Impact of Rail Rationalization on Traffic Densities

CURTIS M. GRIMM, KENT A. PHILLIPS, AND LESLIE J. SELZER

Though the question of the interdependence of branch lines and main lines has long been of policy relevance, there is, to date, little evidence on the relationship among light-density lines, main lines, and overall system traffic densities. This paper provides evidence of the impact of eliminating a substantial number of low-density lines, along with the traffic originating and terminating on these lines, on main-line densities. The relationship between light- and high-density lines is explored using both national and individual railroad line segment density data. The main finding of the study is that elimination of a large number of light-density lines does not dramatically reduce main-line densities.

The rail industry is a complex integrated system capable of producing multiple transportation services. Measuring the structural economics or the production characteristics of railroads is therefore a complex problem (*1*). Most of the previous estimates of rail cost structure have used aggregate cost functions to estimate economies of scale, density, and length of haul. These studies find that economies of density exist in the rail industry. Such economies cause average costs to decrease as traffic density [net ton-miles per mile of road (NTM/RM)] increases. Thus average costs on light-density branch lines are higher than on high-density lines.

Previous research (*2, 3*) on branch-line abandonments suggests that a large proportion of existing light-density lines is not economically viable. However, the impact of abandoning branch lines on this scale has not been examined. Although the vast majority of traffic originating and terminating on branch lines moves over main lines and therefore clearly augments main-line densities, the extent to which low-density branch lines are responsible for high densities on main lines has not, heretofore, been the subject of systematic empirical investigation.

The contribution of branch lines to main-line densities is, however, of importance to both managers and public policy makers. Managers of the rail system must assess the impact that abandonment of light-density lines will have on main-line densities. Although abandonment of one or two light-density lines may not have significant impact on main-line densities, large abandonment programs may have a deleterious effect on the economies of density associated with main lines.

Public policy makers also benefit from heightened awareness of the relationship between feeder and main lines. From their standpoint, the adverse impact of abandonments on the shipper community must be balanced against potential financial benefits to the carrier. If feeder lines are not vital to the efficiency of the high-density lines, they are properly evaluated as independent entities. In the absence of a linkage between light-density branch lines and high-density main lines, both state and federal policy makers should develop strategies for ensuring future transportation services for shippers on nonviable line segments. The link between abandonment of light-density branch lines and main-line density is then of relevance for this determination.

C. M. Grimm, College of Business and Management, University of Maryland, College Park, Md. 20742. K. A. Phillips and L. J. Selzer, Interstate Commerce Commission, 12th Street and Constitution Avenue, N.W., Washington, D.C. 20423.

LITERATURE REVIEW

Although literature on excess railroad capacity is scant, there is a general consensus among transportation economists that the industry is overcapitalized with regard to roadway investment. This excess investment has been directly linked to the industry's overall poor financial performance (*4*). Quantification and identification of redundant capacity have been complicated by the lack of comprehensive data on line segment costs and alternative routings and sources of transportation available to traffic after abandonment. Furthermore, the rigid regulatory structure in place before passage of the railroad regulatory reform acts of 1976 and 1980 deemphasized the pure economic issues of rail line viability. Following the bankruptcy of the Penn Central and six other northeastern railroads in the early 1970s, detailed empirical research on the question of excess capacity was initiated.

Much of the initial research on identifying excess railroad capacity was undertaken by the United States Railway Association (USRA)—an organization established by Congress to resolve the bankruptcy of the northeastern railroads. In its efforts to reorganize the bankrupt lines, the USRA (*5*) concluded that two-thirds of the approximately 9,600 mi of light-density lines owned by seven carriers should be excluded from the final Conrail system.

Comprehensive studies of nationwide light-density rail operations were conducted by Harris (*3, 6*). Those studies concluded that 35,000 mi of branch lines were unprofitable. Harris's estimates were based on a rail movement simulation model that flowed individual movements contained in the Interstate Commerce Commission (ICC) waybill over the Federal Railroad Administration's (FRA's) railroad network model. The viability of potentially excess miles was based on the ability of traffic originating or terminating, or both, on light-density lines to cover their costs. Because Harris used data from the early 1970s, before the major regulatory reforms of the 4R Act, the Staggers Act, and the Motor Carrier Act of 1980, his estimates were predicated on the regulatory structure in place at that time.

