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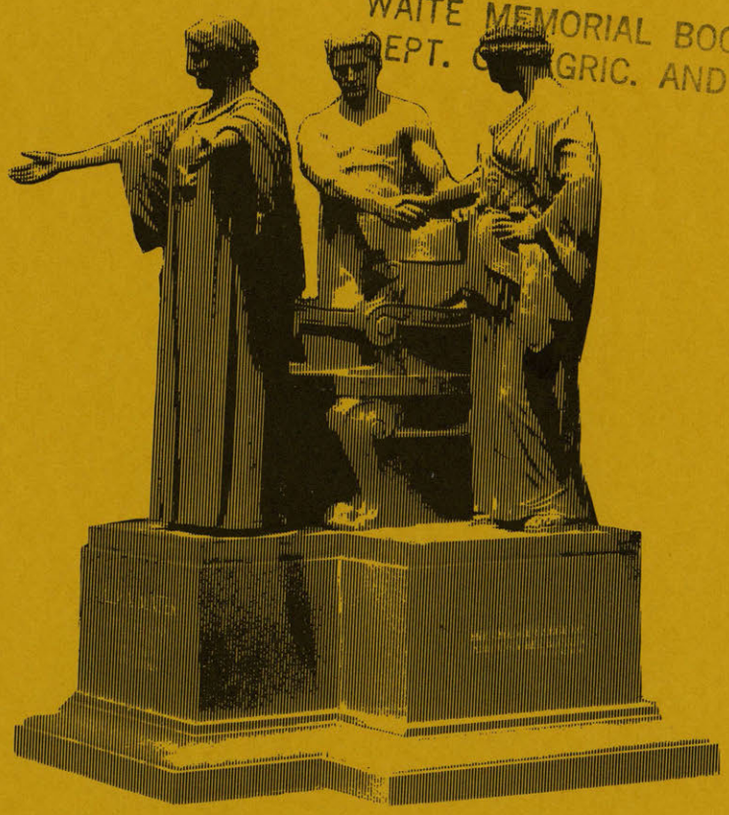

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INTRODUCTION

The inland waterway system plays an important role in the marketing and distribution system for corn and soybeans. About one billion bushels of corn were shipped by barge in 1982-83 on the nation's inland waterways. In comparison, 581 million bushels of soybeans were moved by barge during the same period. A 1977 survey of grain movements revealed that 96 percent of the corn and 94 percent of the soybeans shipped by barge were destined for ports (12, 19).

The Inland Waterways Revenue Act of 1978 (25) contained provisions for imposing an escalating fuel tax on commercial waterway users. This tax was set at four cents per gallon in 1980 and will escalate to 10 cents per gallon by 1985. Other forms of taxation are also being considered to fully recover operation and maintenance expenditures and other costs associated with commercial navigation on the inland waterway system. Uncertainty about the final level of user charges as well as the form of taxation has raised concerns among producers, marketing firms, and transportation companies about the consequences of user fees.

The user fees will increase operating costs for waterway carriers, and these increases in cost will likely be reflected in higher barge rates for grain. Higher rates are expected to affect the competitive position of the barge carriers, alter the comparative advantage of various producing regions and port regions, and increase the total marketing bill for corn and soybeans. The purpose of this paper is to summarize the findings of a recent study that focused on the impacts that user charges could have on the competitive relationships in the production-marketing-distribution system for corn and soybeans. The relative impacts of alternative levels and types of charges on barge movement by river segment, on the comparative locational advantage of producing regions and ports, and on total marketing cost will be examined.

