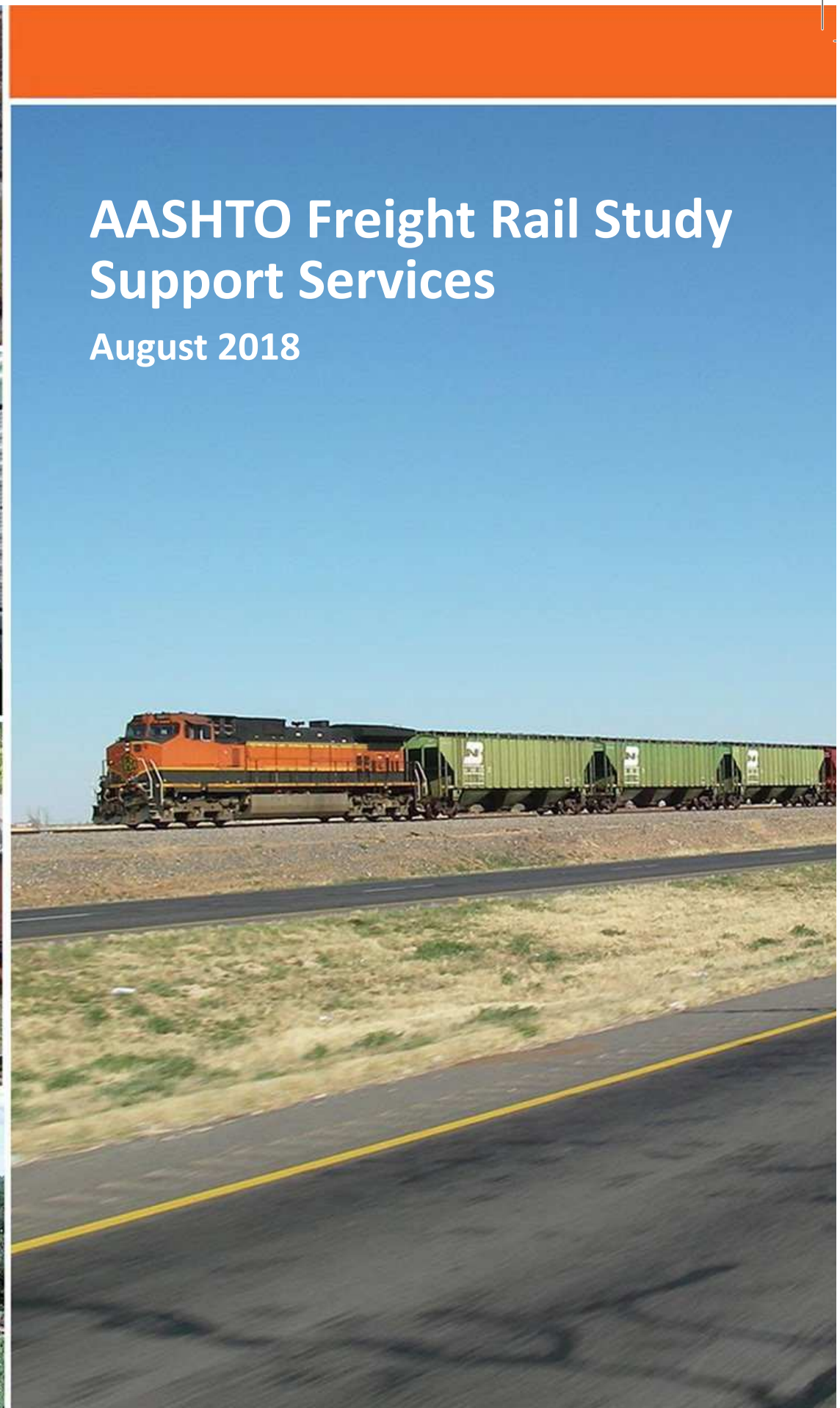


AASHTO Freight Rail Study Support Services

August 2018



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Background to This Document

In 2002 AASHTO published the *Freight-Rail Bottom Line Report (2002 Report)*. That report found that:

- If all freight carried by rail were shifted to trucks, this would add 92 billion vehicle-miles-of-travel to the highway system and cost federal, state, and local transportation agencies an additional \$64 billion over a 20-year period.
- With the assumption that all freight carried by rail were shifted to trucks, railroad customers would pay an additional \$1.4 trillion in freight charges over a 20-year period.
- Freight rail is crucial to the competitiveness of U.S. industries in international trade, and provides environmental health and safety benefits, and is vital in the event of national emergencies.
- Freight rail productivity had increased since the deregulation of the industry in 1980 and freight rates had fallen, but productivity gains and competitive rates were not sufficient to rebuild rail market share and provide railroads with sufficient revenue for investment in required assets.
- Rail productivity improvements had primarily accrued to shippers and the economy in the form of rate reductions, rather than to the railroads and their investors. Railroads were profitable enough to operate but could not cover their capital costs, let alone grow rapidly.
- Without investment from external sources, railroads were projected to lose market share.
- Relatively minor investments in the rail network would be more than compensated by resulting public benefits.
- Traditionally, public participation in rail system investments addressed local issues: grade crossings, branch lines, and commuter rail service. There was a need to treat the key network capacity issues: nationally significant corridor choke points, intermodal terminals and connectors, and urban rail interchanges.
- A “market-driven evolution” of the freight rail system would relieve little of the projected congestion on the highway network, whereas a “public-policy-driven” expansion could produce a rail industry that provides cost-effective transport needed to serve national and global markets, relieve pressure on overburdened highways, and support local social, economic environmental goals.
- This requires a new partnership between railroads, the states, and the federal government.

Whether the *2002 Report* was influential or whether it simply reflected prevailing sentiments, the publication of the study was followed by a number of high-profile partnerships similar to that which the report prescribed, including,

- Intermodal rail clearance and capacity improvement projects, such as the Heartland Corridor, National Gateway, and Crescent Corridor initiatives;
- Major rail-rail crossing improvements such as the Colton Crossing and Tower 55 initiatives;
- The Chicago Region Environmental and Transportation Efficiency Program to de-bottleneck Chicago;
- Numerous individual intermodal-related public/private partnerships across the nation.

Purpose of This Document

The primary purpose of this document is to revisit the earlier report to determine if the earlier findings are still valid given the changes to the economy and rail industry that have occurred over the intervening decade and a half since publication of the report, and to provide further guidance to the role of freight rail public/private partnerships. Additional questions to be explored are:

- Which industries are most impacted by publicly funded improvements to rail infrastructure?
- When are public/private partnerships appropriate, and how can states assess public/private partnerships?

Are the Findings of the 2002 Report Still Valid?

In the most important aspects, yes, the findings of the 2002 *Freight Rail Bottom Line Report* are still valid.

- Relatively minor investments in rail infrastructure yields major public benefits. This will be explored in Chapter 1 of this report.
- There is still a role for the public/private partnerships for nationally significant rail network projects, although this may not necessarily be a top priority.

However, much has changed since the 2002 *Report*. At the time rail traffic volumes seemed to be growing relentlessly. Since that time, freight volume trends are less consistent, and overall rail volumes are much the same as they were back then. Another important development has been what industry watchers refer to as the “Railroad Renaissance”. Class I railroads of today exercise more pricing power, are more profitable, and are better able to invest than was the case in 2002. These changes are explored in Chapter 2 of this report.

Because it is no longer necessarily valid to assume that Class I railroads require public sector support to supply adequate general network capacity, it is important to consider the value of public/private partnership across different types of freight rail projects. For some industries, railroads’ mainline capacity may not be shippers’ top concern. Chapter 3 of this report explores how different shippers experience the rail industry in different ways and how different shippers benefit from different types of rail infrastructure projects.