Grimm (*2*) replicated the Harris study employing postreform data. Using a broad range of revenue, cost, and traffic retention rate assumptions, Grimm found that, despite the large number of abandonments that had taken place since the Harris study, substantial excess capacity remains in the U.S. railroad system. In particular, evaluation of fixed costs consistent with the ICC's standards for revenue adequacy results in estimates of from 28,000 to 33,000 mi of nonviable light-density branch lines.

No study to date, however, has specifically addressed the system impact of abandonments of this order of magnitude. Critics of abandonments have suggested that the elimination of light-density feeder lines could result in significant reductions in high-density line volumes. If the traffic volume were sufficiently reduced, it has been postulated, the economies of density inherent in high-density rail operations could be lost.

DATA AND METHODOLOGY

To determine the impacts of line exclusion on main-line and system densities, the network implications of line eliminations must be taken into account. The FRA network model, an analytical representation of the U.S. railroad system, is ideal for this purpose. The model includes more than 9,000 line segments, with a total mileage nearly equal to that of the rail system itself. The FRA has collected from the owning railroads information about the traffic density on each line segment. At the time of the study, there were six density classifications or categories based on traffic volume measured in gross ton-miles per route-mile (GTM/RM): 1 (less than 1 million GTM/RM), 2 (1 to 5 million GTM/RM), 3 (5 to 10 million GTM/RM), 4 (10 to 20 GTM/RM), 5 (20 to 30 million GTM/RM), and 6 (greater than 30 million GTM/RM).

The FRA network model is a highly detailed representation of the U.S. rail system. In order to use it to test implications of light-density line exclusions, the model must be combined with a rail traffic data base. The data bases used were the ICC's 1981 and 1982 rail waybill files. These samples represent approximately a 1 percent sample of railroad traffic in the respective years. The waybill sample includes detailed information on each movement, including origin, destination, participating carriers, commodity, mileage, and revenues. Each movement in the waybill sample was processed through the FRA network model and information on individual line segment density was captured.

The years 1981 and 1982 were selected as base years because the integration of the waybill data base and the FRA network model is a complex and expensive operation and this integration had already been carried out for other purposes, so the merged network model–waybill file for 1981 and 1982 was available. Although waybill information alone for subsequent years has been released, a more recent merged network model–waybill file is not available. Also, the network model itself accurately reflected the rail system as of mid-1984 in that lines abandoned since original development of the network model were "flagged" and removed from the model. Thus any traffic originating or terminating on these lines was not used in determining baseline line segment densities. Finally, although the rail system itself continues to change, there is no reason to believe that the fundamental relationship between main and branch lines is substantially different now than it was in 1984.

To assess the impact of line exclusions on traffic densities, the waybill traffic was first flowed through the network model and the distribution of lines across the six density categories was recorded. A total of 33,000 mi, slightly more than one-third of Category 1 lines and 18 percent of the total rail system, were cut from the system to test the impact on main-line densities. [More specifically, lines that failed to pass a financial viability test were chosen for exclusion. The viability of each Density Category 1 line segment was based on comparison of the revenues generated by traffic originating and terminating on the line with the fixed cost of the branch line and the variable cost of the traffic generated by the line. Full details of the procedure used to assess financial viability are given by Grimm (*2*).] The traffic originating and terminating on these lines was assumed to be completely lost to the rail industry and removed from the file. This modified waybill file was reflowed through the FRA model and the resulting density information was again recorded and compared with that obtained from the original benchmark flow of the 1981–1982 waybill.

In reviewing the difference between the two flows, the authors attempted to determine if the exclusion of light-density branch lines and loss of all traffic associated with these lines caused a significant number of line segments to fall to a lower density category. If this were the case, branch-line traffic could be making a substantial contribution to main-line densities. A substantial reduction in the number of ton-miles on higher-density lines would indicate a high degree of interdependence between branch lines and main lines. In contrast, minimal impacts on main-line densities would indicate that light-density lines are not a major source of traffic. A secondary impact could also occur: main lines might in some cases remain in the same density class but handle a lower volume of traffic after line exclusion. Data on average net ton-miles in each density category both before and after line exclusion were also studied to gauge this impact.

