Freight Transport on the Mississippi: An Analysis of Time Series Data

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The Mississippi River system has enjoyed a unique growth cycle in comparison with other domestic waterways. In the 1959 to 1973 time period freight increased by 140 percent. The problems of water transport have been largely neglected, however, as government transportation planners have focused on the more readily apparent crises in rail transport. This study analyzes the historical patterns of commodity traffic on the Mississippi and presents a set of econometric forecasting equations. Specific projections of commodity freight are estimated and analyzed for the 1977 to 1990 time period; of particular importance is the analysis of coal transport and its impact on the Mississippi system. The study also discusses institutional changes, such as the controversy over Locks and Dam 26 at Alton, Illinois, which may imperil future capacity expansion programs on the Mississippi.

The growth record of freight transport on the Mississippi River during the past 15 years is impressive: from 109.1 million Mg (120.3 million tons) in 1959 to 274.5 million Mg (302.6 million tons) in 1974, a compound growth rate of approximately 5 percent (Table 1) (4). During the same period, ocean-going and inland waterway freight showed compound growth rates of 5.6 percent and 4.6 percent, respectively. All segments of Mississippi River freight demand have thus significantly outpaced the 3.7 percent growth rate of the real gross national product during this time period. Comparing the growth differential of Mississippi water transport with the economy at large strengthens the theory that inroads have been made into the activity of other transport modes, such as rail; the information in Table 1 is too aggregative, however, to enable us to make conclusions about which commodities are propelling growth in freight shipments on the Mississippi.

The purpose of this paper is to analyze the historical factors that generated demand for logistic services on the Mississippi River system and to develop disaggregated projections of future freight on the Mississippi that can shed some light on current policy issues in water transport. Several major reasons can be cited for such a study. First, the United States is slowly moving toward a national freight transportation plan (1). Up to the present time, attention has been focused on transportation crises such as the bankrupt condition of many eastern railroads and the establishment of the Consolidated Rail Corporation (Conrail). Water transport may not be at the crisis stage, but research to determine likely growth parameters is badly needed. Maintaining water transportation as a viable and efficient part of the national transportation system requires time for advance planning. Both motor carriers and the railroad industry have their freight networks, or roadbeds, in existence, and only normal maintenance is required. To augment system capacity motor freight carriers can add additional power units within 2 to 3 months or expand their trailer fleets within 8 to 12 weeks; railroads can add to their rolling stock within 6 to 9 months. Development of a new and bigger set of locks on the Mississippi, however, may take 7 to 10 years (2).

A second major area of concern that strengthens the need for research in water transport is the political one. Congress, the executive branch, and the courts are all involved in the controversy surrounding the U.S. Army Corps of Engineers plan to expand Locks and Dam 26 at Alton, Illinois. This project, which would greatly increase capacity on the upper Mississippi, would directly threaten rail dominance in grain transport. Congress is also considering legislation that would grant the right of eminent domain to coal slurry pipelines. Although the immediate threat is to western railroads, there is also a potential threat to bulk transport on the Mississippi River system. Thus there are both an immediate and a long-run need to provide political decision makers with information about water freight transport.

DISAGGREGATING GROWTH OF MISSISSIPPI FREIGHT TRANSPORT

The Mississippi River system has enjoyed a unique growth cycle in comparison with other domestic waterways (Table 2) (5). From 1959 to 1973, megagrams at point of origin increased by 140 percent on the Mississippi but fell by 8 percent and 61 percent respectively on the Great Lakes and the Atlantic and Gulf Coast. Pacific Coast carriers experienced steady gains during the 1958 to 1969 period, but the level of traffic has fallen since 1969. [Because the purpose of Table 2 is to compare the relative growth rates of domestic water systems, the Mississippi River figures are not directly comparable to data in Tables 1 and 3.] The strong performance of water transport on the Mississippi raises several questions: What commodities have stimulated this surge in Mississippi freight transport? How will future growth estimates compare with the past growth pattern?

