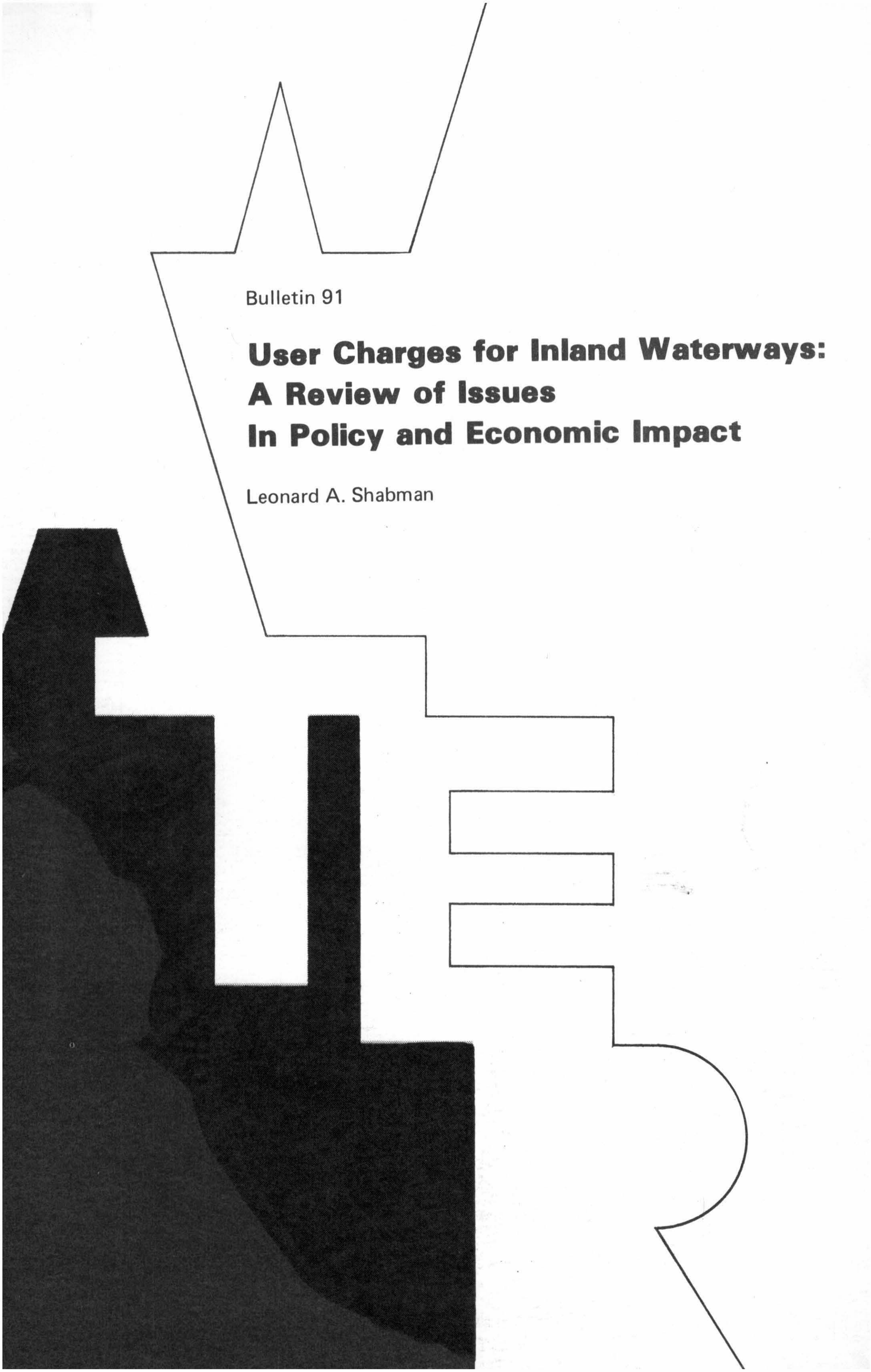

Bulletin 91

User Charges for Inland Waterways: A Review of Issues In Policy and Economic Impact

Leonard A. Shabman

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ERRATA

p. 73, line 12 should read:
promote *efficiency* in resource use....

p. 75, lines 15,16 should read:
subsidy *are divided between the buyer and the seller of the subsidized product in the ratio of the elasticity of supply to the elasticity of demand.*[1] *Therefore* the subsidy is....

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ABSTRACT

Numerous studies have discussed the various issues associated with the adoption of user charges for inland waterways. This study is a synthesis of these discussions, and a preliminary analysis, using secondary data sources, of the economic impact of alternative user charge policies. The main conclusions of this preliminary analysis are: (1) the benefits of a free waterway policy are shifted forward to shippers and their customers; (2) a fuel tax would have limited effects on traffic movements while a segment toll would result in closing of some parts of the waterway system. Under the most severe cost conditions, only 3 percent of the total traffic would move from the system.

INTRODUCTION

Beginning in the early 17th century, the nation's rivers served first as principal routes of exploration, and then developed into principal routes of trade. In the 1970's, navigable waterways remain important in the transportation of commodities between trade areas, although inland waterborne freight movements now represent only about 18 percent of the nation's annual freight tonnage. Most of this traffic consists of bulky commodities with a relatively low value in relation to weight. Such products as fossil fuels, grains, and chemicals comprised fully 75 percent of total tonnage shipped in 1973 [U.S. Army Corps of Engineers, 1973]. These products move on inland waterways that are "free public highways." Indeed, it was a conscious choice of the nation's founders that the nation's waterways remain "common highways and forever free," as the Northwest Ordinance stated it. Perhaps it was a fear that barriers to commerce which had developed in Europe, also would develop in the new nation that prompted Alexander Hamilton to comment:

> The commerce of the German Empire is in continuous trammels from the multiplicity of the duties which the several princes and states exact upon the merchandise passing through their territories, by means of which the fine streams and rivers with which Germany is so happily watered are rendered useless. Though the genius of the people of this country [United States] might never permit this description to be strictly applicable to us, yet one may reasonably expect, from the gradual conflicts of State regulations, that the citizens of each would at length come to be considered and treated by the others in no better light than that of foreigners and aliens.
>
> The Federalist, No. 22

Whatever the cause, the nation's policy concerning waterways became one guaranteeing use free of tolls or duties. Such a policy removed one possible impediment to the use of the only significant overland transportation system in Colonial America. This necessary reliance on water transport encouraged the improvement of the existing waterways by federal and state government. Between 1790 and 1909, over $250 million was spent on navigational improvements for the nation's rivers [Moulton, 1926]. Since 1909, areas once believed unnavigable have been made navigable by federal expenditures for structures to regulate water flows and for continuous maintenance of the inland waterway system. However, as maintenance and construction expenditures have increased substantially in recent years, some have begun to question the wisdom of continuing these federal expenditures without recovery of costs through some system of user charges. The National Water Commission [1974] recommended that a fuel tax and lockage fee be imposed upon waterway users. The Congress has called for a study under Section 80 of PL 93–251 of the question of user charges for water resource development in which some attention will be directed to inland waterway user charges. These actions are the most recent expression of earlier, similar calls. In spite of active debate over many years, knowledge of the nature and extent of the impact of user charges remains uncertain. Indeed, our basic knowledge of the waterway transport industry is minimal. As Dwight Blood observes:

> . . . Numerous attempts have been made by economists, engineers, and journalists to appraise inland waterway transport problems and opportunities. Yet, paradoxically, despite the volumes of literature and reams of material written about inland waterways, surprisingly little substantive information has been developed about the inland waterway industry; thus there exists a crucial deficit in information in evaluating policy alternatives. The same basic hypotheses about waterways have been circulating now for decades, but little improvement has been made in their objective verification [Blood, 1971; p.i].

Blood goes on to note that his study seeks to be "primarily a synthesis of existing information and policy debates about the development and future of inland waterway transport in the U.S." [Blood, 1952, p.ii]. The intention of this study is a similar synthesis; however, it will attempt to focus directly upon the issue of user charges for inland waterways.

The original design of this project was to investigate the existing knowledge base about the multiple potential impacts of charges on users of the nation's inland waterways. The hope was that a comprehensive literature search would find a substantial number of studies on the subject from which to draw a consistent set of conclusions. However, it soon became obvious that such studies did not exist, although several published and unpublished pieces did discuss the issues in general terms. These included presentations by both opponents and proponents of user charges, and a review of these writings did provide a broad base for identifying key points of concern.

The approach taken here was first to develop a conceptual framework for examining the feasibility and impact of user charges, and then, after reviewing the literature on inland waterways, to put qualitative dimensions on this framework. To accomplish this task in as complete a fashion as possible, the review included policy as well as economic issues. The objectives of the study then became the following:

1. **To examine the economic criteria for setting user charges for inland waterway navigation;**

2. To assess the distribution of the subsidy associated with free waterways, and the analogous burden of a user charge, between shippers on inland waterways and barge operators;

3. To determine the impact of user charges for inland waterways upon

   (a) traffic on individual waterway segments,
   (b) ton-miles of waterway freight traffic; and,

4. To identify the most economically and politically viable alternative for the imposition of user charges.

Clearly these objectives are quite limited in scope, and those familiar with the inland waterway user charge debates will recognize that some elements of the controversy are not considered in detail. These include the impact of waterways on regional economic development, the impact of free waterways on final consumer good prices, the uses of waterways by recreational traffic, the problems of waterway congestion, and the relationship of waterway traffic to regulatory policies of the Interstate Commerce Commission. These points are discussed in various places as they bear upon the development of necessary arguments, but the primary objectives do not deal directly with these issues.

Section I is an overview of waterway transportation, the barge industry, federal expenditures on navigational improvements, and the present environment for establishing a user charge policy. Section II discusses the market for waterway transportation, including the production, cost, supply of, and demand for inland waterway transportation. Section III develops the economic issues surrounding the adoption of user charges for inland waterways, and then discusses the economic criteria for setting user charges for inland waterway navigation (Objective 1 above). With this background, Section IV discusses the impact of alternative user-charge charge proposals in terms of Objectives 2 and 3. Because of the limitations of this study, many of the results must be stated in qualitative terms. The data base and our understanding of key parameters are simply too limited to allow quantitative estimates. Finally, in Section V, the economic impact assessment and policy history are brought together to address Objective 4.

One of the hazards of attempting a state-of-the-art summary for a topic of current public concern is that events may move more quickly than the publishing process. The congressionally requested study of waterway user charges under Section 80 of PL 93–251 will be made public by the time the final version of this Bulletin is published. Similarly, other studies have come to the attention of the author that were not included in this review, and were ongoing at the time this review was in progress [Christianson, 1974; Sasaki, 1974]. Finally, in a time of rapidly fluctuating economic conditions, the waterway transport industry itself will be subject to short-term fluctuations in output and structure. Thus, the use of 1973 and earlier data in much of this review may prompt some readers to question the validity of the conclusions drawn. However, the data used here examine relative relationships which provide evidence for qualitative conclusions. The long-term trends and underlying relationships within the barge industry, and between it and its competitors, probably have not altered with the current economic situation. Thus, the general implications of this review are felt to be valid, even given the relatively "old" data base.

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SECTION I

THE ENVIRONMENT FOR A USER CHARGE POLICY

I. The Inland Waterway System

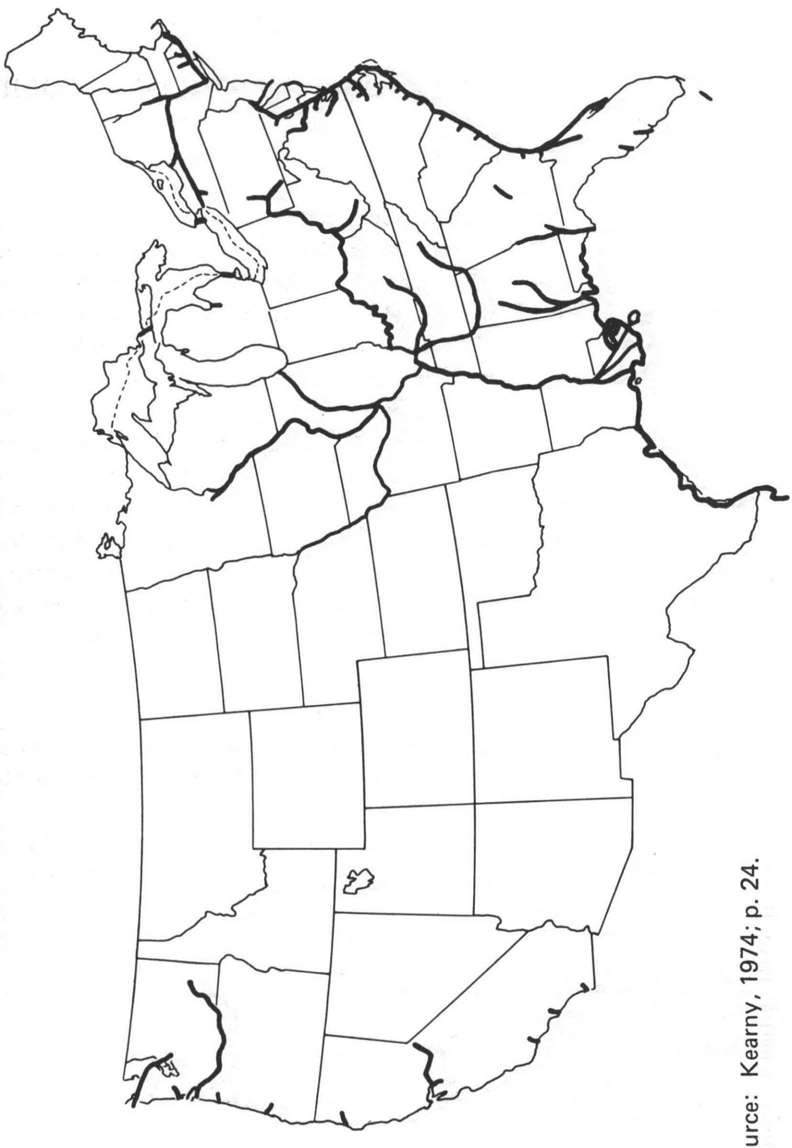
There are 25,543 miles of improved inland waterways in the United States. Of these 15,675 miles exceed the depth of nine feet which is required for the movement of most modern barge traffic, although by the standards of oceangoing vessels all inland waterways traffic can best be characterized as "shallow draft." The inland waterways are a transport mode that provides intercity freight transport in competition with, or as a complement to, airways, highways, pipelines, and railroads. However, inland waterway transportation is restricted to those areas of the nation where rivers flow. Hence a major portion of the system comprises the Mississippi River from Minneapolis-St. Paul to its mouth, including certain tributaries such as the Ohio, Missouri, and Illinois Rivers. In fact, over 5,900 miles of the Mississippi River System have a controlling depth of nine feet or more, representing 35 percent of the nation's total of commercially significant waterways. More detail about the waterways can be found in Table I-1 and Figure I-1.

TABLE I-1
Commercially Navigable Inland Waterways of the United States by Lengths and Depths, Improved and Natural Channel Depth

	Length in Miles of Waterway		
Waterway Group	Under 9 Feet	Greater than 9 Feet	Total
Atlantic Coast Waterways (exclusive of intracoastal waterway system)	2,667	3,103	5,770
Atlantic-Gulf Intracoastal Waterway (Mexican border to Norfolk, Virginia)	65	2,306	2,371
Gulf Coast Waterways (exclusive of intracoastal waterway system)	2,702	1,590	4,292
Mississippi River	2,989	5,965	8,954
Pacific Coast Waterways	1,228	2,347	3,575
Other	217	364	581
All Waterways	9,868	15,675	25,543

Source: American Waterways Operators, 1973; p.1.

FIGURE I-1
Inland Waterways with Controlling Depths Greater Than Nine Feet



Source: Kearny, 1974; p. 24.

II. Inland Waterway Traffic

The freight moved on the inland waterway system is carried in flotillas of unmanned barges which are strung together in "tows" propelled by towboats. Tows consist of from 1 to 40 barges depending upon the type of service and commodity being shipped. Barges may be added to or removed from the tow during the voyage. The drafts of the tow vary from 6 to 12 feet depending upon the waterway to be traversed.

TABLE I-2
Vessels for Freight Transportation on the Inland Waterways, for years 1967-1971 and 1973

	1967	1969	1971	1973
Towboats				
Number	4,395	4,248	4,059	4,064
Average Horsepower	806	908	1039	1095
Cargo Vessels				
Number	18,611	19,171	20,947	22,117
Number/Towboat	4.23	4.51	5.16	5.44

Source: American Waterways Operators, 1973; p. 2-3.

The most common barge in use measures 195 feet by 35 feet and draws approximately eight and one-half feet of water when fully loaded. While barges are designed for the hauling of bulk-loaded commodities, both dry and liquid, there are numerous barges of varying design for the hauling of specialized products such as caustic chemicals and petroleum products. Towboats have two to four deisel engines which drive twin propellors. The technology employed in shipping has been changing over time. As Table I-2 indicates, since 1967 average horsepower per towboat has increased by 35 percent, while the number of cargo vessels per towboat has increased and towboat numbers have fallen. This suggests that larger tows pushed by more powerful towboats are becoming the rule.

However, one study observes,

> Evolutionary development, as opposed to revolutionary advancement, characterizes inland waterways transportation technology. [However,] technological development in many areas of inland marine operation appears to be reaching the point of diminishing returns. This is particularly true in the case of floating equipment (tow boats and barges) due to the physical constraints on the waterway system . . . [Kearny, 1974; p. 44].

This particular view expresses an opinion about the technology per se, but does not directly consider the rate of adoption of the benefits of such technology in the industry. For example, the fact that average horsepower is still around 1,000 suggests that many small towboats are still in operation—which in some instances may suggest that many operators have yet to take advantage of improved technology. Another important aspect of water freight transportation technology is that of cargo handling. The adoption of new technology for handling bulk comodities, which are the principal products transported on the inland waterway system, has been rapid in coal and liquids, but there may still be room for improvement in many areas. Since the total transportation service includes line haul as well as cargo handling, both areas warrant consideration when discussing waterway transport.

The waterborn freight transport industry tends to be competative, with about 1,850 companies providing freight service. Of these, 141 are common carriers regulated by the ICC. The information in Table I-3 for 1970, indicates that the majority of firms are exempt from regulation and are on a for-hire basis to potential shippers, and therefore are likely to compete in rates. The term "exempt" carriers refers to Part III of the Interstate Commerce Act which exempts certain water carriers from regulation. Specific definitions of "exempt" have been at the discretion of the ICC and are subject to change. Private carriers are individual industries which own equipment, and provide their own transportation service. Most of the private carrier fleet is composed of barges and they contract for towboat power with exempt or regulated carriers.

TABLE 1-3

Number and Size of Waterway Transportation Firms by River System and Category, for 1970

River system	firms	% of firms with less than 10 vessels
Mississippi River System and Gulf Intracoastal Waterway		
Regulated by ICC	35	------
Exempt, for hire	764	------
Private	123	------
Total	922	71%
Atlantic and Gulf Coasts		
Regulated by ICC	55	------
Exempt, for hire	538	------
Private	68	------
Total	661	82%
Pacific Coast		
Regulated by ICC	51	------
Exempt, for hire	180	------
Private	35	------
Total	266	79%

Source: Blood, 1972; pp. II-16 and II-20.

One particular point of interest in Table I-3 is the large proportion of firms which own fewer than 10 vessels. The existence of these many small firms suggests a high degree of competition in the industry, but also raises some questions about the ability of these firms to take advantage of the new technologies in waterborne transportation. This point will be pursued in greater depth later, but may be a critical factor to consider in assessing the impact of user charges.

Table I-4 further substantiates that competition in rate setting between barge operators probably characterizes the industry. Total ton-miles carried are provided predominantly by exempt carriers which are free to compete on rates.[1] Regulated carriers take on particular significance in the shipment of iron ore, iron, and steel, while private carriers dominate the low unit-value products of sand, gravel, and stone and shells.

Total waterborne commerce has been increasing substantially each year, as Table I-5 shows. Also of interest in Table I-5 is the average length of haul column. This indicates a trend in water transportation toward providing increasingly long hauls in intercity transport. This probably arises from the improved character of the waterways over time and the long-haul cost advantage of waterway transport, which has been responsible for its increased share of the total market. This changing share is shown in Table I-6. Note also that this share seems to be stabilizing since 1960.

As a general rule, the products shipped by water are of low value in relation to weight. Table I-7 shows traffic in the major commodity groups and its growth between the years 1968 and 1973. Major gains during the period were lead by grains, but chemicals and other products advanced also. Interestingly, petroleum did not increase substantially during the period, which may reflect increasing competition from pipelines. Also in Table I-7 is information on the average haul. The great increase in grain is particularly striking. Also note the great discrepancy between grains and the shortest-haul commodity of sand, gravel, and stone.

---

[1] The ton-mile is the generally accepted measure of output for the freight transportation industry. This measure can be further modified to reflect technical operating efficiencies—for example, ton-miles per day or ton-miles per barge. However, it should be recognized that the ton-mile measure ignores heterogeneity of transport production, which arises from quality differences between transport modes or the characteristics of the different products being shipped. Efforts are made to consider this measurement problem by speaking of specific commodity types, modes, and origin and destination points. Thus, we may speak of a ton-mile of coal between points A and B carried by barge. This becomes quite cumbersome for analytical work and simplifying assumptions are often necessary in order to use the ton-mile measure. In short, the ton-mile is an imperfect measure, and it should be used carefully in analytical discussions.

TABLE I-4

Ton-Miles by Commodity by Carrier Type for 1973 (in thousands)

(Numbers in parentheses are percentages of total commodity carried, by carrier type; ton-mile figures include only internal traffic where the entire movement takes place on inland waterways in shallow-draft vessels.)

Commodity	Total	Regulated	Exempt	Private
Petroleum and Petroleum Products	45,891,605	308,628 (0.77)	37,058,228 (80.8)	8,524,749 (18.6)
Coal and Coke	31,067,599	6,680,810 (21.5)	23,124,639 (74.4)	1,262,150 (4.1)
Iron Ore and Iron and Steel	9,388,681	7,573,223 (80.7)	1,764,516 (18.8)	50,942 (0.5)
Sand, Gravel, Stone	4,435,757	402,209 (9.1)	1,507,721 (34.)	2,525,827 (56.9)
Grains	28,750,492	5,071,936 (17.6)	22,817,738 (79.4)	860,818 (3.0)
Logs and Lumber	1,341,855	158,749 (11.8)	889,238 (66.3)	293,868 (21.9)
Chemicals and Related Products	21,581,173	526,747 (24.4)	18,904,700 (87.6)	2,149,726 (10.0)
Shells	2,039,904	9 (0.00)	94,899 (4.7)	1,944,996 (95.3)
Others	27,393,850	6,462,461 (23.6)	19,115,398 (69.8)	1,815,991 (6.6)
Totals	171,890,916	27,184,772 (15.8)	125,277,077 (72.9)	19,429,067 (11.3)

Source: U.S. Army Board of Engineers for Rivers and Harbors, 1954.

TABLE I-5

Total Traffic Transported on Inland Waterways, For Selected Years

(Total ton-mile figures do not agree with totals from Table I-4 since this traffic includes tonnage carried on the inland waterways in both oceangoing and shallow draft vessels)

Year	Tons	Ton-Miles	Average Length of Haul in Miles
1940	183,417,791	22,411,961,000	122
1950	297,694,832	51,656,637,000	174
1960	395,250,101	120,784,337,000	301
1965	472,480,483	152,812,240,000	323
1970	553,598,222	204,084,966,000	369
1971	560,470,417	214,003,291,000	375
1972	597,255,337	229,754,234,000	385
1973	596,459,513	232,307,988,000	389

Source: American Waterways Operators, 1973; p. 4.