Line segment density data were examined for the U.S. rail system as a whole and for the five railroads with the largest number of miles failing the financial viability test. These railroads were the Burlington Northern (BN) with 6,377 mi, the Chicago and North Western (CNW) with 4,117 mi, the Atchison, Topeka & Santa Fe (ATSF) with 1,932 mi, the Seaboard Coast Line (SCL) with 1,835 mi, and the Southern Pacific (SP) with 1,575 mi (Conrail and the Milwaukee had 2,094 and 3,859 mi, respectively, but were not included because of their unique status). Results are provided in the following section.

RESULTS

The tables give the effect of excluding branch lines and their associated traffic on main-line densities for the U.S. rail system and for the five individual carriers. The results suggest that, with the possible exception of the CNW, large-scale branch-line elimination would not substantially reduce densities on the higher-density lines.

Table 1 gives the distribution of all rail lines in the United States by density classification, along with total net ton-mile output and the average density in each density category. Line 1 gives the system route-miles in each category and Line 2 the percentage of the total in each classification. Lines 3 and 4 supply the same statistics after light-density lines are dropped. Line 5 reflects the net loss in route-miles in each density category. Lines 6 through 10 give data on net ton-mile output using the same format that was used in Lines 1–5. Lines 11 and 12 show average NTM/RM density both for the system and after exclusion of lines.

For the United States as a whole, two-thirds of the total system route-miles reside in the lowest two density categories, and they produce only 7.2 percent of the total net ton-miles. Conversely, lines in Density Categories 5 and 6 make up 15 percent of total system route-miles and produce almost two-thirds of total system output. After exclusion of lines, total system route-miles were reduced by 17.5 percent. Loss of all traffic originating or terminating, or both, on those lines reduces gross ton-mile output by only 5 percent. Thus elimination of a large number of feeder lines in the lowest-density category does not significantly affect the total output produced by the U.S. rail system. Also of interest is the migration of line segments into lower density classifications. After traffic loss, there is an increase in the route-miles in Density Category 4 along with an increase in output. This shift of line segments into lower density categories adversely affects the output generated by lines in Density Categories 5 and 6.

Examination of data for the BN contained in Table 2 shows a reduction in route-miles of 6,377 mi or 22.4 percent of the total system. Despite this significant change in route-miles, the BN's total output as measured by net ton-miles drops a little less than 7 percent or by about 9 million net ton-miles. The greatest change occurs in Density Category 4 and 5 lines. The Category 4 lines pick up 3.6 million net ton-miles, and the Category 5 lines lose 8.8 million net ton-miles from lost traffic and shifts in line segment density. However, this shift does not significantly alter the average NTM/RM output for those density classifications. Average densities for all categories showed no significant changes, but the overall average system density increased by fully 20 percent due to the reduction in route-miles.

Table 3 gives data for the CNW; the results are much the same as for the BN. A little more than 4,000 mi or fully 37 percent of the system was excluded. Loss of these route-miles affects the CNW's output by reducing it by 13.4 percent. This is the largest loss of output (on a percentage basis) for the five railroads in the analysis, but it does not appear to be out of line given the large number of route-miles eliminated. It should be noted that the CNW produced the least output of the rail

TABLE 1 U.S. RAIL SYSTEM

	Density Classification						
	1	2	3	4	5	6	Total
System route-miles (thousands)	89.6	32.0	15.9	18.5	13.6	14.1	183.0
Percentage of total route-miles	48.96	17.49	8.69	10.11	7.43	7.70	100.00
System route-miles after exclusion and traffic loss (thousands)	63.9	27.1	15.5	19.8	12.3	13.1	151.0
Percentage of revised route-miles	42.32	17.95	10.26	13.11	8.15	8.68	100.00
Change in route-miles (Line 1 – Line 3) (thousands)	25.7	4.9	0.4	(1.3)	1.3	1.0	32.0
System net ton-miles (millions)	9,659	39,061	56,310	128,868	152,898	288,088	674,806
Percentage of total net ton-miles	1.43	5.79	8.34	19.10	22.66	42.69	100.00
System net ton-miles after exclusion and traffic loss (millions)	6,616	34,424	54,378	138,016	137,689	265,362	636,487
Percentage of revised net ton-miles	1.04	5.41	8.54	21.68	21.63	41.69	100.00
Change in net ton-miles (millions)	3,043	4,637	1,932	(9,148)	15,209	22,726	38,319
Average system net ton-miles per route-mile (thousands)	107	1,219	3,523	6,940	11,237	20,412	3,668
Average net ton-miles per route-mile after exclusion and traffic loss (thousands)	103	1,270	3,488	6,939	11,153	20,214	4,188

TABLE 2 BURLINGTON NORTHERN INC.