REVIEW OF LITERATURE

Transportation has long been recognized as a major determinant of the location of economic activity. The works of location theorists such as Hover (13), Isard (14), Losch (20), von Thunen (26), and Weber (27) are landmarks in setting forth the relationship between transportation costs and the location of economic activity. Much of the empirical work of recent years dealing with location has focused on interregional competition and the comparative advantage of various production locations in supplying various markets. During the late 1950s and early 1960s, studies in the area of interregional competition ususally focused on the marketing of a single commodity in one period of time. A few of the more prominent studies were: Henry and Bishop - broilers (10), Koch and Snodgrass - tomatoes (16), Hertsgaart and Phillips - cattle (11), Judge and Hieronymus - corn (15), and Nichols, Mathia, and King - fresh snap beans (21).

During the late 1960s and 1970s, attention shifted from the single commodity, single period models to interregional models involving multiple commodities and multiple time periods. One of the early efforts to incorporate both time and space dimensions into a multi-commodity, multi-stage model of the grain marketing system was conducted by Leath and Blakley (18). That model included the existing rate structure for three modes of transportation and was used to determine optimum grain distribution patterns for various grain production regions in supplying various domestic and export markets. This work was extended by Schnake and Franzman (22) to evaluate the effect of introducing cost of service transportation charges into the model on optimum grain distribution patterns. More recent works dealing with grain marketing include studies by Fedeler, Heady, and Koo (8), and Koo and Cramer (17).

The passage of the Inland Waterways Revenue Act of 1978 stimulated new interest in studies focusing on the impact of waterway user charges on the grain marketing system. Some of the more prominent studies are Baumol et al. (1), Beaulieu et al. (2), Binkley et al. (3), Casavant and Thayer (5), Conley and Hill (6), Data Resources, Inc. (7), and Sheehan (23). These studies vary in the method of analysis, commodity coverage, and focus.

This paper summarizes the major findings of a recent study that focused on the impact that user charges would have on the competitive relationships in marketing corn and soybeans.

ANALYTICAL PROCEDURES

A time-staged interregional trade model was formulated and used in the analysis. The model contained 59 domestic regions with production, storage capacity, and consumption demand constraints specified for each quarter of the marketing season. In addition, eleven port areas were included, and export demands were specified by quarter. Beginning and ending inventory constraints were also incorporated so that supplies in excess of current consumption and export needs would be stored in an optimal position from the standpoint of the actual market situation. Storage capacity in each region was designated as on-farm, country elevators, inland subterminal and terminal elevators, river terminal elevators, and port elevators. The costs of in-handling, storing, and out-handling activities were incorporated for each type of facility.

Supply, demand, and capacity restraints were developed for the 1977/78 marketing year, and the model was solved using linear programming methods. The 1977/78 marketing year was selected as the base year so that the "least-cost" flow patterns generated for the base model could be validated using the actual flow patterns that were established for 1977 in the national grain movement survey (12, 19).

Three modes of transportation were included in the analysis, and each type of storage facility was restricted with respect to the type of transportation service available. Truck was specified as the mode for movements from farm storage to country elevators. Shipments from country elevators to terminals, river elevators, and demand points were allowed to move by truck or rail. Shipments from terminals and subterminals moved by truck, 5-car rail units, and unit trains. Unit trains were allowed in movements to port elevators only and were restricted to origins where their use is common. River elevators were specified as transshipment points with grain moving in by truck and rail and out by barge.

Interregional transfer costs for each mode of transportation were estimated using a transportation rate data base developed by the SM-42 and

S-115 Regional Research Committees (9). The rates were updated using data on freight rate increases provided by the Tennessee Valley Authority. Once the base model was solved and validated, the barge rates were varied to reflect alternative levels and types of user charges. Rail and truck rates were assumed to remain fixed since the rate responses these modes will make are unknown at this point in time. In view of the recent excess capacity in the grain hopper car fleet, a significant rate response by railroad was not considered likely.

The extent to which barge rates between various origins and destinations would increase because of user charges depends upon the type of fee imposed (recovery method) and the amount of waterway costs recovered with user charges. Three methods of recovery were considered in this study. These were a fuel tax, a uniform ton-mile fee, and a segment specific ton-mile fee. These schemes were analyzed for 50-percent and 100-percent recovery of the U.S. Army Corps of Engineers operation and maintenance costs and the Coast Guard's navigation aid costs. In addition, the 4-cent and 10-cent per gallon fuel taxes authorized in the 1978 Act were evaluated for comparison purposes.

