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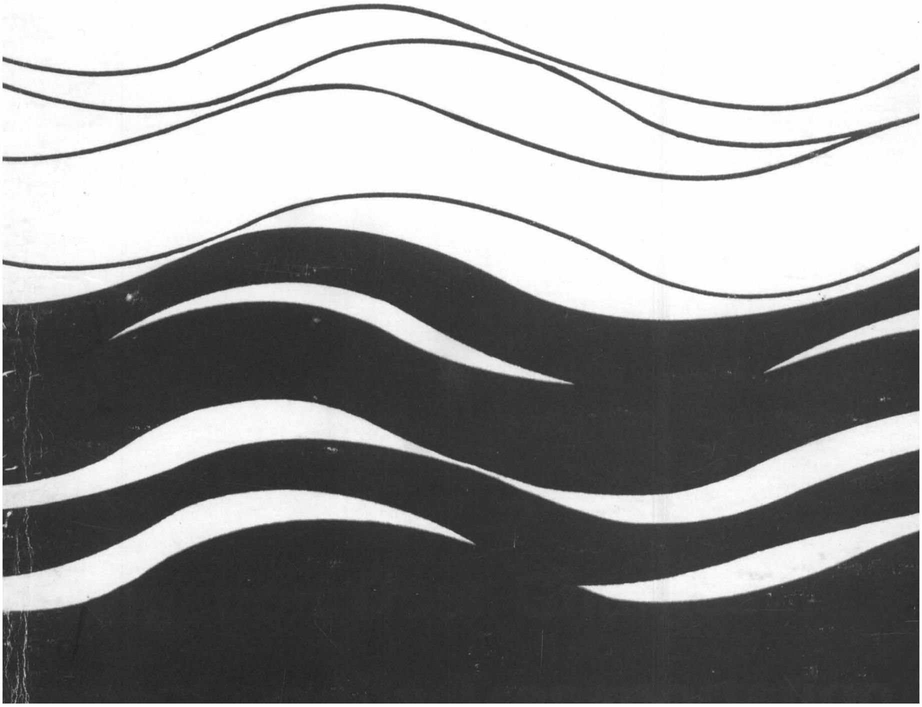
Navigation User Charges: Impact on the Transportation of Agricultural Products

Leonard Shabman, Joseph Havlicek, et al.



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PREFACE

Debate over the merits of toll-free inland waterways predates the writing of the United States Constitution. In the last several years, the topic has become the focus for debate in both the water resources and transportation policy areas, and numerous calls have been made to improve the information base for assessing the implications of a waterway toll for the transportation industry and for water resources planning. This study examined the impact of user fees on barge movements of major agricultural commodities.

The work in this study represents the efforts of many individuals and the continued support of the Office of Water Research and Technology, U.S. Department of the Interior, through a grant for Project B-082-VA, extending from July 1975 through June 1977. The overall project effort was directed by Leonard Shabman and Joseph Havlicek. James Binkley had major responsibility for developing the methodology and computer software used in the project. Much of this work was accomplished in the context of writing his Ph.D. dissertation, which focuses upon the barge movement of wheat. William Luppold and Richard Stillman, using the previously developed methodology, provided the basis for analyzing corn and soybean movement patterns. Walter Spilka and David Kenyon developed an interregional competition model of the broiler industry, which provided the basis for assessing possible impacts of user fees on that particular industry.

While each person had specific responsibilities, the research product was, in the truest sense, the result of a joint effort of all those involved. Many hours of formal meetings and informal discussion, in which ideas were exchanged and debated, were the basis for the successful completion of the project.

George Allen, Jerome Hammond, and Jack Crowdus, of the U.S. Department of Agriculture, helped to acquire data which were not published in usable form for this study. Robert Rauniker of the University of Georgia provided broiler consumption data, which are not currently published and which were essential for the completion of the broiler model.

Finally, the review comments of Lowell D. Hill of the University of Illinois at Urbana-Champaign and Stanley K. Seaver of the University of Connecticut were most valuable in improving the report. Acknowledg-

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ABSTRACT

The inland waterways of the United States historically have been maintained and improved by the federal government at no cost to waterway users. However, in 1978 legislation was enacted that imposed a fuel tax on commercial waterway traffic. The debate over this legislation raised concerns that such charges could reduce significantly the freight tonnage carried on the inland waterway system and could affect adversely major industries dependent upon waterway transportation. This research assessed the likely impact of such a charge on the movement of grains and the location of the broiler chicken industry.

The results of the analysis suggest that a uniform charge administered as a fuel tax on all waterways would have a small impact on grain movements by barge if full federal operation and maintenance costs are recovered. The recent legislation, which requires a lower fuel tax level, would have virtually no effect on grain movements by barge. A toll tied to recovery of operation and maintenance costs of a particular waterway segment would reduce traffic on the high-cost waterways, but such traffic represents only a small proportion of the total movements. The results indicate also that any changes in prices for delivered grain that might be brought about by a user charge would not be of sufficient magnitude to affect the broiler industry, whose location and distribution patterns are sensitive to costs of feed grain transportation.

Key Words: User Charges, Navigation, Water Resources Policy, Transportation, Inland Waterways

PROBLEM SETTING

I. Introduction

Movement of freight by water is one of the oldest forms of transportation in the United States. In the nation's early years, the major rivers often were the only available route into the yet undeveloped interior of the country. In recognition of the commercial importance of the waterways in interstate trade, the nation's founders sought to develop and promote the water transportation mode. As part of this effort, physical impediments to navigation were removed from the rivers and in more recent years, large-scale public investments have been made to modify the depth and flow of the waterways in the interests of navigation. Such improvements were made at public expense and no recovery of costs from users was attempted. The barge industry grew partly in response to this improved "water highway." In fact, barge transportation, as a component of the nation's freight transportation system, has grown dramatically in recent years. Studies calling for a revised look at the long-established public policy of toll-free highways have accompanied this growth. During 1978, legislation that reversed this policy was enacted; the impact of this modification in the toll-free waterway policy provided the focus for this research effort.

II. The Waterway System: Structure and Costs

(Much of the following information is taken from Shabman [1976]). The inland waterway system is composed of more than 15,000 miles of navigable streams. *Figure 1,* which depicts those navigation channels, indicates that the major part of the waterways system is tied to the Mississippi River and its tributaries. In fact, 99 percent of the total ton-miles of freight traffic moved on inland waterways moves on the "Mississippi System," including the Gulf Coast Waterways.

Freight is moved on flotillas of barges strung together in "tows" powered by towboats. With improvements in recent years in barge technology, industry management practices, and the waterways themselves, tows have become larger and are driven by increasingly powerful towboats. In response to all these factors, total ton-miles of freight traffic increased more than 1100 percent between 1940 and 1974. Inland waterway traffic now represents more than 11 percent of total ton-miles of freight movements in the United States, and the barge industry's share of the total freight transportation market has increased 300 percent since 1940. The bulk of waterway commerce is in commodities of low-unit value. *Table 1* shows the range of commodities carried and how the volume of traffic in each commodity grew from 1968 to 1973. Virtually all commodities increased in volume, with grains (representing 17 percent of total freight movements) showing the largest gain.

While the industry's size and market share have grown, so too have public expenditures to support the waterway system. The waterway development program of the U.S. Army Corps of Engineers represents the major public expenditure on these systems, although the Coast Guard, Tennessee Valley Authority, and state and local governments also make expenditures which support waterway traffic. None of the major federal public expenditures currently are reimbursed by the waterway users. *Table 2* indicates the Corps' expenditures for fiscal years 1974-1976.

Although the provision of a publicly financed "water highway" may provide some competitive advantage to water transportation, it is important to gain a broader overview of the modal advantages of water transportation in relation to other modes. In *Table 3*, the various characteristics of each mode are compared. The mode at the top of the list has an advantage over those below it. From the perspective of water carriers, competition stems mainly from rail and pipeline. In general, it can be noted that the advantages of the barge mode can be particularly significant to cost and capacity criteria.

Even a cursory glance at *Table 3* suggests the important role of waterway transportation in the total transportation system. With respect to the long haul of bulk commodities, the water mode appears to have a clear competitive advantage. The question addressed here is whether user charges designed to recover public costs for waterway operation and maintenance will alter significantly that advantage for the agricultural commodities.

III. Policy Review

The policy that the navigable waters of the United States should be free of tolls has origins in the colonial period of our history. (For a more detailed policy history, see Ashton, Cooper-Ruska, and Shabman [1976].) Formal congressional support for this policy was initiated in the Rivers and Harbors Act of 1884:

> No tolls or operating charges whatever shall be levied upon or collected from any vessel, dredge, or other water craft for passing through any lock, canal, canalized river, or other work for the use and benefit of navigation, now belonging to the United States or that may be hereafter acquired or constructed. . .

This policy statement evolved during a period of history when the expenditure of tax dollars for waterway improvements was small, and the freight transportation industry was dominated by the railroads. Therefore, many legislators of that period viewed promotion of water transportation as an inexpensive means of encouraging competition for the railroads. In this century, however, the situation has changed significantly with large public expenditures for improvements of the waterways, and with the rise of water, motor, air, and pipeline carriage as successful competitors for rail transportation.

While the conditions which justified the adoption of the toll-free waterway policy in the nation's early history have changed, that policy has remained in force until the present time. The anomaly of this situation was recognized as early as 1939 by the U.S. Office of the Federal Coordinator of Transportation, in *Public Aids to Transporation by Water:*

> . . . The policy of providing waterway facilities free of toll dates from a period in which there were no railroads, in which there was great need for additional transportation facilities and in which Federal outlays for this purpose were relatively small. It is also to be noted that the statutory expression of this policy came in 1884, when Federal outlays still were small, transportation facilities had not yet been fully developed, and competition of water with rail transportation did not offer the serious consequences for the latter that are faced under the more mature economic conditions that are found today.

This same report continues:

> The fact that the policy is strongly entrenched does not mean it cannot be changed with the emergence of new conditions in the field of transportation.

Recognition of this changing transportation environment led to executive branch proposals during the term of every President since 1940 to recommend that Congress adopt some form of user fee for inland waterways. Nonetheless, the toll-free waterway policy remained in force, due to congressional reluctance to implement user fees.

However, during 1978, legislative action was taken to impose a fuel tax on inland waterway traffic which would begin at four cents per gallon in 1980 and rise to 10 cents per gallon by 1985. The debate over the bill itself was long and tortuous, and the ultimate level of the tax was substantially less than that proposed by the initial sponsors of the user-fee proposal. In fact, the early sponsors had called for full recovery of operation and maintenance costs with recovery of 50 percent of new capital investment costs. A fuel tax to achieve these levels of cost recovery would initially be set at 42 cents and 60 cents per gallon of fuel, respectively.

In the course of arriving at a compromise position, the proponents of the higher charge suggested that it would help promote both efficiency and equity in the nation's transportation and water resources programs. The conclusion was based on the premise that the federal policy of assuming all costs during the formative years of the nation's growth was justifiable, but that an adjustment of this policy to take into account a mature economy and a competitive transportation policy was long overdue. In brief, equity considerations, following the benefit principle of taxation, suggested that those who benefit from a service should bear the cost of providing it. Efficiency arguments noted that as long as the federal government maintained its policy of toll-free waterways, no market test for waterway improvements would develop, and correspondingly, no pricing system for promoting efficiency in the demand for and use of public investments in waterway development could occur.

While these economic arguments were debated and developed, one of the most politically persuasive arguments against higher fees (or any fees at all) was that any change in cost patterns resulting from a user fee might have undesirable consequences for the barge industry and the economy as a whole. As one influential Senator commented during the debate:

> Not enough is known about what the effects of user fees would be. For example, consider the tremendous downstream movement of grain on the Mississippi River, carrying out export trade to deepwater ports, and the corresponding upstream movement of fertilizers and fuel. A user tax would have a profound effect on agriculture in the Middle West and the Mississippi Valley and

> thus a regional economic impact that is of large but unknown magnitude, because it has not even been evaluated.
>
> It seems to me that recently there has been, in parts of government and the public, an air of undue haste about prescribing user fees on waterways—a tendency to treat the subject as "an idea whose time has come," without adequate evaluation of the facts and consequences. The members of this Subcommittee are as well aware as I am of the danger of letting any such attitude enter the preparation of any legislation. And user fee legislation has profound potential effects on the delicate balance of the American economic structure.
>
> Billions of dollars in private funds have been invested in industry along inland waterways, premised upon the present system of barge navigation. Before anything is done to alter the system or the method of financing its operation, the facts must be established and meticulously examined. I think that is self-evident.
>
> If the administration demands user fees, then the Congress must demand the facts—all the facts as to the complex interplay of such fees through the economic structure—so that the consequences of imposing fees can be examined, and then accepted or rejected on a rational basis [U.S. Senate, 1975, pp. 58-59].

Thus, although user fee policy will become a reality, it is important that the likelihood of adverse effects of such fees be assessed. Studies to conduct a complete review of user charge impacts have already been started by the federal government, and this present research will contribute to that effort.

IV. Forms and Levels of User Charges

A user charge policy has been established, and the debate over that policy did consider alternative types of user fees and alternative levels of fees. This research effort will assess impacts of these alternative types and levels of fees.

In general, two basic types of user fees are possible. The first would apply uniformly across the nation on all barge traffic regardless of waterway over which the traffic moved. A second type of fee would be segment-specific in that determination of the fee level would be based upon the costs of operating and maintaining the particular waterway. Extended discussion on the rationale for each fee and the various collection mechanisms for each are provided elsewhere [Shabman, 1976; Congressional Budget Office, 1977]. The most commonly recommended forms of user charges are:

1. A uniform charge on all barge movements (independent of the river system) which would be collected by a tax on barge fuel. The tax level would be set to recover all or a portion of the cost of annual operation and maintenance of the inland waterway system.

2. A segment toll charged to waterway use (ton-miles moved) such that only users of the waterway segment in question pay for its operation and maintenance.

A recent study has estimated segment toll and fuel tax levels per ton-mile of waterway traffic that would have been necessary to recover 1975 operation and maintenance costs (see *Table 4*). Estimates of what the four-cent to 10-cent fuel tax would recover are not readily available. However, the U.S. Department of the Treasury estimated that a six-cent tax would recover 33.4 percent of 1976 operation and maintenance expenditures [Barloon, n.d.]. Based upon this number and rising operation and maintenance costs over time, the newly enacted legislation should cover approximately 50 percent of operation and maintenance costs.

To put these toll levels in perspective, it is illuminating to compare barge rates that would exist (presuming full shifting of the tax to the shipper), as discussed below, with and without the charge for selected grain movements. *Table 5* shows these results; two specific points are worth noting in this *Table.* First, a fuel tax covering 100 percent of operation and maintenance costs raises rates by 12 to 21 percent, and newly enacted fuel tax by half that amount. On the other hand, a segment toll can increase rates by as little as 10 percent or more than 400 percent, the latter occurring when a substantial portion of the movement is over high-cost river segments. Secondly, while in most cases the type of the charge (fuel tax or segment toll) makes little difference, the type of the charge can make a significant difference on occasion. How important any of these charges (by type or by level) will be on (1) the barge mode's share of grain traffic, and (2) the broiler chicken industry, will be the focus of this study.

V. Research Objectives

Three separate objectives guided this research:

1. To assess the impact of a user charge on total barge movements of unprocessed wheat, corn, and soybeans;
2. To determine the impact of user charges on individual river segment movements of wheat, corn, and soybeans; and
3. To determine the impact of navigation user charges on the location of the waterway-dependent broiler chicken industry.

VI. Focus on Agriculture

As *Table 1* indicates, a large variety of bulk commodities are carried on the inland waterway system, and a decision needs to be made on whether to analyze user charge impacts on all movements or only on some portion of the waterway movements. Some previous studies have focused upon all commodity movements [Anderson and Scheussler, 1976; CACI, 1976], but in so doing have had to sacrifice important detailed information to accommodate study needs. In particular, these models have been limited to river origins and destinations, have not quantitatively considered river movements in the context of the total transportation system and all production and consumption points for commodities, and/or have aggregated commodities into large heterogeneous groupings. Such a trade-off of research detail for research scope is one that always must be made. However, at times, particular results of more general models suggest the need to do further research at a more detailed level. Thus, Anderson and Scheussler's report [1976], which focused only upon river origins and destinations (for all commodities), concludes, with respect to grains, that "originators of waterway traffic such as grain should be analyzed from true inland rather than river traffic origins" [Vol. I, p. 8]. On the other hand, some studies have focused upon grain movements in great detail but have done so at a level of geographic specificity that precludes extrapolation of their conclusions to more general impact questions [Bunker, 1976; Beuthe, 1970; Thayer, 1977].

One recent study did focus on grain transportation among virtually all the major producing and consuming regions. However, its primary focus was to assess economic efficiency in transportation movements (least cost) for 1980 [Fedler, Heady, and Koo, 1973]. Therefore, the model used was not capable of examining the impact of a user charge policy on actual movements now occurring.

