs resulted in increases in the costs of soft-wheat milling and transporting durum wheat for export. But, further examination reveals a substantial overall reduction in total marketing costs of over $261 million, to the grain marketing system when cost-of-service transportation charges were substituted for existing transportation rates to determine the optimum flows which would result in the minimum total marketing costs to the system.

The total cost to the system in Model I-C was only 81 percent of the cost of Model I-R, thus if cost-of-service transportation charges had been effective throughout the system in 1966-67, the resulting

TABLE XXXVII

SELECTED COSTS OF MARKETING GRAIN AND FLOUR
MODEL I-R AND MODEL I-C

Product and Activity	Model I-R	Model I-C	Social 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 Grain:			
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

savings over the total costs resulting from a system of optimum flows as a result of existing transportation rates would have been 19 percent.

Hard-wheat milling costs were decreased only slightly in Model I-C (just over a half-million dollars) but, since 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 or social cost for hard-wheat milling resulted from a savings of approximately $13.3 million in distribution of domestic hard-wheat flour. Savings of over $5.1 million also resulted from transporting export hard-wheat flour to ports.

Although the cost of milling hard-wheat flour decreased by $502 thousand, the cost of milling soft-wheat flour increased $409 thousand. However, the savings or social cost in transporting soft wheat to mills was approximately $4.7 million.

Considering the milling industry alone, the estimated social cost of the existing transportation rates in 1966-67 was over $41 million.

The most significant reduction in costs in Model I-C was the reduction of over $90.1 million in the domestic transportation of feed grains. Export-grain transportation costs were reduced over $50 million, resulting in a total feed grain marketing cost reduction of approximately $140.7 million. This, as a measure of the social cost of the existing transportation rate structure, is an underestimation, since feed grains were not carried beyond milling locations in these models.

Social costs 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 $6.1 million increased cost of transporting durum to ports of export resulting in an estimated saving of approximately $2.6 million. The estimated social cost of marketing soybeans was principally in the transportation of soybeans for export. This estimated social cost was in excess of $18.4 million while domestic transportation cost reductions would have been only $1.4 million.

Model II-C and Model I-R Compared

Chapter I briefly mentioned how the relationship of wheat and flour transportation rates evolved until the 1950's, and then went on to mention changes since that time. The relationship of wheat and flour transportation rates was the major factor to be considered at the time that the majority of the present flour mills were located. The stability of such a 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 to fulfill objective number (5) of this study. This was accomplished by relaxing the milling capacity restraints of Model I-C. Thus, this model is similar to Weber's analysis discussed briefly in Chapter II in that raw material sources and market requirements are fixed and location of processing is variable.

Possible savings from such relocation may also be estimated. When using these data, one must remember that the results are conditioned by the supply- and demand-input data and cost-input data for 1966-67. Thus, any changes which modify these data are not included in the analysis.

Any adjustments shown by this analysis should not be interpreted as predictions of the future for the flour milling industry.

The remainder of this section will present the optimum geographical flows of hard and soft wheat and their respective flours in terms of net changes from the shipments of Model I-R. Data on the optimum flows of durum wheat, feed grain, and soybeans will not be presented in tabular form, but will be briefly discussed. These flows had only minor changes resulting when Model I-C had 100 percent utilization of storage capacity in Region 35 (eastern Montana) where hard-wheat was stored. Thus, in Model II-C with no milling capacity restrictions or storage capacity restrictions, there were changes in utilization of hard wheat, in optimum milling capacity location, and location of optimum ending inventories of hard-wheat.

The optimum milling organization will also be presented. Finally, a comparative cost analysis will be presented.

Optimum Geographical Flows

Hard Wheat. The net changes from Model I-R in the optimum volume of hard-wheat shipments are presented in Table XXXVIII. Aggregate mill receipts may be compared by examining the volume of hard wheat milled by region in Table XLII. Since flour storage was not allowed by the model, all wheat received was milled and shipped.

No hard wheat was milled in 15 of the 42 milling regions in Model II-C. Note that 7 of these regions were in the East South Central and South Atlantic states. In these two groups of states, Tennessee and Alabama were the only two regions which milled hard wheat in Model II-C, although Mississippi did not mill in either model. There

TABLE XXXVIII

NET CHANGE FROM MODEL I-R IN THE VOLUME OF HARD WHEAT SHIPPED FROM SUPPLY REGIONS TO DEMAND REGIONS, MODEL II-C

Supply Region	Demand Region	Change in Quantity	Supply Region	Demand Region	Change in Quantity
		10,000 Bu.			10,000 Bu.
2 NY	46 Ab	250	15 ND	15 ND	- 364
	47 Ba	- 5		43 Du	0
3 Pa	3 Pa	- 560		54 Po	- 37
	46 Ab	565	16 SD	11 Mn	-3,521
	47 Ba	- 5		12 Ia	1,571
4 Oh	4 Oh	- 42		16 SD	2
	47 Ba	42		27 Al	3,121
5 In	4 Oh	- 157	17 Ne	17 Ne	2,653
	5 In	157		46 Ab	- 254
6 Il	6 Il	318		47 Ba	378
	47 Ba	- 869		48 Nf	-1,270
	50 NO	318		50 NO	-2,276
7 Il	7 Il	-1,421	18 Ks	2 NY	-2,672
	46 Ab	- 561		18 Ks	-2,937
	47 Ba	682		20 Va	- 205
	48 Nf	1,270		21 NC	- 943
	49 Cs	30		22 SC	- 85
8 Mi	8 Mi	- 28		33 Tx	5,179
	47 Ba	28		50 NO	8,100
9 Wi	4 Oh	-1,210		51 Ho	5,671
	6 Il	408	19 Ks	19 Ks	6,479
	9 Wi	802		26 Tn	715
	44 Ch	0		29 Ar	39
10 Mn	2 NY	-1,767		33 Tx	- 182
	8 Mi	973		50 NO	-1,901
	30 La	794		51 Ho	-3,716
11 Mn	11 Mn	352	20 Va	48 Nf	0
	24 Fl	- 92	29 Ar	49 Cs	121
	26 Tn	-1,316		50 NO	- 121
	49 Cs	- 151	30 La	50 NO	0
12 Ia	11 Mn	- 228	31 Ok	31 Ok	-1,086
	12 Ia	320		51 Ho	1,086
	13 Ia	- 92	32 Tx	32 Tx	333
13 Ia	13 Ia	0		51 Ho	- 333
14 Mo	14 Mo	-1,981	33 Tx	33 Tx	- 571
	23 Ga	- 53		51 Ho	571
	25 Ky	- 268	34 Tx	34 Tx	-2,392
	27 Al	- 238		51 Ho	2,392
	50 NO	2,540	35 Mt	15 ND	120
15 ND	10 Mn	75		35 Mt	41

TABLE XXXVIII (Continued)

Supply Region	Demand Region	Change in Quantity	Supply Region	Demand Region	Change in Quantity
		10,000 Bu			10,000 Bu.
35 Mt	41 Wa	- 117	40 Id	40 Id	966
	50 Po	-1,768		42 Ca	- 966
36 Mt	36 Mt	1,016		52 Lb	0
	54 Po	-1,768		53 Sk	0
	55 Ta	1,289	41 Wa	41 Wa	-1,868
37 Wy	37 Wy	0		54 Po	3,157
38 Co	38 Co	907		55 Ta	-1,289
39 Az	39 Az	21	42 Ca	42 Ca	0

was a net gain in shipments of hard wheat to the East South Central and South Atlantic states, however, due to the decided expansion of hard-wheat milling in Alabama. North Dakota shipped the entire hard-wheat requirements (over 31.2 million bushels) of Alabama in Model II-C, while Missouri shipped the requirements (approximately 2.4 million bushels) in Model I-R. Southern Kansas shipped the requirements of Tennessee (over 7.1 million bushels) in Model II-C while southern Minnesota supplied the approximately 13.2 million bushels in Model I-R. Southern Minnesota, northern Kansas, and Missouri lost the requirements of the other East South Central and South Atlantic states which did not mill hard wheat in Model II-C but did mill in Model I-R.

In the West South Central states, new milling capacity in Arkansas and Louisiana milled hard wheat, 390 thousand and over 7.9 million bushels respectively. These quantities of wheat were shipped by southern Kansas and northern Minnesota respectively. Oklahoma and eastern Texas of the West South Central states did not mill hard wheat in Model II-C, both of which supplied their own mills in Model I-R. In Model II-C, Oklahoma and eastern Texas diverted their hard wheat to export at Houston. Southern Texas and western Texas-New Mexico increased hard-wheat milling. Southern Texas mills received their entire hard-wheat requirements from northern Kansas while western Texas-New Mexico was self-supporting in hard wheat for its mills. Thus, the South as an aggregate increased hard-wheat milling by 27.5 million bushels in Model II-C.

In the North Central states, the East North Central states had a net loss of 2 million bushels of hard-wheat milling in Model II-C. Ohio and southern Illinois each experienced losses of over 14 million bushels, while the remaining regions had increases. Southern Illinois diverted its hard wheat to export at Norfolk and Baltimore. Wisconsin which had been the primary supply of hard wheat to Ohio mills, diverted this wheat to local mills and northern Illinois mills. While the East North Central states experienced a net loss in hard-wheat milling, the West North Central states experienced a net gain of over 24.4 million bushels. However, Missouri never milled hard wheat in Model II-C, a deletion of over 19.8 million bushels which was diverted by Missouri shippers to export at New Orleans. Southern Minnesota and northern Kansas had substantial reductions in volume of hard wheat milled, over 33.9 and 29.3 million bushels, respectively, while northern Iowa and southern Kansas added new capacity which milled hard wheat. The major reduction in shipments of hard wheat was from South Dakota to southern Minnesota mills (over 35.2 million bushels). This wheat in large part was diverted to Alabama mills, with the remainder going to northern Iowa mills. Northern Kansas diverted over 29.3 million bushels from local mills and over 26.7 million bushels from New York mills, most of which was shipped to southern Texas mills, mentioned earlier. Southern Kansas met its entire increased local-mill requirements of over 64.7 million bushels.

New York did not mill hard wheat in Model II-C, a deletion of over 44.3 million bushels. Over 26.7 million bushels of this volume were shipped from northern Kansas (mentioned above) and over 17.6 million bushels from northern Minnesota. The wheat from northern Minnesota was diverted to Michigan and Lousiana mills. Pennsylvania diverted wheat from local mills and export at Baltimore to export at Albany, thus the Middle Atlantic states milled no hard wheat in Model II-C, a reduction of over 49.9 million bushels from Model I-R.

The Mountain states had increased hard-wheat milling in Model II-C with western Montana adding new capacity. Wyoming had no change from Model I-R. Eastern Montana had the greatest increase in hard-wheat milling of the Mountain states, meeting its increased hard-wheat requirements from supplies which were shipped to export at Portland in Model I-R. The increased requirements of Utah-Idaho mills were diverted by local shippers from California mills. Colorado's increased requirements came from inventories it held in Model I-R.

The increased hard-wheat flour production (over 29.5 million bushels in wheat equivalent) of the Mountain states replaced production of Washington-Oregon and California mills. This shift was concurrent with shift of hard wheat by Washington-Oregon shippers from local mills and export at Tacoma to export at Portland. The requirements at Tacoma were met by western Montana.

Hard-Wheat Flour. The net changes in flows of hard wheat to mills had associated net changes in hard-wheat flour flows which are presented in Table XXXIX. A glance at this table indicates many changes in quantities shipped from the various mills to consumption centers. Only 13 of the many point-to-point movements were not changed.

New England, with no milling capacity restraints in Model II-C still did not mill hard wheat. The hard-wheat flour requirements of New England were met by new milling capacity in northern Iowa, replacing shipments by New York mills. New York mills also decreased local shipments which were met by southern Kansas mills. Nebraska replaced hard-wheat flour shipments from North Dakota, northern Kansas, southern Illinois, Michigan, and Pennsylvania to Pennsylvania

TABLE XXXIX

NET CHANGE FROM MODEL I-R IN THE VOLUME OF HARD-WHEAT FLOUR (WHEAT EQUIVALENTS) SHIPPED FROM MILLING REGIONS TO DEMAND REGIONS, MODEL II-C

Milling Region		Demand Region		Change in Quantity	Milling Region		Demand Region		Change in Quantity
				10,000 Bu.					10,000 Bu.
2	NY	1	NE	-1,696	18	Ks	3	Pa	- 385
		2	NY	-2,743			18	Ks	- 267
3	Pa	3	Pa	- 560			21	NC	- 32
4	Oh	4	Oh	-1,409			22	SC	85
5	In	5	In	157			24	Fl	- 952
6	Il	6	Il	760			29	Ar	- 363
		44	Ch	- 34			30	La	- 657
7	Il	3	Pa	-1,510			50	NO	- 366
		7	Il	439	19	Ks	2	NY	-2,640
		25	Ky	- 350			4	Oh	1,869
8	Mi	3	Pa	- 58			5	In	736
		8	Mi	1,003			14	Mo	814
9	Wi	9	Wi	768			18	Ks	267
		44	Ch	34			19	Ks	0
10	Mn	10	Mn	75			20	Va	205
11	Mn	5	In	- 893			21	NC	936
		6	Il	- 760			23	Ga	- 450
		8	Mi	-1,003			28	Ms	451
		9	Wi	- 768			29	Ar	363
		11	Mn	0			31	Ok	453
		43	Du	27			34	Tx	989
12	Ia	1	NE	1,696			50	NO	-1,001
		12	Ia	195			51	Ho	-1,793
13	Ia	2	NY	103	20	Va	20	Va	- 205
		12	Ia	- 195	21	NC	21	NC	- 904
		13	Ia	0			49	Cs	- 39
14	Mo	4	Oh	- 460	22	SC	22	SC	- 85
		7	Il	- 439	23	Ga	23	Ga	- 53
		14	Mo	- 814	24	Fl	24	Fl	- 92
		28	Ms	- 268	25	Ky	25	Ky	- 268
15	ND	3	Pa	- 140	26	Tn	23	Ga	- 191
		10	Mn	- 75			26	Tn	0
		15	ND	0			27	Al	- 410
		16	SD	- 2	27	Al	23	Ga	811
		35	Mt	41			24	Fl	1,044
		43	Du	- 27			25	Ky	618
16	Sd	16	SD	2			27	Al	410
17	Ne	3	Pa	2,653	29	Ar	49	Cs	39
		17	Ne	0			50	NO	794
		47	Ba	0					

TABLE XXXIX (Continued)

Milling Region		Demand Region		Change in Quantity	Milling Region		Demand Region		Change in Quantity
				10,000 Bu.					10,000 Bu.
31	Ok	23	Ga	- 117	37	Wy	37	Wy	0
		28	Ms	- 183	38	Co	38	Co	0
		31	Ok	- 453			39	Az	- 21
		32	Tx	- 333			42	Ca	928
32	Tx	32	Tx	333	39	Az	39	Az	21
33	Tx	30	La	657	40	Ut	40	Ut	0
		33	Tx	0			42	Ca	966
		50	NO	573			53	Sk	0
		51	Ho	3,196	41	Wa	41	Wa	- 847
34	Tx	34	Tx	- 989			42	Ca	- 928
		51	Ho	-1,403			54	Po	- 123
35	Mt	35	Mt	41			55	Ta	- 87
36	Mt	35	Mt	- 41	42	Ca	42	Ca	- 966
		36	Mt	0					
		41	Wa	847					
		54	Po	123					
		55	Ta	87					

consumption centers. Since southern Kansas had such an increase in hard-wheat milling many shipments of Model I-R were replaced by southern Kansas shipments in Model II-C. Among the shipments made by southern Kansas were shipments to Ohio, replacing Missouri and Ohio shipments. Southern Kansas also replaced local shipments in Virginia, North Carolina, Missouri, Oklahoma and eastern Texas. 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 which were supplied by southern Kansas and eastern Texas in Model I-R. Alabama shipped hard-wheat flour to Georgia, Florida, and Kentucky, replacing shipments 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-Idaho mills replaced shipments to California made by California and Washington-Oregon mills.

Soft Wheat. The net changes in shipments of soft wheat are presented in Table XL. In general, the mills of the East North Central states received more soft wheat in Model II-C, but shipments received from other areas did not increase as much as mill receipts although no soft wheat was imported from other areas. Thus, the increased soft-wheat milling in the East North Central states was supported by states in that 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

TABLE XL

NET CHANGE FROM MODEL I-R IN THE VOLUME OF SOFT WHEAT SHIPPED FROM SUPPLY REGIONS TO DEMAND REGIONS, MODEL II-C

Supply Region	Demand Region	Change in Quantity	Supply Region	Demand Region	Change in Quantity
		10,000 Bu.			10,000 Bu.
2 NY	2 NY	-1,157	20 Va	48 Nf	335
	46 Ab	364	21 NC	21 NC	- 373
	47 Ba	38		22 SC	- 24
3 Pa	3 Pa	0		48 Nf	412
	47 Ba	- 170		49 Cs	- 15
4 Oh	4 Oh	985	22 SC	22 SC	- 163
	46 Ab	- 364		49 Cs	15
	48 Nf	- 747	23 Ga	23 Ga	- 175
5 In	5 In	1,312		50 NO	175
	6 Il	582	24 Fl	24 Fl	- 56
	10 Mn	- 36		50 NO	56
	13 Ia	- 128	25 Ky	50 NO	0
	14 Mo	41	26 Tn	26 Tn	0
	17 Ne	- 104	27 Al	27 Al	- 146
	18 Ks	- 40		50 NO	146
	19 Ks	- 80	28 Ms	28 Ms	201
	44 Ch	39		50 NO	- 201
	50 NO	- 191	29 Ar	26 Tn	32
6 Il	26 Tn	- 32		28 Ms	87
	28 Ms	- 24		29 Ar	792
	31 Ok	- 164		50 NO	- 911
	33 Tx	432	30 La	33 Tx	- 99
	50 NO	- 212		50 NO	99
7 Il	7 Il	999	35 Mt	15 ND	48
	50 NO	- 999		16 SD	- 52
8 Mi	6 Il	- 474		35 Mt	16
	8 Mi	- 563		37 Wy	- 107
	13 Ia	128	36 Mt	36 Mt	- 16
	17 NE	104	37 Wy	38 Co	0
	45 To	0	39 Az	39 Az	29
9 Wi	9 Wi	328	40 Id	32 Tx	204
	12 Ia	80		37 Wy	24
	44 Ch	- 39		38 Co	123
10 Mn	10 Mn	- 4		40 Ut	194
	11 Mn	0		52 LB	0
	15 ND	- 48		53 Sk	0
	16 SD	52		54 Po	- 82
14 Mo	14 Mo	-2,125	41 Wa	41 Wa	- 223
	30 La	87		54 Po	82
	50 NO	2,038		55 Ta	0
20 Va	20 Va	- 467	42 Ca	42 Ca	0
	47 Ba	132			

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 over 21.6 million bushels' reduction 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 decreased soft-wheat milling in New York and an increase in inventory in that state.

The South Atlantic states experienced a net loss of over 1.4 million bushels in soft-wheat shipments while experiencing a loss of over 12.5 million bushels in soft-wheat milling. The difference is explained by the fact that the South Atlantic states with the exception of 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 of shipments, thus, increased end inventories.

The East South Central states had no change in volume shipped, but did increase soft wheat milled by 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. Arkansas diverted shipments from export at New Orleans. The remainder of the increased milling was in southern and western Texas with a minor volume milled in new capacity in Louisiana. The soft wheat for these respective mills came from northern Illinois, Utah-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. Utah-Idaho was primarily responsible for the increased shipments of the Mountain states. Net gains in shipments were to local mills and mills in Colorado, Wyoming, and western Texas. The net gain in soft-wheat milling which was not as great as the net gain in soft-wheat shipments was from Colorado, Arizona, Utah-Idaho, and eastern Montana which did not have milling capacity in Model I-R.

Washington-Oregon had a net loss of soft-wheat shipments while California had no changes, thus leaving the Pacific states with a net loss. The loss in shipments to local mills by Washington-Oregon was also the equivalent loss in soft-wheat flour milled by the mills of Washington-Oregon and California.

Soft-Wheat Flour. The net changes in soft-wheat flour shipments are presented in Table XLI. The major shifts in shipments were away from Missouri mills, totaling over 20.8 million bushels' grind. Shipments to Arkansas, Louisiana, southern Texas, and western Texas were replaced by local shipments in those respective regions. The shipments from Arkansas and Lousiana were from new milling capacity. Arkansas also shipped to eastern Texas which was also formerly served by Missouri. Missouri's shipments to Oklahoma were replaced by Indiana shipments and southern Illinois replaced Missouri's local shipments.

Other major shifts in shipments occurred due to the marked increase in soft-wheat milling in Indiana and Ohio. Ohio replaced shipments of over 11.5 million bushels' grind from New York mills to New York and New England consumption centers. Ohio also gained

TABLE XLI

NET CHANGE FROM MODEL I-R IN THE VOLUME OF SOFT-WHEAT FLOUR (WHEAT EQUIVALENTS) SHIPPED FROM MILLING REGIONS TO DEMAND REGIONS, MODEL II-C

Milling Region	Demand Region	Change in Quantity	Milling Region	Demand Region	Change in Quantity
		10,000 Bu.			10,000 Bu.
2 NY	1 NE	- 560	13 Ia	13 Ia	0
	2 NY	- 597	14 Mo	14 Mo	- 271
3 Pa	3 Pa	0		29 Ar	- 224
4 Oh	1 NE	560		30 La	- 384
	2 NY	597		31 Ok	- 100
	4 Oh	0		32 Tx	- 204
	20 Va	467		33 Tx	- 333
	22 SC	115		34 Tx	- 568
	23 Ga	- 305	15 ND	15 ND	0
	24 Fl	- 528	16 SD	16 SD	0
	47 Ba	79	17 Ne	17 Ne	0
	49 Cs	0	18 Ks	18 Ks	0
5 In	5 In	0		38 Co	- 40
	6 Il	- 354	19 Ks	19 Ks	- 80
	7 Il	- 160	20 Va	20 Va	- 467
	19 Ks	80	21 NC	21 NC	- 373
	22 SC	72	22 SC	22 SC	- 187
	23 Ga	480	23 Ga	23 Ga	- 175
	24 Fl	584	24 Fl	24 Fl	- 56
	25 Ky	0	26 Tn	26 Tn	0
	27 Al	146	27 Al	27 Al	- 146
	30 La	384	28 Ms	28 Ms	264
	31 Ok	264	29 Ar	29 Ar	224
	44 Ch	- 18		34 Tx	568
	47 Ba	- 79	30 La	50 NO	87
	50 NO	- 87	31 Ok	31 Ok	- 164
6 Il	6 Il	354	32 Tx	32 Tx	204
	28 Ms	- 264	33 Tx	33 Tx	333
	44 Ch	18	35 Mt	35 Mt	16
7 Il	7 Il	160	36 Mt	35 Mt	- 16
	14 Mo	271		36 Mt	0
	21 NC	568	37 Wy	37 Wy	0
8 MI	8 Mi	0		38 Co	- 83
	9 Wi	- 288	38 Co	38 Co	123
	12 Ia	- 80	39 Az	39 Az	29
	21 NC	- 195	40 Ut	39 Az	- 29
	45 To	0		40 Ut	0
9 Wi	9 Wi	288		42 Ca	223
	10 Mn	40			
10 Mn	10 Mn	40			
11 Mn	11 Mn	0			
12 Ia	12 Ia	80			

TABLE XLI (Continued)

Milling Region	Demand Region	Change in Quantity	Milling Region	Demand Region	Change in Quantity
			41 Wa	41 Wa	0
				42 Ca	- 223
				54 Po	0
			41 Wa	55 Ta	0
			42 Ca	42 Ca	0

shipments to Viriginia and South Carolina, replacing local mill shipments. Ohio also replaced Indiana shipments to Baltimore while losing shipments to Georgia and Florida consumption centers to Indiana mills. Indiana also replaced local shipments in Florida, Alabama, Oklahoma and southern Kansas, plus shipments made by Missouri mills to Louisiana, for a gross gain in volume shipped of over 19 million bushels' grind while only experiencing a gross loss of approximately 5.9 million bushels' grind.

Southern Illinois was the only other soft-wheat milling region which had a net change in shipments of over 5 million bushels' grind. Southern Illinois replaced local shipments in North Carolina and inter-regional shipments from Michigan to North Carolina, local shipments in Missouri, and replaced Indiana in supplying its own local needs.

The largest volume changes in the West were replacements of over 2.2 million bushels' grind shipped from Washington-Oregon mills to California with shipments from Utah-Idaho, and the replacement of shipments made by Wyoming and northern Kansas mills to Colorado consumption centers by local shipments.

Durum Wheat, Feed Grain, and Soybeans. Optimum flows of durum wheat, feed grain, and soybeans in Model II-C were not sufficiently different from those of Model I-C to warrant tabular presentation here.

There were shifts in domestic and export durum wheat shipments involving over 14.5 million bushels. Northern Minnesota gained over 10.6 million bushels in shipments to Wisconsin and southern Minnesota, while North Dakota gained over 3.8 million bushels in shipments to export at Duluth-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, while eastern Montana had net losses of over 17.2 million bushels. These combined losses were offset by gains 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 shipment of over 4.9 million bushels to export at Duluth-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, and in Model II-C storage capacity restraints were realized. Ending inventories for Model II-C will not be elaborated on here since regions with net gains and losses in shipments discussed above were the regions with ending inventory adjustments.

Optimum Milling Industry Organization

The volume of each type of wheat milled by region in Model 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 XLII. Table XLIII presents the capacity utilized in Model I-R and Model II-C and the optimum milling capacity requirements by region in relation to existing (1967) milling capacity when milling capacity restraints are relaxed. Given the incentives suggested by Model I-C, the adjustments indicated here would have resulted in a lower total cost to the industry in satisfying the regional flour requirements with the given wheat supplies of 1967. The most significant increases and decreases in milling volume occurred in hard-wheat milling which can be seen quite easily by examination of Table XLII. The most significant reduction in hard-wheat milling occurred in New York, southern Minnesota, northern Kansas, eastern Texas, Washington-Oregon, Missouri, southern Illinois, Ohio, and Oklahoma. The respective decreases in the volume of hard wheat milled in these regions were 44.39 million, 33.97 million, 29.37 million, 23.92 million, 19.85 million, 19.81 million, 14.21 million, 14.09 million, and 10.86 million bushels. For New York, Washington-Oregon, Ohio, Missouri, Oklahoma, and eastern Texas this amounted to no hard-wheat milling. Of these states only Ohio milled any soft wheat. With such significant declines in hard-wheat milling volume, one would expect some significant increases also. Significant increases did occur in southern Kansas, southern Texas, Alabama, Nebraska, northern Iowa, and western Montana. These respective increases were 64.79 million, 44.26 million, 28.83 million, 26.53 million, 18.91 million, and 10.16 million bushels. Table XLII reveals that the level of concentration of hard-wheat milling was higher in Model II-C, in particular, southern Kansas, Nebraska, northern Iowa, northern Illinois, Michigan, southern Texas, Alabama, Colorado, western Montana, and Utah. A void of any hard-wheat milling is particularly noticeable in the South Atlantic states and the Northeastern states.

The changes in soft-wheat milling activity were much less significant in comparison to hard-wheat milling changes. The most significant changes were the deletion of soft-wheat milling in Missouri and New York of 20.84 million and 11.57 million bushels respectively

TABLE XLII

VOLUME OF HARD AND SOFT WHEAT MILLED BY REGION, MODEL I-R AND MODEL II-C

Milling Region		Hard Wheat Milled Model I-R	Model II-C	Change	Soft Wheat Milled Model I-R	Model II-C	Change
				10,000 Bu.			
1	Ne	a	0	0		0	0
2	NY	4,439	0	-4,439	1,157	0	-1,157
3	Pa	560	0	- 560	1,448	1,448	0
4	Oh	1,409	0	-1,409	2,215	3,200	985
5	In	0	157	157	1,660	2,972	1,312
6	Il	802	1,528	726	474	582	108
7	Il	1,860	439	-1,421	0	999	999
8	Mi	610	1,555	945	1,162	599	- 563
9	Wi	0	802	802	8	336	328
10	Mn	72	147	75	56	16	- 40
11	Mn	3,924	527	-3,397	192	192	0
12	Ia	a	1,891	1,891	a	80	80
13	Ia	514	422	- 92	128	128	0
14	Mo	1,981	0	-1,981	2,125	41	-2,084
15	ND	364	120	- 244	48	48	0
16	SD	124	126	2	52	52	0
17	Ne	1,576	4,229	2,653	104	104	0
18	Ks	3,432	495	-2,937	120	80	- 40
19	Ks	4,552	11,031	6,479	80	0	- 80
20	Va	205	0	- 205	467	0	- 467
21	NC	943	0	- 943	373	0	- 373
22	SC	85	0	- 85	187	0	- 187
23	Ga	53	0	- 53	175	0	- 175
24	Fl	92	0	- 92	56	0	- 56
25	Ky	268	0	- 268	0	0	0
26	Tn	1,316	715	- 601	428	428	0
27	Al	238	3,121	2,883	146	0	- 146
28	Ms	0	0	0	24	288	264
29	Ar	a	39	39	a	792	792
30	La	a	794	794	a	87	87
31	Ok	1,086	0	-1,086	164	0	- 164
32	Tx	64	397	333	0	204	204
33	Tx	753	5,179	4,426	99	432	333
34	Tx	2,392	0	-2,392	0	0	0
35	Mt	a	41	41	a	16	16
36	Mt	124	1,140	1,016	52	36	- 16
37	Wy	53	53	0	107	24	- 83

TABLE XLII (Continued)

Milling Region	Hard Wheat Milled Model I-R	Model II-C	Change	Soft Wheat Milled Model I-R	Model II-C	Change
38 Co	578	1,485	907	13	136	123
39 Az	0	21	21	48	77	29
40 Ut	1,399	2,365	966	201	395	194
41 Wa	1,985	0	-1,985	707	484	- 223
42 Ca	1,036	70	- 966	1,048	1,048	0

[a]No capacity in Model I-R.

and the increases in Indiana, Ohio and southern Illinois of 13.12 million, 9.85 million, and 9.99 million bushels respectively. Arkansas also came in with 7.92 million bushels of soft wheat milled.

