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Introduction

The Inland Waterways Revenue Act of 1978 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 being considered to fully recover operation and maintenance expenditures and other costs associated with commercial navigation on the inland waterway system.

The inland waterways play an important role in the movement of corn and soybeans from regions of concentrated production to points of consumption and export. A 1977 survey of grain movements revealed that 96 percent of the corn shipped by barge was destined for ports, and 99 percent of those shipments moved to Gulf ports (Hill et al.) In comparison, 94 percent of the soybeans shipped by barge in 1977 moved to ports, and 98 percent of those movements were destined for Gulf ports (Leath et al.)

Imposition of user charges will increase operating costs for waterway carriers, and those increases in cost will likely be reflected in higher barge rates. Higher rates will increase the price differentials between various origins and destinations served by barges, will result in a diversion of traffic to competing modes of transport, and will increase the total marketing bill for corn and soybeans. As flow patterns adjust to the new rate structure, the relative locational advantage of

various production, consumption, and port areas will be altered. The extent to which the relative comparative advantage of various locations is affected depends upon the level of user charges, the method in which the charges are imposed, and the response of competing transportation modes with respect to rates.

This investigation joins others which deal with waterway user charges. These studies (Baumol et al., Beaulieu et al., Binkley et al., Conley and Hill, DRI, and Sheehan) vary in the method of analysis, commodity coverage, and focus. This paper summarizes the major findings of a study at the University of Illinois that focused on the impacts that user charges would have on the competitive relationships in marketing corn and soybeans. The relative impact of alternative levels and types of charges on barge shipments by river segment, regional comparative advantages, and total marketing cost will be emphasized.

METHOD OF ANALYSIS

A time-staged interregional trade model was used in the analysis. The model contained 59 domestic regions with quarterly production, storage capacity, and consumption demand constraints. In addition, eleven port areas were specified with quarterly export demand constraints. 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. In-handling, storing, and out-handling activities were incorporated for each type of facility. Country elevators were restricted to shipping by truck and 5-car rail units;

subterminals were allowed to ship by truck, 5-car rail units, and unit trains (to ports only); and river elevators were restricted to barge shipments.

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.

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 (Free et al.) 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 navigational 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.

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, 11).

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 cost 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.

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 per 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 transportation) between the producing farm

and final points of consumption, processing or export. The model allocated available supplies over time and space in an optimum manner.

Barge Shipments by River Segment

The impacts 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, the river segment of origin, 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.

Fuel Tax

Analysis of the four-cent fuel tax imposed in 1980 revealed that barge movements of corn from Ohio River origins were very sensitive to changes in barge rates. The four-cent tax reduced the volume originating on that segment by 25 percent. That tax also resulted in a slight reduction in shipments from Illinois river origins. In contrasts, the effect of that tax on soybean movements was focused on the Upper Mississippi and Arkansas River segments. An interesting finding was the positive effect on the volume of soybeans shipped from origins on the Lower Mississippi. This finding suggests that user fees would enhance the relative competitive positions of soybean producing regions located closer to the Gulf. This implication will be examined in more detail later.

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 contrast, the impact on soybean shipments was somewhat greater at the

Table 2. Percentage Change from Base Model in Volumes of Corn and Soybeans Shipped by Barge Under Alternative User Charge Policies by River Segment.

River segment of origin	Quantity shipped base model	Four cent fuel tax	Ten cent fuel tax	50 Percent Recovery			100 Percent Recovery		
				Fuel tax	Uniform fee	Segment fee	Fuel tax	Uniform fee	Segment fee
	1,000 bu.	Percentage change							
Corn Shipments:									
Upper Mississippi	406,656	0.0	-4.2	-12.7	-4.3	-99.5	-49.5	-49.7	-99.7
Lower Mississippi	213	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illinois	411,634	-3.3	-3.3	-3.3	-3.3	-70.8	-70.8	-70.8	-99.9
Ohio	80,139	-25.4	-29.9	-29.9	-30.5	-99.5	-99.5	-99.3	-99.5
Missouri	221	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tennessee	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All origins	898,863	-3.8	-6.1	-9.9	-6.2	-86.3	-63.7	-63.3	-99.8
Soybean Shipments:									
Upper Mississippi	228,593	-16.2	-16.2	-19.2	-16.2	-53.9	-43.7	-41.8	-86.4
Lower Mississippi	27,768	+3.0	+3.3	+3.3	+3.3	-47.2	+6.8	+3.3	-90.0
Illinois	49,268	0.0	0.0	0.0	0.0	-31.5	-12.8	-12.4	-100.0
Ohio	42,011	0.0	-5.1	-5.1	-5.1	-92.9	-46.3	-45.7	-100.0
Missouri	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	8,847	-20.8	-20.8	-20.8	-20.8	-99.9	-42.4	-42.4	-99.9
Tennessee	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All origins	356,487	-10.7	-11.3	-13.2	-11.3	-56.0	-35.8	-34.7	-90.6