Thus, our knowledge of the potential impact of a charge policy on grain movements is limited, and a research focus on barge movements of grains can fill one important gap in our knowledge base. There are other reasons for selecting agricultural commodity movements as the focus for study. Grain movements are an excellent example of the type of movement best suited to water transportation. (In particular, unprocessed corn, wheat, and soybeans will be the focus for this study. Although not technically correct, soybeans will be referred to as grains for ease of exposition.) They have low unit-value, move in large quantity over long distances, and are storable (hence no requirement for transport speed). Also, grain movements represent a significant share of total waterway transport and their share has grown dramatically in recent years (see *Table 1*).

Finally, in the past, concern has been expressed that low-cost barge transport into the South with no similar competitor for the railroads into the Northeast, has led to differentials in grain transport rates between the two regions. This, in turn, has encouraged movement of the broiler chicken industry to the South [Seaver, 1972]. Whether this locational charge would be reversed by a user charge policy is a question which can help focus on the "second round" impacts of a charge policy.

VII. Research Approach

While grains are produced and consumed in all areas of the United States, the bulk of production occurs through the mid-section of the nation (see *Table 6).* Regions where grains are consumed are more widely dispersed due to widespread use in animal feeding and the large proportion of total production which moves to export points overseas. Domestic processing points for grains (e.g., corn sweetener plants, flour mills) tend to be smaller users and often are located nearer to production areas. Because of the concentration of production and the diffusion of consumption points, those areas of major production became surplus areas dependent upon truck, rail, barge, and ocean freight transportation to haul grains to final consuming areas. Of interest here is whether a user charge policy would result in shifts from barge to other transportation modes.

The analytic technique used in this research was a transshipment model [Boehm, 1976], and the only constraint imposed was that the total quantity to be shipped equalled total requirements. All transshipment points (including ports) were given unlimited handling capacity. Four transportation modes were incorporated: barge, rail, truck, and lake and ocean vessels. The models were constructed so that grain could move either (1) directly from origin to destination by rail or truck, or (2) by a combination involving barge. Non-direct movements using more than one mode could involve two transshipment points. This formulation permitted the modeling of a typical barge movement: from producing region to river point via rail or truck, then via barge to another river point, and finally via rail, truck, or ocean vessel to point of final consumption. The model was solved for the transportation solution without user charges (a base solution). The impacts of user charge policies then were assessed by raising barge rates by the amount of the user charge. Changes in shipping patterns which resulted were identified. All solutions minimized total transport costs under the given transport cost conditions and regional consumption and production levels.

The modeling process was quite complex, and due to its direct concern with policy impacts on actual shipping patterns, care was taken to define the scope of the model in great detail and to use data which most accurately reflected the cost conditions facing shippers of grains. While other models may have incorporated some of the elements of this effort, no studies dealing with barge transport have included all the considerations listed below.

1. This study assesses separately the movements of wheat (three varieties), corn, and soybeans. Previous studies which had a national focus aggregated grains into homogeneous groupings [Fedler, 1973; CACI, 1976].

2. This study identifies more than 150 production and consumption regions for each commodity. Some studies only focused on small areas [Bunker, 1976; Thayer and Casavant, 1977], while others focused on river origins and destinations [Anderson and Scheussler, 1976].

3. Movements by all modes (separately and in combination) between all regions are possible within the model used in this study. Also, the model solution itself predicts modal shifting. Other studies have focused on barge movements only [Anderson and Scheussler, 1976].

4. Transportation costs for line-haul movements to shippers are based upon actual rates paid for point-to-point movement rather than estimated movement costs for the mode. This has not been done in any of the large models for all modes [Anderson and Scheussler, 1976; CACI, 1976; Fedler, 1973].

5. Non-line-haul transportation costs for point-to-point movement are explicitly included in the analysis. Cargo handling (loading and unloading costs) for each mode are part of the cost of movement. Costs of getting to and from river points by truck or rail are included. To better recognize actual rate conditions for truck transport, truck rates used in the wheat model were appropriately reduced in cases where lower back-haul rates are likely to be available.

6. Since grain movements to export points comprise a large proportion of barge movements, world consumption regions were incorporated directly into the analysis with U.S. ports serving as transshipment points. Other models have used U.S. ports as points of final consumption for export grain. The formulation in this model permitted competition not only between rail and barge shipments to a given port, but also competition among ports for export trade.

"Model and Data Base: Detailed Description" (p. 13) outlines in more detail the model used and discusses the data base. "Impacts of User Charge Policies on Grain Movements" (p. 27) discusses the results for movements of wheat, corn, and soybeans. "Impacts of User Charges on Industry Location: The Case of Broiler Chicken Production" (p. 49) presents the results of the broiler location study. Summary and conclusions are presented in the final section.

MODEL AND DATA BASE: DETAILED DESCRIPTION

I. Introduction

Since the impact of user charges is dependent upon the demand for water transportation, the determinants of this demand must be considered (see Binkley [1977] for a detailed discussion). From theory, the demand for transportation of a particular commodity depends upon the supply and demand for the commodity that exists within regions. However, the problem for analysis is reduced if the quantities of the commodity exported and imported by each region are given, since the optimum transportation pattern can be determined by minimizing transport costs. Thus, if regional "exports" and "imports" are known, it is not necessary to have any information about regional supply and demand curves for transported commodities in order to determine the optimal transportation pattern.

With knowledge of transportation costs, the optimal pattern of transportation can be obtained, and movements will be allocated among modes depending upon each mode's relative cost to shippers. Thus, in an empirical analysis of one mode, it is necessary to consider the relative advantage of competing modes, since, if the cost to shippers of one mode should rise, the relative cost of competing modes will determine the amount of diverted traffic.

In more practical terms, when grain is shipped from a producing area to a consuming area, it can move in basically two ways: (1) direct, either by rail or truck (in rare cases by barge); or (2) in a combination move, as, for example, in grain being shipped by truck to a river point, being transferred to barge, moving to another river point, and then being shipped to a final destination by a land mode. Export movements must be in the latter category, since they have to involve at least two modes, with one being ocean freighter. Thus, both theory and the problem under analysis require that the analytical framework provide an efficient technique for allocating movements between producing and consuming regions and for distributing such movements between alternative transportation modes. Given the proposition that shippers are profit maximizers and that quantity shipped is given, a transport pattern that minimizes total transportation cost can be identified. Then changes in cost (from a user charge, for example) can be reflected in changes in the transportation pattern. The problem, as outlined above, suggests that some form of transportation programming model be used.

The theory and methods pertaining to the formulation and solution of transportation problems abound in the literature and numerous examples of applications exist. Therefore, no detailed discussion of transportation models *per se* is presented here. Rather, attention is focused on the necessary modifications of the basic transportation model framework.

In the basic transportation model, commodities are shipped from a set of origins to a set of destinations. This shipment is direct: a transported commodity moves from an origin to a destination without passing through any intermediate points. Since, in reality, commodities often are shipped through intermediate points, it is desirable to have a technique that allows for non-direct movements. Such a technique is the transshipment model—a transportation model which allows shipment from origins through intermediate points to final destinations. These intermediate points (transshipment points) can be destinations or origins for other destinations. The method has been used in several previous studies, including some dealing with grain marketing [Leath and Blakely, 1973; Tyrchniewicz and Tosterud, 1973; Ladd and Lifferth, 1975].

Mathematically, the *n* origin, *m* transshipment point, *p* destination, transshipment problem can be stated as follows:

$$\text{Minimize:} \quad \sum_{i=1}^{n} \sum_{j=1}^{m} t_{ij} X_{ij} + \sum_{j=1}^{m} \sum_{k=1}^{p} t_{jk} X_{jk}$$

$$\text{Subject to:} \quad (1) \quad \sum_{j=1}^{m} X_{ij} = S_i$$

$$(2) \quad \sum_{j=1}^{m} X_{jk} = D_k$$

$$(3) \quad \sum_{i=1}^{n} \sum_{j=1}^{m} X_{ij} = \sum_{j=1}^{m} \sum_{k=1}^{p} X_{jk}$$

$$(4) \quad \sum_{i=1}^{n} S_i = \sum_{j=1}^{m} D_j$$

$$(5) \quad X_{ij}, X_{jk} \geqslant 0$$

where:

t_{qn} = transport cost from point q to point n,

x_{qr} = quantity shipped from point q to point r,

S_i = production at origin i, and

D_j = consumption at destination j.

The only difference between this formulation and a normal transportation model is the peculiar dichotomy of the objective function and the presence of constraint (equation 3). The objective function states that the sum of total transport costs from the n origins to the m intermediate points and from the m intermediate points to the p final destinations should be minimized.

The origins themselves can serve as intermediate points, and any shipment from an origin to itself moves at zero cost. Thus, direct shipment from origins to destinations is not precluded in this framework. Therefore, the transshipment problem is actually a more general case of the traditional transportation problem. This form of transportation model was used to analyze grain movements. A simple transportation framework was used to examine the location of broiler production; that model will be discussed in "Impacts of User Charges on Industry Location: The Case of Broiler Chicken Production" (p. 27).

II. Conditions Imposed on the Model

Three important conditions are required if the transshipment models used in this analysis are to replicate actual shipments:

1. Line-haul transport costs are a linear function of quantity shipped.

2. Regional production and consumption are known, and do not vary with changes in transport costs.

3. Transport costs (including handling costs) are the only factors of importance in shipper decisionmaking.

The first two are a consequence of using transshipment models; the third results from certain simplifications that were introduced into the analysis.

The first condition is not very constraining. In this analysis, the costs used in the models are rail rates, barge rates, and truck costs as rate estimates. The first two costs do not, in fact, vary greatly with quantity shipped. Since increasing truck movements entails adding more trucks, the only possibility for scale economies in grain trucking is overhead expenses. Any such scale economies are probably not large since overhead expenses are not a large portion of grain trucking costs. Thus, in all cases, the assumption of linear transport costs is basically realistic.

The second condition is important for two reasons. Regional production and consumption must be known since they are necessary inputs into the models. The assumption that they do not change when transport rates change allows the ascribing of any changes in shipment patterns to changes in transport costs, and not to changes in the magnitudes of production and consumption with regions brought about by such cost changes. Knowledge of regional production and consumption patterns is obtainable, and it is doubtful that their magnitudes vary with changes in transportation costs of the size suggested by user charge policy.[1] On a bushel basis, few transport cost changes used here exceed 20 cents, and represent rather small percentages of the value of grains in recent years.

The third condition is a possible source of difficulty. There is no doubt that, while transportation rates and costs are the most important factor in shipper decisionmaking, they are not the only factor. Service characteristics of modes such as time in transit can be quite significant, and in some cases, can cause a shipper to choose a higher cost method of shipping over a cheaper one. However, in this analysis, it was necessary to exclude explicit consideration of such factors within the model in order to keep the study manageable and/or in order to maintain the relevance of the model structure for the policy question being addressed.

First, the models do not contain capacity constraints at transshipment points. In most cases, capacity constraints at transshipment points would have been meaningless, since each of the models was run separately. We were particularly averse to imposing any constraints on port facilities, since this would have reduced the flexibility imparted by the incorporation of world regions into the analysis.

Second, no mode capacity constraints were imposed on the models, since it would have created rather severe complications in the solution technique. Also, there would have been serious difficulty in determining reasonable levels for such constraints in view of the use of three separate models for grain movements.

Third, storage was not included in the model. Since grain is harvested at one point in time but used throughout the year, storage capacity and storage costs might be an important factor affecting the pattern of grain movements. This factor may be particularly important at harvest when grain handlers begin to look for "space down the line" in the grain marketing system. The railroads often offer transit privileges so that grain can be moved to where storage exists, although moving through that particular transshipment point to a final destination may not be the lowest line-haul cost. However, transit privileges may permit shippers to minimize the combined cost of storage and transportation. However, it would have been impossible to model transit rates since it is not possible to predict when a shipper would utilize transit privileges.

While the above simplifications were necessitated to make the model "manageable," there exists a very important reason for imposing no constraints on mode capacities, handling capacities, or storage; to do so would, in one sense, presolve the problem. For example, there may now exist grain movements which, due to capacity limitations, make less use of the barge mode than would be true without such limitations. User charges may not affect such a movement, not because user charges are of no consequence, but due rather to the capacity problem. The elimination of capacity constraints from the analysis thus ensured that user charges rather than capacity limits could serve as "binding constraints." The procedure obviously forces a long-run viewpoint onto the results obtained, but this is probably more desirable than the short-run view that would have resulted had constraints, however correct, been imposed. This is particularly important on a relatively newly opened waterway such as the Arkansas River.

Finally, the time frame used was one year, and hence seasonality was not included. Given the fact that some rivers freeze during the winter and hence are not navigable, it may have been preferable to include seasonality. However, considerations of model size would have necessitated an increase in the level of aggregation or a reduction in the number of transshipment stages. Neither of these was desirable. In addition, meaningful inclusion of seasonality would have necessitated building in a storage component.

The omission of seasonality will affect the results only insofar as shippers now willing to defer shipments until rivers thaw would be deterred from doing so by the imposition of user charges. This effect was not considered significant.

III. Model Construction

A. Movement Patterns

The models used in this study permit grain to move from producing regions through none, one, or two transshipment points to final destinations. As has been stated, all transshipment points were water access points. There were two sets of these: the first consisted of water access points for producing regions and hence received shipments from these regions; the second set consisted of water access points for consuming regions and thus sent shipment to such regions (these included U.S. ports for export trade).

In general, barge movements came about through grain first being shipped to a waterside location (a point in the first transshipment set), being loaded on barges, and then moving to another river location (a point in the second transshipment set), and from there being sent to the final destination by rail or truck.

The types of movements possible in the models are illustrated in *Figure 2.* A typical domestic movement (from the producing region at *P* to the consuming region at *S)* and a typical export movement (from *P* to the overseas point at *V)* are illustrated. For the domestic movement, grain can move from *P* directly to *S* (generally by rail); or it can proceed to the river point (by rail or truck) at *Q,* move through the waterway system to river point *R,* and then be transshipped (again by rail or truck) to the consuming region at *S.* For the export movement, the wheat can move directly to the port at *T,* from where it is shipped by ocean freighter to the overseas point *V.* Or, again the movement can proceed from the producing region to the river point at *Q,* then via barge to the port, and from there to its final destination abroad.

For the transshipment model to become operational, the regions and transshipment points must be identified; data must be gathered on regional consumption and production; and transportation costs to shippers for movements between regions with each modal combination must be calculated. The following discussion outlines the data base used and the considerations that went into model construction.

B. The Regions

Different regional delineations were used in each of the grain models, with 134 domestic regions in the wheat model, 164 regions in the corn model, and 161 regions in the soybean model. *Figure 3* is illustrative of the regional delineation used in the models. Two criteria for choosing domestic regions were employed. First, the region must play an important role in production or consumption of the grain being studied. Second, the region must have a commercial center point to serve as the origin or destination for all shipments. All regions were aggregations of counties, crop-reporting districts, or states, although in some cases of consuming areas, they may have been individual cities if consumption (due to grain-processing use) were large enough to justify such a designation.

In general, the size of producing regions chosen was an inverse function of the concentration of grain production. The choice of consuming regions was based on proximity to navigable waterways (primarily in the case of the Tennessee Valley, where regions tended to be rather small) or on volume of consumption. Major processing centers such as Minneapolis, Kansas City, and Decatur (Illinois) were made distinct regions. For exports, the world sectors were based primarily on their likely homogeneity with respect to ocean shipping rates from major U.S. ports.[2]

It should be noted that production regions and consumption regions are not necessarily mutually exclusive. Major producing regions have an internal demand from livestock consumption and/or processing. This was accounted for in the models. All models also included 12 world consuming regions as final export destinations.

C. Transshipment Points

The model included transshipment points for domestic barge movements along the Mississippi River System and included U.S. ports as transshipment points for foreign export. For every region that might conceivably use barge transportation, there is some river access point through which shipments moving to or from the region would most likely pass. In general, an effort was made to include all such points in the set of transshipment points for the models. The number of such points was reduced somewhat due to the fact that published barge rates in many cases are the same over segments of a river; often only one point was used as a transshipment point within such a segment.

All river transshipment points used in any of the models in this analysis are illustrated in *Figure 4,* which is a schematic map of the Mississippi River System. Many regions had access to several points. The ports used in the analysis were Duluth, Chicago, California ports, and North Pacific ports (Seattle and Portland). Ports were aggregated in this fashion (e.g., all Gulf ports into one) since rail rates to broad groups of ports are the same in nearly all cases. In those cases where they were not (and in the case of calculating truck costs), the cheapest was used. With one exception (discussed later), all barge movements to the Gulf were assumed bound for New Orleans. As in the case of rail rates, barge rates to nearby points (e.g., Baton Rouge) are virtually the same.

D. Production and Consumption Data

County level data on production for 1971 is supplied by State Crop Reporting Services. These data were used in the delineation of regions. Then, in order to obtain the exportable surplus for each region (negative in the case of consuming regions), internal usage in the region was estimated. Three sources of such usage were considered: seed, livestock use, and regional processing. Seed use was based on state data in *Agricultural Statistics* [U.S. Department of Agriculture (USDA), 1973]. Livestock consumption was based on unpublished estimates of state livestock consumption made available by USDA, and milling-use data for wheat was obtained also from USDA. These data, in association with data from the Pillsbury Company, have estimated the 1970-71 wheat grind for every flour mill in the U.S. for each wheat variety. Processing capacity and location data for soybean-crushing plants and for corn wet-milling plants were obtained from industry sources. Exports to the 12 world regions were obtained from USDA reports [USDA *(Wheat Situation);* USDA *(FATUS);* USDA *(Fats and Oils Situation)*].

