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SOCIAL SAVINGS DUE TO WESTERN RIVER STEAMBOATS

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I. Introduction

The westward movement of American settlement during the nineteenth century was largely made possible by major developments in internal transportation systems. The three most important transportation developments during this era are canals, railroads and river steamboats. During the past decade a number of studies have attempted to gauge, systematically, the social savings to the American economy attributable to canals and railroads.[1] In contrast, only one set of crude estimates of the social savings attributable to steamboats is available. These estimates made by Fishlow, indicate that western river steamboats provided annual direct benefits from goods movements alone of $1 million in the 1820's, rising to $6.3 million in the 1840's.[2]

Fishlow derived these estimates by multiplying the "rate advantage (of western river steamboats) over nonsteam (flatboats and keelboats) of 2 cents per ton-mile downstream and 8 cents upstream" by his estimates of the ton-mileages.[3] His ton-mileage figures are estimated (by an unknown method) from data on "arrivals at New Orleans, with a generous conversion to allow for the extensive tributary commerce that never reached that terminus."[4] He concludes that regardless of the traffic erosion due to competition from the railroads during the 1850's and the corresponding decline in the social savings attributable to steamboats, "the evident implication...is of enormous social returns to the steamboat in western waters."[5]

Nonetheless, he also concludes that the impact of the western river steamboat on the American economy was limited. This conclusion is based on a comparison of the benefits attributable to steamboats and those attributable to canals and railroads. The benefits due to steamboats are relatively small because "the investment was not a large enough commitment of resources to influence profoundly the economy as a whole."[6]

The object of this paper is to provide more detailed and more comprehensive estimates of the social savings attributable to western river steamboats. We will estimate the direct benefits to both goods and passenger movements. We will also estimate the indirect benefits due to differences in travel times and accident rates. The direct benefits from goods movements are found to be a major component of the total social savings. These benefits are found to be of the same order of magnitude as estimated by Fishlow during the 1820's. But during the later years they substantially exceed his estimates despite the fact that Fishlow overstated the rate advantage of the steamboat.

The next section briefly outlines the theoretical considerations involved in estimating the social savings. The following three sections present, in turn, estimates of the freight and passenger traffic carried by river steamboats during 1850; estimates of the rate advantage offered by steamboats in 1850 and of the direct benefits; and estimates of the indirect benefits attributable to steamboats in 1850. Section VI presents our estimates of the social savings attributable to western river steamboats during other years of the antebellum period. The conclusions are summarized in section VII.

The initial focus is on the year 1850. The reason for this is that there are more data available for this year than for any other year. Specifically there are census returns, collected by mistake, that provide comprehensive data on costs and revenues for 45 steamboats.[7] There are data on steamboat passenger traffic in 1850[8] and data on the goods movements at several of the major cities in 1850.[9] The extensive data available for 1850 are used to establish the validity of estimating procedures that can be applied to the more limited information available for the rest of the antebellum period.

II. Theory

The approach used to estimate the social savings attributable to a transportation innovation is well known.[10] The actual cost to society of the transportation services provided using the specified innovation (river steamboats) is estimated. This is compared to the estimated cost to society of the transportation facilities hypothesized to exist in the absence of the innovation (nonsteam river craft). The cost of the transportation services to society is generally divided into two categories, direct and indirect. The direct costs are those paid by the shippers for the transportation services. In addition, each mode of transportation imposes indirect costs, in the form of travel time and losses due to accidents, on other groups.

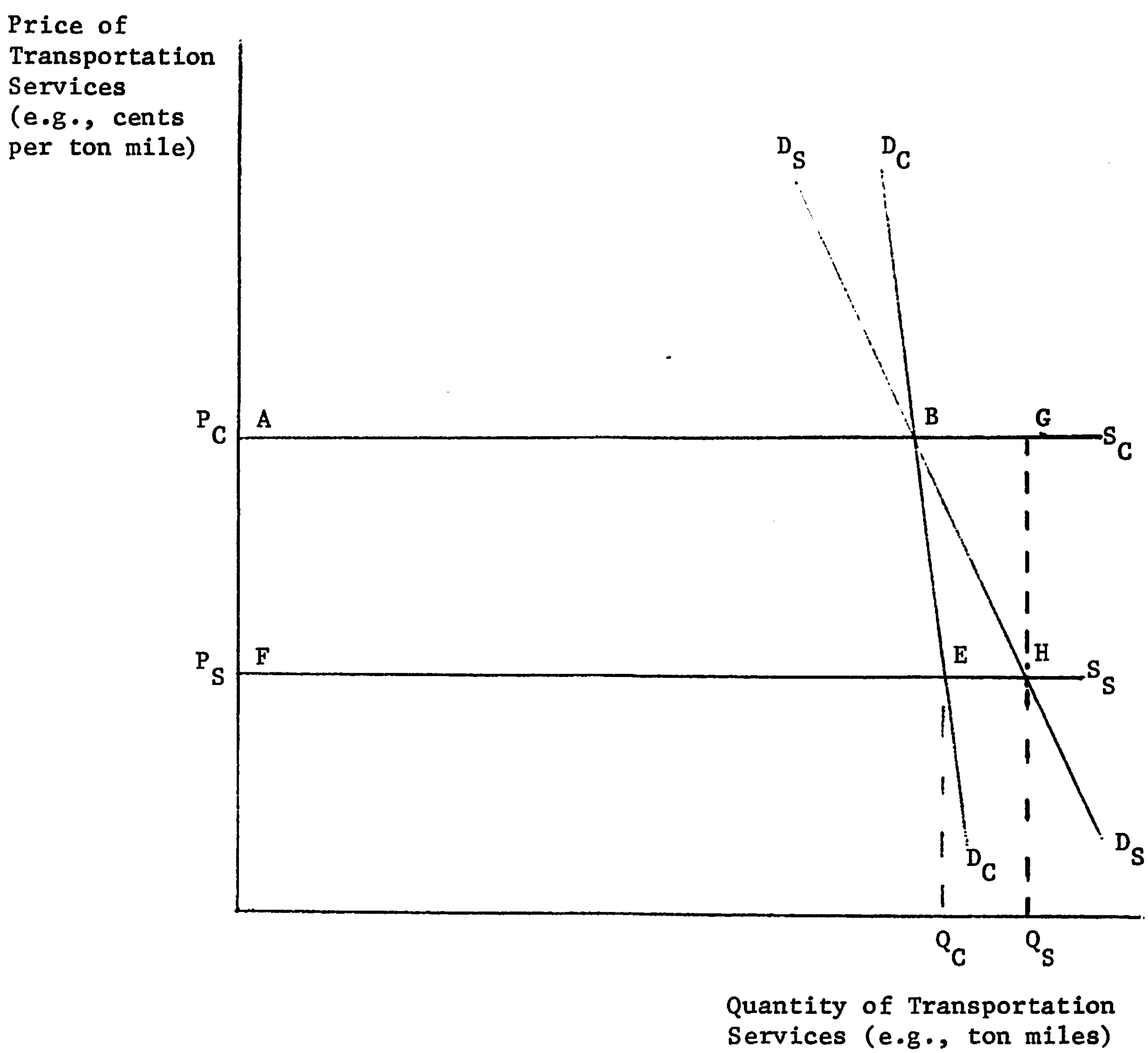
The calculation of the direct benefits is illustrated in Figure 1. It shows the supply curve (S_S) and demand curve (D_S) for river steamboat transportation. The observed equilibrium price and quantity of steamboat transportation services are P_S and Q_S respectively. The supply curve for the counterfactual transportation system is S_C. The assumption of perfect competition and hence of a horizontal supply curve is very important. This assumption is a reasonable one for all forms of river craft given the large number of vessels in operation, the widely dispersed ownership, and the ease of entry.[10A] The demand for transportation services that would have existed given the counterfactual system is D_C. It is less elastic than D_S because the higher cost counterfactual system would produce a less transport-intensive technology given the same level of aggregate income. The appropriate measure of direct benefit is the area ABEF.

The observed data specify the points F and H. It is usually relatively easy to estimate the freight rates of the counterfactual system and so specify the point A. But it is usually very difficult to specify the points B and E. They require information on the price elasticity of demand for transportation

Figure 1

Direct Savings in Transportation Costs Due

To Western River Steamboats



by steamboat and by the counterfactual mode. These elasticities are usually not known. It is customary then to determine the area AGHF and use this as an upper bound estimate of the direct benefits. That will be our approach as well.

The direct benefits will be calculated separately for eight different markets--passengers and freight moving upstream and downstream on both trunk and tributary routes. This division is required because of the differences in either the steamboat rates, or the rates of the counterfactual mode, or both, in these markets.

In addition to the direct savings, there are a number of possible indirect benefits. The most important indirect benefits for transportation systems are possible reductions in travel time for both goods and passengers and possible savings due to lower accident rates. It is possible that these indirect benefits are partially captured in the direct benefits. We will assume that the direct and indirect benefits are totally independent. This is consistent with our approach of obtaining an upper bound estimate of the benefits attributable to steamboats.

III. Freight and Passenger Traffic by Steamboat in 1850

Data on the volumes of freight and passengers transported by steamboats are very limited during most of the antebellum period. However, various bodies of data available for 1850 enable us to prepare estimates of both the freight and passenger traffic during that year. The data provide one direct and two indirect estimates of the freight and passenger traffic. The three estimates, outlined below, all give similar results.

To measure the goods movements directly origin and destination data for all river points are, in theory, required. In practice most goods were shipped via one or more of the major river ports. Data for goods received at and shipped from New Orleans, St. Louis and Cincinnati during 1850 are available.[11] These are shown in Table 1. The average distance travelled by

TABLE 1

Direct Estimate of Goods Movement

by Steamboat in 1850

Port	Goods Shipped or Received (thousand tons)	Distance Shipped (miles)	Goods Movement (thousand ton miles)
New Orleans			
Received	1,058[a]	710[b]	751,180
Shipped	380[a]	710[b]	269,800
St. Louis			
Received	258[c]	410[d]	105,780
Shipped	186[c]	490[d]	91,140
Cincinnati			
Received	215[e]	240[f]	51,600
Shipped	230[e]	235[f]	54,050
Total for New Orleans, St. Louis and Cincinnati			1,323,550

Tonnage of steamboats registered at New Orleans, St. Louis and Cincinnati 91,279[g]

Tonnage of all Western River Steamboats 135,559[g]

Estimated Goods Movement for All Western River Steamboats (million ton miles) $\frac{135,559}{91,279} \times 1324 = 1,966$

Notes: (a) Callender (p 315) reports the quantity of freight received by river at New Orleans during the commercial year 1850-51 as 1,058,200 tons. Only limited data are available on the upstream traffic from New Orleans. Upstream shipments of cotton and sugar are reported in Hunt's Merchants' Magazine (vol 25, pp 603-04). Assuming cotton to weigh 500 lbs per bale and sugar to weigh 1,000 lbs per hogshead gives a minimum estimate of the upstream traffic during the commercial year 1850-51 of 61,625 tons. A maximum estimate of the upstream traffic is obtained by deducting the foreign and coastwise exports from receipts by river and adding the imports. Hunt's Merchants' Magazine (vol 25, pp 603-05) lists the foreign and coastwise exports of twelve major commodities. Using the following factors--bacon = 250 lbs/hogshead; beef - 200 lbs/barrel; corn - 112 lbs/sack; flour - 200 lbs/barrel; lard - 45 lbs/keg; lead - 60 lbs/pig; molasses - 360 lbs/barrel; pork-200 lbs/barrel; tobacco - 1000 lbs/ hogshead; and whiskey - 360 lbs/barrel the foreign and coastwise exports during the commercial year 1850-51 are estimated at 480,576 tons. The value of imports into Louisiana during the year ending June 30, 1851 is given as $12,528,460 in the government reports on trade and commerce. The exports of foreign products during the same year amounted to $445,950, leaving net imports of $12,082,510. Assuming an average value of $100 per ton gives an estimated tonnage of 120,825. Then the maximum estimate of the upstream shipments is 1,058,200 - 480,576 + 120,825 = 698,449 tons. The estimated upstream goods movement is taken to be the average of the minimum and maximum estimates, which is 380,037 tons.

(b) The only information available on the directions of the New Orleans trade consists of the number of steamboat arrivals from each of five areas during the commercial year ending August 31, 1860. These data are reported by Hunter (p 662). The vessels arriving from the different areas vary in size and hence in average load. An index of the average load by area is estimated and shown below. The average distance travelled by boats arriving from each area is also estimated.

Area	Arrivals	Load Index	Freight Index	Distance (miles)	Ton-mile Index(000)
coasts	785	1.5	1177	75	88.3
bayous	1,222	1.0	1222	400	488.0
Mississippi	544	2.0	1088	700	761.6
St. Louis	472	2.0	944	1,200	1,132.8
Ohio	535	2.0	1070	1,350	1,444.5
Total	3,558		5501		3,915.2

From the ton-mile and freight indexes the average distance is found to be 3915200/5501 = 712 miles. This is rounded to 710 miles and is taken to be the average distance travelled by goods shipped as well as received.

