Estimating Barge Transport Costs for Grain and Fertilizer

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INTRODUCTION

Inland waterway transportation has recently come under close scrutiny by diverse special interest groups. Environmentalists are concerned about the impact of proposed waterway improvement projects. Legislative groups are debating waterway expenditures and sources of revenue. Competing transportation modes are examining the intermodal competitive situation. Research groups are trying to determine the role of the inland waterway transportation system in regional economic development. The barge industry itself is, with introspect, trying to present a united front to the special interest groups who would legislate against them.

Of major interest to all parties is barge cost of service. The cost information that is available is generally not detailed enough to provide meaningful input for private investment and public policy decisions.

The difficulty in obtaining true cost of service information for the barge industry stems from the nature of the legislation pertaining to the waterborne mode of transportation and the rate-setting procedure that is common practice in the industry. Barge tariffs for various commodities are published by the Waterways Freight Bureau, an organization that represents the industry before the Interstate Commerce Commission. But many dry, bulk commodities, including agricultural and energy commodities, which represent a large percentage of total traffic on the waterways, are exempt from rate regulation under the Interstate Commerce Act. The actual charges for these commodities are agreed upon by the shippers and barge companies in private negotiations. The only relation between actual shipping charges and published tariffs for the exempt commodities is the fact that negotiations are usually conducted in terms of percent of tariff. During periods of high demand for barge transportation services, barge space may sell for 200 percent of tariff or more. During slack periods and for special cases such as backhauls, quoted rates may be very low, since variable costs tend to be such a small portion of barge cost of service.

Actual negotiated shipping charges are not systematically collected and published. Individual shippers and barge lines are reluctant to reveal what they feel is proprietary information. As a result, decision makers, public and private, have no firm basis for projecting cost of barge transportation services.

The purpose of this report is to gather into one source the available, relevant information on costs of barge movement of grain on the Mississippi and Missouri Rivers. Legislation affecting cost of service will be reviewed. Rate setting procedures used by the barge industry will be examined. The main body of the report will be devoted to a discussion of the methodologies various researchers have used in attempting to synthesize barge cost of service, and to a presentation of their results.

The report should be a useful reference for researchers analyzing various economic issues dealing with inland water transportation. It should also serve to pinpoint areas requiring further research.

Tariff and Negotiated Rates

Conditions for Exemptions

Regulation of water freight transportation began in 1940 as part of the Interstate Commerce Act. Dry, bulk commodities were exempted from the provisions of the Act, provided: the commodity was being carried in bulk by waterway carriers before June 1, 1939; and no more than three different exempt dry bulk commodities were carried in tow. A third condition to qualify cargo for exemption resulted from action by the Interstate Commerce Commission and subsequent court decisions. That condition was that exempt, dry, bulk commodities were not to be mixed with regulated cargo in the same tow.

The first two conditions presented no serious problems to waterway carriers in their day-to-day operations. The third condition which specified no mixing of unregulated and regulated cargo was suspended during World War II to conserve fuel. Despite some recent legislative efforts to reinstate enforcement of the no-mixing rule, at this writing there are no restrictions on mixing of regulated and unregulated commodities in a single tow.

As a result of this legislative history a large portion of the total traffic moving on the inland waterway system is exempt from rate regulation under the Interstate Commerce Act. In its 1973 report to Congress titled "The Barge Mixing Rule Problem" the United States Department of Transportation estimated that exempt commodity carriage represented more than 60 percent of all tonnage moved by a large sample of carriers on the Mississippi River System and Gulf Intracoastal Waterway in 1970. Grain, specifically, moves in large volume on the waterways and most of it qualifies for exempt shipment. Nearly 90 percent of the 30 million tons of grain shipped by barge yearly fulfills the conditions for exempt status.
Tariff History

Tariffs applicable to the barge movement of regulated commodities are issued by the Waterways Freight Bureau, with headquarters in Washington, D.C. Nearly all firms actively engaged in providing inland waterborne transportation services are members. The Bureau acts as agent for its member carriers and represents them in Interstate Commerce Commission proceedings. Freight Tariff 8-C of the Waterways Freight Bureau is the Tariff currently in effect, applying to non-exempt barge movement of a wide range of commodities.

For a brief review of economic theory relating to determination of transportation rates and a discussion of the procedures followed in establishing rates for barge movement of regulated commodities, the reader is referred to Appendix B of this report.

A tariff applying to the exempt barge movement of grain was also in effect until cancelled in February, 1976. Barge Load Bulk Grain Tariff No. 7, issued by the Waterway Freight Bureau on May 17, 1968, and its last supplement, which became effective September 30, 1974, served as the standard by which shipping rates for grain were set. Actual rates, at a premium or a discount to the rates appearing in the Tariff, were negotiated by shipper and carrier. The Waterway Freight Bureau apparently cancelled Tariff No. 7 because of a Justice Department investigation into the Bureau's authority under the Interstate Commerce Act to issue a tariff for the transportation of a commodity supposedly exempt from the jurisdiction of the Interstate Commerce Commission.13

In addition to listing rates for barge shipment of grain, Tariff No. 7 specified other provisions of carriage such as conditions of loading, liability, and routing. Transit privileges and demurrage charges were also spelled out in the Tariff. At times some of these factors, demurrage for example, would be applied on a selective basis depending upon demand for barges and relationships with individual grain firms. However, for the most part, the conditions of carriage were adhered to by carriers, resulting in even-handed treatment of shippers and a consistent base for rate negotiation.

Even though it has officially been cancelled, Tariff No. 7 is still used by shippers and carriers as a base for rate negotiation. It is becoming less important as a base as time goes by because costs have increased since the publication of Supplement 76 in September, 1974. Individual barge lines are taking steps to update Tariff No. 7 by distributing their own rate schedules to their customers. The rate schedules vary from firm to firm, which places an additional burden on grain shippers to compare closely before starting rate negotiations.

Rate Negotiations

Rate negotiations between shipper and carrier for exempt commodities take two forms: long term contract rates, and single shipment or spot rates. Long term contracts are becoming more common for the shipment of grain. Nearly
all contracts for shipment of other exempt commodities such as coal and fertilizer are made on a yearly basis.

An inquiry by a grain shipper to a particular barge line will result in a rate quoted as a discount or premium of the tariff rate for grain. The shipper will accept the rate quoted, contact another carrier to find a lower rate, or make a counter offer.

Many different factors enter into the bargaining process. Special services required by the shipper or offered by the carrier affect the negotiated rate. The availability of barges, towboats, and backhauls affect the position of the carrier. Demand for barge space by other shippers of grain, availability of alternative modes of transportation, and urgency of the need to move grain affects the shipper’s bargaining position. Other factors that affect negotiated rates include time of year, water conditions on the rivers, and waiting time at locks and terminals.