A more nuanced approach toward public/private partnership is now required to evaluate public/private partnership opportunities. It cannot automatically be assumed that all potential partnerships are appropriate. In some cases, projects may best be funded by the private sector alone. Chapter 4 explores the parameters of when public/private partnerships are appropriate and provides state agencies with tools to assess potential opportunities.

Chapter 1: Benefits of Freight Rail and Increasing Freight Rail Market Share

Background

Rail is a key component of many shippers' supply chains. When railroad transportation options are not available or perform poorly, this harms the competitiveness of U.S. industry. Conversely, a well-functioning U.S. rail network supports economic development. Rail connects locations within the U.S. to international markets. For example the Association of American Railroad estimates that railroads carry about a third of U.S. exports.¹ Economic development officials frequently distinguish between "tradable" and "non-tradable" industries. Tradable industries are those that are subject to international competition, while non-tradeable industries are not subject to international competition. The primary tradable industries are agriculture, forestry, and fishing; mining; and manufacturing. These are also the industries that are in many cases heavily reliant on rail. Therefore, rail is a key component of the competitiveness of U.S. industry in international trade.

Rail also provides public benefits. When shippers make modal decisions, their decisions not only impact the direct supply chain costs of bringing goods to market, but the public at large also faces costs as a consequence of the decisions that shippers make. Some freight modes emit more air pollutants than others, or have a higher tendency to cause accidents and loss of human life. These social costs have a direct and measurable impact on society, although they are mostly invisible to shippers because they are not reflected in the prices paid in transportation markets.

The Government Accountability Office (GAO) has estimated that the per-ton-mile social costs of trucking are six times greater than for rail.² This finding echoes a long history of studies that have shown that rail has substantially lower social costs, in total, than trucking.^{3,4,5,6}

¹ Association of American Railroads, "The Economic Impact of America's Freight Railroads," May 2015, <https://www.aar.org/data/economic-impact-americas-freight-railroads>.

² GAO, (2011), A Comparison of the Costs of Road, Rail and Waterways Freight Shipments That are Not Passed on to Consumers.

³ Frokenbrock, D. J. (1998) External Cost of Truck and Rail Freight Transportation, The University of Iowa Public Policy Center, Transportation & Vehicle Safety Policy.

⁴ Winebrake, J. J., Corbett, J. J., Falzarnano, A., Hawker, J. S., Korfmacher, K., Ketha, S., and Zilora, S. (2008), Assessing Energy, Environmental, and Economic Tradeoffs in Intermodal Freight Transportation, Journal of the Air & Waste Management Association 58 (8), 1004-1013.

⁵ Deloitte Access Economics (2011). The True Value of Rail, the Australasian Railway Association, June 3rd 2011.

⁶ TRC Consulting (2013). Maintaining a Track Record of Success: Expanding Rail Infrastructure to Accommodate Growth in Agriculture and Other Sectors

Parameters Used to Estimate the Benefits of Rail

The U.S. Department of Transportation (USDOT) has provided guidance to states regarding appropriate parameters for evaluating rail projects since the federal government first became involved with railroad preservation in the late 1970's and early 1980's. The Federal Railroad Administration (FRA) released the "Benefit-Cost Guidelines for Rail Branch Line Continuation Program" in 1980, and the "FRA Simplified Benefit-Cost Methodology" in 1982 and then the "Benefit-Cost Methodology for the Local Rail Freight Assistance Program" in 1990.

More recently, the *Transportation Investment Generating Economic Recovery* (TIGER) program, which began in 2008, created a new set of USDOT sanctioned values and standards by which to evaluate freight rail projects. The TIGER Program was created following the economic recession of 2008 as a counter-cyclical stimulus to the economy. Since its inception it has been used successfully to help fund a variety of freight rail projects, including the CREATE project in Chicago, Norfolk Southern's Crescent Corridor, the CSX National Gateway, the Tower 55 Multimodal Improvement Project, and many more. This program awards grants competitively on a yearly basis.