Table 3 (4) gives an overview by commodity of the composition of Mississippi River freight (both inland and ocean-going for all carriers) during the 1963 to 1974 period. Comparing the percentage composition of freight in 1963 and 1974 (Table 4) reveals a shift toward a relatively greater concentration in the areas of grain, coal, and chemicals; ores, metal products, and petroleum and petroleum products have made up a declining share of the total traffic. But there has been an across-the-board increase in the absolute freight levels of all major commodity categories (Table 3). Chemicals and fertilizer products exhibited a compound growth rate of 12.1 percent between 1963 and 1974. Coal and lignite also jumped dramatically, climbing by a compound annual rate of 9.5 percent. Grain and soybeans was close behind with a growth rate of 8.7 percent. Although overall growth was moderated by slower growth in some sectors, a dramatic 6.1 percent compound growth rate resulted over the 11-year period from 1963 to 1974.

The data in Table 3 provide a broad picture of the commodity base for total growth in freight transport on the Mississippi; Table 5 (4) further breaks this information down by transport route (upper Mississippi indicates north of St. Louis, above the confluence of the Mississippi and the Missouri) for each commodity category and by megagrams of freight which isolates the divergent growth pattern for each commodity. The corresponding breakdown for aggregate Mississippi freight is also given.

By using the data in Table 4, one can develop a more adequate information base for use in analysis. For example, between 1963 and 1974 the total 92 percent increase in all commodities can be linked to an increase of 89 percent for ocean-going and 94 percent for inland traffic; the latter figure can, in turn, be related to a 100 percent increase in upper inland freight and a 91 percent increase in lower inland freight. Analysis of the 1963 percentage composition reveals that the amount of grain and soybeans carried on the upper Mississippi rose by 185 percent between 1963 and 1974, providing over half the gain in upper Mississippi freight for this time period. As a direct result, grain and soybeans now comprise 40 percent of the freight handled on the upper Mississippi.

1990 FREIGHT FORECAST

Any attempt to develop long-run forecasts is difficult, especially so when one examines individual segments of the total freight transport network. Preparing a freight forecast for the Mississippi means implicitly making an aggregate rail, truck, and barge projection. Thus the task quickly expands into a global forecast. Ideally, an integrated regional forecasting system would be available that was capable of translating macroeconometric scenarios into a commodity-flow grid, but the present state of regional model building is crude compared to the technological capabilities of macroeconometric models. We have been forced, therefore, to rely on a system of equations that directly link macroeconometric output variables (e.g., production indexes for steel, petroleum, and other commodities) to megagrams of Mississippi freight.

The building blocks for this study are the six commodity categories given in Table 4. The major problem in developing freight estimates for the Mississippi is the scarcity of data. We have developed a two-directional forecast approach. First, aggregate (top-down) equations were constructed for upper Mississippi inland, lower Mississippi inland, and lower Mississippi ocean-going traffic. Data were collected for the 1959 to 1974 time period (Table 1). (As expected, 15 data points are insufficient for an elaborate model.) The aggregate equations are listed below.

Table 1. Growth of freight transport on the Mississippi, 1959 to 1974.

	Mississippi[a]				Index (1959 = 100)	
Year	Ocean-Going	Inland Waterway	Total	Upper Mississippi[b]	Total Mississippi	Upper Mississippi
1959	36.3	72.7	109.1	23.5	100	100
1960	41.6	74.8	116.4	24.9	107	106
1961	44.7	79.0	123.7	25.5	113	109
1962	52.5	83.4	136.0	27.7	125	118
1963	54.2	88.9	143.1	28.0	131	119
1964	57.1	92.0	149.4	30.9	137	132
1965	58.1	101.6	159.8	34.3	147	146
1966	67.7	108.3	176.0	37.5	161	160
1967	74.1	119.2	193.3	40.5	177	173
1968	73.1	125.7	198.8	41.8	182	178
1969	74.2	134.0	208.2	45.0	191	192
1970	85.1	142.4	227.5	49.0	209	209
1971	83.8	147.8	231.5	47.9	212	204
1972	84.5	162.2	246.7	55.1	226	234
1973	92.8	157.8	250.6	52.7	230	224
1974	102.3	172.1	274.5	56.0	252	239

Note: Amounts are in millions of megagrams. 1 Mg = 1.1 tons.