(c) Hunt's Merchants' Magazine, (vol 24, p 314) gives the quantities of the major products received by river at St. Louis during the calendar year 1850. Using the conversion factors listed in note (a) above, the total receipts of bacon, beef, corn, flour, lard, pork, sugar, tobacco, wheat and whiskey amounted to 176,516 tons. Hunt's Merchants' Magazine (vol 20, pp 437-38) gives the same information for the calendar year 1847. The receipts of the ten major products listed above during 1847 amounted to 170,749 tons.

De Bow's Review (vol 13, p 613) lists the quantities of major products exported from St. Louis during the year ending June 30, 1851. Exports of the ten specified products amounted to 127,246 tons.

De Bow's Review (vol 5, p 371) lists the quantities of major products exported from St. Louis during 1847. The exports of the specified products amounted to 130,637 tons.

De Bow's Review (vol 7, p 445) gives an estimate of 536,300 tons as the total river trade of St. Louis. The receipts and exports of major products during 1847 amounted to 170,749 + 130,637 = 301,386 tons or 56 percent of the total. It is assumed that the total receipts by river at St. Louis during 1850 are 176,516/.56 = 315,200 tons. Similarly it is assumed that total exports are 127,246/.56 = 227,200 tons.

De Bow's Review (vol 7, p 445) shows the St. Louis-New Orleans trade to be roughly 18 percent of the total St. Louis trade during 1847 and 1848. Since the St. Louis-New Orleans trade is already included in the New Orleans data the above estimates are reduced by 18 percent to avoid double counting. This gives receipts of 258,500 tons and exports of 186,300 tons.

(d) Hunt's Merchants' Magazine (vol 30, pp 488-90) gives the origins of the major products received at St. Louis during 1853. The tonnage from each of the four major areas was calculated. A comparison with the data on the direction of the St. Louis trade given in De Bow's Review (vol 7, p 445) suggests that the receipts shown for the Mississippi River include those for New Orleans, Cairo, Upper Mississippi River and other ports. The 107,462 tons of receipts from Mississippi River ports is therefore allocated to these four sub-categories on the same basis as the total traffic (receipts plus exports) during the years 1847 and 1848; specifically New Orleans - 30.9%; Cairo - 5.9%; Upper Mississippi - 50.9% and Other - 12.3%. This gives virtually the same estimate of the New Orleans receipts as taking 18 percent of the total receipts. The distances used are Illinois River (Peoria) - 205 miles; Missouri River (St. Joseph) - 500 miles; Ohio River (Louisville) - 570 miles; Cairo - 150 miles; Upper Mississippi River (St. Paul) - 680 miles and Other ports - 100 miles.

	Tonnage	Distance	Ton-miles (000)
Illinois	52,135	205	10,688
Missouri	14,748	500	7,374
Ohio	1,650	570	940
Cairo	6,340	150	951
Upper Mississippi	54,698	680	37,195
Other	13,218	100	1,322
Total	142,789		58,470

This gives an average distance of almost 410 miles for goods received at St. Louis from ports other than New Orleans.

De Bow's Review (vol 7, p 445) shows the estimated river trade (receipts plus exports) of St. Louis with seven other areas in 1847 and 1848. The average total traffic for the two years is 613,570 tons, of which 110,000 tons is with New Orleans. From note (c) we see that receipts accounted for about 41.9 percent of the river traffic with ports other than New Orleans. Hence the average receipts for 1847-48 to points other than New Orleans are estimated at 211,000 tons with the corresponding exports being 292,570 tons. The receipts are assumed to be distributed among the various origins on the same basis as the major products listed above. This allows the exports by destination and the average distance to be calculated as follows:

	Total Traffic	Receipts (tons)	Exports (tons)	Distance (miles)	Ton-miles (000)
Illinois	122,000	77,040	44,960	205	9,217
Missouri	56,320	21,793	34,527	500	17,264
Ohio	79,000	2,438	76,562	570	43,640
Cairo	21,500	9,370	12,130	150	1,820
U. Mississippi	181,000	80,827	100,173	680	68,118
Other	43,750	19,532	24,218	100	2,422
Total	503,570	211,000	292,570		142,481

This gives an average distance of almost 490 miles for goods exported from St. Louis to ports other than New Orleans.

(e) Hunt's Merchants' Magazine (vol 25, pp 485-87) gives detailed data on the quantities of all goods imported into and exported from Cincinnati during the commercial year 1850-51. The weights of the various physical measures used are not all available so the total volumes must be estimated. to estimate the total it was assumed that the ten major products - bacon, beef, corn, flour, lard, pork, sugar, tobacco, wheat and whiskey accounted for 56 percent of the total volume as was the case for St. Louis. The imports of the specified items amounted to 155,465 tons while the exports amounted to 167,660 tons. Thus, the estimated total receipts are 277,616 tons and the estimated total shipments are 299,393 tons.

We can get an order of magnitude check on the above estimates from the data on the steamboat traffic of Cincinnati. Hunt's Merchants' Magazine (vol 25, pp 505-506) gives the number of steamboat arrivals and departures at Cincinnati as 3,698 and 3,293 respectively. Table 4 gives the average size of steamboats registered at Cincinnati as 232 tons. Assuming this to be the average size of steamboats calling at Cincinnati, gives the total steamboat tonnage arrived and departed as 857,936 and 763,976 tons respectively. The receipts are about 32 percent of the tonnage arrived and the shipments are about 39 percent of the tonnage departed. These percentages appear reasonable.

The total shipments and receipts must be reduced by the amount of the trade with New Orleans and St. Louis since that traffic has already been estimated. Hunt's Merchants' Magazine (vol 25, p 488) provides some data on the destinations of goods shipped from Cincinnati. The shipments to New Orleans are shown, but those to St. Louis are not. Only a limited number of goods are included and the data indicate that about 58 percent of those goods are shipped to New Orleans. This is grossly inconsistent with the data on steamboat arrivals and departures.

The steamboat arrivals and departures are shown separately for both New Orleans and St. Louis, as well as other ports. We will use those data to estimate the share of the total traffic accounted for by the trade with New Orleans and St. Louis. To do this we need an index of the average load for the steamboats in each trade. The index is assumed to be 2.0 for New Orleans and St. Louis, 1.5 for Pittsburgh and 1.0 for all other ports. The calculation then is as follows:

	Index of Average Load	Arrivals	Index of Receipts	Departures	Index of Shipments
New Orleans	2.0	288	576	249	498
St. Louis	2.0	214	428	222	444
Pittsburgh	1.5	658	987	547	820
Other	1.0	2,538	2,538	2,275	2,275
Total		3,698	4,529	3,293	4,037

The New Orleans and St. Louis trades account for 22 percent of the receipts and 23 percent of the shipments. We will assume that 22.5 percent of Cincinnati's imports and exports are included in the New Orleans and St. Louis estimates. The total receipts from other ports are estimated at approximately 215,000 tons and the total shipments to other ports are estimated at 230,000 tons.

(f) The average distance travelled by imports and exports uses the information on arrivals, departures and average loads given in note (e). In addition the distances to Pittsburgh and "other" ports are required. The distance between Pittsburgh and Cincinnati was 470 miles. The distance to "other" ports was estimated at 150 miles, roughly the distance to Louisville and to Portsmouth. The calculations are as follows:

	Arrivals	Load Index	Receipts Index	Distance (mi)	Ton-mile Index
Pittsburgh	658	1.5	987	470	463,890
Other	2,538	1.0	2,538	150	380,700
Total	3,196		3,525		844,590

	Departures	Load Index	Shipments Index	Distance (mi)	Ton-mile Index
Pittsburgh	547	1.5	820	470	385,400
Other	2,275	1.0	2,275	150	341,250
Total	2,822		3,095		726,650

The average distance travelled by goods received at Cincinnati is 844,590/3,525 = 240 miles and the average distance travelled by goods shipped from Cincinnati is 726,650/3,095 = 235 miles.

Notes: (g) See Table 4 for the registered tonnage by district. There are 14 ferries measuring 1,885 tons in the districts of New Orleans, St. Louis and Cincinnati.

Sources:

G.S. Callender, Selections from the Economic History of the United States 1765 - 1860 (Boston: Ginn and Company, 1909);
J.D.B. De Bow, ed. The Commercial Review of the South and West (De Bow's Review) vols. 5, 7 and 13;
F. Hunt, ed. Merchants' Magazine and Commercial Review (Hunt's Merchants' Magazine) vols. 20, 24, 25 and 30;
L.C. Hunter, Steamboats on the Western Rivers, (Cambridge: Harvard University Press, 1949);
U.S. Congress Senate Tables of the Commerce and Navigation of the United States for the Fiscal Year 1851, Senate Exec. Doc. (unnumbered) 32 Cong., 1 sess., 1852 (serial set 628) pp 322-28.

the goods shipped and received at each of these ports is estimated from the available origin-destination data. The total goods movements for these cities are then calculated at almost 1,324 million ton-miles.

An estimate of the goods movements for the remaining points must still be made. About two-thirds of the total steamboat tonnage was registered at the ports of New Orleans, St. Louis and Cincinnati. So it was assumed that the traffic of those ports was the same proportion of the total goods movements. This assumption introduces an upward bias into our estimates since part of the traffic of the remaining ports is already included in the data for New Orleans, St. Louis and Cincinnati. The assumption that the goods movements are proportional to the registered tonnage gives an estimated total movement of 1,966 million ton-miles for 1850.

The first indirect estimate is calculated using the physical and operating characteristics of the steamboats operating in 1850. The calculation of this estimate is shown in Table 2.

The data on the 45 steamboats for which we have 1850 census returns indicate that boats measuring 200 tons or less generally operated on the tributaries, while the larger vessels operated on the trunk routes.[12] We will assume that all steamboats of 200 tons or less operated on tributary routes and that all larger boats operated on trunk routes. There were a total of 638 steamboats measuring 134,566 tons in operation in 1850.[13] Of this total 386 boats measuring 45,954 tons were, by the above definition, operating on tributary routes. The trunk routes were served by 252 steamboats of more than 200 tons measuring 88,612 tons. This is about 40 percent by number, and about 65 percent by capacity, of the total stock. The average sizes of the trunk and tributary steamboats are 352 tons and 119 tons respectively. These averages compare to 381 tons and 149 tons for the corresponding groups in the 1850 census sample.[14]

TABLE 2

Indirect Estimate of Goods Movements
by Steamboat in 1850

	TRUNK Upstream	TRUNK Downstream	TRIBUTARY Upstream	TRIBUTARY Downstream
Measured tonnage of steamboats operating in 1850[a]	88,612	88,612	45,954	45,954
Cargo capacity/measured tonnage[b]	0.8	1.6	0.8	1.6
Speed: miles per day running[c]	180	250	180	250
Running time annually (days)[d]	75	55	85	60
Annual cargo capacity (million ton-miles)	957.0	1,949.5	562.5	1,102.9
Utilization of capacity (%)[e]	45	75	15	25
Cargo carried (million ton-miles)	430.7	1,462.1	84.4	275.7

Cargo carried - upstream	515.1	million ton-miles
- downstream	1,737.8	million ton-miles
- total	2,252.9	million ton-miles

Notes:

(a) Calculated from the Lytle List assuming that all steamboats of 200 tons or more operated on the trunk routes and that all smaller vessels operated on the tributaries.

(b) Haites, Mak and Walton, Western River Transportation, Table D-2, p. 158.

(c) Ibid., Table C-3, p. 143 gives the average time for the 1350 mile trip between Louisville and New Orleans as 7.5 days upstream and 5.5 days downstream. This is approximately 180 miles per day upstream and 250 miles per day downstream.

(d) Ibid., p. 142 gives the navigation season on the trunk rivers as nine months after 1830. It (Table C-3, p. 143) gives the total running time in the Louisville-New Orleans trade as 75 days upstream and 55 days downstream. It also shows (Table F-5, p. 176) that the navigation season for the boats in the 1850 census sample is nine months on trunk routes and ten months on tributary routes. Hence, the figures for the Louisville-New Orleans route were assumed to apply to all trunk routes. The trunk route figures were multiplied by 10/9 and rounded to running times of 85 days upstream and 60 days downstream.

Notes for Table 2 continued:

(e) Ibid., pp. 159-60 gives the average utilization of capacity for steamboats in the Louisville-New Orleans trade as 45 percent upstream and 75 percent downstream during the 1840's.

Haites and Mak, "Economies of Scale..." (Table 3) gives the cost per ton-mile for five routes represented in the 1850 census sample. The weighted average cost per ton-mile for the three trunk routes (New Orleans, St. Louis, Cincinnati) is 0.384 cents. The corresponding figure for the two tributary routes (Tennessee, Wabash) is 1.238 cents, which is about 3.3 times higher. The paper notes (Table 4) that over 90 percent of the cost difference between trunk and tributary routes is due to differences in utilization of capacity. On this basis the capacity utilization on the tributary routes is estimated at one-third of the utilization on the trunk routes.

Sources:

E. F. Haites and J. Mak, "Economies of Scale in Western River Steamboating," Journal of Economic History (forthcoming); E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975); and W. M. Lytle, Merchant Steam Vessels of the United States, 1807-1868 (Mystic, Conn.; The Steamship Historical Society of America, 1952) and Supplements.