TABLE I-6

Share of Intercity Freight by Modes for Selected Years (as percent of total ton-miles)

Year	Rail	Truck	Pipeline	Great Lakes	Inland Waterway
1950	56.2	16.3	12.1	10.5	4.9
1955	49.5	17.5	15.9	9.3	7.7
1960	44.1	21.8	17.4	7.5	9.2
1965	43.3	21.9	18.7	6.7	9.3
1970	40.6	21.7	22.7	4.1	10.8
1971	39.0	23.2	23.1	3.7	10.9
1972	38.6	23.1	23.4	3.6	11.3
1973	39.5	23.2	22.7	3.9	10.7

Source: American Waterways Operators, 1973; p. 6. and U.S. Department of Transportation, 1971; p. I-9.

TABLE I-7

Inland Waterway Traffic by Commodity Type, for Years 1968 and 1973

Commodity Group	Ton-Miles (in thousands) 1968	Ton-Miles (in thousands) 1973	Percent Change	Average Length of Haul in Miles per Ton 1968	Average Length of Haul in Miles per Ton 1973
Petroleum and Petroleum Products	43,593,056	45,891,605	5.3	315.7	275.6
Coal and Coke	25,259,622	31,067,599	23	252.4	268.5
Iron Ore and Iron and Steel	7,798,154	9,388,681	20.4	848.6	762.9
Sand, Gravel, Stone	3,992,586	4,435,757	2.5	66.0	72.3
Grains	17,719,288	28,750,492	62.2	1082.8	1200.8
Logs and Lumber	1,356,826	1,341,855	–1.1	75.9	79.4
Chemicals and Related Products	15,850,138	21,581,173	36.2	644.8	658.0
Shells	1,975,713	2,039,904	3.2	114.4	117.5
All Other	21,762,197	27,393,850	25.9	463.7	486.8
Total	139,307,580	171,890,916	23.4	323.8	341.6

Source: U.S. Army Corps of Engineers, 1968 and 1973.

III. Public Expenditures

Since the Civil War, waterways have been improved and maintained principally by the Federal government through the Army Corps of Engineers. The Corps program included channel maintenance and improvement through clearing and dredging, the development of canals, and the construction of locks and dams. The inland waterway system is part of a multi-purpose water development program that provides not only for enhanced navigation opportunities, but also flood control, power generation, recreation, irrigation, and water supply. Thus it often is extremely difficult to determine what portion of all federal expenditures are directly attributable to navigation. Data supplied by the Army Corps to the Department of Transportation in 1970 shows total federal construction expenditures of nearly $3 billion through 1969 for inland waterways. The Office of the Chief of Engineers, using an economic life of 50 years and a four and seven-eighths percent discount rate, estimates historical annual interest and amortization of $160 million for this $3 billion expenditure [see Table I-8]. These data also included estimates of operation and maintenance expenditures by the Corps during the previous 12 years. Average annual costs for July 1, 1952 through June 30, 1957 were between $45 to $50 million. By Fiscal Year 1969, these costs had risen to an estimated $78.7 million [see Table I-9].

Other expenditures on waterways are made by local and state governments and other federal agencies. No recent estimates are available, although in 1959 the Corps estimated non-federal government costs at $75 million dollars annually. Significant local costs arise from the requirement that local interests provide disposal sites for dredge spoil. Nonetheless, the largest portion of public costs are borne by the federal government, and it is these costs which have provided the major impetus for the user charge debate.

TABLE I-8
Construction Allotments for Inland and Intracoastal Waterways Through June 30, 1969

Expenditure Category	Amounts (Millions)
Allotted for single-purpose navigation projects	$1,903.6
Portion of allocations for multiple purpose projects allocable to navigation	674.7
Portion of allocations for Mississippi River flood control project allocable to navigation	396.5
Total	$2,924.8

Source: U.S. Department of Transportation, 1971.

TABLE I-9

Expenditures for Operations and Maintenance of Inland Waterways June 30, 1968 to June 30, 1969

(Excluding Great Lakes and seacoast harbors.)

Expenditure Category	Amounts (Millions)
Single-purpose navigation projects	$66.5
Multi-purpose projects—allocable to navigation	5.6
Mississippi River flood control project—allocable to navigation	6.5
Total	$78.7

Source: U.S. Department of Transportation, 1971

Beyond the federal expenditures of the Corps are many other expenditures for aids to navigation such as bouys and markers, search and rescue operations, ice breaking, and the like. An estimate of Fiscal Year 1972 expenditures for all federal cost items by agency as shown in Table I-10.

However, while several estimates of expenditures are available, none of these estimates agree on the exact number of dollars spent yearly on the inland waterways program. Both an inability within agencies like the Corps to

TABLE I-10

Fiscal Year 1972 Outlays for Inland Waterways by Federal Programs

Program	Amount (Millions)
Corps of Engineers New Construction	$173
Corps of Engineers Operation and Maintenance	75
Corps of Engineers Recreational Boating 0 & M and Construction	6
Tennessee Valley Authority Operation and Maintenance	3
United States Coast Goard Boating Safety Program	2
United States Coast Guard Search and Rescue	17
United States Coast Guard Commercial Vessel Safety	3
United States Coast Guard Marine Environmental Protection	6
Total	$299

Source: Franklin, 1973.

exactly allocate funds to a navigation program, and the multiplicity of programs at all levels of geovernment make the development of exact figures impossible. The "Section 80" study referred to in the previous section should be available in 1976, and should provide a more definitive picture of the scope of expenditures.

IV. Policy History

The policy that the inland waterway system should remain "forever free" has its origins in the colonial period of U.S. history. The commerce power of Congress defined in Article 1, Section 8, of the Constitution states that Congress will have the power "to regulate commerce with foreign nations, and among the several States, and with the Indian Tribes." It also gives Congress the power to regulate navigation and navigable waterways. The Second Clause, Section 10, of the first Article protects the freedom of commerce throughout the country by prohibiting the use of "duty of tonnage . . . so as to carry out that intent."

The Ordinance of 1787, which outlined the government for the Northwest Territory of the United States, is the other major document that instituted the free waterway policy. It says:

> It is hereby ordained and declared, by the authority aforesaid, that the following articles shall be considered as articles of compact between the original States, and the people and States in the said territory, and forever remain unalterably free unless by common consent. . . .
>
> The navigable waters of the Mississippi and St. Lawrence, and the carrying places in between the same shall be the common highways, and forever free, as well as to the inhabitants of the said territory, as to the citizens of the United States.

On August 7, 1789, the Ordinance was adopted by Congress into law and in 1790 the Ordinance was extended to include the Southwest Territory of the United States. Legislative acts in 1790, 1796, and 1803 extended the exemptions from taxes, imposts, or duties to the territory south of the Ohio River and declared that navigable rivers within the public lands were public highways. They also provided that all navigable rivers within the territory of the United States south of Tennessee were to remain public highways [U.S. Office of the Federal Coordinator of Transportation, 1939; p. 19].

In Colonial America there were few, if any, overland transportation systems. Indeed, the physical and economic expansion of the country was dependent upon a good system of transportation, and this was offered by the navigable waters of the colonies. Although the federal government began to support the improvement of harbors in 1789, the states took the lead in expenditures and developments. The federal government, however, made substantial contributions by granting rights of way, public land, and some financial allocations for canal and river improvements.

> During the early decades of our national history, it was quite customary for the individual States to undertake harbor improvements as well as projects for the improvement of inland navigation. Expenditures for such purposes were recouped in some measure by the charging of tonnage duties and tolls, respectively [U.S. Office of the Federal Coordinator of Transportation; p. 198].

However, the role of the states has since waned, due both to their inability to finance large-scale expenditures and to the perception of a broader national interest in navigational improvements.

> With the exception of large expenditures for the New York State Barge Canal, successor to the Erie Canal . . . and of certain outlays for flood control, the expenditures for inland waterway improvements (other than terminal facilities) since 1850 by the individual States or their political subdivisions have been comparatively slight [Senate Commerce Committee, 1961; p. 198].

Initially, however, the states performed much of the initial construction of canals, locks, and dams, and it was not unusual for them to charge tolls for their use. The Doyle Report discussed two cases where projects were transferred to federal control, but there was a continued policy of charging tolls [Senate Commerce Committee, 1961]. On the Wisconsin and Fox Rivers, tolls were to be used to reimburse the United States based upon an act passed on July 7, 1870, saying:

> That all tolls and revenues derived from the improvements made or acquired under the provisions of this act, after providing for current expenses of operating and keeping the same in repair, shall be paid into the treasury of the United States, and whenever the United States shall be reimbursed for all sums advanced for the same with interest thereon, then the tolls aforesaid shall be reduced to at least the sum which, together with other revenues properly applicable thereto, if any, shall be sufficient to operate and keep the improvements in repair [Senate Commerce Committee, 1961; p. 198].

For the Louisville and Portland Canal, which was acquired under the act of May 11, 1874, it was noted:

> That the said canal and property appertaining thereto shall be held for the common use and benefit of the people of the United States, free of all tolls and charges except such as are necessary to pay the current expenses of said canal and to keep the same in repair . . . [Senate Commerce Committee, 1961; p. 199].

Because tolls continued to be charged after the federal government had acquired the waterway, the steadfast strategy of "toll-free" waterways was violated.

This was recognized in the Rivers and Harbors Act of 1882, which marked the termination of tolls when a navigation facility was transferred to federal control. It also was the first time Congress specifically legislated a general mandate which prohibited tolls on all federal waterways, indicating:

> That no tolls or operating charges whatsoever shall be levied or collected upon any vessels, boats, dredges, craft or other water craft passing through any canal or other work for the improvement of navigation belonging to the United States [PL-209, Sec. 5].

After the Civil War, inland navigation suffered a severe decline because of the competition from the railroads and because appropriations did not meet the expansion needs of the waterways. "It was urged that . . . improvements would not only afforded needed relief for the railroads and a cheaper form of transportation, particularly for low-grade commodities, but also provide an effective regulator of railroad rates" [U.S. Office of the Federal Coordinator of Transportation, 1939; p. 11].

In 1907 the Inland Waterways Commission was formed by Theodore Roosevelt. The National Waterways Commission was created in 1908. Both studied the possibilities of improvements in the inland navigation system, and both recommended increased development. The National Waterways Commission reported:

> The time is at hand for restoring and developing such inland navigation and water transportation as upon expert examination may appear to confer a benefit commensurate with cost, to utilized independents and as a necessary adjunct to rail transportation [U.S. Senate, 1912; p. 19].

At the same time, the prohibition of tolls and the policy of federal improvement of the waterways was reemphasized in the Rivers and Harbors

Appropriations Act. With such support, a second era of inland navigation improvements began, this time under federal auspices and with a clear toll-free policy. However, by the 1940's this policy began to be questioned.

An extensive study, *Public Aids to Transportation*, published in **1939** stated:

> Gathering together all of the preceeding discussion, it may be concluded that the assessment of tolls would remove an unstablizing influence from the field of transportation, lessen or eliminate the rancor and the lack of willingness to cooperate which mark the relations of rail and water carriers, and make for more successful planning of future waterway improvements and of transportation policies generally. On the other hand, the assessment of such charges would require a radical but not impossible change in a long-established national policy . . . [U.S. Office of the Federal Coordinator of Transportation, 1939; p. 125].

Thus it was suggested that, although the common highway policy was strongly entrenched, this did not mean that it could not be changed with the emergence of new conditions in transportation. In 1940, Franklin D. Roosevelt became the first President to support a policy of user charges. His Budget Message of January 4, 1940 recommended that a portion of the annual costs for dredges, channels, and buoys be recovered from the users through use of minimal fees. However, Congress continued the original policy of "toll-free" waterways.

These incidents represent the first time that the policy of free inland water transportation was seriously questioned with the prospect that the policy would be modified. In the past, individuals had made appeals for the implementation of user charges, although never seriously expecting legislative action. It is noteworthy that this shift in opinion occurred, for it reaffirmed the possibility that tolls could be used to recover costs as they were used on the Erie Canal, the Louisville and Portland Canal, and the Wisconsin and Fox Rivers.

Truman's policy reflected the opinion of Roosevelt, that of implementing some type of user charge. In 1950, the President's Water Resources Policy Commission, under Truman, submitted that:

> Decisions as to user charges, or tolls for water commerce should be worked out as part of the whole problem of reconciling and making workable a coordinated transportation system. But with rates from all forms of transportation based on full costs, an interconnected system of modern waterways, coordinated with

> land transportation, should be able to sustain itself with tolls based on full costs and yield returns on the public investment, while contributing to most economic use of the Nation's resources [President's Water Resources Policy Commission, 1950; p. 202-203].

A 1954 study on the application of user charges on waterways by the Army Corps of Engineers suggested that user charges could be imposed on the inland navigation system to recover the costs related to the waterways. If such a policy ever were approved, the Corps indicated a user charge based on ton-mile units would be the most satisfactory. It appeared to be the most equitable, it would directly relate to the use of inland waterway improvements, and it also would serve as a basis in fixing charges proportionate to use.

> ... [I] t seems quite clear that there is not constitutional barrier to the adoption by the Federal Government of a program of tolls, or user charges, to recover all or part of the cost of Federal funds expended for improvement of the navigable waters of the United States, as well as the cost of maintaining and operating such improvements [U.S. Army Board of Engineers for Rivers and Harbors, 1954].

However, executive and administrative recommendations of this period did not alter Congressional determination to maintain the free waterway policy. The members of Congress continued to base their support of improvement of low-cost water transport on the perceived benefits directly rendered to manufacturers, farmers, and consumers. Another perceived beneficial effect of water transportation was that it provided competition for rail freight charges.

In 1956, the Presidential Advisory Committee on Water Resources Policy under President Eisenhower submitted a report favoring some type of user charges.

> Although it would appear logical, in the interest of a completely uniform policy as to the participation of beneficiaries in the costs of water resource developments, that user charges should be instituted which would at least bear the cost of operation and maintenance of such navigation facilities, it must be recognized that the subject of user charges involves not only water policy but also the whole field of transportation, including many other media. Therefore, it is a more appropriate subject for a survey of the entire field of transportation than one of water policy alone [Senate Committee on Commerce, 1961; p. 32].

However, no Congressional action was taken as a result of the Committee's report.

In 1960, the Department of Commerce issued a study favoring the institution of user charges. Two years later, President Kennedy proposed the institution of a system of user charges on inland waterways. The President suggested a fuel tax of two cents per gallon.

> I also recommend enactment of a new system of user charges for commercial and general aviation and for transportation on inland waterways. . . . To extend the principle of user charges to inland waterways, a tax of two-cents per gallon should be applied to all fuels used in transportation on these waterways, effective January 1, 1963 [*Railway Age Weekly*, 1962].

President Johnson reiterated this proposal in his budget messages. In 1965, Johnson recommended a fuel tax that would extend to all domestic vessels having a maximum draft of 15 feet or less. He reaffirmed his position to the Congress in his *Economic Report of President together with the Annual Report of the Council of Economic Advisors* saying:

> I am recommending the creation of a Department of Transportation
> —to manage the vast Federal promotional programs in highways, waterways, air travel and maritime affairs, and
> —to take leadership in the development of new transportation policies in accord with current realities.
>
> I am proposing again this year increased user charges on highway and aviation and the introduction of nominal user charges on inland waterways. Such charges will improve efficiency in the use of resources, and reimburse the Federal Government for a part of its expenditures which directly benefit the users of these facilities [1966, p. 16].

The 1966 report elaborates on the President's remarks.

> At the same time, cost should reflect the value of all the resources required to provide the service. Federally provided transportation facilities have continually expanded. Users should pay their fair share of the cost and maintenance of the highways, waterways, and airway facilities. As it is, there are uneven payments from different classes of users—some making substantial payments and others none at all. Adequate user charges should be instituted in the interest of both equity and overall transportation efficiency. The President's Budget Message again proposes new or increased

transportation user charges.

During the 1969-71 period of the Nixon administration, the specific impact of waterway user charges upon the transportation system's ability to move bulk commodities was reviewed. However, one White House official claimed that "the timing is not right for cost sharing" [National Waterways Conference, 1974a]. Because of White House reluctance, the Nixon Administration position on user charges for navigation was difficult to predict. In a statement issued on the signing of H.R. 10203, the Water Resources Development Act of 1973, the President stated:

> The Congress in this bill has asked me to present recommendations on such critical policy issues in the water resources field as cost-sharing and project evaluation criteria, including discount rates. I am gratified that the Congress now share my view of the importance of these problems, and I will continue to work in a spirit of receptiveness to update some of what I consider to be anacronistic policies concerning water projects [National Waterways Conference, 1974b].

Although there has been a reversal in Presidential attitude toward the public highway doctrine, the policy still remains intact. Without the support of Congress, the Presidential trend will never become implemented. The decision to institute a user charge program rests with Congress as defined in the Constitution under the Commerce Clause.

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SECTION II

THE MARKET FOR WATERWAY TRANSPORTATION

I. Introduction

Several studies have concluded that the existing literature on inland waterways and the potential impact of user charges is inadequate for the task of careful policy evaluation. For example, Blood [1972] argues that we need to:

> Expand the analytical and conceptual base in both . . . the water resource policy area and the transportation policy area, to permit explicit evaluation of water costs and benefits and transport costs and benefits within these total areas . . . (obtain) more objective evidence about the management and operation of the industry and about the total range of possible effects of water public investments. [pp. 117-20].

This goal cannot be fully accomplished in a literature review of this sort. Rather, this study will develop the economic arguments necessary for any careful analysis of the user charge issue, and then develop the qualitative parameters of those arguments through reference to the limited literature on the subject of waterway transportation. Since this literature may not always deal directly with the user charge issue, the conceptual framework can provide a basis for adapting some of this previous work to the purposes of this study.

Within the economic framework, user charges will fall initially upon the producers of the waterway transport service as an additional cost of production, thus affecting the industry supply schedule. However, changes in the cost and supply condiditons will not exert their influence on the water transport market in isolation. The demand for waterway transportation is an essential element of the total market adjustment process to a user charge. Therefore, the underlying premise is that the transportation system will work toward an equilibrium, resulting in changes in transport rates and quantities shipped by the water mode.[1]

The less elastic the demand for water freight transport, the less quantity shipped will be affected by rate changes that may be induced by user charges. Also, the less elastic the demand, the more likely that the increased cost

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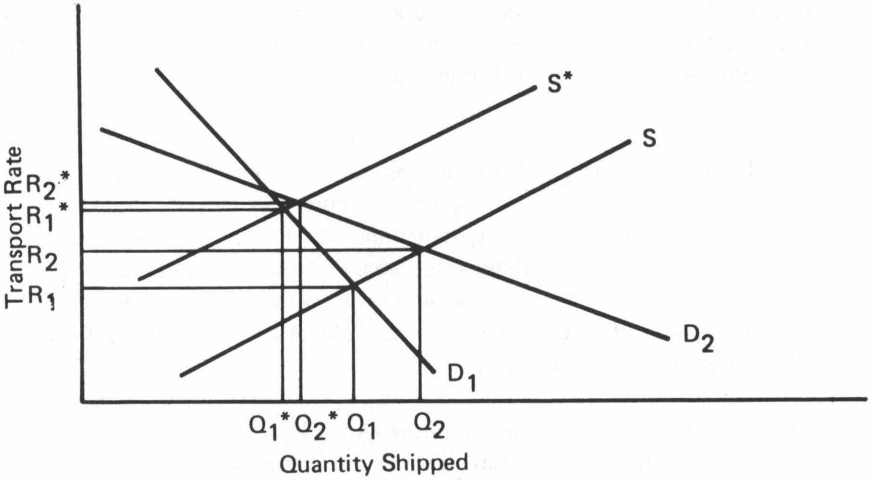
[1] One area of concern in examining the impact of a user charge is the short-run versus long-run question. For purposes of this review, the short run is considered only as it leads to an understanding of long-run adjustments. In essence, the focus is on the before and after impact of a user charge and not what occurs during adjustment.

represented by the user charge will be passed forward to the shipper. Figure II-1 demonstrates these arguments graphically.

FIGURE II-1

Influence of Demand Elasticity



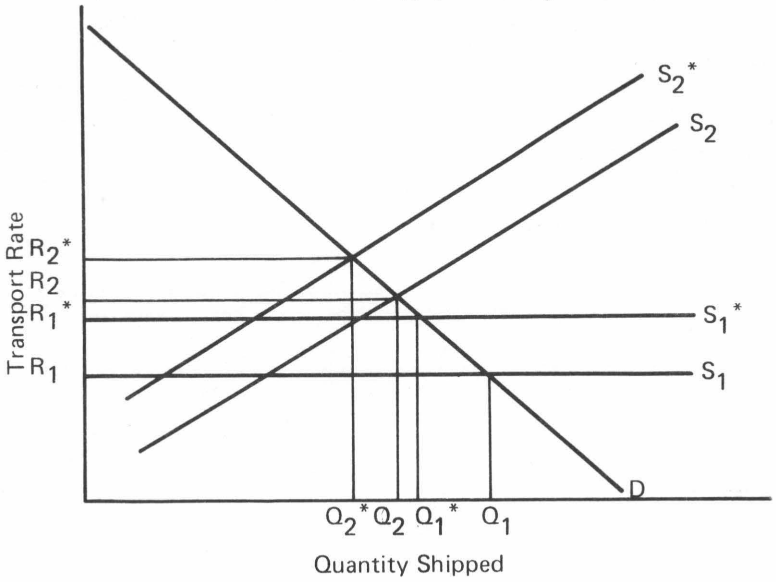
Demand, D_1 is less elastic than demand, D_2. Given a supply shift from S to S*, induced by a constant per unit of output user charge, the effect on quantity taken is less as demand is less elastic. That is, $(Q_1 - Q_1{}^*)$ is less than $(Q_2 - Q_2{}^*)$. However, the increase in the transport rate charged to the shipper is greater for the less elastic demand, that is $(R_1 - R_1{}^*)$ is greater than $R_2 - R_2{}^*)$.

Given a demand curve, a less elastic supply curve results in a small change in quantity shipped and a smaller price increase to the shipper. Indeed, as Figure II-2 shows, a perfectly elastic supply curve will result in a rate increase exactly equal to the change in production cost induced by the user charge, with quantity taken depending entirely upon the elasticity of demand. In Figure II-1, the shift from S_1 and S_2, to $S_1{}^*$ and $S_2{}^*$, respectively, resulted in quantity and rate changing less as supply was less elastic.

One particular aspect of the rate and quantity adjustment process is how a user charge imposed upon the supplier, in fact, will affect industry supply. To the extent that it causes adjustments in production that may induce substitution or scale changes, the magnitude of the supply curve shift may be less than, equal to, or greater than that suggested by the user charge. Therefore, not only must demand and supply elasticity be considered in assessing impact, but so, too, must production and cost adjustments that may be made by the individual barge firm.

FIGURE II-2

Influence of Supply Elasticity



II. Line Haul Production, Cost and Supply

a. Basic Static Theory of Production, Cost, and Supply:

The production function shows how firms employ various combinations of resource inputs to produce their product output with a given state of technology. By restricting analysis to two inputs, an isoquant map can be drawn which allows for a graphic display of the concept of the marginal rate of technical substitution between inputs for the production of given levels of output. From this basis the laws of diminishing returns, and of diminishing returns to scale of the firm can be derived. The former is the case of varying one input while leaving others fixed, and the latter arises from varying all production inputs simultaneously. It is these basic laws of production which give rise to the generally expected shape of total, average, and marginal product curves for an input, and to the fact that returns to all inputs varied together may result in ever smaller increments of total product. Technology in either the familiar form of material innovation, or as changes in management practices, shifts the entire production function allowing for increased output although the same combination of inputs may be in use.