Given the recent importance of the TIGER program in funding freight rail projects, the program's guidance for evaluating rail projects cannot be ignored. In fact, the substantial thinking that USDOT, private railroads, academics, and consultants have applied to the evaluation of public benefits from rail freight projects under TIGER represents a valuable platform for identifying and developing standard approaches for states to utilize in the future.

The key TIGER public benefit categories, as they are relevant to freight rail, include:

- Safety (reduction of vehicle crashes);
- State of good repair (reduction of highway pavement damage);
- Sustainability (reduction of harmful pollutants);
- Livability (reduction of highway congestion); and
- Economic competitiveness (reduction of shipper costs for transportation services)

Safety

Rail is a relatively safe mode of transportation, especially when compared with trucking. As can be seen in Table 1 and Table 2 following, trucks are involved in many more accidents each year in total and on a, per ton-mile basis. On average there are 25 times more truck-related accidents than rail accidents. Moreover, trucks are involved in five times more fatal accidents than rail. Except at crossings, freight trains are physically separated from the millions of passenger vehicles operating on the nation's road network.

Table 1: Truck Crash and Rail Accident Totals

Type	2011	2012	2013	2014	Average per Year
Total Rail Fatalities	646	643	668	746	676
Total Rail Injury Accidents	8,424	8,432	8,745	8,588	8,547
Total Rail Damage Only Accidents	2,438	1,981	2,233	2,664	2,329
Total Truck Fatality Accidents	3,341	3,464	3,541	--	3,449
Total Truck Injury Accidents	60,000	73,000	69,000	--	67,333
Total Truck Damage Only Accidents	210,000	241,000	254,000	--	235,000

Source: FRA⁷ and FMCSA 2014⁸

*2014 data for truck was not available at the time of this publication. Truck includes single-unit and combination heavy-duty vehicles. Rail includes switching and short-line operations.

Rail has a significantly lower accident rate compared to trucking, as can be seen in Table 2. To transport the same freight the same distance by truck compared to rail, risks of fatal accidents are 3.2 times higher, 4.9 times higher for injury accidents, and 6.2 times higher for property damage only accidents.⁹ Diverting freight to rail significantly reduces the frequency of accidents.

Table 2: Truck Crash and Rail Accident Rates per 10 Billion Ton-Miles, 2014

Type	Rail	Truck
Fatal Accidents per Ton-Mile	3.59	11.3
Injury Accidents per Ton-Mile	45.4	221
Damage Only Accidents per Ton-Mile	12.4	771

Source: WSP/PB Analysis, using ton-miles from the National Freight Strategic Plan, USDOT

The federal government has provided guidance to assign a monetary value to fatalities and injuries, which in turn is based on a series of studies completed between 1997 and 2001.¹⁰ These studies assess the public's willingness to pay for safety improvements. The average cost of injuries is weighted by the average severity of truck crash injuries.¹¹ On a scale of one to six with one being a minor injury, two being

⁷ FRA (2015): One Year Accident/Incident Overview – Combined 2015. Office of Safety Analysis, Federal Railroad Administration, U.S. Department of Transportation.

⁸ FMCSA (2014): Large Truck and Bus Crash Facts 2013. FMCSA-RRA-14-004. Analysis Division, Federal Motor Carrier Safety Administration, U.S. Department of Transportation. June 2014.

⁹ Injuries associated with truck and rail transportation are reported differently. Trucking statistics are reported as "crashes," in which a truck strikes something. In the case of rail, most reported injuries do not involve a train hitting something. Rather, railroads are required to report any on-the-job injury or illness, the majority of which do not involve train equipment striking anything.

¹⁰ Memorandum from Office of the Secretary of U.S. Department of Transportation to Modal Administrators, Guidance on Treatment of a Statistical Life (VSL) in U.S. Department of Transportation Analyses – 2015 Adjustment, June 17, 2015.

¹¹ USDOT (2013): Delay and Environmental Costs of Truck Crashes. <https://rosap.ntl.bts.gov/view/dot/10074>

moderate, and six being fatal, the weighting assigns an equivalent cost of an injury between one and two. Most accidents with injuries result in relatively minor injuries.