	Density Classification						
	1	2	3	4	5	6	Total
System route-miles	14,111.6	4,300.8	1,841.6	3,363.4	2,748.7	2,060.0	28,426.0
Percentage of total route-miles	49.64	15.13	6.48	11.83	9.67	7.25	100.00
System route-miles after exclusion and traffic loss	8,979.4	3,440.8	1,764.2	3,974.4	1,938.2	1,952.0	22,049.0
Percentage of revised route-miles	40.72	15.61	8.00	18.03	8.79	8.85	100.00
Change in route-miles (Line 1 – Line 3)	5,132.2	860.0	77.4	(611.0)	810.5	108.0	6,377.0
System net ton-miles (millions)	1,540	5,600	7,037	25,682	32,225	64,088	136,172
Percentage of total net ton-miles	1.13	4.11	5.17	18.86	23.66	47.06	100.00
System net ton-miles after exclusion and traffic loss (millions)	983	4,792	7,079	29,370	23,428	61,212	126,865
Percentage of revised net ton-miles	0.77	3.78	5.58	23.15	18.47	48.25	100.00
Change in net ton-miles (millions)	557	808	(42)	(3,688)	8,797	2,876	9,307
Average system net ton-miles per route-mile (thousands)	109	1,302	3,821	7,636	11,724	31,111	4,790
Average net ton-miles per route-mile after exclusion and traffic loss (thousands)	110	1,393	4,013	7,390	12,087	31,359	5,754

TABLE 3 CHICAGO AND NORTH WESTERN TRANSPORTATION COMPANY

	Density Classification						
	1	2	3	4	5	6	Total
System route-miles	7,117.1	2,085.4	716.0	489.8	94.5	536.7	11,039.5
Percentage of total route-miles	64.47	18.89	6.49	4.44	0.86	4.86	100.00
System route-miles after exclusion and traffic loss	3,913.9	1,337.4	630.3	409.3	106.0	525.2	6,922.1
Percentage of revised route-miles	56.54	19.32	9.11	5.91	1.53	7.59	100.00
Change in route-miles (Line 1 – Line 3)	3,203.2	748.0	85.7	80.5	(11.5)	11.5	4,117.4
System net ton-miles (millions)	658	2,243	2,665	3,355	1,136	9,265	19,322
Percentage of total net ton-miles	3.41	11.61	13.79	17.36	5.88	47.95	100.00
System net ton-miles after exclusion and traffic loss (millions)	414	1,782	2,398	2,707	1,098	8,641	17,040
Percentage of revised net ton-miles	2.43	10.46	14.07	15.89	6.44	50.71	100.00
Change in net ton-miles (millions)	244	461	267	648	38	624	2,282
Average system net ton-miles per route-mile (thousands)	92	1,075	3,722	6,849	12,025	17,263	1,750
Average net ton-miles per route-mile after exclusion and traffic loss (thousands)	106	1,332	3,805	6,613	10,362	16,452	2,462

systems analyzed and that the CNW's Category 1 lines generate a greater percentage of the total system traffic than do the Category 1 lines of other carriers. The changes caused by the loss of traffic and the shift in line segment densities appear to be spread uniformly over all density classifications. Only Category 5 and 6 average density and total system average density change significantly, with the latter increasing by 40 percent.

Data for the ATSF (Table 4), the SCL (Table 5), and the SP (Table 6) all show similar results. Excluded lines range from 11 to 15 percent of total system route-miles. However, the impact on output is not severe, with the carriers losing only 3 to 7 percent of total system net ton-miles. The ATSF data show a substantial shift of route-miles into Density Category 4. This increases the output generated over these lines by fully 60 percent and increases the average density by almost 1 million NTM/RM. Neither the SCL nor the SP shows dramatic changes in NTM/RM in the six density classifications, although there is some shift in output from Category 6 to Category 5 lines for the SP.