Steamboats operating in the Louisville-New Orleans trade during the 1840-49 decade were capable of carrying cargo equivalent to 80 percent of their measured tonnage upstream and equivalent to 160 percent of their measured tonnage downstream. Average operating speeds for steamboats in the Louisville-New Orleans trade during the 1840-1849 decade were 180 miles per day upstream and 250 miles per day downstream. These characteristics are assumed to hold for both trunk and tributary steamboats.[15]

The trunk river boats are estimated to operate 75 days on upstream journeys and 55 days on downstream journeys annually. The corresponding figures for the tributary boats are 85 days upstream and 60 days downstream. The steamboats on trunk routes have been estimated to carry cargo equivalent to 75 percent of capacity upstream and 45 percent of capacity downstream. The tributary boats in the 1850 census sample had costs per ton-mile approximately triple those of the trunk boats. It has been shown that this difference is almost entirely due to differences in the utilization rates.[16] The utilization rates of the tributary vessels were therefore estimated to be one-third of those for the trunk routes.

Table 2 shows the estimated goods movements to be 2,253 million ton-miles in 1850. Approximately 84 percent of the movements were along trunk river routes, leaving the tributary routes with only 16 percent of the movements. The table also shows the predominant movement, 77 percent, to be downstream.

The second indirect estimate is calculated using the economic characteristics of the steamboats operating in 1850. The calculation of this estimate is shown in Table 3.

The calculation starts with the 1850 stock of steamboats divided between trunk and tributary routes as in Table 2. This is necessary because the freight revenues per ton are significantly different for trunk and tributary steamboats.

TABLE 3

Indirect Estimate of Goods Movements

by Steamboat in 1850

	TRUNK		TRIBUTARY	
	Upstream	Downstream	Upstream	Downstream
Measured tonnage of steamboats operating in 1850[a]	88,612	88,612	45,954	45,954
Freight revenue per ton[b] (dollars per ton measure)	$84.92		$176.10	
Total freight revenue (dollars)	$7,524,931		$8,092,499	
Share of traffic volume by direction (%)[c]	25	75	25	75
Average freight rate (cents per ton-mile)[d]	.402	.483	1.300	1.561
Weighted average freight rate (cents per ton mile)	.4628		1.496	
Cargo carried (million ton-miles)	1,626.0		540.9	
Cargo carried (million ton-miles)	406.5	1,219.5	135.2	405.7

Cargo carried	- upstream	541.7 million ton-miles
	- downstream	1,625.2 million ton-miles
	- total	2,166.9 million ton-miles

Notes:

(a) See note (a) to Table 2.

(b) Haites, Mak and Walton, Western River Transportation, Table F-5, p. 176. The freight revenue per ton is significantly different for trunk and tributary steamboats. Since there are no economies or diseconomies of scale and since the industry is competitive, the revenue per ton in each category should be constant regardless of vessel size.

Notes from Table 3 continued:

(c) There is no direct evidence on the relative magnitudes of upstream and downstream shipments. Haites, Mak and Walton, Western River Transportation (Appendix A, pp. 124-28 and Table 2, p. 9) gives data on shipments into and out of the mid-west. Most of the outbound shipments travelled downstream and most of the inbound shipments travelled upstream so we can obtain an approximate measure of the direction of travel from these data.

By assuming the inbound shipments of major products to equal the total inbound shipments we get a low estimate of the upstream traffic,

	Inbound	Outbound	Total	Percent Upstream
1849	365	1,842.9	2,207.9	16.5%
1853	785	2,753.1	3,538.1	22.2%

By assuming the inbound shipments of major products to be one-half of the total inbound shipments we get a high estimate of the upstream traffic (assuming the major products to be only one-third of the total would give inbound (upstream) shipments almost equal to the outbound (downstream) shipments in 1853, a situation which never occurred).

	Inbound	Outbound	Total	Percent Upstream
1849	730	1,842.9	2,572.9	28.4%
1853	1,570	2,753.1	4,323.1	36.3%

The mid-point of these estimates is approximately 25 percent. This compares with a figure of 380/(1058 + 380) = 26 percent implied by the data of Table 1 for the traffic at New Orleans and of 515.1/2,252.9 = 22.9 percent implied by the estimates of Table 2.

(d) See Table 7 for the derivation of the freight rates.

Sources:

E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975).

From the data on the steamboats in the 1850 census sample, trunk river steamboats are found to have annual freight revenues of $84.92 per ton while the tributary boats had annual freight revenues of $176.10 per ton. When these averages are applied to all steamboats operating in 1850 the total freight revenue is found to be $15.6 million.

The limited data on total goods movements suggest that approximately 25 percent of the total volume of shipments travelled upstream. This compares closely to the 23 percent share implied by the estimates of Table 2 and the 26 percent share of the traffic at New Orleans. The 25 percent share is used to calculate a weighted average freight rate, which in turn allows the total goods movements to be estimated.

The total goods movements are estimated at 2,167 million ton-miles. Approximately 75 percent of the movements were along trunk river routes, leaving the tributary routes with 25 percent of the traffic. These shares compare favourably with the 84 and 16 percent shares implied by the estimates of Table 2.

The same three methods can be used to obtain estimates of the volume of passenger travel by steamboat in 1850. The data for a direct estimate of the volume of passenger travel are much better than the comparable data for goods movements. The Federal government collected data on the number of passengers carried and the average distance travelled for the year ending July 1, 1851. The figures for each steamboat are reported in the district where it is registered. Since the data are obtained from the steamboats and not the ports the problem of double counting encountered in making the estimate of the goods movements does not arise here. The calculation of the direct estimate of steamboat passenger travel in 1850 is shown in Table 4. The estimate is 995 million passenger miles. Our estimate of the number of steamboats (excluding ferries) is 634 rather than 558. Adjusting the government data upwards to reflect the larger number of boats gives an estimate of 1,140.2 million passenger miles for 1850.

TABLE 4

Direct Estimate of Passenger Travel by Steamboat in 1850

Registration District	Steamboats Number	Steamboats Tonnage	Passengers Carried	Average Distance (miles)	Passenger Miles (millions)
St. Louis	126	30,949	318,713	891	284.0
Vicksburg	4	688	10,800	350[a]	3.8
New Orleans	111	34,336	419,000	710[b]	297.5
Nashville	18	3,578	24,340	750	18.3
Louisville	56	14,529	120,000	1,000	120.0
Cincinnati	104	24,109	270,796	440[c]	119.2
Wheeling	38	6,843	139,170	220	30.6
Pittsburgh	101	16,349	428,745	280	120.0
Ferries	43	4,178	2,615,991	.75	2.0
TOTAL	601[d]	135,559[d]	4,347,555		995.4

Estimated Total Passenger Travel

Steamboats	$= \frac{638}{(601-43)} * (995.4-2.0)$	1,138.1
Ferries		2.0
	Total	1,140.1 million passenger miles

Notes:

(a) Estimated.

(b) From Table 1.

(c) The average distance is calculated as in note (f) to Table 1, but with New Orleans and St. Louis included, because those passengers have not been counted elsewhere. Specifically,

	Arrivals	Load Index	Passenger Index	Distance (miles)	Passenger Mile Index
New Orleans	288	2.0	576	1,485	855,360
St. Louis	214	2.0	428	700	299,600
Pittsburgh	658	1.5	987	470	463,890
Others	2,538	1.0	2,538	150	380,700
Total	3,698		4,529		1,999,550

Hence the average distance travelled is 1,999,550/4.529 = 441 miles. The same result is obtained if the departures data are used.

(d) These figures do not agree with those - 638 steamboats (excluding ferries) measuring 134,566 tons - reported in Table 2.

Source:

U.S. Senate, The Statistics and History of the Steam Marine of the United States, Senate Exec. Doc. 42, 32 Cong. 1 sess. 1852 (serial set 619) pp. 80-83.

The first indirect estimate of the passenger travel is again based on the physical and operating characteristics of the steamboats. This calculation is shown in Table 5. The division of the 1850 stock of steamboats between trunk and tributary routes, the average operating speeds, and the length of the operating season are the same as in Table 2. Estimates of the average passenger load per measured ton (the utilization rate) are available for the Louisville-New Orleans route. They are assumed to apply to all trunk routes. As in the case of the goods movements the utilization rates on the tributaries were estimated to be one-third of corresponding figures for the trunk routes. The estimated passenger movement is 1,006 million passenger miles.

The second indirect estimate is again calculated using the economic characteristics. The calculations are shown in Table 6. All steamboats are assumed to earn the same revenue per ton as the vessels in the 1850 census sample--$87.38 per ton on the trunk routes and $107.90 per ton on the tributary routes. This gives an estimated total passenger revenue of $12.7 million. The trunk and tributary passenger revenues are each divided by the appropriate fare per passenger mile to give the estimates of passenger travel. Since the upstream and downstream fares are identical, there is no need to be concerned about the relative magnitudes of the upstream and downstream traffic. The estimated passenger traffic is 1,179 million passenger miles.

The three estimates of the passenger traffic are reasonably consistent. As was the case for the goods movements the bulk of the traffic (80 to 84 percent) was on the trunk routes. But in contrast to the goods movements, most of the passenger traffic (57 percent) moved upstream. The passenger traffic is also much more closely balanced, in terms of direction, than the freight traffic.

It is interesting to compare the above figures to a contemporary estimate of the 1849 traffic on western river steamboats.[17] The contemporary estimate of

TABLE 5

Indirect Estimate of Passenger Travel by Steamboat in 1850

	TRUNK		TRIBUTARY	
	Upstream	Downstream	Upstream	Downstream
Measured tonnage of steamboats operating in 1850[a]	88,612	88,612	45,954	45,954
Speed: miles per day running[a]	180	250	180	250
Running time annually (days)[a]	75	55	85	60
Passengers per ton[b]	.40	.30	.133	.10
Passenger travel (million passenger miles)	478.5	365.5	93.5	68.9

Passenger travel	- upstream	572 million passenger miles
	- downstream	434 million passenger miles
	- total	1,006 million passenger miles

Notes:

(a) From Table 2.

(b) Haites, Mak and Walton, Western River Transportation, Table D-4, p. 163 gives the average number of passengers per measured ton during the 1840-60 decades in the Louisville-New Orleans trade as 0.4 upstream and 0.3 downstream. These averages are assumed to apply to all trunk routes.

As discussed in note (e) to Table 2, the utilization of steamboats on the tributary routes was roughly one-third of that on the trunk routes. This is assumed to be the case for the passenger traffic as well, giving average passenger loads on the tributaries of .133 and .10 passengers per ton respectively upstream and downstream.

Source:

E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975).

TABLE 6

Indirect Estimate of Passenger Travel by Steamboat in 1850

	Trunk	Tributary
Measured tonnage of steamboats in operation in 1850[a]	88,612	45,954
Passenger revenue per ton[b]	$ 87.38	$ 107.90
Total passenger revenue	$7,742,917	$4,958,437
Passenger fares (cents per passenger mile)[c]	0.825	2.060
Passenger travel (million passenger miles)	938.5	240.7

Total passenger travel 1,179 million passenger miles.

Notes:

(a) From Table 2.

(b) Haites, Mak and Walton, Western River Transportation, Table F-5, p. 176.

(c) Haites, Mak and Walton (Table 7, p. 32) gives the passenger fares in the Louisville-New Orleans trade. It also gives (Table D-4, p. 163) the relative volumes of deck and cabin passengers. These are used to calculate weighted average passenger fares for the Louisville-New Orleans trade. These fares are then expressed on a cents per mile basis. The trunk route fares are assumed (see Table 7 note (e)) to be 22.5 percent higher than the Louisville-New Orleans fares. The tributary fares are assumed (see Table 7 note (f)) to be 2.5 times the trunk fares. These calculations produce the following results:

	Trunk	Tributary
Upstream and downstream 1840-49	.94¢/mile	2.35¢/mile
Upstream and downstream 1850-60	.71¢/mile	1.77¢/mile
Average	.825¢/mile	2.060¢/mile

Sources:

E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975).

of the passenger traffic was 1.1 billion passenger miles which is about the same as our estimates. The freight traffic was estimated at 3.32 billion ton-miles which is more than 50 percent above our estimates.

IV. Freight and Passenger Tariffs and Direct Savings, 1850

Before the direct savings attributable to steamboats can be calculated, it remains to estimate the freight and passenger tariffs for steamboats and for the counterfactual mode. Average tariffs are required for all eight markets--freight and passenger services on trunk and tributary routes both upstream and downstream.

Average freight and passenger tariffs for steamboats are difficult to establish. "There were no such things as typical freight (passenger) rates during the era of steamboating. Rates varied widely with the supply and demand of boats, the stage of the water and the quantities of freight offered... ."[18] Freight and passenger rates also varied with the length of the trip and between trunk and tributary routes.

The data needed to compute the necessary weighted average freight rates directly do not exist. The published material on freight and passenger rates is very limited. There are no data on the corresponding traffic volumes so a proper weighted average cannot be constructed.