An obvious point in Tables XLII and XLIII is the lack of any milling activity in the South Atlantic states, Kentucky, Oklahoma, eastern Texas and New York. Also, New England was the only region without capacity in Model II-C when milling capacities were not restricted. The data of Table XLIII compare the milling capacity distribution of Model II-C with the existing capacity distribution of 1966-67 which was used in Model I-R. Only one region, South Dakota, maintained a capacity in Model II-C which was not significantly different from the existing 1966-67 capacity, although northern Minnesota was only slightly different. Eight regions had reductions in capacity and eight regions had additions to 1966-67 capacity in excess of 10 million bushels. The largest reductions in milling activities were in New York and Missouri while the greatest need for additional capacity was in southern Kansas. It must be pointed out that the selection of points of production and milling for input data for an interregional model could alter the resulting output information of such a model, due to the sensitivity of the model to small changes in input data. Reductions or increases in assembly costs of wheat would result from different production and milling point-location situations.

The East North Central states had capacity needs over four times their idle capacity when comparing milling capacity distribution of Model II-C with Model I-R. The West North Central states had capacity needs which were less than their idle capacity suggesting redistribution of capacity was needed.

TABLE XLIII

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 Bu			
1	NE	a	a	0		
2	NY	5,596	5,596	0	5,596	
3	Pa	2,008	2,008	1,448	560	
4	Oh	3,624	3,624	3,200	424	
5	In	1,660	1,660	3,129		1,469
6	Il	1,276	1,276	2,110		834
7	Il	1,860	1,860	1,438	422	
8	Mi	1,772	1,772	2,154		382
9	Wi	8	8	1,138		1,130
10	Mn	128	128	163		35
11	Mn	4,116	4,116	719	3,397	
12	Ia	a	a	1,971		1,971
13	Ia	1,224	642	550	674	
14	Mo	4,980	1,107	41	4,939	
15	ND	412	412	168	244	
16	SD	176	176	178		2
17	Ne	1,680	1,680	4,333		2,653
18	Ks	3,552	3,552	575	2,977	
19	Ks	4,632	4,632	11,031		6,399
20	Va	672	672	0	672	
21	NC	1,316	1,316	0	1,316	
22	SC	272	272	0	272	
23	Ga	228	228	0	228	
24	Fl	148	148	0	148	
25	Ky	268	268	0	268	
26	Tn	1,744	1,744	1,143	601	
27	Al	384	384	3,121		2,737
28	Ms	24	24	288		264
29	Ar	a	a	831		831
30	La	a	a	881		881
31	Ok	1,732	1,250	0	1,732	
32	Tx	64	64	601		537
33	Tx	852	852	5,611		4,759
34	Tx	2,392	2,392	0	2,392	
35	Mt	a	a	57		57
36	Mt	600	600	1,176		576
37	Wy	160	47	77	83	
38	Co	704	704	1,621		917
39	Az	48	48	98		50

TABLE XLIII (Continued)

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
40 Ut	1,600	1,600	2,760		1,160
41 Wa	3,112	2,692	484	2,628	
42 Ca	2,084	2,084	1,118	966	

[a]No milling capacity in 1966-67.

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 of capacity. In the West, the capacity situation was just the reverse of Texas and Oklahoma. Colorado, Utah-Idaho, Arizona, and Montana had need for additional capacity equal to approximately 75 percent of the idle capacity of Washington-Oregon and California.

Comparative Cost Analysis

Questions arise pertaining to possible reductions in marketing costs when discussing possible relocation of an industry. Table XLIV presents selected marketing costs for Models I-R, II-C, and I-C. As in Table XXXVII, storage costs are not considered since they do not affect the net differences in the total marketing costs of the system.

The "Summary" data of Table XLIV reveal that 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 is 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 resulted in decreased costs of acquiring hard wheat by over $32 million, and decreased costs of shipping domestic hard-wheat flour by less than $1 million. Soft-wheat flour milling costs were reduced over $2 million. Costs of acquiring soft wheat by mills was reduced over $6 million and transportation costs for shipping domestic soft-wheat flour were reduced over $7 million. The reduction in transportation costs of hard and

TABLE XLIV

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 Grain			
Domestic transportation	557,807	470,155	467,698
Export transportation	170,921	116,936	120,226
Soybeans			
Domestic transportation	56,180	54,752	55,752
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

soft wheat export flours to ports was over $9.2 million. Costs of transporting hard wheat and soft wheat to ports were reduced approximately an additional $62 million.

Reductions in transportation costs of durum wheat, feed, grain, and soybeans when Model II-C and I-C are compared amounted to just over $3.9 million. The addition of storage capacity 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.

Comparison of toal cost reduction of Model I-C and II-C reveals that relocation of milling activity as suggested in Table XLIII would reduce total costs over $19.7 million. Given that the grain marketing system operated with cost-of-service transportation charges, the opportunity cost of the 1966-67 milling capacity distribution is reflected. Such a cost reduction would not justify the relocation of milling capacity to the extent suggested in Table XLIII, but data in Table XXXI on value of additional capacity would suggest that expansion in several regions may be desirable, particularly in the East North Central States, the East South Central states, and the Mountain states. This finding is somewhat contrary to Leath's finding that expansion of capacity may be desirable "primarily in the Southeast."[7]

Thus, one might infer that the transportation rate structure which is currently effective (1966-67) suggests a locational pattern of milling activities somewhat different from a pattern suggested by a cost-of-service transportation rate structure based upon economic theory and which has been argued in cases before the Interstate Commerce Commission cited in Chapter I.

FOOTNOTES

[1]Mack N. Leath, An Interregional Analysis of the United States Grain Marketing Industry, (Unpublished Ph.D. dissertation, Oklahoma State University, 1970).

[2]Regions mentioned in this chapter are those defined in U. S. Department of Commerce, County and City Data Book, 1962 (Washington, 1962), p. 2. These regions are: Northeast, composed of Maine, New Hampshire, Rhode Island, Vermont, and Connecticut as New England and New York. New Jersey, and Pennsylvania as Middle Atlantic; North Central, composed of Ohio, Indiana, Illinois, Michigan, and Wisconsin as the East North Central and Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas as the West North Central; South, composed of Kentucky, Tennessee, Alabama, and Mississippi as the East South Central, Delaware, Maryland, West Virginia, North Carolina, South Carolina, Georgia, Florida, and Virginia as the South Atlantic, and Arkansas, Louisiana, Oklahoma, and Texas as the West South Central; and the West, composed of Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada as the Mountain states, and Washington, Oregon, and California as the Pacific area.

[3]Mack N. Leath, p. 142.

[4]Ibid.

[5]Ibid.

[6]Ibid., p. 181.

[7]Ibid.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

Transportation is a vital link in the marketing of grain and flour in the United States, particularly since production and consumption areas may be quite divergent. Before the turn of the century, the farm team and wagon and the steam railroads were the prime movers of grain in this country. Location of rail lines, enticements and inducements in rates, and railroad monopoly power played an important role in the early location of the milling industry. Later, millers in Mid-America and the railroads reached an accord on grain-flour rate relationships which were advantageous to the millers in that area. This so-called "rate structure" survived until the 1950's. Since then there have been several changes in the grain rate structure and competition among modes of transportation has become vigorous, posing questions and problems for grain marketing firms, grain processing firms, transportation companies, and policy makers about location of facilities, pricing of services, size of plant, and other related matters. The objectives of this study were to: (1) develop regional costs of transportation service to the carrier by mode, that is, rail, barge and truck, for grains and flour; (2) determine the distribution patterns which would minimize the total cost of storage, acquisition, processing, and distribution for the U. S. grain marketing system when the existing structure and competitive conditions prevail; (3) compare the distribution patterns of (2) with those which resulted when existing transportation rates were used; (4) determine intermarket and shipping-point price relationships for grain by computing equilibrium price differentials between major markets and shipping points and evaluate the competitive position of various production and consumption regions; and estimate the savings that would result from a relocation of mills consistent with cost-of-service transportation charges; and (6) estimate the social cost of the existing (1966-67) grain transportation rate structure.

The costs of transporting grain and flour by the three modes of transportation considered were synthesized from various sources of data and are presented in the appendices to this study. The vehicle used to accomplish objectives (2) through (6) was a linear programming formulation of the transhipment problem.

Forty-two domestic regions and thirteen port regions were specified to represent the grain marketing system of the Continental United States. Corresponding data on supplies, demands, storage capacity, processing capacity, and associated costs of handling and storing grain and milling flour were provided. Two basic analyses were made and compared with a previous analysis which employed existing transportation rates.

The first model, Model I-C, assumed the cost conditions, and location and capacity of facilities which existed in 1966-67 in the United States grain marketing system. Optimum (least-cost) flows for five grains, soft wheat, hard wheat, durum wheat, feed grain, and soybeans, and two flours, hard-wheat and soft-wheat, were determined simultaneously. Regional milling volumes were also determined. Social costs of the existing transportation rate structure were estimated by comparing results of this model and Leath's model referred to earlier.

Price differentials were computed for the various grains at origins and grains and flours at destinations for Model I-C in Chapter V. These differentials are the dual variables of linear programming and allow estimation of the comparative price advantage or disadvantage of particular production regions or markets in relation to other production regions or markets.

Model II-C differed from Model I-C in that 1966-67 milling capacity and storage capacity restrictions of Model I-C were related in Model II-C. Thus, optimum milling location was determined, given the milling costs of 1966-67 and cost-of-service transporation charges. This analysis compared with Model I-C allowed determination of the opportunity costs of relocating flour milling activities given that a cost-of-service transportation rate structure was effective in 1966-67.

Model I-C had significantly lower total marketing costs, which serve as an estimate of the social cost of the existing transportation rate structure with given 1966-67 conditions, thus, satisfying objective (6) of this study. Domestic and export transportation costs were about $661 million and $299 million, respectively, with milling costs approximately $155 million. The reduction in marketing costs (or social cost estimate) was over $261 million, a 19 percent reduction in total marketing costs resulting when cost-of-service transportation charges were effective.

Generally, hard wheat was milled closer to points of production when cost-of-service transportation costs were used.

The most significant change in hard-wheat flows was a shift of 23 million bushels of hard-wheat shipped from the North Central states to the South Atlantic and East South Central states in Model I-R to intraregional mills in Model I-C.

More hard wheat was milled in the North Central states with the East North Central states experiencing a net deficit, while the West North Central states had a large offsetting increase. The most significant increase in hard-wheat milling occurred in Missouri. No hard wheat was milled in the reduction. Oklahoma and Texas had minor increases in hard-wheat milling. Decreases in hard-wheat milling in the Pacific states were almost equalled by increases in the Mountain states. The major decline in soft-wheat milling was in Missouri and the West North Central states. The major increase was in the East South Central states. North Carolina was the only state which milled no wheat in Model I-C.

Total milling costs for hard wheat decreased just over one-half million dollars or slightly less than one-half percent of the hard wheat milling costs of Model I-R, while milling costs for soft wheat increased just less than one-half million dollars.

Considering the estimated social cost of the existing rate structure to the milling industry, the existing transportation rates increased marketing costs excluding storage cost, by over $41 million compared with least-cost flows from cost-of-service transportation charges. The social cost in the feed grains sector was estimated to be approximately $140.7 million. Social costs were also incurred in transportation of soybeans and durum wheat, but not as significant in absolute terms as for the other sectors of the grain marketing system. These estimates were $17.0 million and $2.5 million respectively.

When milling capacity restraints were relaxed (Model II-C) numerous shifts in milling location were indicated. The level of concentration of hard wheat milling was higher in Model II-C, in particular in southern Kansas, Nebraska, northern Iowa, northern Illinois, Michigan, southern Texas, Alabama, Colorado, western Montana, and Utah-Idaho. There was a void of hard-wheat milling in the South Atlantic states and the Northeastern states. Alabama was the major hard-wheat miller in the East South Central states. The most significant changes in soft-wheat milling were the deletion of soft-wheat milling in Missouri and New York, and substantial increases in Indiana, Ohio, and southern Illinois with addition of new capacity in Arkansas.

Total marketing cost reduction excluding storage cost was greater than 1.7 percent or $19.7 million when milling capacity was allowed to relocate in Model II-C. Costs of milling activities decreased by more than $3.7 million, while savings in domestic transportation of wheat and flour amounted to more than $46 million.

Conclusions

Inferences from Study

Comparisons of optimum flows of grain and flour for 1966-67 resulting from the solution of a linear programming formulation of the transhipment problem using cost-of-service transportation charges, with the actual flows cannot be made since the latter data do not exist. However, meaningful information can be obtained concerning the results when compared with the optimum flows which resulted when the actual transportation rates were used.

The sensitivity of interregional models to changes in transportation charges was quite evident in Chapter V when changes in flows of grain and flour were examined. In particular, the shift of Missouri soft wheat from local mills to exports was notable. It should be pointed out here that such a shift may be conditioned by the fact that a barge-rail combination rate was not a consideration in Model I-R for the particular points being considered, but was the lowest-cost transportation method in Model I-C. Further, the choice of origins and destinations within regions may affect assembly costs in such a model and thus alter the competitive position of regions.

The optimum solution to a specific transportation problem does not necessarily imply a unique solution, and thus must be considered when interpreting results from such studies. Such is the case in this study. A problem arises because the total cost for a particular region, or industry, or other particular segment of a multiple-staged problem may change in alternate solutions, although the total cost to the system remains the same. This suggests that in reality such a solution would be difficult if not impossible, since each economic unit or firm would most likely seek to minimize its costs. The case of export-soft wheat from Missouri points out a situation where per unit cost was increased for Missouri mills due to decreased volume of milling, but as a result of shipping soft wheat from Missouri to the Gulf, costs of meeting export demands were reduced and the system as a whole had minimum total costs. Thus, for a system to accomplish minimum costs, a single decision making unit is implied.

Considering the results obtained by Leath indicating relocation of milling in the Southeast,[1] this study showed a reduction of milling activity for that area in general. The fact that the Southeast was indicated as a relocation region might possibly result from the existing rates which were used. The Southeast was the first region in general to obtain grain rates which were more nearly representative of cost-of-service transportation and their rates tended to be lower. The sensitivity to transportation charges of the model used to represent the grain marketing system would reflect such shifts in milling location as Leath reported.[2] Thus, when cost-of-service transportation charges are estimated and used in all regions, such shift of milling location to one particular region would not be so likely, unless the other regions had costs which were not significantly different from rates. In view of this and the importance which seems attached to developing a rate structure which more nearly resembles cost-of-service, perhaps decision makers contemplating relocation should strongly consider the stability of the existing rate structure. The study by Leath[3] and the analysis of this study both resulted in estimated opportunity costs of relocation insufficient to justify relocation to the extent suggested by either study. Thus, one might conclude that transportation charges and the stability of the relationship of these charges among regions and between commodities will be quite important in the future of the milling industry.

Researchers in practical problems of economics are usually faced with making certain assumptions in order to accomplish their mission which may be more or less limiting. This study has certain underlying assumptions which are somewhat limiting.

One, feed grain was assumed to be a homogeneous commodity, whereas for most uses other than for animal feeding, specific grains are required. This should not be considered too critical since there is substitution in feeding within limits and livestock feed is the most important use.

Two, flour was the only product of wheat milling considered, thus 28 percent of the product, mill feed, which is 10 percent of the product value, was considered to be used at flour consumption centers by the mixed-feed industry.

Three, the supply of transportation facilities was assumed to be perfectly elastic for all points. For particular seasons, certain modes may be limited, or unavailable to certain points in the case of barges during winter months, thus timeliness of flows was not a consideration.

Need for Further Study

The transhipment model as formulated for this study could be extended by including regional production costs and cropland restraints. By relaxing the fixed supplies assumption in conjunction with such extension, comparative advantages in production could be determined. This integration of production and marketing aspects of agriculture would be most helpful to policy makers.

Additional research into the effects of various transportation technologies such as the rent-a-train, unit train, and LASH system of barging would be beneficial and would more accurately describe the competitive position of regions or sectors.

With the great difficulty experienced in estimating cost-of-service transportation charges for the three modes of transportation considered in this study, this author believes a concerted research effort is needed, worthy of considerable funding, to further study the costs of providing transportation services. This should be comprehensive for agricultural commodities, since there is a general lack of such information.

FOOTNOTES

[1]Mack N. Leath, An Interregional Analysis of the United States Grain Marketing Industry (Unpublished Ph.D. dissertation, Oklahoma State University, 1970), p. 163.

[2]Ibid.

[3]Ibid.

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APPENDIX A

SYNTHESIS OF GRAIN TRUCKING COSTS-OF-SERVICE

Grain is a commodity exempt from Interstate Commerce Commission regulation when hauled by truck and data on costs of hauling grain by truck are virtually non-existent. A study by Cassavant and Nelson[1] for North Dakota has revealed much information on grain trucking costs for that area. Similar studies for other states or regions are non-existent. Despite the paucity of information for this study, data on investment costs and operating costs were gathered with an attempt to incorporate as much disaggregated data as were available.

The costs-of-service of grain transportation by trucks may generally be divided into categories as outlined below.

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

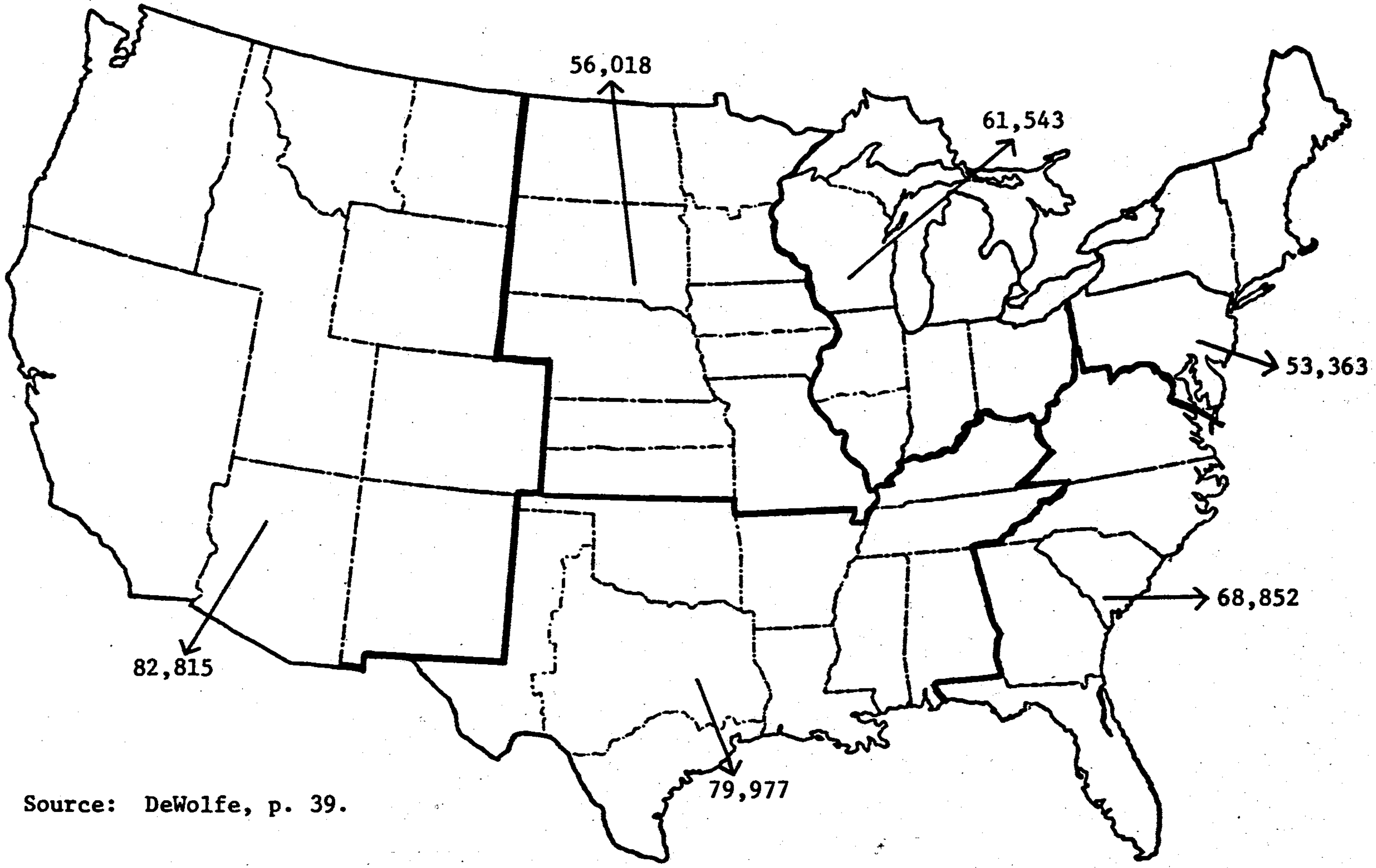
d. Fuel costs

e. Tire costs

f. Maintenance costs

g. Administrative expenses and utilities

Each of the above listed costs will be discussed and presented. But first, a brief word should be mentioned about the firm. Cassavant and Nelson[2] found no noticeable economies of size were realized by increasing the firm's size beyond the three-tractor-four-trailer size. In a 1966 study by Milikus[3], the median sized firm was a five-tractor firm. For this study, firms hauling grain and firms hauling flour were assumed to have three tractors and three trailers. Another consideration is the number of miles the vehicle is driven annually. This is imperative since cost curves were not available, thus assumptions must be made about mileage. Data from the U. S. Department of Commerce[4] indicate 70,000 miles per year for all types of tractor-trailer vehicles. DeWolfe reported mileages by regions for carriers hauling exempt agricultural commodities in 1961.[5] These data are represented in Figure 16. These data are somewhat dated for a study concerned with 1966 transportation, thus they were adjusted to 1966 mileages using ICC data[6] for regulated motor carriers. This assumed that the mileage traveled by grain haulers would follow the same pattern as that of the regulated carriers. The procedure used was to index the ICC data on the mileage for North Dakota firms which were "operating at



Source: DeWolfe, p. 39.

Figure 16. Annual Truck Mileage by Region, 1961

nearly optimum efficiency at the forty-five percent level of capacity or 67,500 miles annually.[7] These adjusted data are presented in Figure 17.

Another consideration which is quite important in grain transportation is backhaul. Backhaul data were estimated using data from DeWolfe[8] on laden miles per vehicle by regions. The percentages of laden miles by regions used in this study are presented in Figure 18.

Investment Costs

For clarity and brevity of presentation of the various items of investment costs, descriptive information will be included in the discussion of the derivation of the costs.

Capital Outlays

Capital items necessary for trucking firms considered in this study were truck-tractors, grain trailers or pneumatic bulk flour trailers. Since grain trucking firms are rather specialized and they 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 this study since 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 specifications for the truck were such that the size (length, axles, and weight) would allow interstate shipments of topographical diversity. Such flexibility allows for mobility of the trucking firm. The tractor specified for the study was a diesel,

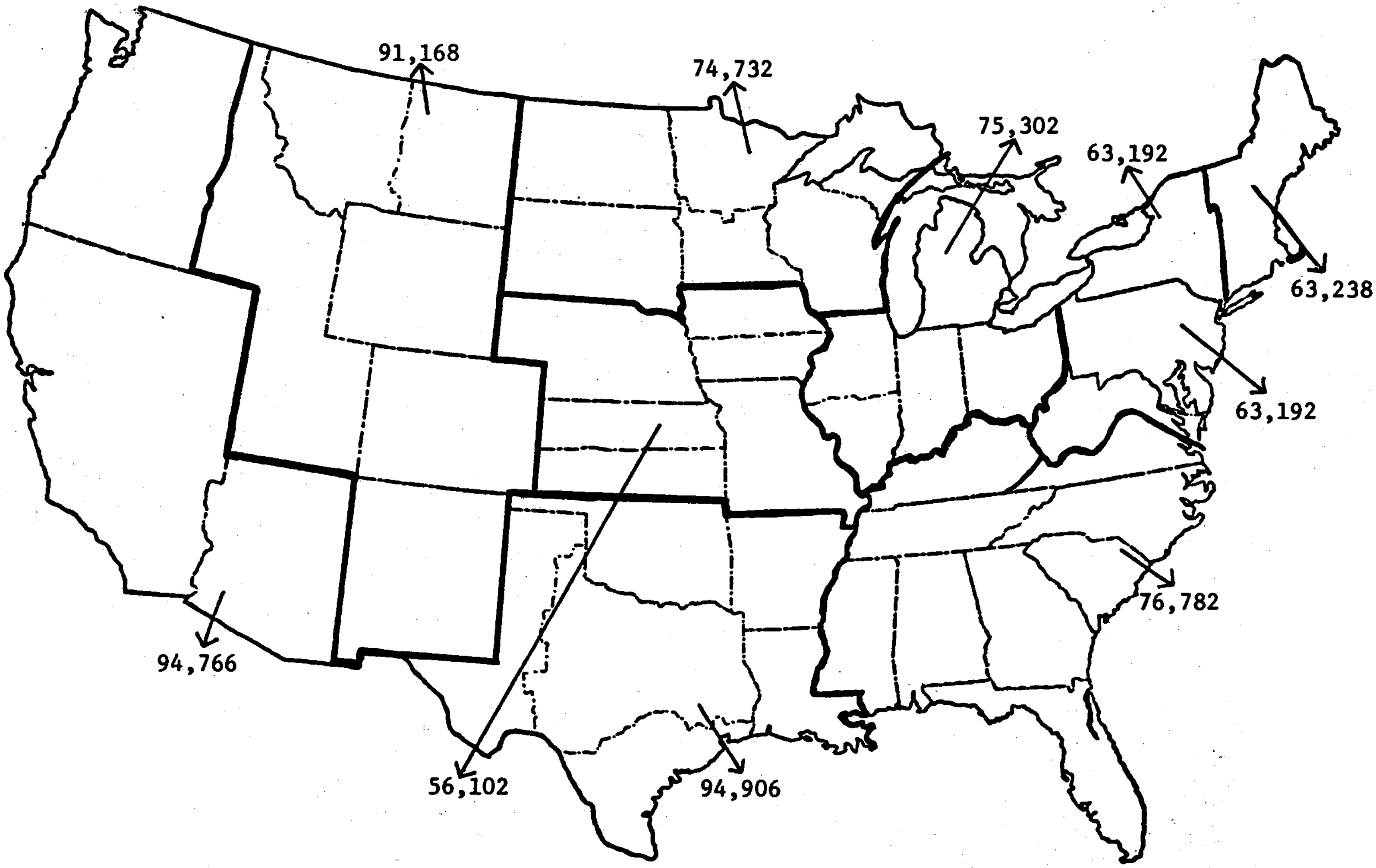
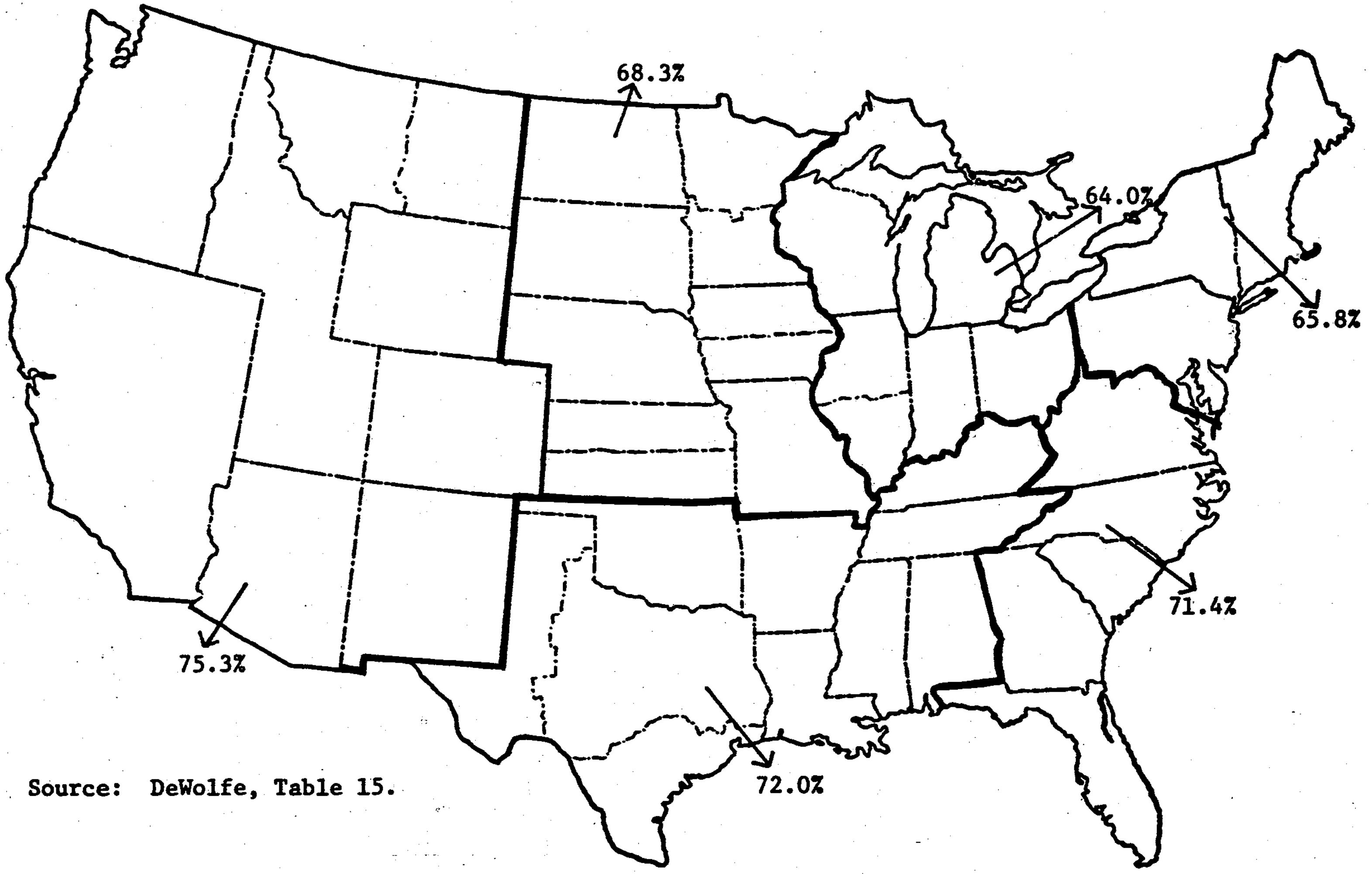


Figure 17. Estimated Annual Truck Mileages by Region, 1966



Source: DeWolfe, Table 15.

Figure 18. Laden Miles of Trucks by Region, 1961

tandem axle capable of pulling 72,000 pounds gross vehicle weight. This particular vehicle has the capability of handling a maximum load for most regions of the model used. The grain trailer was specified to be a tandem axel, aluminum exterior post trailer capable of hauling a pay load 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 auxillary electric motor to furnish the source of power to unload the trailer. Due to the added weight of the flour trailer, the payload on that trailer is 43,000 pounds of flour or 21.5 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 excise 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 excise tax rates[9] used for adjustment are given in Table XLV.