Actual negotiated rates are difficult to obtain. One can understand the reluctance of both shipper and carrier to reveal negotiated rates since the rates reflect bargaining positions and skill, and may include concessions on non-economic considerations.

Several recent studies have reported actual negotiated barge rates. None of the studies stated whether the rates reported were long term contract rates or single shipment rates. They are presumed to be single shipment rates. In two of the three studies, rates were obtained voluntarily with promise of strict anonymity. The third study was undertaken by the Department of Transportation to fulfill the provisions of an Act of Congress. Their survey was conducted with the power of subpoena but measures were taken to insure confidentiality of the carriers involved in the study. Table 1 shows the actual rates compared to the published tariff rate in effect at the time the studies were conducted.

As indicated in Table 1, actual rates can fluctuate over a wide range. All of the studies were conducted in the early 1970s. Increased grain exports, erratic river conditions, increased waiting time at locks, and congestion at export terminals in the last few years have caused rates to fluctuate even more than indicated in Table 1; however, more recent data are unavailable in published form.

Compulsory reporting and publication of negotiated, actual barge rates has been proposed and has received considerable support from various shippers and railroad groups. Arguments for rate publication are based on claims that this would bring about increased economic efficiency, reduction of price discrimination, and improved intermodal and intramodal equity. Proponents of compulsory publication maintain that public knowledge of rates would create an environment in the barge industry as close to perfect competition as possible and therefore would improve economic efficiency. Publishing rates would decrease the likelihood of any one shipper or region being subjected to prejudice or disadvantage through unfair price discrimination. Rates which were common
| Shipping Area | Receiving Area | Tariff Average | High | Low  
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<td>7.18/3</td>
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<td>10.76/3</td>
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<td>5.32</td>
<td>6.00</td>
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<td>Backhauls</td>
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</tr>
<tr>
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<td>3.00</td>
</tr>
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<td>Kansas City</td>
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<td>3.25</td>
<td>3.25</td>
</tr>
<tr>
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<td>Minneapolis</td>
<td>N.A.</td>
<td>1.14</td>
<td>1.14</td>
</tr>
</tbody>
</table>

1/ Unless otherwise noted the rate information in this table came from the U.S. Department of Transportation Report to Congress, The Barge Mixing Rule Problem, March 1973.

2/ These rates are from a report prepared for the U.S. Department of the Army, Corps of Engineers, by Charles Donely and Associates. The report was included in a study on the replacement of Locks and Dam No. 26 called Design Memorandum No. 11, Formulation Evaluation Report, Volume 3, Appendix I, Rate Analysis, March 1975. A survey of traffic moving through Locks and Dam No. 26 was conducted to obtain data on commodity movements and rates.

3/ Rates as reported in An Economic Analysis of Upgrading Branch Rail Lines: A Study of 71 Lines in Iowa by C. Phillip Baumel et al, March 1976. The higher tariff reflects changes during the period 1970 to 1973. Partly to maintain confidentiality, actual rates were reported as a percent of tariff in the report. Actual rates were reported to be 125% of tariff during the period from April to June, 100% of tariff July-September, and 140% October-December. To arrive at a specific dollar per ton rate the average percent of tariff was calculated and that figure, 116.25%, was multiplied by the tariff.
knowledge would allow other barge firms and competitive modes, railroads in particular, to compete more effectively.

The U.S. Department of Transportation in its report to Congress, *The Barge Mixing Rule,¹³* considered these arguments and advised against requiring publication of negotiated rates in the barge transportation of grain. Their recommendation to Congress was as follows:

"Rate publication for exempt water carriage of grain would destroy the flexibility required between grain merchandisers on the one hand, and barge operators on the other to make on-the-spot contracts and match available supply with demand at mutually agreeable transportation rates. Such flexibility permits prompt and efficient response to the vagaries of farm production, weather, and market demands."¹³

**Rates and Cost of Services**

To determine the long run viability of the barge industry it is necessary to compare actual rates charged for shipments and the costs incurred by the carriers in providing the service. If barge carriers are able to negotiate rates which allow them reasonable profits the survivability of the industry seems assured on an economic basis.

Research for this publication did not reveal any studies in which actual barge costs, collected from industry sources, appeared in tabulated form. Industry contacts declined to comment on actual costs, saying costs would vary so much for particular barge lines and for specific shipments that any one cost statement would be misleading and virtually useless for analysis.

Barred access to actual cost information, researchers have had to develop cost information on their own. Some assume shipping costs to be a certain percent of the published tariff.¹¹ The approach taken by most researchers was to synthesize total barge shipping costs from specific elements of investment and operating costs. These included costs for equipment, maintenance, administration, and the various other outlays associated usually with the operation of a barge line. Synthesized costs were usually developed on an hourly basis so they could be included in a computational formula along with variables which incorporated explicit or implied assumptions concerning shipment time, tonnages per barge, utilization as a percent of capacity, loaded or empty backhaul, and operating conditions. Results were expressed as a cost per ton mile or cost per ton for a specified length of haul.

**Methods of Synthesizing Costs**

The approach taken here will be to briefly summarize the methods used by researchers in synthesizing costs. Basic assumptions made by researchers will be discussed. Computational formulas will be presented along with results in a form that lends itself to comparison. A condensation of each study is provided in Appendix A.
Investment for a barge carrier includes capital outlays for towboats and barges. Researchers analyzing towboat investment have taken two approaches. In the earliest study included in this report, Schnake and Franzmann\(^\text{10}\), using 1966 Army Corps of Engineers data developed a complete set of fixed and variable costs for various sizes of towboats ranging from 800 horsepower to 5,600 horsepower. Hourly operating costs were developed by allocating total yearly costs over the total hours of operation per year. The same approach was taken by Reed, Byrne, and Ackley\(^\text{7}\) using 1970 data. They developed investment cost data for two sizes of towboats, 3,200 horsepower and 5,000 horsepower.

Salomone, Moser and Headley\(^\text{8}\), and Baumel, Miller and Drinka\(^\text{4}\) used a different approach to develop costs for towboat investments and service. Both used reciprocal towing charges of barge companies as the actual cost. Barge companies sign towing agreements with one another on a yearly basis. The agreement spells out towing rates the companies will charge each other for towing the other's barges. The agreements specify charges for loaded barges and empties for different waterways. Other terms of the agreements include billing procedures, payment for unusual services, and limits of liability. The reciprocal towing charges are generally regarded in the industry as closely approximating actual towing costs.

The development of barge investment costs was essentially the same in all four studies. Total cost included depreciation, interest, administrative expenses, insurance, taxes, maintenance and repair. Assumptions about initial investment, salvage value, useful life, interest rate, and usage rate all varied slightly. Schnake and Franzmann, as well as Reed, et. al., included maintenance, repair, insurance, cleaning, etc. in their cost calculations. Salomone, et. al., and Baumel, et. al., included only investment-related cost factors in their barge cost calculations. They included the rest of the cost factors in another classification called “other” which was then entered into their final cost estimation equation.