Table 3: Monetized Accident Costs

Type	Value (2015 \$/accident)
Fatal Accident	\$9,471,219
Injury Accident	\$154,805
Damage Accident	\$ 3,957

Source: USDOT TIGER Guidance

Pavement Maintenance

Truck travel causes pavement deterioration more than light-duty vehicles, increasing the cost of roadway maintenance. The most frequently cited national study of pavement damage costs on a national level is a highway cost allocation study conducted by the Federal Highway Administration.¹² One of the key implications of this study is that the severity of pavement damage depends mainly on the axle weight of the trucks and type of road being used. As can be seen in Table 4, increasing total vehicle weight from 60,000 lbs. to 80,000 lbs. can more than triple per-mile pavement damage. Also, costs were found to be significantly greater for urban than rural highways.

Although the cost allocation study was published almost 20 years ago, its results are still widely used today (adjusted to current dollars). When it was first published it agreed with other studies at the time.¹³ It was an update to an earlier 1982 study. This study allocated costs associated ongoing maintenance, as well as reconstruction or capacity enhancing projects. For costs such as pavement maintenance where axle weight is a cost driver, the study allocated costs based on vehicle type and weight. For other costs that vary by vehicle demand, such as capacity enhancements, the study allocated costs based on passenger car equivalents (PCEs). Because they are larger and take more space on roadways, trucks are assigned multiple passenger car equivalents. Several recent domestic and international studies have found that values from the Federal Highway Cost Allocation Study remain plausible. In Louisiana the pavement cost of trucks was estimated to range from \$0.017 to \$0.21 per mile (in 2008 dollars), depending on the axle loading.¹⁴ In Virginia the average pavement cost of trucks was estimated from \$0.011 to \$0.065 per mile (in 2008 dollars), also depending on their axle loading.¹⁵ Internationally, a study by the UK Department of Transport estimated these costs at US\$0.26/mile.¹⁶

¹² FHWA, *Addendum to the 1997 Federal Highway Cost Allocation Study*, Table 13.

<https://www.fhwa.dot.gov/policy/hcas/addendum.cfm>

¹³ Hajek, J. J., Tighe, S. L., and Hutchinson, B. G. (1998). *Allocation of Pavement Damage Due to Trucks Using a Marginal Cost Method*. Transportation Research Record 1613. Washington D.C.: Transportation Research Board, 1998.

¹⁴ Saber A., Roberts F. (2008). *Monitoring System to Determine the Impact of Sugarcane Truckloads on Non-Interstate Bridges*, Louisiana Transportation Research Center, LTRC Project No. 03-2ST.

¹⁵ Virginia Transportation Research Council (2008). *A Review of the Current Overweight Permit Fee Structure in Virginia (HB 1551)*. VTRC, Report November 2008.

¹⁶ UK Department for Transport (2014). *Mode Shift Benefit Values: Refresh*

Table 4: Valuation of Truck Pavement Damage

Type of Pavement Impact	Pavement Damage (2015 \$)
80,000 lbs. Combination Trucks on Urban Hwys.	\$0.553/mi
60,000 lbs. Combination Trucks on Urban Hwys.	\$0.142/mi
80,000 lbs. Combination Trucks on Rural Hwys.	\$0.172/mi
60,000 lbs. Combination Trucks on Rural Hwys.	\$0.045/mi

Source: FHWA, WSP/PB 2015

A more up-to-date cost allocation study would be useful in validating these figures.

Pollutant Emissions

Rail can move freight with lower environmental impacts compared to trucking. The AAR estimates that the fuel efficiency of rail has improved 103 percent improvement since 1980.¹⁷

Table 5 and Table 6 compare the emission rates of trucks and rail. Trucking emissions rates were derived by a simulation using the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES) model, assuming combination trucks hauling long-distances (moves of over 200 miles). This model performs detailed calculations to estimate the emissions of various pollutants by vehicle type, road, location, seasonal condition, and drive cycle. The model also forecasts the impacts of technological improvements and government regulations on emissions rates in the future. NO_x emissions are forecasted to improve on average 5.4 percent per year through 2040, while PM emissions are forecasted to improve 9.6 percent per year and VOC emissions 3.6 percent per year. California's vehicle emissions model¹⁸ produces results for heavy-duty combination trucks that are similar to those in Table 5. For example, for NO_x the model estimates a miles-weighted emission rate of 7.9 grams/mile in 2015 and 1.3 grams/mile in 2045.