[a] 2939 km (1837 miles), from Minneapolis to the Head of Passes.

[b] 1060 km (663 miles), from Minneapolis to the mouth of the Missouri River. Over 99.5 percent of this freight was inland waterway traffic in 1974.

Table 2. Growth rates of domestic water systems by freight originations of class A carriers.

Year	Mississippi River	Great Lakes	Pacific Coast	Atlantic and Gulf Coast	Total
1959	43.1	18.2	10.5	9.9	81.7
1960	44.8	23.5	11.3	9.5	89.3
1961	47.6	20.4	10.4	8.2	86.6
1962	52.4	17.3	11.3	9.5	92.2
1963	55.7	20.9	11.3	9.4	98.8
1964	55.9	15.1	10.8	9.2	92.6
1965	56.8	15.5	12.2	9.1	95.2
1966	69.4	19.9	17.8	6.3	113.6
1967	73.8	20.5	16.6	6.5	118.9
1968	77.1	20.1	17.9	5.5	121.9
1969	83.4	17.2	18.5	3.2	122.3
1970	94.5	17.6	14.0	3.2	129.4
1971	88.8	16.1	12.6	3.0	120.7
1972	107.3	16.0	14.4	3.0	140.9
1973	103.3	16.8	14.3	3.8	138.4

Note: Amounts are in millions of megagrams. 1 Mg = 1.1 tons.

$$LMI = -106.02 + 182.73JMI + 0.91FPI \quad R^2 = 0.94$$
$$(-7.15) \quad (10.37) \quad (2.81) \quad D.W. = 2.11$$
$$S.E. = 5.91 \qquad (1)$$

$$LMO = 0.70 + 35.53J33 + 0.65EX72 \quad R^2 = 0.95$$
$$(0.12) \quad (2.74) \quad (3.64) \quad D.W. = 1.50$$
$$S.E. = 4.57 \qquad (2)$$

$$UMI = -29.9 + 23.95J12 + 49.85JGAS \quad R^2 = 0.98$$
$$(-5.3) \quad (2.10) \quad (8.20) \quad D.W. = 2.84$$
$$S.E. = 8.20 \qquad (3)$$

where

- LMI = lower Mississippi inland freight (millions of megagrams/year),
- LMO = lower Mississippi ocean-going freight (millions of megagrams/year),
- UMI = upper Mississippi inland freight (millions of megagrams/year),
- JMI = Federal Reserve Board (FRB) production index for mining,
- FPI = farm proprietors income (billions of 1972 dollars),
- J33A = FRB production index for primary metals,
- EX72 = Exports in 1972 dollars,
- J12 = FRB production index for coal, and
- JGAS = FRB production index for gasoline.

These equations were simulated by using the long-term

Table 3. Freight transport on the Mississippi for six commodity categories, 1963 to 1974.

	1963		1966		1968		1969		1970		1971		1972		1973		1974		
Commodity	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	1963 to 1974 Increase (%)
Grain, grain products, and soybeans	26.4	18.4	33.2	18.9	37.8	19.0	38.6	18.6	43.0	18.9	42.5	18.4	57.4	23.3	63.6	25.4	65.9	24.0	150.0
Metallic and nonmetallic ores and metal products	15.5	10.8	16.2	9.2	18.3	9.2	18.2	8.8	21.2	9.3	19.5	8.4	17.3	7.0	17.4	6.9	20.0	7.3	28.7
Petroleum and petroleum products	62.7	43.8	66.5	37.8	78.4	39.3	80.7	37.6	84.1	35.4	85.2	36.3	79.1	34.5	81.8	33.3	90.9	33.1	45.0
Coal and lignite	9.2	6.4	13.2	7.5	17.1	8.6	17.6	8.5	20.0	8.8	19.5	8.4	24.1	9.8	21.4	8.5	24.9	9.1	171.3
Chemicals and fertilizers	9.3	6.5	13.2	7.5	15.7	7.9	17.9	8.6	20.5	9.0	26.5	11.4	31.1	12.6	30.1	12.0	32.6	11.9	252.0
Other	20.1	14.1	33.4	19.0	31.6	15.9	35.1	16.9	38.7	16.5	38.3	16.5	37.6	15.3	36.3	14.5	40.5	14.7	100.9
Total	143.2	100.0	175.7	100.0	198.9	100.0	208.1	100.0	227.5	100.0	231.5	100.0	246.6	100.0	250.6	100.0	274.8	100.0	91.8

Note: Amounts are in millions of megagrams. 1 Mg = 1.1 tons.

