Productivity Improvements in the U.S. Rail Freight Industry, 1980-2010

by Carl D. Martland

Between 1980 and 2008, extensive productivity improvements and changes in traffic mix allowed railroads to become more profitable despite declining prices and stronger competition from motor carriers. These productivity improvements enabled the Class I railroads to halve their real costs per ton-mile, even though costs for fuel and other resources rose faster than inflation. Productivity improvements were greatest for bulk traffic moving in unit trains, containers moving in double-stack trains, and high-volume shipments moving long-distances in specialized equipment. While the rail industry indeed achieved tremendous improvements in productivity following passage of the Staggers Act in 1980, it is incorrect to point to deregulation as the primary reason for these gains. Other factors that were even more critical to productivity growth included technological advances, new labor agreements, improved management, and public policy responses to the Northeast Rail Crisis.

BACKGROUND AND OVERVIEW

In the mid-1960s, although the rail industry appeared to be recovering from the stresses of World War II, the Korean War, and the recessions of the 1950s, it was on the brink of what became known as the Northeast Rail Crisis. The unexpected bankruptcy of the Penn Central Railroad in 1970 led to a decade of restructuring the national rail network, the railroads that operated over that network, and the regulations that determined what those railroads could or could not do. The bankruptcy of the Penn Central and a half dozen smaller railroads threatened severe disruption to transportation and distribution systems in the northeast, the loss of tens of thousands of railroad jobs, the loss of rail service to hundreds of communities, and severe costs to electric utilities, automobile assembly plants, chemical plants, steel mills, and other rail-dependent companies.

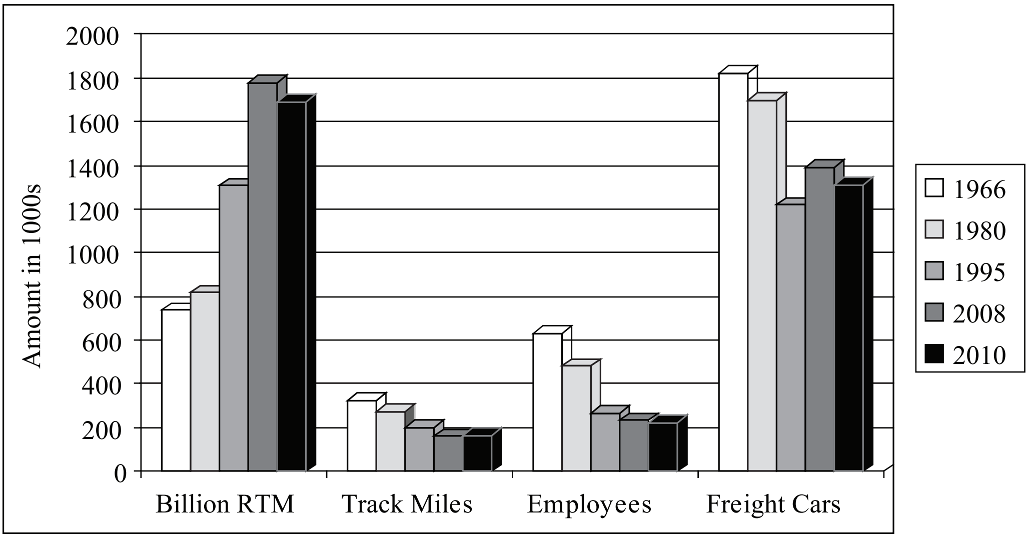
Because of widespread concerns over these possibilities, the federal government took dramatic action. In 1971, Congress created Amtrak, which allowed railroads to exit the unprofitable inter-city passenger business. Next, Congress devised a process that led to the creation of Conrail, a new federally controlled railroad that emerged from the chaos of the bankruptcies in 1975. Although Congress also gave railroads greater pricing freedom and an easier path toward network rationalization,[1] the financial ills of the rail industry continued. In the late 1970s, the Chicago, Rock Island and Pacific Railroad, and the Milwaukee Road filed for bankruptcy, and a Congressionally mandated study highlighted the dire situation facing the industry:

> *Continuation of the trends of the postwar period would result within the next 10 years in an industry facing enormous capital shortages, competing only for bulk shipments of low-value goods, lacking the resources needed for safe operation, and to a very considerable degree, operating under the financial control or ownership of public agencies.* (Secretary of Transportation 1978, p. 3)

Congress considered, but ultimately chose not to extend a Conrail-type solution to that region. Instead, the major legislative actions during the 1970s were enhanced and extended by passage of the Staggers Act in 1980.

Over the next three decades, the rail industry improved its productivity, lowered its prices, and increased its profitability.[2] Despite more than doubling the revenue ton-miles (RTM) that were handled, the industry sharply reduced its track-miles, its employees, and its fleet of freight cars (Figure 1). A series of mergers reduced the number of Class I railroads and ultimately produced two large systems in both the eastern and western portions of the U.S. While tens of thousands of miles of light density lines were abandoned, a similar amount were converted to short line or regional railroads that now play a major role in serving customers.

Figure 1: Output Doubled, but Resource Requirements Declined Between 1966 and 2008



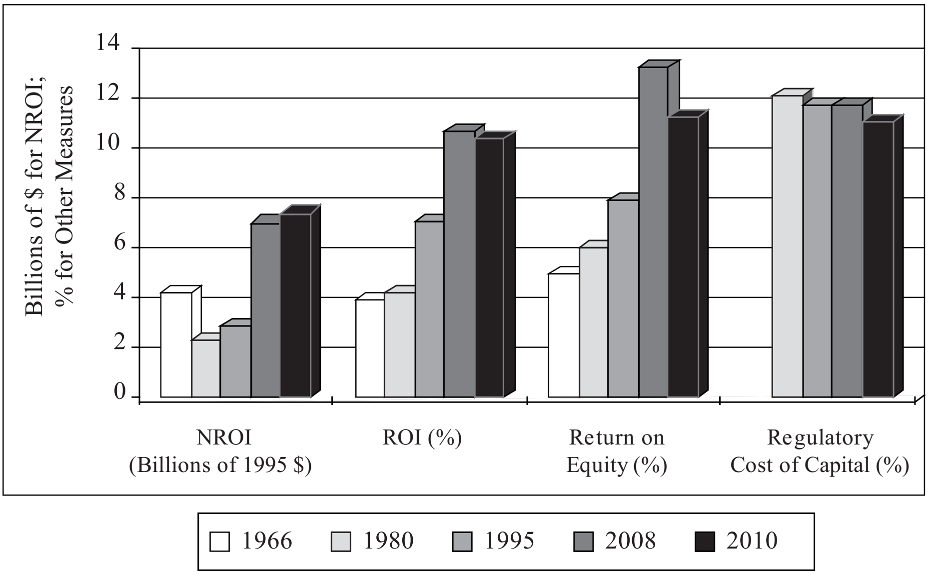
Data Source: AAR, *Railroad Facts*, various editions.

These productivity improvements were instrumental in improving the industry's financial performance (Figure 2). Net railway operating income (NROI), a commonly used measure of railroad profitability, more than tripled (in constant dollars) between 1980 and 2010, while return on investment (ROI) more than doubled. NROI equals operating revenues minus the sum of operating expenses, current and deferred taxes, and rents for equipment and joint facilities; it does not include interest expense or non-operating revenues or expenses. ROI is calculated as the ratio of NROI to average net investment in railroad property. The ability to raise capital is more related to the return on shareholders equity than to ROI; if return on equity is greater than the railroads' cost of capital, then they can more readily raise the funds needed to maintain and improve their services. The Association of American Railroads (AAR) has acknowledged the importance of productivity improvements for the turnaround in the industry's financial performance:

> *Better output per employee, more efficient utilization of infrastructure, and improved locomotive fuel efficiency helped freight railroads attain their best industry operating ratio (78.6%) since World War II. The resulting financial performance, which included a return on equity of 11.3% and a return on investment of 10.2%, was a welcome and long-sought improvement after a disappointing record over the last forty years.* (AAR 2007, p.5)

The deregulation of the rail industry, specifically the passage of the Staggers Act in 1980, is often cited by both economists and rail industry officials as the reason for the productivity improvements the industry achieved (e.g., Morrison and Winston 1999, Gómez-Ibáñez and de Rus 2006, Hamberger 2010). Deregulation certainly facilitated rationalization of the network, encouraged marketing initiatives, and enabled railroads to concentrate on their most profitable lines of business. However, a closer examination of the sources of productivity changes, as summarized in this paper, reveals

Figure 2: Financial Performance Improved Between 1966 and 2010



Data Source: AAR, *Railroad Facts*, various editions.

that it was not deregulation, but changes in traffic mix, rail-related research and development, rapid improvements in communications and computers, new labor agreements, and public investment in railroads that led directly to most of the industry's productivity gains. Furthermore, deregulation was the dominant factor in declining rail rates, which for decades hindered the industry's ability to translate productivity improvements into financial success. The Staggers Act eliminated the regulatory framework that had long allowed railroads to raise their rates to keep pace with inflation. Proponents of deregulation expected the act to allow higher rates, but the dominant long-term results were enhanced competition and decades of declining rates (Lowtan 2004).