The relationship between the production function and cost is direct. It is the price of inputs that determines how they will be substituted in production within the constraint of the marginal rate of technical substitution. The addition of isocost lines to the isoquant map shows the least-cost combinations of inputs a firm will use to produce different levels of output. By holding some inputs fixed in the short run, average and marginal cost schedules are derived. Given the existence of diminishing returns in production (giving rise to a U-shaped average cost curve), and the existence of a competitive industry structure, the firm's optimum level of output is where average cost is at a minimum and where marginal cost and average cost are equal. Shifts in the short-run marginal cost and average variable cost can come from shifts in the production function and/or from changes in the input prices the firm must pay.

In the long run, all inputs are allowed to vary. From another viewpoint, the long run may be thought of as a series of short runs, in which alternative units of some input are varied while others are held constant. The result is a series of short-run, average-cost curves which trace out a long-run average cost by connection of minimum points on the short-run curves. This long run curve has a U-shape arising from *internal* economies and diseconomies in production. As in the short run, optimum output levels occur at the minimum point on the long-run average cost curve. The long-run curve will shift position when either input prices change or the production function is altered. Given perfect competition in the product market, the firm's profits will be normal if it produces where marginal revenue, marginal cost, and average cost are equal, which is at the minimum point on the average-cost curve for both the long run and short run.

In a perfectly competitive market, the supply curve is derived from the summation of those segments of individual firm's marginal-cost curves which lie above average variable cost. Since marginal-cost curves are derived from a firm's production function, the shape and slope of the industry's short-run supply curve depends upon the production functions of the industry's constituent firms. Thus the position of the supply curve is affected by changes in input prices, while curve shifts are mitigated by the feasibility of substitution among inputs and the possible adoption of new technology.

In the long run, firms are able to enter and leave the industry, no resources are fixed, and every firm earns a normal profit. Through the actions of the market, the elasticity and position of the long-run industry-supply curve will depend upon the presence or absence of *external economies or diseconomies* induced by action of firms within the industry leading to constant cost, increasing cost, or decreasing cost industries. These will be termed industry-related externalities. However, the use of the term "long-run industry supply" is somewhat misleading. In fact, the long run is itself only a limited amount of time. The long-run supply curve itself may move about, and at different times show decreasing, constant or increasing costs with changing industry size. As such the long-run supply elasticity can vary over time.

When industry-related external effects are not significant, the industry is termed constant cost. Increasing-cost industries are characterized by industry-related external diseconomies, while decreasing-cost industries show industry-related external economies. Such external effects result from a change in the individual firms's operating environment. These effects can take the form of pecuniary externalities which result in input prices to the firm being affected by changes in the industry demand for the input. In addition, non-pecuniary external effects can occur when the action of one firm in the industry directly affects the production function of another firm. It must be emphasized that such effects should not be confused with *internal* economies or diseconomies that are totally within the control of the firm. Furthermore, industry-related external effects should not be confused with external effects arising from factors exogenous to the industry's behavior. *Movements along* the long-run industry supply trace out the effects of industry-related pecuniary and non-pecuniary external effects. On the other hand, changes in input price which arise from causes exogenous to industry behavior, or changes in technology bearing upon the individual firm's production functions, lead to *shifts in* the long-run supply curve.

The previous discussion is not meant to provide a complete discussion of the economics of cost and supply. However, in order to examine the impact of user charges for inland waterways, which may be viewed as a change in price for the currently zero-priced water highway, some basic points about cost and supply should be set forth. More specifically, the final impact of user charges will depend upon the long-run supply curve. This, in turn, will depend upon individual firm production and cost conditions. Thus, one needs to know:

1. if the barge transport industry is competitive. The competitive nature of the industry was established in Section I of this study;

2. if there are substitution possibilities in the production of waterway transport for the firm that will respond to exogenous changes in input prices;

3 if changes in technology can significantly affect individual firm production and cost;

4 if there are scale economies in the size of the individual firm; and,

5. what items 1-4, above, suggest about the long-run industry supply of waterway transportation.

b. Survey of Empirical Work:

The literature on waterway transportation line-haul production and cost functions is based upon two different estimation techniques: a statistical approach and an engineering approach.[2] Two separate studies which each used a different approach have the following to say. On the engineering approach:

> The data on which engineering production functions are based consist . . . of technological information from controlled experiments. . . .
>
> There are several advantages in estimating production functions from engineering data and principles. The range of applicability of the function is known in advance; it does not depend, in general, on data limitations. Unlike the information used in cross-section and time-series studies, engineering variables are not typically restricted to the range of actual observation. Moreover, the results of production investigations are not biased by the type of equipment actually installed in a plant. Therefore, production functions based on engineering data and relationships more closely conform to the production function of economic theory. It follows that cost curves derived from production functions also possess the same advantages and also approximate more closely those of economic theory [Desalvo, 1970; p. 7].

On the statistical approach:

> There is no easy way of adapting the engineering process function to describe actual operations. The engineering relation is an ideal one, much like the production and cost functions of economic theory. Actual operations consist of equipment which is outmoded or not operating at peak efficiency; it consists of bad weather and channels which are more shallow than they are supposed to be. Some adjustments can be made, such as incorporating a delay analysis; but, basically, it is evident that the engineering relation does not describe actual operations. The

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[2] The discussion of cost here is limited to line-haul operations. Obviously, an important consideration in determining total freight transport costs is the terminal cost of handling cargoes, (loading, packing and unloading). Therefore, when considering costs of producing a ton-mile of freight traffic from A to B, and comparing such costs across modes, line haul and terminal costs are considered. In terms of the arguments of this paper user charges affect line-haul costs. Non-line-haul costs are considered as quality-cost differences between modes and are viewed as shifters of the demand for the different modes line-haul output.

> question of how closely it approximates actual operations is an empirical one. . . .
>
> Economists have estimated statistical production functions for many industries. After obtaining observations on each of many production units, multivariate techniques can be used to isolate the effect of each input factor on output. The estimated function is especially valuable in that it estimates the production relation presently in existence, that is, the one which applies for firms currently going about their business. This relation is not the optimal production relation of the economic's textbook [Case, 1970; p. 40].

1. Howe's Analysis: Howe used engineering and statistical approaches to examine the production and cost function for the individual tow and for the firm [Howe, et al., 1969]. First he used an engineering approach to consider tow production and cost characteristics. Tables II-1 and II-2, as taken from

TABLE II-1

An Illustrative Marginal Productivity Schedule for the Barge Input

(Width of waterway, 200 feet; depth of waterway, 12.0 feet; draft of barge flotilla, 8.5 feet, and 4,000 horsepower.)

Flotilla Deck Area (Square Feet)	Ton-Miles/Hour	Change in Ton-Miles/Hour
6,825	13,030	–
16,825	27,149	14,119
26,825	38,653	11,504
36,825	48,579	9,926
46,825	57,356	8,777
56,825	65,201	7,845
66,825	72,223	7,022
76,825	78,499	6,276
86,825	84,011	5,512
96,825	88,807	4,796
106,825	92,832	4,025
116,825	95,911	3,079
126,825	97,989	2,078
136,825	98,817	828
146,825	98,126	–691
156,825	95,412	–2,714
166,825	90,153	–5,259

Source: Howe, et al., 1969; p. 27.

Howe, provide a useful summary of his results. They show sample marginal product schedules for two production inputs, horsepower and flotilla deck area, when the other inputs and channel characteristics are held constant. The production schedules he developed for the tow showed the normal attribute of diminishing marginal productivity, measured in ton-miles moved per hour, as a variable input is added.

TABLE II-2

An Illustrative Marginal Productivity Schedule for the Towboat (Horsepower) Input

(Width of waterway, 200 feet; depth of waterway, 12.0 feet; draft of barge flotilla, 8.5 feet; overall breadth of barge flotilla, 138.5 feet; and, total deck area of the barge flotilla, 106,825 square feet.)

Horsepower	Ton-Miles/Hour	Change in Ton-Miles/Hour
500	46,683	–
1,000	63,024	16,341
1,500	73,756	10,732
2,000	81,299	7,543
2,500	86,594	5,295
3,000	90,118	3,524
3,500	92,144	2,026
4,000	92,832	688
4,500	92,276	–556
5,000	90,520	–1,756

Source: Howe, et al., 1969; p. 27.

Howe then developed isoquant maps showing the marginal rate of technical substitution between barge and horsepower inputs.[3] He found that substantial substitution possibilities exist between the two inputs, although they become limited at low rates of output. Figure II-3 indicates one family of isoquants.

Using this production information and available input cost data, a family of cost curves for the two was developed, with the envelope cost curve showing a relatively flat minimum point in the area of 65,000 to 100,000 ton-miles per hour. This family of cost curves, shown in Figure II-4, also indicates that smaller tows are unable to achieve the cost economies of larger ones.

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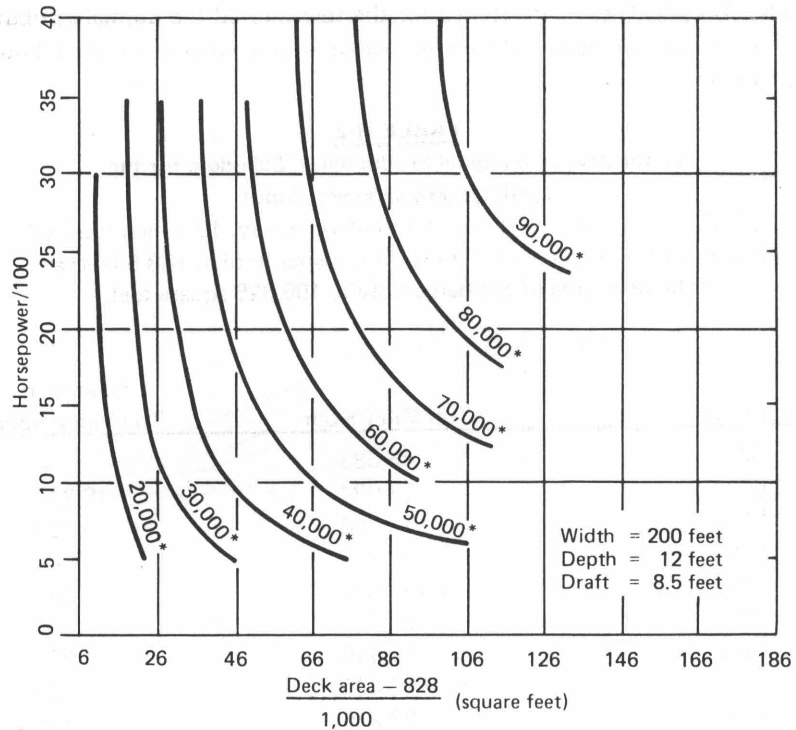
[3] He notes that there are in fact four inputs: horsepower, deck area, fuel and labor, but argues that the later two are tied directly to horsepower. Hence, the substitution of concern is between horsepower and deck area.

FIGURE II-3

Production Isoquant Map for Waterway Transport



*ton miles/hour

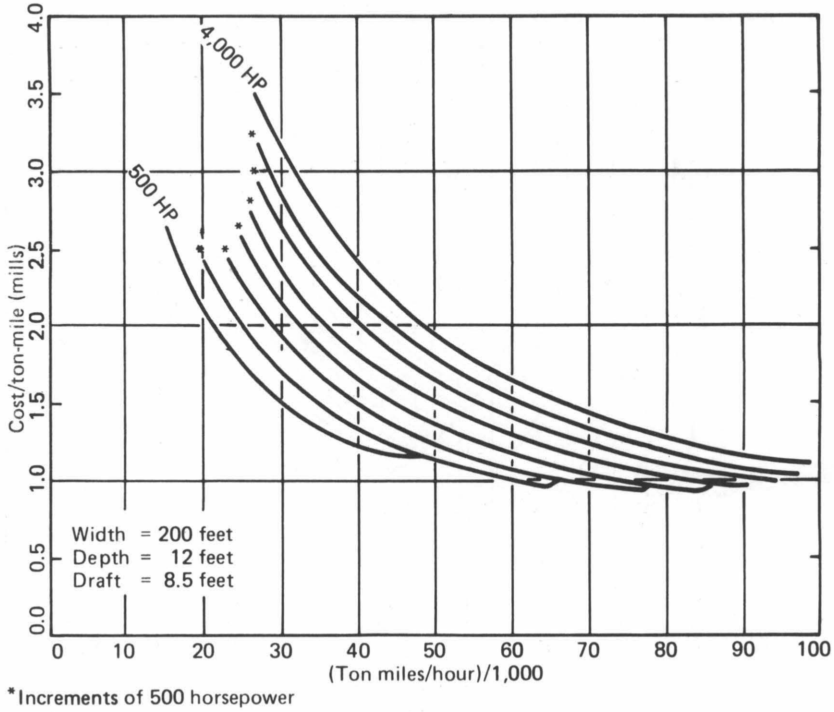
Source: Howe, et al. 1969; p. 28.

Inasmuch as the cost figures are not current, relative price ratios may vary and substitution of inputs could result, especially at the higher levels of output. This may result in different position for the average-cost curves, and perhaps new locations of the minimum average cost. Nonetheless, the scale economies of large tow size still remain.

An important assumption made in developing the cost curves was the use of invariant channel characteristics. Since all of Howe's estimates were constrained by a channel of fixed proportion, he developed a table, Table II-3, to show that changes in channel characteristics are important determinants of production and cost. The cost figures are lower than the current situation, however the general tendency of lower costs with improved channel condition remains. Thus, to estimate cost functions one needs to consider waterway characteristics. The general tone of Howe's conclusions from his engineering approach, therefore, suggests that smaller tows will realize higher

FIGURE II-4

Cost Curves for Waterway Transport



*Increments of 500 horsepower

Source: Howe, et al. 1969; p. 29.

TABLE II-3

Joint Effects of Channel Width and Depth on Line Haul Costs per Ton-Mile (in mills)

(Draft of barge flotilla, 8.5 feet; Overall breadth of barge flotilla, 144.8 feet; total deck area of the barge flotilla, 116,825 square feet; and, 4,500 horsepower.)

Widths	150′	200′	250′	300′	350′
Depths					
12′	23.71	1.21	1.07	1.03	1.00
18′	19.64	1.02	0.90	0.87	0.85
24′	18.11	0.94	0.83	0.80	0.78
30′	17.05	0.88	0.78	0.75	0.73
36′	16.22	0.83	0.74	0.71	0.69
42′	15.52	0.79	0.70	0.67	0.66
48′	14.91	0.76	0.67	0.64	0.63

Source: Howe, et al., 1969; p. 30.

average costs, and in turn will be found on more constricted waterways.[4]

Howe then turned to a statistical analysis of the water transport firm. Based upon his engineering analysis of scale economies in towboat size he formulated the following hypothesis:

> The larger and less constricted the waterway on which the firm carries out most of its operations, the greater will be the returns to scale parameter of that firm; i.e., the greater will be the increase in efficiency with increase in the size of the firm [Howe, et al., 1969; p. 34].

In order to test this hypothesis he gathered data from firms on different size waterways and estimated production functions with output in ton-miles as a function of barge days, towboat horsepower, labor, fuel oil, and towboat hours. The findings are consistent with his hypothesis.

He then moved to a statistical estimation of the firm's "planning function." He distinguishes the planning function from the production function as follows:

> Ultimately, however, the firm must make decisions regarding its stocks of equipment. In the longer term, too, the total output a firm is able to schedule, including peak demands, unanticipated demands, and unusual destinations, will depend upon the stocks of equipment on hand. Much more than technology is involved in the relationship between the stocks of capital inputs and output (say, on an annual basis). For example, the strategy the firm adopts for handling peak demands, the availability of equipment on short-term rental, and the time variability of demand will affect the stock-output relationship. Ultimately this capital stock-output relationship and its scale economies or diseconomies will determine the firm's ability to expand line-haul operations without incurring increasing inefficiency. It seems best to give such a relationship the name of "planning function" to distinguish it from the purely technological production function [Howe, et al., 1969; p. 35].

Here he found diseconomies of scale which he speculated stemmed from scheduling and administrative problems as firm size increased.

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[4] One study suggests the same conclusion in a slightly different way. It claims that the payload of a barge must be lightened 17 tons for every inch reduction in draft [Schnake and Franzman, 1973].

Finally, cost functions were estimated for the firm, with total costs made a function of total tonnage carried by the firm. These results showed increasing returns to scale, leading him to summarize his findings as follows:

> Thus it appears that with volumes of traffic and waterway conditions as they have been to date, firms have been able to increase their efficiency as volume has increased. The production function results show that firms can increase their technical efficiency as the size of their operations increases and by being provided with a deeper and less congested waterway. This seems to be offset to some extent by increased scheduling difficulties or other administrative complications which result in a tendency of stocks of equipment to grow more than in proportion to the growth in output. These difficulties are, in turn, offset by the ability to spread overhead costs and perhaps by more advantageous purchasing of inputs, so that total unit costs fall with increasing firm size [Howe, et al., 1969; p. 42].

2. Other Production and Cost Studies: In an attempt to broaden and refine the Howe analysis, DeSalvo [1970] and Case [1970] separately developed cost functions based upon an engineering approach and statistical approach. DeSalvo, in assessing Howe's work, argued that the engineering tow process function used by Howe was an incomplete description of the line-haul process since it ignored delay time and assumed constant operation speed for the tow. To improve on Howe's analysis he included delay time from locking, making and breaking tow, and acceleration and deceleration into a tow production function. Based upon this improvement he still found no reason to disagree with Howe's general conclusions about scale economies for the tow, and the importance of waterway characteristics in influencing production. However, he felt that the horizontal portion of the average cost curve might flatten out over a narrower range than suggested by Howe.

Case did not find fault with the statistical approach employed by Howe, but was critical of the data used. While acknowledging that it was perhaps the best available data at the time, it was limited in that it was highly aggregated with, for example, total costs including terminal labor, line-haul labor, maintenance labor, janitorial services, and administrative labor. He applied a statistical approach to some of the same questions considered by Howe. The amount of work performed by towboats was extremely sensitive to the horsepower of the towboat, although there are decreasing returns to horsepower input. This coincides with the results of Howe's engineering approach to the tow production function. The River district where operation took place also was of significance, confirming Howe's engineering results that waterway characteristics influence output.[5]

An analysis of towboat cost indicated that larger towboats have lower costs per unit of output. The barge cost analysis indicated that firms are becoming more efficient, with costs falling as the number of barges in the two increases. As in Howe's engineering analysis, river district width, depth and lock congestion are of importance in causing the cost curves to turn up, creating a U-shape.

With respect to firm scale economies, an analysis of single firms over time found that direct costs of line-haul operation fall rapidly as output increases, i.e., as full capacity of the firm is utilized. In addition, larger firms can carry freight at lower costs than smaller ones and that firms carrying specific cargoes have lower costs than those carrying general cargo. Using five firms to evaluate unit costs on a cross-section analysis gave comparable results—falling average costs with expanding output. However, when firm size is considered, increasing returns are found when firm size is measured by number of barges, and decreasing returns to size when measured by towboat horsepower. In general, Case's statistical results follow the same pattern as Howe's study, and DeSalvo's engineering results: *within the constraint of the waterway characteristics increasing returns to size of the individual tow and the firm seem to be the case.*

One finding of Case's warrants special attention. In looking at changes in the towboat production function over time he noticed significant productivity increases. However, attempts to attach such increases to the measures of capital or labor in the production function failed. Instead Case speculated that productivity increases may in large part have come from "neutral" sources such as management and operating rules. This is an interesting finding, since it discounts somewhat the importance of improvements suggested by the new towboat technologies such as the Kort nozzle.[6] In addition, it seems to dispute the findings of Howe who saw decreasing returns to firm size in his planning function. However, Howe's analysis was cross-sectional in character, while Case introduced a time dimension which allowed shifts in the production function. Accepting Case's conclusion, some of the "neutral" changes would include changes in tow configuration, better planning to minimize the amount of empty back-haul, improved practices to minimize the need for, and time spent on making and breaking tow, and increasing cargo specialization.

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[5] One finding of interest is that firms operating on the same waterway did not have identical production functions. This probably indicates difference in the type of service being provided (ex. long-haul vs. short-haul). The difficulty arises in using the same out put variable to measure different types of service, i.e. ton-mile.

3. Budget Studies: Specific insight into various levels of cost can be gained from budget studies which "cost-out" various inputs of the barge firm, although with constantly changing input prices this information is frequently out of date. Using data supplied by the Army Corps of Engineers, Mobile District budgets were developed for annual and hourly costs of operation for different size towboats and for two different size barges [Schnake and Franzmann, 1973] . The budgets developed are shown in Tables II-4 and II-5. These figures are for 1966 and clearly are higher now. A communication to the author from Robert Carmichael, Government Accounting Office, Minneapolis, suggeststhat in 1975, hourly operating costs of a 6,000 horsepower tow were $150. However, several insights still can be gained from this information. The high hourly costs of operation clearly demonstrate the importance of time delay in determining waterway transport cost. This suggests one reason why firms appear to have evolved somewhat successful management practice—or "neutral" technological change, as Case calls it—to avoid time costs. In addition, it makes clear why waterway congestion can be a serious external cost to the shipper. This subject will be discussed in more depth later. The hourly costs of operation do rise for large towboats; however, the hourly costs per unit of horsepower are clearly falling, suggesting the scale economies of larger towboats and larger tows. Also the hourly costs of towboat operations far outweigh those of barge operation, suggesting that a high horsepower towboat with many barges would tend toward least cost per unit of output.

4 Long Run Supply: The long-run supply elasticity of waterway transport cannot be directly evaluated by examining the price-quantity pairs over time, since this set of equilibrium points trace out effect of demand shifts, industry-related external effects, and firm-related external effects. However, given the previous discussion, some qualitative conclusions may be drawn. Table II-6 shows total ton-miles moved and revenue per ton-mile, which can serve as a proxy for price, through 1971. The data reveal a general downward trend in revenue per ton-mile associated with an increase in quantity shipped over time. While, the revenue figures include oceangoing vessels which will have lower rates than shallow draft, the overall pattern of falling rates is probably an accurate picture of the industry as a whole.

Increases in quantity taken of the magnitude indicated in Table II-6 suggest that significant *shifts* in demand have taken place. The changes in quantity taken in are felt to be due primarily to a demand shift rather than a price response, since the elasticity suggested by these large changes far exceeds what is likely to be the case. Thus it will be argued here that, by and large, the price quantity pairs are traced out by rightward shifts of the demand

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[6] This is not to say that such improvements have been unimportant. Rather, of most significance in shifting the production function has been this "neutral" technological change.

TABLE II-4
Total Hourly Costs for Owning and Operating Towboats by Horsepower Rating, 1966

Horsepower Rating	800	2,000	3,200	5,600
Fixed costs:				
Investment	$250,000	$543,500	$800,000	$1,310,000
Ownership costs:				
Depreciation	11,875	25,815	38,000	62,225
Interest	6,875	14,950	22,000	36,025
Return on investment	10,000	21,740	32,000	52,400
Administration	28,445	45,555	57,265	77,260
Insurance	5,000	10,870	16,000	26,200
Taxes	1,250	2,720	4,000	6,550
Total ownership costs	$ 63,445	$121,650	$169,265	$ 260,660
Variable costs:				
Wages and fringe benefits	$129,420	$175,100	$191.130	$ 207,600
Fuel	27,315	68,535	98,430	183,530
Maintenance and repairs	12,500	27,175	40,000	65,500
Supplies	5,750	8,000	10,250	14,750
Subsistence	7,245	10,350	11,385	12,420
Miscellaneous	2,415	10,870	4,380	5,050
Total variable costs	$184,645	$292,830	$365,575	$ 488,850
Total annual costs of operation	$248,090	$414,480	$534,840	$749,510
Total hourly costs of operation	$30	$50	$65	$91
Hourly costs per horsepower	$.0375	$.025	$.020	$.016

Source: Schnake and Franzmann, 1973.