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-subsidation 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.

Commodity Comparisons

The results indicate that soybean tonnage on the waterways would be more responsive to user charges than corn tonnage at recovery levels of 50 percent of less. In contrast, user charges to fully recover costs would have a greater effect on corn tonnage. Barge movements from Ohio River origins to Gulf Ports were not competitive when rates were adjusted to reflect 100-percent cost recovery. The smaller impact on soybean tonnage reflects the fact that soybeans are grown intensely in areas that border waterways because of the relative high humidity in these areas. The relatively smaller decrease in soybean shipments as opposed to corn reflects the strong comparative advantage waterway carriers currently enjoy in moving soybeans to Gulf Ports.

Regional Price Differentials

Once the "least cost" flow patterns were determined using the model, the relative value of the commodities at various supply and demand points were determined from the model solution. The price differentials are based on the assumption that the value of a commodity at a particular destination and point in time should differ from its value at the origin supplying that destination by the cost of transferring a unit of the commodity between the two points and time periods. North Dakota-South Dakota area was selected as the base point in this analysis and assigned a value of zero. The relative values at other origins were then computed.

The relative values in each substate region were weighted by supply in each region and averaged to derive a relative value for each state. The state price differentials derived from the base model are

shown in Table 3. These data reflect the relative locational advantage of each state in marketing corn and soybeans. For example, on average Illinois corn producers had a 4.0 cents per bushel locational advantage over Indiana producers in the marketing of corn (26.4-22.4). The higher values in regions such as the Southeast reflect the fact that those states are deficit areas and corn must be shipped in from Corn Belt origins.

The impacts of fuel taxes to recover 50 percent and 100 percent of waterway costs are also shown in Table 3. The higher barge rates caused by the user charges have the effect of enhancing the relative locational advantage of major soybean producing states located 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 of soybeans 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 3 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 for Illinois producers in comparison with Indiana producers.

The impact of user charges on relative prices at various ports were also evaluated. The lower price differentials at Corn Belt origins were reflected in lower differentials at Great Lake and Atlantic ports. Com-

Table 3. 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	--	--	--

paring price differentials at Atlantic and Gulf ports revealed that a 100 percent recovery fuel tax would improve the relative locational advantage 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.

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 are shown in Table 4. Although fuel taxes and uniform feeds 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.

Table 4. 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 the nation's waterways in a controversial subject. The impact of user charges vary depending upon the level of charges and the methods of imposition. The major conclusions drawn from the study reported here are:

- Segment specific ton-mile fees were found to have a significantly greater impact on the volume of corn and soybeans shipped by barge.
- Uniform ton-mile fees had the least impact in terms of diverted traffic; however, the impact was similar to a fuel tax given a specific cost recovery level.
- Soybean movements by barge were somewhat more sensitive than corn movements when the user charge recovered 50 percent or less of waterway cost. At full-cost recovery, barge movements of corn were affected to a greater degree.
- Analysis of price differentials revealed that the relative locational advantage of most producing regions would be affected, and the relative competitive position of some producing states would be enhanced.
- The relative competitive position of Great Lake and Atlantic ports would be enhanced and the proportion of exports handled by those ports will probably increase.
- At full-recovery levels, the increase in total marketing cost varied from $59 million to $74 million depending upon the type of charge.
- The actual impact of waterway user charges will depend upon how much barge and rail rates change as a result of imposing user charges.

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