The four studies varied greatly in costs included in the “other” classification. It became a catchall category for all other costs depending on assumptions made and costs included in towboat and barge cost classifications. If not included in the first two classifications, “other” included costs for fleeting, switching, cleaning, insurance, maintenance, taxes, and administration. By way of explanation, fleeting refers to the procedure used to pick up barges along a river section to make up a tow or to deliver individual barges to unloading docks upon arrival. Fleeting also refers to taking a barge out of a tow for loading or unloading and returning in to the tow. Switching is usually meant to describe repositioning barges within a tow when drop-offs or additions to the tow require reintegration of the entire tow.

Time is an important factor in determining barging costs, even more important than distance. For example, a 1000 mile haul upstream may take twice as much time as a downstream movement of the same distance. All four
studies viewed all or a portion of barge costs as a function of time. Schnake and Franzmann\textsuperscript{10} developed the most complicated model. However, their model allowed the greatest flexibility in adjusting variables to determine the effect on barging costs. The model was as follows:

\[ T = v + o + l \]

where:
- \( T \) = total cost per loaded barge
- \( v \) = voyage time cost per loaded barge
- \( o \) = other operating time cost per loaded barge
- \( l \) = loss and damage expense

Each of the independent variables in this model, except for one which was assigned a fixed value, was determined by another equation. Some of the factors entering into the equations included: speed of movement, backhaul percentage, number of barges in tow, waiting time, and fleeting charges. For a more complete discussion see Appendix A.

Reed, Byrne, and Ackley,\textsuperscript{1} took a slightly different approach. Their purpose in developing barging costs was for use in a capital investment analysis. They developed operating cost on an annual basis by use of the following model:

\[ C = t + b + f \]

where:
- \( C \) = annual total operating expense
- \( t \) = annual towboat expense
- \( b \) = annual barge expense
- \( f \) = annual fixed expense

Cost per ton mile was found by dividing annual total operating expense by estimated annual tonnage and then dividing again by annual mileage.

Salomone, Moser, and Headley\textsuperscript{8} and Baumel, Miller, and Drinka\textsuperscript{1} used the same approach in determining barging cost. The model in both cases was:

\[ C = i + t + s + o \]

where:
- \( C \) = total round trip cost
- \( i \) = investment cost
- \( t \) = towing cost
- \( s \) = switching cost
- \( o \) = other costs

Investment cost included only the costs of using barges. Towing costs included downstream costs of using a towboat based on reciprocal towing charges. Switching costs included loading and unloading time, fleeting costs, waiting time, and a factor for weather conditions. Other costs included insurance, maintenance, administration, taxes, and cleaning.

Table 2 shows a comparison of the results obtained from the barge cost studies reviewed. Schnake and Franzmann listed no results. Their barge cost formula was utilized in a much larger transhipment model developed to analyze
TABLE 2

COMPARISON OF SYNTHESIZED BARGE COSTS
(Dollars Per Ton Mile)

<table>
<thead>
<tr>
<th>Schnake and Franzmann</th>
<th>Reed, Byrne, and Ackley</th>
<th>Salomone, Moser and Headley</th>
<th>Baumel, Miller and Drinka</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.A.</td>
<td>$.00228&lt;sup&gt;1/&lt;/sup&gt;</td>
<td>$.00267&lt;sup&gt;2/&lt;/sup&gt;</td>
<td>$.00246&lt;sup&gt;3/&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$.003956&lt;sup&gt;4/&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

1. 2,679 mile round trip on the Mississippi River System with New Orleans as unload point but no specific load point given. Estimated 15% backhaul.
2. Round trip Kansas City to New Orleans with no backhaul.
3. Round trip Dubuque, Iowa, to New Orleans with no backhaul.
4. Round trip Sioux City, Iowa, to New Orleans with no backhaul.

the effects of transportation cost on the U.S. grain marketing system. The results from the other three studies are difficult to compare because of differences in assumptions, departure points, and points in time at which cost estimates were made. For example, Reed, Byrne, and Ackley used 1970 cost data, Baumel, Miller and Drinka used 1974 cost data, and Salomone, Moser and Headley used 1975 cost data. Also, some of the examples involve segments of the Missouri River, which involve higher operating costs.

In Table 3, tariff rate, actual reported rate, and computed barging costs are compared for various destination and turnaround points on the Mississippi River System. Baumel's model was used to compute barging costs because the cost data are fairly recent and the model is detailed enough to compute costs between points on the Mississippi River System.

Table 3 clearly shows the wide difference between synthesized barge cost data and actual reported rates. Although Baumel, Miller, and Drinka's formula and estimated cost data were used to compute the synthesized costs shown in Table 3, results obtained by other researchers were not significantly different. The difference between reported negotiated rates and synthesized costs, in this case, was partly due to differences in time periods. Negotiated rates were obtained in 1970. The synthesized costs were based on 1974 cost estimates. Inflationary pressures in the 1970s along with high interest rates caused estimated equipment investment and operating expenses to increase dramatically. Barge lines reporting actual negotiated rates in 1970 were experiencing
### TABLE 3

BARGE TARIFF RATES, NEGOTIATED RATES, AND SYNTHESIZED RATES FOR SELECTED MOVEMENTS OF GRAIN (DOLLARS PER TON)

<table>
<thead>
<tr>
<th>Shipping Area</th>
<th>Receiving Area</th>
<th>Tariff Rate</th>
<th>Negotiated Rate</th>
<th>Synthesized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mississippi River</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minneapolis</td>
<td>New Orleans</td>
<td>$4.86</td>
<td>$4.52</td>
<td>$8.23</td>
</tr>
<tr>
<td>Minneapolis</td>
<td>St. Louis</td>
<td>2.71</td>
<td>2.24</td>
<td>4.56</td>
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<tr>
<td>St. Louis</td>
<td>New Orleans</td>
<td>3.20</td>
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<td>Missouri River</td>
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<td></td>
</tr>
<tr>
<td>Sioux City</td>
<td>New Orleans</td>
<td>7.51</td>
<td>5.72</td>
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<td>2.69</td>
<td>2.79</td>
<td>4.70</td>
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</tbody>
</table>
depreciation expenses based on equipment purchased in the 1950s and 1960s. Investment and operating expenses in 1970 had not yet been affected by inflation.

Another possible cause for the difference between negotiated rates and synthesized costs can be attributed to the assumptions made by the researchers. Assumptions concerning travel time, percentage of backhauls, and costs incurred all affect synthesized cost figures. Only a person with intimate knowledge of a particular firm’s cost structure could develop a set of assumptions that would lead to highly accurate cost estimates. The problem then would be in using synthesized cost data based on one firm’s experience to represent the entire barge industry.