Federal expenditures, tonnage, and estimated fuel consumption for the Mississippi-Gulf Intercoastal Waterway Systems are shown by river segment in Table 1. The impact of a uniform per-gallon fuel tax will vary from one river segment to another because of varying rates of fuel consumption on each segment. The estimated fuel consumption rate per ton mile is influenced by size of tug boats and barge tows, operating, speed, speed of river current, capacity and number of locks, ratio of loaded barges to empty barges, and direction of travel. These factors were taken into account in estimating fuel consumption rates on each river segment. Fuel consumption rates varied from 1.844 gallons per 1,000 ton-miles on the lower Mississippi to 3.207 gallons per 1,000 ton-miles on the Arkansas.

The ton-mile fees were computed directly from the data in Table 1 by dividing the costs to be recovered by the ton-miles for the system or the specific segment. For example, to fully recover the $140 million with a uniform fee would require a charge of about 66 cents per 1,000 ton-miles in 1977. When barge rates were adjusted for fuel taxes, it was assumed that the barge rate on each segment would increase to reflect the estimated

fuel consumption rate on that segment. The 4-cent per gallon and 10-cent per gallon fuel taxes would recover about 13 percent and 32 percent, respectively, of the total cost shown in Table 1. A tax of 31 cents per gallon would fully recover the cost in 1977 given the estimated fuel consumed by commercial waterway users.

Table 1. Estimated Federal Expenditures, Ton-miles, and Fuel Consumption for the Mississippi-Gulf Intercoastal Waterway Systems by River Segment.

River segment	Operation & maintenance expenditures 1977	Coast Guard aid 1975	Ton-miles 1977	Estimated fuel consumption	
				Per 1,000 ton-miles	Total
	-- 1,000 dollars --		Million	Gal.	1,000 gal.
Upper Mississippi	37,408	2,297	11,394	2.555	29,112
Lower Mississippi	18,060	1,830	128,072	1.844	236,165
Illinois	9,071	806	8,047	2.640	21,244
Ohio	22,374	831	37,467	2.662	99,737
Missouri	5,709	448	1,596	2.599	4,148
Arkansas	15,019	300	1,298	3.207	4,163
Tennessee & Cumberland	5,955	119	4,873	2.618	12,758
Gulf Intercoastal Waterway	17,683	2,171	18,227	2.245	40,920
Total	131,279	8,842	210,974	2.125	448,247

Sources: (4, 24)

The user charges were assumed to be passed on by waterway carriers in the form of higher rates. The study by Conley and Hill found that while diesel fuel costs rose by 60 cents per gallon between January 1979 and May 1981, barge rates fell by 20 cents a bushel. That study found that actual barge rates reflect the demand for barge transportation which corresponds to the volume of exports from New Orleans.

ANALYTICAL RESULTS

The impact of alternative types and level of charges were analyzed by comparing the base model solution to model solutions when alternative user charges were imposed. The base model determined the distribution pattern for corn and soybeans that would minimize the total cost of marketing (handling, storage, and transporation) between the producing farm and final points of consumption, processing, and export. The model allocated available supplies over time and space in an optimum manner.

Alternative Policies Compared

The impact of alternative user charge policies on the volume of corn and soybeans shipped by barge are shown in Table 2. The impact of alternative user charge policies varied greatly depending upon the commodity and the level of cost recovery. All types and levels of user charges had the effect of reducing the volume of corn and soybeans shipped by barge.