The average freight and passenger tariffs by steamboat are therefore estimated indirectly. The average freight rates in the Louisville-New Orleans trade during the 1840-49 decade were $0.25 per hundred pounds and $0.30 per hundred pounds upstream and downstream respectively.[19] These rates are equivalent to 0.370 and 0.444 cents per ton-mile upstream and downstream. As noted above, it has been shown that almost the entire cost differential between routes is due to the differences in utilization. To get average trunk and tributary freight rates we will assume that the observed rate differentials are due to the differences in utilization.[20] Since the profits on tributary routes have been shown to be significantly higher than those on trunk routes this procedure should give a low estimate of the tributary freight rates and a high estimate of the social savings.

The estimation of the average trunk and tributary freight rates is shown in Table 7. The average freight rates for trunk routes are estimated at 0.402 and 0.483 cents per ton-mile upstream and downstream respectively. The corresponding figures for tributary routes are 1.300 and 1.561 cents per ton-mile. One disadvantage of this procedure is that the differential between upstream and downstream rates found on the Louisville-New Orleans route is implicitly assumed to prevail on all routes. It is unlikely that this was the case; indeed the upstream rates were higher than the downstream rates on some routes. Simple averages of some available freight rates suggests that the estimates of Table 7 are probably low, which is the desired bias.[21]

The estimation of average passenger fares is further complicated by the existence of two classes of travel--deck and cabin passage. The difference in the fares was substantial, with cabin passage generally being about four times as expensive as deck passage.[22] Passenger fares tended to fluctuate less than freight rates because the steamboat's passenger capacity was not as closely related to the stage of the river. However, passenger fares did fluctuate significantly in response to supply and demand conditions. And, on a per mile basis, fares tended to be higher in the less frequented trades and for short distances.[23]

"The cabin passengers formed the aristocracy of the steamboat, a leisure class which by virtue of money enjoyed all the comforts and luxuries which the boat might afford, and escaped most of the hardships and hazards which fell to the lot of the occupants of the lower deck."[24] Cabin passage, then, included a substantial element of "hotel" services while deck passage consisted solely of transportation services. The deck passenger had to provide his own meals and to accommodate himself in the space not occupied by freight.

To avoid the difficulties arising from the differences in the quality of service we will consider the fare for deck passage to be the cost of the transportation service. The differential between deck and cabin fares then becomes the cost of the hotel services provided to the cabin passengers. The costs of deck travel will be compared to the costs of similar quality service on non-steam river craft and to coach travel by railroad.

Deck passage in the Louisville-New Orleans trade was $3.00 or 0.222 cents per passenger mile both upstream and downstream. The average deck passage fares for trunk routes are obtained from the assumption that the number of deck and cabin passengers per ton is the same as found on

TABLE 7

Freight Rates and Passenger Fares 1850[i]

Freight Rates

		Trunk	Tributary
Steamboat	Upstream	.402[a]	1.300[a]
	Downstream	.483[a]	1.561[a]
Keelboat	Upstream	7.407[b]	7.407[b]
Railroad	Upstream	3.178[c]	3.178[c]
Flatboat	Downstream	1.222[d]	1.222[d]

Passenger Fares

		Trunk	Tributary
Steamboat	Upstream	.272[e]	.680 [f]
	Downstream	.272[e]	.680 [f]
Overland	Upstream	2.222[g]	2.222[g]
Railroad	Upstream	2.559[h]	2.559[h]
Flatboat	Downstream	.741	.741

Notes:

(a) Estimated by assuming that these rates differ from those on the Louisville-New Orleans route only as a result of differences in utilization. The Louisville-New Orleans rates are 0.370 and 0.444 cents per ton-mile upstream and downstream. The average utilization rates are given in Haites and Mak, "Economies of Scale in Western River Steamboating," Table 3. The averages are Louisville-New Orleans: 59.04; trunk routes: 54.33; and tributary routes: 16.80. Hence the rates are estimated as follows:

$$0.370 \times \frac{(1/54.33)}{(1/59.04)} = 0.402$$

(b) Hunter (p. 25) gives the keelboat freight rate from New Orleans to Louisville prior to 1820 as $5.00 per 100 pounds. This is equivalent to $100 per ton and 7.407 cents per ton-mile.

(c) Fishlow (p. 325) gives the average freight rate for railroads in the west in 1848 as 4.0 cents per ton-mile. This is an average round trip revenue of 8.0 cents per ton-mile. Rail and river distances between most points in the west are different. From the data given by Hunter (pp. 490, 659) the rail distance average 0.55 of the river distance. Hence revenues of 8.0 cents per ton-mile by rail are equivalent to revenues of 4.4 cents per ton-mile by river. The downstream rates are assumed to equal those by flatboat (1.222 cents per ton-mile). Hence the upstream rate will average 4.4 - 1.222 = 3.178 cents per ton-mile over the river distance.

(d) Haites, Mak and Walton (p. 168) estimate the flatboat freight rate in the Louisville-New Orleans trade during the 1810-19 decade at $16.55 per ton. During the 1840-49 and 1850-60 periods the estimated rates are $5.20 and $5.55 respectively. These rates reflect the ability of flatboatment to travel upstream quickly as steamboat deck passengers. In the absence of steamboats the upstream trip would be a three month journey by land. To allow for this difference it is assumed that the flatboatmen would receive wages for four months rather than just one month. When this adjustment is made to the flatboat costs estimated by Haites, Mak and Walton (Table 9, p. 37) the total costs become $1,522 and $2,336 respectively for the 1840-49 and 1850-60 periods. Since the average capacities of flatboats were 93 and 146 tons respectively during these periods, these adjusted costs are equivalent to $16.37 and $16.00 per ton respectively. Given this evidence, the average flatboat freight rate in the Louisville-New Orleans trade was estimated at $16.50 per ton or 1.222 cents per ton-mile. For the reasons outlined in the text this rate is assumed to apply to all trunk and tributary routes.

(e) The average deck passenger fare for the Louisville-New Orleans route is 0.222 cents per passenger-mile both upstream and downstream. It is assumed that differences in passenger revenue per ton are strictly due to differences in average fares. Haites, Mak and Walton, <u>Western River Transportation</u>, Tables F-4 and F-5 (pp. 175-76) give the passenger revenue per ton as follows: Louisville-New Orleans route: $71.31; and trunk routes: $87.38. Hence the estimated deck fares on trunk routes are 0.222 x $87.38/$71.31 = 0.272.

Notes from Table 7 continued:

(f) De Bow's Review (vol. 6, p. 62) shows the fares for cabin passengers over various distances. The fare per mile for short distances (up to 400 miles) is between 2 and 3 times the fare per mile for long distances. We will assume then that tributary fares for deck and cabin passage are 2.5 times the corresponding trunk fare.

(g) Baldwin (p. 186) reports that the passenger fare from Wheeling to New Orleans was $5 to $10. The latter figure is used for the Louisville-New Orleans trip because it gives the desired upward bias. The costs of the overland trip from New Orleans to Louisville have been estimated at $30 (see footnote 38). These costs are equivalent to 2.22 cents per mile upstream and 0.74 cents per mile downstream.

(h) Fishlow (p. 325) gives the average railroad passenger fare in 1848 as 3.0 cents per mile. After adjusting for the difference between rail and river distances this is equivalent to a fare of 1.650 cents per mile by river (3.300 cents per mile round trip). The downstream fare is assumed to be equal to the flatboat fare 0.741 cents per mile. This gives an upstream fare of 2.559 cents per mile.

(i) For comparative data see Meyer, pp. 574-582.

Sources:

L. D. Baldwin, The Keelboat Age on Western Waters (Pittsburgh: University of Pittsburgh Press, 1941).

A. Fishlow, American Railroads and the Transformation of the Ante-Bellum Economy (Cambridge: Harvard University Press, 1965); E. F. Haites and J. Mak, "Economies of Scale in Western River Steamboating," Journal of Economic History (forthcoming); E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975); L. C. Hunter, Steamboats on the Western Rivers (Cambridge: Harvard University Press, 1949); and H. B. Meyer, History of Transportation in the United States Before 1860 (Washington: Carnegie Institution, 1917).

the Louisville-New Orleans route. In other words, the sole reason for the differences in passenger revenue per ton is due to differences in the passenger fares. Since the imbalance in the numbers of deck and cabin passengers was greatest in upstream travel from New Orleans, this approach introduces a downward bias into the estimate of the average passenger fares on the trunk routes.[25] The average passenger fares on the tributary routes are estimated to be 2.5 times the average trunk fare.

The estimated fares are 0.272 and 0.680 cents per passenger mile for trunk and tributary routes respectively. Hunter reports that passenger fares in the principal trunkline trades during the 1840's and 1850's were typically 0.25 and 1.0 cents per mile for deck and cabin passage respectively.[26] De Bow's Review reports cabin fares for the late 1840's which average 1.11 cents per mile for trunk routes over 500 miles.[27] Over shorter distances, the fare per mile was more than double this figure. These figures compare favourably to the estimated averages.

The counterfactual transportation system is postulated to consist of keelboats and flatboats during the early part of the period and railroads, where they are less costly, during the latter part of the period. The bulk of the downstream freight would be moved by flatboat. Flatboats were operating on the western rivers before the steamboat was introduced and they continued in use until the late 1840's. The upstream traffic would be moved by keelboat. This was the mode of upstream shipment prior to the introduction of the steamboat. The railroad may or may not have played a role in western goods movements in the absence of the steamboat.[28]

Deck passengers are assumed to travel downstream by flatboat and keelboat finding accommodation among the cargo and providing their own food. For the upstream trip they are assumed to travel on horseback.

Note that there can be no question of the technical feasibility of this counterfactual system. Keelboats and flatboats were used before the steamboat was introduced and, the latter in particular, continued in operation long afterwards. Railroads were also operating in various parts of the United States by the 1830's. It is assumed that the cost of moving goods and people to rail terminals for shipment would have been the same as the cost of moving them to water terminals.

The downstream freight rate on the Louisville-New Orleans route, in the absence of steamboats, is estimated at \$16.50 per ton or 1.22 cents per ton-mile. Haites, Mak and Walton give estimates of flatboat freight rates on the Louisville-New Orleans route.[29] During the 1810-19 decade, when there were virtually no steamboats operating on this route, the rate was estimated at \$16.55 per ton. During the 1840-49 and 1850-60 periods the rates were \$5.20 and \$5.55 per ton. These rates reflect the ability of flatboatmen to travel upstream quickly as deck passengers and so to make several trips per season. If the costs of flatboat operation during the 1840-49 and 1850-60 periods are adjusted to include wages for a three month return trip the breakeven freight rates are \$16.36 and \$16.00 per ton respectively. Thus, once the flatboat costs are adjusted to reflect the absence of the steamboat, a cost of \$16.50 per ton or 1.22 cents per ton-mile appears appropriate for the entire ante-bellum period.

The Louisville-New Orleans rate of 1.22 cents per ton-mile is assumed to apply to all trunk and tributary routes. Because of the ease of entry it is assumed that flatboat freight rates are determined by the costs of operation. The principal cost item is wages. On a per mile basis the wages depend on the speed of the current for downstream travel and on the speed of overland travel for the return trip by the crew. "The velocity of the current did not vary greatly in most navigable parts of the river system..."[30] Since there is no reason to expect the average speed of overland travel to vary between routes, it is reasonable to expect the wage costs per mile to be approximately the same for all routes. The other major expense was the cost of the boat. For the Louisville-New Orleans route this cost is spread over a relatively long distance. Hence, it might be argued that the ton-mile cost for shorter routes should be higher. However, for all routes other than those terminating at New Orleans, flatboats had a resale value because they could be used on routes downstream of the terminal. This would reduce the capital costs on other routes. It is assumed, then, that the capital costs per mile are not significantly different between routes.

Finally, the possibility that flatboat costs, and hence freight rates, varied from route to route because of differences in the risk of loss must be considered. Shippers were responsible for their own insurance so the flatboat costs reflect only the possible loss of part of the capital. Insurance premiums for cargo shipped along trunk routes by flatboat were approximately 2 to 4 percent per 1000 miles, or 0.002 to 0.004 percent per mile.[31] It is apparent that even if the risk of loss on the tributary routes is twice or three times higher, the impact on the cost per mile is insignificant.

Keelboat freight rates for the upstream trip from New Orleans to Louisville prior to the introduction of the steamboat was $5.00 per 100 pounds 7.41 cents per ton-mile.[32] There is again no strong reason to expect the costs, and hence freight rates, to vary significantly from route to route.

Fishlow gives the average freight rate for railroads in the west in 1848 as 4.0 cents per ton-mile.[33] We will again assume that the flatboats establish the downstream rates and that the railroads compensate for this by adjusting their upstream rates. Hunter lists river and railroad distances between various points.[34] The railroad distance is found to average 0.55 of the river distance. Using this ratio the railroad round trip freight revenue of 8.0 cents per ton-mile is equivalent to 4.40 cents per ton-mile by river. On the downstream trip the railroad receives revenues of 1.22 cents per ton-mile. Hence, the required upstream revenue is 3.18 cents per ton-mile.