In any given year, total production of any given grain is unlikely to equal total consumption; 1970-71 was no exception. Thus, it was necessary to alter production to maintain an equality. This was done by proportionally raising or lowering the production of each region producing the grain in deficit or surplus. (This can be viewed as grain moving in and out of storage, with the implicit assumption that storage facilities are uniformly distributed throughout the regions.)

E. Transport Cost Data

Five types of transportation cost inputs were used in the models used for these analyses: barge rates, truck costs, rail rates, ocean shipping rates, and loading and unloading costs for each of the modes. This section describes these data.[3] Data for making cost changes representing application of user charges will be discussed in a subsequent section.

Barge Rates: Until recently, the Waterways Freight Bureau published the *Bargeload Bulk Grain Tariff*, which listed rates for barged grain between all important grain shipping and receiving points. Since most barge rates are unregulated and set on a competitive basis, these listed rates were not religiously followed, but did provide a means of rate quotation—rates generally were quoted as "*x* percent of tariff." Although recently struck down by the U.S. Department of Justice as operating in restraint of trade, this tariff was in use in mid-1975.

Since this tariff was available, all that was required was an estimate of the average deviation of actual rates from those published in the tariff. While no such estimate is available for 1975, it is available for calendar year 1970. As part of a study of the requirement that exempt commodities cannot be mixed with regulated commodities in the same barge tow, the U.S. Department of Transportation (DOT) took a very large (approximately 90 percent) sample of all 1970 barge grain movements, including rates charged [DOT, 1973]. Using monthly shipment data and monthly deviations from tariff published in this study, it was possible to calculate an average weight deviation from tariff.

Rail Rates: Rail rates from any given origin to all reasonable destinations are not published by railroads. If they were, there would be literally billions of separate rail rates in existence in the United States. To avoid this, railroads generally publish rates from, for example, cities in grain-producing areas to major surrounding cities (called flat rates or gathering rates); rates between major cities (proportional rates); and rates from major cities to nearby points of final consumption.[4] This method of rate publication was used in this study. Flat rates were collected from each origin to all nearby major gateways (and to nearby final demand points, when necessary), and proportional rates were obtained between all relevant gateways and from gateways to final demand points. Separate rates had to be gathered for each grain type. There were three principal sources of such rates: the railroads themselves, railroad tariffs, and the *Grain Rate Book No. 12* of the Minneapolis Grain Exchange [1975]. All rates were put on the level in effect during mid-1975. This was done by multiplying rates by percentage increases, where required.[5]

Having collected component rates, a computer program was written to combine rates and to find the lowest through-rate between all points of interest. For any given origin/destination pair, the program found all possible through-rates and then chose the lowest.[6]

Truck Costs: Most grain trucking is done by grain firms themselves, by owner-operators, or by small firms specializing in grain carriage. Only the latter group charges anything that can be termed a rate, and even they are not required to adhere to any set charges, except on some intrastate movements. Therefore, a reasonable procedure is to use truck costs rather than rates in an analysis such as this.

The method chosen to estimate truck costs here was a reworking of that used in an analysis recently completed at Iowa State University [Baumel, Miller, and Drinka, 1976]. Since that report contains a detailed description of this technique, there is little point in repeating it here. It is sufficient to point out that the method essentially estimates truck costs to shippers on distance traveled (based upon truck operation) and costs of inputs.

The major changes were the use of U.S. Department of Labor (Labor) and Interstate Commerce Commission (ICC) data [Labor, 1975; ICC, 1975] to alter costs in order to reflect geographic differences, and an attempt to incorporate backhauls into the calculation of grain trucking costs (the Baumel, Miller, and Drinka [1976] study assumed zero backhauls). Major differences in labor and fuel costs among regions of the country can cause trucking costs per ton-mile to differ. Thus, adjustments in costs of trucking were made to reflect these differences [Binkley, 1977]. A critical assumption made in the Iowa State study was that no backhauls are involved in grain trucking. A telephone survey of grain shippers indicated that in some cases, backhauling of grain can be a significant factor.[7] Two general points emerged: (1) the major determinant of the extent of backhauling is the availability of major truck routes in the areas in question, and (2) backhauling only appears significant for markets nearest to producing areas.

Because of this information, it was decided to account for backhauls in the wheat models. For those destinations for which a backhaul was appropriate (i.e., markets near producing areas) and when an origin was very near a major interstate highway (within approximately 50 miles), a backhaul rate of .3 was assigned; for origins somewhat near to major highways (between 50 and 100 miles), the rate was .2; for those from 100 to 150 miles from major highways, the rate was .1.[8] However, the results of the wheat models were unaffected by backhaul rates, so backhaul was not considered in the soybean and corn models.

Ocean Freight Rates: Ocean freight rates needed for the analysis were obtained from the *Journal of Commerce,* which publishes daily ship charters between world ports for various bulk commodities, most importantly grain [Twin Newspapers, Inc.]. This information includes rates and quantities shipped. All 1975 published grain charters from U.S. ports were compiled, and then a weighted average (weighted by quantity shipped) of rates from each of six major U.S. ports of the 12 world regions was obtained. Any internal Great Lakes rates used in the analysis were obtained from grain shippers.

Handling Costs: The final transport cost component was handling costs. USDA publishes estimates of these, by mode and region [Schienbein, 1974]. They differ by mode due to the different types of loading and unloading equipment used; they differ by region since input costs vary by region. Two general types of these cost estimates are made: those based on book value of capital assets, and those based on replacement costs of assets. Since this is primarily a long-run analysis, the latter was used here.

F. Magnitude of User Charges

As noted earlier, user charge policies initially designed to recover 100 percent of operation and maintenance costs through a fuel tax or segment toll and a 50-percent cost recovery charge through a fuel tax were considered. The full cost recovery charge represents the upper limit of the recovery proposed in recent political debate, although early in the decision process, some capital cost recovery was proposed. The 50-percent recovery is representative of scale of recovery likely to be imposed by the recently enacted legislation which established charges.

Since, for any point-to-point movement, total user charges are based on river miles traversed, it was necessary, for every point-to-point barge movement in the model, to determine river distance as well as barge rates. Furthermore, for purposes of applying specific charges, the distance component on each river segment for each movement was required. Then the net user charge was obtained simply by multiplying the charge per ton-mile on each segment times the miles involved on each segment for that movement. In the case of across-the-board charges, the toll was, of course, the same for each segment. For various levels of cost recovery (e.g., 50 percent of variable cost), the resultant quantity was simply multiplied by a constant factor (e.g., .50).

This study followed the convention of other recent studies [Anderson and Scheussler, 1976; CACI, 1976] and shifted the burden of the charge fully to shippers. Therefore, barge rates were increased in the model in the exact amount of the charge. As a result, relative rates between barge and its direct competition of rail are forced to diverge by the amount of the user charge.

At least two simplifying assumptions are inherent in the approach described above for incorporating user charges in the model. Both have the effect of *increasing* the likely divergence between rail and barge rates as opposed to that without the charge. Therefore, the charges included in the model will represent the most extreme impact.

First, it is assumed that rail rates will not rise in response to increasing barge rates. Historically, railroads facing water competition have been forced to lower their rates in order to retain traffic. Such rate reductions have been allowed by the ICC and have occurred for virtually all commodities, including grains (see, e.g., Fanchi [1976]). For example, Federal Barge Lines, Inc., estimated that whole grain and soybean rail rates to southern points were $6.29/ton for water-competitive rates and $21.20/ton for non-competitive rates [Fanchi, 1976]. Clearly, there are factors influencing these rate differentials other than the existence of water competition. However, there is no doubt that water competition does force lower rail rates. The key point for this study is that if barge rates were to rise due to a user charge, there is every reason to expect that rail rates may also rise, at least to some extent, since rail and barge rates appear linked. While the extent of the rail rate rise must be speculative at best, any rise will reduce the ''wedge'' between existing rail and barge rates and new rail and barge rates after a charge. To the extent that rail rates rise exactly to match barge rate increases, the impact of the charge policy could well be zero.

A second implicit assumption is that the full charge will be shifted forward to shippers. However, there is some reason to expect that the user charge may not appear fully as an increase in barge rates. The conclusions of a previous study on the barge industry response [Shabman, 1976] are as follows:

> 1. Barge firms may substitute inputs in their production process. Larger firms which also have largest tows will be more successful in substituting inputs in the tow process to reduce costs.
>
> 2. Small firms operating on open waterways[9] are now merging or expanding in order to take advantage of tow and firm-size economics.[10]

These general conclusions suggest that the barge industry structure is and will be changing to realize increased scale economics which will lower total costs. As such, this will mitigate the degree to which the user charge will close the ''wedge'' between rail and barge rates.

The results of the analysis of wheat, corn, and soybean movement is reported in the following section. The analysis of broiler production used a different model and data base and is discussed separately later in the report.

IMPACTS OF USER CHARGE POLICIES ON GRAIN MOVEMENTS

I. Introduction

This section examines the impacts of user charge policies which recover full operation and maintenance costs and a policy which recovers costs representative of recently enacted legislation. Transportation movements by barge for wheat, corn, and soybeans are the subject of the impact analysis.

A base solution was obtained for transportation movements by barge prior to application of any user charge policy, and comparisons were made with a five-year time pattern of actual movement data between river segments. Once a base solution was established, user charge policies for uniform and specific tolls were introduced into the model for full operation and maintenance cost recovery and for the newly established cost recovery level.

In the following discussion, some general comments on the model formulation which have implications for interpreting model results are presented. Then, the wheat, soybean, and corn model results are discussed separately and the impacts of charge policies on respective barge movements are presented. Finally, an overall summary, which integrates the discussion of model results with further interpretation of the limits on model construction ("Model and Data Base: Detailed Description," p. 13) is presented, in order to assess qualitatively the impacts of a charge policy.

II. Evaluation of Model Results

In most solutions, major existing shipping patterns were represented, although there were cases in which the magnitudes shipped in model solutions did not correspond to actual quantities. Also, there were cases where model solutions involved shipments between points for which there are no corresponding movements in actuality, and vice-versa. These are attributable to the necessary simplifications introduced into the model construction, i.e., minimizing handling costs and line-haul transportation costs was the only basis for determining shipping patterns by mode between regions.

To better assess the performance of the base models, some of the omitted factors which also influence shipping patterns are reiterated. In each case, the omission of these from model construction will tend to cause model movements to be greater than actual movements.

1. Capacity limits in equipment, elevator, and loading and unloading facilities may constrain the amount of grain that will move over a waterway. These capacity problems are most severe in areas where river transport has only recently been made available and water terminals are not now equipped to handle the volume of shipments suggested by the model. Thus, where capacity constraints exist, model movements will be greater than actual movements. Capacity limits can, in part, be attributed to the fact that barge shipping appears to be in a state of disequilibrium due to dramatic increases in movements over certain routes in the first half of the 1970's.

2. Storage and transit priviliges can affect modal choice. A shipper viewing rail rates not only may be concerned with their level, but also may be concerned with the level of services involved. An important service relevant to grain movements by rail is transit privileges. Transit privileges allow shipments to be stopped at a point en route for storage or processing and then shipped to a final destination at a later time. Thus, due to transit privileges, it is entirely possible that a shipper will ship by rail rather than by barge when, based only on rate levels, it would be optimal to ship by barge. The existence of transit privileges can cause model movements to be greater than actual movements.

3. Navigability characteristics of rivers may affect movements. In the winter months, some waterways, particularly the Upper Mississippi and Missouri, are subject to freezing and at times are impassable. The Missouri River is a shallow, narrow, and circuitous route. These constraints were not included in the analysis, and where relevant, can cause model movements to be greater than actual movements.

The three reasons above can help explain why the omission of certain factors from the model may cause it to overstate actual movements. There is another factor inherent in the type of model used, which may also contribute to the model's not precisely replicating actual movements.

Specifically, aggregation levels for regions used in the model must result in some simplifications about regional movement patterns. The fewer the regions in a transportation model, the fewer the number of movements in an optimal solution. Aggregation may result in model regions being larger than actual regions likely to use the river, since the model will ship all of the regions' surplus to any single destination via a single mode or modal combination. For example, if river points are approximately equidistant from a regional shipping origin, the model would allocate all shipments to one river and none to the other, when in actuality, regional shipments would divide between the two rivers. In other cases, the actual region will ship partially by rail and partially by water to any given destination. The model will allocate all shipments to one mode only, and if that mode is rail, then water movements from that region in the model will be underestimated.

In order to assess the likely impacts of a user charge policy on actual movements, four guidelines were followed for interpretation of model results.

1. If the base solution approximated actual movements, the impact of the charge policy on the base solution was presumed to hold for the actual movements.

2. If the base-solution movements exceeded actual movements, this was due to omission of capacity constraints, transit privileges, or navigability considerations from the model, or because of aggregation problems in model construction. A discussion and analysis of these possible reasons is provided before assessing the impact of a charge policy.

If the base solution exceeds the actual movement, and after a charge policy is imposed, the movement is reduced below actual movements (even though other factors affecting movements were not considered), then it is argued that actual movements will be slightly sensitive to a charge policy.

If, after imposing a charge, the model movement still equals or exceeds actual movements, it is presumed that the movement in the long run (when transport, handling, and storage capacity will be variable) will be affected considerably less and will be less sensitive to a charge policy.

3. If the base solution is less than actual movements, the model result can be attributed to an aggregation problem. If the low (relative to actual) model movements are reduced by a charge, it is presumed that actual movements also will be reduced. If no change results in the model, the same is presumed to happen to actual movements.

4. Many movements were relatively small and irregular during the five years for which actual movement data were available. The irregularity and small size of the shipment suggests that there are supplemental movements to region line-haul movements which take advantage of a unique storage opportunity, a unique capacity consideration or some other non-line-haul "random" occurrence in the grain transport system. In most cases, the model itself shows no movements along these routes, which corroborates the above assessment that line-haul costs advantages do not determine the barge movements. Since the movements are apparently in response to non-line-haul cost factors, a user charge policy affecting line-haul costs is not expected to significantly affect these movements.

Clearly, elements of judgment are necessary in assessing the base solution in relation to the actual movements, since five years of actual (and usually irregular) movement data were examined. Also, some judgment must be exercised in applying the rules for interpreting the results. The following sections on each model will explicitly indicate how this judgment was applied.[11]

In all cases, the base solutions were considered satisfactory since they tended to agree with the existing pattern of movements or to reflect trends in which the grain transportation system (under present rate structures) is moving. This analysis is therefore useful for assessing the effect of user charges on existing movements and the effect on trends in these movements.

III. Wheat Model Results

A. Characteristics of the Wheat Model

The five major classes of wheat grown in the United States have three principal uses: exports, flour milling, and to a lesser extent, livestock-feeding. Only in the case of livestock-feeding does the type of wheat used make little difference. Exports are nearly always variety-specific, and wheat types can be substituted only to a limited extent in flour production. (For example, bread flour is primarily composed of hard wheat, cake and pastry flour of soft wheat, and pasta flour of durum wheat. For an extensive discussion of wheat varieties and their uses, see Gomme [1972].)

Due to the non-homogeneity of wheat, and since the various types of wheat are grown in different regions of the United States, grouping all types into a single commodity is not appropriate for analyzing wheat transportation. This is especially true given the fact that milling of some varieties occurs in the producing regions of other varieties. In this analysis, separate models for three wheat varieties—hard red winter, hard red spring, and soft red winter—were used. The two other major types—white and durum—were not considered.

Hard red spring wheat was chosen since it is produced primarily in the Upper Great Plains and gives rise to substantial barge movements to the Gulf for export and to milling points on the Mississippi, Tennessee, and to a lesser extent, the Ohio River. Hard red winter wheat is produced in the Central Great Plains and the Midwest, and is barged from these points to milling and export points throughout the Mississippi system. Soft red winter wheat is produced in the eastern Midwest and the South. While not barged to the extent of the previous two, it does give rise to a rather large export movement on the Lower Mississippi and is grown in an area well-permeated with navigable waterways.

Durum wheat was not chosen since it is grown in the same area as hard red spring. Wherever large movements of durum exist, there also are large movements of hard red spring wheat, and it was felt that studying barge movements of durum wheat would have been needless duplication. White wheat was not analyzed since the location of major producing areas—the Pacific Northwest and New York State—virtually preclude its ever moving on the Mississippi River system.

Modeling hard red winter wheat presented some interesting problems. This wheat is grown predominately in Kansas, Oklahoma, and Texas, and when exported, is shipped through Gulf ports. There is evidence that most such exports move through Texas Gulf ports. Consider *Table 7* which shows wheat movements (of all varieties) through Texas ports and through Mississippi River ports for several years. Over half the wheat exported through Mississippi River ports can be accounted for by barge movements from areas producing varieties other than hard red winter wheat. Since a substantial amount of wheat from these areas also moves to Mississippi River ports by rail, there is strong evidence that most wheat exported through these ports is not hard red winter wheat. On the other hand, the proximity of hard red winter wheat-producing areas to Texas ports and the fact that the producing areas of other varieties are closer to Louisiana suggest that most of the wheat exported through Texas is of the hard red winter variety.