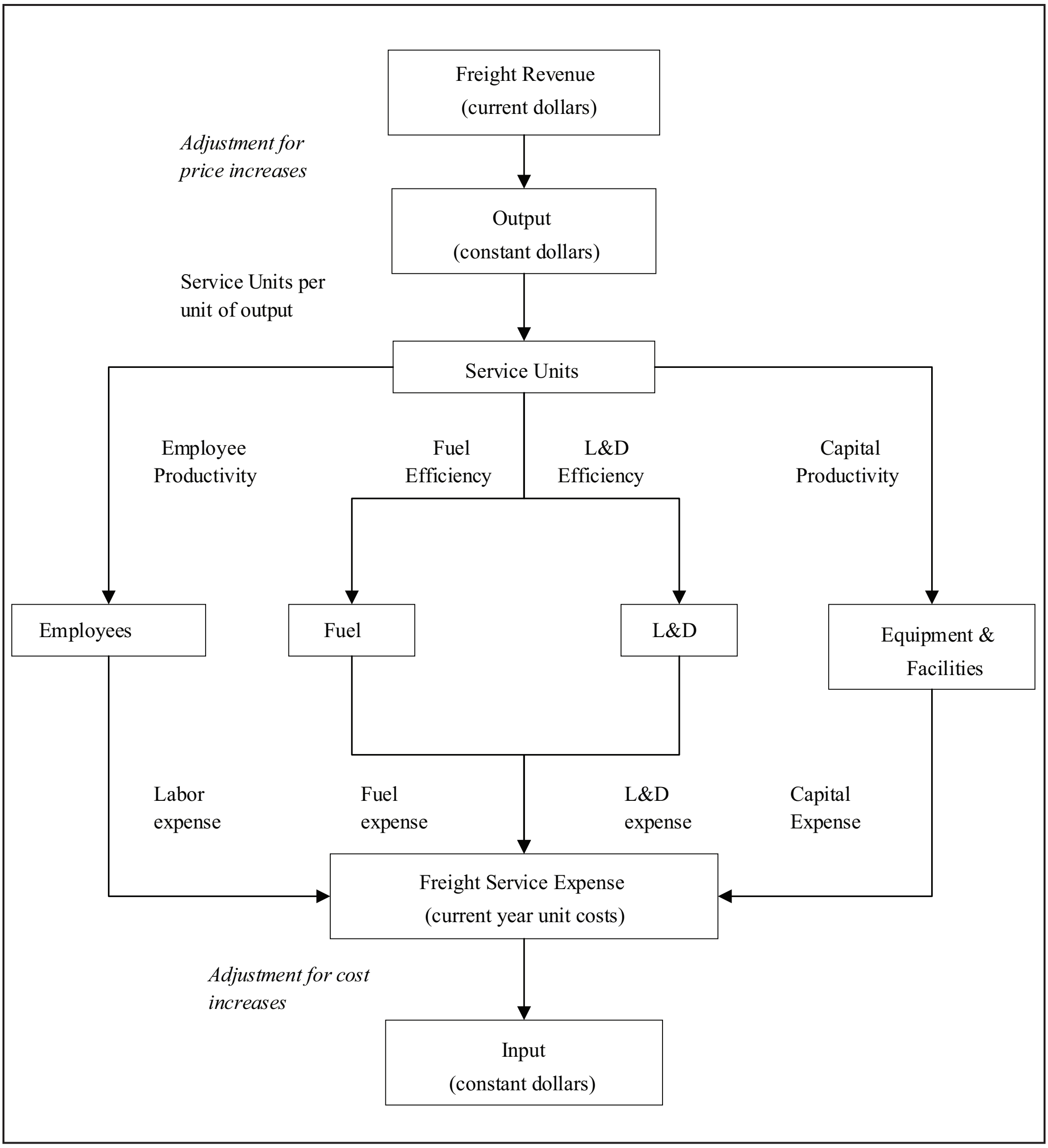
MEASURING PRODUCTIVITY

In basic economic terms, productivity is the ratio of output to input. It is possible to become more productive by producing more output from the same resources or by producing the same output with fewer resources. This simple concept is complicated by the difficulties in measuring outputs and inputs, especially for a complex system with multiple outputs and inputs. Partial measures, such as revenue ton-miles per employee, may be easy to calculate, but they fail to account for the substitutability of inputs, e.g., capital investments that reduce the need for labor. Broader measures are needed to capture overall trends in productivity.

Two quite different approaches have been used to measure and understand trends in railroad productivity. Transportation economists typically employ econometric techniques to calibrate cost functions and to estimate productivity change based upon public data sources. These techniques can be used to investigate important economic concepts such as economies of scale, scope, and density (Bereskin 2009). However, they can only show how costs or productivity change with respect to very aggregate measures such as average length of haul, revenue ton-miles per route-mile, or average route-miles per railroad. For example, Christensen Associates (2010) recently completed an econometric study of railroad costs and productivity for the Surface Transportation Board (STB). They found that the rate of productivity growth declined from 6.8% in 1987 to 1% in 2000 before turning negative in 2008, but their methodology could not explain the causes underlying either the growth or the decline.

Access to railroad information systems enables an analytical approach than can identify the sources of productivity improvement. Earlier studies have measured railroad productivity as the ratio of current year freight revenue deflated by a rail price index to current year freight expense deflated by the AAR's Railroad Cost Recovery Index (Martland and McCullough 1984, Martland 1989, Martland 1999, Martland 2006). With this approach, productivity in the base year is the inverse of the operating ratio, which in fact is commonly cited by railroads as a measure of productivity. Since the measures of both output and input are directly tied to the normal accounting framework used in the industry, it is possible to investigate the causes of productivity changes (Figure 3). Changes in output can be directly related to changes in traffic mix, traffic volume, or revenue per ton, ton-mile or carload. Changes in input can be directly tied to specific aspects of operations, loss and damage (L&D), capital investment, or the makeup of the labor force.

Figure 3: Structure for Analyzing Railroad Productivity



Source: Martland and McCullough, 1984, p. 54.

Moving rail shipment requires various activities known as service units, including train-miles, car-miles, tons, and carloads. The number of service units required per unit of output depends upon actual traffic characteristics and operating conditions, e.g., average length of haul, network structure, operating plans, and train capacity. Resource requirements relate to appropriate service units, e.g., the number of track maintenance employees can be related to gross-ton-miles. Current year freight expense is the summation of the costs of all the inputs. Adjusting for increases in the unit costs for each input provides a measure of inputs for each year. With this framework, changes in overall productivity can reflect changes in rate indices and unit costs as well as changes in traffic characteristics, operating capabilities, and resource utilization. While this approach makes it possible to examine the sources of productivity improvement, it does not as readily deal with issues such as economies of scale, scope, and density that can be addressed within a well-defined economic approach.

OVERALL PRODUCTIVITY IMPROVEMENT 1966 to 2010

Although the primary focus of this paper concerns the post-Staggers period, it is necessary to begin well before 1980 in order to understand trends in performance and in order to have a basis for comparing performance before and after deregulation. This section presents measures related to the overall rate of productivity growth and trends in financial performance. Table 1 shows output, input, productivity, and the ratio of prices to costs for selected years, beginning in 1966. A measure of rail freight output (Row O3) was calculated by dividing the current year freight revenue (Row O2) by a rail price index based upon data published by the Surface Transportation Board (Row O1).[3] This output measure was then converted to an index in which 1985 = 100 (Row O4). Since prices fell steadily as a result of deregulation, this measure of output grew faster than freight revenues. A measure of rail freight input (Row I3) was calculated by dividing current year freight expense (Row I2) by the railroad cost recovery index published by the Association of American Railroads (Row I1). This input measure was then converted into an index in which 1985 equals 100 (Row I4). Although freight operating expenses were much higher in 2010 than in 1985, the input index was much lower. Productivity (Row P1) is the ratio of the output (Row O3) to input (Row I3). Two indices of productivity are shown, one with a base year of 1985 and one with a base year of 1995. The final row of the table shows the compounded annual rate of change:

(1) Rate of Change = $(\text{Productivity Year N})/(\text{Productivity Year 0})^{1/N} - 1$

For example, productivity increased from 230 in 1995 to 310 in 2000, an overall increase of 34.8%. The annual rate of increase was 6.166% (rounded off in the table to 6.2%). Over a five-year period, this rate of increase, compounded annually, would increase productivity by 34.8% (i.e., $(1.06166)^5 - 1 = .348$).

During this 44-year period in which output nearly quadrupled, input declined by nearly two thirds and productivity increased more than seven-fold, from 62 to 476. Productivity improvement was much greater after 1980. The annual rate of change, which was 2% between 1966 and 1980, accelerated to 9.4% in the late 1980s, then began a gradual decline, with productivity improvement of 2.9% per year between 2008 and 2010.

The ratio of the price index to the cost index (Row R1) declined throughout this period, although the ratio was fairly stable from 2005 to 2010. Prior to 1980, when railroad productivity growth was slow, inflation was a national problem. The railroads at that time complained that the Interstate Commerce Commission would not let them adopt general increases that would allow them to recoup their rising costs (Secretary of Transportation 2008; Lowtan 2004). However, rail rates rose by a factor of three between 1966 and 1980, and average constant dollar revenue per ton-mile in 1980 was just 3% less than in 1966 (Row R2). The problem for railroads in 1980 was that rail costs had been rising even faster than prices, and the ratio of the price index to the cost index fell from 1.64 to 1.23. After 1985, the price index actually declined, while the cost index continued to rise. In 2010, the ratio of the price index to the cost index (Row R1) was down to 0.277.