Table 5: Truck Emissions Rates

Type	2015	2020	2030	2040
NO _x grams/mile	9.41	6.13	2.85	2.32
PM grams/mile	0.374	0.212	0.055	0.030
VOC grams/mile	0.987	0.712	0.440	0.392

Source: EPA MOVES¹⁹

In 2008 the EPA introduced new emissions standards for locomotive.²⁰ According to a 2009 EPA analysis as shown in Table 6, average emissions of NO_x will decrease by 5.9 percent per year, PM by 8.2 percent per year, and VOCs by 6.6 percent per year.

¹⁷ Association of American Railroads (2015). The Environmental Benefits of Moving Freight by Rail.

¹⁸ CARB EMFAC Model

¹⁹ EPA MOVES Model, assumed long-haul Long-Combination Vehicles driving at 55 mph.

²⁰ <https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-air-pollution-locomotive>.

Table 6: Rail Emissions Rates

Type	2015	2020	2030	2040
NO _x grams/gallon	129	99	53	28
PM grams/gallon	3.4	2.3	1.0	0.4
VOC grams/gallon	6.0	3.8	2.0	1.1

Source: EPA 2009²¹

Because emission rates for railroads are specified per fuel consumption, it was necessary to obtain information about how the fuel efficiency of the trains is expected to improve over time. Table 7 shows the values used. The baseline was obtained from the Association of American Railroads and a one percent per year improvement was assumed based on the average improvement observed over the past decade.

Table 7: Rail Fuel Efficiency

	2015	2020	2030	2040
Tons-miles / gallon	483.0	508.5	561.7	620.4

Source: WSP/PB Analysis of information from AAR

Emission rates of CO₂ are a function of fuel consumption. Each gallon of diesel emits 22.4 lbs of CO₂.

Table 8: Comparison of Truck and Rail Emission Rates

Type	Rail (adjusted for circuitry)			Truck (adjusted for empty miles)		
	2015	2030	2040	2015	2030	2040
NO _x grams/ton-revenue mile	0.3178	0.1044	0.0475	0.5828	0.1765	0.1437
PM grams/ ton-revenue mile	0.0084	0.0020	0.0007	0.0232	0.0034	0.0019
VOC grams/ ton-revenue mile	0.0148	0.0039	0.0018	0.0611	0.0273	0.0243
CO ₂ grams/ ton-revenue mile	25.033	20.023	17.253	92.197	80.458	79.232

Source: WSP/PB Analysis

The costs of air pollution emissions were obtained from USDOT guidance for TIGER applications (see Table 9) based on a National Highway Traffic Safety Administration study that calculated the various costs associated with NO_x, PM and VOC emissions. These values were inflated to 2015 dollars using a CPI deflator. Rail values are based on typical locomotive fuel consumption per ton-revenue mile. These have been adjusted for the fact that rail routing tends to be more circuitous than truck routing. Truck values have been adjusted by the fact that not all truck vehicle miles traveled are loaded. Sometimes trucks must be repositioned empty to pick up loads.

²¹ EPA (2009). Emission Factors for Locomotives, Office of Transportation and Air Quality, EPA-420-F-09-025 April 2009. <https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF>.

Table 9: Non-CO2 Emission Costs

Type	Emission (2015 \$/metric ton)
NO _x	\$7,937
PM	\$363,113
VOC	\$2,046

Source: USDOT TIGER Guidance

The per-ton costs of carbon were also derived from USDOT guidance. These values were in turn obtained from a Technical Support Document published by the Interagency Working Group on the Social Cost of Carbon.²² For present value calculations, the social cost of carbon was discounted at 3 percent per year, consistent with USDOT's guidance²³, even when all other savings were discounted at 7 percent.