However, it generally does not cost more to ship hard red winter wheat to Louisiana ports than to Texas ports from many producing areas. Barge rates from producing areas to Louisiana are lower than those to Texas (all Texas-bound barge shipments must pass through Louisiana); and rail rates to Gulf ports are in most cases the same regardless of which port serves as the destination. Thus, there must exist some constraint relative to elevator capacities or some institutional factor which has brought about the present configuration of hard red winter wheat export movements. For the above reasons, two versions of the hard red winter wheat model were developed: an unconstrained model and one in which exports of hard red winter wheat moving through the Gulf were required to pass through Texas ports.

B. User Charge Impacts on Wheat Movements: Full Cost Recovery Level

The results of the analysis are summarized in *Table 8.* Actual wheat movements (in tons) between particular origin and destination points by river segment can be compared to the base solution. Also, the movement with user charges based on 100 percent of operation and maintenance costs are shown along with the changes in base-model movements after the charge. The results presented in *Table 8* provide the basis for a discussion of user charge impacts. In the following discussion, the model results are presented according to river origins.

Missouri River Origins: Missouri River movements to Tennessee River destinations reflect the actual movement data fairly well, especially in 1970-1972. A uniform toll (fuel tax) had no effect on the base-model solution. A segment toll reduced shipments by 224,000 tons; however, the increase of 160,000 tons on the Upper Mississippi-Tennessee movement is a transfer from the Missouri River origins. (The Upper Mississippi River includes all Mississippi River points north of Cairo, Illinois.)

Movements in the model to the Ohio River from the Missouri overestimated actual movements. After application of either charge policy, the model movements closely approximate actual movements. Also, in the case of a segment toll, the bulk of the lost Missouri River traffic (62,000 tons) appears on the Upper Mississippi River. These results suggest a long-run stability for a river movement from the wheat-producing areas of the Upper Plains states to the Ohio Valley. In turn, this movement is unlikely to be affected substantially by a user charge.

Movements to Upper Mississippi River points are, in actuality and in the model movements, mostly to those points south of the confluence of the Missouri and Mississippi rivers. The movements appear somewhat variable; however, no movement data were available for 1974 and 1975. Therefore, it is difficult to assess the base-model solution, although it appears to be overstating the actual movements. However, if either charge policy is applied in the model, the entire movement is eliminated.

Missouri-to-Chicago movements are quite variable. All these movements go to Chicago as an export point and are probably supplemental to Gulf port exports as well as being influenced by the seasonality of the river and port facilities. The model seems to overstate the movement for all years except 1970. If this were a supplemental movement (rule 4), it would not have entered the model so strongly.[12] Therefore, the base solution is treated as representative of line-haul cost advantages of the barge movement. When a charge is applied to the base solution (in either form), the base is reduced by approximately 50 percent. The entire diversion appears as a transfer from Missouri River to Upper Mississippi River origin.

Gulf-bound movements from the Missouri River were underestimated by the models which were constrained to export through Texas ports. In reality, most wheat is shipped through Texas Gulf ports to which the majority moves by rail—which is why the model was constrained. However, since even those low movements were eliminated from the model, the results suggest that this movement would be quite sensitive to a user charge *(Table 7)*.[13]

<u>Upper Mississippi River (UM) Origins:</u> UM movements to all destinations except the Gulf were underestimated in the base solution. Application

of a fuel tax to movements to Tennessee points had no impact. A segment toll policy increases the base-model movement threefold, as a result of the transfer from the Missouri River mentioned above. Based on these results, it is expected that the UM-to-Tennessee movements will remain stable or perhaps will increase with a user charge policy.

UM-Ohio movements were stable over time, and as in UM-Tennessee movements above, the base solution was unaffected by a fuel tax and increased (due to Missouri River transfers) by a segment toll. We concluded that user charges will have no impact (fuel tax) or a positive impact (segment toll) on UM-Ohio movements.

UM-UM movements remained in the solution under either of the charges considered, thus suggesting an insensitivity of UM-UM movements to a user charge policy.

UM-Chicago movements were low (especially in recent years) and variable between years. The failure of these movements to enter the model suggests that they were probably supplementary movements that were not being made in response to line-haul costs. Hence, a charge policy on these movements is expected to have no impact.

UM-Gulf movements were the largest movements in the model. The model movement overstates actual movements, but is acceptable, especially in the later years. Indeed, a clear upward trend in tonnage for this movement exists and the base solution reflects that. The base solution was unaffected by either charge, and therefore, a charge policy on this movement is expected to have no impact.

<u>Ohio River Origins:</u> Actual Ohio-Tennessee movements are small and highly irregular in volume. The route between the rivers would be circuitous, and the proximity of producing and consuming regions makes rail and truck movement quite attractive. These movements are presumed to be supplemental movements that are unaffected by line-haul cost considerations and would be unaffected by a user charge policy.

Ohio-Gulf movements are somewhat irregular, but appear to be growing and were quite substantial in 1974 and 1975. The low movement in the base solution is affected by both user charge policies, and in both cases, all diversions switch both mode (to rail) and destination point. Specifically, barge movements for Gulf export points are replaced by rail movements for East Coast export points.

Illinois River Origins: Illinois River-to-Chicago movements are small, probably because of lock costs and capacities and because of the months within the year the waterway is navigable. However, a large movement between the Illinois River and Chicago appears in the model and is unaffected by a charge policy. This suggests that the movement will be unaffected by a charge.

Illinois River-Gulf movements do not appear in the model, despite their significance (although they are somewhat volatile in the actual movement data). Since the movement does not appear in the model, some additional speculation is necessary. As noted above, barge shipments from Midwest points along the Ohio River were responsive to a charge. The general tendency was for such shipments to transfer to East Coast ports via rail when user charges were imposed. Favorable unit train grain rates exist from many points in Indiana and Illinois to the East Coast, which suggests that a similar response is possible for shipments now moving from Illinois River points to the Gulf.

Lower Mississippi River (LM) Origins: Since 1971, LM-Tennessee River movements have been small and highly irregular. The rail distance between these producing areas is much shorter than the water distance. Thus, this movement appears to be supplemental and is based upon non-line-haul cost factors. User charges are not likely to affect these movements.

LM-Gulf movements in the base solution represent actual movements fairly well, especially for 1972 and 1975. The application of charges to the model resulted in no significant change in the movement.

Arkansas River Origins: Actual movements to the Tennessee River only appear in 1974 and 1975, which may reflect the newness of the navigation facilities and the long-run potential of the river for navigation as a whole. However, no movements appear in the model. Because of the high-cost nature of the waterway, and the apparent line-haul cost disadvantage of the movement (since it does not appear in the model base solution), it can be presumed that any growth in traffic will be eliminated or at least severely reduced by a fuel tax or segment toll.

Arkansas-Gulf movements were overstated by the model; this probably occurred because of capacity constraints in handling and also because storage facilities at the river limit total traffic (refer to footnote 11), even though a line-haul cost advantage currently exists. The base solution is reduced significantly by a fuel tax and it is likely that traffic growth over time would be discouraged. A segment toll eliminated the model movements entirely.

C. Impacts of Existing Charge Policy and Summary

The preceding discussion has been based upon a full recovery of operation and maintenance costs through a uniform toll and a segment toll. However, recent legislation suggests that the user charge policy to be implemented will be a fuel tax (a uniform toll) and will recover less than full operation and maintenance costs. The fuel tax will begin at 4 cents per gallon in 1980 and will rise to 10 cents in 1985. As discussed in the first section, the impacts of the newly proposed user charge will be represented by a cost recovery factor of 50 percent of operation and maintenance costs.

As a general rule, the impacts of a 50-percent user charge are far less than the full cost recovery charge. Specifically, in terms of the base solution, the following changes in shipping patterns occur due to charges (see *Table 9)*. Missouri River-Ohio shipments are reduced only slightly and remain above actual movements, suggesting that they are likely to be affected only slightly. Missouri-Gulf shipments fall to zero which also happened with the 100-percent charge. As was discussed for that charge level, the shipments may be eliminated.[14] Arkansas-Gulf shipments are reduced by the charge, but still remain in excess of actual movements. Given the "newness" of the river, the impact would most likely be to limit traffic growth rather than to eliminate this traffic. Impacts on other movements are not expected to be severe.

The model results offer a basis for assessing the impacts of a user charge policy. At full cost recovery, significant impacts would be felt by either the fuel tax or segment toll. To gain an estimate of the quantitative magnitude of these diversions, consider 1975 movement data *(Table 8)*. On the Missouri, shipments to the Upper Mississippi, Chicago, and the Gulf are affected adversely by either charge. Although probably an overestimate, an extreme assumption would be complete elimination of these movements for a loss of 330,000 tons (1974 movements to Chicago were used due to absence of 1975 data). On the Arkansas, the movements to the Tennessee would be reduced by a fuel tax and eliminated by a segment toll. At the extreme, the movement of 87,000 tons might be reduced to zero under either charge. Arkansas-Gulf movements will hold steady under a fuel tax but fall to zero under a segment toll.

Based upon the model results, the Upper Mississippi River shipments increase to absorb 14 percent of the diverted domestic Missouri traffic under a uniform toll and 50 percent of that diverted under a segment toll. Further, consistent with model results, the Ohio-to-Gulf shipments fall by 80 percent with a uniform charge and 25 percent with a segment toll. Illinois-to-Gulf movements, although not in the model, might fall by the same proportion as the Ohio-to-Gulf movements. If all these responses occurred with 1975 movements, the impact would be a diversion of 20 percent of total tonnage from a fuel tax and 10.5 percent from a segment toll (see *Table 10).*[15]

However, the recently enacted legislation will not result in such major shifts in movements by barge. Based upon the analysis shown in *Table 9,* only Missouri-Gulf movements would be adversely affected, resulting in a tonnage loss of one percent. Arkansas River traffic growth potential would be unaffected by a charge at this level.

IV. Soybean Model Results

A. Characteristics of the Soybean Model

Soybeans are used for both animal food and processing into such commercial products as oils. Domestic use of transported soybeans requires their delivery to a crushing plant where soybean oil and meal are produced. The oil is used for human food products and the crush (soybeans with the oil removed) is used for animal feed. All other transported soybeans move into export. Since there is a limited number of export points and soybean-crushing plants, the destination points in the model were relatively few.

The origins of soybean shipments were those areas where the regional production was in excess of the region's crushing plant or export use. The major soybean-producing areas are the midwestern states of Iowa, Illinois, Indiana, and Ohio. The southeastern states of Mississippi, Alabama, Georgia, South Carolina, North Carolina, and Tennessee also are surplus areas. However, within regions of the above states, deficit areas may be found if a major crushing plant exists in the region or the region includes a foreign export point.

For each surplus and deficit area, a regional center was identified, as discussed in "Model and Data Base: Detailed Description" (p. 13). For this model, the soybean-crushing plant location or the export point marked the regional center of deficit areas.

One common result in the base solution was a consistent overestimation of tonnage movements to the Arkansas River. The model would overestimate tonnage because it did not consider capacity constraints on handling facilities that might exist on the relatively newly opened navigable portions of the Arkansas, and because of large deficits in regions bordering the Arkansas, due to the presence of crushing plants. This suggests some potential for future growth.

B. User Charge Impacts on Soybean Movements: Full Cost Recovery Policy

The results of the analysis are summarized in *Table 11.* Actual soybean movements (in tons) between river origins and destinations can be compared to the base solution. In addition, the model movement with the imposition of a full cost-recovery user charge policy is shown. The results shown in *Table 11* provide the basis for the subsequent discussion which is organized by river origin.

Missouri River Origins: Theoverestimate of tonnage for Missouri-Arkansas movements results from the omission of the Missouri's non-line-haul costs (circuity, slow speed, and periods of river freezing) and because the Arkansas River is a relatively new segment with capacity constraints in handling and storage systems and a traffic pattern that has yet to develop. These two factors operating together make Missouri-Arkansas River movements zero in the real world, but these factors were not reflected in the model. Application of a full tax to this movement had no impact on the base solution and suggests that long-run potential for this movement would not be affected by a fuel tax. On the other hand, a segment toll policy does eliminate the entire movement and would be expected to limit any growth in this movement.

Movements to the lower Mississippi were very low and irregular and do not appear in the base solution. For this reason, they are considered supplemental movements which are unlikely to be affected by a charge policy.

Missouri-to-Gulf movements were overstated in the model, and when a fuel tax is applied, the movement still remains far above the actual; this suggests that the impacts on actual movement may not be severe. On the other hand, the segment toll completely eliminates the movement, suggesting a drastic impact on this movement from that policy.

Upper Mississippi River (UM) Origins: Movements to the Tennessee were not reflected in the model at all. Therefore, there is no basis to use the model results directly in evaluating the impacts of a charge policy. Based on the lack of impact on other UM-originated movements and the lack of impact on UM-Tennessee movements in the wheat model, it is possible that no impact could be hypothesized here. On the other hand, the lack of movements in the base solution may give another indication of the likely impact. It appears that this small domestic movement did not appear in the model because of the nearness of the southeastern producing areas to Tennessee Valley crushing plants. The imposition of a charge policy may well mean that the advantage of these producing areas will be enhanced and the model result (no movements) become even more likely. At an extreme, this small movement may be eliminated, but this conclusion must be mainly based upon the speculative reasoning above.

UM-Lower Mississippi movements in the model accurately represent actual movements. The base solution is unaffected by a charge policy, suggesting that actual movements also will be unaffected.

UM-Gulf movements were overstated by the base solution due to model aggregation. It appears that the model allocated all Illinois-Gulf shipments to UM transshipment points. The reason for this lies in the common proximity of producing regions to both rivers' transshipment points. A second reason is that little difference exists in line-haul costs from UM or Illinois River points. This makes movements particularly sensitive to elevator bid prices and other small regional variations which occur throughout the year, and which could not be captured by this model formulation. More detail can be found in other studies [Anderson and Scheussler, 1976; Bunker, 1976]. The model solution was affected slightly by either charge, but the reduction still left the base solution greater than combined actual Illinois-Gulf and UM-Gulf movements. As such, little effect on UM-Gulf movements is expected from either charge policy. A similar conclusion is reached for Illinois-Gulf movements, as discussed below.

Ohio River Origins: Actual Ohio-Tennessee movements are small and irregular; the base solution shows no movements at all. This suggests that the Ohio-Tennessee movements are supplemental movements unrelated to line-haul costs and would be unaffected by a charge policy.

The model was not very good in estimating the Ohio-Arkansas movement, and since no previous movement has taken place, a user charge is unlikely to generate any movement. Ohio-Lower Mississippi River movements are unlikely to be affected since they appear to be supplemental movements. Ohio-Gulf movements in the base solution overstated actual movements. However, application of either charge policy changed these movements only slightly and they remained above actual movements. Therefore, a charge policy is expected to have only very minor impacts on actual movements.

Tennessee River Origins: Tennessee River movements to other Tennessee River points were small in actuality, although quite stable. These movements also appeared in the base solution at a low level and remained in the model with either charge policy, suggesting little impact on actual movements of a charge policy.

Tennessee-Arkansas movements come into the base solutions, although none actually exists. Since no previous movement has taken place, a user charge is unlikely to generate any movement.

Tennessee-Lower Mississippi movements are small (in practical terms are zero) and the model shows this. Therefore, no user charge impacts are possible.

Tennessee-Gulf movements do not enter the model, although actual movements exist. They are, however, highly volatile and normally small, except in 1970 and 1972. The conclusion is that these are supplemental shipments (even the large movements in 1970 and 1972) and are unlikely to be affected by a charge policy.

Arkansas River Origins: Arkansas-Lower Mississippi movements are near zero and the base solution reflects this; therefore, it is not possible to assess user charge impacts. In actuality, Arkansas-Gulf movements are quite large and stable. However, the model shows only a small movement. This result (low model movements and high actual movements on the Arkansas) is counter to the general pattern of results which has consistently overstated tonnage shipped to the Arkansas River.

Examination of the model shows that the larger regional origins in the Arkansas River area were generally deficit. What is occurring is that production areas along the river (which are smaller than the model's regions) are shipping soybeans for export, while the model construction required these "sub-areas" to provide for local use. Nonetheless, the low level of movement in the model is not affected by a fuel tax. This is likely to be true also of actual movements since they are already moving to export points despite overall regional deficits, suggesting a strong profit advantage to shippers for that trade. On the other hand, the segment toll eliminates the model movement, suggesting that even those areas which have the best export option (i.e., they export in the model despite domestic region deficits nearby) will drop out. Similar impacts are predicted to occur in actuality.

Illinois River Origins: Movements to the Arkansas River occur in the model, but not in actuality. This can be accounted for by the explanation about Arkansas River capacity limits at river terminals. Here the elimination of the movement by either charge policy suggests its potential to limit growth of traffic along this route.

Illinois-Lower Mississippi and Illinois-Gulf movements appear as model movements from the Upper Mississippi to these points. Detailed explanation is found in the discussion of Upper Mississippi-to-Gulf movements above. In either case, no user charge policy is expected to affect these shipments.