In general, when rates fail to keep pace with costs, profitability suffers unless productivity improvements can offset rising cost. Because the railroads were able to achieve rapid productivity growth over a prolonged period, they were able to increase their profitability despite rising costs and falling prices. If rail revenue per ton-mile in 2010 had been the same as in 1980, revenue would have been $112 billion rather than $56 billion ($56.3 billion x 4.86 cents/ton-mi / 2.45 cents/ton-mi = $112 billion). Rail revenue per ton-mile fell in part because of changes in traffic mix and in part because of reductions in rates.

Using a rail rate index eliminates the effects of traffic mix and inflation. If prices had remained at 1980 levels, and if there had been no change in traffic volume or traffic mix, then freight revenues would have been higher:

(2) Revenue at 1980 rates = Revenue Year N *(Price Index 1980/Price Index Year N)

For example, if rail rates had simply managed to remain at 1980 levels, then rail revenue for the traffic moved in 2010 would have been $75.7 billion ($56.3 billion x 94.2 / 70 = $75.7 billion), an increase of $19.4 billion. Revenue would have been higher if rates had risen to offset some of the effects of inflation.

While shippers have certainly benefited from lower prices, railroads have also benefited by having higher NROI. In current dollars, NROI rose from approximately $1 billion in 1980 to $10 billion in 2010 (Table 2, Row 1). As a percentage of freight revenues, NROI rose from 5% in 1980 to 17.7 % in 2010 (Table 2, Row 2). If NROI had remained at 5% of freight revenue, NROI would have been much lower in 1985 and in subsequent years (Row 3). For example, NROI would have been $2.9 billion rather than $10 billion in 2010, and the difference of $7.1 billion can be interpreted as the railroads' net gain from productivity improvements.

Row 6 in Table 2 shows the combined benefits to railroads and to their customers, while Row 7 shows that the greatest share of the net benefits went to customers in terms of lower prices[4] rather than to railroads in terms of higher NROI.

This section has documented the overall changes in outputs, inputs, productivity, and profitability. Productivity improvements have enabled the railroads to become more profitable while at the same time providing service at lower rates. Despite increases in output and unit costs, railroads were able to reduce the resources required to move their freight by more than a third over the past 25 years. In 2008 and 2010, when compared with a base year of 1980, benefits from productivity improvements averaged just over $25 million, and approximately three-quarters of these benefits were passed on to rail customers in the form of lower rates.

Table 1: Rail Freight Productivity, 1966 to 2010

		1966	1980	1985	1990	1995	2000	2005	2008	2010
Output										
O1	Rail Rate Index	31.7	94.2	100	80.8	67.2	58.8	60.8	71.7	70.0
O2	Freight Revenue, Class I (Billions)	$9.3	$26.4	$26.7	$27.5	$31.4	$33.0	$44.5	$59.4	$56.3
O3	Output (O2/O1)	.293	.280	0.267	0.340	0.467	0.562	0.731	0.828	0.804
O4	Output Index 1985 = 100	84	105	100	127	175	210	274	310	301
Input										
I1	RR Cost Recovery Index	19.4	76.7	100.0	120	138	161	205	257	253
I2	Operating Expense, Class I (Billions)	$9.2	$26.4	$25.2	$24.7	$27.9	$29.0	$37.8	$47.4	42.7
I3	Input (I2/I1)	.474	.344	0.252	0.205	0.203	0.181	0.185	0.184	0.169
I4	Input Index, 1985 = 100	188	136	100	81	80	72	73	73	67
Productivity										
P1	Productivity (O3/I3)	62	81	106	166	230	310	396	450	476
P2	Productivity Index, 1985 = 100	58	77	100	156	217	293	374	425	450
P3	Productivity Index, 1995 = 100	27	35	46	72	100	135	172	195	207
P4	Annual Rate of Change	n.a.	2.0%	5.4%	9.4%	6.8%	6.2%	5.0%	4.2%	2.9%
Relative Decline in Rail Rates										
R1	Ratio of Price Index to Cost Index (O1/I1)	1.64	1.23	1.00	0.67	0.49	0.37	0.297	0.279	0.277
R2	Revenue per Ton-Mile, (Constant 1995$, cents)	4.99	4.86	4.03	2.99	2.40	2.07	2.13	2.49	2.45

Data Sources: AAR, *Railroad Facts,* Various Editions for Rows O2, I1, and I2. For Row O1, see endnote 3.

Table 2: Sharing the Benefits Since 1980: Higher NROI and Lower Prices (Current Dollars)

		1966	1980	1985	1990	1995	2000	2005	2008	2010
Impact on Railroad Profitability										
1	NROI (billions)	$1.04	$1.3	$1.7	$2.6	$2.9	$3.9	$6.1	$9.2	$10.0
2	NROI as % of Freight Revenue	11.2%	5.0%	6.5%	9.6%	9.1%	11.9%	13.7%	15.3%	17.7%
3	Additional NROI, 1980 base	N.A.	0	$0.4	$1.3	$1.3	$2.3	$3.8	$6.2	$7.1
Savings to Shippers										
4	Operating Revenues, 1980 rates (billions)	N.A	$27.3	$25.1	$32.0	$44.0	$52.9	$68.9	$78.0	$75.7
5	Savings to shippers due to lower rates (billions of current dollars)	N.A	0	-$1.5	$4.6	$12.6	$19.9	$24.4	$18.6	$19.4
Total Benefits										
6	Total Benefits Realized (Additional NROI plus Savings to Shippers, billions)	N.A	0	-$1.1	$5.8	$13.9	$22.1	$28.3	$24.9	$26.5
7	Additional NROI as % of Total Benefits	N.A	N.A	N.A.	11.5%	5.0%	7.1%	9.9%	25.1%	26.8%

SOURCES OF PRODUCTIVITY IMPROVEMENT

The previous section used an aggregate approach to documenting the magnitude of productivity improvements that have been achieved by railroads. That approach simply compared output to input, where output was measured as freight revenue adjusted by a rate index and input was measured as freight service expense adjusted by a cost index. The results from the aggregate analysis indicate that the industry made substantial gains, but do not explain how those gains were achieved. This section uses a more detailed methodology to identify the sources of the improvements in productivity. It examines three major sources of improvement, namely fewer service units per unit of output, fewer resources per service unit, and network rationalization. The objective of this section is to demonstrate that there are quantifiable sources of productivity improvement that together account for the aggregate benefits of more than $25 million per year that have been gained by railroads and their customers despite rising unit costs.

Fewer Service Units per Unit of Output

If there had been no changes in traffic mix, length of haul, equipment, tons/load, or trip distances, then output measured as freight revenue adjusted by a rate index would track changes in carloads, tons, and ton-miles. In fact, all of these factors changed substantially, allowing output to grow faster than any of the service units (Table 3).

Table 3: Indices of Various Measures of Railroad Activity (1995 = 100)

	1980	1984	1990	1995	2000	2005	2008	2010
Revenue Ton-Miles (billion)	70	71	79	100	112	130	136	130
Freight Train-Miles (million)	93	81	83	100	110	120	115	104
Freight Car-Miles (billion)	96	86	86	100	114	124	122	117
Carloads (million)	95	85	90	100	117	131	129	123
Tons (million)	96	92	92	100	112	123	125	119
Output	60	61	73	100	121	157	177	172

Data Source: service units for Class I railroads as reported in AAR, *Railroad Facts*, various editions.

The ratios of service units to output declined dramatically from 1984 through 2008 (Table 4). From 1984 to 1995, the steepest decline was in tons/unit of output; from 1995 to 2008, the steepest decline was in freight train-miles per unit of output.

Table 4: Ratio of Service Units per Unit of Output (1995=1.00)

	1980	1984	1990	1995	2000	2005	2008	2010
Revenue Ton-Miles (billion)	1.17	1.16	1.09	1.000	0.93	0.83	0.77	0.75
Freight Train-Miles (million)	1.56	1.32	1.14	1.000	0.91	0.76	0.65	0.60
Freight Car-Miles (billion)	1.60	1.42	1.18	1.000	0.94	0.79	0.69	0.68
Carloads (million)	1.59	1.40	1.24	1.000	0.97	0.84	0.73	0.72
Tons (million)	1.16	1.51	1.26	1.000	0.93	0.78	0.70	0.69

Data Source: service units for Class I railroads as reported in AAR, *Railroad Facts*, various editions.

To understand why the output measure grew faster than any of the service units, consider the differences between typical coal and intermodal trains in 2008:

- Coal train: 110 cars, each with 114 tons of coal; revenue was $1841/car or $202,510 per train.
- Intermodal train: 200 containers, with an average of 14 tons each; revenue was $1,013 per container or $202,600 per train.