CONCLUSION

The elimination of large segments of Category 1 stub end branch lines does not appear to radically affect railroad main-line densities. With the exception of the CNW, loss of output is between 3 and 7 percent of total net ton-miles. For the entire U.S. rail system the loss is 5.7 percent. These results were obtained using the conservative assumption that no traffic currently originating or terminating on the excluded lines would be retained on the rail system. However, in reality some traffic would be retained through intermodal operations, most commonly by trucking to an adjacent rail connection or employing trailers on flat cars. Moreover, acquisition of abandoned branch lines by short-line operators would also aid in the retention of traffic. According to the Interstate Commerce Commission (7), this practice has become increasingly common in recent years. Overall, retention of some of the excluded traffic could be expected to lessen the loss of output for both the system and individual line segments.

Another observable effect is the degradation of some line segments' output to the extent that they fall into lower density classifications. However, the shift of lines to lower density classes is relatively small.

These results have significance for both management and regulators. When the results are viewed in conjunction with the previous findings of Harris and Grimm, they imply that large-scale sale or abandonment of branch lines may relieve railroads of the economic burden of rehabilitating segments of

TABLE 4 ATCHISON, TOPEKA & SANTA FE RAILWAY COMPANY

	Density Classification						
	1	2	3	4	5	6	Total
System route-miles	4,684.1	2,504.5	1,589.9	649.0	913.1	2,446.5	12,787.1
Percentage of total route-miles	36.63	19.59	12.43	5.08	7.14	19.13	100.00
System route-miles after exclusion and traffic loss	3,505.8	1,895.5	1,451.9	920.0	733.1	2,348.5	10,854.8
Percentage of revised route-miles	32.30	17.46	1.27	8.48	6.75	21.64	100.00
Change in route-miles (Line 1 – Line 3)	1,178.3	609.0	138.0	(271.0)	180.0	98.0	1,932.3
System net ton-miles (millions)	644	3,096	5,673	4,085	10,005	37,101	60,577
Percentage of total net ton-miles	1.06	5.11	9.36	6.74	16.52	61.25	100.00
System net ton-miles after exclusion and traffic loss (millions)	418	2,510	4,991	6,543	7,664	34,236	56,362
Percentage of revised net ton-miles	0.74	4.45	8.86	11.61	13.60	60.74	100.00
Change in net ton-miles (millions)	226	586	682	(2,458)	2,341	2,865	4,215
Average system net ton-miles per route-mile (thousands)	138	1,236	3,568	6,253	10,957	15,165	4,737
Average net ton-miles per route-mile after exclusion and traffic loss (thousands)	119	1,324	3,437	7,112	10,455	14,578	5,192

TABLE 5 SEABOARD COAST LINE RAILROAD

	Density Classification						
	1	2	3	4	5	6	Total
System route-miles	6,266.8	3,257.0	1,137.1	2,627.1	2,526.8	589.1	16,403.9
Percentage of total route-miles	38.20	19.86	6.93	16.02	15.40	3.59	100.00
System route-miles after exclusion and traffic loss	4,941.8	2,792.0	1,085.2	2,793.1	2,347.6	581.3	14,568.9
Percentage of revised route-miles	33.92	19.16	7.45	19.17	16.11	3.99	100.00
Change in route-miles (Line 1 – Line 3)	1,325.0	465.0	51.9	(166.0)	179.2	7.8	1,835.0
System net ton-miles (millions)	937	4,106	3,917	17,842	29,742	9,019	65,563
Percentage of total net ton-miles	1.43	6.26	5.97	27.21	45.36	13.76	100.00
System net ton-miles after exclusion and traffic loss (millions)	743	3,969	3,625	18.393	27,851	8,813	63,394
Percentage of revised net ton-miles	1.17	6.26	5.72	29.01	43.93	13.90	100.00
Change in net ton-miles (millions)	194	137	292	(551)	1,891	206	2,169
Average system net ton-miles per route-mile (thousands)	149	1,261	3,444	6,792	11,770	15,310	3,997
Average net ton-miles per route-mile after exclusion and traffic loss (thousands)	150	1,422	3,340	6,585	11,729	15,162	4,351