Lower Mississippi (LM) Origins: LM-Tennessee and LM-LM movements generally were irregular and small, suggesting their nature as supplemental shipments. They did not appear in the base model, which further supports this contention. No impacts of any charge policy are expected.

LM-Gulf shipments were a bit low in the model, but remained generally stable with the imposition of either charge policy. Therefore, no impact on this movement was expected.

C. Impacts of Current Policy and Summary

Imposition of a 50-percent cost-recovery uniform toll was used to represent the newly enacted user charge policy, as was discussed earlier. At this level, the only impact was a 27-percent decline in Missouri-Gulf traffic; however, even after this reduction, remaining model movements were in excess of actual movements.

The model results and their interpretation offer a basis for assessing the impacts of user charge policy on soybean movements. First, a full O&M cost fuel would appear to leave movements unaffected. No impact of the existing legislation can be expected. However, two movements might be severely affected under a segment toll. In the worst case, the Arkansas-Gulf and Missouri-Gulf movements would fall to zero. The results shown in *Table 12* indicate that this is a loss of 565,000 tons (1975 shipments), with most being the lost Arkansas River movement. This 565,000-ton loss is 8 percent of 1974 total tonnage of soybeans.

V. Corn Model Results

A. Characteristics of the Corn Model

Transported corn is used for domestic and foreign livestock feed, and wet corn processing. Of all corn produced (other than silage or sweet corn) in the United States in the 1970-71 crop year, 80 percent was used in domestic animal production and 11 percent was exported primarily as feed grains. Corn used in the production of corn oil (wet processing) accounted for 5 percent of the total disappearance. Other uses of corn, such as breakfast cereal, corn meal, and distilled spirits production, were not accounted for in the model because of the small amounts of corn used by these types of manufacturers.

Eighty-seven percent of the corn produced in the United States is grown in the North Central Region. In 1970-71, Iowa, Indiana, Ohio, Minnesota, Nebraska, and Missouri produced more corn than was consumed inside each of these states. All other states imported additional corn to fulfill grain requirements for livestock production, processing, or export purposes.

Because the primary use of corn is for livestock feeding, intraregion shipments are extensive. This created particular aggregation problems for the model used here (as will be seen below). In particular, corn movements will be especially sensitive to "spot" prices at river points versus off-river elevators, truck movement alternatives, etc. Although there was a dispersion of points within a region where animal feeding occurred, it was necessary to select some single final destination for shipment. Thus, the corn model is basically different than either the wheat or the soybean model in that the final destination is a center of a region rather than a specific plant in the region or export point. Even though wet corn-processing plants are located at a point within the region, their use was combined with animal use in order to obtain the regional consumption. Therefore, all modeled flows originated from the center of a surplus region and went to the center of a deficit region. As such, if a processing plant were located at a river point, this plant's consumption moved to the regional center, thus removing the line-haul cost advantage of barge since a truck movement to the regional center would be necessary within the model. However, the major movements were reflected in the model and it is felt that the model provides a sound basis for assessing user charge impacts. The model results are exhibited in *Table 13.* One point worth noting is that 96 percent of total barge shipments for 1975 were to Gulf ports. These major movements were well represented. As before, the results are discussed by river origin.

B. User Charge Impacts on Corn Movements: Full Cost Recovery

Missouri River Origins: The base solution shows no movements to any other river points, although some small actual movements do occur. Export movements to the Gulf are the most significant, but they are relatively small when compared to the major export flows from other rivers to the Gulf.

Movements to the Tennessee and Lower Mississippi are supplemental and no impact is expected. Missouri River-Gulf did not enter into the base solution because of the regional delineation used in the corn model which required that all corn must originate from regional centers. Thus, if in reality, corn is grown in an area adjacent to a river port where it might move to Gulf export, the model must show the flow of corn to the regional center for that region. From there it was allocated to western deficit areas. Only in the corn model were the western areas deficit. Therefore, if no major Gulf movement (by rail or barge) existed, and the problem appeared to be one of model aggregation, a maximum impact presumption was made; that is, either charge policy will cause this very small movement to switch to rail or to move to river ports along the Upper Mississippi.

Upper Mississippi River (UM) Origins: The largest single corn movement from the UM in both actuality and in the model is the UM-Gulf movement. Application of either charge policy results in slight reduction in the UM-Gulf movements in the base solution. The shipment continues to move to Gulf ports for export, but the movement is by rail rather than by water.

UM-Tennessee movements exist but have fallen in recent years. However, the base solution shows no movement at all. In addition, the Illinois-Tennessee movement in the base solution is quite large relative to recent years. This implies that an aggregation problem may be present, due to the close proximity of both the Mississippi and the Illinois rivers to the surplus regions.

The lack of impact of either charge policies on the Illinois-Tennessee movement is assumed to hold for the UM-Tennessee movement. However, further examination of *Table 13* shows a long-term decline for actual UM-Tennessee and Illinois-Tennessee movements. Both of these movements may still continue to decline in the future even without a charge policy.

UM-Arkansas movements were overstated in the model, due to the capacity constraints in the Arkansas not being part of the model. Either charge policy eliminates the movement, but it reappears as an Illinois-Arkansas shipment. This is indicative of the long-run potential of movements from these regions to the Arkansas even with a user charge policy (more evidence for this argument follows shortly).

UM-Lower Mississippi (LM) movements did not appear in the base model. However, the appearance of a substantial Illinois-LM movement suggests that the base solution is capturing the overall movement from these regions to Gulf ports, for the same reason discussed with the UM-Tennessee movement. This point is further reinforced by the model solution when a uniform toll is applied and the movement lost on the Illinois reappears in the UM-LM. Under a segment toll, the movement on the Illinois-LM grows, suggesting no negative impact. This is presumed to be the same result for UM-LM movements.

Ohio River Origins: The base solution replicates quite well all Ohio River movements (1975 Ohio-Gulf movements are abnormally high). Movements to the Tennessee were of small significance and varied between years, and the base solution shows no movements, suggesting that this is a supplemental movement and that no impact will occur.

Ohio-Gulf movements were reduced in the model by about 10 percent with the lost traffic moving to rail. A similar response will be expected in actual movements.

Illinois River Origins: Illinois-Tennessee River movements in the base solution are high, but this is due in part to an aggregation problem which caused no model movements to appear for UM-Tennessee (discussed above). The model movements remain in the base solution and suggest no impact on actual movements under either charge policy.

Movements to the Arkansas River are large in the base solution but almost non-existent in the actual movement data. The reasons lie in the capacity limits on the Arkansas River, indicating a long-term growth potential. Under a uniform charge, these movements increase due to a shift from the UM to the Arkansas. However, a segment toll fully eliminates the movement. Thus, the potential growth of the movements to the Arkansas appears unaffected by a fuel tax, but will be impaired by a segment toll.

Model movements to the LM include those from both UM and Illinois River points, as discussed earlier. The loss of traffic in the base solution reappears as a UM-LM movement under a fuel tax, and in fact, the increase on the UM exceeds the amount diverted, due to overall movement adjustments. The segment toll also leads to an overall increase in movements as interregional shipping patterns in the whole system realigned. In summary, no negative impacts in Illinois River movements are expected, and under a segment toll, increases in river movements (by the Illinois or UM) to the LM are possible.

Illinois-Gulf movements in the model are large, although not as large as actual shipments. Application of either charge policy reduces the base solution slightly with all diverted traffic moving to rail and to Great Lakes rather than Gulf ports.

Lower Mississippi (LM) Origins: The base solution shows no movements from LM origins. However, movements from LM to the Tennessee are clearly supplemental and will be unaffected by a charge policy. LM-Gulf shipments are harder to assess because while they are somewhat irregular, they can be significant in some years. The LM regions are not major producers of surplus corn and in the model were net importers of corn from the Illinois River. In fact, it would appear that the actual movements are probably from points right on the river. Given the low user charge that would apply to an LM-Gulf movement and the fact that the movements now exist from generally deficit areas, it seems likely that there would be little impact on this movement.

C. Impacts of Current Legislation and Summary

A fuel tax which recovered 50 percent of costs was used to represent current legislation. At this level, a limited number of changes occurred in the base solution, but the main effect was to shift destinations while leaving total barge tonnage unaltered. *Table 14* shows the impacts of the charge on the base solution. The net loss of 19,000 tons was a diversion to rail and to Great Lakes ports.

The base model did not capture all existing movements, so the model impacts of this charge could not be assessed. Of the movements not appearing in the base solution, the full cost-recovery level may affect only Missouri-Gulf movements.

The model results provide a basis for assessing the impacts of user charge policies. At full cost recovery, some impacts on total movements and shipping patterns would be realized. Using 1975 tonnage and the model results described above, an estimate of the quantitative magnitude of the impacts can be derived. Missouri River-Gulf movements are likely to be eliminated with a loss of 68,000 tons. UM-Gulf movements, using model results, might fall by 11.5 percent under a fuel tax and 3.8 percent under a segment toll. Ohio-Gulf movements decrease by 10 percent in the model. The Illinois-Gulf movements decrease in the model by 3.8 percent with a fuel tax and 3 percent with a segment toll. Application of these results to 1975 movement data *(Table 15)* yields a 7.5-percent decline in movements under a fuel tax and a 4-percent decline in total movements under a segment toll.

In addition, it should be noted that the model suggests future growth potential for corn movements into the Arkansas River. This potential would apparently be unaffected by a fuel tax but would be seriously impaired by a segment toll. However, current policy would have negligible impact on total movements, although some effects on movement patterns may be expected. No impact would be felt on the growth potential for Arkansas River-destination corn shipments.

VI. User Charges and Grain Movements: Concluding Comments on Likely Impacts

The overall results of the analysis suggest that the barge industry's share of total grain movements will not be affected significantly by a user charge policy. However, full cost-recovery segment tolls would have some serious impacts on shippers in the Missouri River area and would inhibit traffic development on the Arkansas River. Of more importance is that the recently enacted user charge policy can be expected to have almost no effect on grain movements. However, for a number of reasons, even these limited impacts most likely are greater than would actually occur. This is because of some elements of the model construction which had the effect of giving "worst case" impact results.

First, the results above are in tons rather than in ton-miles. Loss of ton-miles of traffic would be less since the bulk of both the river miles traveled and total tonnage generally is on the unaffected long-haul export movements. Second, the capital structure of the grain storage and handling system, which has developed along the waterway system, represents a major investment that will not be readily abandoned in response to small changes in line-haul costs. This suggests a "stickiness" in any modal shifting result indicated by the above analysis.

Finally, and most important, recall that these results assume no increases in rail rates ("Model and Data Base: Detailed Description," p. 13). Insofar as rail rates rise in response to higher barge rates, the impacts of a charge are reduced.[16] Also, it was assumed for model construction that the user charge policy would reduce the wedge between rail and barge rates through barge rates rising by the amount of the charge. However, some barge firms will reduce total costs by technological change or changes in firm or tow size to realize scale economies. Thus, forces will be at work to lower barge rates at the same time that the user charge is increasing them. The effect of both of these assumptions in the model construction was to exaggerate the "wedge" that would actually be driven between barge rates and rates for other modes by a user charge policy, and by extension, exaggerate the impact of any charge policy.

As a practical matter, the negligible impact of the currently proposed policy, when considered in the context of the model assumptions, suggests that barge transport of grains will be affected little by the existing policy and would be relatively insensitive to even higher charge levels.

This conclusion is based upon one other model condition—that the consumption patterns and production patterns for grains will not be affected by a charge. If this were to occur, then deficit and surplus areas would change and new shipping patterns and modal shares might well result. The next section of this study will examine this possibility relative to the broiler industry.

IMPACTS OF USER CHARGES ON INDUSTRY LOCATION: THE CASE OF BROILER CHICKEN PRODUCTION

The previous sections of this report have examined the impact of user charges on the relative share of grain and soybean traffic held by each transportation mode when relative rates between barge and other modes vary. However, one constraint on the model used was that the charge itself would not affect regional production or consumption (see "Model and Data Base: Detailed Description," p. 13). While this seems to be a reasonable assumption, it may not hold for industries with small profit margins per unit of output. Such industries would experience erosion of those margins if production costs rose as a result of a change in transportation rates brought on by a user charge. The broiler chicken industry, which now is concentrated in regions of the southeastern United States, may be affected in such a manner. As a major user of feed grains in regions served by the inland waterway system, this industry was analyzed to examine the stability of production and consumption regions for broilers after a user charge policy. Specifically, the issue addressed is whether imposition of a user charge might result in a relocation of broiler production in the United States. This, in turn, could cause a change in the demand pattern for feed grains which would affect barge transport.

I. Focus on the Broiler Industry

The main focus of the research to this point has been upon truck, rail, and barge transportation of wheat, corn, and soybeans. These latter two commodities make up a substantial portion of the broiler feed mix. As such, any changes in transportation costs for these commodities arising from a user charge could affect broiler production costs, and therefore, production decisions. It should be noted here that while broiler feed itself is not moved by barge, a user charge on transport of the feed ration's components may still work its way into the cost structure of broiler firms in a manner which has regional location implications. In order to understand fully how this might occur, it is first necessary to understand the industry itself and its economic history.

In 1950, Delaware led the nation in broiler production with 12.49 percent of the total. By 1957, Georgia led in production with 17.60 percent, a substantial lead over Arkansas, which followed with 6.39 percent. In 1964, Georgia produced 16.91 percent, with Arkansas following with 12.55 percent. As of 1974, Arkansas took the production lead with 16.12

percent, compared to Georgia's 14.65 percent. More generally, throughout this period, the northeastern broiler production area gradually lost its market share to the southeastern area [USDA, 1975].

The obvious question is why did this change occur. Roy [1966] argues that the move to the Southeast was due to lack of better farming opportunities within that region, a large pool of underemployed farm producers, development of contract farming, and low grain freight costs into the region. The importance of freight costs to the competitive position of the poultry industry was discussed more recently by Seaver [1972] who pointed out that differential freight rates can affect agricultural production on a regional basis. The Seaver argument is of interest to this study because his argument focuses upon rail/water competition and its impact on the industry's location.

In broad overview, the argument is that ICC regulatory policy has allowed railroad pricing policies which are based upon minimum traffic diversion to competing modes [Harbeson, 1962]. Thus, in such areas as the Southeast, where effective water competition exists, substantial evidence can be found of low rail rates set to avoid traffic diversion (see "Model and Data Base: Detailed Description," p. 13). Where no such competition exists, rail rates remain relatively high. A review of the geographic dispersion of waterways and traffic flows on the waterways of corn and soybeans, clearly indicates that the Southeast has a regional advantage over the Northeast in terms of available navigation channels.

By extension, one would expect to find, and indeed does find, low rail rates into the Southeast when compared to the Northeast, for bulk products like grain and soybeans. The importance of this result for interregional competition in the broiler industry is argued by Seaver [1972].

> [In the Northeast] the entire livestock industry, especially poultry, has suffered for years from severe interregional competition. This largely stems from the extremely high freight rate from midwest origins to northeast destinations. The deterioration in the competitive position of the northeast poultry industry traces, in large part, to the reduction in rates instituted by the Southern Railway, in order to meet barge and truck competition [Seaver, 1972, p. 238].

The Seaver argument stems directly from standard interregional competition theory and a careful review of rate relationships within the northeast and southeast regions. If valid, a reasonable question to ask is whether increased barge rates resulting from a user charge provide the opportunity for rail rate increases to southeast points with a resulting reduction in the cost advantage of the Southeast over the Northeast and a relocation of broiler production. In short, might a second-round impact from a user charge policy be expected, which would alter the consumption of corn and soybeans within particular regions and hence lower the demand for barge transport into the Southeast? Of course, an equally interesting question is simply whether the charge policy itself could reverse the flow of broiler production to the Southeast.

II. Approach

As in the previous section, a transportation model framework will be used to analyze the problem. (For a more detailed discussion of these results, see Spilka [1979]; Kenyon and Shapiro [1976], and Shabman [1976].) The transportation model formulated incorporates the most important economic aspects of the broiler industry. The model is specified realistically in the sense that consumption of broilers is determined in market areas that represent the entire population of the continental United States; broiler production is accounted for by using the eight major production areas of the United States (90 percent of total U.S. production in 1974) and accounting for all other broiler production by adjusting local consumption figures downward by the amount of local production.

Costs of broiler production, processing, and distribution are taken from survey data within the producing areas. Since the total costs of producing, processing, and distributing ready-to-cook (RTC) broilers from producing areas to consuming areas are known, the linear programming approach allocates the broilers in such a fashion that total costs of production and distribution are minimized. The minimization of production and distribution costs, given regional consumption and production, is referred to as the "base solution." Total costs then are increased by an amount representing the maximum impact of a user charge on southern broiler producers, and the model is resolved to see if the market share of these producers changes in response to the cost increase. This approach assumes no impediments to adjustment in the industry and no brand loyalty tied to regional production in the consuming areas. As such, the model tendency will be to overestimate user charge impacts.