<u>Garaging Facility</u>. The assumption was made that the trucking firm would need to do repair work on 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.[10] This figure was adjusted for states through a construction cost index. The

TABLE XLV

STATE SALES AND DIESEL FUEL TAX RATES, AND DIESEL FUEL PRICES, 1966

Region	General Sales Tax Rate[a]	Diesel Fuel Tax Rate[b]	Fuel Price
	Cents/Dollar	Cents/Gallon	Cents/Gallon
Al	4	7	16.52
Az	3	7	15.90
Ar	3	8.5	14.60
Ca	3	7	15.40
Co	3	7	15.00
Ct	3.5	6	15.74
Dl	0	7	15.93
Fl	3	7	15.91
Ga	3	6.5	17.06
Id	3	6	16.20
Il	3.5	5	15.32
In	2	6	15.84
Ia	2	8	15.75
Ks	3	7	15.61
Kn	3	9	16.87
La	2	7	15.06
Me	4	7	16.27
Md	3	7	15.93
Ma	3	6.5	15.76
Mi	4	6	15.94
Mn	0	6	15.80
Ms	3.5	8	15.26
Mo	3	5	15.25
Mt	0	9	16.50
Ne	0	7.5	15.50
Nv	2	6	16.40
NH	0	7	16.01
NJ	3	6	16.54
NM	3	6	14.72
NY	2	9	16.54
NC	3	7	15.83
ND	2.25	6	16.40
Oh	3	7	17.39
Ok	2	6.5	15.26
Or	0	6	16.50
Pa	5	7	16.81
RI	4	7	15.86

TABLE XLV (Continued)

Region	General Sales Tax Rate[a]	Diesel Fuel Tax Rate[b]	Fuel Price
	Cents/Dollars	Cents/Gallon	Cents/Gallon
SC	3	7	15.83
SD	3	7	16.09
Tn	3	8	15.60
Tx	2	6.5	14.10
Ut	3	6	14.50
Vt	0	0	16.01
Va	2	9	15.88
Wa	4.2	7.5	16.80
WV	3	7	16.32
Wi	3	6	16.06
Wy	2.5	7	15.62

[a]Source: U. S. Department of Commerce, _State Tax Collections in 1966_, "Government Finances/GF No. 8, (Washington, 1966), p. 11.

[b]Source: U. S. Department of Transportation, _Highway Statistics/_ 1965, Federal Highway Administration, Bureau of Public Roads, (Washington, April, 1967), p. 8.

Building Construction Cost Data, 1966 "Total" index of the Robert Snow Means Co., Inc.[11] was regressed on Standard Metropolitan Area populations[12] for the points listed in the index and also dummy variables for regions. The equation was

$$Y = B_i X_i + B_{10}$$

where X_i = dummy variables for nine respective regions

$i = 1,2,000,9$

= the Standard Metropolitan Area population

Y = the Robert Snow Means Co., Inc. Construction cost index.

The resulting regression equation[13] was

$$= 103.17493 - 3.08121X_1 - 7.90527X_2 - 6.25732X_3$$
$$- 13.59441X_4 - 4.47440X_5 - 15.20495X_6 - 14.07675X_7$$
$$+ 1.24344X_8 + 1.31051X_{10}. \qquad (A.1)$$

The computed R^2 statistic was 0.89. No tests of significance of the coefficients were made. If states were not included by cities in the Standard Metropolitan Area population data, indices were estimated by averaging the indices 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. These regions are presented in Figure 19. The resulting garaging facility cost estimates are presented in Table XLVII.

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

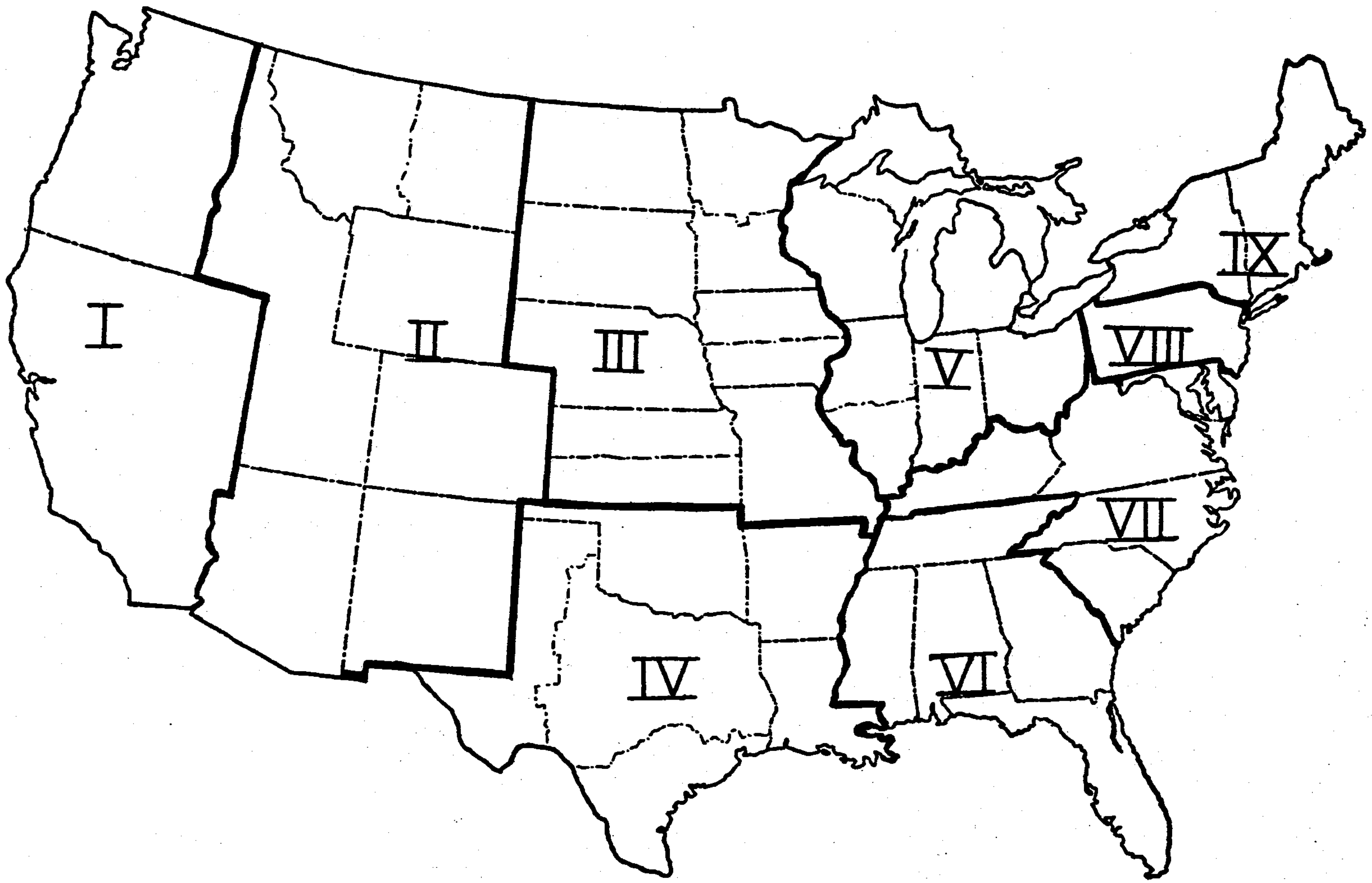


Figure 19. Regional Delineation for Construction Cost Index Estimation

TABLE XLVI

MILEAGES DRIVEN BY FOR-HIRE TRUCKS BY STATE AND MILES PER TRIP OF CLASS I MOTOR CARRIERS, 1966

Region & State	Million[a] Miles 1966	Miles[b] Per Trip	Region & State	Million[a] Miles 1966	Miles[b] Per Trip
Pacific	2,534	385	Central	4,539	216
Az	116		Il	1,170	
Ca	2,056		In	1,019	
Nv	10		Mi	1,023	
Or	205		Oh	1,327	
Wa	147				
			Southern	4,486	250
Rocky Mountain	754	508	Al	380	
Co	331		Fl	785	
Id	118		Ga	523	
Mt	27		Ky	411	
NM	34		Ms	75	
Ut	195		NC	1,314	
Wy	49		SC	208	
			Tn	300	
Middlewest	3,324	307	Va	490	
Ia	489				
Ks	122		Middle Atlantic	4,452	239
Mn	642		Dl	319	
Mo	726		Md	365	
Ne	558		NJ	905	
ND	90		NY	1,235	
SD	129		Pa	1,501	
Wi	568		WV	127	
Southwestern	2,934	438	New England	857	109
Ar	251		Ct	136	
La	195		Me	70	
Ok	731		Ma	419	
Tx	1,757		NH	24	
			RI	157	
			Vt	51	

[a]Source: U. S. Bureau of the Census, "Truck Inventory and Use Survey," 1967 Census of Transportation, Table 11 (Washington, 1967).

[b]Source: Interstate Commerce Commission, Cost of Transporting Freight by Class I and Class II Motor Common of General Commodities By Regions or Territories for the Year 1966, (Washington, September, 1967), pp. 41, 54, 67, 80, 106, 119, 132, 171.

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."[14] Since the utilization rate is less than 100,000 miles per year in this study, depreciation is considered a function of time.

The Internal Revenue Service establishes guidelines for depreciating various types of property.[15] For garaging facilities the estimated useful life is 45 years,[16] which was used in this study. For transportation equipment, "tractor units (over-the-road)," four years are allowed and for "trailers," six years are allowed.[17] Since the transportation equipment which hauls grain is in service of light to medium duty, it is considered that use is not extensive enough to warrant such short amortization period. Cassavant and Nelson[18] in their study used a 10-year life expectancy in truck grain-transportation equipment. A similar life expectancy seems reasonable for this study since new equipment is specified. A salvage value of ten percent of the purchase price is assumed, thus depreciation is on ninety percent of the purchase price of the equipment. These data are presented in Table XLVII.

<u>Returns to Management</u>

Without a detailed study of management, it is difficult to state what returns to management are or should be. The managers of trucking firms considered in this study were also considered to be drivers. Cassavant and Nelson estimated the returns to management by asking various commercial trucking firms what they paid to individuals doing the job that such a person must do in a grain trucking firm.[19] Their estimate was $6,500. This figure was used in this study for lack of better information.

Interest on Investment

Interest on investment must be considered as a cost, since such investment could earn income in other areas. The effective rate of return used in this study was six percent on the non-depreciating value of the garaging facility and transportation equipment.[20]

Real Estate Taxes

Information on real estate taxes on garaging facilities were estimated by converting the market value or construction cost to an assessed value. This was accomplished by computing a ratio of market values and assessed values reported by the U. S. Bureau of the Census for the year 1966.[21] These state ratios were applied to the estimated construction costs for the respective states. The assessment rate was taken from the 1968 Statistical Abstract, United States.[22] The average tax rate was multiplied by the assessed value to determine the tax. Real estate taxes are presented in Table XLVII. Taxes on the truck-equipment are discussed in a later section of this appendix.

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

TABLE XLVII

TRUCKING COST SUMMARY BY STATES AND REGIONS, 1966

Item	Units	I. New England Region						II. Middle Atlantic Region					
		Ct	Me	Ma	NH	RI	Vt	Dl	Md	NJ	NY	Pa	WV
Fixed Costs													
Investments													
Garage Investment	Dollars	5,300	5,300	5,300	5,300	5,300	5,300	4,702	4,702	5,458	5,379	5,458	4,429
Tractor Investment	Dollars	65,550	65,958	65,325	63,423	65,958	63,423	63,423	65,325	65,325	64,689	66,594	65,325
Grain Trailer Investment	Dollars	28,359	28,496	28,220	27,400	28,496	27,400	27,400	28,220	28,220	27,948	28,770	28,220
Flour Trailer Investment	Dollars	94,789	95,247	94,332	91,584	95,247	91,584	91,584	94,332	94,332	93,416	96,163	94,332
Total Investment													
Grain Trucking Firms	Dollars	99,209	99,754	98,845	96,123	99,754	96,123	95,525	98,247	99,003	98,016	100,122	97,974
Flour Trucking Firms	Dollars	165,639	166,505	164,957	160,307	166,505	160,307	159,709	164,379	165,115	163,484	168,215	164,086
Ownership Costs													
Annual Depreciation													
Garage	Dollars	118	118	118	118	118	118	104	104	121	120	121	98
Tractors	Dollars	5,900	5,936	5,879	5,708	5,936	5,708	5,708	5,879	5,879	5,822	5,994	5,879
Trailers, Grain	Dollars	2,552	2,565	2,540	2,466	2,565	2,466	2,466	2,540	2,540	2,514	2,589	2,540
Trailers, Flour	Dollars	8,531	8,572	8,490	8,243	8,572	8,243	8,243	8,490	8,490	8,407	8,655	8,490
Total													
Grain Trucking Firms	Dollars	8,570	8,619	8,537	8,292	8,619	8,278	8,278	8,523	8,540	8,461	8,704	8,517
Flour Trucking Firms	Dollars	14,549	14,626	14,487	14,069	14,626	14,069	14,055	14,473	14,490	14,354	14,770	14,467
Annual Interest													
Grain Trucking Firms	Dollars	5,953	5,985	5,931	5,767	5,985	5,767	5,732	5,895	5,940	5,881	6,049	5,878
Flour Trucking Firms	Dollars	9,938	9,990	9,897	9,618	9,990	9,618	9,583	9,863	9,907	9,809	10,093	9,845
Real Estate Taxes	Dollars	94	171	204	122	104	160	47	63	298	139	107	36
Total Ownership Costs													
Grain Trucking Costs	Dollars	14,617	14,775	14,672	14,181	14,708	14,205	14,057	14,481	14,778	14,481	14,860	14,431
Flour Trucking Firms	Dollars	24,581	24,787	24,588	23,809	24,720	23,847	23,685	24,399	24,695	24,302	24,970	24,348
Operating Costs													
Returns to Management	Dollars	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	Dollars	298	298	298	298	298	298	318	318	182	318	318	182
Cargo Loss and Damage	Dollars	20	20	20	20	20	20	20	20	17	20	20	20
Fire	Dollars	43	43	43	43	43	43	52	52	36	52	52	52
Fire Insurance-Garage	Dollars	55	55	55	55	55	55	49	49	46	56	57	46
Licenses and Road-User Taxes/Vehicle	Dollars	2,372	2,141	2,236	1,855	2,335	1,875	1,599	1,556	1,550	216	1,641	216
Licenses and Road-User Taxes/Firm	Dollars	7,116	6,423	6,708	5,565	7,005	5,625	4,797	4,668	4,650	648	4,923	648
Administrative Expenses and Utilities	Dollars	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	Dollars	15,652	14,959	15,244	14,101	15,541	14,161	13,356	13,227	13,051	9,214	13,490	9,068
Fixed Operating Costs/Laden Mile-Grain	Cents	11.70	12.97	11.73	10.66	15.46	14.93	10.14	11.44	10.51	8.13	10.36	8.57
Fixed Operating Costs/Laden Mile-Flour	Cents	16.50	15.77	16.07	14.87	16.38	14.93	14.09	13.95	13.77	9.72	14.23	9.57

TABLE XLVII (Continued)

Item	Units	I. New England Region						II. Middle Atlantic Region					
		Ct	Me	Ma	NH	RI	Vt	Dl	Md	NJ	NY	Pa	WV
Variable Costs													
Operating-Grain Trucking													
Driver-Mechanic Wages/Laden Mile	Cents	10.04	11.63	10.34	10.11	13.36	14.16	10.80	8.86	10.46	11.45	9.97	9.68
Fuel Cost/Laden Mile	Cents	4.56	5.45	4.69	4.67	6.11	6.53	6.50	5.33	5.15	5.65	4.99	5.97
Maintenance Cost/Laden Mile	Cents	4.52	5.24	4.66	4.56	6.02	6.38	6.38	5.23	4.87	5.33	4.64	5.72
Tire Cost/Laden Mile	Cents	3.25	3.77	3.35	3.20	4.33	4.59	5.25	4.30	4.01	4.39	3.82	4.70
Total Variable Operating Costs/ Laden Mile-Grain Trucking	Cents	22.38	26.08	23.03	22.61	29.81	31.66	28.93	23.72	24.49	26.83	23.43	26.07
Operating-Flour Trucking													
Driver-Mechanic Wages/Laden Mile	Cents	14.15	14.15	14.15	14.15	14.15	14.16	10.80	10.80	13.70	13.70	13.70	10.80
Fuel Cost/Laden Mile	Cents	6.42	6.64	6.43	6.53	6.47	6.53	6.50	6.50	7.75	7.75	6.86	6.66
Maintenance Cost/Laden Mile	Cents	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	Cents	5.58	5.59	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	Cents	31.54	31.76	31.55	31.65	31.59	31.66	28.93	28.93	32.08	32.08	32.19	29.09
Laden Mileage Percentage													
Grain Trucks	Percent	70.50	60.80	68.50	70.00	53.00	50.00	69.50	61.00	65.50	59.80	68.70	55.80
Flour Trucks	Percent	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													
Grain Trucking Firms	Miles	133,748	115,346	129,954	132,280	100,548	94,857	131,755	115,641	124,172	113,366	130,239	105,783
Flour Trucking Firms	Miles	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	11.29	10.72	14.62	14.97	10.66	12.52	11.90	12.77	11.40	13.64
Operating Costs/Laden Mile	Cents	34.08	39.05	34.76	33.27	45.26	46.59	39.07	35.16	35.00	34.96	33.79	34.64
Grand Total	Cents	45.04	51.85	46.05	43.99	59.88	61.56	49.73	47.68	46.90	47.73	45.19	48.28
Total Costs-Flour Trucking Firms													
Ownership Costs/Laden Mile	Cents	25.91	26.13	25.92	25.09	26.06	25.13	24.98	25.74	26.05	25.64	26.34	25.68
Operating Costs/Laden Mile	Cents	48.04	47.53	47.62	46.52	47.97	46.69	43.02	42.88	45.85	41.80	56.42	38.66
Grand Total	Cents	73.95	73.66	73.54	71.61	74.03	71.82	68.00	68.62	71.90	67.44	82.76	64.34
Regional Weighting Factor	-----	.1587	.0817	.4889	.0280	.1832	.0595	.0717	.0820	.2033	.2774	.3371	.0285
Regional Cost/Laden Mile													
Grain Trucking	Cents			49.76						46.86			
Flour Trucking	Cents			73.55						73.56			

TABLE XLVII (Continued)

Item	Units	III. Southern Region								
		Al	Fl	Ga	Ky	Ms	NC	SC	Tn	Va
Fixed Costs										
Investments										
Garage Investment	Dollars	4,389	4,441	4,422	4,447	4,358	4,414	4,414	4,360	4,429
Tractor Investment	Dollars	65,958	65,325	65,325	65,325	65,550	65,325	65,325	65,325	64,689
Grain Trailer Investment	Dollars	28,496	28,220	28,220	28,220	28,359	28,220	28,220	28,220	27,948
Flour Trailer Investment	Dollars	95,247	94,332	94,332	94,332	94,789	94,332	94,332	94,332	93,416
Total Investment										
Grain Trucking Firms	Dollars	98,843	97,986	97,967	97,992	98,267	97,959	97,959	97,905	97,066
Flour Trucking Firms	Dollars	165,594	164,098	164,079	164,104	164,697	164,071	164,071	164,017	162,534
Ownership Costs										
Annual Depreciation										
Garage	Dollars	98	98	98	99	97	98	98	97	98
Tractors	Dollars	5,936	5,879	5,879	5,879	5,900	5,879	5,879	5,879	5,822
Trailers, Grain	Dollars	2,565	2,540	2,540	2,540	2,552	2,540	2,540	2,540	2,514
Trailers, Flour	Dollars	8,572	8,490	8,490	8,490	8,531	8,490	8,490	8,490	8,407
Total										
Grain Trucking Firms	Dollars	8,599	8,517	8,517	8,518	8,549	8,517	8,517	8,516	8,434
Flour Trucking Firms	Dollars	14,606	14,467	14,467	14,468	14,528	14,467	14,467	14,486	14,327
Annual Interest										
Grain Trucking Firms	Dollars	5,931	5,879	5,878	5,880	5,896	5,878	5,878	5,874	5,824
Flour Trucking Firms	Dollars	9,936	9,846	9,845	9,846	9,882	9,844	9,844	9,241	9,752
Real Estate Taxes	Dollars	12	98	66	97	22	49	22	46	160
Total Ownership Costs										
Grain Trucking Firms	Dollars	14,542	14,494	14,461	14,495	14,517	14,444	14,417	14,436	14,418
Flour Trucking Firms	Dollars	24,504	24,411	24,378	24,411	24,432	24,360	24,333	23,773	24,239
Operating Costs										
Returns to Management	Dollars	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Insurance										
Public Liability	Dollars	182	182	182	182	182	182	182	182	318
Cargo Loss and Damage	Dollars	17	17	17	17	17	17	17	17	17
Fire	Dollars	36	36	36	36	36	36	36	36	36
Fire Insurance-Garage	Dollars	46	46	46	46	45	46	46	45	46
Licenses and Road-User Taxes/Vehicle	Dollars	1,841	1,539	1,805	2,489	2,621	2,071	1,992	2,235	216
Licenses and Road-User Taxes/Firm	Dollars	5,523	4,617	5,415	7,467	7,863	6,213	5,976	6,705	648
Administrative Expenses and Utilities	Dollars	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Total Fixed Operating Costs	Dollars	13,924	13,018	13,816	15,868	16,263	14,614	14,377	15,105	9,185
Fixed Operating Costs/Laden Mile-Grain	Cents	6.92	7.50	8.11	10.85	10.19	9.01	9.84	11.40	7.42
Fixed Operating Costs/Laden Mile-Flour	Cents	12.09	11.30	12.00	13.78	14.12	12.69	12.48	13.12	9.69

TABLE XLVII (Continued)

Item	Units	Al	Fl	Ga	Ky	Ms	NC	SC	Tn	Va
		III. Southern Region								
Variable Costs										
Operating-Grain Trucking										
Driver-Mechanic Wages/Laden Mile	Cents	6.44	7.46	7.60	8.51	8.11	7.99	8.87	9.78	8.27
Fuel Cost/Laden Mile	Cents	3.86	4.31	4.71	5.42	4.49	4.59	5.10	5.54	4.96
Maintenance Cost/Laden Mile	Cents	3.65	4.23	4.31	5.02	4.60	4.53	5.03	5.55	4.89
Tire Cost/Laden Mile	Cents	2.42	2.80	2.86	3.33	3.05	3.00	3.33	3.68	3.24
Total Variable Operating Costs/ Laden Mile-Grain Trucking	Cents	16.38	18.80	19.15	22.28	20.26	20.11	22.33	24.54	21.36
Operating-Flour Trucking										
Driver-Mechanic Wages/Laden Mile	Cents	11.24	11.24	11.24	10.80	11.24	11.24	11.24	11.24	10.80
Fuel Cost/Laden Mile	Cents	6.74	6.49	6.96	6.89	6.23	6.46	6.46	6.37	6.48
Maintenance Cost/Laden Mile	Cents	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38
Tire Cost/Laden Mile	Cents	4.23	4.23	4.23	4.23	4.23	4.23	4.23	4.23	4.23
Total Variable Operating Costs/ Laden Mile-Flour Trucking	Cents	28.59	28.34	28.34	28.29	28.08	28.31	28.31	28.22	27.99
Laden Mileage Percentage										
Grain Trucks	Percent	87.30	75.40	74.00	63.50	69.30	70.40	63.40	57.50	65.30
Flour Trucks	Percent	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Annual Mileage/Vehicle	Miles	76,782	76,782	76,782	76,782	76,782	76,782	76,782	76,782	63,192
Total Annual Laden Miles										
Grain Trucking Firms	Miles	201,092	173,681	170,456	146,270	159,630	162,164	146,039	132,449	123,793
Flour Trucking Firms	Miles	115,173	115,173	115,173	115,173	115,173	115,173	115,173	115,173	94,788
Total Costs-Grain Trucking Firms										
Ownership Costs/Laden Mile	Cents	7.23	8.34	8.48	9.90	9.09	8.90	9.87	10.89	11.64
Operating Costs/Laden Mile	Cents	23.30	26.30	27.26	33.13	30.45	29.12	32.17	35.94	28.78
Grand Total	Cents	30.53	34.64	35.74	43.03	39.54	38.02	42.04	46.83	40.42
Total Costs-Flour Trucking Firms										
Ownership Costs/Laden Mile	Cents	21.27	21.19	21.16	21.19	21.21	21.15	21.12	20.64	25.57
Operating Costs/Laden Mile	Cents	40.68	39.64	40.34	42.07	42.20	41.00	40.79	41.34	37.68
Grand Total	Cents	61.95	60.83	61.50	63.26	63.41	62.15	61.91	61.98	63.25
Regional Weighting Factor	-----	.0847	.1750	.1166	.0916	.0167	.2929	.0464	.0669	.1092
Regional Cost/Laden Mile										
Grain Trucking	Cents	38.05								
Flour Trucking	Cents	62.05								

TABLE XLVII (Continued)

Item	Units	IV. Central Region Il	In	Oh	Mi	V. Midwest Region Ia	Ks	Mn	Mo	Ne	ND	SD	Wi
Fixed Costs													
Investments													
Garage Investment	Dollars	4,935	4,937	4,926	5,133	4,805	4,808	4,887	4,860	4,815	4,800	4,800	4,957
Tractor Investment	Dollars	65,550	64,689	65,325	65,958	64,689	65,325	63,423	65,325	63,423	64,848	65,325	65,325
Grain Trailer Investment	Dollars	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 Trailer Investment	Dollars	94,789	93,416	94,332	95,247	93,416	94,332	91,458	94,332	91,458	93,645	94,332	94,332
Total Investment													
Grain Trucking Firms	Dollars	98,844	97,574	98,470		97,442	98,353	94,701	98,405	95,638	97,664	98,345	98,502
Flour Trucking Firms	Dollars	165,274	163,042	164,582	166,338	162,910	164,465	159,768	164,517	159,696	163,293	164,457	164,614
Ownership Costs													
Annual Depreciation													
Garage	Dollars	110	110	109	114	107	107	109	108	107	107	107	110
Tractors	Dollars	5,900	5,822	5,879	5,936	5,822	5,879	5,708	5,879	5,708	5,836	5,879	5,879
Trailers, Grain	Dollars	2,552	2,514	2,540	2,565	2,514	2,540	2,466	2,540	2,466	2,521	2,540	2,540
Trailers, Flour	Dollars	8,531	8,407	8,490	8,572	8,407	8,490	8,243	8,490	8,243	8,428	8,490	8,490
Total													
Grain Trucking Firms	Dollars	8,562	8,446	8,528	8,615	8,443	8,526	8,283	8,527	8,281	8,464	8,526	8,529
Flour Trucking Firms	Dollars	14,541	14,339	14,478	14,622	14,336	14,476	14,060	14,477	14,058	14,371	14,476	14,479
Annual Interest													
Grain Trucking Firms	Dollars	5,931	5,854	5,908	5,975	5,847	5,901	5,742	5,904	5,738	5,860	5,901	5,910
Flour Trucking Firms	Dollars	9,916	9,783	9,875	9,980	9,775	9,868	9,586	9,871	9,582	9,798	9,867	9,877
Real Estate Taxes	Dollars	106	83	51	92	92	75	141	61	55	79	91	123
Total Ownership Costs													
Grain Trucking Costs	Dollars	14,563	14,383	14,487	14,682	14,382	14,502	14,166	14,492	14,074	14,403	14,518	14,562
Flour Trucking Costs	Dollars	24,563	24,205	24,404	24,694	24,203	24,419	23,787	24,409	23,695	24,248	24,434	24,479
Operating Costs													
Returns to Management	Dollars	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	Dollars	226	226	226	226	176	176	185	176	176	185	185	185
Cargo Loss and Damage	Dollars	17	17	17	17	21	21	20	21	21	20	20	20
Fire	Dollars	39	39	39	39	34	34	33	34	34	33	33	33
Fire Insurance-Garage	Dollars	51	51	51	53	50	50	51	51	50	50	50	52
Licenses and Road-User Taxes/Vehicle	Dollars	2,574	2,052	3,143	1,782	2,254	2,996	2,279	2,278	2,774	2,035	2,630	2,178
Licenses and Road-User Taxes/Firm	Dollars	7,722	6,156	9,429	5,346	6,762	8,988	6,837	6,834	8,322	6,105	7,890	6,534
Administrative Expenses and Utilities	Dollars	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	Dollars	16,175	14,609	17,882	13,801	15,163	17,389	15,246	15,236	16,723	14,513	16,298	14,944
Fixed Operating Costs/Laden Mile-Grain	Cents	11.10	10.23	13.00	9.17	13.27	16.43	9.87	12.88	13.90	10.54	11.45	10.15
Fixed Operating Costs/Laden Mile-Flour	Cents	14.32	12.93	15.83	12.22	18.02	20.66	18.12	18.11	19.87	12.95	14.54	13.33

TABLE XLVII (Continued)