TABLE 6 SOUTHERN PACIFIC TRANSPORTATION COMPANY

	Density Classification						
	1	2	3	4	5	6	Total
System route-miles	5,738.3	1,718.2	1,061.2	1,361.8	1,847.5	1,947.7	13,674.7
Percentage of total route-miles	41.96	12.56	7.76	9.96	13.51	14.24	100.00
System route-miles after exclusion and traffic loss	4,274.7	1,672.2	1,005.2	1,401.8	2,007.5	1,738.7	12,100.1
Percentage of revised route-miles	35.33	13.82	8.31	11.59	16.59	14.37	100.00
Change in route-miles (Line 1 – Line 3)	1,463.6	46.0	56.0	(40.0)	(160.0)	209.0	1,574.6
System net ton-miles (millions)	7,847	2,010	3,037	9,370	18,566	27,062	60,830
Percentage of total net ton-miles	12.90	3.30	4.99	15.40	30.52	44.49	100.00
System net ton-miles after exclusion and traffic loss (millions)	6,422	1,923	2,737	9,451	20,169	23,280	58,202
Percentage of revised net ton-miles	11.03	3.30	4.70	16.24	34.65	40.00	100.00
Change in net ton-miles (millions)	1,425	87	300	(81)	(1,603)	3,782	2,628
Average system net ton-miles per route-mile (thousands)	137	1,170	2,862	6,881	10,049	13,894	4,448
Average net ton-miles per route-mile after exclusion and traffic loss (thousands)	150	1,150	2,723	6,742	10,047	13,389	4,810

their systems with little or no effect on the amount of traffic carried.

Regulators and legislators need to be aware that light-density line elimination does not necessarily imply substantial loss of main-line output and the corresponding efficiency associated with the high densities on these lines. Thus regulators can scrutinize individual line segment abandonments as isolated occurrences and appropriately weigh the economic benefits of reduced costs to the carrier against the social ramifications of reduced service to specific shippers in each case. If service is found to be in the public interest, state or federal resources can be provided to ensure continued transportation services. These results have particular significance for guiding legislative actions. As discussed in Keeler (*8*, p. 101), the 4R Act and the Staggers Act liberalized abandonment procedures on the basis that allowing railroads to shed unprofitable lines was an important step toward returning the industry to financial health. However, recent legislative initiatives would place greater restrictions on abandonments. [A proposal passed by a House subcommittee "requires ICC hearings on abandonment of lines over 256 miles long and provides that a one-year freeze be put on lines where abandonment was denied" (*8*, p. 6).] Thus the results provide important evidence for legislators as they consider abandonment policy and suggest that lawmakers exercise caution when imposing further restrictions on abandonments.

REFERENCES

1. C. M. Grimm and R. G. Harris. Structural Economies of the U.S. Rail Freight Industry: Concepts, Evidence, and Merger Policy Implications. *Transportation Research,* Vol. 17A, No. 4, July 1983.
2. C. M. Grimm. Branch Line Capacity in the U.S. Railroad Industry: A Simulation Model Approach. *Logistics and Transportation Review,* Vol. 22, No. 3, 1986.
3. R. G. Harris. Economic Analysis of Light Density Rail Lines. *Logistics and Transportation Review,* Vol. 16, No. 1, 1980.
4. T. E. Keeler. *Railroads, Freight, and Public Policy.* Brookings Institution, Washington, D.C., 1983.
5. *Preliminary System Plan.* United States Railway Association, Feb. 1975, Vol. 1, Chapter 7.
6. R. G. Harris. *Rationalizing the Rail Freight Industry: A Case Study in Institutional Failure and Proposals for Reform.* Ph.D. dissertation. University of California, Berkeley, Sept. 1977.
7. *New Short Lines and Regional Railroads.* Office of Transportation Analysis, Interstate Commerce Commission, Sept 1987.
8. *Traffic World,* Nov. 9, 1987.

The views expressed by the authors are their own and do not reflect those of the Interstate Commerce Commission.

Publication of this paper sponsored by Committee on Surface Freight Transport Regulation.