In the absence of the steamboat deck passengers are assumed to travel downstream by keelboat and flatboat and upstream on horseback.[35] The equivalent standard of travel by rail is assumed to be coach class.

Data on passenger fares by keelboat and flatboat are very scarce. From the available data the flatboat fare in the Louisville-New Orleans trade is estimated at \$10 downstream.[37] The cost of the return trip by land is estimated at \$30.[38] These fares correspond to fares of 0.74 and 2.22 cents per passenger mile respectively.

Fishlow gives the average railroad passenger fares in the west in 1848 as 3.0 cents per mile.[40] After adjusting for the difference between rail and river distances this is equivalent to an average fare of 1.65 cents per mile. The average passenger fare by non-steam craft and land is 1.48 cents per mile which is lower than the railroad fare. Hence the railroad does not form part of the counterfactual passenger transportation system.

The data needed to calculate the upper bound estimate of the direct savings attributable to steamboats are now at hand. The calculation is shown in Table 8. The estimated goods movements of Table 2 are used for the calculation since they produce a higher estimate of the direct savings than the goods movements of Table 3. The passenger movements used for the calculation are those of Table 6, again because they introduce an upward bias into the calculation. The estimates of Table 6 are divided between upstream and downstream movements by assuming that the relative magnitudes of these flows are the same as in Table 5.

TABLE 8

Estimate of the Direct Savings Attributable to Steamboats 1850

Market	Freight/Passenger Rates (¢/ton-mile) (¢/mile) Counter-factual mode (a)	Steam-boat (b)	Difference	Traffic Volume (ton-miles) (pass.-miles) (c)	Direct Savings ($1,000,000) (d)	Share of Total Savings (%)
Freight						
Trunk - upstream	3.178	.402	2.776	430.7	$11.956	31.6
Trunk - downstream	1.222	.483	.739	1,462.1	10.805	28.5
Tributary - upstream	3.178	1.300	1.878	84.4	1.585	4.2
Tributary - downstream	1.222	1.561	-.339	275.7	-.935	- 2.5
Passengers						
Trunk - upstream	2.222	.272	1.950	532.1	10.376	27.4
Trunk - downstream	.741	.272	.469	406.4	1.906	5.0
Tributary - upstream	2.222	.680	1.542	138.6	2.137	5.6
Tributary - downstream	.741	.680	.061	102.1	.062	0.2
Total					$37.892	

Notes:

(a) From Table 7 - flatboat and railroad figures for freight and flatboat and overland figures for passengers.

(b) From Table 7 - steamboat tariffs for freight and passengers.

(c) Goods movements are from Table 2 since they produce a higher estimate of direct savings than the goods movements of Table 3. Passenger movements are from Table 6. They are divided between upstream and downstream travel on the basis of the relative magnitudes of those flows estimated in Table 5.

(d) Direct Savings = Traffic Volume x Difference ÷ 100 (to convert the difference from cents to dollars).

The direct savings attributable to the steamboat in 1850 are estimated at \$38 million. The upstream and downstream freight movements on trunk routes generate sixty percent of this saving. The passenger movements on trunk routes contribute over 32 percent. Using the upstream keelboat rates rather than the railroad rates shown in Table 8 yields direct savings for freight movements of \$46.1 million. Thus, if the railroad is excluded from the counterfactual mode the estimated direct savings are about \$60 million in 1850.

V. Indirect Savings Due to Steamboats

The alternative modes of transportation have different speeds and accident rates. These differences in characteristics generate indirect savings. A faster speed reduces the time required to accomplish the same goods and passenger movements. The travel time saved allows passengers to engage in additional productive activities and reduces the inventory costs for goods. Lower accident rates result in reduced accidental losses for goods and reduced losses due to personal injury and loss of life. Estimates of all of these items except personal injury and loss of life are developed below.

The speeds of the alternative modes of travel are shown in Table 9. The steamboat speeds are calculated from Table 2, assuming that the steamboats operated 24 hours per day while en route. The downstream trip by keelboat or flatboat from Louisville to New Orleans took between 20 and 30 days.[41] We will use 30 days or 1.75 miles per hour since this imparts an upward bias to the estimated social savings. The trip from New Orleans to Louisville by land or

TABLE 9

Value of Time Savings Attributable to Steamboats 1850

Average Speeds (mph)

Mode	Upstream	Downstream
Steamboat	7.5	10.4
Keelboat - Flatboat	.45	1.75
Railroad - freight	17.0	17.0
- passenger	34.0	34.0

Travel Time (millions of hours)

Mode	Upstream	Downstream	Total
Freight			
Steamboat	68.68	167.10	234.78
Keelboat - Flatboat	1,144.67	993.03	2,137.70
Railroad	30.30	102.22	132.52
Passengers			
Steamboat	104.01	57.08	161.09
Keelboat - Flatboat	1,733.56	339.20	2,072.76
Railroad	22.94	17.46	40.40

Value of Travel Time (millions of dollars)

Mode	Freight	Passengers	Total
Steamboat	.22	8.06	8.28
Flatboat - Keelboat	1.95	103.64	105.59
Railroad	.12	2.02	2.14

or by keelboat took between 90 and 120 days. We will use 120 days or 0.45 miles per hour, again because of the upward bias this imparts to the social savings. Boyd and Walton cite 20 miles per hour as the average speed of passenger trains in 1860.[42] Data presented by Hunter allows the average speed of passenger trains in the late 1850's to be calculated as 19.5 miles per hour.[43] This is equivalent to a speed of approximately 34 miles per hour over the river distances.[44] The average speed of freight trains is estimated to be half the speed of passenger trains.[45]

Given these speeds, the total time in transit, for both goods and passengers, can be calculated for each mode. The results of these calculations are shown in Table 9. To calculate the indirect savings it is necessary to place a value on the time saved. The value of time for passenger travel is estimated at 5 cents per hour.[46] The value of time for goods movements is estimated at $8.00 per ton per year.[47] This gives an upward bias to the estimate of the indirect savings.

The travel times for freight exceed those for passengers on all modes. But because the value of time is greater for passengers than freight--5.0 vs. 0.091 cents per hour--the value of passenger travel time dominates the total. The estimated value of the travel time by steamboat is $8.28 million and by the counterfactual mode of railroads for freight and non-steam craft for passengers is $103.76 million. Hence the benefit attributable to the steamboat is $95.48 million. If the railroads are excluded from the counterfactual transportation system, the steamboats provide benefits of almost $100 million in terms of reduced travel time.

To calculate the benefits due to differences in the accident rates we will assume that the losses are equal to the cost of insurance. Only the value of the freight losses will be estimated. The data needed to estimate the value of personal injury and loss of life are not available.

The railroad freight rates include the cost of cargo insurance.[48] The freight rates for river craft did not include such insurance, rather the shipper had to purchase the insurance separately. The rate of cargo insurance on western river steamboats averaged about one percent per thousand miles in 1850.[49] The rate for steamboats is also assumed to apply to keelboats. This gives an upward bias to the keelboat insurance rates since keelboats were subject to fewer risks than steamboats. The cargo insurance rates for flatboats were estimated above at 4 percent per thousand miles.[50] Using the value of $80 per ton the cost of cargo insurance is found to be $1.8 million for steamboats and $4.7 million for the keelboat-flatboat alternative. Hence the benefit attributable to the steamboat is--$1.8 million if the counterfactual system includes the railroads and $2.5 million if it does not.

The principal component of the indirect benefits is found to be the value of time saved by passengers. When comparing the steamboats to a counterfactual system that includes railroads for goods movements and non-steam craft for passengers the indirect benefits are $95.5 million. If the counterfactual system does not include the railroads, the indirect benefits are approximately $100 million. In either case, the indirect benefits greatly exceed the direct benefits.

VI. Social Savings Attributable to Western River Steamboats, 1815-1855

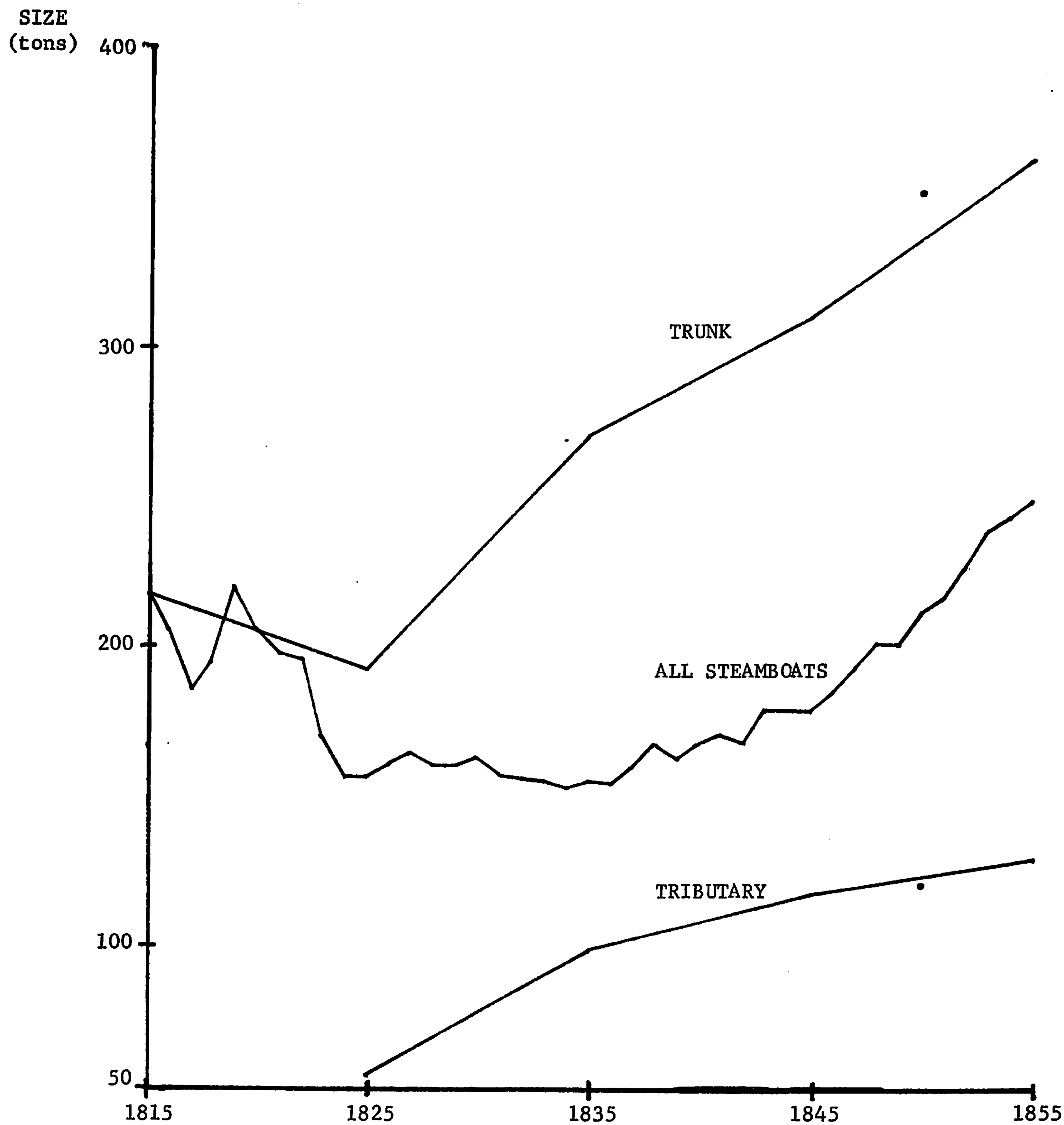
The methods developed above can be used to estimate the social savings attributable to western river steamboats at various times during the antebellum period. The most complete and consistent data on western river transportation are the decade estimates prepared by Haites, Mak and Walton. Since these data represent a major part of the information needed to estimate the social savings we will prepare such estimates for the middle of each decade.

The first step is to develop estimates of the goods and passenger movements. Of the three methods outlined in Section III, only the indirect method that forms the basis for Tables 2 and 5 can be used throughout the antebellum period. This method requires that the stock of steamboats be divided between trunk and tributary vessels. It is evident from the historical descriptions of the introduction of the steamboat on the western rivers that all boats operating in 1815 were on trunk routes.[51] It is assumed that all steamboats of less than 100 tons operating in 1825 ran on the tributary routes. The corresponding divisions for the subsequent decades are 150 tons in 1835 and 200 tons in 1845 and 1855.

This method of dividing the stock of steamboats between trunk and tributary vessels is quite arbitrary. Some of the implications of the assumed division are shown in Figures 2 and 3. Figure 2 shows the average sizes of trunk and tributary vessels. Both averages increase although the increase is greater for the trunk routes. This pattern appears reasonable because the navigation restrictions are more severe on the tributary routes than on the trunk routes. Figure 3 shows the shares of total vessels and total tonnage assigned to the trunk routes. It might be argued that the shares for 1835 and 1845 are too low. To increase these shares would require that the minimum size of a trunk vessel be increased. This minimum size is assumed to be 200 tons in 1845. As we saw above there is good reason to accept the 200 ton size for 1850.[52] Hence, to increase the shares for 1845 would require a minimum trunk route vessel size of more than 200 tons in 1845 but only 200 tons in 1850. In light of these patterns, the assumed division between trunk and tributary routes appears reasonable. The assumed division gives an upward bias to the share of the trunk routes in 1815 and 1855. Since the trunk traffic is the source of most of the social savings, this will give the desired upward bias to our estimates.