Item	Units	IV. Central Region				V. Midwest Region							
		Il	In	Oh	Mi	Ia	Ks	Mn	Mo	Ne	ND	SD	Wi
Variable Costs													
Operating-Grain Trucking													
Driver-Mechanic Wages/Laden Mile	Cents	9.20	9.39	9.75	8.91	7.67	8.28	8.62	7.41	7.29	8.49	8.20	9.03
Fuel Cost/Laden Mile	Cents	4.85	5.12	5.83	4.88	4.73	5.07	4.68	4.43	4.42	5.45	5.17	4.99
Maintenance Cost/Laden Mile	Cents	4.95	5.05	5.24	4.79	4.70	5.07	4.63	4.54	4.46	5.20	5.02	4.86
Tire Cost/Laden Mile	Cents	4.33	4.42	4.59	4.20	4.12	5.13	2.77	4.59	4.51	3.11	3.00	2.90
Total Variable Operating Costs/ Laden Mile-Grain Trucking	Cents	22.49	23.98	25.40	22.78	21.22	23.55	20.69	20.96	20.69	22.23	21.40	21.78
Operating-Flour Trucking													
Driver-Mechanic Wages/Laden Mile	Cents	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	Cents	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	Cents	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	Cents	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	Cents	29.01	30.31	30.94	30.35	28.82	29.63	28.51	29.47	29.58	27.31	27.18	28.62
Laden Mileage Percentage													
Grain Trucks	Percent	64.50	63.20	60.90	66.60	67.90	62.90	68.90	70.30	71.50	61.40	63.50	65.70
Flour Trucks	Percent	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	75,302	75,302	75,302	75,302	56,102	56,102	74,732	56,102	56,102	74,732	74,732	74,732
Total Annual Laden Miles													
Grain Trucking Firms	Miles	145,709	142,773	137,577	150,453	114,280	105,864	154,471	118,319	120,339	137,656	142,364	147,297
Flour Trucking Firms	Miles	112,953	112,953	112,953	112,953	84,153	84,153	112,098	84,153	84,153	112,098	112,098	112,098
Total Costs-Grain Trucking Firms													
Ownership Costs/Laden Mile	Cents	9.99	10.07	10.53	9.75	12.58	13.69	9.17	12.24	11.69	10.46	10.19	9.88
Operating Costs/Laden Mile	Cents	33.59	34.21	38.50	31.97	34.49	39.98	30.56	33.84	34.59	32.77	33.85	31.93
Grand Total	Cents	43.58	44.28	49.03	41.72	47.07	53.67	39.73	46.08	46.28	43.23	44.04	41.81
Total Costs-Flour Trucking Firms													
Ownership Costs/Laden Mile	Cents	21.74	21.42	21.60	21.86	28.76	29.01	21.21	29.00	28.15	21.63	21.79	21.83
Operating Costs/Laden Mile	Cents	43.33	43.24	46.77	42.57	46.84	50.29	46.63	47.58	49.45	30.26	41.72	41.95
Grand Total	Cents	65.07	64.66	68.37	64.43	75.60	79.30	67.84	76.58	77.60	51.89	63.51	63.78
Regional Weighting Factor	-----	.2578	.2245	.2923	.2254	.1471	.0367	.1931	.2184	.1678	.0271	.0388	.1709
Regional Cost/Laden Mile													
Grain Trucking	Cents	44.91				44.42							
Flour Trucking	Cents	65.80				71.65							

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TABLE XLVII (Continued)

Item	Units	VI. Southwest Region				VII. Rocky Mountain Region					
		Ar	La	Ok	Tx	Co	Id	Mt	NM	Ut	Wy
Fixed Costs											
Investments											
Garage Investment	Dollars	4,441	4,487	4,459	4,462	4,771	4,921	4,900	4,724	4,735	4,844
Tractor Investment	Dollars	65,325	64,689	64,689	64,689	65,325	65,325	63,423	65,325	65,325	65,007
Grain Trailer Investment	Dollars	28,220	27,948	27,948	27,948	28,220	28,220	27,400	28,220	28,220	28,085
Flour Trailer Investment	Dollars	94,332	93,416	93,416	93,416	94,332	94,332	91,458	94,332	94,332	93,874
Total Investment											
Grain Trucking Firms	Dollars	97,986	97,124	97,096	97,099	98,316	98,466	95,723	98,269	98,280	97,936
Flour Trucking Firms	Dollars	164,098	162,592	162,564	162,567	164,428	164,578	159,781	164,381	164,392	163,725
Ownership Costs											
Annual Depreciation											
Garage	Dollars	99	98	99	99	106	109	109	105	105	108
Tractors	Dollars	5,879	5,822	5,822	5,822	5,879	5,879	5,708	5,879	5,879	5,851
Trailers, Grain	Dollars	2,540	2,514	2,514	2,514	2,540	2,540	2,466	2,540	2,540	2,528
Trailers, Flour	Dollars	8,490	8,407	8,407	8,407	8,490	8,490	8,243	8,490	8,490	8,449
Total											
Grain Trucking Firms	Dollars	8,518	8,434	8,435	8,435	8,525	8,528	8,283	8,524	8,524	8,487
Flour Trucking Firms	Dollars	14,468	14,327	14,328	14,328	14,475	14,478	14,060	14,474	14,474	14,408
Annual Interest											
Grain Trucking Firms	Dollars	5,879	5,827	5,826	5,826	5,899	5,908	5,743	5,896	5,897	5,876
Flour Trucking Firms	Dollars	9,846	9,756	9,754	9,754	9,866	9,875	9,587	9,863	9,864	9,824
Real Estate Taxes	Dollars	34	34	36	56	63	49	76	30	43	29
Total Ownership Costs											
Grain Trucking Costs	Dollars	14,431	14,295	14,297	14,317	15,828	14,485	14,102	14,450	14,464	14,392
Flour Trucking Firms	Dollars	24,348	24,117	24,118	24,138	24,404	24,402	23,723	24,368	24,381	24,261
Operating Costs											
Returns to Management	Dollars	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Insurance											
Public Liability	Dollars	162	162	162	162	117	117	117	117	117	117
Cargo Loss and Damage	Dollars	21	21	21	21	18	18	18	18	18	18
Fire	Dollars	18	18	18	18	30	30	30	30	30	30
Fire Insurance-Garage	Dollars	46	47	46	46	50	51	51	49	49	50
Licenses and Road-User Taxes/Vehicle	Dollars	2,485	1,706	1,799	2,106	4,416	3,472	2,813	1,538	2,109	3,083
Licenses and Road-User Taxes/Firm	Dollars	7,455	5,118	5,397	6,318	13,248	10,416	8,439	4,614	6,327	9,249
Administrative Expenses and Utilities	Dollars	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Total Fixed Operating Costs	Dollars	15,822	13,486	13,764	14,685	21,583	18,752	16,775	12,948	14,661	17,584
Fixed Operating Costs/Laden Mile-Grain	Cents	6.97	5.65	7.41	7.16	9.93	9.40	9.41	7.29	6.60	11.71
Fixed Operating Costs/Laden Mile-Flour	Cents	11.11	9.47	9.67	10.32	15.78	13.71	12.27	9.47	10.72	12.86

TABLE XLVII (Continued)

Item	Units	VI. Southwest Region				VII. Rocky Mountain Region					
		Ar	La	Ok	Tx	Co	Id	Mt	NM	Ut	Wy
Variable Costs											
Operating-Grain Trucking											
Driver-Mechanic Wages/Laden Mile	Cents	6.33	6.02	7.74	7.00	6.57	7.17	8.01	8.05	6.43	9.51
Fuel Cost/Laden Mile	Cents	3.74	3.67	4.78	4.00	3.85	4.54	5.16	4.63	3.64	5.81
Maintenance Cost/Laden Mile	Cents	4.00	3.81	4.89	4.43	4.01	4.38	4.89	4.92	3.93	5.81
Tire Cost/Laden Mile	Cents	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	Cents	17.42	16.67	21.49	19.14	17.49	19.41	21.80	21.34	16.26	25.56
Operating-Flour Trucking											
Driver-Mechanic Wages/Laden Mile	Cents	10.09	10.09	10.09	10.09	10.45	10.45	10.45	10.45	10.45	10.45
Fuel Cost/Laden Mile	Cents	5.96	6.15	6.23	5.75	6.12	6.61	6.73	6.01	5.91	6.37
Maintenance Cost/Laden Mile	Cents	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38
Tire Cost/Laden Mile	Cents	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	Cents	27.65	27.95	28.03	27.55	27.81	28.31	28.43	27.70	26.41	28.07
Laden Mileage Percentage											
Grain Trucks	Percent	79.70	83.80	65.20	72.00	79.50	72.90	65.20	64.90	81.20	54.90
Flour Trucks	Percent	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Annual Mileage/Vehicle	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	Miles	226,920	238,594	185,636	204,997	217,436	199,384	178,325	177,504	222,085	150,154
Flour Trucking Firms	Miles	142,359	142,359	142,359	142,359	136,752	136,752	136,752	136,752	136,752	136,752
Total Costs-Grain Trucking Firms											
Ownership Costs/Laden Mile	Cents	6.35	5.99	7.70	6.98	7.27	7.26	7.90	8.14	6.51	9.58
Operating Costs/Laden Mile	Cents	24.39	22.32	28.93	26.30	27.42	28.81	31.20	28.63	22.86	37.27
Grand Total	Cents	30.74	28.31	36.63	33.28	34.69	36.07	39.11	36.77	29.37	46.85
Total Costs-Flour Trucking Firms											
Ownership Costs/Laden Mile	Cents	17.10	16.94	16.94	16.95	17.84	17.84	17.34	17.81	17.82	17.74
Operating Costs/Laden Mile	Cents	38.76	37.42	37.70	37.87	43.59	42.02	40.70	37.17	37.13	40.93
Grand Total	Cents	55.86	54.36	54.64	44.82	61.43	59.86	58.04	54.98	54.95	58.67
Regional Weighting Factor	-----	.0855	.0666	.2491	.5988	.4390	.1565	.0358	.0451	.2586	.0650
Regional Cost/Laden Mile											
Grain Trucking	Cents	33.57				34.57					
Flour Trucking	Cents	48.85				58.92					

TABLE XLVII (Continued)

Item	Units	VIII. Pacific Region Az	Ca	Nv	Or	Wa
Fixed Costs						
Investments						
Garage Investment	Dollars	4,756	4,988	4,966	4,999	4,999
Tractor Investment	Dollars	65,325	65,325	64,689	63,423	66,069
Grain Trailer Investment	Dollars	28,220	28,220	27,948	27,400	28,551
Flour Trailer Investment	Dollars	94,332	94,332	93,416	91,584	95,431
Total Investment						
Grain Trucking Firms	Dollars	98,301	98,533	97,603	95,822	99,619
Flour Trucking Firms	Dollars	164,413	164,645	163,071	160,006	166,499
Ownership Costs						
Annual Depreciation						
Garage	Dollars	106	111	110	110	111
Tractors	Dollars	5,879	5,879	5,822	5,708	5,946
Trailers, Grain	Dollars	2,540	2,540	2,514	2,466	2,570
Trailers, Flour	Dollars	8,490	8,490	8,407	8,243	8,589
Total						
Grain Trucking Firms	Dollars	8,525	8,530	8,446	8,285	8,627
Flour Trucking Firms	Dollars	14,475	14,480	14,339	14,062	14,646
Annual Interest						
Grain Trucking Firms	Dollars	5,898	5,912	5,856	5,749	5,977
Flour Trucking Firms	Dollars	9,865	9,879	9,784	9,600	9,990
Real Estate Taxes	Dollars	44	71	35	63	47
Total Ownership Costs						
Grain Trucking Costs	Dollars	14,467	9,192	14,337	14,097	14,651
Flour Trucking Firms	Dollars	24,384	24,430	24,158	23,725	24,683
Operating Costs						
Returns to Management	Dollars	6,500	6,500	6,500	6,500	6,500
Insurance						
Public Liability	Dollars	156	156	156	156	156
Cargo Loss and Damage	Dollars	18	18	18	18	18
Fire	Dollars	67	67	67	67	67
Fire Insurance-Garage	Dollars	49	52	52	52	52
Licenses and Road-User Taxes/Vehicle	Dollars	1,839	1,952	1,830	4,256	2,589
Licenses and Road-User Taxes/Firm	Dollars	5,517	5,586	5,490	12,768	7,767
Administrative Expenses and Utilities	Dollars	1,620	1,620	1,620	1,620	1,620
Total Fixed Operating Costs	Dollars	13,927	13,999	13,903	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 Mile-Flour	Cents	9.70	10.04	9.78	14.90	11.35

TABLE XLVII (Continued)

Item	Units	VIII. Pacific Region Az	Ca	Nv	Or	Wa
Variable Costs						
Operating-Grain Trucking						
Driver-Mechanic Wages/Laden Mile	Cents	6.47	8.80	9.77	8.79	7.69
Fuel Cost/Laden Mile	Cents	4.02	4.34	5.13	4.64	4.14
Maintenance Cost/Laden Mile	Cents	3.95	4.41	4.89	4.40	3.85
Tire Cost/Laden Mile	Cents	2.56	2.86	2.17	2.85	2.49
Total Variable Operating Costs/ Laden Mile-Grain Trucking	Cents	17.01	20.40	22.97	20.69	18.17
Operating-Flour Trucking						
Driver-Mechanic Wages/Laden Mile	Cents	10.44	12.74	12.74	12.74	12.74
Fuel Cost/Laden Mile	Cents	6.48	6.28	6.69	6.73	6.85
Maintenance Cost/Laden Mile	Cents	6.38	6.38	6.38	6.38	6.38
Tire Cost/Laden Mile	Cents	4.13	4.13	4.13	4.13	4.13
Total Variable Operating Costs/ Laden Mile-Flour Trucking	Cents	27.44	29.54	29.95	29.99	30.11
Laden Mileage Percentage						
Grain Trucks	Percent	80.70	72.40	65.20	72.50	82.90
Flour Trucks	Percent	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	Miles	229,428	205,832	185,362	206,116	235,683
Flour Trucking Firms	Miles	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	Cents	23.08	27.20	30.47	30.97	25.03
Grand Total	Cents	29.38	31.66	38.20	37.80	31.22
Total Costs-Flour Trucking Firms						
Ownership Costs/Laden Mile	Cents	17.15	17.18	16.99	16.69	17.36
Operating Costs/Laden Mile	Cents	37.24	39.58	39.73	44.89	41.46
Grand Total	Cents	54.39	56.76	56.72	61.58	58.82
Regional Weighting Factor	-----	.0458	.8137	.0395	.0809	.0580
Regional Cost/Laden Mile						
Grain Trucking	Cents			32.05		
Flour Trucking	Cents			59.31		

variable. Those items which may be considered variable are fuel, tires, and maintenance which are a function of equipment use. The remainder might be considered fixed.

Insurance

Insurance expenses to the grain trucking firm are incurred for public liability, cargo loss and damage, and fire insurance.

Public Liability Insurance. The amount of coverage for this insurance was assumed to be the same as that used by Cassavant and Nelson,[23] $50,000/$100,000 and $10,000 property damage. The cost per vehicle was adjusted to regions by using the Class II Motor Carrier public liability insurance costs per mile as an index.[24] These data are presented in Table XLVII.

Cargo Loss and Damage Insurance. The same data sources and procedures were used to obtain estimates of cargo loss and damage insurance costs as were mentioned in the section for public liability insurance. These data are also presented in Table XLVII.

Fire, Theft, and Collision Insurance. The cost for this insurance was computed as a percentage of the public liability insurance, again utilizing the Class II Motor Carrier data mentioned above. These cost data are presented in Table XLVII.

Garaging Facility Insurance. A standard insurance policy and rates were specified for the insurance on the garaging facility. The policy is that stated by the American Mutual Insurance Alliance. The rates were furnished by Mr. D. B. Jeffrey (now deceased) of the Agricultural Economics Department, Oklahoma State University. These data are presented in Table XLVII.

Licenses and Road-User Taxes

Costs which have been included under this heading include registration fees, property tax, mileage or ton-mile tax and other taxes and fees paid by private carriers as reported by the U. S. Department of Commerce in *Road-User and Property Taxes on Selected Vehicles - 1968*, for a diesel-powered, five-axle, tractor-semitrailer, 72,000 gross vehicle weight.[25] Since these data do not include Federal annual vehicle use taxes, these taxes, $3 per 1,000 pounds gross combination weight or $216 for 72,000 gross combination weight, have been added.[26] These data are presented in Table XLVII.

Driver-Mechanic Wages

The drivers for firms in this study have been assumed to perform the vehicle maintenance. In the study by Kerchner[27] 0.92 cents per mile for vehicle-maintenance labor was used. Thus, this amount, 0.92 cents per mile, which is included as maintenance cost in Table XLVII, is received by the drivers for maintenance labor. Cassavant and Nelson used a figure of five cents per mile for driver's wages.[28] This figure was adjusted to region levels by using Bureau of Labor Statistics'[29] hourly union wages for truck drivers divided by Interstate Commerce Commission line-haul miles per hour of regulated truckers[30] to derive a wage per mile which, in turn was indexed, with the North Dakota derived wage per mile as the base. The derived wages were then adjusted to include the employers' social security costs of 4.2 percent of the wages.[31] These data are presented in Figure 20.

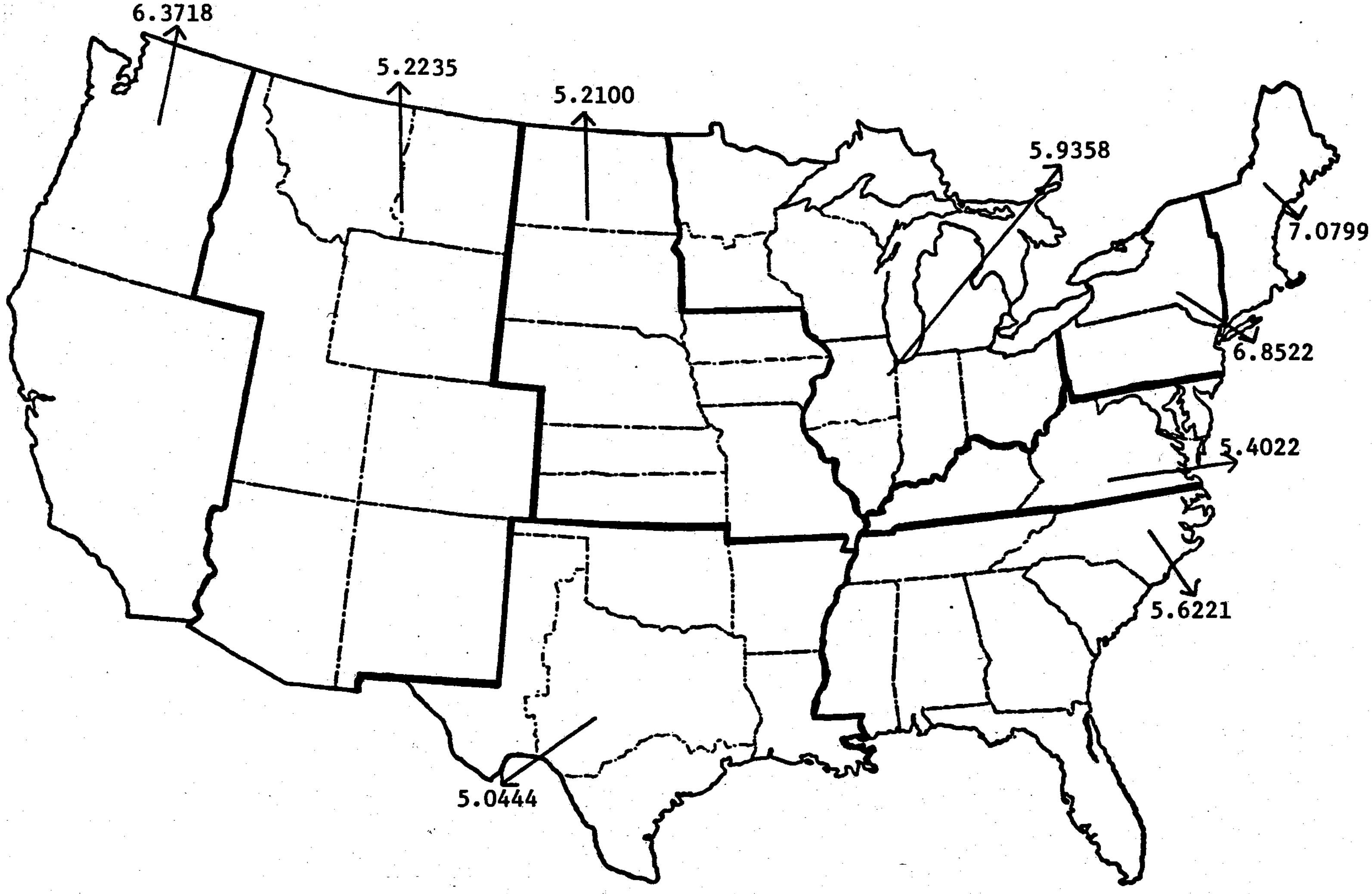

Figure 20. Estimated Drivers' Wages in Cents Per Mile, by Region, 1966

Fuel Costs

No data are published on wholesale or retail prices of diesel fuel for motor trucks. That price data are not published on diesel fuel for motor trucks was verified by correspondence with Platt's Oil-gram Price Service.[32] Thus, diesel-fuel-number-two prices for this study were obtained through correspondence and telephone conversations with the Managers of Price Services of the various regional offices of the American Oil Company. Transportation costs of fuel were also furnished by American Oil to mid-points of their distribution regions. Most truckers contract their fuel and receive it in tanker lots. When on the raod, fuel is purchased from the contracting company at the contracted price using the contract number.[33] State fuel taxes as well as the Federal fuel tax were obtained from Highway Statistics/1965.[34] To convert these data to a cost per mile, a fuel efficiency factor of 4.9 miles per gallon was used.[35] Fuel tax rates per gallon and cost per gallon including taxes are presented in Table XLV. Fuel costs per running mile are presented in Table XLVII,

Tire and Tube Costs

Tire wear is a function of several variables, none of which should vary to a great degree according to 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 truck firms.[36] Thus tire and tube cost per running mile were derived from data reported by the ICC.[37] These data are presented in Figure 21.

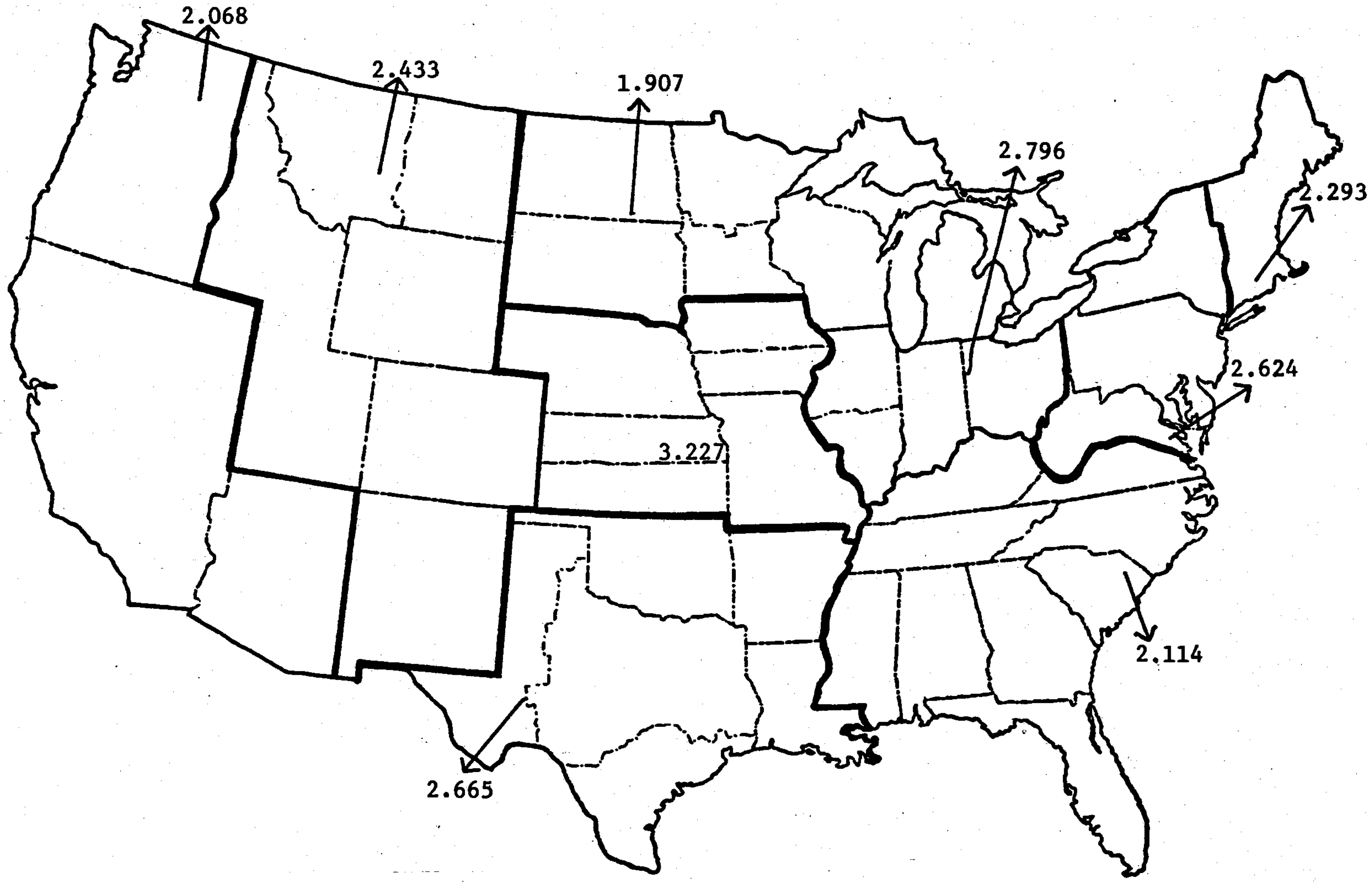

Figure 21. Estimated Tire and Tube Costs for Grain Trucks, Per Mile, by Region, 1966

Maintenance Costs

For the trucking firm to avoid excessive costs, a good program of preventive maintenance will result in fewer major repairs. In the long run, such a program more than pays for itself by reducing the number of costly replacements.

In the study at North Dakota, Cassavant and Nelson[38] used a figure of 0.9 cents per mile for maintenance. This figure is only for engine maintenance and does not include other costs for transmissions, differentials, brakes, general chasis maintenance or trailer maintenance. A more realistic figure is reported by Kerchner of 3.19 cents per mile which includes 0.92 cents per mile for maintenance labor which is performed by the driver in this study.[39]

Administrative Expenses and Utilities

A cost will be incurred in a grain trucking operation for record keeping and general management of the business. These expenses have been grouped here under the title of administrative expenses and utilities, but do not include administrative salaries which are considered to be a part of the returns to management. Estimation of these expenses was made considering data from Cassavant and Nelson's study,[40] Hunter,[41] and Kerchner.[42] Telephone costs vary as well as utility costs and general administrative expenses. An average figure of $135 per month or $1,620 per year was used.

Trucking Cost Summary

The summary of trucking costs by states is presented in Table XLVII. Since grain handling costs and many of the transportation cost items are given on a regional basis only, any attempt to specify grain trucking costs on a state-to-state basis for the model in this study, poses the task of computing a host of interregional costs which would be a conglomeration of various regional data. To reduce the task involved, ICC regions were specified to delineate trucking costs. These regions, as specified by name by the ICC and by number by this author, are presented in Figure 22.

To derive regional trucking costs for grain and bulk flour, weighted-state data were used. The states' costs within the ICC regions[43] in Figure 22 were weighted by the proportional miles driven by for-hire trucks in each state.[44] Mileages driven by for-hire trucks are given in Table XLVI. The proportional weights and regional costs are presented in Table XLVII. Regional costs per laden mile for grain and bulk flour are also shown in Figure 23. 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 22. These regional trip-mileages are presented in Table XLVI. The interregional costs per laden mile for transporting grain and bulk flour are presented in Table XLVIII and Figures 24 and 25, respectively.

For these data to be used in the model specified in Chapter III, the costs per laden mile discussed above, must be converted to a unit basis. To maintain identity throughout the model, common units of expression had to be specified. In this case the bushel was used, thus, flour is expressed in terms of bushel equivalents of wheat. Further, since transfer costs between any two points had to be predetermined for the model, the mode of expression used is cost per bushel-mile.