Table 4. Changing freight commodity mix on the Mississippi, 1963 to 1974.

Commodity Category	Route	1963 Amount	1963 Percent	1974 Amount	1974 Percent	Increase (percent)
Grains and soybeans	Total	26.4	18	65.9	24	150
	Ocean	14.2	26	33.6	33	136
	Inland	12.2	14	32.4	19	166
	Upper	7.9	28	22.5	40	185
	Lower	4.3	7	9.9	8.5	132
Coal	Total	9.2	6	24.9	9	171
	Ocean	0.7	1	4.0	4	450
	Inland	8.4	9	20.9	12	147
	Upper	4.4	16	6.9	12	58
	Lower	4.1	7	14.0	12	242
Petroleum and petroleum products	Total	62.7	44	90.7	33	45
	Ocean	23.9	44	32.4	32	35
	Inland	38.7	44	58.3	34	51
	Upper	8.7	31	10.6	19	22
	Lower	30.0	49	47.7	41	59
Construction materials and metals	Total	15.5	11	20.0	7	29
	Ocean	6.0	11	8.9	9	48
	Inland	9.5	11	11.1	6	16
	Upper	3.4	12	4.5	8	35
	Lower	6.2	10	6.5	6	6
Chemicals and fertilizers	Total	9.3	6	32.6	12	252
	Ocean	3.0	6	12.2	12	309
	Inland	6.3	7	20.3	12	225
	Upper	1.3	5	5.0	10	321
	Lower	5.0	8	15.3	13	207
Other commodities	Total	20.1	14	40.5	15	101
	Ocean	6.3	12	11.2	11	77
	Inland	13.8	16	29.2	17	112
	Upper	2.4	9	6.1	11	148
	Lower	11.3	19	23.1	20	104
All commodities	Total	143.1	100	274.5	100	92
	Ocean	54.2	100	102.3	100	89
	Inland	88.9	100	172.1	100	94
	Upper	28.0	100	56.0	100	100
	Lower	60.9	100	116.2	100	91

Note: Amounts are in millions of megagrams. 1 Mg = 1.1 tons.

Table 5. Forecast of growth of freight transport on the Mississippi, 1974 to 1990.

Item	1974	1980	1985	1990	1974 to 1990 Increase (percent)
Commodity category					
Grain	65.9	86.0	107.0	140.4	112.9
Coal	24.9	37.3	52.2	73.1	194.2
Petroleum	90.7	105.6	125.0	149.4	64.7
Construction	20.0	20.7	22.0	23.7	18.6
Chemicals	32.6	50.0	69.7	95.6	193.6
Other	40.5	54.3	65.8	79.5	96.6
Total	274.5	353.8	441.7	561.7	104.7
Route					
Total	274.5	353.8	441.7	561.7	104.7
Ocean	102.3	129.1	161.2	205.0	100.4
Inland	172.1	224.8	280.5	356.7	107.2
Upper	56.0	74.8	93.3	118.7	112.2
Lower	116.1	149.9	187.2	238.0	104.8

Note: Amounts are in millions of megagrams. 1 Mg = 1.1 tons.

economy model developed by Data Resources, Inc., which provided a top-down set of freight projections. An alternative bottom-up set of estimates was constructed by using the six commodity categories listed in Table 5. Equations constructed for each commodity category linked, for example, megagrams of petroleum on the Mississippi to the FRB production index for petroleum products (FRB 29). These equations were then simulated and aggregated to find total megagrams of freight. As might be expected, the top-down and bottom-up projections differed (by about 10 percent in aggregate). The final figures in Table 6 are, therefore, a hybrid set.