Summary and Conclusions

The purpose of this report was to present, in one source, relevant barge cost of service information relating to the movement of grain on the Mississippi and Missouri Rivers. Legislative and procedural aspects of barge rate setting were discussed. Rates for grain, as one of the dry, bulk commodities exempt from the Interstate Commerce Act, differ from the published Tariff. Negotiated rates that could be obtained are presented in this bulletin.

Research for this report uncovered no documented cost of service data. Several studies in which attempts were made to develop barge cost of service information were reviewed to give researchers an understanding of approaches that have been taken. The resulting synthesized costs differed substantially from reported negotiated rates and the tariff for grain, which was cancelled but is still used as a basis for negotiated rate quotations. Several possible reasons for the differences are offered.

The difficulty in obtaining negotiated barge rates, the possible error in developing synthesized cost information, and the cancellation of the Tariff all suggest a needed re-examination of the rate publication issue. Would publication of rate schedules by individual barge firms lead to more effective competition in the industry or would this reduce the flexibility of barge firms and grain merchandisers?

Another area of research needs in barge transportation of grain is the nature of rate negotiation. What are the critical factors in rate negotiation? Who has the greatest relative bargaining advantage, the barge firm or the grain shipper?

Research for this paper revealed nothing about long term contract rates for barging services. How do they compare to single movement rates? Are high long term rates the reason grain companies have purchased their own barges and have invested in barge lines?
References


APPENDIX A

Comparison of Procedures for Estimating Costs of Barging Grain on the Mississippi and Missouri Rivers

Estimated Cost of Barging Grain on the Mississippi River\(^{(10)}\) (1966/67 Cost Data)

I. Assumptions
   A. Towboat Costs
      20 year lifespan.
      5% salvage value.
      Investment capital one-half from internal sources and one-half from the market.
      Interest rate 5\(\frac{1}{2}\)% on funds from the market and 8% on internally generated funds.
      Taxes .5% of initial investment.
      Towboat operates 24 hours per day, 345 days per year.
### Summary Table—Costs for owning and operating towboats, by horsepower rating, 1966

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<td>Depreciation</td>
<td>11,875</td>
<td>16,625</td>
<td>23,750</td>
<td>25,815</td>
<td>27,880</td>
<td>29,925</td>
<td>38,000</td>
<td>62,225</td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>6,875</td>
<td>9,625</td>
<td>13,750</td>
<td>14,950</td>
<td>16,140</td>
<td>17,325</td>
<td>22,000</td>
<td>36,025</td>
<td></td>
</tr>
<tr>
<td>Return on investment</td>
<td>10,000</td>
<td>14,000</td>
<td>20,000</td>
<td>21,740</td>
<td>23,480</td>
<td>25,200</td>
<td>32,000</td>
<td>52,400</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td>28,445</td>
<td>33,825</td>
<td>41,360</td>
<td>45,555</td>
<td>47,115</td>
<td>48,675</td>
<td>57,265</td>
<td>77,260</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>5,000</td>
<td>7,000</td>
<td>10,000</td>
<td>10,870</td>
<td>11,740</td>
<td>12,600</td>
<td>16,000</td>
<td>26,200</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>1,250</td>
<td>1,750</td>
<td>2,500</td>
<td>2,720</td>
<td>2,940</td>
<td>3,140</td>
<td>4,000</td>
<td>6,550</td>
<td></td>
</tr>
<tr>
<td>Total ownership costs</td>
<td>63,445</td>
<td>82,825</td>
<td>111,360</td>
<td>121,650</td>
<td>129,295</td>
<td>136,875</td>
<td>169,265</td>
<td>260,660</td>
<td></td>
</tr>
<tr>
<td><strong>Variable costs:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages and fringe benefits</td>
<td>129,420</td>
<td>141,570</td>
<td>158,360</td>
<td>175,100</td>
<td>175,100</td>
<td>175,100</td>
<td>191,130</td>
<td>207,600</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>27,315</td>
<td>41,695</td>
<td>62,120</td>
<td>68,535</td>
<td>75,530</td>
<td>82,520</td>
<td>198,430</td>
<td>183,530</td>
<td></td>
</tr>
<tr>
<td>Maintenance and repairs</td>
<td>12,500</td>
<td>17,500</td>
<td>25,000</td>
<td>27,175</td>
<td>20,350</td>
<td>31,500</td>
<td>40,000</td>
<td>65,500</td>
<td></td>
</tr>
<tr>
<td>Supplies</td>
<td>5,750</td>
<td>6,500</td>
<td>7,625</td>
<td>8,000</td>
<td>8,375</td>
<td>8,750</td>
<td>10,250</td>
<td>14,750</td>
<td></td>
</tr>
<tr>
<td>Subsistence</td>
<td>7,245</td>
<td>8,280</td>
<td>9,315</td>
<td>10,350</td>
<td>10,350</td>
<td>10,350</td>
<td>11,385</td>
<td>12,420</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>2,415</td>
<td>2,955</td>
<td>10,000</td>
<td>10,870</td>
<td>11,740</td>
<td>3,670</td>
<td>4,380</td>
<td>5,050</td>
<td></td>
</tr>
<tr>
<td>Total variable costs</td>
<td>184,645</td>
<td>218,500</td>
<td>265,730</td>
<td>292,830</td>
<td>302,375</td>
<td>311,890</td>
<td>365,575</td>
<td>488,850</td>
<td></td>
</tr>
<tr>
<td><strong>Total annual costs of operation</strong></td>
<td>248,090</td>
<td>301,325</td>
<td>377,090</td>
<td>414,480</td>
<td>431,670</td>
<td>448,765</td>
<td>534,840</td>
<td>749,510</td>
<td></td>
</tr>
<tr>
<td><strong>Total hourly costs of operation</strong></td>
<td>30</td>
<td>36</td>
<td>46</td>
<td>50</td>
<td>52</td>
<td>57</td>
<td>65</td>
<td>91</td>
<td></td>
</tr>
</tbody>
</table>
B. Barge costs

Jumbo barge

Administrative expenses 6.26% of depreciation and interest expense.

Maintenance and insurance 3.13% of the investment, proportioned as .36 and .64.

Taxes 10% of the return on investment.

Loss and damage 20 cents per ton.

Summary Table--Costs of service for barges, 1966.