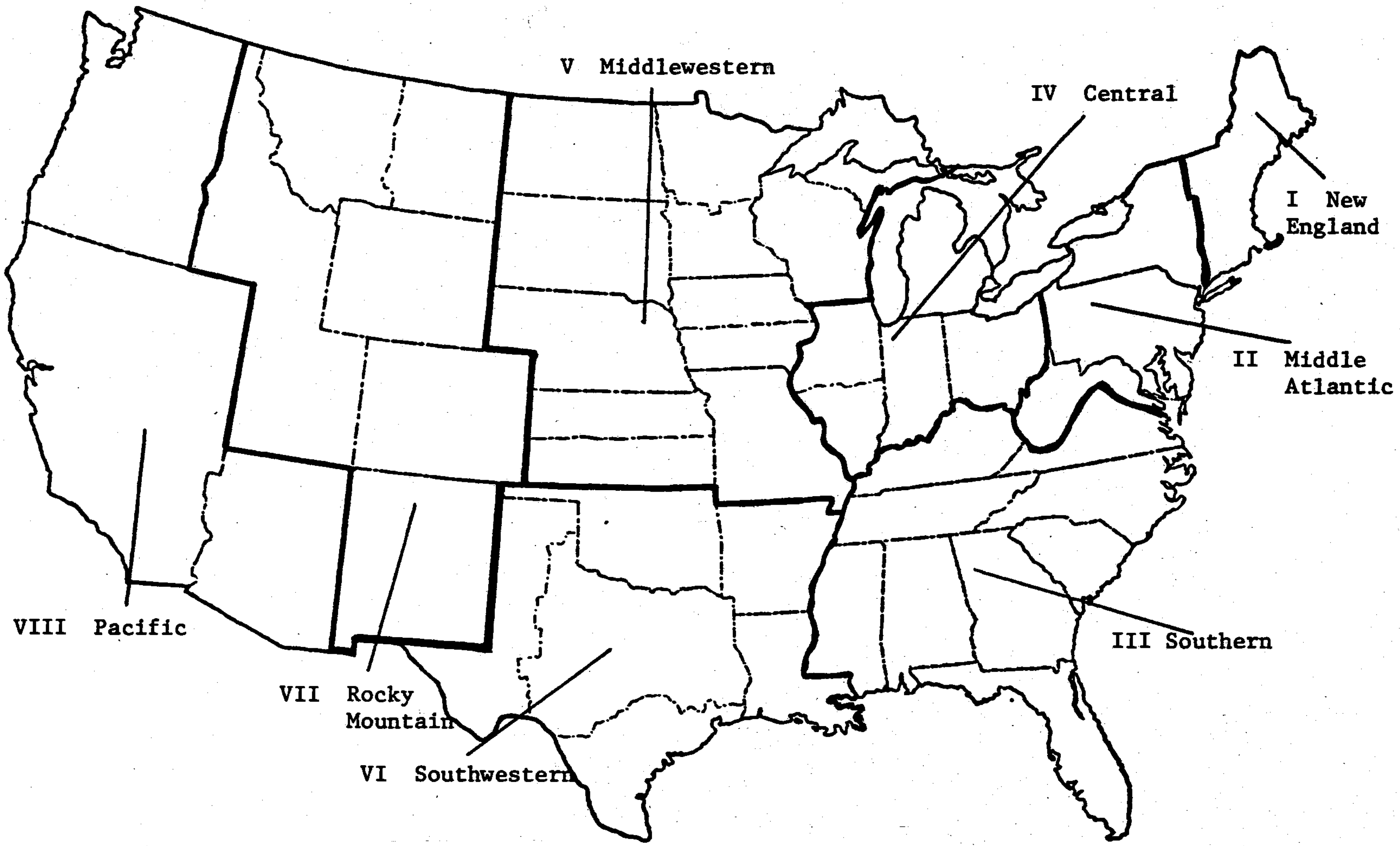

Figure 22. ICC Truck-Cost Regions Numbered, 1966

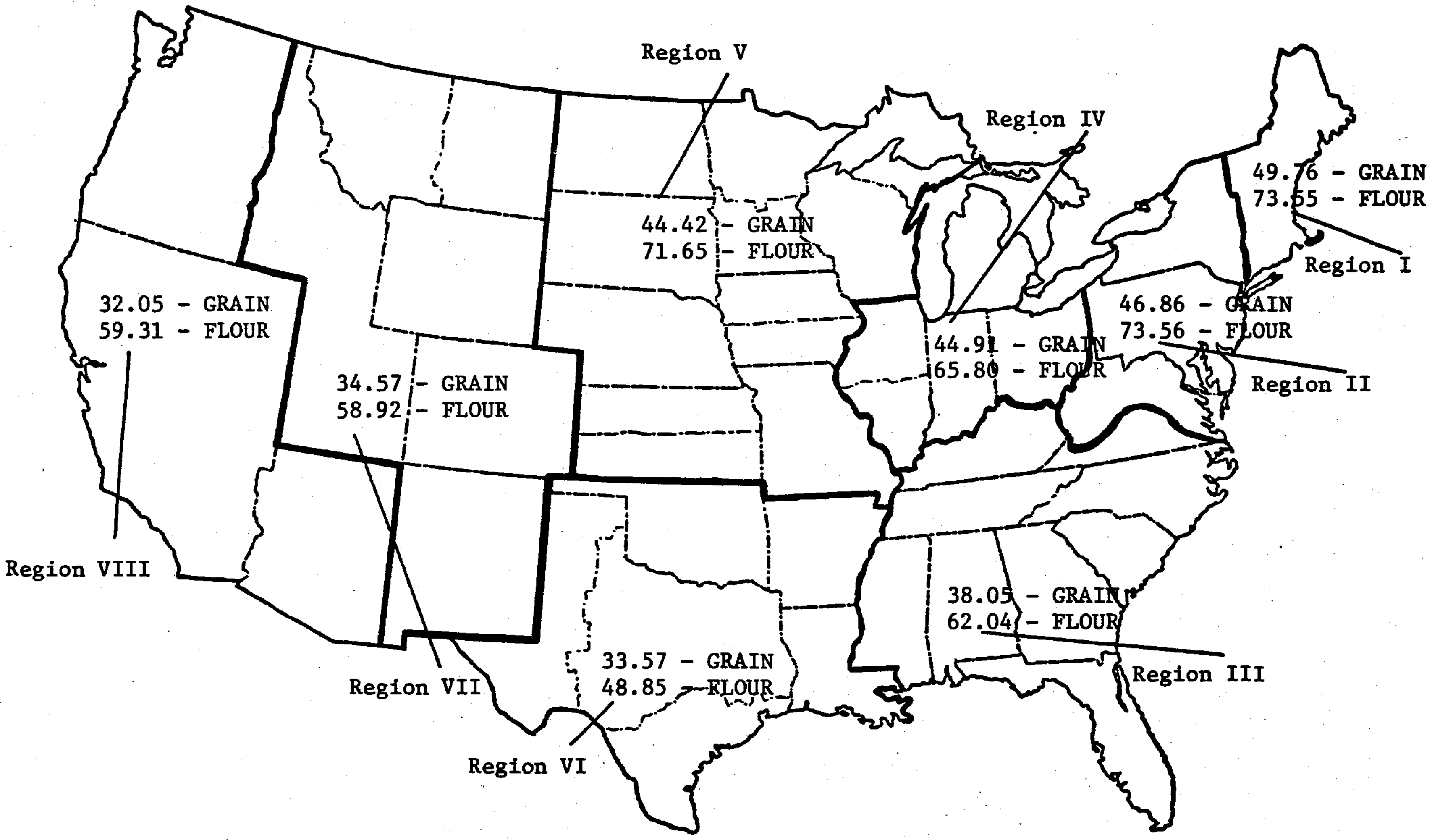

Figure 23. Regional Trucking Costs for Grain and Flour Per Laden Mile, In Cents Per Laden Mile, 1966

TABLE XLVIII

INTERREGIONAL TRUCKING COSTS PER LADEN MILE
FOR GRAIN AND BULK FLOUR, 1966

Region of Origin	Region of Destination	Transportation Cost Grain	Flour
		(Cents/Laden Mi.)	
II	I	47.77	73.56
II	III	42.36	67.68
II	V	45.49	72.49
II	VI	38.26	57.57
III	I	41.61	65.55
III	IV	41.23	48.74
III	VI	35.20	53.65
IV	I	46.54	68.40
IV	II	45.93	59.96
IV	VI	37.32	47.55
V	IV	44.91	69.23
V	VI	38.04	58.25
VI	VIII	32.86	53.74
VII	V	38.28	63.72
VII	VI	34.11	54.26
VIII	VII	33.48	59.09

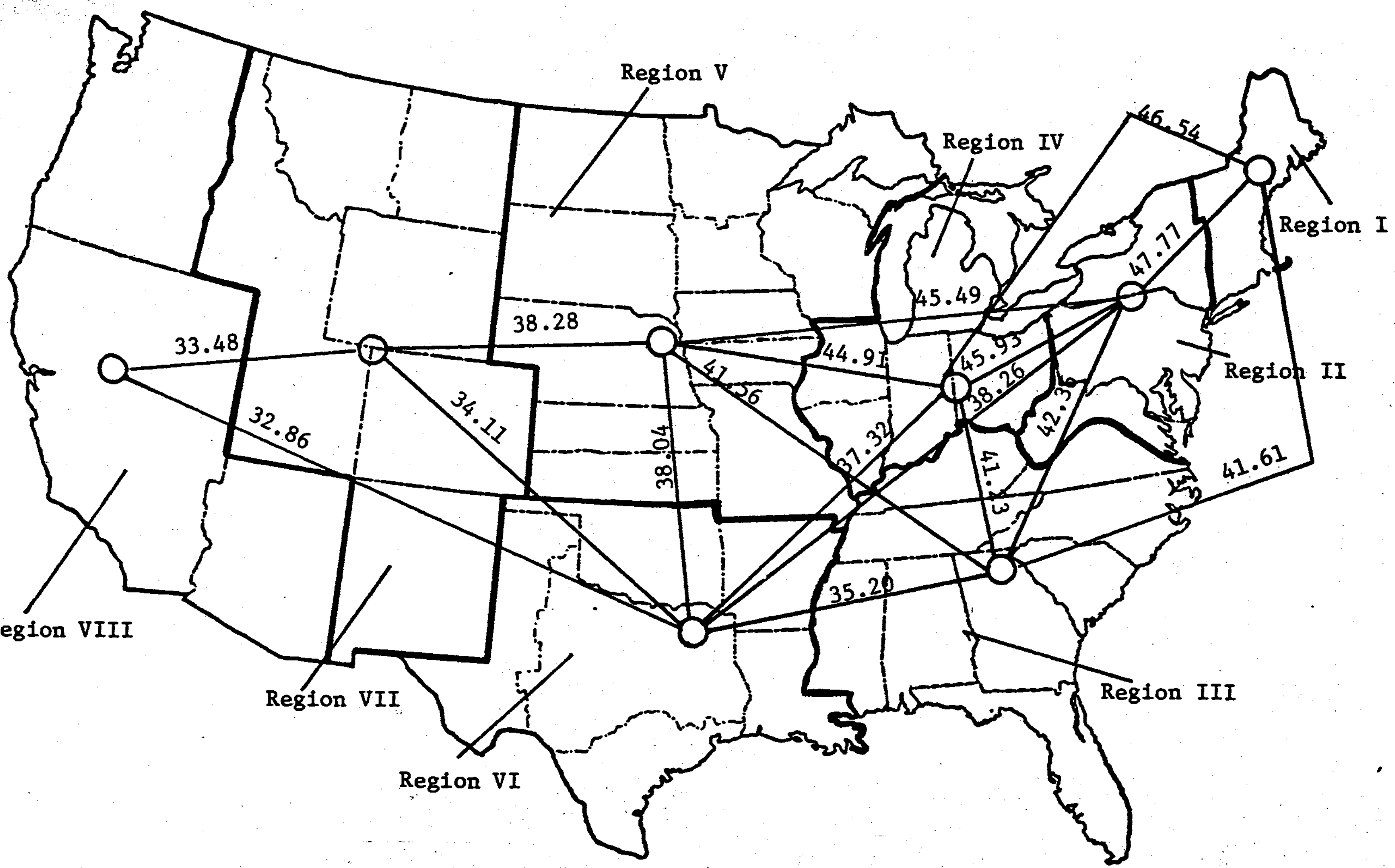

Figure 24. Interregional Grain Trucking Costs Per Laden Mile, in Cents, 1966

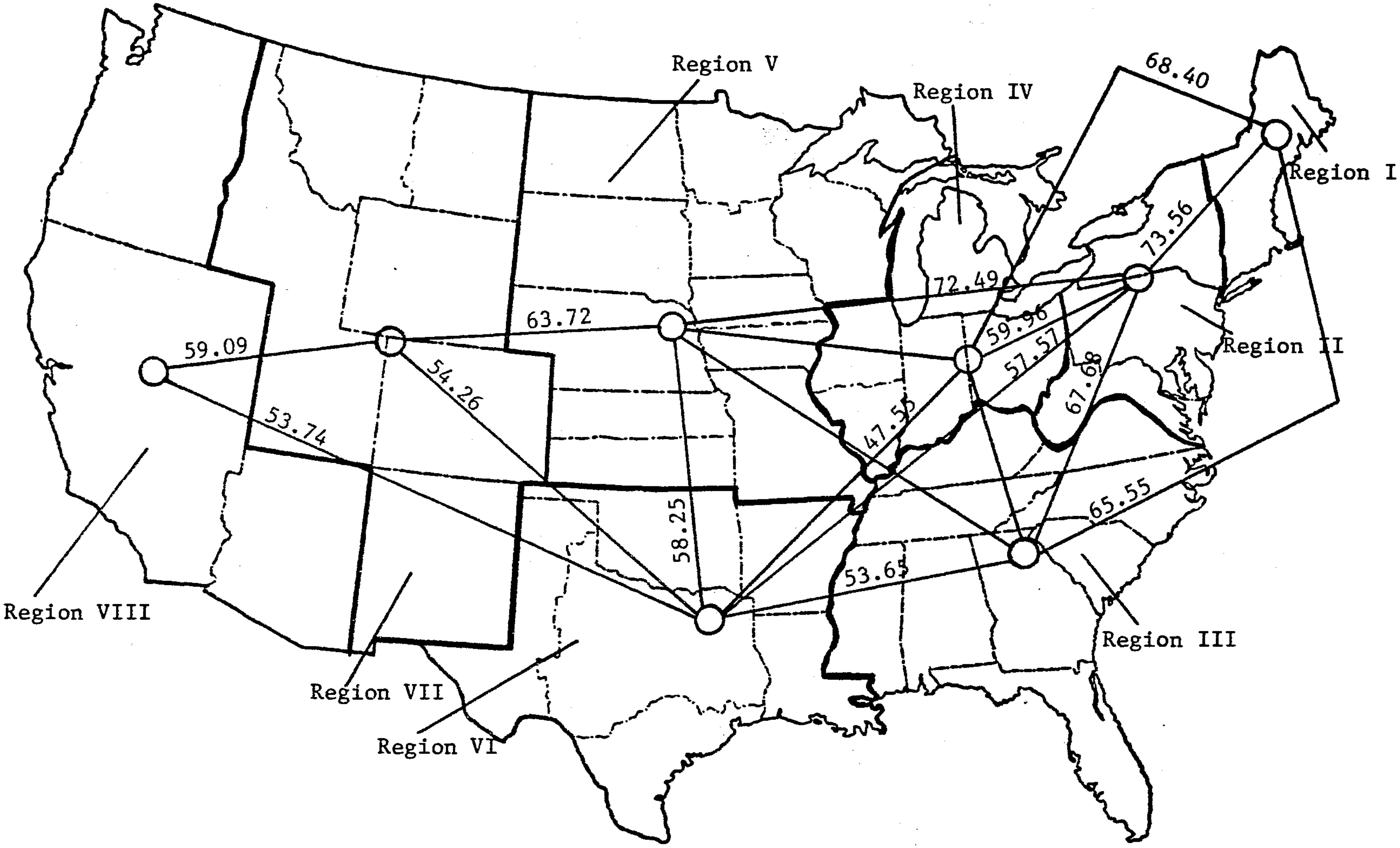

Figure 25. Interregional Bulk Flour Trucking Costs Per Laden Mile in Cents, 1966

Following the assumption that the grain trailer would haul 800 bushels, the costs per laden mile are divided by 800 bushels to derive a cost per bushel-mile for grain transportation. Regional and interregional truck transportation costs-of-service for grain are given in Figures 26 and 27 respectively. Costs per cwt-mile of transporting bulk flour are given in Figures 28 and 29. Since flour is transported both in bags and in bulk, it would not be realistic to use 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.[46] Commercial soft flour was assumed to move 35.36 percent bulk[47] 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 Table XLVIX for bagged flour. By subtraction from 100 percent, the remainder was bulk flour. The estimated costs per hundredweight-mile of hauling flour, 58 percent bagged and 42 percent bulk by regions and interregionally are presented in Figures 30 and 31 respectively. These data were computed by assuming the trailer truck which hauls grain would transport a 450 hundredweight payload to be within legal highway weight limits. Then by weighting the grain trucking cost figures by 0.58 and dividing by 480 hundredweights, and weighting the flour trucking cost figures by 0.42 and dividing by 450 hundredweights, a composite cost for transporting flour is derived as a cost per hundredweight mile.

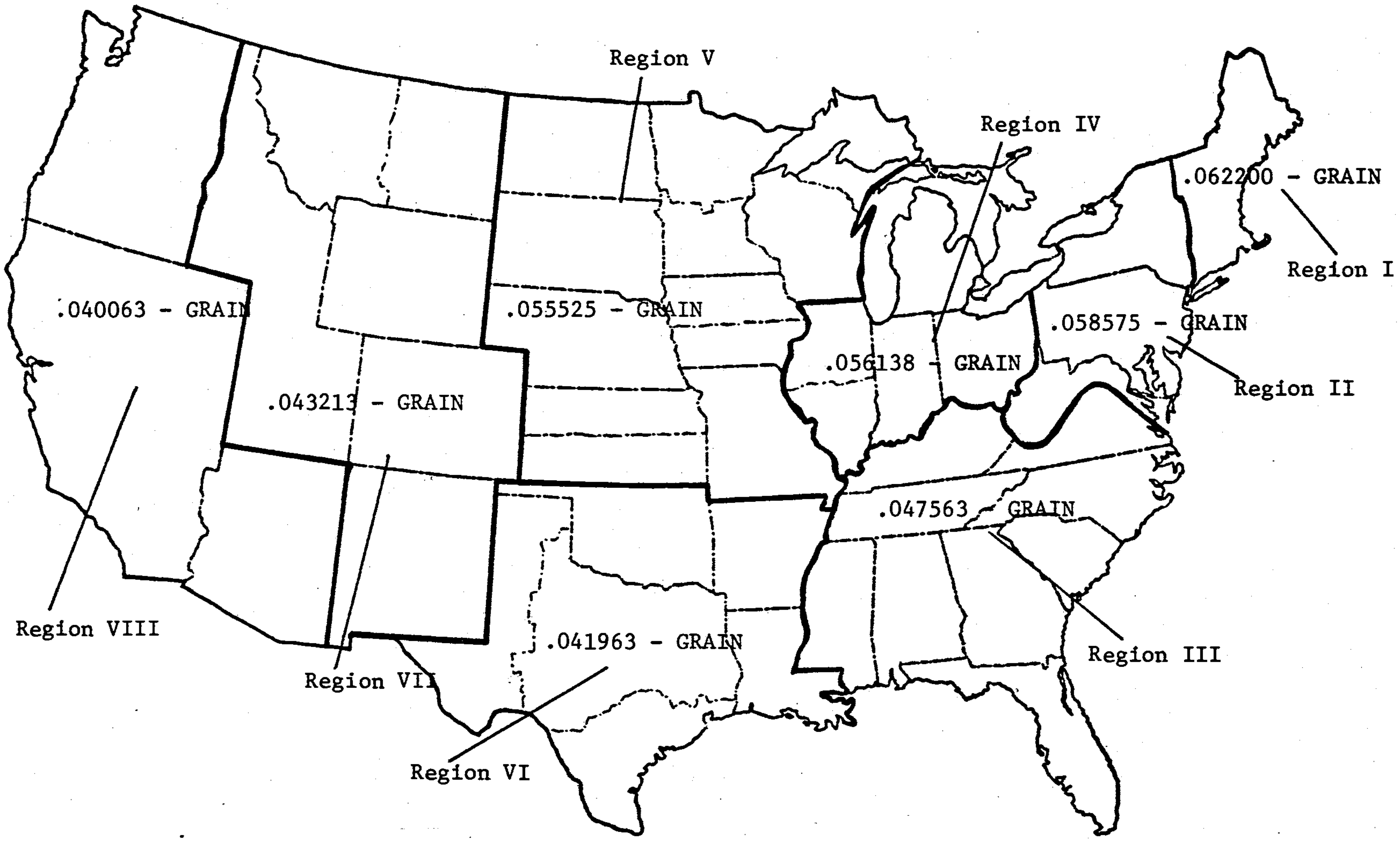

Figure 26. Regional Trucking Costs-of-Service for Grain Transportation, Cents Per Bushel-Mile, 1966

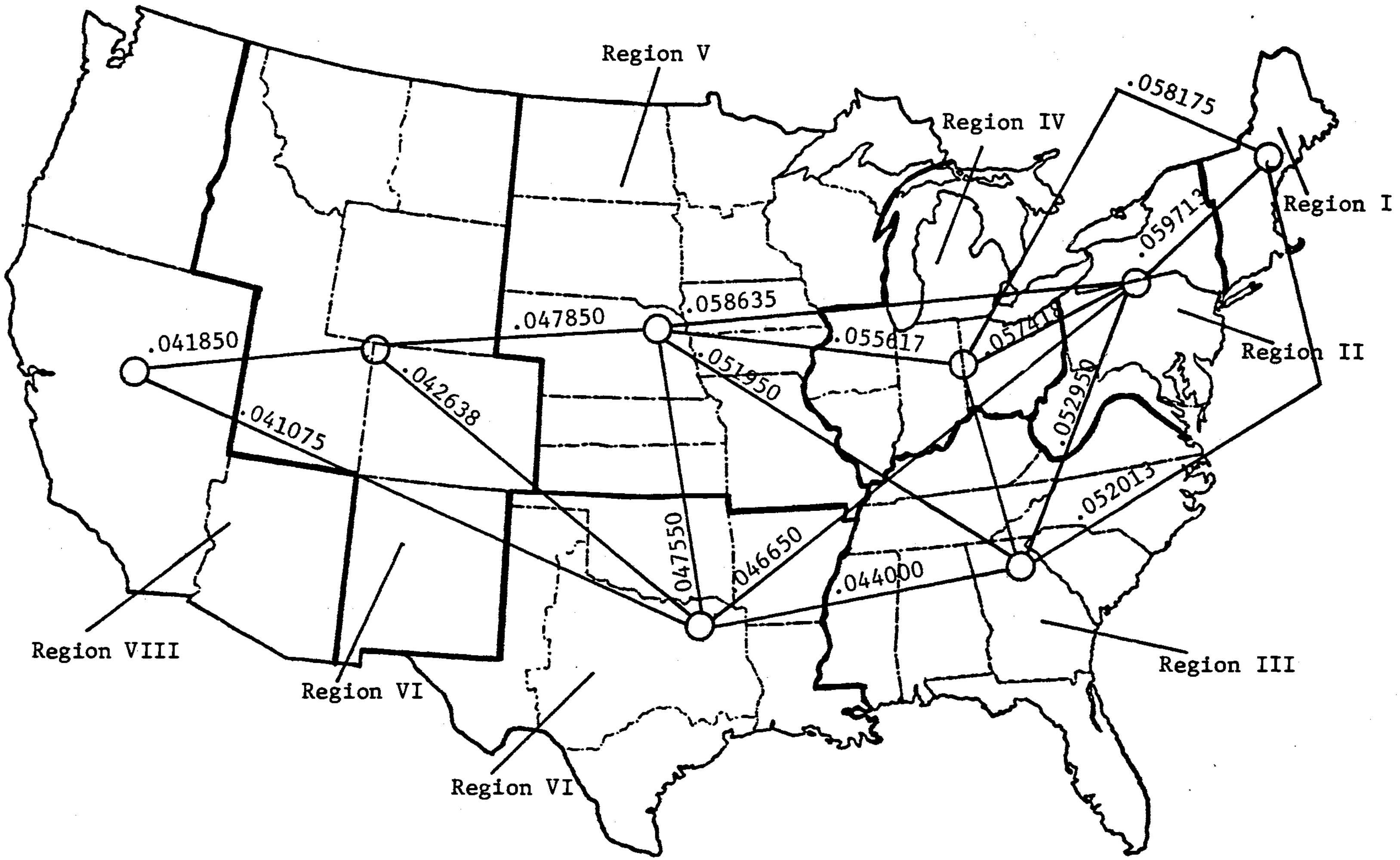

Figure 27. Interregional Trucking Costs-of-Service for Grain Transportation, Cents Per Bushel-Mile, 1966

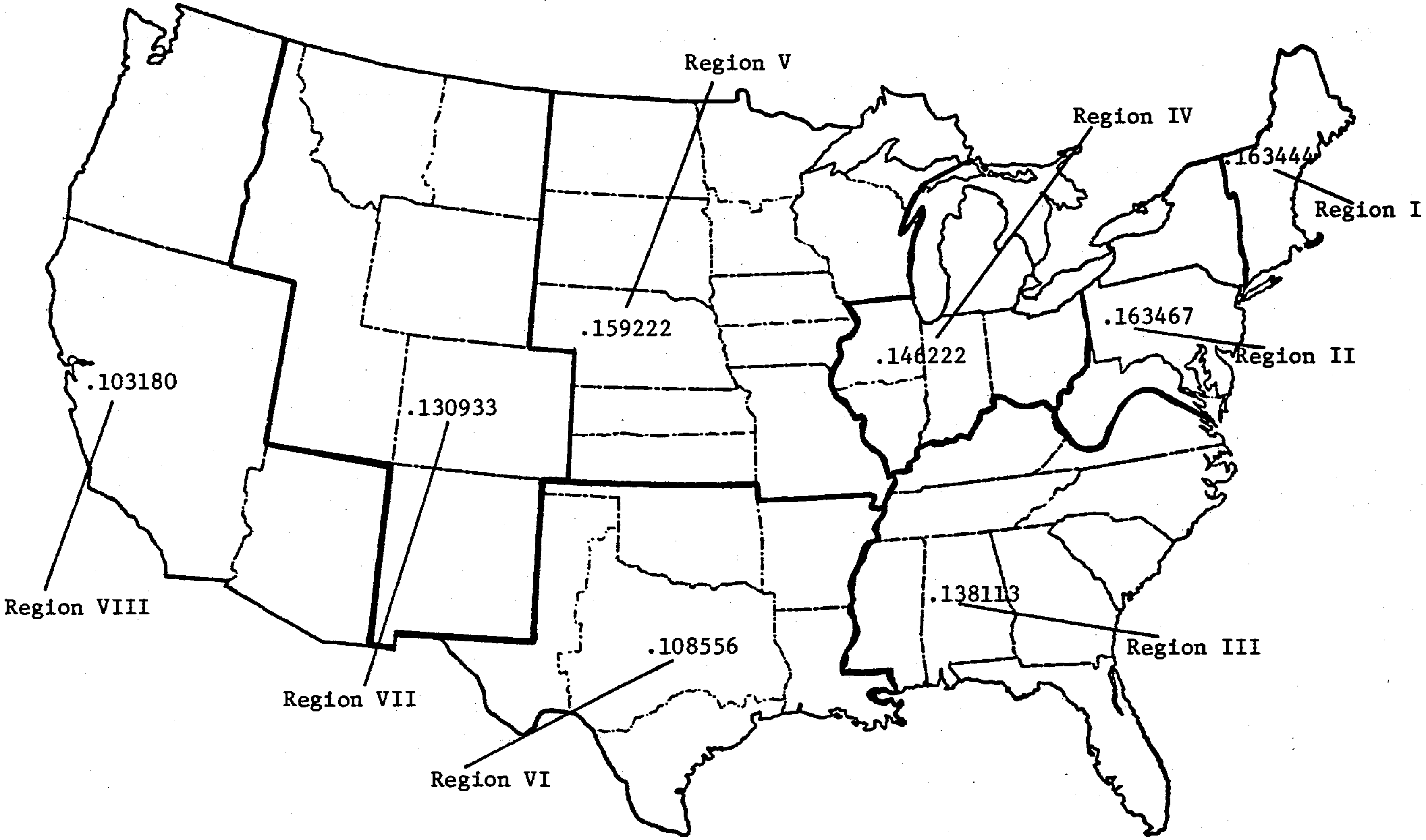

Figure 28. Regional Trucking Costs-of-Service for Bulk Flour Transportation, Cents Per Cwt-Mile, 1966

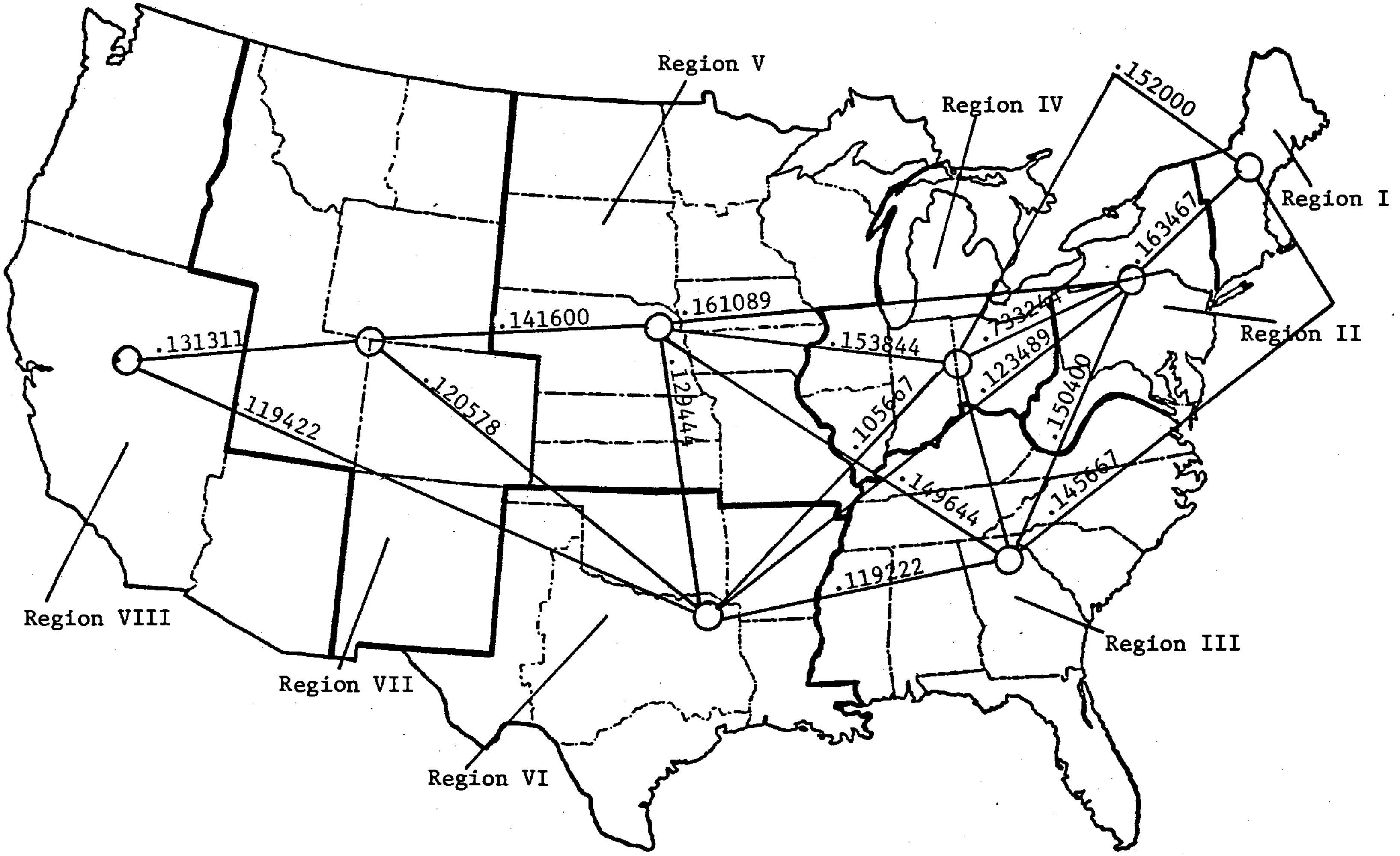

Figure 29. Interregional Trucking Costs-of-Service for Bulk Flour Transportation, Cents per Cwt-Mile, 1966