Figure 2

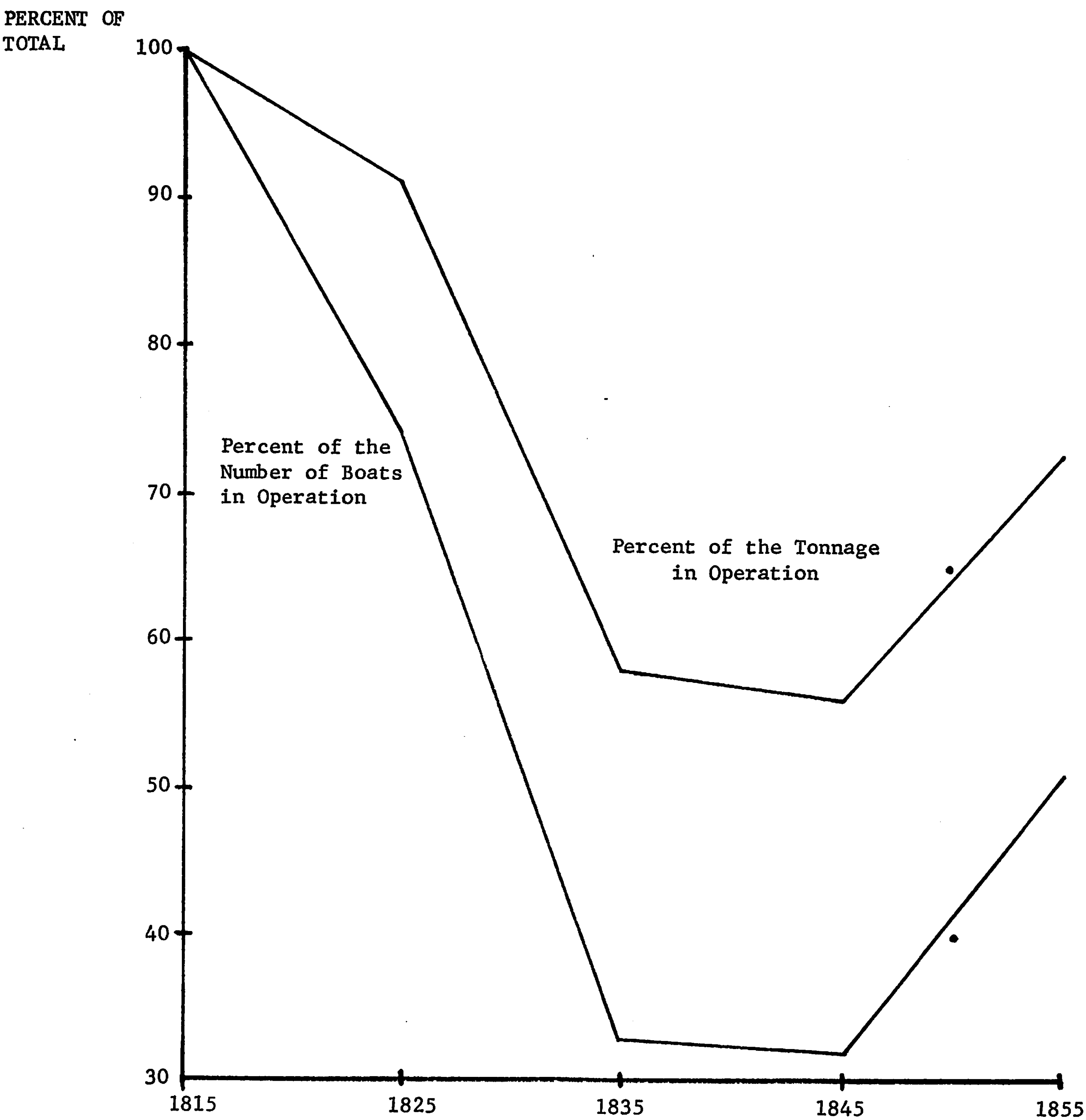
Average Sizes of Trunk and Tributary Steamboats 1815-1855



Source: Calculated from Tables 2 and 10 and E. F. Haites, J. Mak, and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975), Table B-1, pp. 130-31.

Figure 3

<u>Trunk Route Share of Number of Boats and Tonnage in Operation 1815-1855</u>



<u>Source</u>: Tables 2 and 10

The division of the steamboat stock between trunk and tributary routes is shown in Table 10. The table also shows the calculation of the estimated goods movements for each year. The factors affecting the capacity to move goods--the tonnage of steamboats in operation, the ratio of cargo capacity to measured tonnage, the average speed, and the number of operating days--all increase between 1815 and 1855. The utilization of capacity remains constant from 1815 through 1835 and then declines during the final two decades. The combined result, however, is a steady increase in the estimated goods movements from 3.5 million ton-miles in 1815 to 3,442.1 million ton-miles in 1855.

The estimated passenger traffic for each of the selected years is calculated in Table 11. The rate of growth of the passenger traffic is about half that of the freight traffic. Passenger travel rises from 3.2 million miles in 1815 to 1,646.2 million miles in 1855.

The estimated freight rates and passenger fares for steamboats and the alternative modes are presented in Table 12. The average speeds for the various modes are shown in Table 13. These speeds are used to calculate the total travel time by mode for freight and passengers from the estimated volumes of Tables 10 and 11. The rates for cargo insurance for keelboats and steamboats are taken to be 2 percent per 1000 miles during 1815 and 1825, 1.5 percent per 1000 miles during 1835 and 1.0 percent per 1000 miles thereafter.[53] For flatboats the rates are assumed to fall from 6 to 5 to 4 percent per 1000 miles between 1815 and 1835 and to remain at 4 percent per 1000 miles thereafter.[54] These rates are biased downwards for steamboats and upwards for keelboats and flatboats. The average value of goods shipped is assumed to be as follows: 1815 - \$120 per ton; 1825 - \$100 per ton; 1835 - \$95 per ton; 1845 - \$80 per ton; and 1855 - \$95 per ton.[55]

TABLE 10

Estimated Goods Movements by Steamboat

1815 to 1855

	1815	1825	1835	1845	1855
Trunk route steamboats[a]					
number	7	59	107	174	357
tonnage	1,516	11,359	28,961	53,899	129,411
Tributary river steamboats[a]					
number	--	21	217	364	339
tonnage	--	1,168	21,162	42,256	43,284
Ratio of cargo capacity to measured tonnage upstream	.25	.4	.5	.8	.9
downstream	.50	.8	1.0	1.6	1.75
Speed - miles per day running[c]					
upstream	67.5	110	145	180	205
downstream	135.0	180	210	250	260
Days running per year					
Trunk upstream	60.0	62.5	75.0	75.0	78.0
downstream	30.0	37.5	53.0	55.0	63.0
Tributary upstream	--	70.0	85.0	85.0	90.0
downstream	--	40.0	59.0	60.0	70.0
Utilization of capacity (%)					
Trunk upstream	75	75	75	45	15
downstream	75	75	75	75	75
Tributary upstream	--	25	25	15	5
downstream	--	25	25	25	25
Goods movements (million ton-miles) Trunk upstream	1.2	23.4	118.1	261.9	279.4
Tributary upstream	--	.9	32.6	77.6	35.9
Total upstream	1.2	24.3	150.7	339.5	315.3
Trunk downstream	2.3	46.0	241.8	889.3	2,782.2
Tributary downstream	--	1.7	65.5	253.5	334.6
Total downstream	2.3	47.7	307.3	1,142.8	3,126.8
Total	3.5	72.0	458.0	1,482.3	3,442.1

Notes:

(a) The stock of steamboats operating during each year is divided between trunk and tributary routes on the following basis. In 1815 all boats are assumed to operate exclusively on trunk routes. In 1825 all boats of less than 100 tons are assigned to tributary routes. For 1835, 1845 and 1855 the corresponding figures are 150, 200 and 200 tons.

(b) Haites, Mak and Walton, Western River Transportation, Table D-2, p. 158.

(c) Ibid., Table C-3, p. 143 gives the average travel times for the 1350 mile trip between Louisville and New Orleans. These are used to calculate the speeds.

(d) Ibid., Table C-3, p. 143 gives the number of operating days per year. These figures are used for the trunk routes. The tributary boats are assumed to be able to operate 11 percent longer (see Note (d) to Table 2).

(e) Ibid., pp. 159-160 gives the average utilization rates for the Louisville-New Orleans route. These rates are assumed to apply to all trunk routes. The utilization rates for tributary vessels are assumed to be one-third of those for the trunk routes (see Note (e) to Table 2).

Source:

E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975).

TABLE 11

Estimated Passenger Travel by Steamboat

1815 to 1855

	1815	1825	1835	1845	1855
Trunk route steamboats[a]					
number	7	59	107	174	357
tonnage	1,516	11,359	28,961	53,899	129,411
Tributary river steamboats[a]					
number	--	21	217	364	339
tonnage	--	1,168	21,162	42,256	43,284
Speed - miles per day running[a]					
upstream	67.5	110	145	180	205
downstream	135.0	180	210	250	260
Days running per year[a]					
Trunk upstream	60	62.5	75.0	75.0	78.0
downstream	30	37.5	53.0	55.0	63.0
Tributary upstream	--	70.0	85.0	85.0	90.0
downstream	--	40.0	59.0	60.0	70.0
Passengers per ton					
Trunk upstream[b]	.30	.35	.40	.40	.40
downstream	.22	.26	.30	.30	.30
Tributary upstream	--	.12	.13	.13	.13
downstream	--	.09	.10	.10	.10
Passenger movements (millions of miles)					
Trunk upstream	1.8	27.3	126.0	291.1	827.7
Tributary upstream	--	1.1	33.9	84.0	103.8
Total upstream	1.8	28.4	159.9	375.1	931.5
Trunk downstream	1.4	19.9	96.7	222.3	635.9
Tributary downstream	--	0.8	26.2	63.4	78.8
Total downstream	1.4	20.7	122.9	285.7	714.7
Total	3.2	49.1	282.8	660.8	1,646.2

Notes:

(a) See Notes to Table 10.

(b) Haites, Mak and Walton, Western River Transportation, Table D-4, p. 163 gives data on passengers per measured ton. Those data, for the Louisville-New Orleans route are assumed to apply to all trunk routes. The figures for the tributary routes are assumed to be one-third of the corresponding trunk route figure (see Note (b) to Table 5).

Source:

E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975).

TABLE 12

Freight Rates and Passenger Fares by Steamboat and Alternative Modes 1815 to 1855

Freight Rates (cents per ton-mile)

	1815	1825	1835	1845	1855
Upstream					
Steamboat[a] - trunk	8.05	1.61	.81	.40	.40
- tributary	--	5.21	2.61	1.30	1.30
Keelboat[b]	7.41	7.41	7.41	7.41	7.41
Railroad[c]	--	--	7.03	3.18	2.08
Downstream					
Steamboat[a] - trunk	1.61	1.01	.81	.48	.52
- tributary	--	3.26	2.61	1.56	1.69
Flatboat[b]	1.22	1.22	1.22	1.22	1.22
Railroad[c]	--	--	1.22	1.22	1.22

Passenger Fares (cents per mile)

	1815	1825	1835	1845	1855
Upstream					
Steamboat[d] - trunk	2.27	.91	.54	.36	.27
- tributary	--	2.27	1.36	.91	.68
Keelboat-Overland[e]	2.22	2.22	2.22	2.22	2.22
Railroad[f]	--	--	4.76	2.56	2.01
Downstream					
Steamboat[d] - trunk	1.63	.54	.54	.36	.27
- tributary	--	1.36	1.36	.91	.68
Keelboat-Flatboat[e]	0.74	0.74	0.74	0.74	0.74
Railroad[f]	--	--	0.74	0.74	0.74

Notes:

(a) Haites, Mak and Walton, Table 7, p. 32 gives freight rates for the Louisville-New Orleans trade. These rates were converted to cents per ton-mile. The trunk and tributary rates were then calculated by assuming the same relationship to the Louisville-New Orleans rates as was found in 1850. Specifically the trunk rates are 8.1 percent higher and the tributary rates are 251.4 percent higher.

(b) From Table 7.

Notes from Table 12 continued:

(c) Fishlow (p. 321) gives the average railroad freight rates as 7.5 cents per ton-mile in the 1830's; 4.0 cents per ton-mile in the 1840's (p. 325); and 3.19 cents per ton-mile in the 1850's (p. 334). These rates are doubled to give the round trip revenue requirement. They are then multiplied by 0.55 to give the equivalent revenue requirement over the river distance. The downstream rates are assumed to be equal to those by flatboat--1.22 cents per ton-mile. The upstream rates are set equal to the remainder of the round trip revenue requirement. Specifically for 1835 the round trip revenue is 15.0 (2 x 7.5) cents per ton-mile. This is equivalent to 8.25 (15.0 x 0.55) cents per ton-mile over the river distance. The downstream rate is 1.22 cents per ton-mile so the upstream rate is 8.25 - 1.22 = 7.03 cents per ton-mile.