<table>
<thead>
<tr>
<th>Item</th>
<th>Barge dimensions 195' x 35'</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed costs:</strong></td>
<td></td>
</tr>
<tr>
<td>Investment</td>
<td>$76,000</td>
</tr>
<tr>
<td>Ownership costs:</td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>3,610</td>
</tr>
<tr>
<td>Interest</td>
<td>2,090</td>
</tr>
<tr>
<td>Return on investment</td>
<td>3,040</td>
</tr>
<tr>
<td>Administration</td>
<td>357</td>
</tr>
<tr>
<td>Insurance</td>
<td>1,520</td>
</tr>
<tr>
<td>Taxes</td>
<td>380</td>
</tr>
<tr>
<td><strong>Total ownership costs</strong></td>
<td>$10,997</td>
</tr>
<tr>
<td><strong>Variable costs:</strong></td>
<td></td>
</tr>
<tr>
<td>Maintenance and repairs</td>
<td>859</td>
</tr>
<tr>
<td>Cleaning costs</td>
<td>643</td>
</tr>
<tr>
<td><strong>Total variable costs</strong></td>
<td>$1,502</td>
</tr>
<tr>
<td><strong>Total annual costs of operation</strong></td>
<td>$12,499</td>
</tr>
<tr>
<td><strong>Total hourly costs of operation</strong></td>
<td>$1.47</td>
</tr>
</tbody>
</table>
C. **Time Factors**

Average total time to load and unload a grain barge assumed to be 96 hours.

Estimated time to change tow size to conform to river conditions when routing over two or more connecting waterways, 48 hours per interchange between waterways.

Fleeting cost assumed to be $480 per round trip when movement involves the Lower Mississippi River.

For each barge movement each makeup and breakup operation assumed to take 1-1/2 hours.

Costs for time factors were determined by multiplying the number of hours required by the applicable cost per hour.

D. **Backhaul**

An empty to loaded ratio was developed as a measure of backhaul. The following is a summary of ratios for the Mississippi and Missouri Rivers.

<table>
<thead>
<tr>
<th>River</th>
<th>Above Missouri River Mouth</th>
<th>Missouri Mouth to Ohio Mouth</th>
<th>Ohio Mouth to Gulf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mississippi</td>
<td>.65</td>
<td>.67</td>
<td>.68</td>
</tr>
<tr>
<td>Missouri</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above Omaha</td>
<td>.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omaha to Kansas City</td>
<td>.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kansas City to Mississippi River</td>
<td>.95</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

II. **Computational Formula**

\[ T = v + o + l \]

where:

- **T** = total round trip cost
- **v** = voyage time cost per loaded barge
- **o** = other operating time cost per loaded barge
- **l** = loss and damage expense
Voyage time was further defined:

\[ V = \frac{D}{S} + \frac{D}{U} \cdot Bn \div (1 + \lambda)n \]

Dividing through by \( n \) and simplifying:

\[ V = \frac{1}{S} + \frac{1}{U} \cdot \frac{BD}{1 + \lambda} \]

where:

- \( D \) = distance between two points
- \( S \) = speed in miles per hour downstream
- \( U \) = speed in miles per hour upstream
- \( B \) = cost per hour of operation per barge
- \( \lambda \) = backhaul percentage
- \( n \) = number of barges in the tow

Other operating time cost per loaded barge was defined as:

\[ o = K_1 + K_2 + K_3 + K_4 \]

- \( K_1 \) was layover time charge per loaded barge.

\[ K_1 = \frac{(nwk_1)B}{(1 + \lambda)n} \]

where:

- \( w \) = number of waterway junctions per trip
- \( k_1 \) = a constant, 96 hours.

- \( K_2 \) was makeup and breakup charge per loaded barge.

\[ K_2 = \frac{(nmk_2)B}{(1 + \lambda)n} \]

where:

- \( m \) = number of makeup and breakup operations
- \( k_2 \) = constant of 1.5 hours.

- \( K_3 \) was loading and unloading charge per loaded barge.

\[ K_3 = k_3B \]

where:

- \( k_3 \) = loading and unloading time per barge for loaded barges.
K₄ was fleeting charge per round trip per loaded barge for movements utilizing the Mississippi River.

\[ K₄ = \frac{k₄}{(1 + \lambda)n} \]

where \( k₄ \) = constant, $480.

### III. Results

No specific costs of barging grain were presented in this study. The model developed for estimating the cost of barging grain was used as part of a much larger multimodal transshipment model used to analyze the effects of a cost-of-service transportation rate structure on the U.S. grain marketing system.

**Estimated Cost of Barging Grain on the Mississippi River** (1970 Cost Data)

### I. Assumptions

A. Towboat Costs

Initial investment for a 3,200 h.p. towboat $1,100,000.

15 year lifespan

Towboat operates 24 hours per day, 350 days per year.

Summary Table--Annual and hourly costs of owning and operating a 3,200 h.p. and 5,000 h.p. towboat.

<table>
<thead>
<tr>
<th></th>
<th>3,200 h.p. towboat</th>
<th>5,000 h.p. towboat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual</td>
<td>Hourly</td>
</tr>
<tr>
<td>Depreciation</td>
<td>$69,667</td>
<td>$8.29</td>
</tr>
<tr>
<td>Interest</td>
<td>44,000</td>
<td>5.22</td>
</tr>
<tr>
<td>Insurance</td>
<td>110,000</td>
<td>13.10</td>
</tr>
<tr>
<td>Taxes</td>
<td>5,500</td>
<td>.65</td>
</tr>
<tr>
<td>Crew labor</td>
<td>245,000</td>
<td>29.17</td>
</tr>
<tr>
<td>Fuel</td>
<td>134,400</td>
<td>16.00</td>
</tr>
<tr>
<td>Supplies</td>
<td>35,000</td>
<td>4.17</td>
</tr>
<tr>
<td>Maintenance and Repairs</td>
<td>140,000</td>
<td>16.67</td>
</tr>
<tr>
<td>Administrative</td>
<td>97,946</td>
<td>11.66</td>
</tr>
<tr>
<td>Total</td>
<td>$881,513</td>
<td>$104.93</td>
</tr>
</tbody>
</table>
B. **Barge Costs**

**Jumbo Barge**

Initial Cost $130,000

20 year life span

Summary Table--Annual and hourly costs of owning and using a jumbo covered barge.

<table>
<thead>
<tr>
<th></th>
<th>Annual</th>
<th>Hourly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation</td>
<td>$6,175</td>
<td>$.73</td>
</tr>
<tr>
<td>Interest</td>
<td>5,200</td>
<td>.62</td>
</tr>
<tr>
<td>Insurance</td>
<td>13,000</td>
<td>1.55</td>
</tr>
<tr>
<td>Taxes</td>
<td>650</td>
<td>.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$25,025</td>
<td>$2.98</td>
</tr>
</tbody>
</table>

C. **Time and distance factors**

Average distance and tonnage of southbound grain shipments used were 1,415 miles and 1,404 tons per barge.

Estimated tow speeds: **Northbound** | **Southbound**

(Miles per hour)

<table>
<thead>
<tr>
<th></th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loaded</td>
<td>4.3</td>
<td>7.5</td>
</tr>
<tr>
<td>Empty</td>
<td>8.6</td>
<td>---</td>
</tr>
</tbody>
</table>

Estimated loading time was 3 hours per barge. Unloading time, 3 hours. Cleaning time, 4 hours.

Estimated hours per round trip 740.2 hours.

Round trips per year 11.34.