TABLE II-5
Total Hourly Costs of Service for Barges, by Barge Size, 1966

Barge Dimensions	195′ x 35′	250′ x 42′
Fixed costs:		
Investment	$76,000	$109,615
Ownership costs:		
Depreciation	$ 3,610	$ 5,207
Interest	2,090	3,014
Return on investment	3,040	4,385
Administration	357	515
Insurance	1,520	2,196
Taxes	380	438
Total ownership costs	$10,997	$15,755
Variable costs:		
Maintenance and repairs	$ 859	$1,236
Cleaning costs	643	643
Total variable costs	$1,502	$1,879
Total annual costs of operation	$12,499	$17,634
Total hourly costs of operation		
Mississippi River System (using 355 days or 8,520 hours of annual operation)	$1.47	——*
Columbia-Snake Rivers (using 345 days, or 8,280 hours of annual operation)	$1.51	$2.13

*Not considered to be used on the Mississippi River System
Source: Schnake and Franzmann, 1973.

curve along either a stable and/or shifting, long-run supply curve. This pattern of price-quantity pairs then may suggest a decreasing cost industry. However, some of the information from the precious discussion should be incorporated here before drawing any final conclusion.

The relatively flat minimum sections of the average cost curves for individual firms suggests potential adjustments to industry induced external costs within

TABLE II-6

Inland Coastal and Waterway Traffic and Revenues

Year	Ton-Miles (in thousands)	Revenue per Ton-Mile (in cents)
1960	433,992,337	.381
1961	434,885,905	.368
1962	450,439,652	.359
1963	454,976,956	.354
1964	456,104,677	.360
1965	455,357,240	.345
1966	471,294,798	.328
1967	485,011,978	.289
1968	483,816,707	.306
1969	488,614,323	.287
1970	563,868,966	.303
1971	570,208,291	.339

Source: American Waterways Operators, 1973.

a constant cost framework. More specifically, the marginal cost curves for most firms are nearly perfectly elastic within the relevant range and this in turn suggests an elastic supply curve. Given this perspective, distinctions must be made between movements along the long-run supply curve and shifts in it. During the past ten years, the price of inputs in the barging industry has increased as it has for other industries. Labor costs, fuel costs and equipment costs have risen. However, it seems unlikely that these cost increases have been induced by industry action, i.e. are industry-related pecuniary external costs. Rather, these price increases might best be viewed as exogeneous to industry behavior, which suggests that they are acting as long-run supply-curve shifters rather than reflecting movements along such a curve. In turn, the influence of such price increases is to shift the curve upward, which if considered alone, would suggest a *rising* long-run equilibrium price.

One form of industry-related external cost that has been increasing under certain conditions is congestion. There are some locks and waterway segments where delay has become an important cost of operation, and at hourly costs of operation shown in Tables II-4 and II-5, this could significantly influence cost of waterway transportation. However, such congestion problems have been limited in the past, and would not generally result in an upward sloping long-run supply curve.

Given the previous comments, the major influence on waterway costs has been an upward shift in the long-run supply curve. The pattern of falling unit revenue over time with output expansion can therefore be best explained by offsetting downward shifts in long-run supply. This shift has resulted from substitution and scale economies brought about by technological change. In turn this technological change may in fact have been induced by exogeneous price changes.

The conclusions about industry supply now seem a bit clearer. In general the industry appears to be best characterized as of constant cost; that is, the long-run supply is nearly elastic. Historically, falling average revenues with increased quantities can be explained by downward *shifts* in the long-run supply curve.

c. Conclusions on Production, Cost, and Supply:

Given the imposition of some form of user charge which raises input prices, the following general conclusions can be reached:

1. All firms will seek to substitute inputs in the production process. However, larger firms which also have largest tows will be more successful in substituting inputs in tow process (Figure II-3). This substitution process may mitigate some of the impact on the level of transportation rates.

2. Small firms operating on open waterways[7] (of which there are many—Table I-3) will be encouraged to merge or to expand in order to take advantage of tow and firm size economies. This will mitigate the degree to which the user charge will be passed through as increased transportation rates.[8]

3. Small firms operating on constricted waterways will have less substitution possibilities and be unable to capture tow and firm size economies. They will be forced to pass forward most of the increased cost. Therefore, firms on constricted waterways currently have highest line-haul costs, and a user charge would increase these costs in proportion to the level of the charge. This rise in costs would be most severe as waterway constriction increases.

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[7] The degree of "openness" can be thought of as a function of width and depth, although circuity, number of locks and levels of congestion may also enter here.

[8] In fact this change in firm size is already occurring, however the user charge may speed up the change. 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, A. T. Inc., 1974].

> 4. The best approximation of supply elasticity is to view the barging industry as constant cost, i.e. perfectly elastic supply. The user charge can then be viewed as an increased input price which is a force leading to an upward shift in the long-run supply curve of a constant cost industry. The degree of shift will depend upon the forces and opportunities facing individual firms. Indeed, in the past the net result of exogenously rising input prices, of which the user charge is just one more, and adoption of tow and scale economies has been a *net downward* movement in the curve and in the equilibrium price for water transportation. In some instances, where the waterway allows, such a result may be induced by the user charge.

III. The Demand for Waterway Transportation

The elasticity of demand for waterway transport must be known in order to assess the impact of a user charge on shipments. However, the literature on waterway transportation demand is limited, so that no specific estimates of elasticity are available. Therefore the procedure here will be to develope the general arguments which relate transport demand to the demand and supply for the product under consideration and to the characteristics and cost of shipment by competing modes. Based upon this discussion, it will be possible to develope a series of verbal arguments that will allow for a general assessment of the demand for inland waterway transport.

a. Economic Considerations in Transportation Demand:

Simple models of interregional competition demonstrate that the demand elasticity for freight transportation by all modes will initially depend upon the demand and supply for the commodity being transported. Given two regions where a commodity is both demanded and supplied, and the existence of trade between the two regions, it can be shown that:

> . . . the slope of the transport demand function implies that, given the commodity demand functions in the two regions, the traffic generated [or lost] by a fall [or rise] in transport cost will be greater, the greater the price responsiveness of either one or both commodity supply functions. Similarily, the amount of generated [or lost] traffic will be greater, the greater the price responsiveness of either one or both commodity demand curves given the commodity supply functions. If the initial volumes of production and consumption are known, one can translate this observation into terms of price elasticities. Again, *ceteris paribus* the higher the absolute value of price elasticity of demand and supply curves at the initial point, the higher will be the absolute

value of the elasticity of the transport demand curve at that point [Van Der Tak and Anandarup, 1971].

When a transportation service can be provided by more than one mode, a particular mode's share of the transport market will be affected by the cross elasticity of demand between modes. Thus both the total transport demand and the cross elasticity of demand between modes must be known in order to assess a mode's "own elasticity of demand." It should be noted that the cross elasticities are determined by the shipper's total costs of movement by alternative modes, including both explicit line-haul rate costs as well as implicit associated costs. In short, in seeking to assess the elasticity of demand for a particular transport mode, consideration must be given to transport demand for the product itself as well as *all* costs associated with shipment by alternative modes.

This conclusion can be demonstrated in more detail.[9] Five determinants of transportation demand are considered in this model: 1) the shippers' (transport demanders) cost of production; 2) an interest rate; 3) the rate charged for transportation services; 4) average travel time for each mode; and, 5) the demand for the commodity being shipped. Each producer is assumed to know the price he will receive for his product at the market. Also, revenues from sales are received only after the product reaches the market. Using the following notation, a firm's demand *for a single transport mode* can be developed:

π = the shipper's profit
Q = the quantity it shipped
P = the market price of the product shipped
α = time in days to ship the product from point of production to point of sale
R = transport rate per unit of output for line-haul movement
i = interest per day

The shipper's profit is:

$$\pi = \frac{(P - R)Q}{(1 + i)^{\alpha}} - f(Q)$$

where: $f(Q)$ is the total cost of production.

The numerator of the first term is revenue from the sale of the product less the transportation rate change. Since revenue is received only after α days,

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[9] This discussion is based upon Moses and Lave [1970]. It assumes a stable product demand and supply situation in the two trading regions.

the division by $(1 + i)^{\alpha}$ puts the net revenue figure on a present value basis. This point is worth further emphasis. The decrease in net revenue which occurs if α is greater than zero represents a non-line-haul transport rate cost. In this particular instance, this associated cost represents an inventory charge that varies inversely with the speed of the particular mode (for slow modes, α is larger). Other forms of associated costs will be discussed shortly.

Differentiating profit with respect to Q and setting the result equal zero gives the marginal cost equal marginal revenue profit maximizing condition.

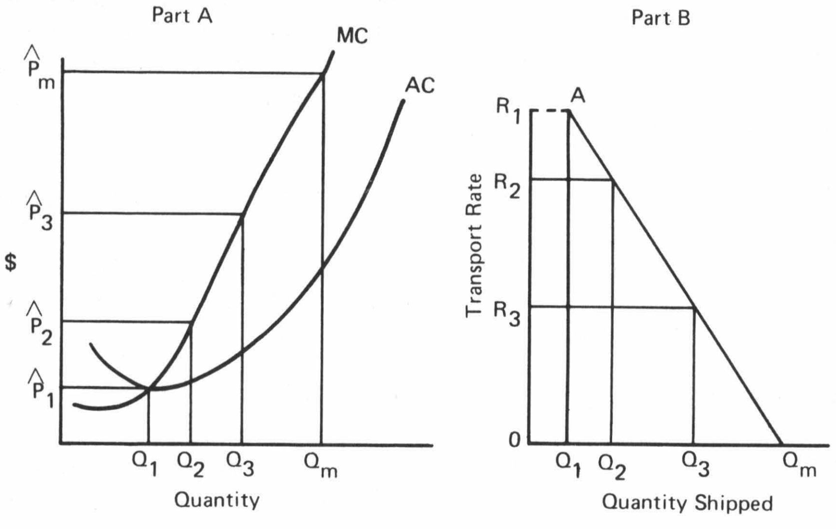
$$\frac{d\pi}{dQ} = \frac{P - R}{(1 + i)^{\alpha}} - f'(Q) = 0, \quad \text{or} \quad f'(Q) = \frac{P - R}{(1 + i)^{\alpha}}$$

Letting R be variable, while holding P, i, and α constant, traces out the firm's demand schedule for transportation, with quantity of transport being an inverse function of R. Also of interest is that the associated cost components, i and α, are transport demand shifters with quantity shipped increasing as their values fall for any given value of R.

Letting $P_t - R_t/(1 + i)^{\alpha} = \hat{P}_t$, a demand curve for transportation can be developed graphically for values of R_t, given the usual assumptions about the shape of cost curves. This is shown in Figure II-5-A,B.

FIGURE II-5

Demand for Transportation



In Figure II-5—A costs and net product prices are measured on the vertical axis, while Q on the horizontal axis is the quantity the firm would produce to ship at a constant price P and at variable levels of R. $\hat{P}_m$ shows the quantity shipped if the transport charge were zero. The price recieved would just equal the product price at the market, and marginal revenue would equal marginal cost at quantity Q_m. As R increased from zero to R_3, R_2 then R_1, $\hat{P}_t$ would get smaller corresponding to $\hat{P}_3$, $\hat{P}_2$ then $\hat{P}_1$, in Figure II-5-A. In Figure II-5-B the rates R_3, R_2, R_1 are shown with the corresponding quantities shipped. At A, R_t rises to the point where $P_t - R_t/(1 + i)$ is just equal minimum average variable cost. Therefore, at rates higher than R_1 no transport will take place.

Extending this analysis to different modes entails simply viewing R_1, R_2, R_3 as the transport rates changed by alternative modes, each of which may have a different associated inventory cost as measured by α and i. Having information on α and i, the firms solve for the highest net π and then ship some quantity by the chosen mode.

The implications of the above discussion should be clear. First, at some point, transport rates can be high enough to curtail all shipping of a particular commodity. Second, rate changes can result in complete modal shifting much as they can result in termination of all shipments. Third, there may be a range of rates, for examples between R_1 and R_2, where modal shifting will not occur but less of the commodity will be shipped on the particular mode as the rate rises.

It is often asserted that of the many determinants of shipping patterns, the transport rate charged by the various modes is of the least importance. In short, the price elasticity is very low for all modes. Furthermore, it is argued that the choice to ship at all, as well as the choice of modes, will be only slightly influenced by transport rates within the normal range of these rates as they exist in the real world. It is this assertion that can only be considered with reference to empirical analysis since, in theory, rates can be shown to be a significant factor.

In summary, quantity of transport demanded from a particular mode depends upon:

1. The demand for and supply of the commodity being shipped;
2. The line-haul transport rates charged by different modes; and,
3. The associated costs of different modes.

b. Empirical Evidence on Water Transport Demand:

For the movement of bulk commodities inland waterway navigation provides the lowest line-haul cost alternative due to the low costs required in developing power to overcome fluid friction created by the waterway. On the other hand, there are disadvantages to the water mode such as slow speed, with the implicit inventory costs this gives rise to, and lack of door-to-door delivery since the "water highway" is confined to the river bed. As noted above, it is the combination of the real rate costs, and associated costs that can determine freight mode choice. However, limited availablility of theoretical work prevents estimation of own price elasticity of demand for waterway transportation. Instead, subsequent discussion will examine modal choice based upon line-haul and associated cost advantages of different modes. From this discussion implications about the impact of rate shifts on modal choice can be discussed.

In Table II-7 the various characteristics of different modes are compared. The mode at the top of the list has the competitive advantage in the particular area of concern. From the perspective of the water carrier, competition stems primarily from rail and pipeline. The marine mode falls between rail and pipeline on every criteria although the pipeline and rail modes shift in their position under the different criteria. These differences now will be discussed separately as line-haul advantage and associated cost advantage.

I. Line Haul Cost and Rate Advantage: Figure II-6 depicts the line-haul costs for representative rail and barge loads. The vertical distance measure of cents per ton-mile represents fully allocated costs rather than variable costs, including terminal costs. In this sense it is also suggestive of rate charges by each mode. For rail, as shipment size and length of haul increases costs per ton-mile fall. The barge-line cost curves illustrate the effect of tow size and speed on ton-mile costs. Clearly barge transport is less costly than rail for large-volume shipments. Only when compared to small and or slow tows does rail appear to have a cost advantage. As such, only larger trains can be competitive with water, or trains in competition with smaller tows with low average speeds. Insofar as waterborne shipments can exceed feasible train capacity (see Table II-7), line-haul costs will definitely favor waterborne commerce.

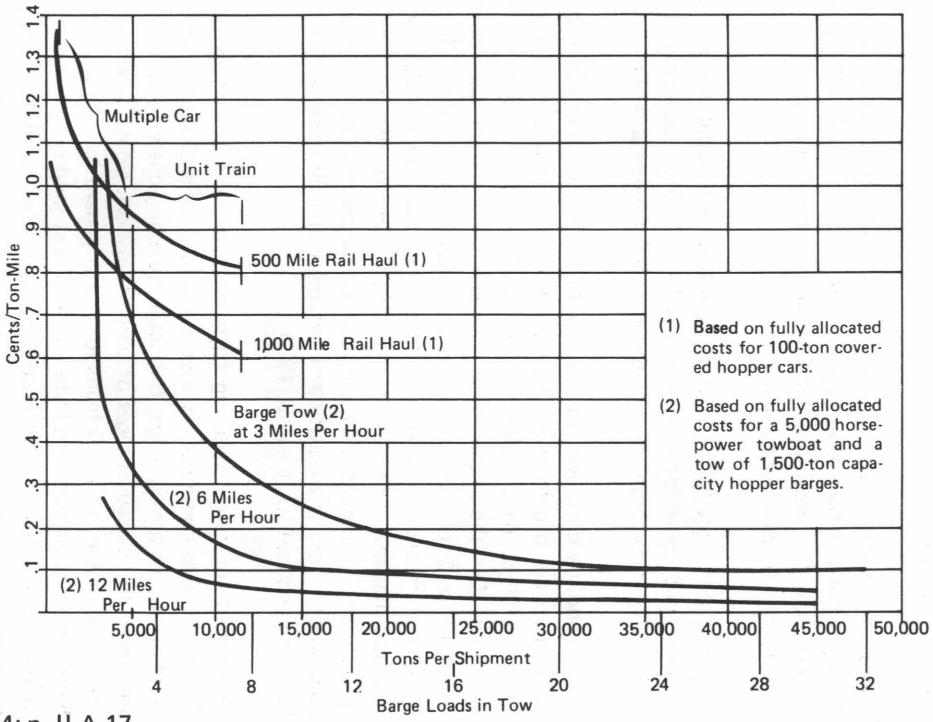
Line-haul costs directly affect line-haul rates. Using regression analysis, Strucker explained rates charged by truck, rail and water modes (revenue in cents per ton) as a function of length of haul, tons moved, average tons per barge, and the value per ton of the product shipped [Stucker, 1970]. For commodities shipped by water, increases in distance-hauled increased the total transport rate by about 30 cents per 100 miles. However, for rail this figure is $1.36 and for truck $2.81. Thus the long-haul cost advantage of barge also creates a rate advantage. The quantity shipped had a negative effect on rates per ton for water transport, while the effect of quantity shipped on rail rates

TABLE II-7
Comparative Advantages of Domestic Freight Transport Modes

Cost	Flexability	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 capacity	Pipeline 3 to 6 mph

Source: Adapted from Kearny, 1974.

FIGURE II-6
Line-Haul Cost Relationships
Rail versus Barge



Source: Kearny, 1974; p. II-A-17.

is positive. Therefore, the capacity advantage of the water mode does show in rate differentials. The density effect (tons per load) is negative for all mode's transport rates although it was difficult to attach an advantage to any mode. The rate charged for shipment is, in most instances, positively related to higher unit valued products. That is, high-valued products are charged higher rates indicating a tendency in most modes for some form of value of service pricing. In short this suggests the elasticity of demand for transport of a given product is considered in rate making with more inelastic demanders being charged higher rates.

These conclusions about determinants of rates conform quite well with the discussion of line-haul advantage for larger loads pulled on long hauls. Also of interest was the possibility of "value of service" pricing—suggesting higher rates for the more inelastic demands.

2. Associated Cost Advantage: Also influencing modal demand are a number of associated costs for completing point-to-point movement. The best data available here compare some of these costs for barge and rail.

Cargo handling costs will generally be lower for rail than water shipment. The rail carriers can usually place their equipment directly at the plant of both the shipper and receiver, allowing direct handling of the freight at either end of the haul. On the other hand, barge service rarely can provide such a convenience since usually either the shipper or receiver is located off the waterway. Hence, loading and unloading must be handled by a dockside terminal that may not handle sufficient volume of the commodity to justify specialized equipment that will reduce handling costs. In fact, only when commodity flow is of sufficient volume will technological improvements in handling be justified [Kearny, 1974].

The effects of cargo handling costs on total cost advantage can be seen in Table II-8. For commodities that are hauled long distances in bulk, and are used on the waterway edge, the cargo handling costs do not adversely affect the line-haul cost advantages of barge transport. Coal, for example, is used at the water's edge in New Orleans for power generation. As such, rail and water handling costs are equal and the line-haul cost (and rate) advantage of water is unaffected by this associated cost. On the other hand, paper products are an example of a waterway disadvantage in cargo handling costs. In this instance the lower rates on line haul that barge offers may be offset in part by cargo handling costs to the shipper.

Implicit in the previous discussion of cargo costs was the need to transport the product to be shipped to or from dockside facilities after loading or unloading. Thus, whenever either the shipper or receiver is not located on the waterside, it results in "feeder" costs to move the shipment to the dock and

TABLE II-8

Comparison of Cost Advantages by Mode for Line Haul and Cargo Handling for Selected Traffic Movements* (in Dollars per Ton)

			Line Haul			Cargo Handling			
Commodity	Origin	Destination	Rail Cost	Barge Cost	Barge Advantage	Rail Cost	Barge Cost	Barge Advantage	Net Barge Advantage
Cash Grains	Sioux City	Chattanooga	$9.80	$6.39	$3.41	$ .85	$ .80	$ .05	$3.46
Grain Mill Products	Chicago	St. Louis	3.46	1.45	2.01	.85	.80	.05	2.06
Primary Iron and Steel	Pittsburgh	Louisville	5.12	1.33	3.79	.60	3.00	−2.40	1.39
Paper	Vicksburg	Chicago	6.13	3.02	3.11	.80	2.60	−1.80	1.31
Fabricated Metal Products	Chicago	St. Louis	4.32	1.45	2.87	3.00	3.00	0	1.87
Metal Ores	Corpus Christi	Sheffield, Ala.	10.19	5.66	4.53	1.05	.80	.35	4.78
Nonferrous Primary Metals	Little Rock, Ark.	Mobile, Ala.	5.89	3.18	2.71	.60	3.00	−2.40	.31
Sugar	New Orleans	Chicago	6.44	3.91	2.53	1.20	.90	.30	2.83
Coal	Huntington, W. Va.	New Orleans	7.17	4.44	2.73	1.35	1.35	0	2.73

*Variable costs for line haul service

Source: Adapted from Kearny, 1974.

50
34
2 | 26
12

"distributor" costs to move the shipment to the inland destination. These costs again enter the total transport cost the shipper faces and can further erode any competitive advantage barge firms may have. To take one example of this, consider paper moved from Vicksburg to Chicago. In Table II-8 the barge line-haul cost advantage of $3.11, was reduced to $1.31 when cargo handling was included. This $1.31 remains for feeder and distribution charges, if the barge mode is to remain competitive with rail. Using a cost for truck hauling of 4 cents per ton-mile, and assuming that the handling charge of $1.80 covered costs of loading and unloading between the truck or barge, the land portion of the shipment from the producer to the receiver cannot exceed 34 miles ($1.31/.04). Any distance exceeding this will eliminate the barge cost advantage. These figures are indicative of another of the associated costs of barge transport that can influence the demand for that mode [Kearny, 1974].

Inventory costs are a form of associated cost that was developed in some detail in the theoretical discussion. Table II-7 indicates that low speed is an inherent disadvantage of the water mode. These costs are computed for the cargo as it is in transit and clearly will depend upon the interest rate and the value of the cargo. On this criteria, the barge mode suffers in comparison to other modes, although for the low value commodities that move by barge, this may not be a significant cost.

What then of the net effect of all these positives and negatives on the demand for barge transport? Clearly, it will depend on individual circumstances of geography and time. A study on corn shipments in Illinois illustrates both this point and the impact of associated costs on the competitive position of barge transportation [Beuthe, 1970]. To demonstrate quality differences between modes the technique of discriminant analysis was used. It was argued that modal choice for moving a good between two points depends upon the transport rate charged, given some product price at the market, and some quality cost which, because of its nature, cannot be directly observed by the analyst[10] [Beuthe, 1970]. The sum of these quality costs was represented in a model as a net difference in the shipper's profit that resulted from shipping by rail, truck, or barge. The model developed was able to fairly accurately predict actual mode choice. By using the functions estimated to allocate shipments to modes, and by knowing the transport rate charged, the quality difference between modes was estimated in cents per hundred pounds for the shipment of corn. Table II-9 below shows the results for two selected months [Beuthe, 1970; p. 43].