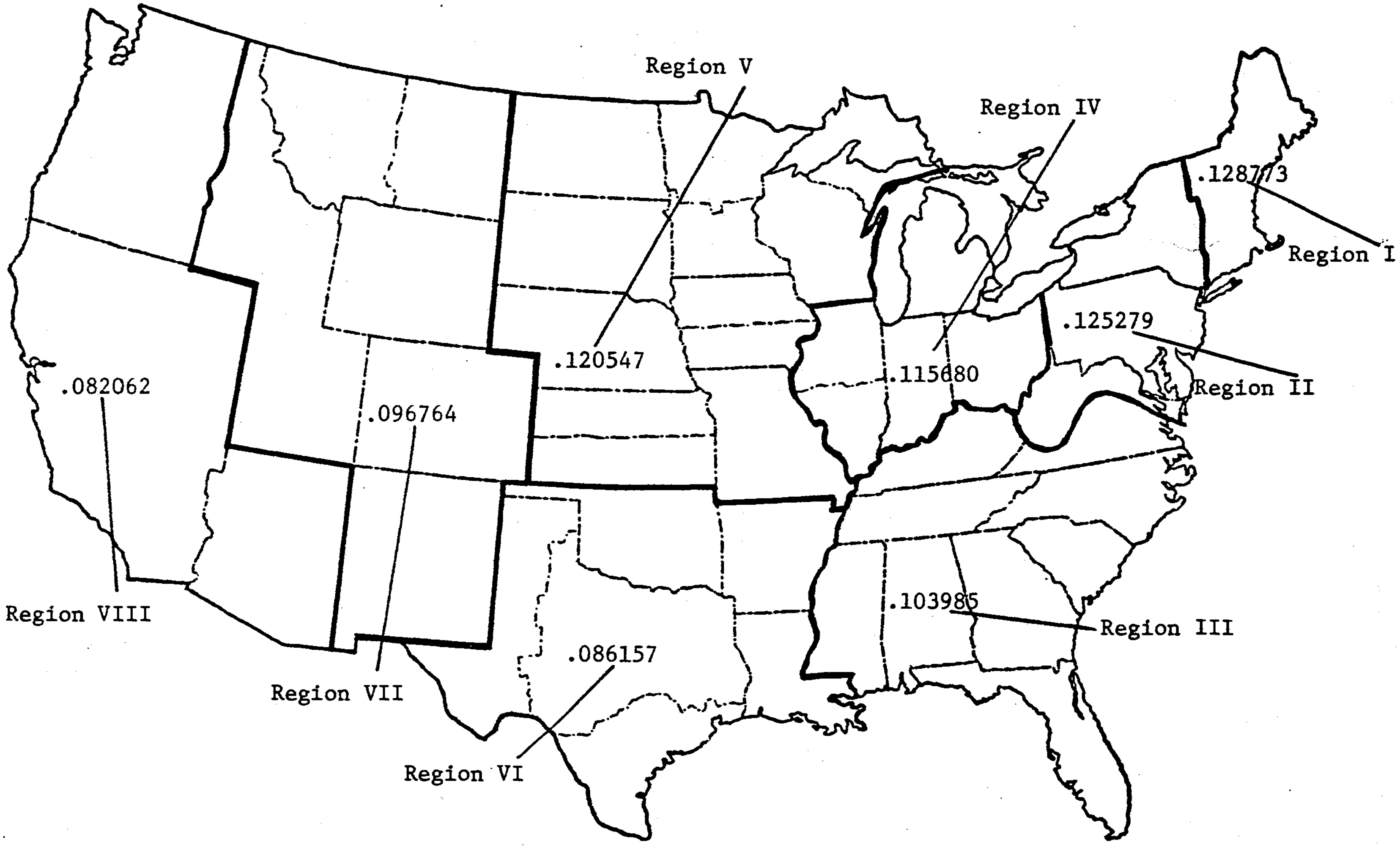

Figure 30. Regional Composite Costs-of-Transporting Flour, Fifty-Eight Percent Bagged and Forty-Two Percent Bulk, Cents Per Cwt-Mile, 1966

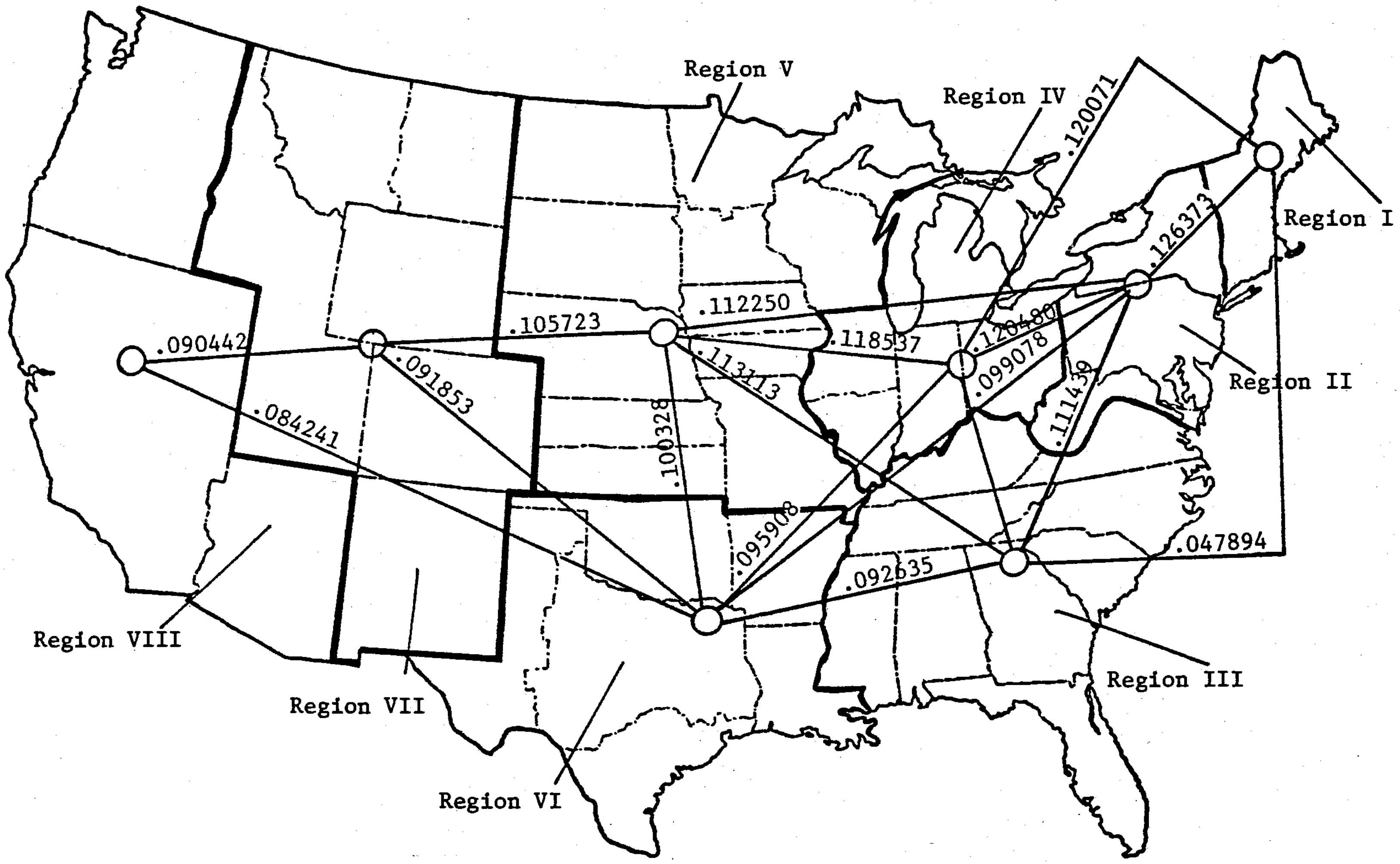

Figure 31. Interregional Composite Costs of Transporting Flour, Fifty-Eight Percent Bagged and Forty-Two Percent Bulk, Cents Per Cwt-Mile, 1966

TABLE XLVIX

ESTIMATED PERCENTAGE OF FLOUR
TRANSPORTED IN BAGS, 1966

Type of Flour	Percent of All Flour	Percent In Bags
Bakers' White Bread-Type Flour		
Commercial	66.48	54.42
Government	6.44	54.42
Export	8.67	54.42
Commercial Soft		
White Flour	7.49	35.36
Family Flour	10.92	100.00
All Flour	100.00	57.97

To solve the product-identity problem mentioned, these data were converted to a bushel of wheat-equivalent basis considering the fact that a hundred-weight of flour is milled from 139.697 pounds of wheat or 2.328 bushels of wheat. Thus the costs per hundred-weight mile were multiplied by 0.4295 ($1 \div 2.328$) to obtain a cost per bushel-mile in wheat equivalents. These data are presented for regional and inter-regional movements in Figures 32 and 33 respectively.

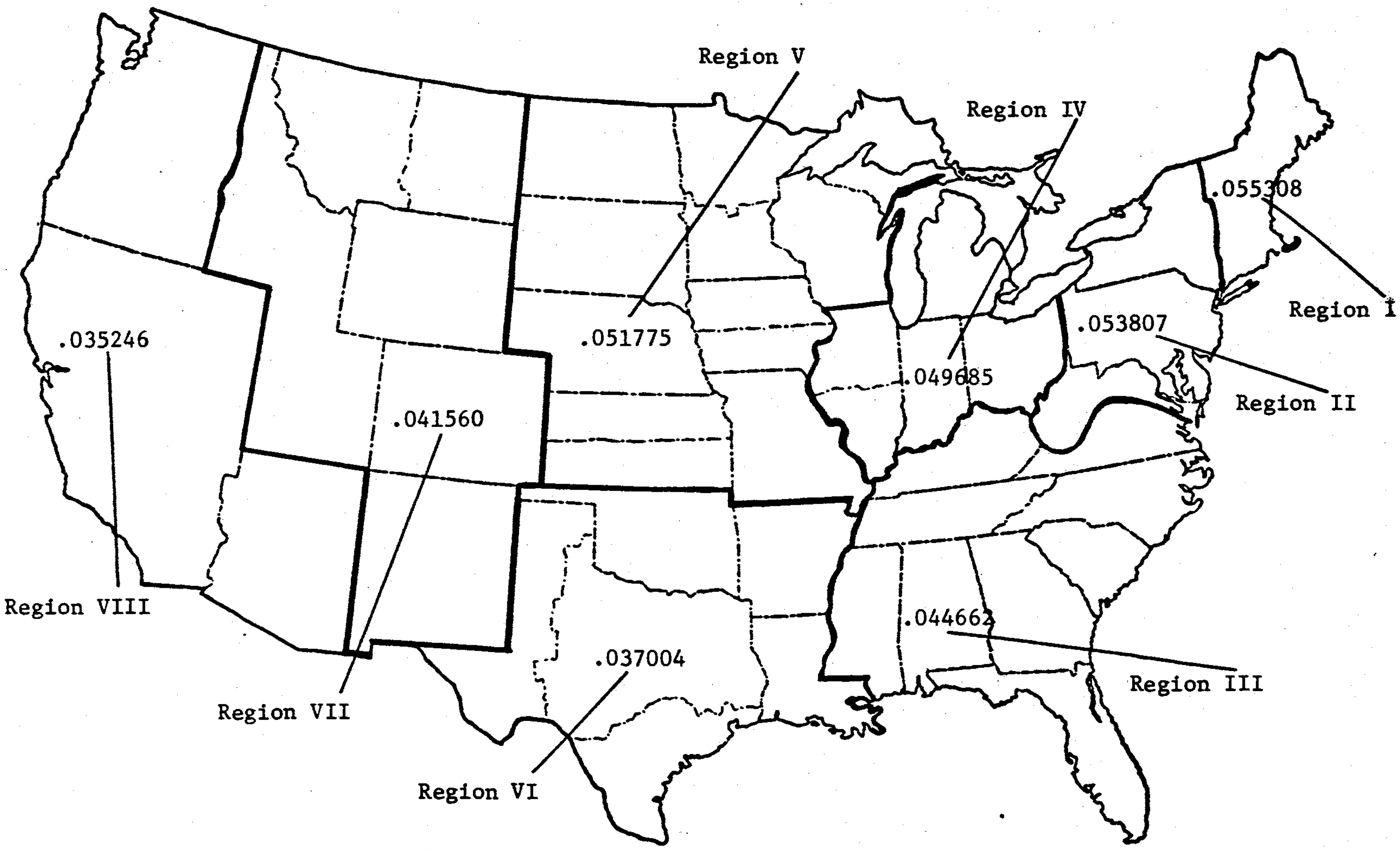

Figure 32. Regional Composite Costs of Transporting Flour, Fifty-Eight Percent Bagged and Forty-Two Percent Bulk, Cents Per Bu.-Mile (Wheat Equiv.), 1966

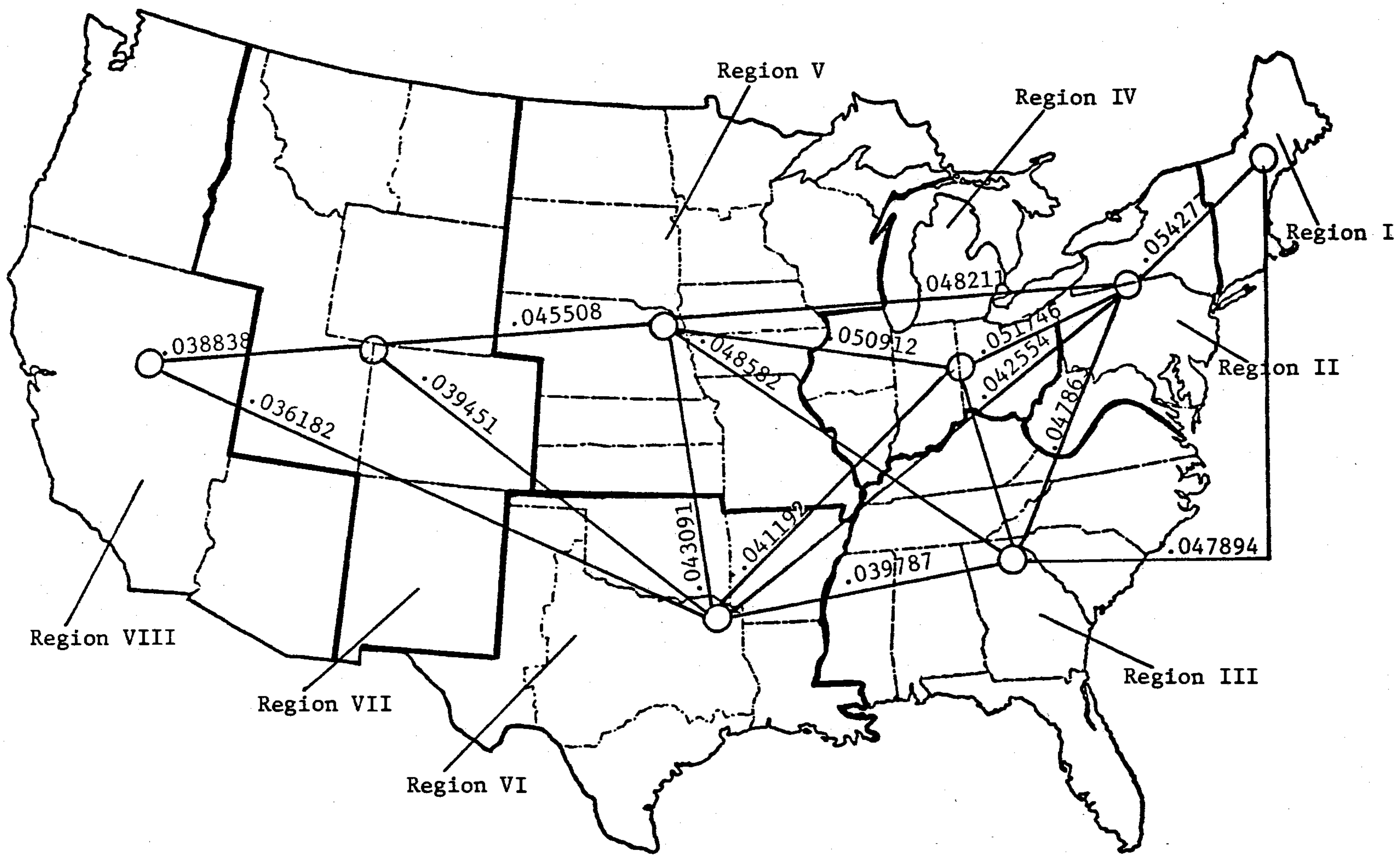

Figure 33. Interregional Composite Costs of Transporting Flour Fifty-Eight Percent Bagged And Forty-Two Percent Bulk, Cents Per Bu.-Mile (Wheat Equivalents), 1966

FOOTNOTES

[1]Kenneth L. Cassavant and David C. Nelson, *An Economic Analysis of Costs of Operating Grain Trucking Firms in North Dakota*, North Dakota Agricultural Experiment Station, Agricultural Economics Report No. 54 (Fargo, July, 1967).

[2]Cassavant and Nelson, p. 33.

[3]W. Milikus, *Comparison of For-Hire Motor Carriers Operating Under the Agricultural Exemption with Regulated Motor Carriers*, U. S. Department of Agriculture, Marketing Research Report No. 769 (Washington, August, 1966), p. 6.

[4]U. S. Department of Commerce, *Road-User and Property Taxes on Selected Motor Vehicles -- 1968*, Bureau of Public Roads (Washington, 1968), p. 9.

[5]Mildred R. DeWolfe, *For-Hire Motor Carriers Hauling Exempt Agricultural Commodities*, U. S. Department of Agriculture, Marketing Research Report No. 585 (Washington, January, 1963), p. 39.

[6]Interstate Commerce Commission, *Transport Studies in the United States for the Year Ended December 31,1966 Part 7, Motor Carriers*, Bureau of Accounts (Washington, 1968), pp. 32-33.

[7]Cassavant and Nelson, p. 42.

[8]DeWolfe, p. 12.

[9]U. S. Department of Commerce, *State Tax Collections in 1966*, "Government Finances/GF No. 8" (Washington, 1966), p. 11.

[10]Cassavant and Nelson, p. 16.

[11]Robert Snow Means Co., Inc., *Building Construction Cost Data, 1966*, "Total" index (Chicago, 1966), p. 95.

[12]U. S. Bureau of the Census, *Current Population Reports, Population Estimates*, Series P-25, Pub. No. 411 (Washington, December 5, 1968).

[13]The explanation of the necessity of dropping one dummy variable for computational procedures which results in an equation of the form of (A.1) is explained by J. Johnston in *Econometric Methods* (New York, 1963), pp. 222-223.

[14] Walter Y. Oi, Economics of Private Truck Transportation (Evanston, 1965), p. 167.

[15] U. S. Department of Treasury, Depreciation Guidelines and Rules, Internal Revenue Service Pub. No. 456, Revised August, 1965 (Washington, 1964).

[16] Ibid, p. 4.

[17] Ibid, p. 3.

[18] Cassavant and Nelson, p. 18.

[19] Ibid, p. 20.

[20] Orval Kerchner, Costs of Transporting Bulk and Packaged Milk by Truck, U. S. Department of Agriculture, Economic Research Service, Marketing Research Report No. 791 (Washington, May, 1967), p. 4.

[21] U. S. Bureau of the Census, 1967 Census of Governments, Volume 2, "Taxable Property Values," Table 9, "Measureable Sales of Ordinary Real Estate. . .by Type of Property, by States: 1966" (Washington, 1967), pp. 42-47.

[22] United States, 1968, Statistical Abstract, "State and Local Finances and Employment," Item 604 (Washington, 1968), p. 428.

[23] Cassavant and Nelson, p. 18.

[24] Interstate Commerce Commission, Transport Statistics in the United States, Part 7, Motor Carriers, Table 8, "Operation and Maintenance Expenses Class I Common Carriers of General Freight Engaged in Inter-city Service" (Washington, 1968), pp. 24-25.

[25] U. S. Department of Commerce, Road-User and Property Taxes on Selected Vehicles-1968, Table 14 (Washington, 1969), p. 62.

[26] U. S. Department of Transportation, Highway Statistics/1965, Federal Highway Administration, Bureau of Public Roads (Washington, April, 1967), p. 61.

[27] Kerchner, p. 6.

[28] Cassavant and Nelson, p. 21.

[29] U. S. Department of Labor, Union Wages and Hours: Motor Truck Drivers and Helpers, Bureau of Labor Statistics Bulletin No. 1488, Table No. 7 (Washington, May, 1966).

[30] 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, Bureau of Accounts Statement No. 8-67, (Washington, 1967), p. vi.

[31]U. S. Department of Health, Education, and Welfare, Social Security Amendments, 1965, Social Security Administration (Washington, 1965).

[32]Platt's Oilgram Price Service, Correspondence with Mr. Marshall Thomas, Assistant Editor, March, 1969.

[33]Hoy A. Richards, transportation consultant to Fiber and Grains Branch, Marketing Economics Division, United States Department of Agriculture.

[34]U. S. Department of Transportation, p. 8.

[35]Ibid, p. 54.

[36]Hoy A. Richards

[37]Interstate Commerce Commission, Table 8, "Tires and tubes. . . Revenue Equipment" divided by "Total miles operated-owned vehicles in intercity service," pp. 24-25.

[38]Cassavant and Nelson, p. 23.

[39]Kerchner, p. 6.

[40]Cassavant and Nelson, p. 20.

[41]John H. Hunter, Jr., Costs of Operating Exempt for Hire Motor Carriers of Agricultural Commodities--A Pilot Study in Delaware, Maryland, and Virginia, U. S. Department of Agriculture, Economic Research Service, ERS-109 (Washington, February, 1963), p. 13.

[42]Kerchner, p. 4.

[43]Interstate Commerce Commission, Cost of Transporting Freight by Class I and Class II Motor Common Carriers of General Commodities - By Regions or Territories for the Year 1966 (Washington, September, 1967), cover page.

[44]U. S. Bureau of the Census, "Truck Inventory and Use Survey," 1967 Census of Transportation, Table 11 (Washington, 1967).

[45]Interstate Commerce Commission, 1967, pp. 41, 54, 67, 80.

[46]National Commission on Food Marketing, Organization and Competition in the Milling and Baking Industries, Technical Study No. 5 (Washington, June, 1966), pp. 42-43.

[47]National Commission on Food Marketing, Table 2-40, p. 43.

APPENDIX B

DEVELOPMENT OF RAIL COST EQUATIONS

Unlike grain transported by trucks, grain transported by rail is a regulated commodity. Flour is regulated in both instances.

Data on rail transportation of commodities are virtually limited to those data required to be reported to the Interstate Commerce Commission (ICC) and those data reported in various rate hearings before the ICC.

For this study, the prime source of rail-cost data was *Rail Carload Cost Scales By Territories for the Year 1966*.[1] Table III of this publication is a detailed tabular presentation of rail carload unit costs by territory and by type of train (average-weight, way, and through) for thirteen types of equipment which are discussed in a later section. The cost coefficients of this table were obtained from Summary 1 of the rail cost formula known as *Rail Form A*[2], and are based on the year 1966 operations.

The purpose of this appendix is to explain how the costs of Table III of *Rail Carload Cost Scales By Territories for the Year 1966*[3] were adjusted to estimate rail costs-of-service for transporting grain and flour in 1966.

Cost Territories

The cost factors developed from Rail Form A by the ICC are classified according to "territories" or regions as presented in

Table L. These classifications consists of groups of carriers operating in the same general geographical area, as presented in Figure 8. It should be noted that these "territories" are actually groupings of entire railroad lines rather than the portions of these lines which lie within rigid geographical boundaries, and hence, involve some geographical overlapping. To avoid as much geographical overlapping as possible, only regions I, II, IV, and VII are considered in this study.

Types of Costs

The cost coefficients presented in ICC Table III may be used to compute what the ICC terms "out-of-pocket" costs, "constant expenses," and "fully distributed" costs as presented in Table LI.[4]

Type of Train

ICC Table III gives cost coefficients for each type of equipment for three types of trains, average-weight train, way train, and through train. The coefficients for the average-weight train reflect the average of all trains for the total train miles for each region.[5] Way-train coefficients are representative of movements between major rail terminals and way stations (local rail stations), while through-train coefficients represent movements between major rail terminals or distribution points.[6]

Using the data for way trains and through trains necessitates two mileage computations per region for interregional movements. For simplicity of computations, average-weight trains are specified for this study.[7]

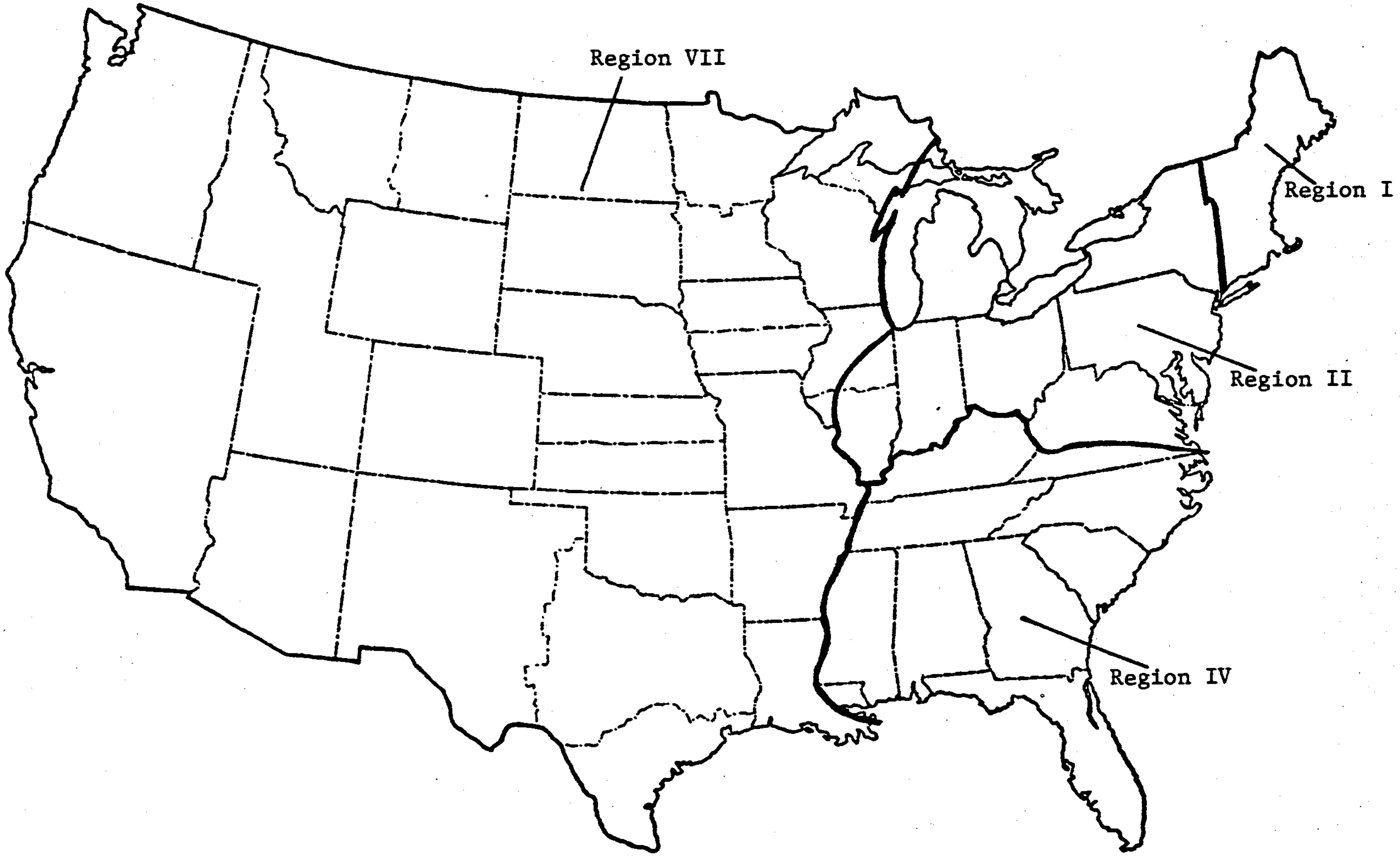

Figure 34. ICC Geographical Classification of Rail Regions Used in this Study

TABLE L

INTERSTATE COMMERCE COMMISSION 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 Trans-Territory
VI	Mountain Pacific and Trans-Territory
VII	Western District

Source: Interstate Commerce Commission, Rail Carload Cost Scales by Territories for the Year 1966, Bureau of Accounts, Statement No. 2-68 (Washington, May, 1968), p. 1.

TABLE LI

REGIONAL CARLOAD UNIT COSTS BY TYPE OF EQUIPMENT FOR AN AVERAGE-WEIGHT TRAIN, 1966[a]

Type of Equipment	Empty Return ratio	Out-of-Pocket Expenses: Line-haul: Per car-mile	Out-of-Pocket Expenses: Line-haul: Per cwt.-mile	Out-of-Pocket Expenses: Terminal: Per carload	Out-of-Pocket Expenses: Terminal: Per cwt.	Constant Expenses: Line-haul: Per cwt.-mile	Constant Expenses: Terminal: Per cwt.
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Region I		------------------Cents Per Unit--------------					
Box-General Service	.59	31.07205	.01746	7827.138	.173	.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	33.53472	.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	.1182	2.323
Stock	1.05	24.13523	.01004	7599.338	.173	.01182	2.323
Refrigerator	.78	31.73701	.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

TABLE LI (Continued)

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)
Region IV		---Cents Per Unit---					
Box-General Service	.42	14.38257	.00925	4891.630	.142	.01145	1.694
Box-Special Service	.79	20.41393	.00925	5204.931	.142	.01145	1.694
Gondola	.89	18.96827	.00925	5204.931	.024	.01145	1.694
Hopper, Open	.86	18.73597	.09925	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

[a]Excerpted from Interstate Commerce Commission, Rail Carload Cost Scales by Territories for the Year 1966, Bureau of Accounts, (Washington, May, 1968), pp. 163, 165, 169, 175. All ICC details remain for further discussion in this appendix.

Type of Equipment

Of the thirteen types of equipment listed in ICC Table III, two types of equipment are used to haul flour and grain by railroad. These two types of equipment are covered hopper cars and general service box cars.[8]

Adjustments of ICC Table III Coefficients

Car Ownership Cost Adjustments

The covered hopper cars used to haul grain and to haul flour are somewhat different from the "average" covered hopper car represented in ICC Table III. The covered hopper car specified to haul grain in this study, has 3,000 bushels' capacity and is classified as a jumbo covered hopper car. Such a car has a higher purchase price than smaller and older hopper cars. Likewise, the covered hopper car which hauls flour is also a specialized car and limited to the types of other commodities which 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 which are presented in Table LII. The procedure used to adjust the "average" ownership costs of ICC Table III was specified by Mr. M. Paolo, Director, Bureau of Accounts, Interstate Commerce Commission, Washington, D.C., as presented in Tables LIII and LIV.[9] The initial purchase price of a jumbo covered hopper car to haul grain for the year 1966 was $16,000.[10] The same price for a 100-ton covered hopper car equiped to haul flour was $24,000.[11]

TABLE LII

CAR OWNERSHIP COSTS BY REGION INCLUDED IN ICC STATEMENT NO. 2-68, 1966[a]

Region	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 Per Unit					
I	Box-General Service	xxx	7.68631	xxx	2209.173	xxx	.00175	.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

TABLE LIII

ADJUSTMENT OF CAR OWNERSHIP COSTS IN ICC STATEMENT NO. 2-68
TO ADAPT TO GRAIN HOPPER CARS

Line No.	Item	Average Car	Adjustment Factor	$16,000 Cars (Col. 2x Col. 3)
1.	Original Cost	$7,775	---	$16,000
2.	Net Investment (Original Cost minus accrued depreciation[b] (i.e. $480 for 1 year)	$5,061	---	$15,520
3.	Line-haul car ownership cost per car mile (Statement 2-68, p. 176, line 44, col. (4))	6.30743¢	---	---
	Elements Included in Line 3			
4.	Car depreciation	1.58213¢	2.06[c]	3.25919¢
5.	Return on investment (cost minus depreciation reserve)	1.42755¢	3.06[d]	4.36830¢
6.	Remainder (Repairs and overheads)	3.29775¢	1.0	3.29775¢
7.	Totals (lines 4, 5 & 6)	6.30743¢	---	10.92524¢

TABLE LIII (continued)

Line No.	Item	Average Car	Adjustment Factor	$16,000 Cars (Col. 2x Col. 3)
8.	Terminal Car Ownership cost per carload (Statement 2-68, p. 176, line 44, col. (6))	2.031.178¢	---	---
	Elements Included in Line 8			
9.	Car Depreciation	435.460¢	2.06[c]	897.0476¢
10.	Return on Investment (cost minus depreciation reserve)	1,042.460¢	3.06[d]	3,189.9276¢
11.	Remainder (Repairs and overheads)	553.258¢	1.0	553.258¢
12.	Totals (lines 9, 10 & 11)	2.031.178¢	---	4.640.243¢

[a]This table does not deviate from Mr. Paolo's references to ICC Statement No. 2-68.