Backhauls estimated at 15% of southbound grain shipments.

D. **Other Costs**--treated as fixed cost per trip.

Fleeting--$320 per round trip.

Cleaning--$142 per barge.
II. Computational Formula

\[ C = t + b + f \]

where:

- \( C \) = Annual total operating expense
- \( t \) = Annual towboat expense
- \( b \) = Annual barge expense
- \( f \) = Annual fixed expense

Annual fixed expense was equal to fleeting cost times round trips per year plus cleaning cost times number of barges used per year.

Cost per ton of grain shipped was found by dividing \( C \) by \( T \).

where:

- \( T \) = estimated annual tonnage

III. Results

Annual cost per ton of grain shipped was found to be $3.18.

Estimated Cost of Barging Grain on the Mississippi River (1974 Cost Data)

I. Assumptions - Dubuque to New Orleans and returning empty.

A. Investment Costs

- **Jumbo covered hopper barge**
  - Cost $160,000
  - Salvage Value $24,000
  - Useful life 20 years
  - Interest rate 10%

  The present value of the annual cost to recover the initial investment of a jumbo covered barge at a 10 percent interest rate = $18,374 per year or $50.34 per day.

  Round trip investment cost = (50.34) (54-day round trip) = $2,718.

B. Towing Costs

- **Upper Mississippi River, above St. Louis**
  - 4,300 h.p. towboat
  - 12 barges per tow
  - 1,400 net tons per loaded barge

  Towing costs based on reciprocal towing agreements of barge companies in 1974.
Lower Mississippi River, below St. Louis
8,400 h.p. towboat
30 barges per tow
1,400 net tons per loaded barge
Towing costs based on reciprocal towing agreements of barge companies in 1974.

1. Downstream Costs
   a. Dubuque to St. Louis
      2.3 mills per ton-mile
      Distance of 400 miles
      Per barge cost = $1,288
   b. St. Louis to New Orleans
      1.13 mills per ton-mile
      Distance of 1,050 miles
      Per barge cost = $1,661
   Total downstream cost = $2,949

2. Upstream Costs
   a. New Orleans to St. Louis
      $1.25 per mile
      Distance of 1,050 miles
      Per barge cost = $1,313
   b. St. Louis to Dubuque
      $2.00 per mile
      Distance of 400 miles
      Per barge cost = $800

3. Total round trip towing cost
   Loaded down and return empty
   $2,949 + $2,113 = $5,062
C. Switching Costs and Turnaround Times

<table>
<thead>
<tr>
<th>Movement</th>
<th>Number of Days Required</th>
<th>Cost per Day</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load in Dubuque</td>
<td>2.0</td>
<td></td>
<td>$85</td>
</tr>
<tr>
<td>Move from elevator</td>
<td>0.5</td>
<td>$10</td>
<td>30</td>
</tr>
<tr>
<td>Fleet Dubuque</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make up Dubuque</td>
<td>0.5</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Travel to St. Louis 400 miles @ 4.4 mph</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break up St. Louis</td>
<td>0.5</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Fleet St. Louis</td>
<td>2.0</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Make up St. Louis</td>
<td>0.5</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Travel to New Orleans 1,050 miles @ 8.1 mph</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break up New Orleans</td>
<td>0.5</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Fleet New Orleans</td>
<td>5.0</td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>Move to elevator</td>
<td>0.5</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td>Unload at elevator</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move to fleet</td>
<td>0.5</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td>Fleet New Orleans (clean during fleeting)</td>
<td>3.0</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Make up New Orleans</td>
<td>0.5</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Travel to St. Louis 1,050 miles @ 4.5 mph</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break up St. Louis</td>
<td>0.5</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Fleet St. Louis</td>
<td>2.0</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Make up St. Louis</td>
<td>0.5</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Travel to Dubuque 400 miles @ 3.5 mph</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break up Dubuque</td>
<td>0.5</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Fleet Dubuque</td>
<td>3.0</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Move to elevator</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Dry dock repair and unforeseen delays</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL NUMBER OF DAYS PER ROUND TRIP</td>
<td>54.0</td>
<td></td>
<td>$988</td>
</tr>
</tbody>
</table>

D. Other costs per round trip

1. Insurance on barge and cargo ($4.00 per day) (54 days) = $216
2. Maintenance and repairs ($7.00 per day) (54 days) = $378
3. Administration and taxes ($9.10 per day) (54 days) = $491
4. Cleaning of barge
   Once per trip = $150
   Total other costs = $1,235
II. Computational Formula

\[ C = i + t + s + o \]

where:
- \( C \) = total round trip cost
- \( i \) = investment cost
- \( t \) = towing cost
- \( s \) = switching cost
- \( o \) = other cost

III. Results - total round trip cost

- **A. Investment Cost**
  - $2,718

- **B. Towing Cost**
  - $5,062

- **C. Switching Cost**
  - $988

- **D. Other Cost**
  - $1,235

Total round trip cost to barge grain from Dubuque to New Orleans and return empty = $10,003.

Total round trip cost per ton

\[ \$10,003 \div 1,400 = \$7.15 \]

Estimated Cost of Barging Grain on the Missouri River\(^{1/}\) (1974 Cost Data)

I. Assumptions - Sioux City to New Orleans and returning empty.

A. **Investment Costs**

- Jumbo covered hopper barge
  - Cost $160,000
  - Salvage value $24,000
  - Useful life 20 years
  - Interest rate 10%

  Present value of the annual cost to recover the initial investment of a jumbo covered barge at 10 percent interest rate = $18,374 per year or $50.34 per day.

  Round trip investment cost = ($50.34) (67 day round trip) = $3,373

B. **Towing Costs**

- Sioux City to Omaha
  - 1,800 h.p. towboat
  - 2 barges per tow

- Omaha to Kansas City
  - 1,800 h.p. towboat
  - 4 barges per tow
Kansas City to St. Louis
3,200 h. p. towboat
8 barges per tow

St. Louis to New Orleans
8,400 h. p. towboat
30 barges per tow

1,050 net tons per loaded barge on all river sections.
Towing costs based on reciprocal towing agreements
of barge companies in 1974.