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[10] This model did include explicit recognition of inventory costs.

TABLE II-9

Estimates of Quality Differences Between Shipping Modes (in Cents per Hundred Pounds)

Month	Truck-Barge	Rail-Barge
January	8.59	4.45
July	3.39	–2.89

Thus, in January a modal shift from barge to truck would occur if barge rates came to within 8.59 cents per hundred pounds of shipment by truck between a given origin and destination point. That is, quality of truck transport compared to barge is worth 8.59 cents per hundred pounds shipped. Similar results for the July and other mode combinations can be seen. In most cases, truck is preferred to rail and rail to barge except in July, a case which arises from the rail capacity constraint during the harvesting season, indicating a barge advantage. These results offer a quantitative demonstration of both the associated cost differences that exist between modes as the shippers perceive them, and the influence on modal shares of the implicit cost associtated with these differences. More specifically the evidence for grain shipment seems to indicate, with one seasonal exception, that the water mode falls below the other modes. During that season, the barge mode in fact has the advantage due to its capacity advantage.

However not all studies suggest, as this review does, that rates and associated costs can affect competitive mode advantage. When Kearny Associates studied the factors affecting modal choice in freight transport, they argued that in the past many studies concentrated on what they termed a "tactical" view on the choice between modes, which emphasized transport rates and service quality. They then argued that this viewpoint may be appropriate for the competition between rail and truck shipment of manufactured goods, but for water transportation mode choice is a "strategic" decision.

> Now, the water mode is largely characterized by low ton-mile cost, slow speed, large lot size and infrequent service (compared to land modes) because of the size and propulsion of the vehicles. Hence, the lower valued commodities to which the water mode appeals are primarily the bulks and neo-bulks that move in large quantities; and as raw or semi-finished materials they move in relatively stable patterns over time and geography. . . .
>
> Consider a grain elevator, or a consumer of coal or iron ore, or a producer or consumer of liquid bulk chemicals, primary iron and steel products, or limber. In choosing the location for a plant, the

> planner would consider the costs of shipment of these very water-susceptible commodities by water vs. by rail, and would decide for or against a waterside location as one of the principal elements in the site choice. Once this choice is made, his mode of shipment is heavily influenced thereafter. If he has opted for the water's edge, the ship or barge is very attractive in cost, especially as in some cases the costs to be considered are the *variable* costs, since capital expenditures for terminals and vehicles may be sunk costs. If not, the costs and inconveniences of transloading almost force the use of rail. In cases where the transloading in unavoidable—e.g., movement of iron ore from Mesabi to Pittsburg—the watermode is used (where geography permits) nevertheless, because shipment patterns are stable enough to permit investment in large-scale vehicles and terminals, which in turn offer such low cost as to be unbeatable. Again, the committment is largely a long-term strategic one [Kearny, 1974; p. II-A-32-34].

To demonstrate the validity of their position, Kearny performed a statistical analysis of historical modal shares (percent of freight carried by water) in relation to strategic factors such as length of haul, circuity of the route traveled, seasonality of the waterway and commodity characteristics such as value per ton. They found significant correlation. However, little significance came from attempts to correlate modal shares with tactical variables such as transport costs and time.

They found that the most important factor in modal choice was the length of haul. The longer the distance along the waterway the more likely it was that the movement would be by water. Increasing value per ton of the commodity has a depressing affect on water hauling (probably reflecting the inventory cost associated with a slow speed mode). Beyond a certain quantity of point-to-point tonnage the advantages of water take hold and larger annual flows of tonnage are more likely to move by water.

They give examples of their findings as follows:

> . . . take a commodity worth $10 per ton (approximately right for coal). Other things being equal, 15% of a small flow (10,000 tons/years) or 37% of a large flow (1,000,000 ton/year) will go by water. If the value were $100 per ton (primary iron and steel products, flour, or chemicals) the corresponding percentages would be only 5% and 22% [Kearny, 1974; p. II-A-34].

These results are then used to argue that rates and quality of service appear to be unimportant in modal choice. However, in discussing their procedures they admit that transport rates would be correlated with distance, and use this as a basis for deleting a rate variable from their model of strategic model choice. Also, it seems clear that the factors they do consider are those which others found to be determinants of transport rates. Given this perspective, it seems likely that the Kearny study used a series of price and associated cost proxies in their intermodal choice analysis. Further, even they note that "the line-haul cost of the marine mode compared with its chief competitor, the railroad, is its major competitive advantage." When these considerations are combined with the discriminant analysis showing that rates and consideration of quality differences can predict modal choice fairly well, the argument that price and quality appear to have little influence seems weak.

Kearny does not, however, argue that rates and service quality have no effect on water transport demand. In their terminology "tactical error could give away a strategic advantage" [Kearny, 1974; p. II-A-35]. In short, the influence of rates may be somewhat important, but the impact will be felt only slowly. Given the descriptive arguments they make, this may be a reasonable argument, with the real question being "how slow is slowly?" Nonetheless, in looking at the demand for waterway transporation, it seems clear that the "long run" competitive advantage and disadvantage in line haul and associated costs will greatly influence modal shares.

c. Conclusions about Demand:

Asserting for the moment that a user charge will be passed on in some degree to the shipper, the following qualitative conclusions on the impact of such a charge seem warranted by the previous discussion.[11]

1. Products shipped on long haul will be less affected since their line haul cost advantage prior to the user charge will be substantial.

2. Products which currently move in large quantities on the waterways and utilize the capacity advantage of barge will be less affected.

3. Shipment of products incurring substantial cargo handling, feeder, and distribution costs will be adversely affected, while products which find use at the water's edge will be less affected. In addition, cargo handling costs will be highest for commodities shipped in small quantities, because there is little justification for improvements in handling facilities if volume is small.

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[11] In a sense these conclusions can be viewed as a means of assessing own demand elasticity for water transport with least affected commodity movements being viewed as most inelastic demanders.

4. Products with high regional demand and supply elasticity will be more likely to shift modes or reduce consumption.

5. Products for which speed can be a significant cost will be more likely to shift modes at the transport rate rises. In general, this will be products with high value per ton due to increased inventory charge.

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SECTION III

ECONOMICS OF USER CHARGES

I. Introduction

Although not concerned directly with navigation, theoretical discussions of the pricing of public services provide a fairly clear set of objectives for administering user charge policies. The objectives for navigation would include:

> 1. recovery by the public treasury of the costs of maintaining and operating existing waterways and developing new waterways;
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> 2. promotion of an equitable distribution of the burden of payment, such that beneficiaries pay for the use of services consumed;
>
> 3. promotion of economic efficiency in the use of water resources and the production of transportation services; and,
>
> 4. finding the optimal administrative schemes for a system of user charges.

Perhaps it is best to begin this discussion by stating one of Milliman's conclusions from his review of the user charge literature:

> The more I examined the literature and the world about me, the more I realized that the question of beneficiary charges and efficiency were not well worked out in the literature. . . . The theoretical relations between beneficiary charges and optimal resource allocation are simply not well understood [Milliman, 1969; p.317]

While it is important to bear this conclusion in mind, it does not suggest abandonment of user charges as a public policy tool. Rather, one should proceed with caution, considering initial user charge policies as experiments from which the results will suggest future modifications.

II. Defining User Charge

A user charge is some form of payment required from an individual or group in return for services provided. Insofar as federal operation and maintenance of inland waterways provides service to users of the waterways, then a fee in exchange for provision of service would be a user charge.[1] User charges as discussed here refer not only to fees that might be charged, but also to specific taxes designed to relate to the provision of the service. Thus, a fuel *tax* used to provide waterway service is deemed a user charge in the same broad category as for example a lockage *fee* at lock and dam facilities.[2]

III. Economic Guidelines for User Charge Policy

a. Equity and Revenue Production:

The public finance and public utility literature in economics has dominated the debate over user charges. These approaches emphasize (1) the "equity" argument that beneficiaries should pay for services rendered, and (2) that public facilities should be self-financing, i.e. user charges should bear the cost of providing the service. This argument comes directly from the benefit principle of taxation found in the traditional public finance literature. A second view of equity derives from this same source, and is known as the ability-to-pay principle of taxation. Here equity might imply a divergence between the costs borne by users and the benefits derived, if society chooses to make a transfer from one group of individuals to another [Shoup, 1969]. This later view of equity is not the one which predominates in the discussion of user charges for inland waterways. Thus, as used in the remainder of this discussion, the term equity means that beneficiaries should pay.

While there seems to be substantial agreement that those who benefit should pay for the cost of the waterway, the issue becomes a question of who really benefits. The uncertainty about who benefits stems directly from the fact that waterway transportation is an intermediate good. This fact is used to support the argument that beneficiaries of low-cost water transport, encouraged by the federal expenditures to operate and maintain the water "highway," are the consumers of final goods [National Waterways Conference Incorporated, 1968]. Implicit in this argument is that the benefits are

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[1] Milliman prefers the use of the term beneficiary charge which suggests in a broader context that beneficiaries may not all be direct consumers of the service. In the case of inland waterway maintenance the beneficiaries may be the consumers of the final products of which transportation is simply an input into the production process. Since the term user charge is the one commonly used in policy debates, it will be used here. However, implicit in the use of the word "user" is the recognition that immediate users are not necessarily the ultimate beneficiaries of the service in question [Milliman, 1969].

[2] While this combination of taxes and fees into the general term of user charge will simplify discussion here, it can be an extremely important distinction to maintain when making final policy recommendations. The power of government to impose fees for use of waterways may be subject to extremely complex legal arguments, while the use of taxes may face no legal problems. See Cooper-Ruska, 1974.

so diffuse that payments from general tax revenue make sense on *equity* grounds. In addition it asserts that neither shippers or receivers of the shipped good can capture the lower transport cost as an economic rent or through exercise of market power. Hence, lower transport costs, it is argued, will be passed along as lower prices for fossil fuels, food stuffs or any product that moves by water. To see how this argument can lead to unacceptable conclusions, consider the following:

> . . . It is correct that virtually all consumers benefit, but not all benefit equally. In particular, consumers who live near waterways tend to reap a substantially greater benefit than those living in areas not served by water transport. In addition, this cheap waterway transportation results in a distortion of resource allocation (violating the efficiency objective) since other transport modes are not treated equally and since producers and firms located far from the waterway are not given the same advantages. Thus, the railroads contend that the current system distorts resource allocation and is unfair to them.
>
> Indeed, the same argument could be made for any publicly or privately produced *intermediate* good that is used in producing a widely used consumer good. Thus, the case could be made that the entire freight transportation and industrial infrastructure should be provided at no charge to users since the lower cost inputs could be reflected in lower prices in consumer goods. A more modest and symmetrical argument would be one that called for government maintenance and operations of rail facilities at no charge to train operators. Trucks, by the same argument, should pay no user charges for roads. Carrying the argument to this point brings out the fundamental error in such an approach, i.e., underpricing transport would lead to location inefficiencies and the purchase of too much transport relative to other sectors of the economy [U.S. Department of Transportation, 1971].

A more reasonable equity argument is that consumers of products shipped by water do receive benefits. Therefore, they should be willing to pay whatever costs are involved in achieving those benefits. Since it would be difficult to trace down these beneficiaries, the equitable approach would be to charge those who ship on the waterways and let the market system reallocate the burden of the charge.

The issue of cost recovery, or revenue production, is quite straight forward. After costs of providing the service are accounted for, and the unit upon which the charge is to be levied is identified (e.g. the barge, a ton-mile, a gallon of fuel), the appropriate charge per unit can be computed. The importance attached to this objective will depend in part upon the access of the supplier of the service to other sources of revenue. Clearly, a regulated utility would place cost-recovery as the primary goal since, in the absence of subsidies from government, bankruptcy may be the only other alternative. On the other hand, a government jurisdiction with a broad tax base may place other goals ahead of cost-recovery when setting a charge for a service since it would have access to other revenue sources through taxation. This becomes especially important when pursuit of the revenue production objective may not promote the economic efficiency objective.

b. Economic Efficiency:

Marginal cost pricing literature, as it evolves from neoclassical welfare economics, demonstrates that when the demand price for a given product equals the cost of producing the marginal unit, economically efficient resource allocation will result. When resources are attracted from other uses, marginal costs should reflect the opportunities foregone. An equality of price and marginal cost will insure that consumers equate marginal benefits from the use of resources with alternatives forgone elsewhere. Perfectly competitive markets operate to insure this result. Therefore, when firms shipping products on the inland waterways pay a price for shipping equal to marginal costs of providing the service, the appropriate mix of intermodal transport services will be produced, and the appropriate mix of of inputs will be used to produce waterway transport, including the requirement that the optimum amount of the nation's water resources will be devoted to this purpose.

The soundness of the marginal cost pricing principle is not in question in the following discussion. Modifications in the application of the principle must therefore reflect a compromise between it and some other objective, such as administrative cost of putting the policy in effect.[3] As Vickery notes:

> . . . whatever arguments may be advanced for departing from the marginal cost pricing policy, no sound pricing policy can be developed without marginal costs as one of the principle determinants [Vickery, 1955].

In applying marginal cost pricing guidelines to the development of user charges at least four complicating factors may be encountered. These include, (1) the existence of decreasing costs of production; (2) questions of

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[3] This assertion would not meet with total agreement among all economists. However, it is safe to argue that a detailed review of the economics literature would find this to be the dominant theoretical position.

short-run versus long-run efficiency; (3) external effects; and, (4) "second-best" problems.

c. Considerations in Marginal Cost Pricing:

When technology of production is characterized by decreasing costs, marginal cost will fall below average cost over the relevant range of the cost function. Any pricing policy which sets price equal to marginal cost will therefore not cover total cost of producing the service. Under these circumstances funds from some other source, usually a general tax levy, must be found to cover the resulting operating deficit [Vickery, 1955]. Indeed, an important point is that the marginal cost pricing principle neither requires nor guarantees full cost recovery. For example, with respect to the inland waterways, user charges are often recommended as a means of promoting efficiency in resource use, but are usually set to recover costs with the implicit or explicit assertion that the cost recovery level of charges will also promote efficiency. In fact, the types of expenditures for which marginal cost pricing is often suggested have a high component of fixed to variable costs, for example, a navigation lock and dam. Because of this, on the "the day after" construction, most of the resources in the project are sunk and operation and maintenance costs are all that remain. In such cases marginal cost pricing may mean a constant deficit, as only recovery of operation and maintenance costs is justified. In this sense, the difficult issue in discussing user charges is not one of zero price versus full cost recovery, but rather finding that price (user charge) which should be used to ration demand and supply in line with recovery of marginal opportunity costs and therefore the promotion of economic efficiency.

An implicit problem in the previous discussion is deciding what margin is under discussion. Marginal cost is the extra cost of providing an increment of any good or service, but in what units is the increment to be measured? There may be marginal costs of providing a ton-mile of service, or marginal costs of moving a ton of freight from A to B, or marginal costs per barge, or marginal costs of adding X ton-miles capacity to an existing transportation system. One way out of this dilemma is to identify a planning period of some length and to assess all costs expected within that period as short run, and all those beyond that period as long run. Given this framework, it can be argued that the efficiency question in setting user charges has two components: (1) what user charge will most efficiently allocate short-run expenditures for maintaining services with the existing investment; and, (2) how should user charges relate to the question of expanding capacity. In both questions the basic criteria remain the same—the user charge should reflect marginal opportunity cost for provision of the marginal increment of service.[4]

The problem of "second best" suggests that marginal cost pricing in one sector of the economy, when prices in other related sectors are not based upon marginal costs, can just as easily lead the allocation of resources away from efficiency as toward it [Milliman, 1969]. The implication of this argument is that there may be grounds for setting user charges above marginal cost of providing the service in an attempt to promote efficiency between all sectors of the economy providing a specific service.

External effects occur when one economic actor's production or consumption choice enters the production or utility function of some other actor in a positive or negative way, over which the latter has no control. As such an opportunity cost exists, but is not reflected in marginal cost borne by the choice maker, i.e. private marginal costs and social marginal cost diverge. Given this perspective, one objective of a user charge may be to publically administer a charge which will reflect social cost, and therefore force all individuals to consider total social opportunity cost when making production or consumption decisions.

IV. Marginal Cost Pricing for Inland Waterways

In using marginal cost pricing as a basis for waterway user charges, all the previous arguments must be considered. One aspect of the argument is that waterway operators are provided a transportation "highway" at government expense. Since they do not consider resource costs involved in this provision, marginal private costs diverge from total marginal costs. Hence, a charge levied on all users would eliminate this divergence and "induce barge operators to make decisions that were based upon the real resource costs associated with the provision of inland waterway transportation" [Hanke and Davis, 1974; p. 56]. In addition, such a toll would aid water resource planners in deciding on the desirability of making new investments or phasing out old ones" [Hanke and Davis, 1974; p. 56].

However, in one view, inland waterways exhibit decreasing cost of production characteristics such that marginal public cost falls close to zero for the second and all additional users of a waterway facility once the facility is in place. Operation costs on a given waterway segment are in essence fixed costs as

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[4] While the long-run short-run question may be a difficult one to sort out, marginal cost pricing is clear on the issue of historical costs prior to imposition of a user charge policy. Expenditures for provision of services in the past are of historical interest only. From either a short-run or long-run efficiency pricing standpoint, they are to be ignored in the development of user charges.

long as the segment is kept open to navigation. Cost of dredging, bank stabilization, and lock operation are almost totally unrelated to variations in ton-miles moved over a waterway segment. As Eckstein [1955] notes:

> The marginal cost of waterways will usually be a relatively small percentage of average cost since the waterway has to be made navigable and maintained in safe condition to permit any vessel to use it; the addition of any increment in traffic would lead to relatively little extra expense [p. 189].

Thus, the public costs of adding an additional tow to the waterway are close to zero, and any user charge seeking to promote economic efficiency based upon marginal public costs must also be close to zero. While this result may conflict with other criteria for setting user charges, it must be recognized that a positive user charge may not promote efficiency from this perspective.

This does raise the issue of exactly what is the marginal unit in the production of waterway transport services. If the adopted planning period is a year, for example, then the variable costs associated with a year's use of the waterway constitute the marginal cost and the sum of all the passages for the year constitute the incremental use. Hence, a charge which recovered a share of a year's variable costs from each user during the year would be efficient in the marginal cost pricing sense. Clearly then an issue of importance is of exactly what constitutes a short-run marginal unit of use.

Before developing this argument in more detail, the question of "second best" needs to be examined. Since the main competitors of waterways, the railroads, do not marginal cost price, then water transport should not be priced at marginal cost if efficient intermodal allocations are to be obtained. Thus Hanke and Davis [1974] argue:

> To obtain the proper allocation between modes of transport when [second best] conditions exist, prices should be set so that the ratio of prices between modes is equal to the ratio of their marginal costs. This rule suggests that, from an efficiency point of view, a price should be charged for waterway services that exceeds marginal costs. [p.58]

However, as observed by the U.S. Department of Transportation [1971]:

> A case can be made that since railroads, on the average, price above marginal costs, that water transport should do the same. This would lead to a better allocation of traffic between rail and water, *even though it would encourage the* purchase of less than the optimal amount of transportation. . . . [p. II-2]

Thus the argument for setting waterway user charges above marginal cost on the grounds of the second best argument implicitly argues that intermodal efficiency in transportation is more important than intersectoral efficiency in the overall economy. It might also be noted that attempts to force intermodal efficiency through imposition of a user charge on waterway users is a backhanded attempt to deal with inefficiencies promoted by Interstate Commerce Commission pricing regulations on the railroads.

In developing another aspect of this argument one author cites evidence that the specific lines where water competition exists for railroads, railroads lower price with ICC consent, to approximate marginal costs [U.S. Department of Transportation, 1971, p. II-3]. Therefore, he argues, railroads are not pricing above marginal cost in those areas where water provides an alternative, and there is little need for user charges to deal with the second best problem. This argument ignores the fact that the railroads then raise rates far above marginal costs on non-water competitive routes. Hence interregional inefficiencies in production of products dependent upon transport may result.[5] Clearly, trying to develop a strict interpretation of the second best argument raises some problems, just as an attempt to strictly apply marginal cost pricing.

To this point the discussion has considered marginal cost pricing for promotion of short-run efficiency on an uncongested waterway. If congestion occurs at locks, external costs, as measured by delay time, are imposed by one tow upon another. The existence of such external effects (which are a marginal opportunity cost) may suggest adjustments in a user charge so that this externality is internalized. The high hourly costs of operating towboat and barge equipment suggests that such external costs may be significant and a charge might allocate time in the lock to tows which have the highest value for their time. In fact, some waterway promoters argue that waterway investments of the future will be for expansion and replacement of existing facilities to eliminate such congestion, as opposed to creation of entirely new waterways. From this perspective, a congestion charge would be a means of testing willingness to pay for investment in expansion or replacement of crowded facilities.

V. Toward a User Charge Policy

The previous discussion has briefly surveyed some of the key issues in setting forth a user charge policy. For inland waterways it seems unreasonable to be particularly concerned with the equity issue in any sense other than that immediate users of the waterways should pay. This does however raise one practical question of some concern. Different waterways do require different

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[5] For an excellent discussion of this effect see Seaver, 1972.

levels of expenditures. Therefore, the equity criteria may suggest that users might be required to pay different levels of charges for use of different waterways. The cost recovery goal is clearly one that can be achieved through user charges although the level of cost recovery sought may be mitigated by the desire to simultaneously promote economic efficiency.

Within the efficiency context problems of isolating long-run versus short-run increments of output will always be difficult. From a practical standpoint it appears that adoption of a year's traffic would be a viable short-run increment, with additions to total waterway capacity or replacement of old capacity as long-run decisions. Defining the exact long-run marginal unit will be extremely difficult. Given the "state of the art" it makes sense to look at the long-run investment user charge as a way of introducing some discipline into the public choice process. The exact level is an unsettled question that will need further investigation [Milliman, 1969]. The second best question has unclear implications for navigation. However, since any inefficiencies that may exist are probably due to regulatory policies on the railroads, it hardly seems reasonable to promote user charges on waterways as the correct policy instrument for dealing with the regulatory problem. The external effects question is one that may bear consideration in setting user charges. However, recall that the opportunity cost it represents is time delay imposed on other users, as opposed to direct cost expenditures on maintenance of the water highway.

In summary, while the user charge arguments can become complex, the practical need to evaluate, consider and perhaps impose user charges means a compromise between practical needs and theoretical rigor. Indeed, to pursue such rigor to an extreme may in itself be economically inefficient in that the gains in efficiency or other objectives from a theoretically rigorous pricing policy may not be large enough to justify additional outlays for administration of such a scheme. Consider Figure III-1.

EE represents the incremental gain in economic efficiency, equity and revenue production as more administratively complex user charge schemes are introduced. It suggests that the marginal gain will be greatest early in the user charge program and fall as more complexity is added.[6] CC represents the marginal cost of administering more complex schemes and slopes upward indicating the need for ever more detailed and costly information and the higher enforcement costs of more complex schemes. Point A suggests an optimum degree of complexity in the system. Therefore, an overriding criterion in setting user charge policy is often one of administrative

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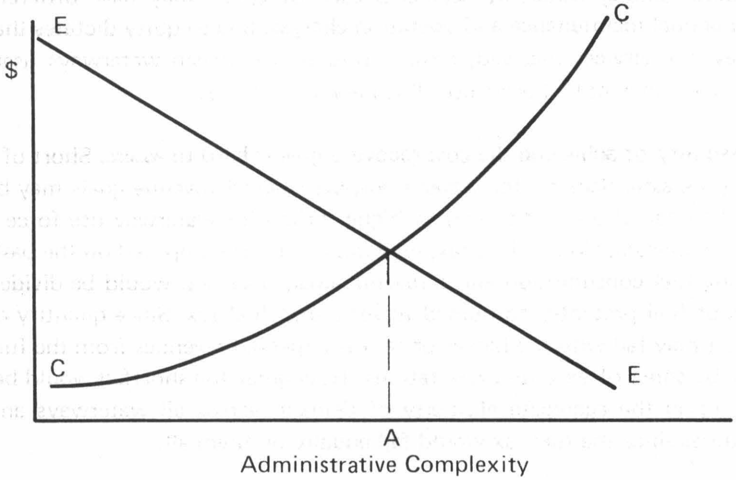
[6] It is plausible that EE could be a horizontal or upward sloping function although the negative slope does seem most logical.