Table 10: Social Cost of Carbon at 3 percent Discounting (2015 \$ / metric ton)

	2014	2020	2030	2040
Social Cost of Carbon	\$45.34	\$52.39	\$63.48	\$74.56

Source: USDOT; WSP/PB 2015

Congestion

Trucks consume highway space, increasing the volume to capacity ratio of roadways. One freight train can take hundreds of trucks off the roads, improving operations for passenger vehicles and reducing costs. Congestion imposes many costs on society, including increased travel time, increased vehicle operating costs.

Congestion is nonlinear. Highways operate well at high speeds for a wide range of vehicle volumes, and descend into congestion rapidly once a particular threshold is reached. Adding a truck to a road has a negligible impact on other vehicles most of the time, except when the roadway is approaching its saturation threshold.

In the U.S., the most commonly used study of congestion impacts is the FHWA's Highway Cost Allocation Study²⁴ published in 2000. This study used the FHWA Freeway Simulation (FRESIM) model to estimate the delay impact of adding various vehicle types to the highway network. The analysis took into account the relative impact of additional vehicles during peak/off-peak time periods and whether vehicles were added to urban or rural highways. The impact of various vehicles was based on passenger car equivalents (PCE), so that a truck would have a value of several PCE's. Table 11 contains the parameters proposed by that publication, updated to 2015 dollars using the BLS's CPI indicator.

²² <https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf>.

²³ U.S. DOT (2015). *Tiger Benefit-Cost Analysis (BCA) Resource Guide*, p.7-9.

(http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf)

²⁴ Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000. See <http://www.fhwa.dot.gov/policy/hcas/addendum.cfm>.

Table 11: Valuation of Truck Marginal Congestion Cost, 2015 \$

Type of Congestion Impact	Marginal Congestion Cost (2015 \$)
80,000 lbs. Combination Trucks on Urban Hwys.	\$0.277/mi
60,000 lbs. Combination Trucks on Urban Hwys.	\$0.254/mi
80,000 lbs. Combination Trucks on Rural Hwys.	\$0.031/mi
60,000 lbs. Combination Trucks on Rural Hwys.	\$0.026/mi

Source: FHWA, 2015

Shipper Savings

For those supply-chains and inventory strategies that permit shipping by rail, rail can offer substantial transportation cost savings. This section provides an approximation of the relative price advantages of rail over trucking, for commodities that can typically utilize either mode of transportation. The analysis therefore excluded bulk commodities transported in large blocks of cars, usually on unit trains; and revenues associated with farm products, coal, crude petroleum, metallic ores, and nonmetallic minerals were excluded. The analysis also included truck drayage to and from rail terminals for intermodal traffic.

Trucking revenues per mile were obtained from a survey of trucking companies by TransCore in 2011 and indexed to 2015 by the Cass Truckload Linehaul Index^{TM25}. The survey found that average truckload motor carrier revenue per loaded mile was \$2.03 in 2011.²⁶ When indexed to 2014, the rate per mile was \$2.24. Estimated truck revenue per mile was converted to revenue per ton-mile by dividing the revenue per mile figure by an estimated average truck payload of 20.70 tons. The average payload was developed using average truck payload figures for truck movements over 500 miles as reported in the *Quick Response Freight Manual*.²⁷ The 20.70 tons was a weighted average, weighing average truck payloads by commodity by the extent that those commodities are also shipped in carload manifest or intermodal rail service. The resulting estimated shipper cost of truck was found to be \$0.108 per ton-mile.