1. Downstream costs
   a. Sioux City to Omaha
      5.15 mills per ton mile
      Distance of 120 miles
      Per barge cost = $649
   b. Omaha to Kansas City
      4.5 mills per ton mile
      Distance of 248 miles
      Per barge cost = $1,172
   c. Kansas City to St. Louis
      3.65 mills per ton mile
      Distance of 364 miles
      Per barge cost = $1,395
   d. St. Louis to New Orleans
      1.13 mills per ton mile
      Distance of 1,050 miles
      Per barge cost = $1,246

   Total downstream costs = $4,462

2. Upstream costs
   a. New Orleans to St. Louis
      $1.25 per mile
      Distance of 1,050 miles
      Per barge cost = $1,313
   b. St. Louis to Kansas City
      $3.00 per mile
      Distance of 364 miles
      Per barge cost = $1,092
   c. Kansas City to Omaha
      $3.23 per mile
      Distance of 248 miles
      Per barge cost = $801
   d. Omaha to Sioux City
      $4.00 per mile
      Distance of 120 miles
      Per barge cost = $480

   Total upstream costs = $3,686

3. Total round trip towing cost
   Loaded down and return empty
   $4,462 + $3,686 = $8,148
C. Switching Costs and Turnaround Times

<table>
<thead>
<tr>
<th>Description</th>
<th>Days Required</th>
<th>Cost per Day</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load in Sioux City</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move from elevator</td>
<td>1.0</td>
<td>$85</td>
<td></td>
</tr>
<tr>
<td>Fleet Sioux City</td>
<td>2.0</td>
<td>$7</td>
<td>14</td>
</tr>
<tr>
<td>Make up Sioux City</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Travel to Omaha</td>
<td>120 miles @ 8 mph</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Break up Omaha</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Fleet Omaha</td>
<td>2.0</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Make up Omaha</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Travel to Kansas City</td>
<td>248 miles @ 7 mph</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Break up Kansas City</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Fleet Kansas City</td>
<td>2.0</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Make up Kansas City</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Travel to St. Louis</td>
<td>364 miles @ 7.5 mph</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Break up St. Louis</td>
<td>0.5</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Fleet St. Louis</td>
<td>2.0</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Make up St. Louis</td>
<td>0.5</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Travel to New Orleans</td>
<td>1,050 miles @ 8.1 mph</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>Break up New Orleans</td>
<td>0.5</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Fleet New Orleans</td>
<td>5.0</td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>Move to elevator</td>
<td>0.5</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td>Unload at elevator</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move to fleet</td>
<td>0.5</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td>Fleet New Orleans (clean during fleeting)</td>
<td>3.0</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Make up New Orleans</td>
<td>0.5</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Travel to St. Louis</td>
<td>1,050 miles @ 4.5 mph</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Break up St. Louis</td>
<td>0.5</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Fleet St. Louis</td>
<td>2.0</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Make up St. Louis</td>
<td>0.5</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Travel to Kansas City</td>
<td>364 miles @ 4 mph</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>Break up Kansas City</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Fleet Kansas City</td>
<td>2.0</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Make up Kansas City</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Travel to Omaha</td>
<td>248 miles @ 4 mph</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Break up Omaha</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Fleet Omaha</td>
<td>2.0</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Make up Omaha</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Travel to Sioux City</td>
<td>120 miles @ 5 mph</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Break up Sioux City</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Fleet Sioux City</td>
<td>2.0</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Move to elevator</td>
<td>0.5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Dry dock repair and unforeseen delays</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL NUMBER OF DAYS PER ROUND TRIP</td>
<td>64.5</td>
<td>$1,785</td>
<td></td>
</tr>
</tbody>
</table>
D. Other costs per round trip

1. Insurance on barge and cargo
   ($4.00 per day) (67 days) = $268

2. Maintenance and repairs
   ($7.00 per day) (67 days) = $469

3. Administration and taxes
   ($9.10 per day) (67 days) = $610

4. Cleaning of barge
   Once per trip = $150

Total other costs = $1,497

II. Computational Formula

\[ C = i + t + s + o \]

where:

- \( C \) = total round trip cost
- \( i \) = investment cost
- \( t \) = towing cost
- \( s \) = switching cost
- \( o \) = other cost

III. Results - total round trip cost

A. Investment cost = $3,373
B. Towing cost = 8,148
C. Switching cost = 1,785
D. Other cost = 1,497

Total round trip cost to barge grain from Sioux City to New Orleans and return empty = $14,803.

Total round trip cost per ton
\[ \frac{14,803}{1,050} = \$14.10 \]
Estimated Cost of Barging Grain From
Kansas City to New Orleans\(^3/\) (1975 Cost Data)

I. Assumptions
1. Size of barge is the Jumbo Covered Hopper Barge (195' x 35' x 12').
2. 1,100 tons of grain per loaded barge
3. Travel speeds based on average rather than ideal river conditions.
4. River distances
   Kansas City to St. Louis - 380 miles
   St. Louis to New Orleans - 1,050 miles
5. Tow charges based on reciprocal towing agreements of barge companies in 1975.
6. Empty backhauling occurs on 10% of one way mileage.
7. Insurance and administrative costs based on actual reported costs incurred by a large barge firm.

A. Investment Costs
   Jumbo Hopper Barge
   Cost $170,000
   Salvage value $20,000
   Useful life 20 years
   Interest rate 10%

   Present value of the annual cost to recover the initial investment = $19,618 per year or $53.75 per day.

   Round trip investment cost = ($53.75)(52.5 day round trip) = $2,822

B. Towing Costs
   Kansas City to St. Louis
   3,200 h.p. towboat
   380 mile distance
   10 barges per tow

   St. Louis to New Orleans
   No assumptions made concerning size of towboat and number of barges per tow.
   1,050 mile distance.

1. Downstream costs
   a. Kansas City to St. Louis
      3.7 mills per ton-mile
      Distance of 380 miles
      Per barge cost $1,546
   b. St. Louis to New Orleans
      1.15 mills per ton-mile
      Distance of 1,050 miles
      Per barge cost $1,328

   Total downstream cost = $2,874
2. Upstream costs - because of the assumption of 10% empty backhaul only 10% of the upstream costs were charged to the grain.
   a. New Orleans to St. Louis  
      loaded - 1.75 mills per ton-mile  
      empty - $1.25 per mile  
   b. St. Louis to Kansas City  
      loaded - 5.16 mills per ton-mile  
      empty - $2.95 per mile  

Total upstream empty return costs:
Empty return 10% of downstream miles = 143 empty return miles.  