These two trains had essentially the same revenue, so they would have had essentially the same output if 2008 were the base year for a productivity study. However, the coal train hauled 12,500 tons of coal in 110 carloads, whereas the intermodal train hauled only 2,800 tons of freight in 200 loads. When intermodal grows faster than coal, then there are fewer tons and ton-miles, but more loads per unit of output. Changes in traffic mix, equipment type, average length of haul, and other factors have also affected the service units required per unit of output.

Table 5 shows the total number of service units that would have been needed if the ratio of service units to output were the same as in 1995. By comparing the numbers in this table with the actual numbers of service units, it is possible to estimate how many more or how many fewer units were actually used. The annual savings were estimated by assuming unit costs of $5/1,000 revenue ton-miles (track expenses), $5/train-mile (train crew and locomotive expense), $0.06/car-mile (car maintenance and ownership), and $150/Carload (administration and overhead). These same unit costs were used previously to represent typical costs per service unit in 1995 (Martland 1999).[5] In 1995, the total annual savings relative to 1980 was $2.8 billion (Table 6). In 2010, the annual savings relative to 1995 was $7.1 billion. The savings are additive, so the savings in 2010 relative to 1980 was nearly $10 billion. The largest portion of these savings came from the reduction in RTM per unit of output, which is closely related to the rise in intermodal traffic. The next largest portion came from the reduction in carloads per unit of output, which is related to increases in car capacity. Savings in freight-train-miles reflect the operation of longer, heavier trains. The following sub-sections provide more detail concerning the changes in traffic mix, length of haul, and train capacity.

Table 5: Service Units at 1995 Level of Service Units per Unit of Output

	1980	1984	1990	1995	2000	2005	2008	2010
Revenue Ton-Miles (billion)	552	562	753	1306	1574	2046	2318	2250
Freight Train-Miles (million)	275	279	333	458	552	718	813	789
Freight Car-Miles (billion)	18.3	18.6	22.2	30.5	36.8	47.8	54.1	52.5
Carloads (million)	14.2	14.5	17.3	23.7	28.6	37.2	42.1	40.9

Table 6: Estimated Savings in Billions of 1995 $ (negative numbers indicate higher costs relative to 1995)

	1980	1984	1990	1995	2000	2005	2008	2010
Revenue Ton-Miles	-$1.4	-$1.8	-$1.4	$0	$0.5	$1.8	$2.7	$2.8
Freight Train-Miles	-$0.4	-$0.4	-$0.2	$0	$0.2	$0.9	$1.4	$1.6
Freight Car-Miles	-$0.4	-$0.5	-$0.2	$0	$0.1	$0.6	$1.0	$1.0
Carloads	-$0.7	-$0.9	-$0.6	$0	$0.1	$0.9	$1.7	$1.8
Total Savings	-$2.8	-$3.6	-$2.5	$0	$1.0	$4.1	$6.9	$7.1

Traffic Mix. One of the most important trends affecting aggregate measures of productivity was the general shift in traffic mix toward commodities best suited for transportation by rail (Table 7). In 1969, a third of rail carloads consisted of coal, metallic ore, grain or other bulk commodities that could move in multi-car shipments or unit trains. Intermodal carloads, which do not require local switching, were less than 6% of carloads in 1969. Motor vehicles and chemicals, which can be effectively moved in highly specialized rail equipment, were less than 10% of rail freight carloads in 1969. The majority of rail traffic moved almost entirely in general freight service that involved complex terminal operations, extensive intermediate classification work, and complicated operating plans. Over time, bulk commodities remained a third of total carloads, while intermodal, automobiles and chemicals together accounted for another third. The remaining general freight traffic declined from more than half of the total prior to 1970 to barely a third in 2010. Railroad operations are no longer dominated by traditional carload services.

Table 7: Traffic Mix: Carloadings by Major Commodity Group, Selected Years

Commodities	1969	1980	1995	2003	2008	2010
Suitable for Unit Trains (Coal, Metallic Ore, and Farm Products)	33.1%	39.8%	34.8%	30.8%	33.0%	33.1%
Intermodal[6]	5.5%	7.4%	15.2%	19.7%	20.7%	20.6%
Specialized (Motor Vehicles and Chemicals)	9.3%	10.0%	12.8%	12.5%	11.0%	11.5%
All Other (General Freight)	52.1%	42.8%	37.2%	35.2%	35.4%	34.9%

Data Source: traffic data from AAR, *Railroad Facts,* various editions.

Length of haul. There was a steady increase in the length of haul from 503 ton-miles/ton in 1965 to 615 in 1980, to 843 in 1995, and to 919 in 2008 (AAR, *Railroad Facts*, various editions). Increasing the average length of haul appears to improve system productivity for several reasons. First, there are fixed costs unrelated to distance associated with each trip: obtaining an empty car, filing a waybill, and obtaining payment as well as the relatively high costs of pickup and delivery. Increasing trip length simply adds additional car-miles moving in long, heavy trains over the high-density main line network. Hence rail costs per car-mile decline with distance, allowing a similar reduction in rates. According to a study conducted by the Surface Transportation Board (Office of Economics 2009), average revenue per ton-mile for coal and grain declined by at least 25% between 1985 and 2003 for each of three distance categories (less than 500 miles, 500-1,000 miles, and greater than 1,000 miles). For both commodities, the average revenue per ton-mile for long distance trips was at least 50% lower than the average revenue per ton-mile for short distance trips. Thus, even if there are no actual changes in rates or operations, an increase in average trip length is likely to result in decreases in both average cost and revenue per ton-mile.

Train Capacity. Train productivity (net tons/train-mile) improved by 1%-2% per year from 1980 to 2006 as a result of increases in train length and increases in the average loading density. Increases in siding length, modifications to freight yards, and higher capacity facilities for loading and unloading bulk trains enabled railroads to increase average train length. R&D efforts helped produce stronger track components that allowed the industry to increase axle loads, while investments that increased clearances along major routes allowed operation of double stack container trains. The ability to run longer trains of heavier cars resulted in very significant increases in train capacity and the amount of freight handled by main line trains.

Table 8 shows that the gross tonnage of a typical general merchandise train increased by two-thirds over this period.[7] General merchandise trains carry a mixture of loaded and empty cars, so the table shows the average gross tons per train rather than net tons. The 50% increase in tons/car reflected the introduction of 50’ and 60’ boxcars as well as the increase in axle load limits. The increase in train length reflects the combined effect of two factors. First, the maximum train length increased as a result of railroad investments to extend the length of sidings and to modify the layout of classification yards to allow them to receive and assemble longer trains. Second, as part of ongoing efforts to reduce crew costs and to make better use of line capacity, the railroads adjusted their operating plans so that the average train length was closer to the maximum train length for general merchandise trains.

Table 8: Characteristics of Typical General Merchandise Trains, 1980 and 2006

	1980	2006	% Change
Gross tons per car (average of load and empty)	61	92	50%
Train length	5100	6400 feet	25%
Gross tons per train	4500	7500 tons	67%

Data Source: see End Note 7.

Table 9 shows that the net tonnage carried by a typical loaded bulk unit trains increased by about a quarter between 1980 and 2006. These trains were already quite efficient in 1980, as their train length was generally close to the maximum allowable train length. Further increases in train length therefore reflected increases in siding length rather than a change in operating philosophy. The increases in tons/car reflected the shift from the 263,000 lb. GVW of the early 1980s to the 286,000 lb. GVW that was standard by the beginning of the 21st century. The increase in the maximum GVW allowed an extra 12.5 tons per car to be loaded in existing cars beginning in 1990. An additional boost in load capacity resulted from constructing new equipment with lower tare weight; a 286,000 lb. car with an aluminum rather than a steel body can carry more than 120 net tons, a 20% increase over what could be carried in the steel 263,000 lb. cars used in 1980.

Table 9: Characteristics of Typical Loaded Bulk Trains, 1980 and 2006

	1980	2006	% Change
Eastern Railroads			
Net tons per loaded car	80	86	7.5%
Train length	100	112	12%
Net tons per loaded train	8,000	9,700	21%
Western Railroads			
Net tons per loaded car	100	112.5	12.5%
Train length	100	112	12%
Net tons per loaded train	10,000	12,600	26%

Data Source: see End Note 7.

The improvement in line haul productivity was greatest for intermodal trains. In 1980, the typical intermodal train used 89-foot flat cars for trailer-on-flat-car (TOFC) or container-on-flat-car (COFC) service. Double stack trains, which were first introduced in the early 1980s and which can handle twice as many containers as a COFC train, are now widely used for domestic as well as for international intermodal freight.

Sources of Productivity Improvement: Fewer Resources per Service Unit

The next major source of productivity improvements came from improvements in resource utilization. Analyses are given in this section for fuel, freight cars, labor, and track, because these are areas that made major contributions to productivity improvement.