Table 2. Change in Volumes Shipped by Barge Under Alternative User Charge Policies

Item	Corn	Soybeans
	1,000 bushels	
Base Model Volume	898,863	356,487
USER CHARGE POLICY:	Percentage Change	
Four cent Fuel Tax	-3.8	-10.7
Ten cent Fuel Tax	-6.1	-11.3
50% Fuel Tax	-9.9	-13.2
50% Uniform Fee	-6.2	-11.3
50% Segment Fee	-86.3	-56.0
100% Fuel Tax	-63.7	-35.8
100% Uniform Fee	-63.3	-34.7
100% Segment Fee	-99.8	-90.6

Fuel Tax

Analysis of the four-cent fuel tax imposed in 1980 revealed that barge movements of soybeans were more sensitive to initial changes in barge rates. The four-cent tax reduced the volume of soybeans shipped almost 11 percent.

Increasing fuel taxes to the 50 percent recovery level reduced corn shipments by barge by 10 percent below the base model. The volume of soybeans shipped by barge was 13 percent below the base model total. Full recovery of waterway costs through fuel taxes would have a substantially greater impact on corn shipments than on soybean shipments. In constrast, the impact on soybean shipments was somewhat greater at the 50 percent recovery level.

Uniform Fee

A uniform ton-mile fee was the second recovery method analyzed. Imposing user charges in this manner involves cross-subsidization where fees collected on high-volume segments would subsidize low-volume or high-cost river segments. This approach is appealing in that the high-cost segments generate traffic which contributes to the volume on the Lower Mississippi and reduces the cost burden on the remaining traffic. The impact of a uniform fee was less than the impact resulting from fuel taxes at the 50-percent recovery level, and the differential impact involved the Upper Mississippi segment. Measured in terms of traffic diversion alone, a uniform ton-mile fee and a fuel tax were found to have about the same impact.

Segment-Specific Fee

Some observers argue that each segment should be responsible for its own costs. A segment-specific ton-mile fee would have the effect of allocating the cost burden in this manner. The evidence in Table 2 suggests that this form of user charges would likely result in the greatest diversion of grain tonnage to other modes of transport. The analysis assumes a full rate response by water carriers and no rate response from rail carriers so the impact of user charges on volume moved by barge will probably be less than shown in Table 2. However, the same rail rate structure was used in all models so the different response under segment fees is real and very significant. In view of these findings, the segment-specific fee has the potential to be self-defeating by eliminating grain traffic on low-volume segments. This form of user charge would definitely have the greatest adverse effect on the competitive position of waterway carriers.

Barge Movements by River Segment

The impacts of alternative tax levels on the volume of corn and soybeans originating on each river segment are shown in Table 3. The 16 cents

per gallon tax would recover about 50 percent of waterway cost while 31 cents would approximate full recovery of the cost shown in Table 1.

Table 3. Impact of Alternative Fuel Tax Levels on Barge Shipments by River Segment

Commodity and River Segment	Base Model Volume	FUEL TAX LEVEL (Cents per gallon)			
		4	10	16	31
	1,000 bu.				
CORN					
Upper Mississippi	406,656	0.0	-4.2	-12.7	-49.5
Lower Mississippi	213	0.0	0.0	0.0	0.0
Illinois	411,634	-3.3	-3.3	-3.3	-70.8
Ohio	80,139	-25.4	-29.9	-30.5	-99.5
Missouri	221	0.0	0.0	0.0	0.0
Arkansas	0	0.0	0.0	0.0	0.0
Tennessee	0	0.0	0.0	0.0	0.0
All Origins	898,863	-3.8	-6.1	-9.9	-63.7
SOYBEANS					
Upper Mississippi	228,593	-16.2	-16.2	-19.2	-43.7
Lower Mississippi	27,768	+3.0	+3.3	+3.3	+6.8
Illinois	49,268	0.0	0.0	0.0	-12.8
Ohio	42,011	0.0	-5.1	-5.1	-46.3
Missouri	0	0.0	0.0	0.0	0.0
Arkansas	8,847	-20.8	-20.8	-20.8	-42.4
Tennessee	0	0.0	0.0	0.0	0.0
All Origins	356,487	-10.7	-11.3	-13.3	-35.8

The analysis revealed that barge movements of corn from Ohio River origins were very sensitive to changes in barge rates. Traffic diversion on that segment occurred primarily at Indiana origins when taxes were 16 cents or less. User fees to fully recover waterway costs would have a substantial impact on corn shipments from origins on the Upper Mississippi and Illinois river segments. Tax levels of 16 cents or less had a much smaller impact on flows from those origins.