FIGURE III-1

Gains and Costs of User Charge Policies



complexity. This should *not* be confused with considering only administrative cost.[7] Consideration of administrative complexity deals with both the efficiency equity and revenue production gains *and* the costs of administering a user charge program.

VI. Alternative User Charges

a. Fuel Tax

The fuel tax has been a common recommendation of those seeking to impose user charges on inland waterways. Indeed, virtually all recent executive branch efforts to impose a user charge have been for a per unit charge on fuel used by barge operators. The level of the charge would vary depending upon the level of cost recovery desired. Usually the distinction is between recovery of annual operation and maintenance costs, and recovery of these costs plus new construction expenses. The proponents of a fuel tax argue that of all the user charge mechanisms it would be least costly to administer. While true, these administrative costs would have to be compared to the gains in efficiency and equity that a fuel tax implies.

Since a fuel tax would fall equally upon all operators it would violate both efficiency and equity criteria, whether one accepts the tow (and hence zero marginal cost) as the marginal unit or a year's traffic of tows. If the tow is the

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[7] This confusion frequently appears in the literature. See Charles River Associates, 1970.

marginal unit, the fuel tax imposes a positive charge for a product for which marginal cost equals zero. If a year's traffic is the marginal unit, it does not discriminate among waterway segments each of which may have different levels of annual maintenance and operation charges. Since equity dictates that users pay for services received, cross subsidation between waterways users would result, since not all users use all waterways equally.

The possibility of achieving the cost-recovery goal is hard to assess. Short of a perfectly inelastic demand for water transport original revenue goals may be expected to fall short in the end as higher prices for waterway use force a cutback in consumption. A fuel tax, ex ante, would be computed on the basis of existing fuel consumption and a revenue goal, once set, would be divided by units of fuel presently consumed to set a unit fuel tax. Since quantity of fuel taken may fall with the higher price, the expected revenues from the fuel tax may be short of ex ante expectations. How great the shortfall would be, depends upon the aggregate elasticity of demand across all waterways and commodities since the fuel tax would fall equally on them all.

One aspect of the efficiency argument that warrants consideration was discussed in Section II. The use of inputs in the production a ton-mile of transport by the barge industry is, at this time, economically efficient, within the context of a free water highway. A fuel tax is a levy on one produciton input (fuel) to pay for another (the water highway). Such a tax will distort the relative price ratios that lead to the optimum input combinations and may lead to produciton inefficiencies.

b. License Fee:

A license fee parallels the concept of an admission charge. Once the fee is paid, it would not be related to use of the waterway during the period for which the license is effective. Such a fee would be levied on the equipment (barge capacity and/or horsepower) of the barge firm. The level of the fee, as with the fuel tax, would vary depending upon the revenue goal.

The license fee would be inexpensive to administer, however, as was argued with the fuel tax, this is not in itself a criterion for adoption. Also, as with the fuel tax, it would fall equally on all waterways and might be viewed as inequitable. On limited efficiency grounds, it might score high marks if one views the tow as the marginal unit, since once the fee is paid no additional charge is required. In this sense, it suggests a marginal use charge equal to zero which meets marginal cost pricing criteria. However, if the year's traffic is considered the marginal unit then efficiency criteria are not met since all pay the same fee although costs differ between waterways. Again, as with the fuel tax, it is a tax on one input to pay for another and may lead to inefficiencies in production.

c. Segment Toll:

This approach explicitly recognizes differences between waterway segment costs and then charges accordingly. Users of particular parts of the waterway segment pay a share of annual costs associated with operation maintenance, and if desired, improvements in that waterway segment. Using historical traffic data rates per ton or per ton-mile of traffic would be computed and this would serve as the base against which the toll would be levied and collected for each passage. In this case the equity goal is more nearly met than with either a fuel tax or license fee. The efficiency goal is clearly met if a year's traffic is considered the marginal unit for each waterway. However, once again any positive charge will not meet the efficiency criteria if the tow is viewed as the marginal unit.

Cost recovery may be well served if the higher cost segments are also the ones with the most elastic demand, since the high cost segments would probably be closed down for lack of traffic while the lower costs of maintaining the remaining waterways would be easily captured from the remaining inelastic demanders. One further advantage of the segment toll is that it relates more directly to the service provided by the waterway itself and does not create input price distortions by falling on fuel or equipment.

Segment tolls might be more administratively complex than license fees or fuel taxes. Records would have to be more complete and would be required in several different locations. However, the equity, efficiency and cost recovery gains of a segment toll compared to a license fee or fuel tax may outweigh the additional cost of administration.

VII. Lockage Fees and Congestion Tolls

Much of the inland waterways system depends upon the operation and maintenance of locks in addition to the navigation channels. In this case, a lockage fee might be imposed for use of a lock. Such a fee should reflect only the costs of lock operation and maintenance and not be used to recover costs for the entire waterway segment.[8]

The efficiency and equity arguments that would be made in favor of such a charge should be clear by now. Once again if the tow is viewed as the marginal unit, lockage fees would have to be quite small, if not zero, to promote economic efficiency. Using a year's traffic as the marginal unit, a

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[8] Other discussions consider the locking fee as a method of recovering all costs [Charles River Associates, 1970; p. 10].

lockage fee would cover costs by charging a unit rate per lockage. Such a mechanism would make sense as long as there is no congestion at the locks. Once congestion becomes a problem, efficiency considerations dictate that a charge be set to allocate the scarce resource of time to those tows which value it most highly. As has been noted above, tow delay time is a significant cost and can affect rates charged and waterway demand. The methods that have been suggested for charging for time all would ultimately reflect the value of a passage. In addition, several forms of the congestion toll have been suggested. The following discussion from a recent Department of Transportation report captures the essence of the arguments.

> If tows have different costs associated with waiting, resource costs can be lowered by developing procedures other than "first come, first served." One procedure would be to auction places in the queue. Assuming that all bidders acted independently and without collusion, this procedure would result in both the greatest toll revenue and the best resource allocation. Marginal tows could wait until no one was waiting and go through for nothing; priority cargo could avoid delay.
>
> A second procedure would involve serving tows on a first come, first served basis unless they elected to give up their positions. Each would be charged the average value of time for each hour of delay for each tow in back of it (unless vacated its position). No bidding would be required and so it would be administratively simpler, although it would lead to less efficient resource allocation.
>
> A third procedure would be to charge the average value of time per hour for delaying other tows, without provision for vacating one's position. A final scheme would involve charging tows based on the average wait during a period (such as daylight hours during winter). While this average toll or lockage fee would eliminate uncertainty about the amount of the toll, it would not enable marginal towboats to pass free or allow priority tows to go first. . . .
>
> The revenues generated by a congestion toll are not related to the operating or construction costs of the system and are not intended to be so related. The most obvious way to spend these revenues is in relieving congestion. In doing this any proposed investment should be judged by the criterion of whether its benefits exceed its cost (using the correct rate of discount and considering all benefits and costs including income redistribution). Waterway investments can take many forms, such

> as improving the speed and size of locks, dredging the waterway to a greater depth, increasing the distance between dams (and therefore locks), or improving navigation aids and getting rid of barriers to navigation, such as bridges. Each of these improvements must be judged on its own merits. It is important to recognize that projects for which costs exceed benefits should not be undertaken even if funds are available from congestion toll charges. This would reduce the wealth of the country [U.S. Department of Transportation, 1971; p. II-10].

Congestion tolls might induce better scheduling by firms of towboat arrival at locks, although there is every reason to believe that congestion costs themselves have encouraged this. Possible use of switch boats would eliminate the need to pass the towboat through the system multiple times when the tow must be broken up for locking. The implementation of congestion tolls would definitely be difficult at first; however, it appears that the efficiency gains may justify it.

Congestion tolls should not be seen as alternatives to user charges but as a means of dealing with a special problem. However, they can provide guidelines for the long-run investment decision problem, as noted previously.

VIII. Conclusions

From the previous discussion it appears that a congestion toll would be a viable alternative for dealing with the specific problem of external costs of delay. While it would meet the criteria of equity and efficiency, it would, in its most sophisticated form, be administratively complex. As such there may be some question as to the *net* gains that might be achieved through imposition of such a toll. The relatively few areas where congestion problems do now exist suggests that for this study the impact of such charges will not be worthwhile to consider.

Of more immediate concern is the imposition of charges related to non-congestion costs. In this area a segment toll for the waterway itself seems most desirable, with lockage charges for use of lock facilities. An alternative would be to consider locks and channel maintenance as part of the same waterway segment and simply charge a segment toll related to these combined costs. Given the enhanced simplicity of this type of charge, it seems on all grounds to be the most desirable. As such, subsequent discussion will evaluate the impact of segment tolls on waterways and waterway traffic.

While the fuel tax appears less than desirable on economic grounds, it does continuely reappear in the various policy recommendations. As one study notes:

> The justification for this proposal [fuel tax] is more political than economic. In fact, the fuel tax is readily understood and has an element of fairness about it. It would be the easiest tax for the government to collect and the user to pay. There is general public acceptance of fuel taxes in other cases such as highways and aviation [Franklin, 1973].

Given these considerations it seems that the impact of a fuel tax should be evaluated along with the segment toll.

Finally, it is worth recalling the argument that the marginal cost of a tow is near zero. Under this assertion only a congestion toll could be justified on efficiency grounds. If this argument is accepted any positive toll will not promote inefficiency in resource use, although equity and revenue production goals may be met.

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SECTION IV

THE IMPACT OF USER CHARGES ON THE WATERWAY TRANSPORTATION MARKET

Previous discussion of production, cost, supply, and demand will now be brought to bear on two specific questions: (1) which group would bear the burden of a user charge, or analogously which group benefits from the free waterway subsidy, and (2) what will be the impact on traffic movements of a user charge?

I. On the Distribution of Benefits and Costs

In the debate over user charge policy, all parties agree that some adjustments in transportation modes and patterns will take place if a user charge program is adopted. One undecided question is who gains and who loses from such a policy. The absence of user charges for inland waterways has been viewed by some as a subsidy, provoking the equity based argument that some form of fee be levied to recover this subsidy. In a competitive industry a per unit subsidy for a product (here a ton-mile) of waterway traffic) simultaneously increases output and lowers the price the product sells for [Sharp, 1969]. Under normal demand and supply elasticity assumptions the benefits of the subsidy for a product (here a ton-mile of waterway traffic) simultaneously increases output and lowers the price the product sells for [Shoup, 1969]. the subsidy is divided between a fall in the price of the product and a fall in marginal costs of production. If conditions are such that supply is perfectly inelastic and demand is perfectly elastic the producer of the product receives the full subsidy, while if demand is perfectly inelastic and supply is perfectly elastic the benefits accrue to the buyer of the product. However, no change in quantity produced results in either of these extreme cases.

Short-run adjustments to a subsidy see the competitive firm increasing output to the point where the initial demand price is equal to marginal cost less the subsidy, with the result that as all firms take such action, market price falls. Next, abnormal profits become the rule of the day and new firms enter the industry depressing market price until long-run equilibrium is reached. For an increasing cost industry the new market price will be greater than the old price less the subsidy. In addition the new level of output will be greater as long as demand is not perfectly inelastic. For a constant cost industry (elastic long-run supply) output expands and price is the pre-subsidy level less the subsidy. In this instance the subsidy ultimately accrues to the buyer due to

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[1] The arguments in the economics literature of this subject are well established and need not be developed here in any depth. They are analogues of the excise tax argument presented in Musgrave [1959] and Shoup [1969].

the elastic supply curve. The imposition of a user charge as a form of excise tax would see the burden fall principally on those who currently benefit from the subsidy as determined by the relevant demand and supply elasticities.[2]

For an intermediate good such as transportation, the analysis may not stop here. The producer of the transportation service, insofar as a subsidy accrues to him, will employ more or different combinations of resource inputs. In this sense the suppliers of factors of production may gain from a subsidy. The exact amount of gain depends upon the market within which the factors are purchased. On the other hand, the imposition of a charge to recover the subsidy can lead to changes in total and particular factor demands. On the other side of the market the purchasers of the transportation service, insofar as the subsidy shifts to them, see a cost of production reduced and, depending upon the product market conditions, will either retain the subsidy or shift it forward to their customers. Given the arguments in Section III on equity and user charges, the concern here will be only with the incidence between the waterway transportation industry as a whole and their customers. How they then adjust to a subsidy or charge resulting in forward or backward shifting need not be of concern.

Hilton argues that the barge industry:

> . . . receives a major direct subsidy from the toll-free character of the rivers on which they operate. There is little question that the [absence of tolls] cause barge traffic to be greater than it would be in a competitive organization of the [transport] industry with appropriate user charges. This, however, merely attracts generally unspecialized resources to the industry, rather than creating monopoly gain [Hilton, 1973; p. 732].

Others also have argued that the absence of user charges represents a subsidy to the barge industry [White, 1969]. The previous analysis of supply and demand for waterway transport can shed some light on this question. Recall that the long-run supply function appears to be perfectly elastic. Furthermore, the free waterways policy has the effect of shifting this long-run curve downward. Given the arguments above, this results in the benefits of the subsidy accruing entirely to the shippers (or customers) of the waterway transport industry. The supply of this increased volume of waterway transport may come, as Hilton observes, from attracting unspecialized resources to the industry. In terms of the cost analysis of Section II, small firms operating on both constricted and open waterways are

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[2] The segment toll would be an excise tax in a true sense since it would be a tax on output. A fuel tax is a tax on inputs which may lead to slightly different impacts although the general conclusion discussed here would hold [Musgrave, 1959].

encouraged to remain in the industry to to use existing resource inputs to provide a water transport service without needing to seek enhanced produciton economies. In this sense, the subsidy encourages these resources to be used in water transport rather than elsewhere in the economy where thay may have a higher net social return. This still does not mean that these marginal firms receive the subsidy, *only* that they respond to a distorted price signal in committing resources to water transport rather than other uses. The subsidy inherent in free waterways still accrues to the shippers.

Beyond this conclusion it can be argued that the actual level of subsidy to shippers will differ between waterway segments as the costs of providing the waterways differs. In this sense, the long-run supply curve is shifted downward in different amounts for each waterway. When this is considered in the context of differing demand elasticities by commodity and waterway segment, it is clear that the subsidy which does accrue to shippers differs between regions and economic sectors as the supply shift is greater and demand is more elastic.

II. User Charge Impact on Waterway Traffic Movements

a. Considerations in Assessing Impact:

The cost changes implied by a full operation and maintenance cost recovery user charge will be the focus of the following analysis. A fuel tax and a segment toll will be the mechanisms considered for accomplishing this revenue goal. Although the discussion in Section III suggests that simply pursuing cost recovery alone may not promote economic efficiency, if annual traffic is viewed as the marginal increment in the system there may be some justification on efficiency grounds for collection of operation and maintenance costs from users. Also, if this level of charge should appear to have little impact on traffic movements, then the efficiency argument becomes moot. The more difficult question is that of recovery of capacity expansion or replacement costs. The long-run marginal costs of such expansion are difficult to estimate at best. Policy debate on the subject is also somewhat unclear, although most proposals suggest recovery of operation and maintenance from users, with investment decisions hinging upon competent application of rigorous benefit-cost analysis [Moses and Lave, 1970].

The following analysis will follow this procedure and consider recovery on annual operation and maintenance (O&M) costs based upon a five-year average expenditure. The necessary levels for both a fuel tax and segment toll will be developed on a cost per ton-mile basis. The discussion will then proceed by analyzing, for waterway segments, the impact of such charges on adjustments within the industry, and as they influence demand for waterway transport. The discussion guidelines will be from Section II of this study. A general summary discussion of the points made in Section II follows.

The waterway transportation industry is quite competitive and is dominated by small firms. There are scale economies of tow and firm size that can be realized, and indeed firms are showing a tendency toward larger scale. In addition, input substitution possibilities exist for larger tows. Thus, a user charge may encourage industry movement toward larger firms which in turn will help keep rates down in spite of the increased cost represented by the user charge. However, not all firms will be able to realize similar degrees of scale economies. The most obvious, and perhaps the most significant, limiting factor on firm and tow size are the waterway characteristics themselves. Width and depth as well as other possible factors such as lock size, number of locks, and length of navigation season, may prevent scale expansion and therefore prohibit individual firms from changing their produciton technology and/or scale to maintain low rates in the face of the user charge. In short, firms operating on constricted waterways will be forced to pass forward a larger portion of the user charge, while those on open waterways will be able to absorb some of its effects by produciton modifications. When it is considered that the open waterway operator already is able to realize lower operating costs, then any user charge will tend to diminish the line-haul cost advantage to a greater degree on small constricted waterways than on long open waterways.

The barge mode offers several cost advantages and can offer substantially lower rates than competing modes. Particular commodity movements are able to benefit from that advantage. Barge rates can be expected to be most competitive for commodities that:

1. are shipped on long haul to take advantage of the long-haul economy advantage of barge.

2. are likely to find use on the water's edge (implies low feeder and distribution costs).

3. are shipped in large quantities by water (implies lower cargo handling costs and possibilities of "neutral" technological change such as scheduling improvements.

4. are of low value to minimize implicit inventory charge of barge which is true for virtually all commodities transported by water.

Therefore, as the commodity shipment better meets each of these characteristics the barge mode has a competitive advantage over other modes and will be less affected by whatever cost increases may come about through a user charge.

b. Review and Critique of Previous Studies:

The major studies of user charge impacts reach opposite conclusions. The National Waterways Conference published a monograph in 1968 on the impact of waterway user charges on traffic movement. That analysis has formed a basis since then for three further discussions of the subject [Charles River Associates, 1970; U.S. Department of Transportation, 1971; U.S. Water Resources Council, 1973]. The user charge impact on waterway traffic was estimated to be quite severe. The collection of $150 million annually through tolls was seen as increasing rates by as much as fifty percent, causing much of the traffic to cease flowing and nearly one half of the mileage of the inland waterway system to shut down for lack of traffic. With respect to demand elasticity they suggested that a one-third increase in rates would lead to one-third decline in traffic, implying an elasticity of demand of minus one. The Water Resources Council Staff Report [1973] used this basic argument to examine the impact of collecting tolls to cover, first an $80 million operation and maintenance cost, and second, a $240 million dollar annual charge to cover new construction and O & M. These were seen as causing a 19 and 57 percent increase, respectively, in average water transportation rate charges. They reached the following conclusions:

> . . . On the average one could expect about a 15 percent decrease in existing traffic if present annual O&M costs were allocated on a ton-mile basis. The revenue goal would then fall short by 15 percent. One hesitates to speculate on the impact of the 57 percent increase. The traffic decrease would then probably have a significant impact on service characteristics. It would not be difficult to envision the loss of as much as 50 percent of present traffic with such an imposition.
>
> Loss of traffic involves two types of shipper responses: diversion to other modes, and cessation of shipments. Diversion, at least in the medium run would account for most of the loss, and would depend on the rate levels offered by rail and pipeline competitors.
>
> Rail competitive commodities are coal and grain, accounting for 28 percent waterborne tonnage. In 1970, barge rates averaged approximately 2.9 mills per ton-mile. The lowest rail rates for unit trains were about 6 mills per ton-mile. Recovering O&M costs only, barge rates could rise to 3.5 mills per ton-mile. Attempting to recover both O&M and capital costs could raise

> barge rates to 4.5 mills per ton-mile. With rail providing better service characteristics a major part of waterborne traffic would appear to be vulnerable to rail cometition at the higher toll level. . . .
>
> Pipeline competitive commodities comprise about 25 percent of the waterborne tonnage. In 1970 the barge cost of about 2 mills per ton-mile over the more circuitous river routes compare favorably with the terminal-to-terminal costs of pipelines of about 2.5 mills per ton-mile. There are, however, some estimates that hauling petroleum on the Lower Mississippi by barge costs only 1 mill per ton-mile. Imposition of a 0.6 mill increase could be absorbed. A 1.6 mill increase would erase the competitive edge of petroleum barging except on segments like the Lower Mississippi. . . .
>
> If the form of the user charge were a fuel tax, the regional impact of traffic losses would be fairly uniform. If, however, the segment toll becomes the mechanism for collecting user charges and annual O&M costs for each segment are to be borne by traffic on that segment, the regional impact becomes much more pronounced.
>
> A high-volume, low-cost waterway such as the Lower Mississippi would require a charge of .1 mill per ton-mile to cover annual O&M costs, hardly affecting the competitive position of traffic on this segment. The Ohio River, heavily canalized with costly locks, has such high traffic volumes that the toll for recovery of O&M costs would amount to only .4 mills per ton-mile. At the other extreme, the high-cost, low-volume Kentucky River would require a toll of 35 mills per ton-mile to recover annual O&M costs. Any attempt to recover this cost would amount to closing this river to commercial traffic. Similarly, the Apalachicola-Flint, Allegheny, Missouri, portions of the Intracoastal Waterways, and the Cumberland would probably not survive an attempt to collect annual operating costs. If the Corps of Engineers were to decide to cease maintaining these waterways and all traffic movements ceased on these segments, only 2 percent of the total traffic would be lost while saving 24 percent of the 1969 Corps O&M expenditure for inland waterway navigation [U.S. Water Resources Council, 1973; p. 12-6].

As part of their study of waterborne shipping, Kearny Associates reached somewhat different conclusions. Since they felt a fuel tax was a most likely

TABLE IV-1
The Impact of Fuel Taxes as a Waterway User Charge

Waterway Expenditures to be Recovered $ Millions	Barge Operator's Fuel Expense		Total Towboat Operating Expense*
	Cents per Gallon	Cents per Ton-Mile	Cents per Ton-Mile
$ 0	12 ¢	.048 ¢	.144 ¢
77	21	.084	.180
233	39	.156	.252

*Fully allocated cost of operating a 5,000 horsepower towboat under average conditions.

Source: Kearny, 1974; p. II-B-3.

form for a user charge, they assessed how such a tax would affect the competitive position of the marine mode vs. rail (see Table IV-1).

The first line of Table IV-1 shows costs with no fuel tax while the second and third show the results on operating costs of different levels of user charges. Recovery of $77 million indicates a cost and hence rate increase of 25 percent, while recovery of $233 million would increase costs by 75 percent. It is worth noting here that these increases are in fact greater than estimated by the Water Resources Council, but as will be noted, the expected impact is not seen to be nearly as great. Table IV-2, taken from Kearny, compares variable line-haul, inventory and handling cost for selected rail and water movements under assumptions of 9 and 27 cents per gallon fuel taxes.