Table 5 represents a business-as-usual projection for the Mississippi: Aggregate freight grows at a compound rate of 4.5 percent over the forecast period from 1974 to 1990, which is lower than the 5 percent rate experienced from 1959 to 1974. Commodities in Table 5 show diverse growth patterns, from an 18 percent increase in construction to a 194 percent increase in both coal and chemicals. A detailed commodity-by-commodity approach is therefore necessary in any intelligent discussion of future Mississippi growth.

Coal projections in Table 5 illustrate the uncertainties that must be considered in developing long-run forecasts. On the one hand, Project Independence has created some optimism in the coal sector. On the other hand, the level of national coal production in 1985 is unpredictable. The following table gives forecasts of national coal production and demand, in millions of megagrams, as developed by various private and government sources (1 Mg = 1.1 tons).

Source	Forecast 1980	Forecast 1985
Temple, Barker and Sloane (6)	669	932
Office of Coal Research (7)		
5 percent growth	797	1017
3.5 percent growth	712	844
Project Independence (8)		
Business as usual	812	998
Intermediate	862	1088
Accelerated	1248	1871
National Petroleum Council (9)	766	908
Task Group on Coal Supply Potential (10)	776	—
Mitre Corporation (11)	775	882
U.S. Bureau of Mines (12)	731	905

Even if there is a rapid increase in coal production, the location of mines and market areas is important to any forecast for the Mississippi. It is dangerous to conclude that, because average barge costs are 1.875 mills/Mg•km (3 mills/ton-mile) compared to 5.6 to 7.5 mills (9 to 12 mills) for railroad, the boom in western coal will automatically cause an increase in megagrams of coal carried on the Mississippi (3).

As pointed out in a recent study by the Hudson Institute (3), the western coal fields are 644 and 966 km (400 and 600 miles) from the nearest navigable river (the Missouri). The Hudson study also mentions that the Burlington Northern is considering a potential intermodal link at St. Louis that would directly affect freight on the lower Mississippi. An alternative means of rail-water access to the East is the Great Lakes.

Table 5 forecasts 1990 coal freight at 73.1 million Mg (80.6 million tons), a level almost triple that of 1974. To put this in historical perspective, however, Mississippi coal freight increased from 9.2 million Mg (10.1 million tons) in 1963 to 24.9 million Mg (27.4 million tons) in 1974—a period of stagnation in national coal production—which indicates that even these coal projections are conservative.

Grain and soybean transport is also unpredictable. As given in Table 4, this category experienced the largest absolute growth—more than 39 million Mg (43 million tons)—in the 1963 to 1974 period. With a forecast increase of 74.5 million Mg (Table 5), it again provides the largest absolute impetus for growth.

As in the case of coal, barge transport of grain offers significant savings to shippers. But, because of the seasonal nature of the commodity, capacity can be a critical problem, particularly in view of the 7 to 10-year lead time required for major water improvement projects. A study recently carried out for the Illinois Department of Transportation estimated that the proposed expansion of capacity at Locks and Dam 26 on the Mississippi River near Alton, Illinois, would divert $70 million/year of traffic (mostly grain) from the Illinois Central Gulf Railroad to the Illinois waterway and that a significant portion of that traffic would make its way to the Mississippi (2). Environmentalists have, for the time being, blocked the dam expansion project through legal action. By itself this controversy may seem unimportant; as a precedent, however, it could bring expansion of capacity on the Mississippi to a halt.

Projected growth in grain transport is lower than that experienced during the 1963 to 1974 period. Most excess agricultural capacity has now disappeared, and it is unlikely that the historical pattern of growth will persist. Strong domestic and world demand for grain, however, will continue to buoy grain shipments on the Mississippi.

Historical shipments of petroleum and petroleum products on the Mississippi have shown steady growth, comprising roughly 40 percent crude oil, 18 percent gasoline, 17 percent residual fuel oil, 11 percent distillate fuel oil, and the remainder in products such as naphtha and tar. Over half of the crude petroleum is ocean going, and about 75 percent of the refined product is inland; the entire range of petroleum products is thus sensitive to shifts in energy policy. We have linked future growth in transport of petroleum on the Mississippi (Table 5) to national output of petroleum and petroleum products, as forecast by the macroeconomic model of Data Resources, Inc.