In the case of soybeans, the impacts of user fees on volume shipped by barge were focused on the Upper Mississippi and Arkansas River segments. The impact on movements from Ohio river origins was small until taxes were

raised to full recovery levels. An interesting finding was the positive effect on volume of soybeans shipped from origins on the Lower Mississippi. These findings suggest that user fees would enhance the relative competitive position of soybean producing areas adjacent to that river segment. This implication will be examined in the next section.

Comparative Advantage of Production Regions

In addition to the optimum flow patterns discussed above, the "least cost" solutions to the models also provide information about the relative value of the commodities at various origins and destinations. In theory, pricing over space is efficient if the values of a commodity at a particular destination point and the origin point(s) supplying that destination differ by the costs of handling and transporting a unit of the commodity between the two locations. Likewise, pricing is efficient over time if the value of a commodity at different points in time at a particular storage location differs by the cost of storage. The dual variables of linear programming are consistent with this theory and may be used to evaluate the relative comparative advantage of the various supply and demand points.

In this analysis, the North Dakota-South Dakota area was selected as the base point, and commodities were assigned values of zero at that origin. The relative values at other origins during the fall quarter were then computed from the model solutions. The relative values of corn and soybeans in each state that were derived from the base solution are shown in Table 4. In cases where a state was split into substate regions in the model, the relative value in each substate region was weighted by production and averaged to derive a relative value for the entire state. The base model price differentials reflect the relative locational advantage of each state in marketing corn and soybeans. For example, on average Ohio soybean producers enjoyed a 6.3 cents per bushel locational advantage over Indiana producers (29.2-22.9).

The impacts of fuel taxes to recover 50 percent and 100 percent of waterway costs on the relative values in each state are also shown in Table 4. The higher barge rates caused by the user charges had the effect of enhancing the relative locational advantage of major soybean producing states located

Table 4. Shifts in Regional Price Differentials in Response to User Charges Imposed Through a Fuel Tax.

Region	Corn			Soybeans		
	Base model	50 Percent recovery	100 Percent recovery	Base model	50 Percent recovery	100 Percent recovery
	Cents per bushel					
Northeast						
All states	39.4	-2.4	-3.2	14.1	- .4	-1.8
Lake States						
Michigan	20.5	-2.5	-3.2	16.1	- .4	-1.8
Minnesota	21.8	-3.5	-4.6	13.9	-1.5	-4.0
Wisconsin	13.2	0	0	14.8	- .4	-1.8
Corn Belt						
Ohio	26.1	-2.6	-3.0	29.2	- .5	-1.2
Indiana	22.4	-2.4	-3.1	22.9	- .4	-1.6
Illinois	26.4	-2.5	-4.3	21.2	- .4	-1.6
Iowa	10.6	- .4	- .2	8.9	+ .7	+1.8
Missouri	27.6	-1.1	-2.2	20.0	0	0
Northern Plains						
North Dakota	0	0	0	0	0	0
South Dakota	0	0	0	0	0	0
Nebraska	16.7	+ .5	+ .8	23.8	0	0
Kansas	20.9	0	0	32.8	0	0
Appalachian						
Virginia	40.8	-2.5	-3.0	35.7	- .4	- .9
North Carolina	37.0	-2.3	-3.1	32.4	- .4	-1.8
Kentucky	27.2	-2.0	-2.6	19.7	0	+ .1
Tennessee	32.4	-1.5	-2.1	24.8	+ .4	+ .8
Southeast						
Alabama	40.2	-2.2	-2.7	30.1	+ .3	+1.3
Georgia	48.1	-2.3	-2.8	26.8	- .4	- .9
Florida	56.6	-2.3	-2.8	--	--	--
South Carolina	42.0	-2.3	-2.9	24.1	- .4	- .9
Delta						
Arkansas	41.2	- .1	- .8	26.0	+2.4	+4.0
Louisiana	55.7	- .3	- .4	27.5	+2.6	+4.1
Mississippi	38.2	-1.1	-2.2	27.4	+1.9	+3.2
Southern Plains						
Oklahoma	39.9	0	0	9.4	+ .9	+ .9
Texas	29.8	- .1	- .9	11.4	+2.5	+4.1
Mountain						
All states	47.9	+ .5	+ .8	--	--	--
Pacific						
Washington	73.0	+ .5	+ .9	--	--	--
Oregon	73.0	+ .5	+ .9	--	--	--
California	94.4	+ .5	+ .8	--	--	--