(d) Haites, Mak and Walton (Table 7, p. 32) gives the deck passenger fares in the Louisville-New Orleans trade. These fares are expressed on a cents per mile basis. The trunk route fares are assumed, as in 1850, to be 22.5 percent higher than the Louisville-New Orleans fares. The tributary fares are again assumed to be 2.5 times the trunk fares.

(e) From the available data the flatboat fares in the Louisville-New Orleans trade are estimated at $10. The cost of the return trip by land is estimated at $30. These fares correspond to fares of 0.74 and 2.22 cents per passenger mile respectively.

(f) Fishlow (p. 321) gives the average railroad passenger fares as 5.0 cents per mile in the 1830's; 3.0 cents per mile in the 1840's (p. 325); and 2.5 cents per mile in the 1850's (p. 334). The same procedure as was used with rail freight rates is employed to get the differential upstream and downstream rates.

Sources: A Fishlow, American Railroads and the Transportation of the Ante-Bellum Economy (Cambridge: Harvard University Press, 1965); and E. F. Haites, J. Mak and G. M. Walton, Western River Transportation (Baltimore: Johns Hopkins University Press, 1975).

TABLE 13

Average Speeds of and Travel Times via Alternative Transportation Modes 1815 to 1855

Average Speeds (miles per hour)

Mode	1815	1825	1835	1845	1855
Steamboats[a]					
Upstream	2.80	4.50	6.00	7.50	8.50
Downstream	5.60	7.50	8.75	10.40	10.80
Keelboat/Overland[b]	.45	.45	.45	.45	.45
Keelboat/Flatboat[c]	1.75	1.75	1.75	1.75	1.75
Railroad					
Passenger trains[d]	--	--	14.0	27.0	34.0
Freight trains	--	--	7.0	13.5	17.0

Travel Times (millions of hours)

Mode	1815	1825	1835	1845	1855
Freight					
Steamboat	.84	11.76	60.24	155.15	326.61
Keelboat/Flatboat	3.98	81.26	510.49	1,407.47	2,487.41
Railroad	--	--	65.43	109.80	202.48
Passengers					
Steamboat	.89	9.07	40.70	77.48	175.77
Keelboat/Flatboat	4.80	74.94	425.56	996.82	2,478.40
Railroad	--	--	20.20	24.47	48.42

Notes:

(a) Calculated from the data on average speeds in Table 10. The miles per day of running time were divided by 24 to get the miles per hour.

(b) The upstream trip from New Orleans to Louisville (1,350 miles) by keelboat and by foot required three to four months. We have assumed the trip took 125 days to impart an upward bias to the indirect savings. This is equivalent to a speed of 0.45 miles per hour.

(c) The downstream trip from Louisville to New Orleans took about one month. We have assumed a trip length of 32 days or a speed of 1.75 mph to impart an upward bias to the indirect savings.

(d) Passenger train speeds were estimated at 20 mph in 1855, 15 mph in 1845 and 8 mph in 1835. These speeds were then converted to equivalent speeds over river distances by dividing by 0.579 and rounding off. Freight train speeds were assumed to be half the passenger train speeds.

The calculation of the direct and indirect savings attributable to steamboats is shown in Table 14. The preferred estimates compare the costs of steamboat transportation to the keelboat-flatboat alternative through 1835 and to the railroad alternative thereafter. The direct savings rise continuously from -$30,000 in 1815 to about $42 million in 1855. The estimated direct savings on goods movements are $1.4 million in 1825 and $14.5 million in 1845. These compare to Fishlow's estimates of $1.0 and $6.3 million respectively.

The changing role of the steamboat is reflected in various components of the direct savings estimates. Initially the savings generated by the upstream movements dominate. Over the antebellum period the steamboat came to rely increasingly on the much larger volume of downstream traffic, and this pattern is reflected in the relative magnitudes of the upstream and downstream savings. The latter became progressively larger over the period. It should also be noted that the savings generated by the trunk river traffic dominate throughout the period. This is not surprising since these routes carried the largest traffic volumes at the lowest rates.

The principal component of the indirect savings is the value of time saved, especially for passenger travel. The indirect savings are large and positive from 1815 through 1835 when the alternatives are nonsteam river craft. The indirect savings become negative when the alternative is the railroad. Between 1845 and 1855 the indirect savings rise from 18 percent to 24 percent of the direct savings. The result remains one of a net saving throughout the antebellum period.

TABLE 14

Direct and Indirect Savings Attributable to Steamboats, 1815 to 1855
(thousands of dollars)

	1815	1825	1835	1845	1855
Keelboat-Flatboat Revenues					
Freight	117.0	2,382.5	14,916.0	39,099.2	61,510.6
Passengers	50.4	783.7	4,459.3	10,441.4	25,968.1
Total	167.4	3,166.2	19,375.3	49,540.6	87,478.7
Railroad Revenues					
Freight			14,343.3	24,738.3	44,705.1
Passengers			8,082.8	10,805.4	24,012.0
Total			22,426.1	35,543.7	68,717.1
Steamboat Revenues					
Freight	133.6	943.6	5,475.7	10,279.6	21,875.4
Passengers	63.7	391.8	2,019.9	3,189.6	5,193.3
Total	197.3	1,335.4	7,495.6	13,469.2	27,068.7
Direct Savings					
Preferred estimate	-29.9	1,830.8	11,879.7	22,074.5	41,648.4
Value of Travel Time					
Keelboat-Flatboat	245.5	3,839.6	21,829.3	51,121.8	126,606.4
Railroads			1,080.7	1,323.4	2,639.7
Steamboats	45.7	466.9	2,100.1	4,015.2	9,141.2
Cargo Insurance					
Keelboat-Flatboat	13.7	189.9	881.4	3,113.8	11,282.8
Steamboats	8.4	108.0	435.1	1,185.8	3,270.0
Indirect Savings					
Preferred estimate	205.1	3,454.6	20,175.5	-3,877.6	-9,771.5

VII. Summary and Conclusions

This paper has developed the first detailed estimates of the social savings of western river steamboats. Work on this topic had been inhibited by the lack of data on steamboat goods and passenger movements. However, data available for the year 1850 allow the preparation of three separate estimates of the steamboat traffic. The three approaches produce remarkably consistent estimates of approximately two billion ton-miles and 1.1 billion passenger miles. The data required for one of these methods are available for other years of the antebellum period. The steamboat traffic is estimated by this method to have increased from 3.5 million ton-miles and 3.2 million passenger miles in 1815 to 3.4 billion ton-miles and 1.6 billion passenger miles in 1855.

The counterfactual transportation system is assumed to consist of keelboats and flatboats exclusively until the mid-1830's. Thereafter it is the railroads. The direct savings attributable to the steamboat are calculated with the conventional upward bias. In 1850 these savings amounted to $38 million or approximately 1.37 percent of GNP.[56] Over the antebellum period the annual direct savings are estimated to rise from -$30,000 in 1815 to $22 million in 1845 and $42 million in 1855. The direct savings are equivalent to approximately 1.2 percent of GNP after 1835. This compares with savings of up to 2 percent of GNP for canals during the years 1837-46 and about 4 percent of GNP for railroads in the 1850's.[57]

The indirect savings in the form of reduced travel times and accident rates were also estimated. The largest component of this item is the value of passenger travel time. During the early years of the period when the nonsteam river craft are the alternative mode these indirect savings are positive and larger than the direct savings. During the later years, when the railroad is the alternative, they are negative but substantially less than the direct savings.

The relative magnitudes of the components of the direct savings reflect the changing role of the steamboat. Initially, also the upstream traffic generates the bulk of the savings because the rate reductions attributable to the steamboat were much greater for the upstream trip than for the downstream trip. But during the latter half of the period the much larger volume of downstream traffic causes the downstream savings to become the more important. The trunk river traffic accounts for most of the savings throughout the period.

Fishlow's estimates of the freight traffic are of the proper order of magnitude during the 1820's, but they ignore the more significant passenger savings. His estimates of the savings on the freight traffic during the 1840's are less than half of our estimate despite the fact that he used a considerably higher estimate of the rate advantage of steam over nonsteam craft. Fishlow's conclusions, however, remain valid. We find that the steamboat generated savings are about 1.2 percent of GNP after 1830. This is substantially less than the total impact of canals and railroads. The return on steamboat investment was, as Fishlow noted, extraordinarily high. Assume the tonnage operating during each year is value at its original cost and the return is the sum of the direct and indirect savings after 1835.[58] These assumptions clearly impart a strong downward bias to the estimated return. The estimated return to the steamboat investment declines from 215 percent in 1825 to 128 percent in 1855. These returns are far greater than those obtained from the canal and railroad investments.[59]

FOOTNOTES

We are indebted to L. Anderson for helpful comments.

[1]See H.H. Segal, "Canals and Economic Development," in C. Goodrich, ed., Canals and American Economic Development (New York, Columbia University Press, 1961); R.L. Ransom, "Canals and Development: A Discussion of the Issues," American Economic Review, (Proceedings), vol. 54, 1964, pp 365-376; R.L. Ransom, "Social Returns from Public Transport Investment: A Case Study of the Ohio Canal," Journal of Political Economy, vol. 78, 1970, pp 1041-1060; R.W. Fogel, Railroads and American Economic Growth, (Baltimore, Johns Hopkins Press, 1964); A. Fishlow, American Railroads and the Transformation of the Ante-Bellum Economy (Cambridge, Harvard University Press, 1965).

[2]A. Fishlow, "Internal Transportation," Chapter 13 of L.E. Davis, R.A. Easterlin, W.N. Parker, et al, American Economic Growth (New York: Harper and Row, 1972) p 518.

[3]Ibid. p 518 apparently the rate advantages were assumed to remain constant throughout the ante-bellum period, despite the substantial declines in steamboat freight rates.

[4]Ibid. p 518. There are extensive data on the volumes of goods received by river at New Orleans but very few data on the volumes of goods shipped by river from New Orleans. The limited data available (see E.F. Haites, J. Mak, and G.M. Walton, Western River Transportation; Baltimore, Johns Hopkins University Press, 1975, Tables 2 and A-1 pp 9, 124) indicate that the upstream traffic varied between 12 and 18 percent of the downstream traffic. It is not clear whether Fishlow's estimates reflect this pattern. It is also not clear how he estimated the average distance shipped or the relationship between the New Orleans traffic and all other traffic.

[5]*Ibid.* p 519.

[6]*Ibid.* p 519.

[7]The data were uncovered by Jeremy Atack, Fred Bateman, James Foust and Thomas Weiss in the course of their research into nineteenth century U.S. manufacturing. They consist of the 1850 manuscript census returns for 45 steamboats at Louisville which were collected by mistake because the Assistant Marshall at Louisville failed to follow instructions properly. The returns include: - the name of the vessel, - the "trade" in which it was engaged, - the construction cost of the vessel, - the number of crew members, - the monthly wage bill, - the annual expenditures for fuel, provisions, insurance, general expenses and lockage, - the number and horsepower of the engines, - the number of months operated, - the annual freight and passenger revenue.
From W.M. Lytle, *Merchant Steam Vessels of the United States, 1807-68* (Mystic Conn: The Steamship Historical Society of America, 1952) and *Supplements* it was possible to obtain the measured tonnage and year of construction of each of the vessels. The sample represents 7 percent by number and 10 percent by tonnage of the steamboats in operation on the western rivers in 1850.

[8]U.S. Senate, *The Statistics and History of the Steam Marine of the United States*, Senate Exec. Doc. 42, 32 Cong., 1 sess., 1852 (serial set 619) pp 80-83.

[9]See Table 1. The published data on goods movements by river at St. Louis, Cincinnati and New Orleans are generally available only after the mid-1840's.

[10] See R.W. Fogel, Railroads and American Economic Growth; A. Fishlow, American Railroads and the Transformation of the Ante-Bellum Economy; G. Gunderson, "The Nature of Social Saving," Economic History Review, vol. 23, 1970, pp 207-19; J.H. Boyd and G.M. Walton, "The Social Savings from Nineteenth-Century Rail Passenger Services," Explorations in Economic History, vol 9, 1972, pp 233-54; J. Metzer, "Some Economic Aspects of Railroad Development in Tsarist Russia," Ph.D. thesis, University of Chicago, 1972; and C. M. White, "The Concept of Social Savings in Theory and Practice," Economic History Review, Vol. 29, 1976, pp. 82-100.

[10A] See E. F. Haites and J. Mak, "Ohio and Mississippi River Transportation: 1810-1860," Explorations in Economic History, 8, 1970-71, pp. 153-180; and E. F. Haites and J. Mak, "Steamboating on the Mississippi: A Study of a Purely Competitive Industry," Business History Review, 45, 1971, pp. 52-78.

[11] The published data appear to cover all river traffic, not just steamboats. Hence the use of these statistics will introduce an upward bias into our direct estimate of the total goods movements by steamboat.