In reference to this table and to their other studies they note:

> [Other studies estimate] that 20% of barge traffic might be diverted to other modes as a result of the imposition of fuel taxes to cover operating and maintenance expenditures. However, as a result of the modal split analysis conducted in the course of this study, it does not appear likely that such a large diversion of traffic would result. An analysis of the factors which are significant in determining modal share in barge markets has indicated that short-term cost relationships between the modes are less significant than long-term locational decisions.
>
> Hence, increases in barge rates to reflect fuel taxes, for instance, are unlikely to cause an immediate shift in traffic. The cost analyses in Table IV-1 illustrate that the impact of the 9 cents per

TABLE IV-2
The Impact of Fuel Taxes on Intermodal Competition

Commodity	Origin — Destination	Present* Barge Cost	Barge** Advantage	Barge Cost with 9 Cents/Gallon Fuel Tax	Barge Advantage	Barge Cost with 27 Cents/Gallon Fuel Tax	Barge Advantage
Primary Iron and Steel	Pittsburgh Louisville	$4.57	$1.13	$4.78	$ .92	$5.22	$.48
Coal	Huntington, W. Va. New Orleans	5.90	2.66	6.47	2.09	7.58	.98
Sugar	New Orleans Chicago	5.39	2.42	5.91	1.90	6.93	88
Nonferrous Metals	Little Rock Mobil	6.21	.52	6.49	.24	7.05	–.32
Paper	Vicksburg, Miss. Chicago	6.51	.87	6.89	.49	7.66	–.28
Cash Grains	Sioux City Chattanooga	8.58	2.22	9.18	1.62	10.36	.44

*Variable costs in all cases, per ton.

**Difference between barge and rail variable costs including handling and inventory costs.

Source: Kearny, 1974; p. II-B-5.

> gallon fuel tax (to cover operating and maintenance expenditures) is minimal when comparing the total costs of barge and rail service (including variable line-haul costs, handling costs, and inventory costs). The increase in barge costs for the movements displayed in the table are between 5% and 10% and the marine mode maintained its cost advantage in all cases. Hence, it is unlikely that the cost of barge service will be increased sufficiently to alter the modal choice of shippers in the short term. Modal split analysis conducted in the course of this study has indicated that such factors as proximity to the waterway, length of haul, and volume of movement are far more significant in explaining local market share than short-term modal price relationships.
>
> ... [I] t appears likely that a mild cost impact of a reasonable fuel tax coupled with the short-term insensitivity of marine markets to slight price changes will tend to dampen much of the adverse market impact of user charges [Kearny, 1974; p. II-13-7] .

c. Discussion of Previous Work:

There are compelling arguments in both studies reviewed here. However, both have several drawbacks that also should be noted. The Water Resource Council argument aggregated over all waterways and total shipments of all commodities. Clearly this masks the high variability that the inland waterway system exhibits. The Kearny study on the other hand did look carefully at specific commodity movements, although they were quite limited and probably selected routes for which the barge mode had a significant competative advantage. Also Kearny did not consider feeder and distribution costs in looking at the net barge advantage. These costs are clearly of some importance to shippers and would affect shipper demand. On the other hand, the consideration of non-line haul rates is sketchy, at best, in the Water Council discussion. While the elasticity "estimate" of minus one would include these non-line haul cost features, the source of the minus one figure is somewhat suspect. In fact, there is every reason to believe that it varies with commodity and waterway—a fact of utmost importance if one wishes to consider how the sum of individual impacts may affect the total of all shipments.

With respect to waterways themselves, both studies ignore scale and production economies which are in turn influenced by different waterways. Clearly a user charge will bear harder on some waterways than others since some currently do not have a significant cost advantage due to limits on capturing such economies. Kearny assumes a particular tow size and says nothing about the firm, while Water Resources Council says nothing on either subject.

In short, the use of average rates, average shipments and average tow sizes for analysis can be quite misleading, as the diametrically opposed conclusions of the two studies demonstrate. More detail on commodity type and waterway are necessary in order to assess the impact on traffic of a user charge. While the reviews of this study will not allow generation of quantitative estimates of magnitudes, a qualitative study is feasible with the background provided.

III. Impact of Fuel Taxes and Segment Tolls

a. Data Base

There are few consistent sources of information about traffic movements on inland waterways and public costs for operation and maintenance of the waterways. Where there are reporting requirements for barge operators (to the Army Corps of Engineers), there are problems of double counting shipments, allocation of shipments to waterway segments, and the like. Costs are incurred by many agencies and levels of government (Section I). In order to procede, however, it was necessary to select a data series that appears most useful and use it consistently. For this study, statistics published by the American Waterways Operators, Inc. (AWO) [1972, 1973] were adopted. Their data is compiled from reports of the U.S. Army Corps of Engineers on a yearly basis and are published for the inland waterway system as a whole and for individual waterway segments. Subsequent discussion will use AWO estimates of ton-miles shipped by waterway segment, five year average 0 and M (1968-1972), shipments in tons by commodity by waterway segment, and of industrial locations on waterways. Also this source provides information on waterway width, controlling depth and number of locks.

b. The Level of the Fuel Tax:

A first priority was to estimate a fuel tax induced cost on a ton-mile basis. The fuel tax will apply equally to all cargoes and all waterway segments, and in all likelihood will vary every few years to reflect general historical patterns in public 0 and M costs. Since there are no precise figures on fuel use by inland waterway operators, an estimate was developed using data from a 1969 Department of Transportation Report. The estimate of total 1968 fuel consumption for line haul, as well as dredging, drilling, and construction operations was 895,633,000 gallons. Of this 849,226,000 were consumed in line-haul operations exclusive of traffic on the Great Lakes. During this same year 179,336,707,000 ton miles were moved in inland waterway line haul operations implying a fuel use rate of .004735 gallons per ton mile [U.S. Department of Transportation, 1971]. This later figure was then assumed to be the same fuel efficiency rate in line-haul operations that existed in 1973.[3] Since 201,375,000,000 ton-miles were moved in 1973 in line-haul operations, this implies total line-haul fuel consumption of 953,510,625 gallons. No data to compute 1973 non-line-haul fuel use was available. It was assumed to increase slightly to 47,000,000 gallons by 1973, implying total fuel use in 1973 of 1,000,510,625 gallons. During the five year period, 1967-1972, estimated average annual operation and maintenance expenditures were $104,888,000 [Table IV-3]. Using this figure, an 11 cent per gallon fuel tax would recover O and M cost based upon 1973 freight traffic on the inland wateway system exclusive of the Great Lakes. If the fuel used in that traffic were also taxed, the average tax per gallon would be lower.

Using the conversion figure of .004535 gallons of fuel per ton-mile in line-haul operation, the average cost per ton-mile of an 11-cent fuel tax would be .52 mills per ton-mile on all waterway segments. With an estimated current rate in the range of four to five mills per ton-mile, this level of tax represents average cost increases to the barge mode between 13 and 10.4 percent.[4] However, insofar as tow scale economies exist, average cost per ton-mile and the fuel tax cost per ton-mile will be lower. These percentage figures also ignore the possibility of firm scale and substitution economies to reduce the actual cost per ton-mile implied by the 11-cent per gallon tax.

c. The Segment Toll

The level of this toll is easily established. Separate waterway segments have been identified and five year average operation and maintenance costs have been compiled by segment. Using 1973 segment traffic data, a charge per ton-mile of traffic can be set that will be necessary to recover O and M. The segment toll will range from 32.8 mills per ton-mile on the Appalachicola, Chatahoochee and Flint Waterway to .13 mills on the Lower Mississippi. Again using the 4-5 mills average cost, this will represent a 3 percent to 700 percent increase in costs. Table IV-3 provides information on the level of this charge for each waterway as well as other information that will be useful in discussing the impact of a user charge.

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[3] Although technology may have changed, there is little evidence that fuel use per horsepower changes significantly as horsepower increases (see Table II-4). Fuel use per ton-mile will, however, become less as tow size increases, a fact ignored here by the use of average figures for fuel consumption over all size tows [Kearny, 1974]. It might be noted here that this fuel efficiency rate estimate conforms with the Kearny Associate estimate of .004 gallons per ton-mile for a 5,000 horsepower towboat.

[4] No estimates of rates by commodity by waterway segment were available. In subsequent discussion the range of 4-5 mills suggested by American Waterways Operators [1972] will therefore be used for all shipments.

TABLE IV-3
Traffic, Cost and Toll Information by Waterway Segment

Waterway Segment	1973 ton-miles (in 1,000's)	% of ton-miles by segment & (cumulative)		0 & M 5-Year Avg. (in 1,000's)
Lower Mississippi*	96,078,818	47.7	(47.7)	$12,100
Ohio River*	29,942,196	14.9	(62.6)	$10,700
Gulf Intra Coastal Waterway*	17,449,160	8.7	(71.3)	$ 7,500
Upper Mississippi*	10,879,201	5.4	(76.7)	$10,700
Delaware River*	10,744,206	5.3	(82.0)	$ 5,379
Illinois River*	8,450,727	4.2	(86,2)	$ 3,600
Tennessee River	3,928,499	2.0	(88.2)	$ 8,000
Houston Ship Channel*	3,741,921	1.9	(90.1)	$ 1,944
Black Warrior, Warrior, Tombigbee*	3,728,750	1.9	(92.0)	$ 2,537
Columbia River	3,185,991	1.6	(93.6)	$ 6,481
Chesapeake Bay*	2,756,580	1.4	(95.0)	$ 905
Hudson River*	2,461,659	1.2	(96.2)	$ 515
Monongohelia River	1,494,803	.7	(96.9)	$ 1,900
Green and Barren Rivers*	1,395,537	.7	(97.5)	$ 569
Cumberland River	1,054,754	.5	(98.0)	$ 3,160
Missouri River	884,406	.4	(98.4)	$11,500
Kanawha River	796,230	.4	(98.8)	$ 981
Atlantic Intra Coastal Waterway	626,006	.3	(99.1)	$ 3,486
Potomac River*	578,515	.3	(99.4)	0
James River	482,359	.2	(99.6)	$ 441
McClellan-Kerr, Arkansas River System	338,623	.2	(99.8)	$ 5,300
Applachicola, Chatahoochee, Flint	124,189	.05	(99.86)	$ 4,079
Sacremento River	95,705	.04	(99.91)	$ 1,176
Alleghany River	83,911	.04	(99.95)	$ 800
San Joaquin River	81,337	.04	(99.99)	$ 262
Kentucky River	52,282	.01	(100.0)	$ 873
TOTALS	201,375,000,000	100.		$104,888

*Indicates segment tolls of less than one mill.
Source: American Waterways Operators, 1972 and 1973.

TABLE IV-3 (continued)

% of O & M segment	& (cumulative)	Ton-Mile segment toll (in mills)	Depth (feet)	Width (feet)	Length (miles)	No. of Locks
11.5	(11.5)	.13	9–40	300–1100	1174	30
10.2	(21.7)	.36	9	400–600	981	43
7.1	(28.8)	.43	12	125	113	9
10.2	(39.0)	.98	9	300–1000	663	27
5.1	(41.1)	.50	12–40	150–2300	129	0
3.4	(44.4)	.43	9	225	354	7
7.6	(52.0)	2.0	11	300	650	10
1.9	(53.9)	.52	8–40	60–400	50	0
2.4	(56.3)	.68	9	200	466	6
6.1	(62.4)	2.0	7–42	300–2640	670	8
.9	(63.3)	.33	42	1000	200	0
.5	(63.8)	.21	14–32	200–600	55	0
1.8	(65.6)	1.3	7–9	300	129	11
.5	(66.1)	.41	5.5–9	100–200	180	5
3.0	(69.1)	3.0	9	n.a.	317	3
11.0	(80.1)	13	6–9	300	732	0
.9	(81.0)	1.2	9	300	91	3
3.3	(84.3)	5.6	12	90	1129	2
0	(84.3)	0	24	200	113	0
4.2	(88.5)	.9	18–35	200–300	89	0
5.1	(93.6)	15.7	9	150–300	448	17
3.9	(97.5)	32.8	9	100	297	3
1.1	(98.6)	12.3	6–10	100–300	145	1
.8	(99.4)	9.5	9	200	72	9
.2	(99.6)	3.2	3–30	225–400	127	0
.8	(100.4)	16.7	6	100	286	14
100,	(100.4)	n.a.				

d. Commodity Movements, Waterway Segments and the User Charge:

As noted in Table I-8, petroleum, coal, grains, and chemicals make up nearly 75 percent of total waterway ton-mile traffic. Also of interest is that these same commodity groups are the ones which make up the bulk of the "exempt-for-hire" traffic (Table I-4). Therefore, a user charge will fall on a limited number of commodity types and upon those in which rates are most competitive within the industry.

However, of importance is that over 80 percent of the iron ore and iron and steel movements are subject to ICC regulation. Any user charge that affects this commodity will probably be fit within the rate schedule so that the competitive position of the water mode, for this commodity, will not be hurt. Although predicting ICC behavior is a risky business, it would seem safe to assume that regulatory actions would lead to rates that did not seriously alter the modal shares for shipment of this product.

Another aspect of traffic movements worth noting is that the low unit value commodities of sand, gravel and stone, and shells move in large part by privately owned carriers and on very short haul. Since the current price of these products is probably over 50 prcent transportation cost, a rise in this cost will have a significant effect on product price [Locklin, 1972]. The effect of the user charge here is somewhat uncertain, since a shift in modes by the shipper does not imply asking another firm for a service, but rather suggests abandonment of part of the shipper's own assets. This would suggest at least some short-run reluctance to shift modes. Longer-run effects would depend upon not only the level of the charge, but the convenience and cost advantage the shipper realizes from having his own barge fleet. Clearly there are some advantages to private ownership that may not be eliminated by a user charge. One might speculate that the private carrier dominates these commodities since the barge can provide not only transportation but also storage on the water's edge, thus minimizing the cargo handling requirements for this low value commodity. To shift modes implies the need for more storage and handling. Thus, while these shipments are primarily short haul, there may be cost advantages of the barge mode in non-line haul areas.

The commodity movements most subject to competitive rate making can now be considered in more detail. The following discussion quotes in detail from a 1969 Department of Transportation study:

> The primary market for inland riverborne coal is the Pittsburgh industrial area, which includes portions of the Ohio, Allegheny. and Monongahela Rivers. Over 50 percent of all riverborne coal terminates in this area. Well over half of the coal terminating in Pittsburgh originates in coal fields served by the Monongahela. A

second major market for riverborne coal is the series of industrial centers on the lower Ohio River including Cincinnati and Louisville. Most of this coal originates on the Ohio River between Huntington, West Virginia, and Louisville. A smaller volume comes from the Kanawha River. The Tennessee Valley provides a market for about 7 million tons of waterborne coal annually, 85 percent originating on the Tennessee itself and the remainder orginating on the lower Ohio River. The Chicago coal market receives its riverborne coal predominantly from the Illinois Waterway. A volume of about 2 million tons annually also moves by barge from the southern Illinois coal fields to the Twin Cities via the Upper Mississippi.

As the Ohio dominates the coal movement, the waterways adjacent to the Gulf of Mexico dominate the barge movement of petroleum and its products. Barged petroleum in many areas faces the tough competition of pipelines which may provide more direct routing for both crude oil and refined products, are more convenient, and in many cases more economical than barge transportation. As a result, a large part of the barge tonnage of petroleum and its products is supplementary to pipeline movements, barges being used in new oil fields prior to the construction of pipelines or for movements to special locations where pipeline construction is not economical. In the latter case, barge transportation is often an extension of a prior pipeline movement.

Tidelands and off-shore oil wells in the Gulf district offer especially good opportunities for barge traffic in crude petroleum, due to the difficulties of pipeline construction in the swampy and submerged areas. Barges are used for both drilling operations and for transporting the crude petroleum to nearby refining centers. Half of the movement terminates in refining centers on the Gulf Intracoastal Walterway and another 25 percent originates on the lower Mississippi and terminates principally in New Orleans and Baton Rouge. A smaller movement originating in the Gulf Intracoastal Waterway transfers to the lower Mississippi. Outside of the Gulf producing area, the only major barge traffic in crude oil is on the Ohio River. The latter apparently represents movement of oil produced in Kentucky, southern Illinois, and adjacent areas. It may also include some oil shipped from the Gulf area by pipeline and transferred to barge for movement to smaller refineries without pipeline facilities. A relatively small amount of crude oil moves from the southern Illinois-St. Louis area into the Upper Mississippi.

Movement of refined products by barge is much more complex, due to the various locations of refining centers and widely dispersed wholesale and retail outlets for petroleum products. Almost every improved waterway has a substantial traffic in refined petroleum products. A concentration of tonnage does occur on the Lower Mississippi where one-fifth of the total riverborne traffic originates and terminates. Other large quantities move into and out of the Lower Mississippi, the largest such movement being via the Gulf Intracoastal Waterway west of New Orleans. Other tonnage originating on the Lower Mississippi proceeds upriver to destinations on the Ohio, the Upper Mississippi and the Illinois Waterway. The sources of Lower Mississippi refined products are diverse. A very large volume enters the river from product pipelines in the St. Louis area and proceeds mainly to destinations on the Upper Mississippi and Illinois Waterway. The Ohio is the second area of products concentration, representing both barge-pipeline coordinated movements and the output of refineries in the area. . . .

Food products, principally grains and refined sugar, constitute a major tonnage item for inland river barges. . . . There are two major wheat movements, one from upstream points on the Mississippi such as St. Louis and the Twin Cities and from the Illinois River to down river points, particularly New Orleans, and the other into Chicago from the Illinois, Missouri, the Upper Mississippi, and from the St. Louis area. A lesser but substantial movement proceeds from producing areas along the Missouri and Mississippi Rivers into the Tennessee River. Soybeans follow a traffic flow pattern very similar to that of wheat. Barge traffic in corn originates mainly on the Illinois River; most of this grain moves to Chicago. Another large quantity moves down river from Illinois to New Orleans. New Orleans also receives large quantities of corn from the St. Louis area. St. Louis also ships corn into the southeastern States, both via Memphis on the Lower Mississippi and the Tennessee River. In contrast to grains, sugar is an upstream movement entirely, being distributed by barge from New Orleans to major consuming points in the Upper Mississippi Valley, including St. Louis, the Twin Cities, and Chicago as well as to points on the Ohio River. . . .

Traffic from the chemical industry is widely dispersed along the interconnected waterway system. Principal concentrations are on

> the Gulf Coast and Lower Mississippi where petroleum is used as a basis for the industry, and on the Ohio and Kanawha Rivers where abundant coal can be utilized. Barge shipments to nearby consuming and distributing points predominate in the chemical traffic. One principal interregional movement by barge appears to be from the petrochemical area of the Gulf to the Ohio River Valley. A substantial volume also moves into the Chicago area by barge from the principal chemical producing areas [U.S. Department of Transportation, 1971].

The implication of this extensive quotation is that the most of the major commodity flow is along the main segments of the waterway system. These flows generally are able to take advantage of either the line-haul cost advantage of the barge mode, and/or are composed of commodities that are used or produced on the waterway's edge in order to minimize feeder and distribution costs. All of these major commodities move in large volume thus being able to take advantage of the barge mode's capacity advantage, as well as encouraging economies in cargo handling procedures. In short, there appear to be excellent cost of shipment advantages for the current traffic in these commodities moved by barge.

From the arguments above, it appears that shipment of iron ore and steel products would probably not be affected, and sand, gravel, rock and shells will continue to move if the charge does not get "too high." The question that remains is how the major commodity flows would be affected by a user charge.

The waterways marked with an asterisk in Table IV-3 all would have segment tolls of less than one mill. Using an average current water transport rate of 4.5 mills per ton-mile, the maximum increase due to a user charge would be 22 percent on the Upper Mississippi, ranging down to three percent on the Lower Mississippi. However, these increases are more than would probably be the case. These low cost waterways are also the most open waterways and are high volume waterways. There is every reason to expect some production changes to take place which will allow the operators to merge or enlarge firms, modify tow size and configuration, i.e., to improve along the lines of "neutral" technological change which will allow them to maintain constant costs in the face of this small price increase. In fact, historically when costs have risen, industry adjustments have been made and average rates have fallen.

Viewed from the demand side, shipments on these waterways would have the greatest cost advantages over other modes. Because of their open nature average costs are no doubt below the national average of four to five mills. The large volumes of traffic and the location of industries on the water's edge suggest that any cargo handling or feeder and distribution cost disadvantages of the barge mode are not significant in these areas. These waterways have encouraged the location of many industries on the water's edge [American Waterways Operators, 1972]. Long hauls characterize traffic movements for these waterways and thus the long-haul cost advantage of barge over other modes is especially significant.

Petroleum products which, as noted above, actually move as complements to pipeline traffic, long-haul grain movements that realize great line-haul cost economies, and chemical shipments which are long haul, move predominantly on these waterways. Indeed, most of these waterway segments comprise what might be called the main stream of the current system, and should not be viewed as waterway segments but as a highly integrated water highway network which carries about 95 percent of the waterway traffic (Table IV-3). In short, the current total cost advantage (line haul and non-line haul) of barge is likely to be great enough on these waterways that a rate increase of even 22 percent would not affect demand in any substantial way. When it is considered that these same waterway segments will probably be able to maintain nearly constant rates in the face of these slight cost increases, the conclusion is that a segment toll would have little effect on traffic.[5]

Given these arguments, it is clear that the same "no impact conclusion" can be drawn about a fuel tax. The estimated .52-mills level of a fuel tax would bear differently upon the waterways in this group, with some paying more and others less. Nonetheless the overall result would be the same. The waterways not noted with an asterisk in Table IV-3 are more difficult cases to draw conclusions about. These will be discussed individually.

The *Kentucky* waterway is 259 miles long with a controlling depth of six feet and an effective navigable width of 100 feet. It has 14 locks on its 259 mile length. As such it is a highly constricted waterway suggesting that small tows operate on the waterway. Over 99 percent of the total tons shipped on the waterway are sand, gravel and crushed rock,[6] thus, the segment toll and the fuel tax will apply to the shipment of this commodity.

The highly constricted nature of this waterway suggests little chance for tow or firm production changes if a user charge is imposed. Therefore, any charge

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[5] This is essentially the same conclusion reached in Kearny. However, here it is limited to the particular waterway segments noted in Table IV-1 with an asterisk.

[6] Data is not available for individual commodity movements by ton-mile. Therefore, tonnage is the only basis for determining proportion of each commodity moved on a waterway. These figures can, of course, led some bias to the breakdown of traffic between commodities, since different commodities are hauled different distance as Table I-7 indicates.

will bear directly on the shipper. It is difficult to speculate on the nature of shipper demand for waterway transport on the Kentucky River, although the modal advantage of barge transport would seem to be slight. The only industry directly on the waterway that would use sand, gravel and rock is a concrete plant. They might look to other sources of transport if a user charge were imposed. When it is also considered that a segment toll of 16.7 mills would represent a three fold increase in rates, if the rates were currently at 4-5 mills per ton-mile, it seems unlikely that the barge transport mode would remain competitive. In fact, the waterway would probably be shut down if such a toll were imposed. On the other hand, if private carriers dominate this traffic the short run may see some continuation, but this still remains a significant toll.

The impact of the fuel tax on traffic is less certain. A 10-15 percent average rate increase (.52 mills added to a four to five mill rate) for all commodities is probably too low an estimate for this waterway due to its constricted nature. While no specific estimate is possible, it is asserted here that one half of current traffic would leave the waterway.[7]

The *San Joaquin River* begins in east-central California and flows to its confluence with the Sacramento River, about 48 miles northeast of San Francisco. Total mileage is 127 miles with project width of 225-400 feet. Controlling depth is 3-30 feet. There are no locks on the waterway. These considerations suggest that there may be some room for scale economics. In fact about two-thirds of the waterway tonnage is carried on oceangoing ships, which suggests the openness of the waterway. Principal commodities on barges are petroleum products; sand, gravel and rock; grain and grain products. On oceangoing vessels iron ore and grain dominate the traffic. There are numerous industries located on the waterway that rely on the waterway shipments.