[b]At the rate of 3 percent.

[c]$16,000 ÷ $7,775 = 2.06 (see line 1).

[d]$15,520 ÷ $5,061 = 3.06 (see line 2).

TABLE LIV

ADJUSTMENT OF CAR OWNERSHIP COSTS IN ICC STATEMENT NO. 2-68
TO ADAPT TO FLOUR HOPPER CARS

Line No.	Item	Average Car	Adjustment Factor	$24,000 Cars (Col. 2x Col. 3)
1.	Original Cost	$7,775	---	$24,000
2.	Net Investment (Original Cost minus accrued depreciation[b] (i.e. $720 for one year)	$5,061	---	23,280
3.	Line-haul car ownership cost per car mile (Statement 2-68, p. 176, line 44, col. (4))	6.30743¢	---	---
	Elements Included in Line 3			
4.	Car depreciation	1.58213¢	3.09[c]	4.8878¢
5.	Return on investment (cost minus depreciation reserve)	1.42755¢	4.60[d]	6.56673¢
6.	Remainder (Repairs and overheads)	3.29775¢	1.0	3.29775¢
7.	Totals (lines 4, 5 & 6)	6.30743¢	---	14.75326¢

TABLE LIV (continued)

Line No.	Item	Average Car	Adjustment Factor	$24,000 Cars (Col. 2x Col. 3)
8.	Terminal Car Ownership cost per carload (Statement 2-68, p. 176, line 44, col. (6))	2,031.178¢	---	---
	Elements Included in Line 8			
9.	Car Depreciation	435.460¢	3.09[c]	1,345.571¢
10.	Return on Investment (cost minus depreciation reserve)	1,042.460¢	4.60[d]	4,795.316¢
11.	Remainder (Repairs and overheads)	553.258¢	1.0	553.258¢
12.	Totals (lines 9, 10 & 11)	2,031.178¢	---	6,694.145¢

[a]This table does not deviate from Mr. Paolo's references to ICC Statement No. 2-68.

[b]at the rate of 3 percent.

[c]$24,000 ÷ $7,775 = 3.09 (see line 1).

[d]$24,280 ÷ $5,061 = 4.60 (see line 2).

The adjustments factors by region for grain and flour covered hopper cars are given in Table LX. As can be seen, 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, it is inappropriate that these commodities should bear losses from carriage of any other commodities,[12] therefore, passenger-train deficits are subtracted in Table LX. The adjustment percentages from ICC Statement No. 2-68, p. 6, Item No. 5, and are given in Table LV below.

TABLE LV

PASSENGER-TRAIN DEFICITS BY REGION, 1966[a]

	Rail Region			
	I	II	IV	VIII
	Percent			
Deficits	8	4	7	5

[a]Given as percentages of rail territorial fully distributed costs.

Floating Equipment Costs

Costs for floating equipment services are diffused over all traffic rather than being distributed over the actual traffic receiving floating service, but these costs have been subtracted from the costs of Table LI. For specific movements involving line-haul service across Lake Michigan or floating service at terminal harbors, these costs should be included. The corrections for floating equipment costs are given in Table LX. For a detailed explanation of floating equipment costs, see ICC Statement No. 2-68, pp. 202, 218, 219.

Platform Handling Costs

ICC Table III includes an average terminal cost for platform handling of carload traffic for general service box cars of 0.10926 cent per hundredweight for Region VII. Since neither grain nor flour receive such services, this cost is subtracted from the data in Table LI. This adjustment is presented in Table X. For further detail on platform handling costs, see ICC Statement No. 2-68, pp. 201-202.[13]

Loss and Damage

Loss and damage claims are excluded from ICC Table III. Therefore, they must be added to the data presented in Table LII. For movements of both grain and flour in covered hopper cars (i.e. bulk shipments) no cost is included for loss and damage. For shipments in box cars, a figure of $5.628 per carload is added to column 6 of Table LX for grain and $8.720 per carload for flour.[14]

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 has been included in ICC Table III by region for these services. These amounts which are included in column 6 of Table LI are: Region I, $3.96 per carload; Region II, $2.68 per carload; Region IV, $1.79 per carload; and Region VII, $3.82 per carload.[15]

According to testimony given in Investigation and Suspension Docket Number 8464, costs to the Rock Island Railroad for furnishing grain car doors were $6.03 per load.[16] The difference in this figure and the data above was used as an adjustment for special services for box cars in each region. The assumption was that special services for box cars should be at least the cost of grain doors. In the case of box cars to haul flour, the assumption was that the special service cost would be the average cost given in the first paragraph of this section.

The special services cost adjustment for hopper cars hauling flour was computed to be the difference of 5 cents per hundredweight for 100 tons per car or $100 per car and the data which were listed in the first paragraph of this section.[17] These adjustments are found in Table LX. No adjustments for special services were made for jumbo covered hopper cars hauling grain.

<u>Origin-Destination Switching Cost Adjustment</u>

A basic assumption made pertaining to the movement of grain and flour cited earlier was that grain would move in multiples of 5 cars and that flour would move in single cars.

It would seem logical that the per-unit time required to make a multiple-car switch would be less than for a single-car switch. According to a study by Wright in 1960, this reasoning is substantiated.[18] Wright's study showed that for a single-car cut the average time required was 3.16646 minutes and for a 5-car cut the average time required per car was 0.8650 minute per car or a total of 4.32486 minutes for 5 cars.

The switching cost per car is included in column 6 of Table LI. These costs and the associated times are given by region below in Table LVI.

TABLE LVI

SWITCHING TIME IN MINUTES PER CAR AND COST IN DOLLARS PER CAR, 1966

Type of Car	Region I Cost	Region I Time	Region II Cost	Region II Time	Region IV Cost	Region IV Time	Region VII Cost	Region VII Time
	Col.	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

The times and costs given in Table LVI above were adjusted using the procedure used by Coffin at Connecticut.[19] The switch engine time per car in minutes at origin or destination is represented by equation (B.1) below:

$$T_s = \frac{a_0}{N} + a_1 \qquad \text{(B.1)}$$

where T_s = switch engine minutes per car,

N = the number of cars in the shipment, and

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

These two constants are determined by assuming proportionality between them and the respective coefficients of equation (B.2) below:

$$T_s = \frac{3.16646}{N} + 0.2890 \qquad (B.2)$$

where, 3.16646 = the time in minutes for switching a single car in a 5-car cut,

0.2890 = the average time for each of the remaining 4 cars in a 5-car switch, and

N = the number of cars in a cut.

Thus, $\frac{3.16646}{a_0} = \frac{0.28960}{a_1}$. (B.3)

Rearranging (B.3) and substituting the average time per car for the appropriate region, a system of equations is developed for each region for each car:

$$a_0 + a_1 = T_{ICC} \qquad (B.4)$$

$$\frac{3.16646}{a_0} - \frac{0.28860}{a_1} = 0 \qquad (B.5)$$

where T_{ICC} = the average time in minutes per car taken from Table LVI.

Solving the above system of equations for each region for each type of car, box and hopper, the switching times per car in minutes were derived and are shown in Table LVII below.

TABLE LVII

DERIVED REGIONAL AVERAGE SWITCHING TIMES BY TYPE OF CAR, 1966

Type of Car	Region I	Region II	Region IV	Region VII
		Minutes Per Car		
Box Car	5.63346	6.86282	4.80665	6.45086
Hopper Car	6.24870	7.61052	5.34072	7.12986

TABLE LVIII

DERIVED REGIONAL AVERAGE SWITCHING COSTS BY TYPE OF CAR, 1966

Type of Car	Region I	Region II	Region IV	Region VII
		Dollars Per Car		
Box Car	4.82	5.04	2.73	4.32
Hopper Car	5.36	5.59	3.04	4.76

The switching cost adjustment factors were computed by subtracting the costs computed above from those in Table LVI. These factors are subtracted in column 6 of Table LX.

Station Clerical Cost Adjustment

Station clerical costs represent a portion of salaries and wages of employees engaged in the preparation of waybills, freightbills, interline settlements, etc. These costs are sometimes regarded as constant for each shipment since one waybill can be made to cover any number of cars. Thus, station clerical costs may be assumed to vary with the size of shipment.

The assumption made in this study is that 10 percent of the station clerical cost shown in Table XV of ICC Statement No. 2-68[20] is fixed for each car and that the remainder is distributable over all cars in the shipment.[21] This adjustment will apply to grain shipments only. The adjustment factors are computed in Table LIX and shown in Table LX.

TABLE LIX

STATION CLERICAL COST ADJUSTMENT FACTORS BY REGION, 1966

Item No.	Region I	Region II	Region IV	Region VII
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 & Item 5	4.51	3.61	2.91	5.43
7. Adjustment (negative) (Item 1 - Item 6)	-11.61	-9.27	-7.46	-13.97

Equation Development

The preceding section has explained the adjustments made to the ICC rail territorial cost scales for the year 1966 and has shown the results in summary form with the resulting adjusted territorial coefficients for two basic types of equipment to haul two different commodities, grain and flour (Table LX).

This section will explain the procedure for using the coefficients to determine the cost to the rail carrier for transporting grain and flour.[22]

Examination of Table LI will reveal that the ICC reports the rails' costs in three denominators, cents per car-mile, cents per hundredweight-mile, and cents per carload. To be meaningful in terms of a commodity, these costs must be expressed on the basis of a

TABLE LX

ADJUSTMENTS TO ICC RAIL TERRITORIAL COST SCALES, BY REGION AND TYPE OF EQUIPMENT, 1966

Region I - Grain	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
			Cents Per Unit			
Type of Equipment and Adjustment						
<u>Box Car, General Service</u>	31.07205	.01746	7,827.138	.17300	.02553	3.847
Car Ownership Costs	---	---	---	---	---	---
Passenger Train Deficits	- 2.48567	-.00140	- 626.171	-.01400	-.00204	- .308
Floating Equipment Costs	- .56742	-.00021	- 36.924	---	-.00023	- .006
Platform Handling Costs	---	---	---	-.10926	---	---
Loss and Damage	---	---	+ 562.800	---	---	---
Special Services						
Grain Car Doors	---	---	+ 396.000	---	---	---
Flour Car Cleaning Costs	---	---	---	---	---	---
Switching Cost Adjustment	---	---	-1,323.000	---	---	---
Station Clerical Cost Adjustment	---	---	-1,161.000	---	---	---
Coefficients Before Circuity Adjustment[c]	28.01896	.01585	5,638.843	.04974	.02326	3.533
Adjustments with Circuity	31.66142	.01791	---	---	.02628	---
<u>Hopper Covered</u>	40.79.95	.01746	/ 8,344.552	.06400	.02553	3.847
Car Ownership Costs	+ 1.06355	---	+2,314.797	---	---	---
Passenger Train Deficits	- 3.26336	-.00140	- 667.564	-.00500	-.00204	- .308
Floating Equipment Costs	- .73903	-.00021	- 41.027	---	-.00023	- .006
Platform Handling Costs	---	---	---	---	---	---
Loss and Damage	---	---	---	---	---	---
Special Services						
Grain Car Doors	---	---	---	---	---	---
Flour Car Cleaning Costs	---	---	---	---	---	---
Switching Cost Adjustment	---	---	-1,470.000	---	---	---
Station Clerical Cost Adjustment	---	---	-1,161.000	---	---	---
Coefficients Before Circuity Adjustment[c]	37.85311	.01585	7,319.758	.05900	.02326	3.533
Adjustments with Circuity	42.77401	.01791	---	---	.02628	---

[a] See footnotes b and c at the end of Table LX.

TABLE LX (Continued)

Region I - Flour	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
			Cents Per Unit			
Type of Equipment and Adjustment						
Box Car, General Service	31.07205	.01746	7,827.138	.17300	.02553	3.847
Car Ownership Costs	---	---	---	---	---	---
Passenger Train Deficits	- 2.48567	-.00140	- 626.171	-.01400	-.00204	- .308
Floating Equipment Costs	- .56742	-.00021	- 36.924	---	-.00023	- .006
Platform Handling Costs	---	---	---	-.10926	---	---
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[c]	28.01896	.01585	8,036.043	.04974	.02326	3.533
Adjustments with Circutiy	31.66142	.01791	---	---	.02628	---
Hopper, Covered	40.79195	.01746	8,344.552	.06400	.02553	3.847
Car Ownership Costs	+ 4.89157	---	+4,368.699	---	---	---
Passenger Train Deficits	- 3.26336	-.00140	- 667.564	-.00500	-.00204	- .308
Floating Equipment Costs	- .73903	-.00021	- 41.027	---	-.00023	- .006
Platform Handling Costs	---	---	---	---	---	---
Loss and Damage	---	---	---	---	---	---
Special Services						
Grain Car Doors	---	---	---	---	---	---
Flour Car Cleaning Costs	---	---	+9,604.000	---	---	---
Switching Cost Adjustment	---	---	---	---	---	---
Station Clerical Cost Adjustment	---	---	---	---	---	---
Coefficients Before Circuity Adjustment[c]	41.68113	.01585	21,608.660	.05900	.02326	3.533
Adjustments with Circuity	47.09968	.01791	---	---	.02628	---

TABLE LX (Continued)

Region II - Grain	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
			Cents Per Unit			
Type of Equipment and Adjustment						
Box Car, General Service	18.33217	.01004	7,087.715	.17300	.01182	2.323
Car Ownership Costs	---	---	---	---	---	---
Passenger Train Deficits	- .73329	-.00040	- 283.509	-.00700	-.00047	- .093
Floating Equipment Costs	- .29261	-.00009	- 125.132	---	-.00011	- .015
Platform Handling Costs	---	---	---	-.12625	---	---
Loss and Damage	---	---	+ 562.800	---	---	---
Special Services						
Grain Car Doors	---	---	+ 335.000	---	---	---
Flour Car Cleaning Costs	---	---	---	---	---	---
Switching Cost Adjustment	---	---	-1,382.000	---	---	---
Station Clerical Cost Adjustment	---	---	- 927.000	---	---	---
Coefficients Before Circuity Adjustment[c]	17.30627	.00955	5,267.874	.03975	.01124	2.215
Adjustments with Circuity	19.55609	.01079	---	---	.01270	---
Hopper, Covered	26.65993	.01004	7,599.338	.04700	.01182	2.323
Car Ownership Costs	+ 3.71215	---	+2,787.792	---	---	---
Passenger Train Deficits	- 1.06640	-.00040	- 303.974	-.00200	-.00047	- .093
Floating Equipment Costs	- .42184	-.00009	- 139.035	---	-.00011	- .015
Platform Handling Costs	---	---	---	---	---	---
Loss and Damage	---	---	---	---	---	---
Special Services						
Grain Car Doors	---	---	---	---	---	---
Flour Car Cleaning Costs	---	---	---	---	---	---
Switching Cost Adjustment	---	---	-1,536.000	---	---	---
Station Clerical Cost Adjustment	---	---	- 927.000	---	---	---
Coefficients Before Circuity Adjustment[c]	28.88384	.00955	7,481.121	.04500	.01124	2.215
Adjustments with Circuity	32.63874	.01079	---	---	.01270	---

TABLE LX (Continued)

Region II - Flour	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
	Cents Per Unit					
Type of Equipment and Adjustment						
Box Car, General Service	18.33217	.01004	7,078.715	.17300	.01182	2.323
Car Ownership Costs	---	---	---	---	---	---
Passenger Train Deficits	- .73329	-.00040	- 283.509	-.00700	-.00047	- .093
Floating Equipment Costs	- .29261	-.00009	- 125.132	---	-.00011	- .015
Platform Handling Costs	---	---	---	-.12625	---	---
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[c]	17.30627	.00955	7,551.074	.03975	.01124	2.215
Adjustments with Circuity	19.55609	.01079	---	---	.01270	---
Hopper, Covered	26.65993	.01004	7,599.338	.04700	.01182	2.323
Car Ownership Costs	+ 7.54017	---	+4,841.694	---	---	---
Passenger Train Deficits	- 1.06640	-.00040	- 303.974	-.00200	-.00047	- .093
Floating Equipment Costs	- .42184	-.00009	- 139.035	---	-.00011	- .015
Platform Handling Costs	---	---	---	---	---	---
Loss and Damage	---	---	---	---	---	---
Special Services						
Grain Car Doors	---	---	---	---	---	---
Flour Car Cleaning Costs	---	---	+9,732.000	---	---	---
Switching Cost Adjustment	---	---	---	---	---	---
Station Clerical Cost Adjustment	---	---	---	---	---	---
Coefficients Before Circuity Adjustment[c]	32.71186	.00955	21,730.023	.04500	.01124	2.215
Adjustments with Circuity	36.96440	.01079	---	---	.01270	---

TABLE LX (Continued)

Region IV - Grain	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
			Cents Per Unit			
Type of Equipment and Adjustment						
Box Car, General Service	14.38257	.00925	4,891.630	.14200	.01145	1.694
Car Ownership Costs	---	---	---	---	---	---
Passenger Train Deficits	- 1.00678	-.00065	- 342.414	-.01000	-.00080	- .119
Floating Equipment Costs	- .00176	---	- 1.364	---	---	---
Platform Handling Costs	---	---	---	-.11816	---	---
Loss and Damage	---	---	+ 562.800	---	---	---
Special Services						
Grain Car Doors	---	---	+ 424.000	---	---	---
Flour Car Cleaning Costs	---	---	---	---	---	---
Switching Cost Adjustment	---	---	- 751.000	---	---	---
Station Clerical Cost Adjustment	---	---	- 746.000	---	---	---
Coefficients Before Circuity Adjustment[c]	13.37403	.00860	4,037.652	.01384	.01065	1.575
Adjustments with Circuity	15.11265	.00925	---	---	.01203	---
Hopper, Covered	20.53052	.00925	5,204.931	.02400	.01145	1.694
Car Ownership Costs	+ 4.39110	---	+2,927.360	---	---	---
Passenger Train Deficits	- 1.43714	-.00065	- 364.345	-.00200	-.00080	- .119
Floating Equipment Costs	- .00246	---	- 1.516	---	---	---
Platform Handling Costs	---	---	---	---	---	---
Loss and Damage	---	---	---	---	---	---
Special Services						
Grain Car Doors	---	---	---	---	---	---
Flour Car Cle ning Costs	---	---	---	---	---	---
Switching Cost Adjustment	---	---	- 834.000	---	---	---
Station Clerical Cost Adjustment	---	---	- 746.000	---	---	---
Coefficients Before Circuity Adjustment[c]	23.48202	.00860	6,186.430	.02200	.01065	1.575
Adjustments with Circuity	26.53468	.00972	---	---	.01203	---

TABLE LX (Continued)

Region IV - Flour	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
			Cents Per Unit			
Type of Equipment and Adjustment						
Box Car, General Service	14.38257	.00925	4,891.630	.14200	.01145	1.694
Car Ownership Costs	—	—	—	—	—	—
Passenger Train Deficits	- 1.00678	-.00065	- 342.414	-.01000	-.00080	- .119
Floating Equipment Costs	- .00176	—	- 1.364	—	—	—
Platform Handling Costs	—	—	—	-.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[c]	13.37403	.00860	5,419.852	.01384	.01065	1.575
Adjustments with Circuity	15.11265	.00972	—	—	.01203	—
Hopper, Covered	20.53052	.00925	5,204.931	.02400	.01145	1.694
Car Ownership Costs	+ 8.21912	—	+4,981.262	—	—	—
Passenger Train Deficits	- 1.43714	-.00065	- 364.345	-.00200	-.00080	- .119
Floating Equipment Costs	- .00246	—	- 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[c]	27.31004	.00860	19,641.332	.02200	.01065	1.575
Adjustments with Circuity	30.86035	.00972	—	—	.01203	—

TABLE LX (Continued)

Region VII - Grain	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
			Cents Per Unit			
Type of Equipment and Adjustment						
Box Car, 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	---	---	+ 221.000	---	---	---
Flour Car Cleaning Costs	---	---	---	---	---	---
Switching Cost Adjustment	---	---	-1,174.000	---	---	---
Station Clerical Cost Adjustment	---	---	-1,397.000	---	---	---
Coefficients Before Circuity Adjustment[c]	14.53495	.01014	5,299.838	.07158	.01216	2.571
Adjustments with Circuity	16.42449	.01146	---	---	.01374	---
Hopper, Covered	23.27384	.01067	7921.483	.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[c]	26.71291	.01014	7,426.258	.08900	.01216	2.571
Adjustments with Circuity	30.18559	.01146	---	---	.01374	---

TABLE LX (Continued)

Region VII - Flour	(4) Per Car Mile[b]	(5) Per Cwt.-Mile[b]	(6) Per Carload[b]	(7) Per Cwt.[b]	(8) Per Cwt.-Mile[b]	(9) Per Cwt.[b]
			Cents Per Unit			
Type of Equipment and Adjustment						
Box Car, 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[c]	14.53495	.01014	7,959.038	.07158	.01216	2.571
Adjustments with Circuity	16.42449	.01146	---	---	.01374	---
Hopper, Covered	23.27284	.01067	7,921.483	.09400	.01281	2.706
Car Ownership Costs	+ 8.44583	---	+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	---	---	---	---	---	---
Flour Car Cleaning Costs	---	---	+9,618.000	---	---	---
Switching Cost Adjustment	---	---	---	---	---	---
Station Clerical Cost Adjustment	---	---	---	---	---	---
Coefficients Before Circuity Adjustment[c]	30.54093	.01014	21,603.160	.08900	.01216	2.571
Adjustments with Circuity	34.51125	.01146	---	---	.01374	---

[b]The column number represents the identical column in Interstate Commerce Commission, Rail Carload Cost Scales by Territories for the Year 1966, Bureau of Accounts, Statement No. 2-68, (Washington, May, 1968), Table 3.

[c]Circuity is discussed in the section of this appendix titled, "Equation Development."

common unit.

Further examination of Table LI and Table LX will reveal that "Terminal Costs," 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 purposes of this study, a box car of grain hauls 2,000 bushels or 1,200 hundredweights.[23] This same box car can haul 1154.16 hundredweights of bagged flour (space is lost from space between bags). A hopper car to haul grain carries 3,000 bushels or 1,800 hundredweights,[24] while a hopper car equipped to haul flour carries 2,000 hundredweights (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 ICC Carload Waybill Statistics.[25] The percentage of grain moving by type of car by regions for the year 1966 are presented in Table LXI. Flour was assumed to move in single car movements.[26] Fifty-eight percent of the flour was assumed to be hauled in bags in box cars and 42 percent bulk in "airslide" (pneumatic-like) covered hopper cars.[27]

TABLE LXI

GRAIN MOVEMENTS PROPORTIONED BY TYPE OF CAR, BY RAIL REGION, 1966

Region Number		Proportion of Grain Moved By Car Type	
Origin	Destination	Box	Hopper
I	I	.8585	.1415
II	I	.8585	.1415
II	II	.8585	.1415
II	IV	.4010	.5990
VII	II	.8037	.1963
VII	IV	.9240	.0760
VII	VII	.7842	.2158

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

Tables LXII, LXIII, and LXIV computed from Tables LX and LXI give that portion of the total cost per bushel including circuity[28] for grain and the cost per hundredweight for flour which can be expressed as a function of weight.[29] Tables LXV and LXVI, also taken from Table LX, present that portion of the total cost for intra-regional movements expressed as a per weight-mile basis for hauling grain and flour.

Intraregional Equations

Equations for intra-regional movements of grain and intra-regional movements of flour as a function of mileage, X, can be obtained by taking the necessary coefficients directly from Tables LXII, LXIII, LXV, and LXVI, remembering the incorporated specifications made in this study. These equations for rail regions I, II, IV, and VII are given in Table LXVII. Interregional equations were developed using the data of Tables LXI through LXVI.

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. These costs are presented in Table LXI. The coefficients for the miles travelled in each region (Line-Haul Costs) were developed using the car ratios of Table LXI and the "Line-Haul Cost" coefficients of Tables LXV

TABLE LXII

INTRAREGIONAL RAIL TERMINAL COST ANALYSIS FOR GRAIN, 1966

Region	Type of Equipment	(6)		(7)		(9)		Total
		Cents/Carload	Cents/Bu.	Cents/Cwt.	Cents/Bu.	Cents/Cwt.	Cents/Bu.	Cents/Bu.
I	Box	5638.843	2.81900	.04974	.02984	3.533	2.11980	4.96864
	Hopper	7319.758	2.43992	.05900	.03540	3.533	2.11980	4.59512
	Composite	---	2.76536	---	.03063	---	2.11980	4.91579
II	Box	5267.874	2.63394	.03975	.02385	2.215	1.32900	3.98679
	Hopper	7481.121	2.49371	.04500	.02700	2.215	1.32900	3.84971
	Composite	---	2.61410	---	.02430	---	1.32900	3.96739
IV	Box	4037.652	2.01883	.01384	.00830	1.575	.94500	2.97213
	Hopper	6186.430	2.06214	.02200	.01320	1.575	.94500	3.02034
	Composite	---	2.04156	---	.01087	---	.94500	2.99743
VII	Box	5299.838	2.64991	.07158	.04295	2.571	1.54260	4.23546
	Hopper	7426.258	2.47542	.08900	.05340	2.571	1.54260	4.07142
	Composite	---	2.61226	---	.04521	---	1.54260	4.20006

TABLE LXIII

INTRAREGIONAL RAIL TERMINAL COST ANALYSIS FOR FLOUR, 1966

Region	Type of Equipment	(6)		(7)		(9)		Total
		Cents/Carload	Cents/Cwt.					
I	Box	8,036.043	6.96268	.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

TABLE LXIV

INTERREGIONAL RAIL TERMINAL COST ANALYSIS FOR GRAIN, 1966

Type of Equipment	Cost in Cents Per Bushel: Origin	Cost in Cents Per Bushel: Destination	Cost in Cents Per Bushel: Simple Average	Car Ratio	Weighted Average Cost
					Cents/Bu.
	II	I			
Box	3.98679	4.96864	4.47772	.8585	---
Hopper	3.84971	4.59512	4.22242	.1415	---
Composite	---	---	---	---	4.44160
	II	IV			
Box	3.98679	2.972.3	3.47946	.4010	---
Hopper	3.84971	3.02034	3.43502	.5990	---
Composite	---	---	---	---	3.45284
	VII	II			
Box	4.23546	3.98679	4.11112	.8037	---
Hopper	4.07142	3.84971	3.96056	.1963	---
Composite	---	---	---	---	4.08157
	VII	IV			
Box	4.23546	2.97213	3.60380	.9240	---
Hopper	4.07142	3.02034	3.54588	.0760	---
Composite	---	---	---	---	3.59940

TABLE LXV

INTRAREGIONAL RAIL LINE-HAUL COST ANALYSIS FOR GRAIN, 1966

Region	Type of Equipment	(4)		(5)		(8)		Total
		Cents/ Car-Mi.	Cents/ Bu.-Mi.	Cents/ Cwt.-Mi.	Cents/ Bu.-Mi.	Cents/ Cwt.-Mi.	Cents/ Bu.-Mi.	Cents/ Bu.-Mi.
I	Box	31.66142	.01583	.01791	---	.02628	---	.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

TABLE LXVI

INTRAREGIONAL RAIL LINE-HAUL COST ANALYSIS FOR FLOUR, 1966

Region	Type of Equipment	(4)		(5)		(8)		Total
		Cents/ Car-Mi.	--------------	Cents/Cwt.-Mi.	--------------			
I	Box	31.66142	.02743	.01791	---	.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	---	---
	Compsoite	---	.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

TABLE LXVII

INTRAREGIONAL RAIL COST EQUATIONS FOR GRAIN AND FLOUR, 1966

Rail Region	Commodity	Total Cost	=	Terminal Cost	+	Linehaul Cost	Cost Measure
I	Grain	Y	=	4.91579	+	.04213X	Cents per bu.
	Grain	Y	=	8.19298	+	.07022X	Cents per cwt.
	Flour	Y	=	12.16280	+	.06999X	Cents per cwt.
II	Grain	Y	=	3.96739	+	.02403X	Cents per bu.
	Grain	Y	=	6.61232	+	.04005X	Cents per cwt.
	Flour	Y	=	10.61490	+	.04108X	Cents per cwt.
IV	Grain	Y	=	2.99743	+	.02128X	Cents per bu.
	Grain	Y	=	4.99572	+	.03547X	Cents per cwt.
	Flour	Y	=	8.44059	+	.03582X	Cents per cwt.
VII	Grain	Y	=	4.20006	+	.02373X	Cents per bu.
	Grain	Y	=	7.00010	+	.03955X	Cents per cwt.
	Flour	Y	=	11.18622	+	.04070X	Cents per cwt.

and LXVI for each likely interregional movement. These equations are presented in Table LXVII.

For the mathematical model of this study with specified supply and demand points, costs for transportation services for grain and flour must be specific for origins and destinations. Thus, for interregional shipments, the mileage travelled in each rail region must be known to use the equations of Table LXVII, thus at least doubling the mileage input requirements if such equations are used. To minimize mileage computations, an equation as a function of a single mileage between origin and destination is desirable. Such "averaged" equations can be developed from the equations in Table LXVIII when the movements of grain and flour are known on an interregional basis.