[12] Of the 31 steamboats in the sample operating on trunk river routes, only 2 were under 200 tons. And of the 14 steamboats operating on the tributaries only one was over 200 tons.

[13] E.F. Haites, J. Mak and G.M. Walton, Western River Transportation, (Baltimore: Johns Hopkins University Press, 1975), Table B-1, p 131.

[14] Haites, Mak and Walton, Western River Transportation, Table F-5, p 176.

[15] This assumption introduces an upward bias into the estimates. The water was deeper on the Louisville-New Orleans section than on most other parts of the river system. Hence it is likely that the ratio of carrying

capacity to measured tonnage would be higher in this trade than elsewhere on the river. Similarly, the navigation between Louisville and New Orleans was generally easier and involved fewer stops than elsewhere. Hence the average speed would be higher on the Louisville-New Orleans route.

[16]See E.F. Haites and J. Mak, "Economies of Scale in Western River Steamboating," Journal of Economic History, (forthcoming).

[17]U.S. Congress Senate Dept. of the Treasury, The Statistics and History of the Steam Marine of the U.S. Senate Exec. Doc. 42, 32 Cong., 1 sess., 1852 (serial set 619) p 114. This estimate was made by Davis Embree and first published in the Western Boatman (Jan. 1849) of which he was the editor. The assumptions made were as follows: 572 steamboats with an average size of 211 tons travelling 180 miles per day, 18 days per month for 8.5 months. The average load was assumed to be 211 tons of freight and 70 passengers. Embree's estimate of the average distance travelled annually is only slightly lower than ours (27,540 miles vs 28,291 miles). His estimate of the stock of steamboats operating in 1850 (120,692 tons vs 134,566) is more than ten percent below ours. But his average load estimates are above ours. He estimates 0.332 passengers per ton which compares to our weighted average of .270. For passengers these differences almost offset each other. Embree estimates the average cargo to be 1.0 tons of freight per ton of measurement. Our weighted average is 0.605 tons of freight per ton of measurement. The main reason for the difference in the estimates, then, is the much higher load factors used by Embree.

Embree also made estimates of steamboat revenues - $7.472 million for passengers and $9.957 for freight. Our estimates are $12.7 and $15.5 million respectively.

[18]F.H. Dixon, A Traffic History of the Mississippi River System, National Waterways Commission, Doc. no. 11, Washington, Government Printing Office, 1909, p 27.

[19]Haites, Mak and Walton, Western River Transportation, Table D-1, p 157. Since the downstream rate for the 1850-60 period is higher than for the 1840-49 decade while the upstream rates are the same, using the 1840-49 rates gives an upward bias to the social savings calculation.

[20]Haites and Mak, "Economies of Scale in Western River Steamboating," Table 4. Table 3 of that paper shows the average cost per unit of output and utilization rate by route. Either of those variables could be used to adjust the freight rates. The cost per unit of output reflects both freight and passenger traffic. Using the cost per unit of output to adjust the freight rates yields higher estimates than if the utilization rate is used. Since the latter is more consistent with the bias we wish to introduce, it is used.

[21]The freight rates used for the comparison are as follows:

Route	Distance (miles)	Freight Rate (¢/100 lbs)	Freight Rate (¢/ton mile)
Pittsburg - Cincinnati	470	13	.553
Pittsburg - Louisville	604	15	.497
Pittsburg - St. Louis	1170	28	.479
Louisville - St. Louis	566	12.5	.442
Louisville - New Orleans	1350	30	.444
Trunk downstream			.483
Louisville - Pittsburg	604	20	.662
Louisville - Cincinnati	134	9	1.343
New Orleans - Louisville	1350	25	.370
Trunk upstream			.792
Pittsburg - Brownsville	55	10	3.636
Pittsburg - Franklin	127	30	4.724
St. Louis - Peoria	205	18	1.756
St. Louis - St. Joseph	498	75	3.012
St. Louis - Council Bluffs	678	100	2.950
Tributary upstream			3.216
Louisville - Bowling Green	360	35	1.944
Louisville - Terre Haute	479	32.5	1.357
Louisville - Florence	577	50	1.733
Louisville - Nashville	506	38	1.502
Pittsburg - Zanesville	248	25	2.016
Trunk down - Tributary upstream			1.710

The freight rates are from L.C. Hunter, Steamboats on the Western Rivers, pp 490, 658, 659; Haites, Mak and Walton, Western River Transportation, p 157 and Louisville Daily Journal (1850) averages of rates on pound freight quoted weekly over the peak season.

[22]L.C. Hunter, Steamboats on the Western Rivers, p 421.

[23]Ibid., p 421.

[24]Ibid., pp. 391-92.

[25]Ibid., p. 421.

[26]Ibid.

[27]De Bow's Review, vol. 6 (July - Dec 1848) p 62.

[28]Fishlow considered a counterfactual system consisting only of flatboats and keelboats. He does not specify the freight rates for this system but they are at least 2 cents per ton-mile downstream and 8 cents per ton-mile upstream. See L.E. Davis, R.A. Easterlin, W.N. Parker, et al, American Economic Growth, pp 518-19.

[29]E.F. Haites, J. Mak and G.M. Walton, Steamboats on the Western Rivers, Table E-2, p 168.

[30]L.C. Hunter, Steamboats on the Western Rivers, p 226.

[31]L.C. Hunter, Steamboats on the Western Rivers, p 369 reports "one authority, writing about 1850, estimated the rate of cargo insurance (for steamboats) at about 1 percent per thousand miles. As an average for all stages of the river on the Ohio and Mississippi trunk lines, this figure is fairly satisfactory...," Haites, Mak and Walton, Western River Transportation, Table E-2, p 168 reports the differential between flatboat and steamboat cargo insurance as 1 to 3 percent on the Louisville-New Orleans route (1350 miles). Hence the insurance rates for cargo sent by flatboat were between 2 and 4 percent per thousand miles on the trunk routes.

[32]L. C. Hunter, Steamboats on the Western Rivers, p. 25. E. F. Haites, J. Mak and G. M. Walton, Western River Transportation, pp. 40-41 indicates that there is considerable uncertainty over keelboat costs. It is clear however, that with an upstram freight rate of $5.00 per 100 pounds keelboats could cover their costs. This rate, then, gives us the desired upward bias.

[33]A. Fishlow, American Railroads and the Transformation of the Ante-Bellum Economy, p 325.

[34]L.C. Hunter, Steamboats on the Western Rivers, pp 490, 658, 659 shows the rail and river distances for sixteen different routes. The total rail distance is 5,095 miles, which is 0.579 of the total river distance of 8,801 miles. This ratio is rounded down to 0.55 to introduce an upward bias into the counterfactual rates.

[35]A. Fishlow, American Railroads and the Transformation of the Ante-Bellum Economy, p 91 reports stagecoach fares ranging between 5.0 and 7.5 cents per mile. These fares are substantially above the railroad fare of 3.0 cents per mile. These fares are also above those calculated below for the keelboat-flatboat alternative, namely an average of 1.5 cents per mile. Hence, the stagecoach does not form part of our counterfactual passenger transportation system.

[37]L.D. Baldwin, The Keelboat Age on Western Waters, p 186 reports that the passenger fare from Wheeling to New Orleans by flatboat was five to ten dollars. The latter figure is used because it gives the desired upward bias.

[38]No direct estimates of the cost of the overland trip have been found. Since the trip took about three times as long as the downstream trip, the cost was estimated to be three times as much, namely $30. L. D. Baldwin,

The Keelboat Age on Western Waters (Pittsburgh, University of Pittsburgh Press, 1941), gives the following information on the fares for the equivalent of cabin passage: $25 for a 515 mile trip by keelboat during the 1780's (p. 139) and $150 from New Orleans to Louisville on the steamboat Washington in 1816 (p. 193). This scant evidence together with the fact that the upstream trip took about three times as long as the downstream trip suggests cabin fares of $50 downstream and $150 upstream. These are five times the estimated deck passage fares of the counterfactual.

[40] A. Fishlow, American Railroads and the Transformation of the Ante-Bellum Economy, p 325.

[41] See L.D. Baldwin, The Keelboat Age on Western Waters, pp 68, 89; G.S. Callender, Selections from the Economic History of the United States, 1765-1860, p 416; H.B. Meyer, History of Transportation in the United States Before 1860, (Washington: Carnegie Institution, 1917), pp 96, 99.

[42] J.H. Boyd and G.M. Walton, "The Social Savings from Nineteenth-Century Rail Passenger Services," Explorations in Economic History, vol. 9, 1972, p 246.

[43]L.C. Hunter, Steamboats on the Western Rivers, p 490.

[44]To maintain the upward bias in the social savings the railroad speeds should be biased downward (because this will minimize the negative indirect benefits). The railroad speed is therefore estimated as 20 mph/.579 = 34.54 $\simeq$ 34 mph.

[45]L.C. Hunter, Steamboats on the Western Rivers, p 490.

[46]The wages for unskilled labour on steamboats and flatboats was approximately $25 per month during this period (Haites, Mak and Walton, Western River Transportation, Table 11, p 41 and Table C-2, p 141). This represents an hourly wage of $0.10 assuming 25 working days of ten hours per month. The value of travel time is estimated at half the hourly wage, or $0.05 per hour. J.H. Boyd and G.M. Walton, "The Social Savings from Nineteenth-Century Rail Passenger Services," use a value of travel time of $0.20 per hour in 1890. This is their estimate of the hourly wage in 1890. Since GNP per capita approximately doubled between 1850 and 1890 our estimate of the hourly wage seems reasonable. On the question of the relationship between the wage rate and the value of travel time we have chosen to impart a downward bias to our estimates by assuming the latter to be half the former.

[47]Haites, Mak and Walton, Western River Transportation, Table E-2, p 168 gives the average value of goods received at New Orleans during the 1840's as $80 per ton. The opportunity cost of funds is assumed to be 10 percent per year. This makes the value of time for the goods movements $8.00 per ton per year.

[48]Only the cargo insurance is relevant here. The losses on transportation equipment are included in the freight rates of the respective modes.

[49] L.C. Hunter, Steamboats on the Western Rivers, p 369.

[50] See footnote 31 above.

[51] L.C. Hunter, Steamboats on the Western Rivers, pp 1-27.

[52] See footnote 12 above.

[53] The pattern of cargo insurance rates for steamboats is assumed to approximate that for steamboat insurance. Haites, Mak and Walton, Western River Transportation, p 139 gives the rates of steamboat insurance as follows: 1815 - 18%; 1825 - 15%; 1835 - 12%; 1845 - 10%; 1855 - 9%. Hunter (p 369) reports the rate of cargo insurance during the 1850's as 1 percent per thousand miles. The cargo insurance rates are then estimated to decline from 2 percent per 1,000 miles in 1815 to 1 percent per 1,000 miles in 1855. The rates are rounded down to the nearest half of one percent.

[54] Haites, Mak and Walton, Western River Transportation, Table E-2, p 168 gives the differential insurance premium for flatboat cargo on the 1,350 mile Louisville to New Orleans trip. It is assumed that the same differential would apply to a 1,000 mile trip. The differential is then added to the steamboat cargo insurance rate and the result is rounded up to the nearest percent to give the desired upward bias.

[55] Haites, Mak and Walton, Western River Transportation, fn 19, p 169.

[56] R.E. Gallman, "Gross National Product in the United States, 1834-1909," in Output, Employment, and Productivity in the United States After 1800, National Bureau of Economic Research Studies in Income and Wealth, vol. 30, (New York: Columbia University Press, 1966), p 26 gives the following values for the current dollar GNP (in billions): 1839 - \$1.54; 1844 - \$1.80; 1849 - \$2.32; 1854 - \$3.53 and 1859 - \$4.17.

[57] Davis, Easterlin, Parker, et al, American Economic Growth, pp 518-19.

[58] Haites, Mak and Walton, Western River Transportation, Table C-1, p 137 gives the construction cost per ton for steamboats as follows: 1815 - \$125; 1825 - \$110; 1835 - \$110; 1845 - \$90 and 1855 \$100. Then the total construction costs of the vessels operating in these years are as follows (in thousands of dollars): 1815 - \$189.5; 1825 - \$1,338.0; 1835 - \$5,513.5; 1845 - \$8,654.0 and 1855 - \$17,270.0. These figures are obviously an upper bound estimate of the capital invested in the steamboat stock in those years since it does not provide for any depreciation. The investment in river improvements, etc. should be added to these figures but as indicated by Haites, Mak and Walton, Table 20, p 96, these amounts are very small.

To calculate the return for 1815 and 1825 only the direct savings are used. For the years 1835 through 1855 the direct savings are reduced by the indirect losses and then used in the calculation. This imparts a downward bias to the calculated return.

[59] Davis, Easterlin, Parker, et al, American Economic Growth, pp 518-19 reports the rates of return on canals and railroads as 15 percent. It is well known (T.R. Stauffer, "The Measurement of Corporate Rates of Return: A Generalized Formulation," Bell Journal of Economics and Management Science, vol. 2, 1971, pp 434-70) that the accounting rates of return as calculated here overstate the economic rates of return. Despite this bias it is evident that the returns to investment in steamboats greatly exceeded those obtained from railroad and canal investments.