near Gulf ports. For example, in the base model the average value of soybeans at Louisiana supply points was 6.3 cents per bushel higher than the average value at Illinois supply points because of location. The soybean price differential between Illinois and Louisiana increases to 12 cents when user charges were imposed to recover 100 percent of costs.

The data in Table 4 should not be interpreted as showing the absolute change in prices resulting from user charges. However, they can be used to study the relative impact on producers in various states. For example, the 4 cents per bushel locational advantage Illinois corn producers had over Indiana producers in the base model decreased to 2.8 cents per bushel with the adoption of a 100 percent recovery fuel tax. Thus, the impact would be 1.8 cents greater on average for Illinois producers in comparison with Indiana producers.

Comparative Advantage of Port Regions

The impact of user charges on relative prices at various ports were also evaluated. The price differentials at the various ports in the fourth quarter are shown in Table 5. The fourth quarter was selected for this analysis so that all marketing charges (handling, storing, and transporting) incurred in the marketing process are reflected in the differentials. These differentials may be compared directly with the origin-point values presented in Table 4.

The results reported in Table 5 reveal that imposing user charges on waterway carriers will alter the relative competitive position of various ports. The lower price differentials at Corn Belt origins were reflected in lower differentials at Great Lake and Atlantic ports. Comparing price differentials at Atlantic and Gulf ports revealed that a 100 percent recovery fuel tax would enhance the relative competitive position of Atlantic ports by four cents per bushel for corn and five cents per bushel for soybeans. The average comparative advantage of Lake ports relative to the Gulf was improved by three cents for corn and five cents for soybeans.

The volume exported through each port was held constant in the model, so a change in flow patterns in response to these price changes did not occur. The imposition of user fees on waterway carriers will reduce the

comparative advantage of ports located on the Gulf of Mexico, and unit train movements from eastern Corn Belt origin to Atlantic ports can be expected to increase as user fees escalate.

Table 5. Shift in Price Differentials at Ports in Response to User Charges Imposed Through a Fuel Tax

Region and port	Corn			Soybeans		
	Base model	50-percent recovery	100-percent recovery	Base model	50-percent recovery	100-percent recovery
	Cents per bushel					
Lake Ports						
Duluth	63.4	-3.3	-4.5	55.6	-1.5	-3.9
Chicago	64.8	-2.4	-3.2	68.1	-0.4	-1.8
Toledo	73.6	0.0	0.0	89.6	-0.4	-1.8
average	67.4	-1.8	-2.5	78.6	-0.5	-2.0
Atlantic Ports						
Albany	92.0	-2.5	-3.3	86.4	-0.4	-1.1
Baltimore	92.0	-2.5	-3.3	86.4	-0.4	-1.1
N. Charleston	93.5	-2.4	-3.2	84.2	-0.4	-0.9
average	92.0	-2.5	-3.3	86.2	-0.4	-1.1
Gulf Ports						
Mobile	92.2	-1.2	-2.3	86.4	+0.2	+0.3
New Orleans	92.1	+0.6	+0.9	86.4	+2.6	+4.1
Houston	92.6	+0.5	+0.8	86.8	+2.6	+3.6
average	92.1	+0.4	+0.5	86.4	+2.5	+3.9
Pacific Ports						
Portland	118.9	+0.5	+0.8	173.7	+2.5	+4.1
Sacramento	139.2	+0.5	+0.8	173.7	+2.5	+2.2
average	126.4	+0.5	+0.8	173.7	+2.5	+4.1