To analyze the problem, consumption of RTC broilers was estimated for 49 separate marketing areas, each of which included a major city *(Figure 5).* Total broiler consumption in each marketing area was based upon estimates of 1974 population and per capita consumption in each area. (Per capita figures were provided by Robert Raunikar, University of Georgia [unpublished data]. Other minor adjustments were necessary and are detailed elsewhere. See Spilka, Kenyon, and Shabman [1979].) Production of broilers occurs in eight locations—four in the Southeast and Southwest and four in the Northeast. The southern areas are Gainesville, Georgia; Gadsden, Alabama; Jackson, Mississippi; and Fayetteville, Arkansas. Northern producing areas are represented by Belfast, Maine; Harrisburg, Pennsylvania; Salisbury, Maryland; and Lexington, North Carolina. (Due to similarities in costs and locations, the production of Texas, Delaware, and Virginia has been added to the production of Arkansas, Maryland, and Pennsylvania, respectively.) Location of the production areas is shown in *Figure 6,* relative to the river system.

Cost budgets were developed for each production area. Using published USDA data, costs of producing, processing, and assembling broilers were calculated for each of the eight production areas. Transportation costs to move RTC broilers from producing to consuming areas were estimated, based upon a recently completed study of shippers' costs to move vegetables by refrigerated truck, and a telephone survey of four major broiler trucking companies [Boles, 1977; Spilka, Kenyon, and Shabman, 1979].

The actual effect of a user charge on broiler production costs could not be determined since data indicating the percentage of feed shipped by barge is not available for each broiler-producing area. Therefore, the approach was to conduct the analysis with the model reflecting the maximum possible impact of the user charge on production costs. If no change in industry location occurs under this assumption, then no impact at lower levels would exist. This meant an assumption that the full user charge on all grain used would be borne by broiler producers. There are several reasons why this would probably not be the case.

In the first instance, any charge will be paid by the barge industry itself. It has been argued elsewhere that in all likelihood, such a charge would be passed on to transportation demanders rather than backward to factors of production in the barge industry [Shabman, 1976]. The demand for transportation between two points depends upon the demand conditions in the exporting region. In this case, grain farmers would be in the exporting region and broiler producers in the importing region, and the increased transportation cost would appear as a leftward shift in the supply function for grain in the importing region. The incidence of the charge will fall between exporters (farmers) and importers (broiler producers) in proportion to the ratio of the price elasticity of supply to the price elasticity of demand for grain in the importing region. The full incidence of the charge will fall backward to the farmer in the exporting (surplus) region if supply is perfectly inelastic. Since the supply of agricultural products in the short run can be viewed as price-inelastic [Tomek and Robinson, 1972], a reasonable assumption would be that grain farmers would bear the charge. However, for purposes of this study, it will be presumed instead that broiler producers will see increases in their costs. To further establish the extreme case, it is assumed that rail rate increases will exactly match any barge rate increases induced by a user charge. (This assumption was not made in the previous sections of this study.) Finally, all grain into broiler-producing areas is assumed to be imported so that the full transport price impact appears in grain prices. (An alternative assumption is that prices for grain produced in broiler-growing areas is set by grain prices in export areas plus transportation from the export to the import area.)

The result of these extreme arguments is to suggest that, for analytical purposes, the full burden of the user charge will be assumed to fall upon southern broiler producers. Calculations elsewhere indicate that the level of user charge for full O&M cost recovery represents approximately four cents per bushel on the farm price of corn and soybeans [Congressional Budget Office, 1977]. In this analysis, we will presume that the four cents will fall, not upon the grower, but rather upon the broiler producer.

Since the impact of a user charge will be to increase the cost of soybeans and corn that the broiler producer uses in the feed ration, estimation of feed costs was important for this model. Feed costs to produce a pound of liveweight broiler were found by averaging the 1974 monthly cost of broiler feed in each production area and multiplying this by the area's feed conversion ratio. This cost is multiplied by the factor 1.34 (representing an assumed dressing percentage of .745) to yield the feed cost of producing one pound of RTC broiler. This cost then was added to the cost budgets in each production area.

Since the impact of the user charge is on delivered broiler feed components (corn and soybeans), these must be separated from the broiler ration. A recently developed ration was assumed to be used by all producers [Kenyon and Shapiro, 1976]. Since a ton of broiler feed contains 30.86 bushels of these two ingredients and a maximum user charge will raise their cost four cents a bushel, the effect is to increase feed price by 123.44 cents per ton. The increased feed cost is converted to a per pound RTC cost, which is added to the total costs of producing RTC broilers to represent the impact of the maximum user charge. As mentioned previously, this impact is assumed to fall entirely on the four southern production areas.

III. Initial Model

An initial model was formulated in which the production of broilers in the eight production areas equaled the consumption of broilers after adjustment in the 49 marketing areas. The optimal solution indicates a distribution of broilers that is shown in *Table 16.* Generally, marketing areas are served by production areas that are nearest, thus minimizing transportation costs. The northern producers serve the large markets in the Northeast, while Georgia and Alabama serve the Midwest and deep South. Mississippi serves Texas, while the large production of Arkansas is sent to a multitude of markets in the Midwest and far West. This solution compares very favorably with the actual delivery of broilers. A recent USDA study [Benson and Witzig, 1978], showing the origin of receipts of broilers for 13 major cities in 1975, shows a distribution pattern quite similar to the one established for this study *(Table 17).*

To allow for a production response in the event of changing relative costs after a user charge, the model was analyzed with each production area being able to produce five percent more broilers than its 1974 actual production. With five-percent excess capacity, the Maine area does not produce any broilers. Similarly, the Pennsylvania area with a five-percent excess capacity produces only 79 percent of its 1974 output. The reason for this is that when each area can produce more broilers, the consumption requirement in the model is met by the other production areas, since Maine and Pennsylvania are relatively high-cost producers (see *Table 18).* This suggests that as constant costs in southern areas are assumed (which is reasonable over the range of increased output allowed in this model), there would be a continuing tendency for southern producers to take markets from northern producers.

The question then is whether a user charge policy might alter this situation. The model was run with higher southern production costs based upon a user charge policy to address this question. The results indicated that the user charge would not alter the strong advantage of southern producers since no change from the base solution with five-percent excess capacity occurred *(Table 18).* Given that the user charge impact is the maximum that could be expected under full cost recovery, it seems reasonable to conclude that a user charge policy would not affect current location of the broiler chicken industry. Rather, other factors such as climate and labor costs have been largely responsible for the shift to the Southeast, and these factors will remain predominant [Spilka, Kenyon, and Shabman, 1979]. (In fact, subsequent runs of the model showed that charges would have to rise to more than 22 cents per bushel before any of the southern producers began to lose market share [Spilka, Kenyon, and Shabman, 1979].)

IV. Summary

This section has sought to examine second-round impacts of a user charge policy. The case study focused upon the broiler chicken industry whose location was initially hypothesized to be most sensitive to change in transport costs which might arise from a user charge. It was concluded that even under the most severe forward shifting argument for the user charge, no impact would be felt upon industry location. As such, it offers strong evidence that the assumption that regional production and consumption (surplus and deficit areas) will not be affected by a charge policy is sound. This assumption was critical to the conclusions drawn in "Impacts of User Charge Policies on Grain Movements" (p. 27). Clearly, these results illustrate the insensitivity of this industry's location to the charge policy, and it should be one of the industries most sensitive to cost changes.

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CONCLUSIONS

The results of the study have been summarized at the end of "Impacts of User Charge Policies on Grain Movements" (p. 27) and "Impacts of User Charges on Industry Location: The Case of Broiler Chicken Production" (p. 49). The most important conclusion of this study is that the recently enacted user charge policy will have no significant effect upon grain movements on the nation's waterways. In fact, fuel taxes of up to 100 percent of annual operation and maintenance would only have slight impacts on total movements. Segment toll impacts would be more severe, but would still leave most traffic remaining on the major waterways. These conclusions are based upon the direct model results and the interpretation of those results when movements in the model do not match actual movement data. The "little impact conclusion" is further substantiated by a recognition that if railroad rates rise (a likely situation) and/or if changes in the structure of the barge industry reduce average costs (also likely), then the impact of the user charge would be less than that suggested here. Furthermore, the insensitivity of the location of the broiler industry to a charge policy is evidence that the regional consumption points which utilize or benefit from barge transportation will be unaffected by a charge. Thus, no second-round impacts which may shift the demand for barge transport are expected.

While the overall impact on grain movements is small for the current policy, there were certain movements which were sensitive to a 100 per cent cost-recovery charge policy, and as such, the application of the recently enacted fuel tax may bear monitoring for impacts. Movements from the Missouri River, especially for Gulf export, were quite sensitive to higher charges. Also, many movements to Arkansas River destinations were sensitive. This was especially true of movements which appeared in the model but not in reality, which suggests that a charge policy could reduce traffic growth potential. Movements for export from Ohio River points were somewhat sensitive and some exports may switch from barge to the Gulf to rail to the East Coast. Again, it should be emphasized that these changes occurred in the model primarily at the 100-percent charge levels. These movements are a small percentage of total barge movements, and adjustments in rail rates and the barge industry may mitigate these impacts even further.

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FOOTNOTES

1. The analysis of broiler production puts this to a specific test ("Impact of User Charges on Industry Location: The Case of Broiler Chicken Production," p. 49). It should also be noted that while the model will hold export demand constant, it will allow for port switching so domestic "demand points" for export may change in response to the charge policies.

2. World regions were selected by aggregating countries with approximately equal access to ocean vessels from U.S. ports. Thus, the world regions included as final destinations in the model were: (1) Mexico, West Indies, Central America; (2) Eastern South America; (3) Western South America; (4) Western Europe (to west coast of Spain); (5) Eastern Europe; (6) Western Mediterranean (south coast of Spain to west coast of Italy); (7) Eastern Mediterranean; (8) Russia; (9) West Africa; (10) East Africa; (11) Western Orient, including China; and (12) Eastern Orient.

3. The year 1970 was used for production and consumption due to the availability of processing data for that year. Transport costs for 1975 were used since that was the latest year for which all needed information was readily available. Transport data for 1970 were not used since rapidly escalating energy prices in the early 1970's changed relative costs between transport modes.

4. The distinction between a flat rate and a proportional rate is that a proportional rate can be applied only after a flat rate has been used. Proportional rates are always lower (some proportion of) flat rates, and forcing a shipper to first use a flat rate is a means of increasing rail revenues by ensuring that a particular shipment moves the entire distance by rail. Otherwise, for example, a shipper might truck grain to a rail center to avoid a high gathering rate. If he did this under the existing system, he could not utilize the favorable proportional rate from the rail center.

5. All rail rates are published at a particular *ex-parte* level, although not the same for each rate. Whenever a general rate increase is granted by the ICC, rates move to a new *ex-parte* level. Changing a rate from an old level (as it might appear in a tariff) to a new (as it might be in practice) is a matter of applying the appropriate percentage increase.

6. The rate-collecting and generating method described appears simple, and conceptually, it is. However, a great deal of work was required to collect the component rates for the process. For this reason, some rates were estimated. Estimated rates were significantly relied on only in the model analyzing soft red winter wheat movements. This was simply a result of the fact that collecting actual rates for the geographic areas involved proved to be especially difficult. See Binkley [1977].

7. The following shippers were contacted: Cargill & Co., Omaha; Cargill & Co., Chicago; Burris Milling, Ft. Worth; Mid-Continent Farmers Coop., Oklahoma City; Shawnee Milling Co., Shawnee, Oklahoma; Continental Grain, Houston; Cargill & Co., Minneapolis; Bartlett & Co., Kansas City; Continental Grain, St. Louis.

8. The .3 rate was arrived at because applying this rate in the Iowa State University method yielded truck costs similar to typical charges paid by any shipper on grain moving from areas in favorable backhaul situations, as that information was provided by the companies noted in footnote 7.

9. The degree of openness can be considered a function of width and depth, although circuity, number of locks, and levels of congestion may also enter here.

10. Indeed, one study concludes that detailed analysis of available industry data suggests a continued pattern of growth for inland waterway carriers from small to medium and perhaps, to large [Kearny, 1974].

11. The difficulty in trying to determine why discrepancies between research results and observed reality exist is admittedly disconcerting. Of course, some arise due to the simplifications imposed by research. However, we were frankly surprised by the fact that contacts with grain firms and other researchers often yielded no explanations of some of the discrepancies we encountered. We have gone to great lengths to describe our base model results, partly with the interest of describing some of these unexplained discrepancies. In examining other studies, we generally found no such descriptions. Either results were presented in a very aggregate fashion (arrows on maps, etc.), or analyses were so heavily constrained as to be forced to resemble actuality.

While we realize that some of the deviations we encountered resulted from simplifications we imposed, we feel that either the grain transportation system is out of equilibrium and moving very slowly to a new one, or (perhaps particularly with respect to exports) the pattern of movements is subject to so many random influences that such considerations as equipment availability are far more important to shippers than rates. The recent rail car shortage provides some dramatic empirical evidence of this possibility. Perhaps future research in transportation needs to concentrate on the important role that stochastic disturbances play in influencing the transport system.

12. Also, when hard red spring wheat is constrained through Texas ports, movements to Chicago are still higher.

13. However, insofar as the costs used in the analysis are concerned, for many producing areas it is cheaper to move export shipments of hard winter wheat through ports in the Lower Mississippi area. Therefore, an alternative model—which allowed exports through Louisiana ports—was run. The base solution of this model overstated actual shipments to the Gulf nearly tenfold; however, virtually most of these inflated shipments were eliminated from the model at the 100-percent user charge level. Nonetheless, the movements which did remain after the charge were above actual movements. For a more detailed discussion, see Binkley [1977].

14. This may be something of an overstatement if wheat of Missouri River origin is exported through Louisiana rather than through Texas ports. However, it is treated here as an upper limit on the impact.

15. In the model, export movements remained on the Arkansas after a fuel tax and many domestic movements from the Missouri remained after either charge. However, if serious traffic diversions began to occur on these high-cost rivers, and since annual waterway costs for operation and maintenance are independent of annual tonnage moved, the toll would have to keep rising if a cost recovery goal is being pursued. This would ultimately shut these high-cost rivers down. The result of this would be a drop in charges on the main stem of the system as lower total costs would have to be recovered.

16. Historically, rail rates have been closely tied to barge rates along water-competitive rail routes. Thus, rail rates are quite likely to rise (see "Model and Data Base: Detailed Description," p. 13).