Fuel Efficiency. In 1966, when the industry moved 744 billion revenue ton-miles (RTM), their fuel efficiency measured was 188 RTM/gallon. By 1995, efficiency had increased to 373 RTM/gallon; and by 2010, when the industry moved 1,691 billion RTM, efficiency had grown another 29% to 484 RTM/gallon (AAR, *Railroad Facts*, various editions). These benefits largely resulted from better management of operations and better locomotive technology. Total fuel costs are a function of fuel price, traffic volume, and fuel efficiency:

(3) Fuel cost = (Price per gallon) x RTM/(RTM per gallon)

If fuel efficiency had been at 1995 levels throughout the entire period from 1966 to 2010, then less fuel would have been needed in the earlier years and more fuel would have been needed in later years. Fuel costs would have been $600 million higher in 2010, assuming the price per gallon remained at the 1995 level of $0.60/gallon (1691 billion RTM/373 RTM per gallon – 1691 billion RTM/484 RTM per gallon = 4.5 billion gallons at 1995 levels of efficiency minus 3.5 billion gallons at 2010 levels of efficiency = 1 billion gallons saved, which means that $600 million would have been saved if the average fuel price had still been $0.60 per gallon). The benefits of higher fuel efficiency were actually $2.3 billion in 2010 because of the increase in fuel price from $0.60 to $2.24/gallon ($2.3 billion = $600 million savings at $0.60 per gallon x $2.24 per gallon / $0.60 per gallon). However, these efficiency savings were more than offset by the extra $5.7 billion in fuel costs related to the increase in fuel prices (3.5 billion gallons x ($1.64 per gallon - $0.60 per gallon) = $5.7 billion).

The cost of fuel has a marked effect on overall rail costs. In 2008, when diesel fuel cost peaked at an average of $3.12 per gallon, fuel accounted for 19.9% of operating revenue. In 1980, when fuel costs were also high in real terms, fuel was 11.8 % of revenue. In 1995, when costs declined to the levels of the early 1970s, fuel costs were only 6.5% of operating revenues.

Freight Car Utilization. Several trends stand out concerning freight cars (Table 10). First, the fleet is much smaller than it was in 1980, despite the increase in carloads from 22.2 million in 1980 to a peak of 30.6 million in 2008. Second, ownership shifted from railroads, who now own less than half of the fleet, toward customers and car supply companies. Third, average capacity increased dramatically. There are several main reasons for these trends. Changes in demand favored the growth of intermodal shipments and bulk commodities moving in unit trains. Equipment used for these rapidly growing market segments is highly utilized, with cycle times less than 10 days per load. Cycle times for general freight equipment exceed 20 days, because of the additional time required for loading, intermediate classifications, unloading, and empty distribution.

Table 10: Characteristics of the Freight Car Fleet, Selected Years 1966-2008

	1966	1980	1985	1990	1995	2000	2005	2008
Freight Cars (millions)	1.826	1.711	1.422	1.212	1.218	1.38	1.317	1.393
Ownership								
Class I Railroads	81.5%	68.3%	61.0%	54.4%	47.9%	40.6%	36.0%	32.3%
Other Railroads	1.9%	6.0%	7.8%	8.6%	7.0%	9.6%	9.1%	7.8%
Shippers & Other	16.6%	25.8%	31.2%	37.1%	45.2%	49.9%	54.4%	59.8%
Utilization								
Annual Carloads per car	16.2	13.2	13.7	17.7	19.5	20.1	23.6	22.0
Average Car Cycle (car-days per carload)	22.5	27.6	26.6	20.7	18.7	18.1	15.4	16.6
Average Capacity (Tons)	61.4	79.4	84.3	88.2	89	92.7	97.2	100.5

Source of Data: AAR, *Railroad Facts*, various editions.

The more than ten-day reduction in the average car cycle time reduced car costs per carload by more than $200 between 1980 and 2008, assuming ownership costs of $20 per day.[8] If cycle times had remained at 1980 levels, annual equipment costs would have been $6 billion/year higher by 2008 ($200 per load x 30.6 million loads > $6 billion). Most of these savings reflect changes in traffic mix rather than improvements in cycle times for specific types of equipment, as studies of rail freight service have not documented any long-term trends toward improvements for general service freight since the 1970s (Martland and Alpert 2007).

The shift in ownership also relates to traffic mix. High-volume customers, such as electric utilities, can justify owning or leasing their own equipment. Other customers, notably chemical companies, prefer to own or lease equipment to ensure equipment quality and cleanliness. If railroads' share of the fleet had remained at 1980 levels, they would have owned an additional 474,000 cars that were actually owned by customers and car supply companies in 2008 (Table 11). At $20/car day, the annual costs associated with these cars would be $3.46 billion. Shippers point to this as an example of costs that they have incurred that offset some of the lower rates that they have received since 1980.

Table 11: Impacts of Improvements in Car Cycle Time and Changes in Freight Car Ownership

	1980	1985	1990	1995	2000	2005	2008
Car Cost/Carload ($20/car day)	$553	$532	$413	$375	$363	$309	$332
Annual savings related to reduction in average cycle time since 1980 (Billions)	$0.0	$0.6	$3.9	$4.8	$4.8	$6.4	$6.0
Additional Cars Owned by Car Companies & Shippers After 1980 (millions)		0.078	0.138	0.237	0.332	0.378	0.474
Cost shifted to Customers (Billions)		$0.57	$1.00	$1.73	$2.43	$2.76	$3.46

Source of Data: analysis based upon information in prior table.

The percentage of shipments that can use general purpose, free-running equipment is a declining portion of rail traffic. The change in traffic has affected the composition of the car fleet. Box cars declined from a third of the fleet in 1966 to a quarter in 1980 and a twelfth in 2008, largely because much of the traffic base that supported the use of box cars and other general purpose equipment disappeared (Lewis 2012).

Labor Productivity. As depicted above in Figure 1, total Class I railroad employment dropped 22% from nearly 600,000 in 1966 to 460,000 in 1980, a decline of 1.6% per year. Employment dropped another 64% to 164,000 in 2008, a decline of 1.8% per year, despite increases in output. The fact that railroads are highly unionized did not prevent this very significant reduction in the work force, and labor agreements, which were re-negotiated periodically, shared productivity gains with employees in the form of higher wages. In constant 2005 dollars, wages increased from $16.02 in 1968 to $26.40 in 2008, which is an average rate of 1.25% per year compounded over the entire 40-year period.

The number of employees in each major category dropped dramatically between 1968 and 2008 according to data published annually by the AAR (AAR, *Railroad Facts*, various editions). The largest drop—nearly 90%—occurred for professional and administrative employees, because of the tremendous advances in communications and computers. A 70% reduction in maintenance of way employees resulted from the introduction of better track materials and better maintenance equipment. Similar reductions were achieved for maintenance of equipment, reflecting the use of larger cars with better components and more modern maintenance facilities, but also the shift of fleet ownership away from the Class I railroads. The number of train and enginemen (i.e. engineers, firemen, conductors, and brakemen) declined 64% because of the loss of merchandise traffic, the reduction in yard activity, labor agreements that reduced crew consist and changed work rules, the operation of longer and heavier trains, and the shift of many light density lines and smaller terminals to short lines and regional railroads.

A measure of labor productivity can be obtained by relating the total number of employees in each category to the number of service units that are most closely related to that category. Table 12 shows indices of employees per service unit, with 1995 = 100. The improvement in employee productivity was even greater than the sharp decline in the number of employees. The index of executives, officials, and assistants per carload fell by more than 50% between 1980 and 2008. Professional and administrative employees per carload dropped by 90% largely because of advances in computers and communications, while maintenance employees per service unit, both for track and for equipment, dropped to a quarter of their 1980 level by 2008. Transportation T&E (train and enginemen) declined less rapidly than the other operating categories, particularly between 1995 and

2008. Other transportation, which includes yard employees, continued its steady decline throughout the entire 40-year period.

Table 12: Employees Per Service Unit, by Category (1995 =100)

	Service Unit	1968	1980	1995	2008
Executives, Officials and Assistants	Carloads (millions)	124	170	100	74
Professional & Administrative	Carloads (millions)	397	362	100	39
Maintenance of Way & Structures	Revenue ton-miles (billions)	390	300	100	65
Maintenance of Equipment & Stores	Car Miles (millions)	361	280	100	68
Transportation, Other than T&E	Train Miles (millions)	678	325	100	61
Transportation, T&E	Train Miles (millions)	277	228	100	93

Source of data: AAR, *Railroad Facts*, various editions.

The continuing improvements in employee productivity had a significant effect on the workforce and the payroll of the Class I railroads. The number of employees in any category can be shown as a function of workload and a measure of labor productivity:

(4) Employees = Service Units x (Employees per Service Unit)

The total payroll can be calculated as a function of the size of the work force, the average wage, and the benefits percentage (i.e., average benefits expressed as a percentage of the average wage):

(5) Payroll plus benefits = Employees x Average Wage x (1 + Benefits Percentage)

These two equations make it possible to estimate the benefits associated with improvements in labor productivity using wage rates and benefits percentage for each major category of employees for any desired base year. Table 13 shows rail employment by category for 1980, 1995 and 2008 along with two additional columns: 1) the number of employees that would have been required in 1995 assuming that labor productivity (service units per employee) had remained at 1980 levels for each category of employment and 2) the number of employees that would have been required in 2008 assuming that productivity had remained at 1995 levels.

If labor productivity had not improved, then total 1995 employment would have increased by 328,000 to 516,000, and total wage payments would have added $15.0 billion to railroad operating costs. These estimates are based upon the average wage rates and the changes in employment for each category of employees. The final row of Table 13 calculates the average savings per employee as the total savings in wages divided by the total reduction in employees.