Construction materials and metals have lagged far behind other commodity sectors (Table 4). Megagrams of sand, gravel, and crushed rock amounted to 5.8 million (6.4 million tons) in both 1963 and 1974. After peaking at 21.2 million Mg (23.4 million tons) in 1970, construction materials and metals have fluctuated around 18 to 21 million Mg (20 to 23 million tons). The slow growth of this sector is reflected in the forecast in Table 5.

Chemicals and fertilizers generated the best track record in percentage growth during the 1963 to 1974 period (Table 4). The major subcategories of this sector include dry and liquid sulfur (14 percent of total), fertilizer and fertilizer materials (40 percent), and chemicals and products (46 percent). Nearly half of the fertilizers, 40 percent of the sulfur, and 25 percent of the chemicals represented ocean-going traffic in 1974. Fertilizer traffic has grown from 2.3 million Mg (2.5 million tons) in 1963 to 12.7 million Mg (14 million tons) in 1974. Phosphate, a critical input to fertilizer production, is the source of a mining boom in Wyoming, which should contribute to future traffic on the Mississippi. Chemicals and fertilizers are projected to reach 95.6 million Mg (105 million tons) in 1990, approximately three times the 1974 traffic level (Table 5).

The commodity category labeled other contains all remaining products, such as molasses, lumber, and automobiles. Historically this category closely paralleled the economy; we have therefore based its future movements on projected values of key economic indicators.

The aggregate outlook, according to the projections contained in Table 5, is for sustained growth propelled by coal, chemicals, and grain. Because of the disproportionate share of coal going inland, ocean-going traffic lags slightly behind. Overall, the picture is for relatively balanced growth between upper and lower Mississippi traffic.

FREIGHT DEMAND AND INSTITUTIONAL CHANGE

It is relatively easy to translate next year's increase in gross national product into freight demand. One can safely assume no radical institutional changes in such a short time. This is obviously not the case in a long-run forecast. It is possible, as mentioned above, that environmental concerns will lead to capacity restrictions on the Mississippi. It is also increasingly likely that the government will start to charge user fees for those governmentally financed projects, such as Locks and Dam 26, that produce direct benefits to users of the Mississippi. Whatever affects the railroads (for example, slurry pipelines) will also have undetermined spillover effects on water transport. It is conceivable that the government will develop subsidies for railroads in the West to match its aid to eastern railroads, and that might have the effect of distorting the rate structure and altering the relative cost advantages of the different transport modes. None of these contingencies has been factored into our analysis. To the extent that significant institutional change does take place we should expect to depart from a business-as-usual forecast.

REFERENCES

1. 1974 National Transportation Report. U.S. Department of Transportation, July 1975.
2. Comments of Illinois State Agencies on Chief of Engineers' Report for Locks and Dam 26. Illinois Department of Transportation, Springfield, June 14, 1976.
3. Research Analysis of Factors Affecting Transportation of Coal by Rail and Slurry Pipeline. Hudson Institute, New York, Vol. 2, April 1976.
4. Inland Waterborne Commerce Statistics. American Waterways Operators, Inc., Washington, D.C.
5. Moody's Transportation Manual. Moody's Investor Service, 1975.
6. Final System Plan. U.S. Railway Assoc., Washington, D.C., Vol. 1, July 1975.
7. Prospective Regional Markets for Coal Conversion Plant Products Projected to 1980 and 1985. Office of Coal Research, U.S. Department of Interior.
8. Report on Project Independence Blueprint. Interagency Coal Task Force; U.S. Department of Interior, Aug. 1974.
9. U.S. Energy Outlook: Coal Availability, National Petroleum Council; U.S. Department of Interior, 1973.
10. Utility Oil Saving Study. Task Group on Coal Supply Potential, Washington, D.C., Jan. 1975.
11. An Analysis of Constraints on Increased Coal Production. Mitre Corp., McLean, Va., Jan. 1975.
12. United States Energy Through the Year 2000. Bureau of Mines, U.S. Department of Interior, Dec. 1975, revised.