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FIGURES

FIGURE 1
The Inland Waterway System

FIGURE 2
Typical Model Movements

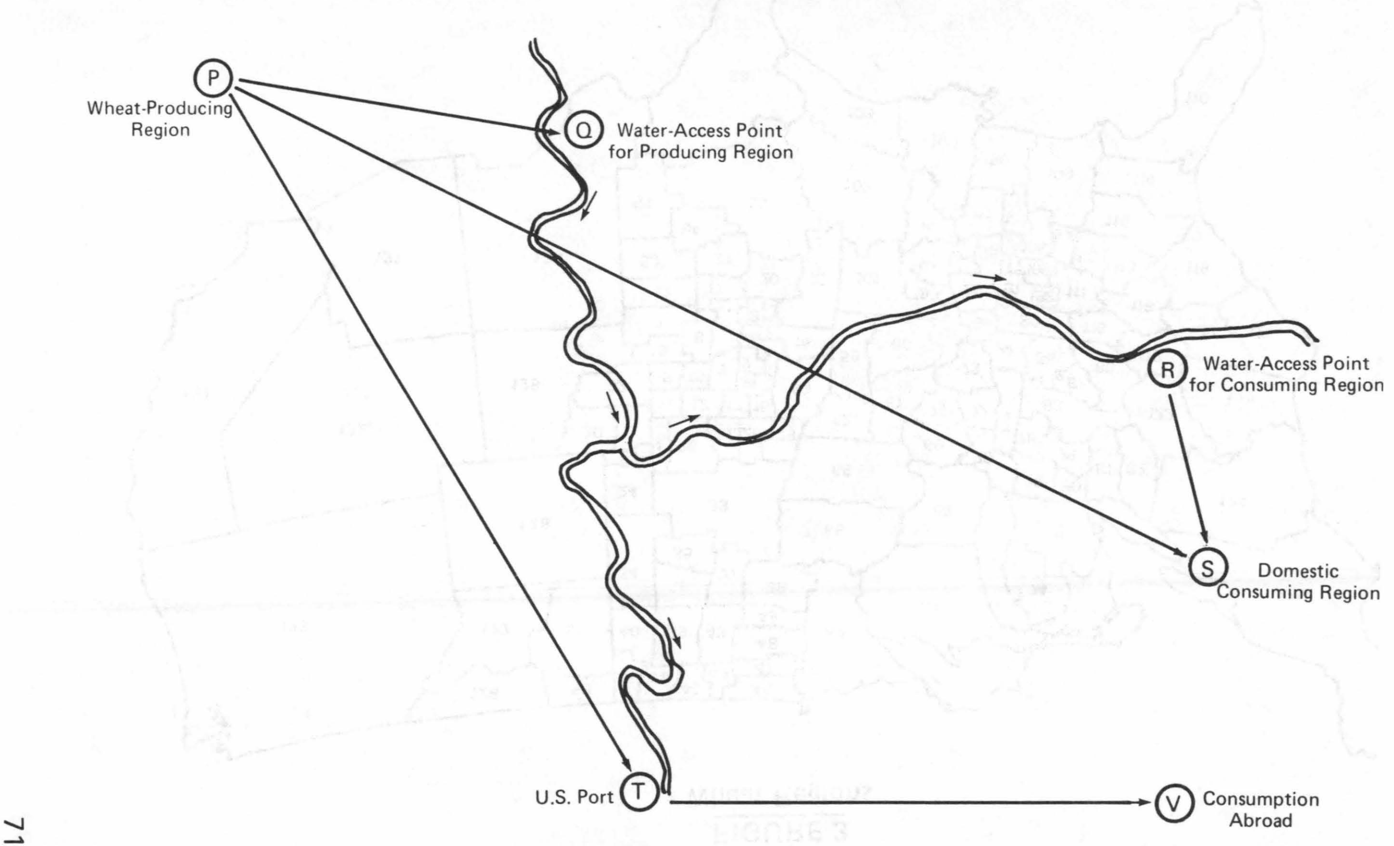


FIGURE 3

Wheat Regions

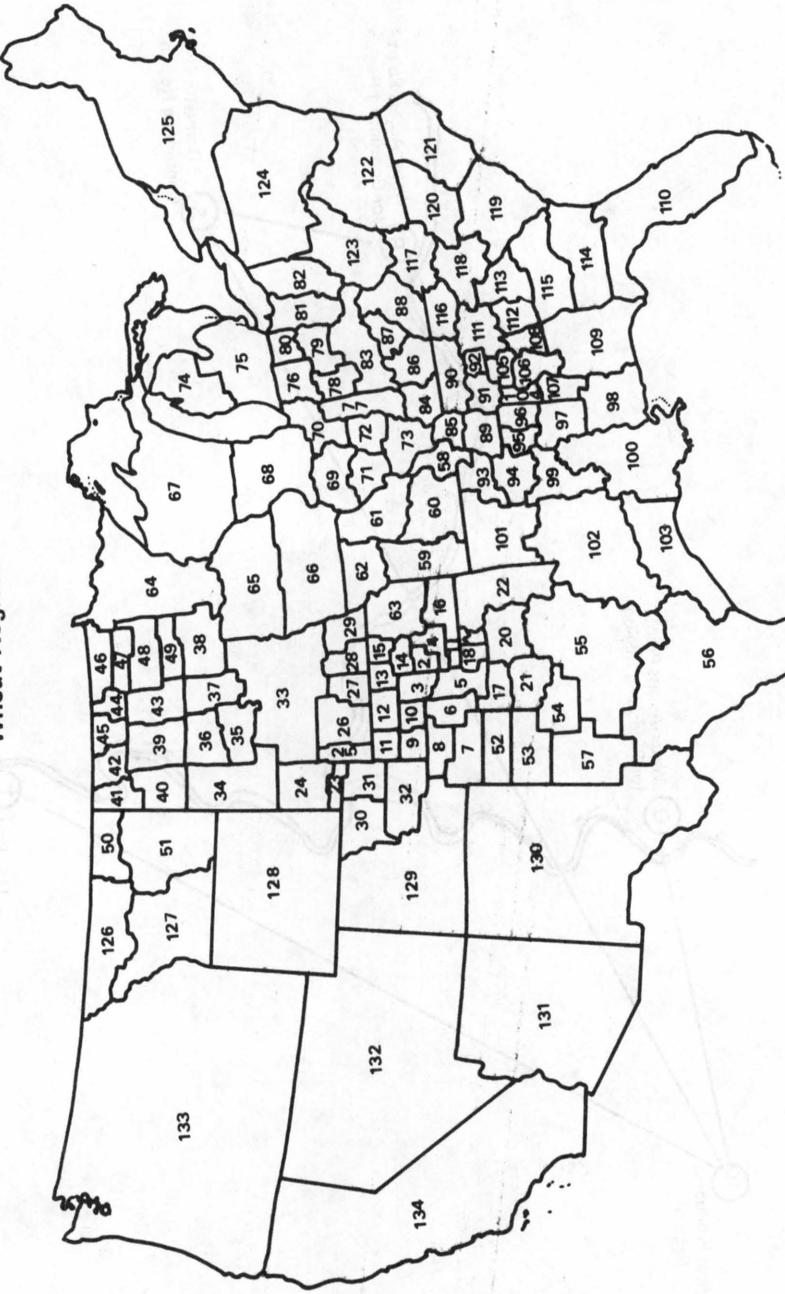


FIGURE 4
River Transshipment Points Schematic

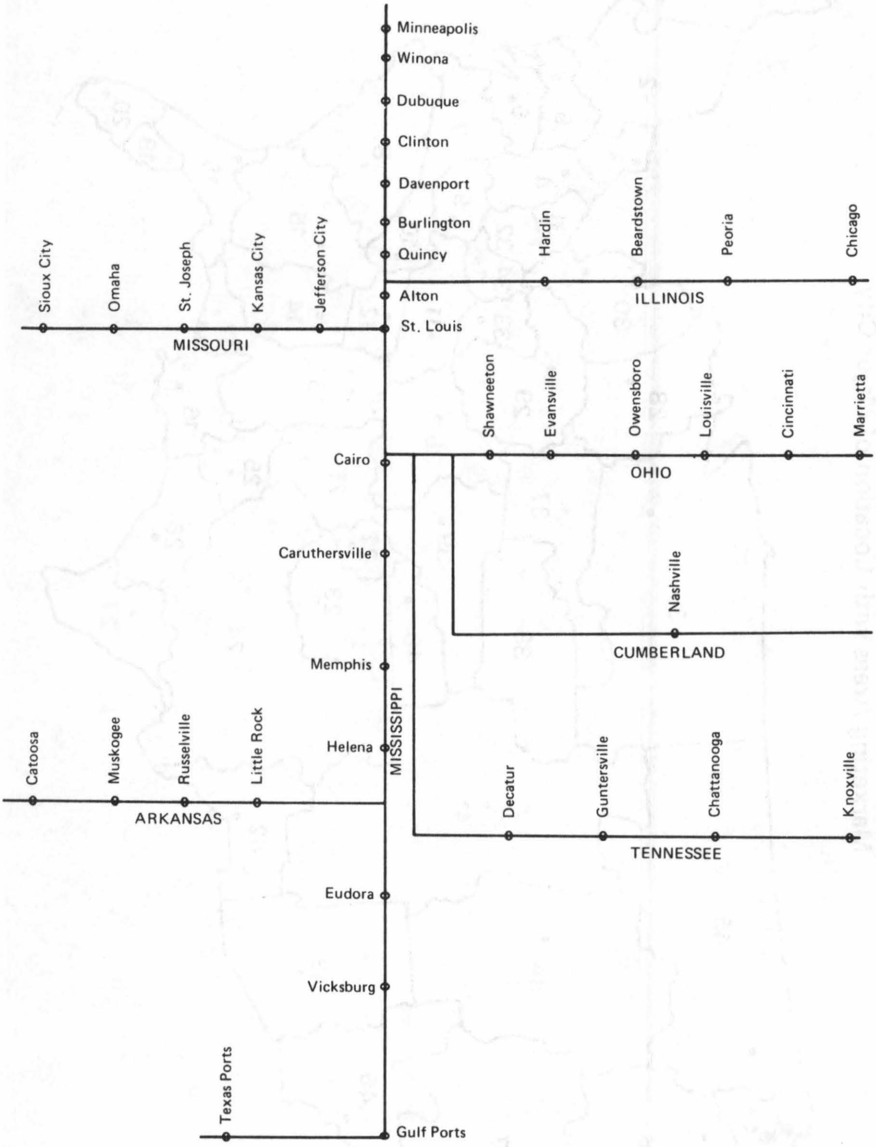


FIGURE 5

Marketing Areas with Location of Major City

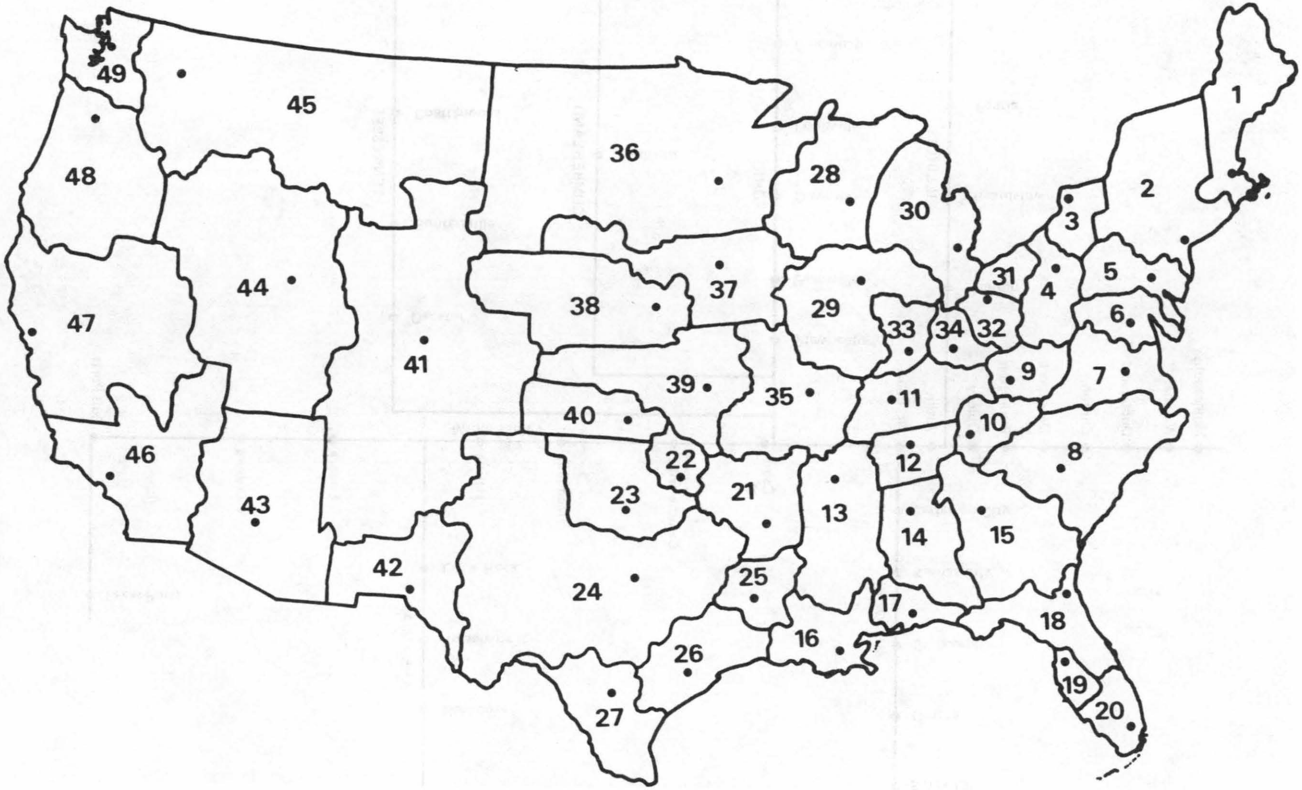
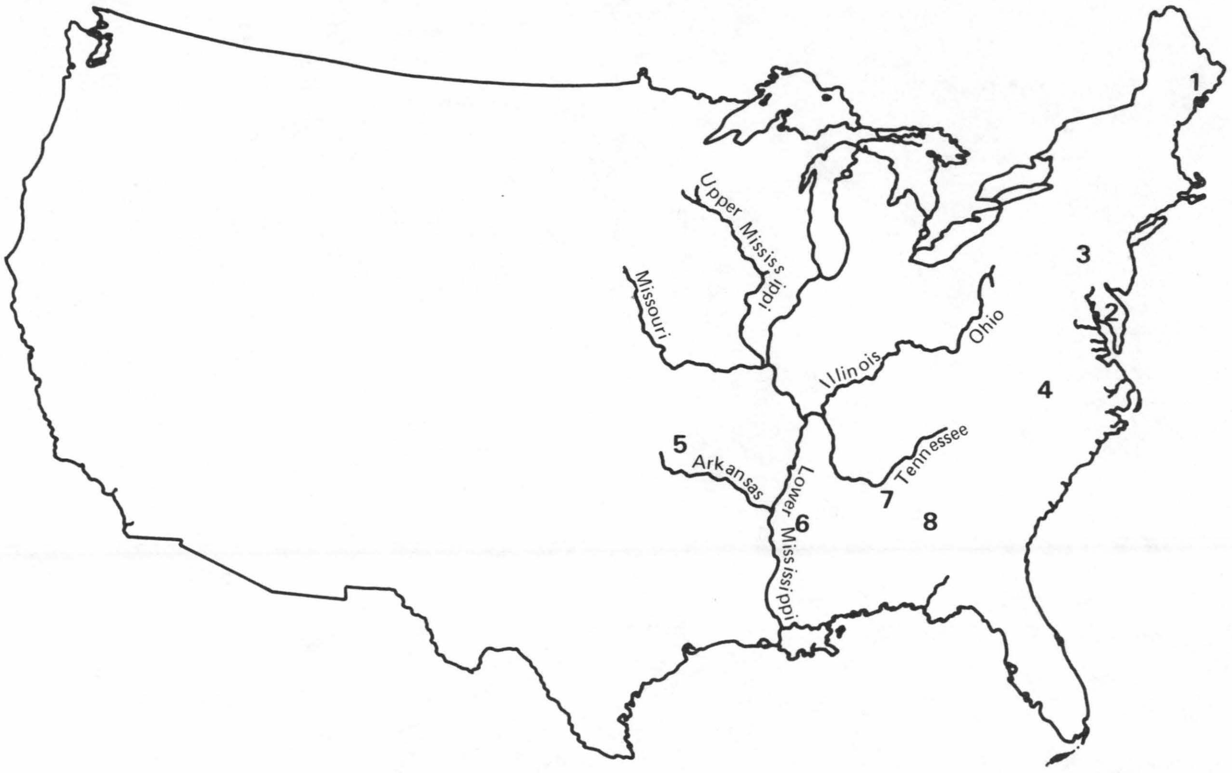


FIGURE 6

Major Components of the Mississippi River System with Location of Major Broiler-Producing Areas



TABLES

TABLE 1

Inland Waterway Traffic by Commodity Type, for Year

Commodity Group	Ton-Miles (in thousands) 1968*	Ton-Miles (in thousands) 1973*	Percent Change (1969-1973)
Petroleum and Petroleum Products	43,593,056	45,891,605	5.3
Coal and Coke	25,259,622	31,067,599	23.0
Iron Ore and Iron and Steel	7,798,154	9,388,681	20.4
Sand, Gravel, and Stone	3,992,586	4,435,757	2.5
Grains	17,719,288	28,750,492	62.2
Logs and Lumber	1,356,826	1,341,855	-1.1
Chemicals and Related Products	15,850,138	21,581,173	36.2
Shells	1,975,713	2,039,904	3.2
All Other	21,762,197	27,393,850	25.9
Total	139,307,580	171,890,916	23.4

*Source: U.S. Army Corps of Engineers (1968 and 1973).

TABLE 2

Corps of Engineers Navigation Expenditures:* Fiscal Years 1974-1976
(Millions of Current Dollars)

	1974 O&M†	Construction	1975 O&M	Construction	1976 O&M	Construction
Shallow Draft Inland and Intracoastal Waterways	136	257	137	282	146	240
Shallow Draft Harbors and Channels	17	12	13	9	17	11
Great Lakes Harbors	25	8	58	6	47	3
Deep Draft Harbors and Channels	105	34	124	39	134	43
Small Boat Harbors	11	–	7	1	8	–
Total	295	311	339	338	352	297

*Source: Congressional Budget Office [1977, p. 11].
†Operation and Maintenance.

TABLE 3

Comparative Advantages of Domestic Freight Transport Modes*

Cost	Flexibility	Capacity	Speed
Pipeline— .1 to .25 cents/ton-mile	Truck— Can provide "door-to-door" service to almost any inland point	Pipeline— 30,000 to 2,500,000-ton unit capacity	Airline— 300 to 600 mph
Barge— .1 to 1.1 cents/ton-mile	Rail— Rail sidings permit "door-to-door" service between many inland points	Barge— 1,000 to 60,000-ton unit capacity	Truck— 40 to 60 mph
Rail— .5 to 2.5 cents/ton-mile	Barge— Range of direct service is geographically limited to areas adjacent to a waterway	Rail— 50 to 12,000-ton unit capacity	Rail— 20 to 45 mph
Truck— 2.0 to 4.0 cents/ton-mile	Pipeline— Can offer direct service only to those mechanically linked to the system	Airline— 5 to 125-ton unit capacity	Barge— 3 to 10 mph
Airline— 15 to 20 cents/ton-mile	Airline— Cannot provide "door-to-door" service; range of service depends on airport locations	Truck— 10 to 25-ton unit	Pipeline— 3 to 6 mph

*Source: Adapted from Kearny [1974].

TABLE 4

Segment Tolls, 100-Percent Variable Cost Recovery Various River Segments (Dollars per Ton-Mile)*

Segment	Toll
Lower Mississippi, Baton Rouge to Gulf	$.000000
Lower Mississippi, Cairo to Baton Rouge	.000438
Upper Mississippi	.000964
Arkansas River	.035488
Ohio River	.000510
Tennessee River	.000810
Illinois Waterway	.000693
Missouri River	.008232
Gulf Intercoastal Waterway, west of Mississippi River	.000811
Inland Waterway System (fuel tax)	.000843

*Source: Anderson and Scheussler [1976].