Additional costs would also have been incurred related to railroad retirement and other employee benefits (which equaled 38.5% of wages in 2008). If labor productivity had remained at the 1995 levels until 2008, the workforce in 2008 would have included 236,000 people, adding $3.2 billion to the payroll. In other words, if labor productivity had not improved, the work force would have expanded to keep up with the increases in carloads, RTM, car-miles, and train-miles. By 2008, the added payroll would have been over $18 billion higher relative to 1980, and the total additional cost including benefits would have been on the order of $25 billion per year. And these numbers are all calculated using 1995 wage levels, when the average wage was $19/hour. In 2008, when the average wage was $30/hour, annual savings from labor productivity were $39 billion in current dollars.

Table 13: Savings Resulting from Improvements in Labor Productivity (Constant 1995 $)

	1980 Employees	1995 Employees, 1980 Productivity	1995 Employees	2008 Employees, 1995 Productivity	2008 Employees
Executives, Officials and Assistants	17,328	18,193	10,708	13,979	10,183
Professional & Administrative	92,780	97,411	26,940	36,522	13,637
Maintenance of Way & Structures	84,390	120,058	40,033	55,405	35,664
Maintenance of Equipment & Stores	99,614	103,724	37,106	45,866	30,659
Transportation, Other than T&E	29,141	31,184	9,597	11,373	6,664
Transportation, T&E	135,741	145,256	63,831	73,131	67,632
Total	458,994	515,826	188,215	236,277	164,439
Reduction in employees			327,611		71,838
Total Savings			$15.0 billion		$3.2 billion
Average wages saved per position			$46,000		$44,000

Data Source: AAR, *Railroad Facts*, various editions.

Improved Track Materials and Track Maintenance Technology. When 100-ton cars were introduced in the 1960s, the railroads reduced operating costs because more tons could be carried in each car and heavier trains could be handled without having to increase siding lengths or changing yard layouts. However, the heavier cars put much greater stress on the track structure at a time when many railroads were dealing with financial problems by deferring maintenance. As a result, track costs rose during the 1970s, spurring the industry toward the development of better rail, stronger track structures, and more effective maintenance practices, which ultimately led to longer rail and tie lives and reduced maintenance requirements (Table 14). Despite the fact that wheel loads increased again in 1990, the tons of rail replaced and the number of new ties installed declined. Using approximate 1995 costs of $300,000 per mile of rail and $40 per tie,[9] the annual cost of track maintenance dropped by 50% between 1980 and 1995. The cost per 10,000 revenue ton miles dropped even more. After increasing 18% between 1966 and 1980, costs declined 65% by 1995, dropping from $39.13 to $13.61. If rail and tie replacement had continued at the 1980 level, costs would have been $2.3 billion higher in 1995 and $2.1 billion higher in 2010. For more detailed information concerning track technology, track costs, and track productivity, see Chapman and Martland (1997 and 1998).

Table 14: Track Maintenance Costs for Materials and Equipment (estimated 1995 cost of $300,000 per mile of rail and $40 per tie)

	1966	1980	1995	2008
Revenue Ton-Miles (billion)	738	918	1306	1777
Maximum Gross Vehicle Weight (1000 lbs.)	263	263	286	286
Estimated Cost for Rail and Tie Programs (1995 $)	$2.5 billion	$3.6 billion	$1.8 billion	$2.2 billion
Cost/10,000 RTM (1995 $)	$33.22	$39.13	$13.61	$12.53
Extra Cost Relative to 1995 (1995 $)	$1.5 billion	$2.3 billion	0	($0.2 billion)

Data Sources: C.D. Martland, P. Lewis, and Y. Kriem, 2011.

Sources of Productivity Improvement: Network Rationalization

Line Abandonment. The U.S. rail network has been shrinking since the 1920s, when railroads began to shed underutilized lines and restructure their systems to meet changing demands for rail transportation. In 1950, there were approximately 225,000 miles in the U.S. Rail System. Over the next 60 years, 65,000 route-miles were abandoned and another 19,000 were converted to rail trails, leaving 140,000 route-miles in operation in 2009 (Table 15).

Table 15: Changes in the Size of the U.S. Rail System 1950 to 2010

Decade	Initial Route Miles (1000s)	Miles Abandoned During Decade	Route-Miles, End of Decade (1000s)	Route-Miles Operated, End of Decade (1000s)	Open Rail Trails (1000s)
1950-59	225	8,776	216	N.A.	N.A.
1960-69	216	12,640	203	N.A.	N.A.
1970-79	203	19,770	183	N.A.	N.A.
1980-89	183	18,920	165	158	N.A.
1990-99	165	4504	160	144	N.A.
2000-09	160	315 (2000-2004)	159	140	19

Source of data: miles abandoned from ICC and STB Annual Reports, as summarized by Ozment and Spraggins (2008); route-miles calculated by subtracting miles abandoned from initial route miles; route-miles operated from summary of miles operated by state in *Railroad Facts*, 1990, 2000, and 2010; rail trails from website of Rail-to-Trails Conservancy website (accessed July 7, 2011).

When lines are no longer operated, abandoned, or converted to rail trails, the minimum annual maintenance to keep a line operational is no longer needed. The greatest savings will usually relate to ties, because ties deteriorate no matter how few trains are run. There are on the order of 3,000 ties per mile on a light density line; if 100 are replaced each year at a cost of $60 each for labor and materials, the annual cost would be $6,000 per mile. The annual savings in tie replacement and all other routine maintenance activities would be in excess of $10,000 per mile. If unprofitable operations were ceased, annual savings could be twice as large. For example, a study of abandonment applications between 1951 and 1960 found average annual savings of $4,600 in 1973 dollars, which would be $18,000 in 2009 dollars (Sloss, Humphrey and Krutter 1975). Using this estimate of savings per mile abandoned, the benefits to the rail industry of eliminating 70,000 miles of light density lines would exceed $1 billion per year.

Short Line and Regional Railroads. Between 1980 and 2008, the Class I railroads transferred nearly 30,000 route-miles to short-line and regional railroads, many of which were newly formed as a means of maintaining service on these lines. By the end of this period, approximately 550 small railroads operated a third of the industry's route-miles, originated or terminated more than a third of the rail industry's general merchandise traffic, and earned more than $3 billion in revenue.

Table 16: Route-Miles Operated

Category	1967	1980	1987	1995	2008
Class I	198,603	164,822	147,568	125.072	94,082
Regional			15,100	18,815	16,690
Local			14,534	26,546	28,554
Switching & Terminal			4,011		
Total Non-Class I	11,223	18,255	33,645	45361	45244
Total	209,826	183,077	181,213	170,433	139,887
Non Class I as % of Total	5%	10%	19%	27%	32%

Source of data: *Railroad Facts*, 1982, p. 42 (totals for 1967 and 1980); *Railroad Facts*, 1984, p. 42 (Class I mileage for 1967 and 1980); *Railroad Facts*, 1988, 1996, and 2009.

Mergers. The number of Class I rail systems declined from more than 40 during the 1970s to just seven in 2010. The role of mergers in improving productivity is difficult to quantify, and the most recent major mergers all resulted in lengthy periods of confused operations and poor customer service. Nevertheless, mergers create larger railroads with more opportunities for line and terminal consolidation, and they facilitate comprehensive, integrated planning for operations and investments. With a broader perspective concerning network structure and the ability to route traffic over multiple routes, a large railroad can implement coordinated marketing, operating, and investment strategies, tasks that were much more difficult when multiple railroads owned small pieces of the network.

Terminal Consolidation and Transformation. During the 1960s and 1970s, many railroads invested in hump yards in order to reduce terminal costs, increase capacity and improve service. Most were built to handle 2,000 to 3,000 cars per day, and each allowed multiple small yards to be closed or downgraded. When general merchandise traffic collapsed in the early 1980s, this spurt of yard construction ended abruptly. Mergers of the Class I railroads made it feasible to eliminate redundant facilities, while changes in traffic mix and the competitive environment made it necessary to restructure old class yards as intermodal terminals.

SUMMARY OF PRODUCTIVITY IMPROVEMENTS

The rail industry in recent years has been more productive and more profitable than at any other time since World War II. More traffic moves over the system, rates are lower for most customers than they were in 1980, and resources are used more effectively. Mainline operations have been consolidated to the extent that seven Class I major railroads dominate the industry. Longer, heavier trains operate over tracks that handle traffic volumes unimagined in the 1970s.

Productivity improvements have been essential to the current prosperity of the industry. Changes in traffic mix, better railroad technology, vastly improved information technology and the growing role of short line railroads allowed Class I railroads to cut their workforce from nearly 600,000 in 1968 to 164,000 in 2008. The industry was able to achieve very substantial improvements in labor productivity despite the fact that it remained highly unionized. Changes in work rules and wage rates resulted from negotiations between management and labor, which limited the pace, but not the ultimate extent of improvements. The workforce shrank largely through attrition, and wages grew faster than inflation.