ICC Statement SS-2, 1966, <u>Carload Waybill Statistics - 1966</u>, "State-to-State Distribution, Traffic and Revenue"[30] gives a one percent sample of carload grain movements and of flour movements by states for the year 1966. The origin and destination for each movement listed in these data was classified by rail region as given in Figure 34. 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 travelled if the origins and destinations in the <u>Carload Waybill Statistics</u> were the same as those used in this study. These data are presented as decimal fractions in Table LXIX.

The equations which result from this weighted averaging procedure is a simple linear function of mileage such as

$$Y = a + bX \qquad (B.6)$$

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

TABLE LXVIII

SELECTED INTERREGIONAL RAIL COST EQUATIONS FOR GRAIN AND FLOUR, 1966
WHEN MILEAGES OF MULTIPLE REGIONS ARE KNOWN

Rail Region							
Origin	Destination	Commodity	Total Cost	=	Terminal Cost	+ Line Haul Cost	Cost Measure
II	I	Grain	Y	=	4.44160	+ .02403X + .04213Z	Cents per bushel
		Grain	Y	=	7.40267	+ .04005X + .07022Z	Cents per hundredweight
		Flour	Y	=	11.38885	+ .04108X + .06999Z	Cents per hundredweight
II	IV	Grain	Y	=	3.45284	+ .02932X + .02138Z	Cents per bushel
		Grain	Y	=	5.75473	+ .04887X + .03563Z	Cents per hundredweight
		Flour	Y	=	9.52774	+ .04108X + .03582Z	Cents per hundredweight
VII	II	Grain	Y	=	4.08157	+ .02369X + .02409Z	Cents per bushel
		Grain	Y	=	6.80262	+ .03948X + .04015Z	Cents per hundredweight
		Flour	Y	=	10.90056	+ .04070X + .04108Z	Cents per hundredweight
VII	IV	Grain	Y	=	3.59940	+ .02347X + .02071Z	Cents per bushel
		Grain	Y	=	5.99900	+ .03912X + .03452Z	Cents per hundredweight
		Flour	Y	=	9.81341	+ .04070X + .03582Z	Cents per hundredweight

[a]The X represents the miles traveled in the origin rail region and Z represents the miles traveled in rail region of the destination.

TABLE LXIX

TON-MILEAGES BY REGION FOR GRAIN AND FLOUR IN SELECTED INTERREGIONAL MOVEMENTS, 1966

	Origin		Destination	
Commodity	Region No.	Weighting Factor	Region No.	Weighting Factor
Grain	II	.8305	I	.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

The "a" term for interregional equations of the form of B.6 can be taken from Table LXVII. Likewise data from Tables LXI, LXV, LXVI, and LXIX can be combined to yield the "b" term (Line-Haul Costs/ Unit-Mile). These data are presented in Table LXX.

Selected single-mileage interregional equations are presented in Table LXXI.

TABLE LXX

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 No.	Weight	Coefficient	Region No.	Weight	Coefficient		
Grain	II	.8305	.02403	I	.1695	.04213	.02710	Per Bu.-Mi.
Grain		.8305	.04005		.1695	.07022	.04517	Per Cwt.-Mi.
Flour		.7244	.04108		.2556	.06999	.04765	Per Cwt.-Mi.
Grain	II	.3712	.02932	IV	.6288	.02138	.02533	Per Bu.-Mi.
Grain		.3712	.04887		.6288	.03563	.04055	Per Cwt.-Mi.
Flour		.3960	.04108		.6040	.03582	.03790	Per Cwt.-Mi.
Grain	VII	.4529	.02369	II	.5471	.02409	.02396	Per Bu.-Mi.
Grain		.4529	.03948		.5471	.04015	.03985	Per Cwt.-Mi.
Flour		.3847	.04070		.6153	.04108	.04093	Per Cwt.-Mi.
Grain	VII	.6575	.02347	IV	.3425	.02071	.02252	Per Bu.-Mi
Grain		.6575	.03912		.3425	.03452	.03753	Per Cwt.-Mi.
Flour		.6443	.04070		.3557	.03582	.03896	Per Cwt.-Mi.

TABLE LXXI

SELECTED SINGLE-MILEAGE INTERREGIONAL RAIL COST EQUATIONS
FOR GRAIN AND FLOUR, 1966

Origin	Destination	Total Cost	=	Terminal Cost	+	Line-Haul Cost	Unit of Cost	Commodity
							(Cents)	
II	I	Y	=	4.44160	+	.02710X	Per Bu.	Grain
		Y	=	7.40267	+	.04517X	Per Cwt.	Grain
		Y	=	11.38885	+	.04765X	Per Cwt.	Flour
II	IV	Y	=	3.45284	+	.02433X	Per Bu.	Grain
		Y	=	5.75473	+	.04055X	Per Cwt.	Grain
		Y	=	9.52774	+	.03790X	Per Cwt.	Flour
VII	II	Y	=	4.08157	+	.02391X	Per Bu.	Grain
		Y	=	6.80262	+	.03985X	Per Cwt.	Grain
		Y	=	10.90056	+	.04093X	Per Cwt.	Flour
VII	IV	Y	=	3.59940	+	.02252X	Per Bu.	Grain
		Y	=	5.99900	+	.03753X	Per Cwt.	Grain
		Y	=	9.81341	+	.03896X	Per Cwt.	Flour

FOOTNOTES

[1]Interstate Commerce Commission, Rail Carload Cost Scales by Territories for the Year 1966, Bureau of Accoutns, Statement No. 2-68 (Washington, May, 1968).

[2]Interstate Commerce Commission, Formula for Use in Determining Rail Freight Service Costs, Bureau of Accounts, Statement No. 9-66 (Washington, 1966).

[3]Throughout the remainder of this appendix, this reference will be referred to as ICC Table III.

[4]Interstate Commerce Commission, Explanation of Rail Cost Finding Procedures and Principles Relating to the Use of Costs, Bureau of Accounts, Statement No. 7-63 (Washington, November, 1963), pp. 2,3,25, define these terms respectively, out-of-pocket costs are "the expenses which can be directly assigned to any given product or 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. . ."

[5]Interstate Commerce Commission, 1968, p. 185, Item No. 12 has a thorough discussion of "average-weight train."

[6]Interstate Commerce Commission, Interstate Commerce Commission Reports, "Petroleum Rail Shippers' Association versus Alton and Southern Railroad," Vol. 243 (Washington, March, 1941), pp. 589, 646, 647.

[7]Researchers wishing to use way-train and through-train coefficients should consult Interstate Commerce Commission, 1968, p. 6, Item No. 6.

[8]For a specific description of any type of rail car, see a current issue of The Official Railway Equipment Register, issued quarterly.

[9]Interstate Commerce Commission, Correspondence with Mr. M. Paola, Director, Bureau of Accounts (Washington, July, 1969).

[10]U. S. Department of Transportation, Federal Railraod Administration, Policy Division, Telephone Conversation with Mr. James McClellan (Washington, June, 1969).

[11]Ibid.

[12]This assumption does not consider social costs.

[13]Interstate Commerce Commission, 1968, pp. 201-202.

[14]Due to the construction of jumbo covered hopper cars, it is the policy of some railroads to pay no claims for loss and damage of grain or flour hauled in these cars, unless such cost or damage can be proven. For further information see The Chicago Rock Island, and Pacific Railroad, Exhibit No. 2 Schedule DJL-4, p. 8, before the Interstate Commerce Commission in Investigation and Suspension Docket No. 8364, Grain from Various Iowa Origins to Chicago, Illinois, and Houston, Texas, for Export (unpublished). The costs for loss and damage sustained from box cars were obtained from Interstate Commerce Commission, 1968, p. 204.

[15]Interstate Commerce Commission, 1968, p. 188.

[16]The Chicago, Rock Island, and Pacific Railroad, in Exhibit No. 2, Schedule DJL-4, before the Interstate Commerce Commission in Investigation and Suspension Docket No. 8364, Grain from Various Iowa Origins to Chicago, Illinois, and Houston, Texas, for Export (Unpublished).

[17]The five cents per hundredweight charge for cleaning covered hopper cars that haul flour was derived from Jeff Maillie and Dale Solum, An Analysis and Evaluation of Factors Which are Deleterious to the Competitive Interests of the Mid-America Wheat Flour Milling Industry (Kansas City, July, 1969), p. 80. An association of millers in the North Central and Northeast United States charge five cents per hundredweight for bulk transfer of flour at bulk transfer stations. The total cost of transfer and cleaning of the cars was estimated to be ten cents per hundred-weight, thus the difference, five cents, for car cleaning.

[18]Walter B. Wright, "How Cars in Multiple Cut Costs," Railway Age, January 4, 1960, pp. 23, 24, 35.

[19]H. G. Coffin and W. R. Reilly, Rail Freight Rates: Potential Reductions on Corn Shipped to New England, Storrs Agricultural Experiment Station, Bulletin 407 (Storrs, December, 1968), pp. 24-25.

[20]Interstate Commerce Commission, 1968.

[21]Coffin, p. 26.

[22]Interstate Commerce Commission, 1963, is devoted entirely to discussing the use of ICC rail territorial costs.

[23]Interstate Commerce Commission.

[24]Ibid.

[25]Interstate Commerce Commission, "Territorial Distribution of Cars by Commodity Class and by Type of Car (TC-3)," Carload Waybill Statistics, 1966, Bureau of Economics (Washington, 1967).

[26]Edmund A. Nightengale, "Some Effects of Recent Changes in the Railway Grain-Rate Structure on Interregional Competition and Regional Development," Transportation Problems and Policies in the Trans-Missouri West (Lincoln, 1967), p. 156: "Flour moves in single cars because it is not ordinarily shipped in quantities sufficient to qualify for the minimum weights associated with the volume movements on account of the nature of the trade or marketing practices. . ."

[27]This was explained in Appendix A.

[28]Adjustment for circuity is to allow for the actual miles traveled by a shipment rather than the short-line or most direct mileage upon which rail rates are based.

[29]Interstate Commerce Commission, Circuity of Rail Carload Freight, Bureau of Economics, Statement No. 68-1 (Washington, April, 1968), p. 1.

APPENDIX C

GRAIN BARGING COSTS OF SERVICE

Grain which is barged is regulated by the Interstate Commerce Commission only if more than three commodities are present in the tow. With modern fleeting operations, it is quite easy to have a flotilla of twenty-two or even more barges on the Mississippi River with three or fewer commodities. Thus in general we may say that barge movements of grain are unregulated and move at charges which are not published.[1]

As with truck transportation of grain, published data on costs-of-service for barge transportation of grain are virtually non-existent. Although, the Interstate Commerce Commission requires reports on operations of regulated carriers, these data are of an aggregated nature and, therefore, are 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 author was unable to confirm this generality when examining the published tariffs. Navigation factors such as controlling channel depth and width, and locks and dams, influence the barging operation time which is a most influential element of the costs of barge movements.

The purpose of this appendix is to discuss the data used to derive barging costs-of-service for grain transportation available to those regions in this study which had feasible access to the Mississippi

River system, the Columbia-Snake Rivers, or the Gulf Intra-coastal Waterway. These regions are denoted in Figure 35 by the black dots which appear. Specific points of river origin and destination for grain were taken from Freight Tariff No. 7[2] for the Mississippi River System and from information supplied by the Pacific Northwest Grain and Grain Products Association[3] and the North Pacific Grain Growers, Incorporated[4] 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, using the theoretical framework of Launhardt discussed in Chapter II.

The order of presentation in this appendix will be to present data on navigational factors and equipment to be followed by cost data. The cost data will include investment costs for barges and towboats, operating costs of barges and towboats, and associated costs of operation which include costs for loading and unloading time, barge cleaning costs, and loss and damage expenses. Following the cost-data presentation, factors which affect barging time will be discussed.

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 this study, the industry-standard barge, or the jumbo covered hopper barge as it is known, a 195 feet x 35 feet barge, was specified[5] for the Mississippi River System.[6] Since technology is somewhat different on the Columbia River,

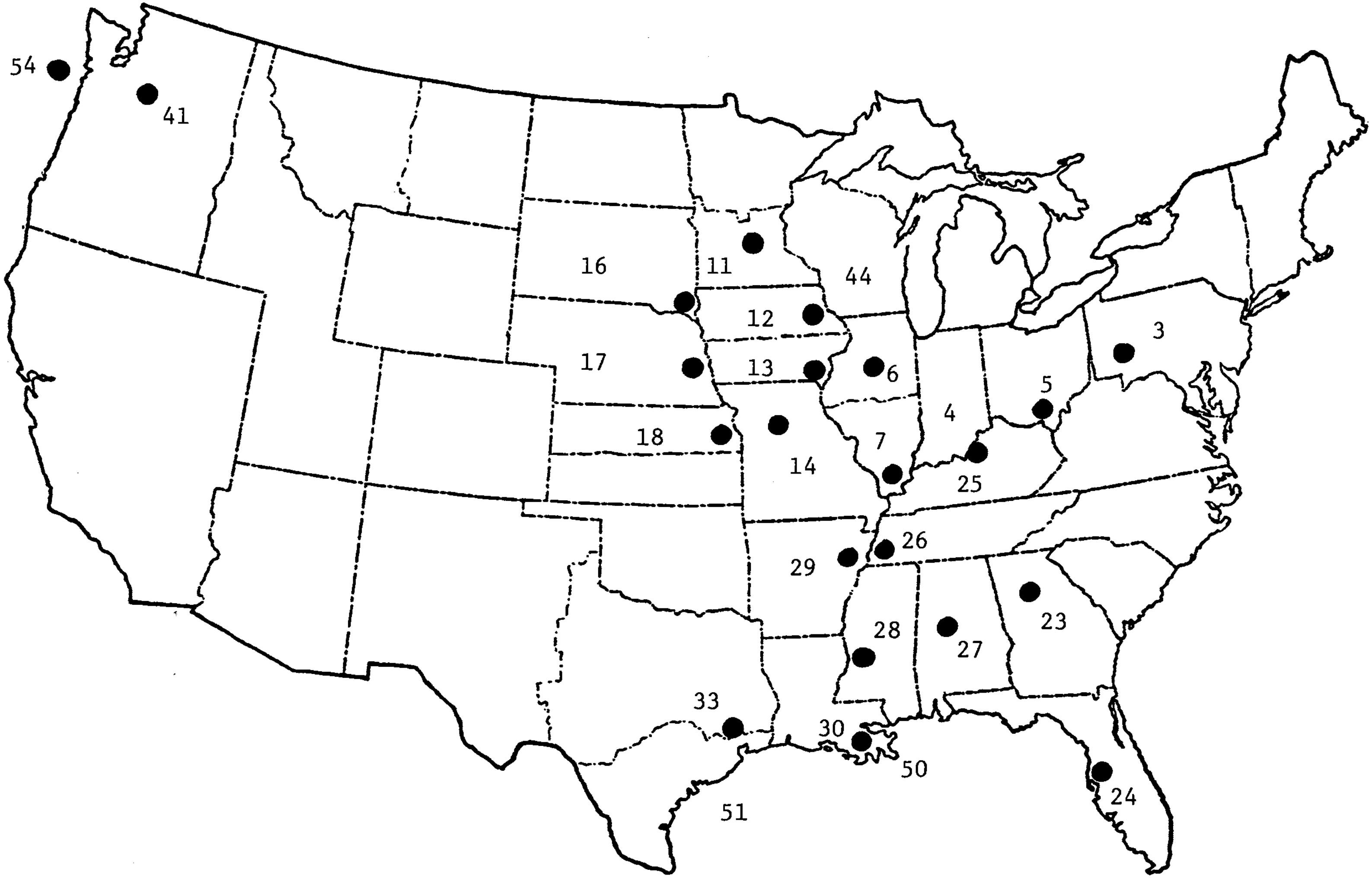

FIGURE 35. REGIONS CONSIDERED TO HAVE BARGING FEASIBILITY, 1966

TABLE LXXII

SELECTED NAVIGATIONAL CHARACTERISTICS, BY WATERWAY, 1966

River or Waterway	Draft	Towboat Horsepower	Number of Barges/Tow	Load Per Barge	Towboat Speed Upstream	Towboat Speed Downstream
	Feet			Bushels	Miles per hour	
Columbia River	8.5	2,400	3	45,000	6.2	6.2
Intra-Coastal Waterway		1,200				
East of			4			
West of			4			
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	8.5	5,600	22	45,000	4.0	10.0
Missouri River						
Above Omaha	6.5			31,400		
Omaha to Kansas City	7.0	3,200	8	35,200	3.5	10.0
Below Kansas City	7.5			38,200		
Ohio River	8.5	3,200	12	45,000	5.3	7.4
Tennessee River						
Above Chattanooga	8.5	800	3	45,000		
Below Chattanooga	8.5	2,000	8	45,000	5.3	7.4

[a]Source: U. S. Army Corps of Engineers, "Reevaluation of Project Economics", Supplement to the General Design Memorandum, Tennessee-Tombigbee Waterway, Alabama and Mississippi, Appendix B, Mobile District (Mobile, 1966).

TABLE LXXIII

TOTAL HOURLY COSTS FOR TOWBOATS, BY HORSEPOWER RATING, 1966

Item	800	1,200	1,800	2,000	2,200	2,400	3,200	5,600
				Horsepower Rating				
				Dollars				
Fixed Costs								
Investment	250,000	350,000	500,000	543,500	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 Ownerhsip 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 LXXIV

TOTAL HOURLY COSTS 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	1.47[a] 1.51[b]	2.13[b]

[a]Mississippi River system - using 355 days or 8,520 hours of annual operation.

[b]Columbia-Snake River - using 345 days or 8,280 hours of annual operation.

covered barges which are 250 feet x 42 feet are also considered to move in tows on that river.[7]

Adequate sized lock chambers on waterways which require locks, are necessary for typical tows operating on those waterways. The efficient operation of the locks are 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. Break-up and reassembly of the tow, plus any waiting time which might occur if other tows are waiting for lockage[8] imposes added costs to operators when considering towboat operating costs (1966) of $66 per hour to $105 per hour for 3200 to 6500 horsepower towboats respectively.[9]

Channel depth also affects the costs of barging operations. When considering that 17 tons of payload must be reduced for every inch reduction of draft, the cost per unit barged increases rapidly from reduced channel depth.[10]

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

Data used in this study pertaining to channel depth, towboat speeds, tow sizes, towboat horsepower, and number of barges per tow are presented in Table LXXII.

Cost Data

The only barging cost data which this author found in his research were data which are not readily accessible. But, with the cooperation of the Mobile District, Army Corps of Engineers, these data were made available on a loan basis.[11] Consultation with Tennessee Valley

Authority officials confirmed that these data were excellent.[12] Their only suggestion for improvement to more fully reflect grain barging costs-of-service was to include costs for cleaning barges which the Corps of Engineers data do not include. This section will present the costs for towboats and barges as determined by the U. S. Army Corps of Engineers and amendments by this author for this study.

Towboat Costs-of-Service

The costs-of-service for towboats as developed by the Corps of Engineers[12] include the ownership costs, depreciation, interest, return on investment, administration, insurance, and taxes and the variable costs, wages, maintenance and repairs, supplies, subsistence, and miscellaneous costs.

Ownership Costs

Towboats were depreciated over a twenty-year period and were assumed to have a five-percent salvage value. Thus annual depreciation is computed on 95 percent of the new cost of the equipment which is presented as "Investment" in Table LXXIII.

The firm operating towboats has been assumed to obtain one-half of its investment capital from the market and to supply the other half from internal sources. Thus, an interest cost is incurred on one-half of the investment at a rate of 5-1/2 percent.[13] Interest expense is presented in Table LXXIII.

A return on investment must be charged for the portion of the investment borne by internal capital. A rate of 8 percent on one-half of the investment has been used since the risk involved in carrying a mortgage equal to the investment supported by internal capital may be considered a cost.[14] Return on investment is presented in Table LXXIII.

Administrative and supervisory expenses have also been grouped with ownership costs. These costs as given by the Corps of Engineers are presented in Table LXXIII.[15]

Insurance costs for towboats have not been separated as to type and are presented in aggregate in Table LXXIV.[16]

Taxes for towboats were found to be 0.5 percent of the initial investment cost.[17] Tax costs are presented in Table LXXIV.

Variable Costs

The variable costs considered are all costs related to operation. The costs for wages and fringe benefits, fuel, maintenance and repairs, supplies, subsistence, and miscellaneous expenses are presented individually in Table LXXIII.

Total Annual Costs of Operation

Total annual costs of operation are the sum of the ownership and variable costs. Since barging firms have a large investment in a towboat, towboats are kept in operation as nearly as possible for 24 hours per day. The only downtime considered is for major repairs. Thus, for the Mississippi River System operations, towboats are considered to operate 345 days per year[18] or 8,280 hours. For towboats operating on the Columbia-Snake Rivers, annual operation is considered to be 330 days or 7,920 hours annually.[19] Thus, hourly operating costs presented in Table LXXIII were derived by allocating total annual costs of operation over total annual hours of operation. In a later section of this appendix, an explanation of allocating hourly total costs to bushels of grain is given.

Barge Costs of Service

Total costs of operation for barges considered by the Corps of Engineers[20] include the ownership costs, depreciation, interest, return on investment, administration, insurance and taxes, and the variable cost associated with operations, maintenance and repairs. These costs are presented for the 195 feet x 35 feet jumbo barge as developed by the Mobile District of the Corps of Engineers with the exception of the revision for return on investment made by the Tulsa District as mentioned in the section on towboat costs of service and the development of barge cleaning costs by this author.

The costs presented for the 250 feet x 42 feet super jumbo covered barge used on the Columbia River were synthesized from relationships found to exist in the Corps of Engineers data.[21] The investment cost was derived by assuming that the relationship of the costs of a 42 feet x 250 feet dry cargo covered (jumbo) barge to a similar 195 feet x 35 feet barge was the same as the relationship of a 195 x 35 feet cylindrical pressure barge and a similar barge 240 feet x 50 feet.[22] Administrative expenses were found to be 6.26 percent of depreciation and interest expenses; maintenance and insurance were found to be 3.13 percent of the investment and proportioned as 0.36 and 0.64, respectively, as found for the 195 x 35 feet barge; and taxes were found to be 10 percent of the return on investment. These data are presented in Table LXXIV.

Cleaning cost data were not found to be readily available. The cost associated with cleaning grain barges was derived from data presented before the Interstate Commerce Commission[23] on barge cleaning costs. Total cleaning costs for barges were presented for 1963 for a major barging firm. The total number of barges were also presented. 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."[24] The total annual cleaning costs per barge are presented in Table LXXIV.

The total costs per hour of operation by type of barge are presented in Table LXXIV. The costs for barges on the Mississippi River System and the Columbia-Snake Rivers 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 considered to be 345 days or 8,280 hours per year.

Costs for loss and damage were not considered in Corps of Engineers data.[25] These data were constructed from data on tons of grain lost by grains from barging[26] and average prices for 1966.[27] The cost derived per ton was 20 cents or 6 cents per bushel.

Time Factors and Backhaul

Time Factors

Since costs have been developed on a time basis, other cost factors not mentioned thus far which are a function of time must be considered. These factors may be categorized by the part of the tow which incurrs the time.[28] There are three such categories, the barge, the towboat, and both the barge and towboat.

The two factors which account for barge time only are loading and unloading time, and lay-over time at river interchanges.

The average total time for loading and unloading a grain barge was assumed to be 96 hours.[29] Thus the cost for loading and unloading time is 96 hours multiplied by the applicable cost per hour presented in Table LXXIV.

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 is an average of 48 hours at each interchange.[30] Thus for each barge movement of grain in this 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 twenty or more barges as specified for movements on the Mississippi River only in this study, the assistance of an extra towboat is required to assemble or disassemble the barge tow, or fleeting as it is known in the industry.[31] The fleeting cost, which is applicable to the towboat costs only used for this study, was assumed to be $480 for a round trip for those movements which used the Mississippi River.

The costs for time which involve both the tow boat and barges are make-up and break-up costs or costs for turn-around time, and costs for mileage. These costs are for time needed to "make-up" at origin or point of interchange,[32] and for travel between these points. For each barge movement in this study one and a half hours for each make-up and break-up operation were charged to barges and towboats. Travel time for individual movements was computed by dividing distances traveled on each waterway by the corresponding waterway speed as given in Table LXXII.

Backhaul

The discussion up to this point has presented total hourly costs of operation and aspects of total hours for movements of grain by barges. These costs must be further specified for the unit being transported, for instance, in this case, the bushel. To accurately reflect costs of service, as with trucks and rails, backhaul must be considered.

Specific data on backhaul of barges hauling grain in 1966 were not found. Thus these data were estimated from Waterborne Commerce of the United States, Calendar Year 1966,[33] using the method of Federal Barge Lines in Investigation and Suspension Docket Number 7656.[34] Data of Waterborne Commerce Statistics[35] are reported by rivers for the number of trips of vessels (barges) by draft going upstream and going downstream. Assuming that any draft three feet and under as an empty barge, any draft over three feet is considered a loaded barge.[36] Thus the number of empty and loaded barges going upstream and downstream were estimated.

Then by developing a ratio of empty barges upstream to loaded barges downstream, for movements going downstream, and ratios of empty barges downstream to loaded barges upstream, a measure of backhaul is developed which accounts for direction of movement.

Consequently, the costs for all barges in a tow can be allocated to the loaded barges and thus in turn to a unit of product hauled, in this case the bushel. The empty:loaded ratios by rivers are presented in Table LXXV.

TABLE LXXV

EMPTY UPSTREAM:LOADED DOWNSTREAM AND EMPTY DOWNSTREAM:LOADED UPSTREAM BARGE RATIOS BY RIVER, 1966

Rivers[a]	Ratio of Barges Loaded and Empty By Stream Flow: Empty-Up / Loaded-Down	Empty-Down / Loaded Up
Columbia[b]	1.00	1.00
Illinois	.69	.74
Mississippi		
Above the Mo. R. Mouth	.65	.53
Mo. R. Mouth to Ohio R. Mouth	.67	.48
Ohio R. Mouth to Gulf	.68	.41
Missouri		
Above Omaha	.92	.91
Omaha to Kansas City	.93	.85
Kansas City to Miss.	.95	.92
Ohio	.91	.88
Tennessee	.97	.97

[a]The Gulf Intra-Coastal Waterway ratios were assumed to be the same as for the section of the Mississippi River at the Gulf, since adequate data were not published to compute ratios.

[b]The information to compute the ratios for the Columbia River were furnished by Mr. Paul Light, Pacific Inland Navigation Company, Incorporated.

FOOTNOTES

[1]U. S. Army Corps of Engineers, Waterborne Commerce of the United States, 1966, Part 5 (New Orleans, 1967), p. 122, reveals that 84.34 percent of the total grain tonnage moved in 1966 on the inland waterways was moved exempt or by private carriers, thus indicating that much of the barged grain moved at rates which were not necessarily the same as published rates.

[2]Waterways Freight Bureau, Local, Joint, Proportional, Import and Export All-Water Commodity Rates on Grain and Grain Products, and Related Articles in Bulk, Freight Tariff No. 7, Washington, 1968), p. 3.

[3]Pacific Northwest Grain and Grain Products Association, correspondence with Mr. Richard Crabtree (Portland, June, 1970).

[4]North Pacific Grain Growers, Incorporated, correspondence with Mr. W. E. Balsiger (Portland, June, 1970).

[5]This information was confirmed by Mr. D. R. Brandenborg, Vice President, Cargo Carriers Incorporated, correspondence (Minneapolis, September, 1969).

[6]The rivers of the Mississippi River System included in this study are the Missouri River, the Illinois Waterway, the Ohio River, and the Tennessee River.

[7]This information was supplied by Mr. Paul W. Light, Traffic Coordinator, Pacific Inland Navigation Company, Incorporated, correspondence (Vancouver, May, 1970).

[8]U. S. Army Corps of Engineers, Regulations Prescribed by the Secretary of the Army for Ohio River, Mississippi River Above Cairo, Illinois, and Their Tributaries; Use, Administration, and Navigation (Washington, 1961).

[9]U. S. Army Corps of Engineers, "Reevaluation of Project Economics," Supplement to the General Design Memorandum, Tennessee-Tombigbee Waterway, Alabama and Mississippi, Mobile District (Mobile, 1966).

[10]D. R. Brandenborg.

[11]U. S. Army Corps of Engineers, Mobile District.

[12]Ibid, p. B-7.

[13]U. S. Army Corps of Engineers, Mobile District, p. B-8.

[14]The data of the U. S. Army Corps of Engineers, Mobile District, uses a return on investment of 10 percent, but an 8 percent figure was used in revised data furnished by the U. S. Army Corps of Engineers, Tulsa District.

[15]U. S. Army Corps of Engineers, Mobile District, p. B-8.

[16]Ibid.

[17]Ibid.

[18]Ibid, p. B-11.

[19]Paul W. Light.

[20]U. S. Army Corps of Engineers, Mobile District, p. B-8.

[21]Ibid.

[22]Ibid, p. B-10.

[23]Interstate Commerce Commission, Grain in Multiple-Car Shipments--River Crossings to the South, Investigation and Suspension Docket No. 7656 (Unpublished Exhibit No. 393, Schedules B and C, Washington, 1963).

[24]U. S. Department of Labor, "Average (Median) General Wage Changes in Major Collective Bargaining Situations," Long-Term Trend Data for Selected Occupations and Metropolitan Areas, 1907-1966, Bureau of Labor Statistics, Bulletin No. 1505 (Washington, November 1966), Table II.

[25]U. S. Army Corps of Engineers, Mobile District, 1966.

[26]U. S. Department of Agriculture, Losses in Transporting and Handling Grain by Selected Grain Marketing Cooperatives, Farmer Cooperative Service, Marketing Research Report No. 766 (Washington, 1966), p. 19.

[27]U. S. Department of Agriculture, Agricultural Statistics, 1969 (Washington, 1970), Tables 17, 49, 50, and 201.

[28]U. S. Army Corps of Engineers, p. B-3.

[29]Ibid, p. B-4.

[30]Ibid, p. B-3.

[31]Ibid.

[32]Ibid.

[33]U. S. Army Corps of Engineers, Waterborne Commerce of the United States, Calendar Year 1966, Part 2 (Washington, 1967).

[34]Interstate Commerce Commission, 1963, pp. 5, 5a, and 6.

[35]U. S. Army Corps of Engineers, New Orleans.

[36]U. S. Army Corps of Engineers, U. S. Engineer Division, Lower Mississippi Valley, Office of the Division Engineer, Telephone Conversation (Vicksburg, May, 1969).

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