An initial segment toll of 3.2 mills would ultimately be quite severe for all commodities. It would represent substantial increases in costs for the low unit value products and shipments of these would fall. This would then force toll increases on the remaining traffic. This would cause further cuts in shipments. For example, oceangoing cargo would begin to be unloaded in San Francisco, and be hauled by other modes to the industries on the waterway. In short, the segment toll that would initially mean a near doubling of rates would probably close down this waterway.

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[7] This estimate is based mainly on conjecture. The National Waterway Conference estimate of minus 1 for all commodities seems low for the sand, gravel and crushed rock commodity. The implied 10-15 percent increase in ton-mile costs due to fuel tax is assumed to reduce this traffic tonnage by 50 percent, or an elasticity much above minus one. Given the nature of this commodity, this seems likely. Total shipments would probably not cease due to the nonline haul advantages of barges for this low valued commodity.

On the other hand, a fuel tax of .52 mills would probably have little effect. Oceangoing cargo has no real alternative mode to shift to. Unloading at San Francisco would not help avoid the fuel tax which would exist there also. Inland waterway traffic in low value products (stone and salt) might be affected; however, this represents only eight percent of traffic tonnage and about the same in ton-miles. While the waterway is open, the low volume of traffic would severely limit scale economics. However, it appears that the demand would be such for petroleum movements and other commodities on the water's edge that the fuel tax would not affect their movements.

The *Alleghany River* waterway is 72 miles long with a controlling depth of nine feet and a width of 200 feet. There are nine locks on the river. The short length and numerous locks suggest that the waterway is somewhat constricted in character with small tows in operation. Total tonnage moved is comprised of 43 percent coal and lignite, 35 percent sand, gravel and crushed rock, and 10 percent petroleum and petroleum products. Virtually all the coal shipped terminates in the Pittsburgh area after being mined in the coal fields of western Pennsylvania. This is a relatively short haul. Sand, gravel and crushed rock, and petroleum products, primarily distillate fuel oil, are also moved locally. Thus, only insignificant amounts of the major traffic flow moving on the Alleghany take advantage of the long-haul cost advantage offered by barge. The barge mode has probably been chosen because of its capacity as well as the fact that much of the products shipped will find use at the water's edge in the Pittsburgh industrial area. Furthermore, given the short haul required, the competitive advantage of barge over rail still remains since line-haul economies in rail traffic are not realized over such short distances.

Using 1973 ton-mile figures, O & M expenditures of 9.6 mills per ton-mile for each cargo shipped would be incurred. The constricted nature of the waterway suggests little chance for tow or firm production economies beyond those that probably already exist. Therefore, it seems probable that any user charge will have to be passed on fully as a direct increase in rates. While the barge mode has some advantage over other modes at this time, it seems unlikely that the current products shipped would remain with barge if rates essentially were to be tripled as a result of the 9.6 mill segment toll.

The impact of the fuel tax is less certain. As on the Kentucky waterway, discussed above, sand and gravel shipments may fall somewhat. The use of coal is on the water's edge, and petroleum shipments are probably supplementary to pipeline and other modes. As such, a 10-15 percent increase in rates due to a fuel tax may not be significant in affecting what is essentially a small "convenience" waterway. As a best estimate a fuel tax would hit hardest on sand, gravel and rock shipments, probably resulting in termination of about 50 percent of the ton-miles shipped. Although no precise estimate is possible, it seems that 10-25 percent of the remaining traffic might cease flowing.

The navigable portion of the *Sacremento River* flows south from Coulusa, California for 145 miles to San Francisco Bay. There is one lock on the system, which has a project depth between 6 and 10 feet and a width of 100 to 300 feet. Oceangoing cargo makes up nearly 75 percent of the traffic and is handled at ports in San Francisco Bay and at the Port of Sacremento. This oceangoing cargo is dominated by grains and grain products, and wood chips, stakes and moldings. Inland waterway traffic is dominated by sand, gravel, and crushed rock shipments. Chemical, gypsum and grain handling plants are located on the waterway. Using 1973 figures, a segment toll of 12.4 mills would be required for cost recovery. This level of toll would probably eliminate all inland waterway traffic and might influence some traffic flows around the ports at San Francisco and Sacremento, and may encourage unloading in San Francisco with hauls by other modes to points upstream. A fuel tax would have less effect although the sand, gravel and rock shipments might be affected. If all this traffic were lost it would result in 20 percent reduction in tonnage. It seems unlikely that a fuel tax would have any effect on oceangoing cargos.

The Apalachicola, Chatahoochee, and Flint (ACF) Rivers System has 297 total miles with a controlling project depth of nine feet and width of 100 feet. There are three locks on the system. Its narrow width suggests that the river constricts the size of tow that might be used. Forty-five percent of total tonnage is petroleum and petroleum products, with sand, gravel and crushed rock comprising another 36 percent. The third most common cargo is basic chemicals. The ACF is one of the waterways adjacent to the Gulf of Mexico which dominates the barge movement of petroleum and its products. Given this it is likely that, at current relative costs, barge may be a supplement to pipeline movement of petroleum products. Most petroleum products move from Gulf Coast locations and then into this river segment. This same general pattern is true for basic chemicals. It is safe to assume that sand, gravel and rock products are moved only on short haul. From 1969 to 1973 traffic on this waterway nearly doubled indicating its importance as a transport mode. However, annual O and M expenditures on this segment were $4,079,000 which represents an expenditure of 33 mills per ton-mile. A segment toll to recover such costs would be prohibitive and would eliminate all traffic from the system.

The fuel tax effect would be mixed. As argued above, it seems fair to say that about 50 percent of the sand, gravel and crushed rock tonnage would be eliminated. Petroleum and chemical products might continue to flow. Fertilizer and chemical plants located on the waterway would not find the slight increase in rate a significant cost of doing business. While pipeline transportation may be lower cost when competing with barge, it is unlikely that these two modes are competitors here. Rather they are complementary and as such the slight increase in costs due to a fuel tax should not damage the advantage of the barge mode.

The McClellan-Kerr Arkansas River Navigation System has a total mileage of 448 miles with a channel depth of nine feet and project width varying between 150 and 300 feet. There are 17 locks on the system. Average haul on the system in 1973 was only 68 miles. This may be explained by the dominance of traffic movements in sand, gravel and rock and waterway improvement materials which together make up 53 percent of total tonnage. Petroleum products, soybeans, fertilizer, and aluminum ores and concentrates are the other major products moved on the waterway. A cost recovery segment toll of 15.7 mills per ton-mile would result in closing the waterway since it represents an additional cost of probably three to four times the current transport rate.[8]

The fuel tax effect might be severe here also since a large portion of the traffic is low valued commodities that would not be able to absorb a 10-15 percent increase in freight transportation costs. In addition, few industries are currently located on the water's edge and feeder and distribution costs may become significant for products such as newsprint, paper board, lumber, chemicals, fertilizer, etc. It seems likely that a fuel tax may result in as much as a 50 percent reduction in traffic.

Total navigable mileage on the *James River* is 89 miles and the depth varies from 18 to 35 feet. There are no locks on the system. In this sense the James can be considered an open waterway that could accomodate large tows. However, the short mileage of this segment would prohibit large tows for any local traffic movements. Commodities moving into the James at the end of a long haul, or long-haul traffic originating in the area may take advantage of scale economies of tow size.

Forty-six percent of the James River tonnage is sand, gravel and crushed rock. Forty-one percent is petroleum and petroleum products and seven percent of the tonnage is fertilizer. These latter two commodities normally are at the end or beginning of long hauls, for example, from petroleum refineries in Delaware and New Jersey. Industries along the waterway include chemicals, lumber and paper. A cost recovery user charge would be .9 mills per ton-mile. This figure represents about twice the charge per ton-mile that would be presented to operators by a fuel tax. The segment toll would probably not

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[8] The 1973 figures were far below 1972. The decreases in ton and ton-mile traffic were 7 percent and 35 percent respectively. Using 1972 figures, segment tolls of 10.2 mills per ton-mile would be required, still a substantial change.

eliminate all sand, gravel and rock shipments but might reduce them substantially. Since it has been argued above that the .52 mills per ton mile fuel tax would reduce tonnage in low value commodities by about 50 percent, this higher tax would be even more severe in its impact. An estimate of a 75 percent reduction in tonnage of low value commodities does not seem unreasonable. Since the other major products are moving on long haul and find use at the water's edge, and since larger tows may be possible for these shipments, the impact will initially be negligible on shipments. However, in the longer run, reduction in local traffic would require heavier levies on remaining traffic resulting in an increased segment toll. This increase may cause some cessation of water shipment of petroleum and fertilizer products and result in total traffic losses of up to 50 percent.

The fuel tax impact will probably be less severe. The 10 to 15 percent increase in costs will be mitigated somewhat by the possibility of scale economies on long-haul traffic, and the cost advantage of barge on petroleum and fertilizer will remain. Nonetheless, sand, gravel and rock tonnage will probably fall by 50 percent or a ton-mile loss on about 25 percent of total waterway traffic.

The *Atlantic Intra Coastal Waterway* extends 1,129 miles from Norfolk, Virginia to Miami, Florida. It has a controlling depth of 12 feet with a narrow 90 foot width. There are only two locks along its entire length. Petroleum and petroleum products make up 52 percent of the tonnage moved on the waterway. Wood and wood products make up 18 percent and iron and steel products make up seven percent. The average haul on this waterway is 122 miles. The narrow width of the waterway does not suggest the possibility of large tows.

During 1968-1972, average annual O and M costs were $3,486,000. However, these costs were not incurred evenly over the entire segment. With an average haul of 121 miles on this long segment, careful analysis should be completed on pieces of the waterway to determine the location of the expenditures. The O and M recovery charge works out to 5.6 mills per ton-mile. This is clearly a large charge and would double current rates on the system, probably eliminating traffic. However, since the system is quite large relative to average haul, it may be possible that a segment toll applied more precisely to areas according to cost would be higher than 5.6 mills in some cases and lower in others. In this sense traffic might continue on the low cost areas.

The fuel tax would not represent as significant a price change as the segment tolls. The relatively long haul, the use of many products at industries on the water edge, the role of barge shipment of petroleum as a supplement to, as opposed to competition with, pipeline, all indicate that the 10-15 percent increase in costs would not seriously impair the competitive advantage of the barge mode on this waterway.

The Kanawha River is 91 miles long with a controlling depth of 9 feet and width of 300 feet. There are three locks on the system. On these criteria it is an open waterway although the lock widths are somewhat confining and will limit tow boat size. Fifty-two percent of the tonnage on the waterway is coal and lignite 21 percent is chemicals and chemical products and four percent sand, gravel and crushed rock. Average length of haul is 56 miles, suggesting short-haul traffic of some commodities. Most of the coal moves out of this segment and along the Ohio to the Louisville and Pittsburgh areas. Chemical products are moved into the area to serve the chemical industries along the river. Substantial shipments come from as far away as Galveston Bay, Texas.

A segment toll would be set a 1.2 mills per ton-mile. The fuel tax of .52 mills per ton mile would be substantially less than the segment toll. Because of the extremely long haul of chemical products it seems unlikely that either form of user charge would reduce the line-haul cost advantage of barge of this commodity. Coal and lignite products are finding use currently on the water's edge favoring the barge mode. The fuel tax would in all likelihood not effect these shipments. However, the segment toll would probably move the rate up to the point where the rail mode becomes quite competitive with barge. The increase in rates from a segment toll would also affect other commodities moved in small amounts. Many would probably find it wise to shift modes. This in turn would cause the segment toll per ton-mile to have to be raised further still. It seems reasonable to expect that an equilibrium point would see about 50 percent of the traffic flow reduced by a segment toll.

The head of navigation on the *Missouri River* is at Souix City, Iowa, flowing southward to the Mississippi River. Total mileage is 732 miles with a depth of six to nine feet and project width of 300 feet. While these figures suggest an open waterway conducive to large scale operations, the waterway itself is navigable for only seven and one-half months per year. Therefore, it would be uneconomical to develop large scale operations on a waterway. Tonnage on the waterway is 43 percent sand, gravel and crushed rock, 28 percent waterway improvement materials, and 6 percent petroleum and petroleum products. A fourth major commodity movement is food and agricultural products. The average haul for all products was 133 miles in 1973 although in most previous years it averaged over 200 miles. Considering the dominance in tonnage of short-haul commodities the 200 mile figure suggests that petroleum and agriculture products are moving on extremely long haul, with petroleum moving into the area and food and agriculture products out of the area. A segment toll would have to be set at nine mills per ton-mile which would probably shut down the waterway. The fuel tax rate would substantially reduce traffic in sand, gravel, and rock, but due to the long haul of agricultural and petroleum products the competitive advantage of the barge mode would probably be maintained, while about 50 percent of the short-haul traffic will be eliminated.

Navigation is possible along the *Cumberland River* from the Ohio River at Smithfield, Kentucky to Carthage, Tennessee. From Nashville to Carthage the river has numerous bends, thus the total mileage figure of 317 miles overstates the actual ground distance substantially. The project depth is nine feet. There are three locks along the waterway. Of total tonnage, 43 percent is coal and lignite, while non-matalic ores make up 25 percent. Excluding waterway improvement materials, petroleum products are the third largest commodity group shipped. Petroleum products are moving into the area on long haul from Gulf Coast locations. Coal also enters the river for movement to power plants along the river's edge. The same is true of chemical products which find use at the plants on the water's edge. The river itself would provide sufficient depth to handle large tows and any user charge might encourage this action. Given this perspective and the long-haul nature of the cargo carried, it would seem that the barge mode does have a reasonable cost advantage. Only a large toll would result in substantial traffic diversion. However, a segment toll would be 3 mills per ton-mile. This charge would result in a near doubling of current rates even if some were absorbed. It seems unlikely that this doubling would allow this segment to remain competitive in spite of the current cost advantage it has. On the other hand, the fuel tax induced increase in rates would probably have little effect on traffic, especially since the waterway itself may allow for recognition of scale economies.

The Monongohelia River is 129 total miles long with controlling depth of seven to nine feet. Project width is 300 feet. There are nine locks. This all suggests that small tows would be the standard. Coal and lignite make up 79 percent of the tonnage. Virtually all of this is used in the Pittsburgh industrial area. Petroleum products make up six percent of the traffic and enter the waterway to serve various industries along the water's edge. Chemical products also are a substantial part of the flow. Sand, gravel and crushed rock represent four percent of the total tonnage.

1968-1972 average O and M costs were $1,900,000 for this river segment, requiring a segment toll of 1.3 mills per ton-mile. This charge would probably substantially reduce sand, gravel and rock movements, but would be of much less significance on chemical and petroleum product movements on long haul, since they would still have substantial line-haul cost advantage over other modes. The fate of coal traffic is harder to assess. While the charge may mean a substantial increase in rates charged, the volume of coal moved (nearly 30 million tons) will tend to favor barge capacity. Coal finds use on the waterway edge, and this will also favor the mode. Looking from another angle, the average haul on the waterway of about 40 miles and when applied to coal, means a cost per ton inrease of 5.2 cents. This is a relatively insignificant cost that would be unlikely to induce major transportation pattern changes in the Pittsburgh area. Given the argument that the segment toll would have limited effect on traffic movements, the impact of the lower fuel tax need not be discussed.

Navigation on the *Columbia River* extends from the Pacific Ocean 340 miles to the confluence with the Snake River. This is a deep open system with eight locks along its length. About two-thirds of the tonnage is oceangoing cargo. Grain is the principal oceangoing product (34 percent) and with chemicals, lumber and petroleum make up 70 percent of the traffic. Inland commerce is dominated by petroleum, chemicals, fertilizers, logs and grain. The size of the waterway, the dominance of oceangoing cargo, the nature of the commodities shipped (such as grain for foreign markets) suggest that a small fuel tax would be easily adjusted to by the industry. A segment toll raises some interesting questions. The average annual O and M costs for 1968 to 1972 were $6,841,000. However, this was for lock and dam operation. Insofar as much of the oceangoing commerce depends on the inland waterway traffic, a segment toll might be legitimately charged to all cargo. Using this assumption, a charge of 2 mills per ton-mile would have been levied in 1973. At this rate, some of the traffic might well move to other modes. However, there are numerous industries on the water's edge that make direct use of shipped products such as pulp and paper, chemical, and fuel oil products. Without a much more detailed look at this system, even a "ball park" estimate of the traffic loss from a segment toll would be difficult to develop. It would appear that there is every possibility that the effect would be insignificant. However, a generous estimate of 50 percent traffic diversion will be made here.

The *Tennessee River* is formed at Knoxville, Tennessee and flows into the Ohio at Paducah, Kentucky. The waterway is 652 miles long with a project depth of 11 feet and width of 300 feet. There are 10 locks along the waterway. This is one of the most open waterways in the system suggesting both relatively lower average line-haul cost and an ability to make production modifications that will reduce the impact of a user charge. River transportation has become an important component of the development of the Tennessee Valley Region, and industries located on the waterway include oil terminals, chemical plants, power plants, grain elevators, aluminum plants, paper mills, feed and flour mills and ferroalloy plants. Coal and lignite shipments account for 42 percent of the tonnage. About half the tonnage moves into the area on long haul from other waterways. Of the tonnage traffic which originates on the waterway, about one-half moves outside the waterway and the rest remains in the system. Sand, gravel and rock products move on a short haul within the system. Petroleum products move into the area on long haul, probably as a supplement to pipeline traffic. Grain and grain products are also part of long-haul traffic.

Five year average O and M costs were $8,000,000 from 1968-1972. Using 1973 ton-mile figures this represents 2 mills per ton-mile. Given the probability of low cost of operationg on this system, this level of charge could represent as much as a 50-75 percent increase in average rates. On the other hand, production changes may be possible that will mitigate some of this effect. Of particular importance is that even a 50 percent increase may still leave the barge mode at a competitive advantage with others. The location of firms on the waterway, the long-haul nature of much of the traffic, and the great quantities in which some of the shipments are made all favor the barge mode and the user charge may not affect this. However, there is little doubt that some of the low value short-haul products like clay, sand, gravel and rock products, lime, pulpwood, cement, etc. may be reduced. These products now represent 23 percent of total tonnage and about 12 percent of total ton-miles. In the unlikely event of elimination of all this traffic the total would not be significant. Since a fuel tax would be only a fraction of the segment toll, the arguments above can be extended to conclude that it too would have little effect on traffic on the waterway, although the low value short-haul commodities might suffer somewhat.

e. Conclusions on Impact:

The previous discussion seems to indicate that a fuel tax would have only minimum impact on total traffic movements. Although estimates are qualitative, it seems that the small increment such a change represents could only influence movement of commodities of low value such as rocks and shells. These commodities are, however, dominated by private carriers and may not be as severely affected as might first seem possible. Generally the fuel tax would raise average rates by 10-15 percent, with some variation between waterways. The Kentucky, Alleghany, ACF System, McClellan-Kerr, James and Missouri Systems would all feel the effect of this tax. If the most severe impact were to be a total shutdown of traffic on these waterways (virtually out of the question) this still would represent only a 1.0 percent of total waterway traffic in the system. A more likely situation is that they all will continue to have traffic, but somewhat reduced, while other waterways will be virtually unaffected.

The segment toll would clearly result in the closing of many segments and miles of the system. The previous discussion would indicate that the Kentucky, San Joaquin, Alleghany, Sacremento, ACF, McClellan-Kerr, Arkansas, Atlantic Intra Coastal Waterway, Missouri and Cumberland River Systems would all close down. The result of closing these segments would be a loss of l.6 percent of the total system traffic. In addition, losses on the James, Kanawha, Columbia, and Tennessee would occur. Using a *high* estimate of 50 percent of the traffic on these four segments being lost suggests an additional loss of l.5 percent of total system traffic. The total loss result is loss of just over three percent of total system traffic from a segment toll.[9] Of particular interest is that the closing down of the above waterways would result in a loss of three percent of traffic, but would save over 29 percent of annual O and M costs, or $30,627,296.

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[9] Given the discussion above, it is felt that the lower cost, high valued segments such as the Mississippi and Ohio will be unaffected by a segment toll.

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SECTION V

CONSIDERATIONS IN A USER CHARGE POLICY: SUMMARY AND CONCLUSIONS

Based upon discussion in Section III, it appears that there is substantial concern about the efficiency implications of a free waterway policy which can distort the pattern of commodity flows as well as intermodal shares of freight traffic. However, the conclusion of Section IV is that either of two major forms of user charge to recover operation and maintenance expenses is not likely to have a major impact on ton-mile traffic carried on the inland waterway system. This conclusion is most interesting, since it suggests that less importance be attached to the efficiency arguments, makes a moot point of the debate of what constitutes the short-run marginal unit in barge operations, and minimizes the potential conflict between the goals of cost recovery and efficiency.

However, the equity argument remains an important one to consider. Any subsidy inherent in the free waterway policy of the United States would be passed on entirely to the shippers of products on the system and their customers. This can be demonstrated with reference to the demand, supply, and cost findings of Section II. Whether it is "equitable" for the public treasury to provide a subsidy to this group remains an open question in the development of a user charge policy. Another aspect of the equity argument is the distribution of the subsidy between waterways (and therefore the users of these waterways). As Table 1, Section IV, illustrates, the expenditures on individual waterway segments vary substantially, and, as a general rule, as ton-miles carried fall, expenditures on the waterway segment rise. In fact, virtually all the ton mile traffic (over 96 percent) is carried on segments which incur only 63.8 percent of the annual operation and maintenance costs. This explains why a segment toll, which would possibly close eight of the 26 waterway segments discussed, and seriously reduce traffic on three others will reduce total traffic by only three percent.

It is on these grounds that the question of a fuel tax versus segment toll needs to be assessed. Table 1, Section IV, shows that only eight waterway segments would have a segment toll lower than the fuel tax of .52 mills per ton-mile. Therefore, all other segments would see costs rise less under a fuel tax than a segment toll. It is revenues from traffic on these eight segments, then, that would subsidize traffic flows on the other segments. Referring back to the efficiency issue, the segment toll would be preferred since it ties most closely to the marginal unit of production, whether this be the tow or annual tow traffic by segment. However, this efficiency question is, as noted, of less concern due to the limited effect on total traffic that any such charge would appear to have. The equity basis for choice between the two tolls will depend on how equity is defined. On a "beneficiary pays" basis, the segment toll appears desirable, since it ties most closely to the actual beneficiaries. On the other hand, the economic effect of such a toll on a particular region where a waterway closes down may be deemed inequitable. However, as long as full operation and maintenance costs are recovered from users, the equity question is no longer one of redistribution from the general tax system to shippers, but rather between shippers on different waterways as different forms of tolls are considered. The policy process, of which shippers and barge operators are a significant part, must ultimately come to grips with this "equity" question when user charge policy is being made.

With these summary remarks it is now possible to state the general conclusions of this study. These are based upon a careful review of relevant literature and a qualitative analysis of secondary data.

1. Inland waterway transportation fills a necessary role in the total transportation system in the United States. With respect to long haul of bulk commodities this mode has a distinct competitive advantage over rail and truck and is competitive with pipeline under certain conditions. As such the nation's economy is well served by the continued existence of a viable inland waterway transportation network.

2. The benefits inherent in the implicit subsidy of a free waterway policy appear to be shifted forward to shippers and their customers.

3. The unequal distribution of federal expenditures between waterway segments contributes to an unequal distribution of benefits.

4. The imposition of a user charge in the form of a fuel tax may have very limited effects on total traffic movements and on the pattern of these movements. A segment toll would bear harder on some waterways than others, resulting in the closing of some parts of the waterway system. This would still represent only a small portion of total traffic and result in savings of nearly 30 percent of annual operation and maintenance expenditures.

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