Total Marketing Cost

The alternative user charge policies may also be compared from the standpoint of their impact on the total cost of marketing corn and soybeans. The total cost for each of the model solutions is shown in Table 6. Although

fuel taxes and uniform fees were found to have about the same impact on volumes shipped by barge, a uniform fee would have a smaller impact on total marketing cost. Marketing cost would increase by an estimated $30 million if a uniform fee were imposed at the 50-percent recovery level. Full recovery with a uniform fee would add an additional $23 million to the marketing bill.

To the extent that the impact of user charge policies on volume moved by barge is less than what is shown in Table 2, impacts of the policies on total marketing cost may be higher than those presented in Table 6. A positive rate response by railroads will definitely increase the cost of marketing corn and soybeans.

Table 6. Impact of Alternative User Charge Policies on Industry Cost

User charge policy	Total marketing cost 1/	Increase in cost	Percentage change
	Millions of dollars		Percent
Base model	3,016		
Four cents fuel tax	3,026	10	0.3
Ten cents fuel tax	3,039	23	0.8
50 percent recovery:			
Fuel tax	3,052	36	1.2
Uniform fee	3,046	30	1.0
Segment fee	3,086	69	2.3
100 percent recovery:			
Fuel tax	3,075	59	2.0
Uniform fee	3,069	53	1.8
Segment fee	3,091	74	2.5

1/ Total cost of handling, transportation and storage (1977/78 price levels).

CONCLUSIONS

Imposing user charges on commercial users of the nation's inland waterways is a controversial subject. All participants in the grain marketing system will be affected; however, the impact will vary depending upon the method of imposition, level of charges, and location of participant.

A comparison of alternative methods of imposition revealed that segment-specific ton-mile fees would probably have a significantly greater impact on the volume of corn and soybeans shipped on the nation's waterwyas. Low volume river segments will not continue to transport grain if 100 percent of waterway costs are recovered in this manner. Uniform ton-mile fees and fuel taxes were found to have smaller impacts in terms of diverted traffic.

Comparing traffic diversion in response to various levels of fuel taxes revealed that the impact varies greatly from one river segment to another. Corn movements on the Ohio River were very sensitive to user fees, indicating that the comparative advantage of the barge mode in moving corn from those origins is not very great. In the case of soybeans, user fees are expected to have the greatest impact on the Upper Mississippi and Arkansas Rivers.

The relative competitive position of most producing regions will be affected by user fees. The impacts are very uneven and can differ by as much as five cents per bushel for corn. The impact on relative prices of soybeans in various states varied even more, and the relative competitive position of producers in the South should be enhanced. The comparative advantage of various ports will also be affected, and this may increase the share of total exports handled by Great Lake and Atlantic ports.

Legislation is currently being considered that would limit user charges to a 70-percent recovery level. In view of this activity, the study results for the 50-percent recovery level would appear to represent the most likely impacts at this time.

This study involved the basic assumption that railroads would not make a rate response to waterway user fees. If railroads do respond by increasing rates as barge rates increase,less grain traffic will be diverted from the barge mode. However, this action would have additional impacts on the comparative advantage of various production and export points, and the bill for marketing grain and soybeans would increase more than the results of this study indicated. Recent legislation to deregulate rail rates has increased the uncertainty about the response that the railroads will make with respect to rates.

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