Between 1980 and 2010, productivity improvements ultimately led to annual cost savings of approximately $60 billion per year. The greatest savings came from two independent sources[10]:

- Reductions in service units per unit of output. If the traffic mix and operating conditions in 2010 had been the same as in 1980, there would have been many more RTM, train-miles, car-miles, and carloads, and annual operating costs would have been $10 billion higher.
- Reductions in resources per service unit ($49 billion per year). If resource utilization had remained the same in 2010 as in 1980, the industry would have needed many more employees, much more diesel fuel, more freight cars, more rail and more ties, and annual operating costs would have been $49 billion higher.
    - Labor productivity measured as service units per employee for major categories of rail employment ($39 billion per year)
    - Fuel efficiency, measured as RTM per gallon ($2 billion per year)
    - Equipment utilization, measured as average car-days per load ($6 billion per year)
    - Track costs (2 billion/year)

Additional savings came from network rationalization, including $1 billion annually related to the reduction in the number of track-miles operated. The total savings, which reached $60 billion per year by 2010, are indeed sufficient to explain how the Class I railroads were able to increase their profitability even though they faced rising unit costs for labor and materials and falling rail rates because of increased competition within the freight transportation market.

The great majority of the productivity benefits went to rail customers. Until recently, railroads retained well under 20% of the benefits in terms of increases in net railway operating income. Customers benefited because rates not only did not keep pace with inflation, they actually declined. In constant dollars, there was more than a 50% decline in average revenue per ton-mile from 1980 to 2010. If average revenue per ton-mile had kept pace with inflation, then rail revenues would have increased by more than $50 billion in recent years. However, even following several years of rail rate increases related to rising fuel prices, rail rates remained lower than they were in the early 1980s. Average revenue per ton-mile was 3.18 cents in 1981, the first full year after the Staggers Act; between 2006 and 2010, average revenue per ton-mile was just 3.12 cents. Based upon the Surface Transportation Board's rail rate index, rail customers saved $20-$25 billion per year in recent years because rates were lower than they were in the early 1980s.

Productivity improvements have helped the railroads to overcome the difficulties of the 1970s and to rationalize their network. In the 1970s, the prospect of rail line abandonments caused controversy among railroads, their customers, and state and local governments. Federal legislation made it easier for railroads to abandon lines, but at the same time encouraged the revitalization of remaining light density lines by transferring them to short-line or regional railroads, many of which were created after 1980. Today, the remaining light density lines are in better physical condition, they have managers focused on local conditions, and most enjoy prospects for further growth.

The traffic base of the railroads changed dramatically over the past 50 years. In 1968, general freight traffic dominated the system, unit trains of coal and grain were secondary, and piggyback service was negligible. Over time, intermodal traffic became much more important, while traditional single-car shipments declined; both trends reflect the globalization of the economy. Most intermodal traffic consists of international containers, a market more suited to railroad capabilities than general domestic freight, which has steadily shifted to truck. Small shipments, shorter-distance shipments, and shipments from customers with smaller annual volumes are now much less likely to move by rail.

Productivity improvements in the rail industry can be traced to specific technological, managerial, or institutional causes. For example, labor productivity improved largely because of technological and institutional innovations. The widespread use of computers and communications allowed reductions in clerical and professional staff. Labor negotiations led to reductions in crew consist, changes in the basis of pay, and more flexible operating rules. Research by the railroads, suppliers, and the federal government led to better materials and maintenance techniques that reduced the need for track maintenance; new track machinery reduced the time and labor required to maintain and upgrade track.

Resource utilization improved largely because of technological and operational innovation coupled with investment decisions concerning railroad equipment and infrastructure. Suppliers built more powerful, reliable, and fuel efficient locomotives. Railroads and suppliers strengthened the track structure to allow heavier loads and introduced larger, more efficient freight cars. Double-stack container trains reduced the cost of intermodal transportation by nearly half, thereby making intermodal much cheaper than trucks for moving containers. Railroads, at times with financial support from public agencies, lengthened sidings, increased clearances and modified yard layouts in order to allow longer trains and larger freight equipment.

CONCLUSION

By the mid-1990s, the long, slow process of rationalization was essentially complete. Rationalization eliminated hundreds of unnecessary lines and terminals that were left over from the 19th century, when railroads dominated intercity transportation. The underutilized facilities and unprofitable branch lines that plagued the railroads during the Northeast Rail Crisis of the 1970s were gone or revitalized. The system was smaller, but it had more capacity and it was better suited to the long-haul, high-volume traffic that moves most efficiently by rail. The organizational structure of the industry was stronger, and the largest railroads offered single-line service to vast regions of the country. Numerous small railroads continued to serve thousands of customers on light density lines and offered sites for industrial development that had competitive access to multiple Class I railroads.

Although the Staggers Act is frequently cited as the dominant factor causing productivity improvements in the rail industry, this act was only one element of federal actions taken to buttress the rail industry during the 1970s and 1980s. Legislation resulting from the Northeast Rail Crisis created Amtrak and Conrail, helped accelerate the rationalization process, and introduced more flexibility in pricing, including contract rates. The U.S. Department of Transportation constructed the Transportation Test Center in Pueblo, supported a great deal of research related to track quality and railroad safety, and worked with the railroads and suppliers to build the research underpinnings of a new generation of track materials and maintenance techniques. While Staggers provided much more pricing freedom, it led to two decades of declining prices. Staggers was undoubtedly good for most rail customers, who enjoyed lower rates, but the railroads survived only because of their success in improving productivity.

Many of the rail industry's actions that led to productivity improvements simply continued efforts that were begun well before 1980. Railroads have been pursuing mergers, facility consolidation, and other network rationalization activities since the 19th century (Locklin 1966). The R&D efforts that enabled improvements in track and equipment also continued ongoing efforts since the 19th century. The labor agreements that allowed crew consist reductions for essentially all the Class I railroads by the early 1990s culminated negotiations that began in the 1950s, that resulted in major work stoppages in the 1960s, and that only began to be resolved in the mid-1970s when a few small railroads agreed to share the potential cost savings with their employees (Martland 1983).

Information technology was another vital factor that had nothing to do with deregulation. The potential of computers was evident in the 1960s, when railroads began introducing information systems that ultimately eliminated rooms full of clerical employees, enabled consolidation of offices, and extended planning and control capabilities. Railroad managers deserve credit for recognizing the potential of computers and communications for managing their systems.

In the future, continued emphasis on productivity improvement could have negative implications related to capacity and public policy. In 1980, the rail industry was far more concerned about over-capacity than under-capacity, and railroads could advance by cutting back. Today, railroads must invest to increase capacity. Between 2006 and 2010, the Class I railroads invested more than $9.4 billion per year in track and equipment, which was 18% of their total freight revenue. Whether or not the industry will continue to be willing and able to make such investments remains to be seen, as railroads may continue to focus on traffic best suited to rail, leaving a growing volume of shorter haul, lower volume freight shipments on the highways.

Although rail's share of total intercity ton-miles recently returned to where it was in the late 1960s (42.7% in 2007 vs. 41.4% in 1967), truck's share increased much more rapidly, from 22% to 31% over that same period (BTS 2011). Many public agencies would like to reverse this trend by moving freight from truck to rail, which will require a coordinated effort involving railroads, suppliers, and public agencies. John Horsley, executive director of the American Association of State Highway and Transportation Officials, summarized the challenges in his foreword to his organization's assessment of investment needs for the rail freight industry:

> *Given the forecasts of substantial increases in freight over the coming years, it will be a challenge for the freight-rail industry to maintain its share of freight movement, and an even greater challenge to increase it.* (AASHTO 2003, p. i)

Endnotes

1. The Regional Rail Reorganization Act of 1973 led to the creation of Conrail and the Regional Revitalization and Regulatory Reform Act of 1976, eased abandonment procedures, allowed rate flexibility, authorized contract rates, and also required intensive studies of the fundamental causes of and potential solutions to the "railroad problem."

2. This paper estimates changes in productivity by comparing peak years to avoid interpreting factors related to the business cycle as changes in productivity. Peak years, based upon trends in profitability and return on investment, were 1966, 1980, 1995, and 2008. Data for 2010 for intervening years are sometimes included to give additional insight to trends in performance. Unless otherwise noted, data were obtained from *Railroad Facts*, published annually by the Association of American Railroads.

3. The STB rail rate index was used where possible (Office of Economics, Environmental Analysis & Administration, 2009). For earlier and later years, the index was extrapolated using the change in the average constant dollar revenue per ton-mile as reported by the AAR in *Railroad Facts.*

4. Some of these savings were offset by the fact that substantial costs related to equipment were transferred to customers, some of whom had to invest in higher-capacity loading facilities to take advantage of unit train rates.

5. These unit costs per service are similar to the unit costs used in various studies conducted by MIT Rail Group in cooperation with the AAR and individual railroads during the mid-1990s. They were intended to represent the costs associated with moving freight over the main-line railroad system in the United States and Canada circa 1995. As in the much more detailed

service unit costing used in regulatory proceedings, double-counting is avoided by allocating specific categories of expenses to specific service units. For example, in the simplified approach used in this paper, a) equipment maintenance costs are allocated to car-miles and equipment ownership costs to fleet size, b) maintenance of way labor costs are allocated to ton-miles, while materials and equipment cost are allocated to the level of rail and tie replacements, and c) crew costs are allocated to train miles, while fuel costs are allocated to ton-miles. Some costs are left out of this simplified approach, but none are double counted.