TABLE 5

Barge Rates Under Varying Levels of User Charges (Cents per Hundredweight)*

Origins and Destinations	1975 Rate (no charge)	Rate with Fuel Tax for 50 Percent of Operation and Management (New Policy)		Rate with Fuel Tax for 100 Percent of Operation and Management		Rate with Segment Toll for 100 Percent of Operation and Management	
		Rate	Percent of Increase	Rate	Percent of Increase	Rate	Percent of Increase
Minneapolis-New Orleans	27.42	30.34	11	33.26	21	32.41	18
Kansas City-New Orleans	28.71	31.73	11	34.74	21	46.32	61
Sioux City-Knoxville	48.50	51.92	7	55.34	14	82.32	70
St. Louis-Chicago	12.58	13.35	6	14.12	12	13.90	10
Minneapolis-Evansville	21.44	23.64	10	25.83	20	26.03	21
Catoosa-New Orleans	24.99	26.96	8	28.92	16	103.55	414

*Source: Computed from data in Waterways Freight Bureau [1975] and U.S. Department of Transportation [1973].

TABLE 6

Grain Production, Selected States (Millions of Bushels)*

State	Wheat	Corn	Soybeans
Ohio	41.5	322.6	80.3
Indiana	31.9	556.4	111.4
Illinois	46.0	1,067.4	235.9
Michigan	17.8	119.3	10.2
Wisconsin	1.3	225.7	3.0
Minnesota	59.6	475.1	63.9
Iowa	1.3	1,178.1	178.7
Missouri	31.0	272.0	97.3
North Dakota	291.5	9.9	2.9
South Dakota	65.4	120.7	4.8
Nebraska	102.2	450.5	15.2
Kansas	313.6	124.5	17.8
North Carolina	10.5	89.2	23.7
South Carolina	4.7	27.3	23.0
Georgia	7.6	90.2	15.3
Alabama	3.4	28.1	17.0
Mississippi	3.6	8.5	56.5
Arkansas	8.0	1.5	92.4
Oklahoma	72.0	4.7	3.5
Texas	31.4	44.1	2.7

*Source: USDA [1973].

TABLE 7

Wheat Exports from Texas Ports and Mississippi Ports for Selected Years (Tons)*

Year	Mississippi River	Texas
1970	1,872,418	6,281,715
1971	2,170,512	7,192,475
1972	2,827,685	6,275,359
1973	2,732,259	15,494,776
1974	2,974,086	7,893,064
1975	3,598,002	10,271,462

*Source: U.S. Army Corps of Engineers (years 1970-1975).

TABLE 8
Actual Wheat Movement, Base Solution, and Model Results with User Charge Policy, by River Segment

Pts. of Origin/Destination (by River Segment)	Actual Movements, by Year* (Thousands of Tons)						Model Results (Thousands of Tons)				
	1970	1971	1972	1973	1974	1975	Base Soln. for 1970 Production & Consumption	Movemt. w/U.T.* (Fuel Tax)	Movemt. w/S.T.*	Change from Base Soln. w/U.T.*†	Change from Base Soln. w/S.T.*†
Missouri-Tennessee	326	396	294	159	249	236	347	347	123	0	-224
Missouri-Ohio	79	79	49	34	62	90	142	92	80	-50	-62
Missouri-Upper Mississippi	104	112	2	§	24	§	189	0	0	-189	-189
Missouri-Chicago	114	84	3	0	54	34	104	66	54	-38	-50
Missouri-Gulf‡	8	173	413	255	340	272	29	0	0	-29	-29
Upper Mississippi-Tennessee	122	328	380	329	232	272	63	63	223	0	+160
Upper Mississippi-Ohio	45	57	59	49	74	47	29	29	79	0	+50
Upper Miss.-Upper Miss.	79	112	122	103	112	§	58	58	58	0	0
Upper Mississippi-Chicago	42	26	13	3	3	12	0	38	53	+38	+53
Upper Mississippi-Gulf	662	833	1275	741	1872	2522	2794	2794	2794	0	0
Illinois-Chicago	65	8	9	7	17	41	117	117	117	0	0
Illinois-Gulf	47	145	194	92	189	311	0	0	0	0	0
Ohio-Tennessee	22	1	0	16	10	10	0	0	0	0	0
Ohio-Gulf	8	138	255	45	305	510	48	10	36	-38	-12
Lower Mississippi-Tennessee	49	0	2	24	3	11	0	0	0	0	0
Lower Mississippi-Gulf	272	324	438	169	364	491	467	454	467	-13	0

(continued)

TABLE 8 (continued)

Pts. of Origin/Destination (by River Segment)	Actual Movements, by Year* (Thousands of Tons) 1970	1971	1972	1973	1974	1975	Model Results (Thousands of Tons) Base Soln. for 1970 Production & Consumption	Movemt. w/U.T.* (Fuel Tax)	Movemt. w/S.T.*	Change from Base Soln. w/U.T.*†	Change from Base Soln. w/S.T.*†
Arkansas-Tennessee	0	1	0	1	46	87	0	0	0	0	0
Arkansas-Gulf	4	11	14	28	78	76	357	106	0	-251	-357

*Source: [U.S. Army Corps of Engineers].

†U.T. = uniform toll; S.T. = segment toll.

‡Hard red winter wheat movements through Texas ports.

§Not available.

TABLE 9

Impacts of 50-Percent Cost Recovery Level (Thousands of Tons)

	Base Solution	Movement with Policy
Missouri-Ohio	142	130
Missouri-Gulf	29	0*
Upper Mississippi-Gulf	2,794	2,791
Arkansas-Gulf	357	290

*This may be something of an overstatement if wheat of Missouri River origin is exported through Louisiana rather than through Texas ports. However, it is treated here as an upper limit on the impact.

TABLE 10

Estimated Net Change in 1974 Wheat Tonnage from Full Cost Recovery Charges (Thousands of Tons)

River Origin	1975 Tonnage	Fuel Tax	Segment Toll
Missouri	632	-330	-330
Upper Mississippi	2,853	+ 46	+165
Illinois/Ohio	872	-656	-205
Arkansas	163	- 87	-163
		-1,027	-533

TABLE 11

Actual Soybean Movement, Base Solution, and Model Results with User Charge Policy by River Segment

Pts. of Origin/Destination (by River Segment)	Actual Movements, by Year* (Thousands of Tons)						Model Results (Thousands of Tons)				
	1970	1971	1972	1973	1974	1975	Base Soln. for 1970 Production & Consumption	Movemt. w/U.T.* (Fuel Tax)	Movemt. w/S.T.*	Change from Base Soln. w/U.T.*†	Change from Base Soln. w/S.T.*†
Missouri-Arkansas	0	0	0	0	0	0	273	273	0	0	-273
Missouri-Lower Mississippi	26	15	0	1	1	0	0	0	0	0	0
Missouri-Gulf	176	137	90	61	109	84	626	457	0	169	-626
Upper Mississippi-Tennessee	133	141	42	122	87	95	0	0	0	0	0
Upper Miss.-Lower Miss.	164	178	118	68	102	36	124	124	124	0	0
Upper Mississippi-Gulf	2996	2813	2904	2481	3466	2765	5555	5070	5131	-485	-424
Ohio-Tennessee	4	11	15	44	27	20	0	0	0	0	0
Ohio-Arkansas	0	0	0	0	0	0	310	310	310	0	0
Ohio-Lower Mississippi	20	20	48	36	7	7	0	0	0	0	0
Ohio-Gulf	201	469	469	469	15	735	1181	979	1226	-202	45
Tennessee-Tennessee	27	17	25	29	21	15	6	6	6	0	0
Tennessee-Arkansas	0	0	0	0	0	0	310	310	310	0	0
Tennessee-Lower Mississippi	0	0	2	1	2	0	0	0	0	0	0
Tennessee-Gulf	163	15	477	48	23	56	0	0	0	0	0
Arkansas-Lower Mississippi	1	0	2	7	1	0	0	0	0	0	0
Arkansas-Gulf	417	428	477	470	531	481	23	23	0	0	-23

TABLE 11 (continued)

Pts. of Origin/Destination (by River Segment)	Actual Movements, by Year* (Thousands of Tons) 1970	1971	1972	1973	1974	1975	Model Results (Thousands of Tons) Base Soln. for 1970 Production & Consumption	Movemt. w/U.T.* (Fuel Tax)	Movemt. w/S.T.*	Change from Base Soln. w/U.T.*†	Change from Base Soln. w/S.T.*†
Illinois-Arkansas	0	0	0	0	0	0	498	498	0	0	-498
Illinois-Lower Mississippi	293	235	137	62	40	57	0	0	0	0	0
Illinois-Gulf	1357	1104	2014	2177	1732	1981	0	0	0	0	0
Lower Mississippi-Tennessee	0	3	5	3	3	1	0	0	0	0	0
Lower Miss.-Lower Miss.	34	81	75	40	44	35	0	0	0	0	0
Lower Mississippi-Gulf	1669	1719	1862	1608	2270	2270	1271	1204	1284	-67	13

*Source: U.S. Army Corps of Engineers.

†U.T. = uniform toll; S.T. = segment toll.

TABLE 12

Diverted Soybean Tonnage Under Uniform or Specific Charge at Full Cost Recovery (1975)

Movement	Diverted Tonnage from Segment Toll (Thousands of Tons)
Missouri to Gulf	- 84
Arkansas to Gulf	-481
	-565

TABLE 13

Actual Corn Movement, Base Solution, and Model Results with User Charge Policy by River Segment

	Actual Movements, by Year* (Thousands of Tons)						Model Results (Thousands of Tons)				
Pts. of Origin/Destination (by River Segment)	1970	1971	1972	1973	1974	1975	Base Soln. for 1970 Production & Consumption	Movemt. w/U.T.* (Fuel Tax)	Movemt. w/S.T.*	Change from Base Soln. w/U.T.*†	Change from Base Soln. w/S.T.*†
Missouri-Tennessee	14	16	0	28	0	3	0	0	0	0	0
Missouri-Lower Mississippi	8	0	0	8	2	1	0	0	0	0	0
Missouri-Gulf	113	62	19	19	24	68	0	0	0	0	0
Upper Mississippi-Tennessee	721	803	285	359	271	119	0	0	0	0	0
Upper Mississippi-Arkansas	0	0	5	3	0	0	538	0	0	-538	-538
Upper Miss.-Lower Miss.	195	101	79	61	34	23	0	602	0	+602	0
Upper Mississippi-Gulf	3968	3473	5780	8711	8457	7964	7799	6900	7505	-899	-294
Ohio-Tennessee	55	41	26	50	15	29	0	0	0	0	0
Ohio-Arkansas	0	4	0	0	0	0	0	0	0	0	0
Ohio-Lower Mississippi	3	2	1	0	0	2	0	0	0	0	0
Ohio-Gulf	166	298	292	486	492	1239	264	240	240	-24	-24
Illinois-Tennessee	898	867	624	451	374	268	809	809	809	0	0
Illinois-Arkansas	3	18	41	2	0	1	1121	1728	0	+607	-1121
Illinois-Lower Mississippi	292	447	394	245	172	127	684	79	1316	-605	+632
Illinois-Gulf	‡	4232	9714	8109	7095	9923	3029	2911	2936	-118	-93

(continued)

TABLE 13 (continued)

Pts. of Origin/Destination (by River Segment)	Actual Movements, by Year* (Thousands of Tons)						Model Results (Thousands of Tons)				
	1970	1971	1972	1973	1974	1975	Base Soln. for 1970 Production & Consumption	Movemt. w/U.T.* (Fuel Tax)	Movemt. w/S.T.*	Change from Base Soln. w/U.T.*†	Change from Base Soln. w/S.T.*†
Lower Mississippi-Tennessee	4	3	2	0	4	0	0	0	0	0	0
Lower Mississippi-Gulf	75	116	65	23	72	162	0	0	0	0	0

*Source: [U.S. Army Corps of Engineers].

†U.T. = uniform toll; S.T. = segment toll.

‡Not available.

TABLE 14
Impact of Current Policy on Base Solution for Corn Movements

Origin-Destination	Base Solution	Change from Base
Upper Mississippi-Gulf	7,799	+ 4
Upper Mississippi-Arkansas	538	-538
Upper Mississippi-Lower Mississippi	0	+534
Illinois-Arkansas	1,121	+539
Illinois-Lower Mississippi	684	-534
Ohio-Gulf		- 24
		Net -19

TABLE 15
Impacts on Total 1975 Movements of Full Cost Recovery User Charge Policies Based Upon Model Results (Thousands of Tons)

Origin-Destination	Fuel Tax Tonnage Results	Segment Toll Tonnage Results
Missouri-Gulf	- 68	- 68
Upper Mississippi-Gulf	-915	-302
Ohio-Gulf	-123	-123
Illinois-Gulf	-377	-298
	-1,483	-791

TABLE 16

Distribution of Broilers When Consumption Equals Production

Distribution	Pounds	Distribution	Pounds
MD to Boston	343,626,000	AR to Dallas	256,465,000
PA to New York	373,368,000	MS to Shreveport	36,504,000
MD to New York	685,735,000	MS to Houston	128,837,000
ME to New York	136,386,000	MS to San Antonio	89,013,000
ME to Buffalo	119,075,000	AL to Milwaukee	106,867,000
NC to Pittsburgh	59,227,000	AL to Chicago	404,673,000
AL to Pittsburgh	130,632,000	MS to Chicago	119,516,000
MD to Philadelphia	28,514,000	GA to Detroit	375,182,000
NC to Philadelphia	358,877,000	GA to Cleveland	170,222,000
NC to Washington	309,674,000	PA to Columbus	56,118,000
NC to Richmond	160,502,000	AL to Indianapolis	62,687,000
GA to Charlotte	280,740,000	AL to Cincinnati	118,268,000
NC to Charleston	12,191,000	AR to St. Louis	163,857,000
AL to Knoxville	24,311,000	AR to Minneapolis	158,358,000
AL to Louisville	105,519,000	AR to Des Moines	73,231,000
AL to Nashville	19,554,000	AR to Omaha	53,544,000
MS to Memphis	114,891,000	AR to Kansas City	52,181,000
AL to Birmingham	129,255,000	AR to Wichita	26,624,000
GA to Atlanta	219,570,000	AR to Denver	129,980,000
AL to Atlanta	24,680,000	AR to El Paso	23,663,000
MS to New Orleans	107,259,000	AR to Phoenix	50,732,000
MS to Mobile	42,618,000	MS to Phoenix	21,810,000
GA to Jacksonville	69,184,000	AR to Salt Lake City	60,312,000
GA to Tampa	33,904,000	AR to Spokane	36,362,000
GA to Miami	91,959,000	AR to Los Angeles	369,667,000
AR to Little Rock	32,219,000	AR to San Francisco	205,386,000
AR to Tulsa	11,490,000	AR to Portland	48,051,000
AR to Oklahoma City	46,532,000	AR to Seattle	81,833,000

TABLE 17

Base Solution and Actual Producing Areas for 12 Consuming Areas

Consuming Area	Producing Area in Base Solution	Actual Producing Area[*,†]
Boston	Maryland (Delmarva)	Delmarva New England North Carolina
New York	Maryland (Delmarva) Pennsylvania Maine (New England)	Delmarva North Carolina New England
Washington, D.C.	North Carolina	North Carolina Virginia Delmarva
Cleveland	Georgia	Georgia Mississippi Arkansas
Chicago	Alabama Mississippi	Georgia Mississippi Arkansas
Minneapolis	Arkansas	Alabama Georgia Mississippi
St. Louis	Arkansas	Georgia Mississippi Arkansas
Atlanta	Georgia Alabama	Georgia North Carolina
Denver	Arkansas	Arkansas Mississippi Georgia
Los Angeles	Arkansas	Mississippi Arkansas California[‡]
San Francisco	Arkansas	California[‡] Mississippi Arkansas

(continued)

TABLE 17 (continued)

Consuming Area	Producing Area in Base Solution	Actual Producing Area*†
Seattle	Arkansas	Washington‡ Arkansas California‡

*Source: Benson and Witzig [1976, p. 33]. First three producing areas are listed.

†The model does not allow the market to be split unless production area capacity i exhausted and a new area enters the solution. Therefore, the most relevant comparison is between the model solution and the most important source.

‡Local production was netted from local consumption and could not appear in th base solution. Comparison should be between the model solution and the most important area for imports.

Model Results

Production Area*	1974 Actual Production* (Thousands of Pounds)	Base Solution with 5% Excess Capacity (Thousands of Pounds)	Base Solution with 5% Excess Capacity and a User Charge Policy (Thousands of Pounds)
Pennsylvania	429,481	341,555	341,555
Maryland	1,057,870	1,110,763	1,110,763
Georgia	1,240,756	1,302,794	1,302,794
Arkansas	1,882,482	1,976,606	1,976,606
Maine	255,458	0	0
North Carolina	900,466	945,489	945,489
Alabama	1,126,441	1,182,763	1,182,763
Mississippi	660,443	693,462	693,462

*Adjusted to include smaller surrounding production areas. See Spilka, Kenyon, and Shabman [1979].

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