- 27% Missouri River - 380/1430 = 39 miles  
- 73% Mississippi River - 1040/1430 = 104 miles  

(39 miles) ($2.95) = $115.05  
(104 miles) ($1.25) = 130.00  

Total towing cost  
Downstream Costs + Upstream Costs  
$2,874 + $245 = $3,119
C. Switching Charges and Turnaround Times

<table>
<thead>
<tr>
<th>Movement</th>
<th>Number of Days Required</th>
<th>Cost per Day</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load in Kansas City</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move from elevator</td>
<td>0.5</td>
<td>$156.00</td>
<td></td>
</tr>
<tr>
<td>Fleet Kansas City</td>
<td>3.0</td>
<td>$6</td>
<td>18.00</td>
</tr>
<tr>
<td>Make Up Kansas City</td>
<td>0.5</td>
<td></td>
<td>24.29</td>
</tr>
<tr>
<td>Travel to St. Louis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>380 miles @ 4 mph</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break up St. Louis</td>
<td>0.5</td>
<td></td>
<td>35.95</td>
</tr>
<tr>
<td>Fleet St. Louis</td>
<td>2.5</td>
<td>15</td>
<td>37.50</td>
</tr>
<tr>
<td>Make Up St. Louis</td>
<td>0.5</td>
<td></td>
<td>35.95</td>
</tr>
<tr>
<td>Travel to New Orleans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,050 miles @ 8.1 mph</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Up New Orleans</td>
<td>0.5</td>
<td></td>
<td>69.12</td>
</tr>
<tr>
<td>Fleet New Orleans</td>
<td>5.0</td>
<td>25</td>
<td>125.00</td>
</tr>
<tr>
<td>Move to elevator</td>
<td>0.5</td>
<td></td>
<td>156.00</td>
</tr>
<tr>
<td>Unload New Orleans</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move from elevator</td>
<td>0.5</td>
<td></td>
<td>156.00</td>
</tr>
<tr>
<td>Make Up New Orleans</td>
<td>2.5</td>
<td></td>
<td>69.12</td>
</tr>
<tr>
<td>Travel to St. Louis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,050 miles @ 4.6 mph</td>
<td>9.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Up St. Louis</td>
<td>0.5</td>
<td></td>
<td>35.95</td>
</tr>
<tr>
<td>Fleet St. Louis</td>
<td>3.0</td>
<td>15</td>
<td>45.00</td>
</tr>
<tr>
<td>Make Up St. Louis</td>
<td>0.5</td>
<td></td>
<td>35.95</td>
</tr>
<tr>
<td>Travel to Kansas City</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>400 miles @ 3.2 mph</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Up Kansas City</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet Kansas City</td>
<td>3.0</td>
<td>6</td>
<td>18.00</td>
</tr>
<tr>
<td>Move to Elevator</td>
<td>0.5</td>
<td></td>
<td>156.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52.5</td>
<td>$1,173.83</td>
</tr>
</tbody>
</table>
D. Other costs per round trip

1. Insurance on equipment
   ($6.40 per day)(52.5 days) = $336

2. Maintenance and Repair
   ($2.00 per day)(52.5 days) = 105

3. Property Taxes
   ($0.31 per day)(52.5 days) = 16

4. Cleaning per barge = 112

5. Barge preparation = 19

6. Cargo inspection = 7

7. Cargo Insurance = 15

8. Losses = 58

9. Administration = 646

Total other costs = $1,314

II. Computational Formula

\[ C = i + t + s + o \]

where:
- \( C \) = total round trip cost
- \( i \) = investment cost
- \( t \) = towing cost
- \( s \) = switching cost
- \( o \) = other cost

III. Results - total round trip cost

A. Investment cost = $2,822
B. Towing cost = 3,119
C. Switching cost = 1,174
D. Other cost = 1,314

Total round trip cost to barge grain from Kansas City to New Orleans and return with 10% empty backhaul = $8,429.

Total round trip cost per ton
\[ \$8,429 \div 1,100 = 7.66 \]
APPENDIX B
Procedures for Determining Barge Rates on Regulated Commodities

The transportation industries are nearly always cited in basic economics textbooks as examples of industries which because of their natural tendency toward monopoly, or the vital nature of the services provided, or for technological considerations, should be subject to public regulation to protect the public interest. In regulated industries, interacting market forces are not allowed to determine price and quantity. This function is performed by regulatory agencies which follow federal, state, and local legislative guidelines in ruling on appropriate rates and services.

The rate making procedure followed by the particular regulatory agency responsible for waterway transportation, the Interstate Commerce Commission, is as follows: A request for a rate change may be made by any shipper, carrier, or rate bureau. In most cases, a request for rate change is channeled through a rate bureau or freight association—an organization of carriers providing similar services in a particular geographical area. The requested rate change is judged according to standards agreed upon by members of the organization. If approved, the rate change is filed with the Interstate Commerce Commission. The I.C.C.'s role is primarily that of an appeal board. Protests may be filed with the I.C.C. by a shipper affected by the rate, a carrier who feels the rate might damage his competitive position, or a third party. In the absence of protest, the rate change is published in the form of a tariff and becomes the legally applicable rate.

A very small percentage of the thousands of requests for rate change are actually protested. When a protest is filed, the I.C.C. is required to consider the rate change and make a ruling. The broad guidelines used by the I.C.C. in carrying out the provisions of the Interstate Commerce Act are as follows: 1) recognize and preserve the inherent advantages of each mode of transportation; and 2) promote the establishment and maintenance of just and reasonable rates.

Specific factors considered by the I.C.C. in applying these guidelines to cases requiring a ruling can be grouped into two categories. The first is cost of service factors which include quantity shipped, distance, and operating conditions. Cost of service factors are aimed at allowing an individual carrier a reasonable profit to insure the service will be continued. They are also meant to guarantee the shipper availability of transportation services at prices that are as low as practical.

The second category of rate setting elements is value of service factors. These factors are meant to maintain the advantages of each mode of transportation and take into consideration the intramodal and intermodal competitive situation. One other component is included in value of service and is referred to as the equalization factor. The equalization factor, briefly, guarantees that transportation services will continue to be available in areas and to shippers of products that do not produce enough revenue to cover costs. The deficits are subsidized by discriminatory pricing in areas and for products which produce profits for the carriers.
The rate setting factors, particularly the cost of service factors, used by the I.C.C. have been the subject of criticism by transportation economists. The controversy centers on costs relevant to rate setting. Neither the I.C.C. nor carriers are able to measure the cost of providing a particular transportation service accurately.13

The problem of cost measurement in transportation industries can be traced to three sources—fixed costs, joint costs, and external costs. Fixed costs tend to make up a high proportion of total cost in the transportation industry. The usual approach is to allocate fixed costs to individual transportation services by a rigid accounting formula regardless of actual fixed costs incurred in providing that service.3 Joint costs are costs for variable inputs used to provide transportation services where more than one service is produced. Again, the problem becomes one of apportioning costs to each service.

External costs have become a topic of central focus in the waterway transportation industry. Several proposals to internalize the costs of providing and maintaining waterways by the imposition of user charges are currently being considered. However, external costs are not unique to barge lines. Subsidies in the form of outright grants, continuing financial support, guaranteed government business, and publicly financed facilities are common throughout the transportation industry. To the extent that external costs are not included as a cost of providing a specific service, the actual cost is understated.

The general approach taken by the I.C.C. in considering costs in ruling on tariffs is to use as a base the average fully allocated cost for the industry.3 A reasonable profit is allowed above the cost base, depending upon the nature of the commodity and the distance the commodity must be moved to find a market. This is sometimes referred to as the rule of what the traffic will bear.5 Deviations from this approach are considered by the I.C.C. only if a lower rate is proposed to meet a competitor. Higher rates are not allowed if they selectively discriminate against a small group of shippers or a particular commodity.5