Because of the rail industry's productivity gains, unit costs per service have been fairly constant despite marked productivity growth. The STB publishes a quarterly index of railroad inflation (the Rail Cost Adjustment Factor or RCAF) that includes both an unadjusted measure that is equivalent to the AAR's Railroad Cost Recovery Index (RCR) and a measure that is adjusted for productivity. Both the RCAF and the RCR are published annually by the AAR in *Railroad Facts*. The unadjusted RCAF rose 104% from 1987 to 2010, which is similar to the 117% increase in the RCR over that period. When adjusted for productivity improvements, the RCAF fluctuated, but the trend was stable, averaging 0.521 in 1987, 0.515 in 2008, and 0.520 in 2011. Thus, the costs per service unit in 1995, which are based upon 1995 costs and productivity, are believed to be representative of costs per service unit for the entire period from 1987 to 2011.

6. Intermodal carloads as reported by the AAR for 1969 and 1980; 60% of the total of "Miscellaneous Mixed Freight" and "Other" carloads for later years.

7. Source of data for Tables 8 and 9: C.D. Martland, "Productivity Improvements Related to Train Length and Tonnage," unpublished memo dated February 8, 2010. This memo documented typical train characteristics by synthesizing data from studies conducted for individual railroads, FRA, AAR, and TTCI between 1971 and 2007.

8. The cost of freight cars varies with the type of car; new box cars, gondolas, and hoppers acquired since 2000 have cost an average of $71,000; the average new car in 2010 cost $75,000 (AAR, *Railroad Facts* 2011). The car cost savings are based upon average ownership costs of 10% of the purchase price, rounded off to $7,300 per year or $20 per car-day.

9. These approximate numbers assume renewal of ballast and replacement of turnouts as well as replacement of the rail. The cost includes the cost of materials and track equipment, but not the cost of labor, which is captured elsewhere in the analysis.

10. The reduction in service units per unit of output and the reduction of employees per service unit are two different aspects of productivity improvement whose combined effects, along with changes in output and unit costs, will determine the magnitude of labor cost savings. For example, if train length increases, then fewer train-miles and fewer train crews will be needed, i.e., there will be a reduction in service units per unit of output. If the size of the train crew decline from more than four to less than three, and if the length of the average crew district increases, then there will be fewer train crew members per train-mile, i.e., there will be a reduction in employees per service unit. The labor costs associated with train crew members, or any other class of employees, is calculated as follows:
    (a) Payroll(t) = Employees(t) x Average Wage(t) (1 + benefit percentage(t))
    (b) Employees = Service Units(t) x Employees per Service Unit(t)
    (c) Service Units = Output(t) x Service Units per Unit of Output(t)

    Solving these equations for a base year and another year will show how much payroll increased, and it will be possible to determine the extent to which changes in any of the factors resulted in a change in total labor cost, i.e., in the payroll for this category of employees. In this paper, the savings related to service units per unit of output (i.e., equation (b)) are discussed in relation to Table 6, assuming 1995 labor productivity, wage rates, and unit costs per service unit; as discussed in Endnote 5, the costs per service unit have been stable going back at least to 1987. The savings related to employees per unit of output (i.e., equation (c)) are discussed in relation to Table 13, which shows savings based upon average wages for 1995. The paper then adjusts for the changes in wage rates to estimate current savings.

References

AASHTO. *Freight-Rail Bottom Line Report*. American Association of State Highway and Transportation Officials, 2003.

Association of American Railrods. *Railroad Facts*. Association of American Railroads, Washington D.C., various editions.

Bereskin, C. Gregory. "Railroad Economies of Scale, Scope, and Density Revisited." *Journal of the Transportation Research Forum* 48 (2), (2009): 23-38.

Bureau of Transportation Statistics. *National Transportation Statistics* 2011. U.S. Department of Transportation, 2012.

Chapman, J.D. and C.D. Martland. "Railroad Track Productivity: A Historical Perspective." *Transportation Quarterly* (Summer 1997): 105-118.

Chapman, Jeffrey D. and Carl D. Martland. "The Effects of Fixed Plant and Rolling Stock Technology on Railroad Track Costs." Presentation to the American Railroad Engineering and Maintenance Association (AREMA), Chicago, IL, Sept. 15, 1998.

Christensen Associates. *An Update to the Study of Competition in the U.S. Freight Railroad Industry.* Final Report for The Surface Transportation Board. L.R. Christensen Associates, Inc., Madison, WI, January 2010.

Gómez-Ibáñez, J. A. and G. de Rus. *Competition in the Railway Industry.* Edward Elgar, Northampton, MA, 2006.

Hamberger, Edward R. "The Anniversary of Our American Express Story." *The Huffington Post,* October 8, 2010.

Lewis, Paul. "Analysis of Rail Freight Traffic: Gaining a Better Understanding of the Industry and the Factors that Influence Traffic." *Proceedings, Transportation Research Forum.* Transportation Research Forum, Fargo ND, 2012.

Locklin, Philip. *Economics of Transportation.* Richard D. Irwin Inc, Homewood, IL, 6th ed, 1966.

Lowtan, Donovan. "Assessing the Impact of Regulation and Deregulation on the Rail and Trucking Industries." Thesis (MST). Massachusetts Institute of Technology, February 2004.

Martland, C.D. "Workload Measurement and Train Crew Consist Adjustments: The Boston & Maine Experience." *Transportation Journal* 21 (3), (1983): 34-57.

Martland, C.D. "Improving Railroad Productivity: Implications of U.S. Experience for Canadian Railroads." *Journal of the Transportation Research Forum* 29 (2), (1989): 427-436.

Martland, Carl D. “Productivity and Prices in the U.S. Rail Industry: Experience from 1965 to 1995 and Prospects for the Future.” *Journal of the Transportation Research Forum* 38 (1), (1999): 12-25.

Martland, C.D., “Productivity, Pricing and Profitability in the U.S. Rail Freight Industry, 1995-2004.” *Journal of the Transportation Research Forum* 45 (3), (2006): 93-108.

Martland, C.D. and Steven Alpert, “Origin-to-Destination Performance for General Merchandise Traffic Moving to or from Short Line Railroads.” *Journal of the Transportation Research Forum* 46 (3), (2007): 51-68.

Martland, C.D., P. Lewis, and Y. Kriem. *Productivity Improvements in the US Rail Freight Industry 1980 to 2010.* Final Report. MIT School of Engineering, August 2011.

Martland, C.D. and Gerard McCullough. *Improving Railroad Productivity*. MIT Center for Transportation Studies, 1984.

Morrison, S.A. and C. Winston. “Regulatory Reform of U.S. Intercity Transportation.” Gómez-Ibáñez, J. A., W.B. Tye, and C. Winston, eds. *Essays in Transportation Economics and Policy*. Washington, D.C.: Brookings Institution Press (1999): 469-492.

Office of Economics, Environmental Analysis & Administration. *Study of Railroad Rates: 1985-2007*. Surface Transportation Board, January 16, 2009.

Ozment, John and Barry Spraggins. “A Study of Long Term Economic Impact of Rail Line Abandonments.” *Journal of Academy of Business and Economics* 8 (4), (2008).

Secretary of Transportation. *A Prospectus for Change in the Freight Railroad Industry*. U.S. Department of Transportation, 1978.

Sloss, James, Thomas J. Humphrey, and Forrest Krutter, *An Analysis and Evaluation of Past Experience in Rationalizing Railroad Networks.* Studies in Railroad Operations and Economics 16. MIT Department of Civil and Environmental Engineering, 1975.

Acknowledgement

This paper summarizes some of the major results of a study of railroad productivity conducted at MIT (Martland, Lewis, and Kriem 2011).

***Carl D. Martland** retired from MIT in 2007, but continues to work with the rail industry and public agencies on research related to transportation systems. A senior research associate and lecturer in the MIT Department of Civil and Environmental Engineering, he was the director of the MIT Rail Group from 1978-2001 and the program manager of the Association of American Railroad's Affiliated Research Laboratory at MIT from 1983-2001.*

Martland has taught project evaluation, engineering systems design, freight transportation management, transportation systems analysis, and transportation demand & economics at MIT. The author of more than 120 papers and research reports, he recently published a textbook "Toward More Sustainable Infrastructure: Project Evaluation for Planners and Engineers." In 1991, he was a co-author of the paper that won TRF's Outstanding Paper Award; in 1989, 1990, 1991, 1993, and 1994 he won the Conrail Award for the Best Paper on Railroads presented to TRF. In 1997, TRF selected Martland as the recipient of the Distinguished Transportation Researcher Award "in recognition of his pioneering the planning and costing techniques that are now commonly used by many U.S. railroads; his research has aided the revitalization of America's railroads, improving their efficiency, productivity, and service quality."

Martland has been active in professional organizations, including TRF, INFORMS, and TRB. He was TRF's program vice president in 1984 and president in 1986; in 1991, he was selected to be the second recipient of the Herbert O. Whitten Award for lifetime service to TRF. In 1998, Martland served as the president of the Rail Applications Special Interest Group of INFORMS.