Rail revenue per ton-mile was estimated using the Association of American Railroads' *Railroad Ten-Year Trends*. The analysis also includes assumed drayage costs for intermodal movements, which were derived from data by the Surface Transportation Board (STB) Uniform Railroad Cost (URCS) model. The resulting average railroad revenue per ton-mile for divertible traffic was \$0.70. Average revenue per ton-mile was then adjusted for the additional circuitry that trains need to travel to deliver shipments relative to trucking. Analysis by WSP | Parsons Brinckerhoff of the relative truck and rail distances between Freight Analysis Framework (FAF) zones using the FAF-3 suggest that to ship products to or from the same locations using truck or rail, requires 1.19 times the mileage by rail as by truck. This is roughly consistent with other studies, such as by Upper Great Plains Transportation Institute.²⁸ After this adjustment, the ton-miles

²⁵ Carrier Benchmark Survey, TransCore 2011, Cass Information Systems, Inc., Cass Truckload Linehaul Index, December 2015.

²⁶ TransCore, 2011. Carrier Benchmark Survey, DAT Special Report.

²⁷ U.S. Federal Highway Administration, *Quick Response Freight Manual II*, September 2007, Table 4.20.

²⁸ Denver Tolliver, Pan Lu, Douglas Benson of the Upper Great Plains Transportation Institute, *Analysis of Railroad Energy Efficiency in the United States*, May 2013.

weighted revenue for rail was found to be \$0.083/ton-mile. Therefore, when compared to trucking, shifting an average truck shipment to rail saves shippers \$0.025/ton-mile.

With an average trucking cost of \$0.108 per ton mile for trucking, an average cost of \$0.083 per ton mile for rail, and a savings of \$0.025 per ton mile for trucking, rail offers a computed savings of 23% versus trucking. However, this analysis does not consider modal differences in other logistics costs beyond transportation costs, such as inventory carrying costs (where applicable), administrative costs, or additional facility or operating costs that might be incurred by the railroad in providing new services.

Growing Rail Mode Share

Approach

Shifting freight from truck to rail can provide transportation savings and benefit society. This section quantifies the magnitude of these benefits under several mode-shift scenarios. Table 12 summarizes some of the additional assumptions that were needed. The proportion of empty miles was obtained from a survey of the trucking sector conducted by ATRI.²⁹ This survey found that 22 percent of miles driven by truckload trucking companies are empty, which is comparable to the findings of other surveys of the industry.^{30,31} While the average payload of loaded trucks was found to be 20.7 tons,³² the average payload of all trucks, including empty ones, would be 16.15 tons.

²⁹ Fender, K. J. and Pierce, D. A., 2013. An Analysis of the Operational Costs of Trucking: 2013 Update. American Transportation Research Institute.

³⁰ DAT, 2013. 2013 DAT Carrier Benchmark Survey Q1 2013, DAT Special Report.

³¹ Alam, M. Rajamanickam, G., 2007. Development of Truck Payload Equivalent Factor, Submitted to FHWA Office of Freight Management and Operations, 2007.

³² U.S. Federal Highway Administration, *Quick Response Freight Manual II*, September 2007, Table 4.20.

Table 12: Calculation Assumptions

Input	Value	Definition and Source
Rail to Truck Circuity (miles of rail/miles of truck)	1.19	This parameter indicates the additional miles of rail that would be required to transport goods relative to trucking, taking into account that travel on the rail network is usually less direct than travel on the highway. This parameter was calculated based on an analysis of the FAF dataset. Its value was also corroborated based on the results of other studies.
Mix of highway travel	10% Urban and 90% Rural	This variable has a large impact on the pavement deterioration costs and congestion externality costs of trucking. It was determined based on the characteristics of a representative truck trip.
Mix of Truck Weight	25% 80 kip trucks and 75% 60 kip trucks	This variable has a large impact on pavement deterioration costs because they are a high power function of axle loading. It was determined based on an analysis of VIUS. This variable considers the travel of empty trucks.
Average truck payload	20.7 tons	This value was obtained from represents a weighted average of payloads for long-haul trucking from the FHWA <i>Quick Response Freight Manual</i> .
Proportion of empty truck miles	22%	This value was obtained from a survey of truck-load trucking companies conducted by ATRI ³³ .

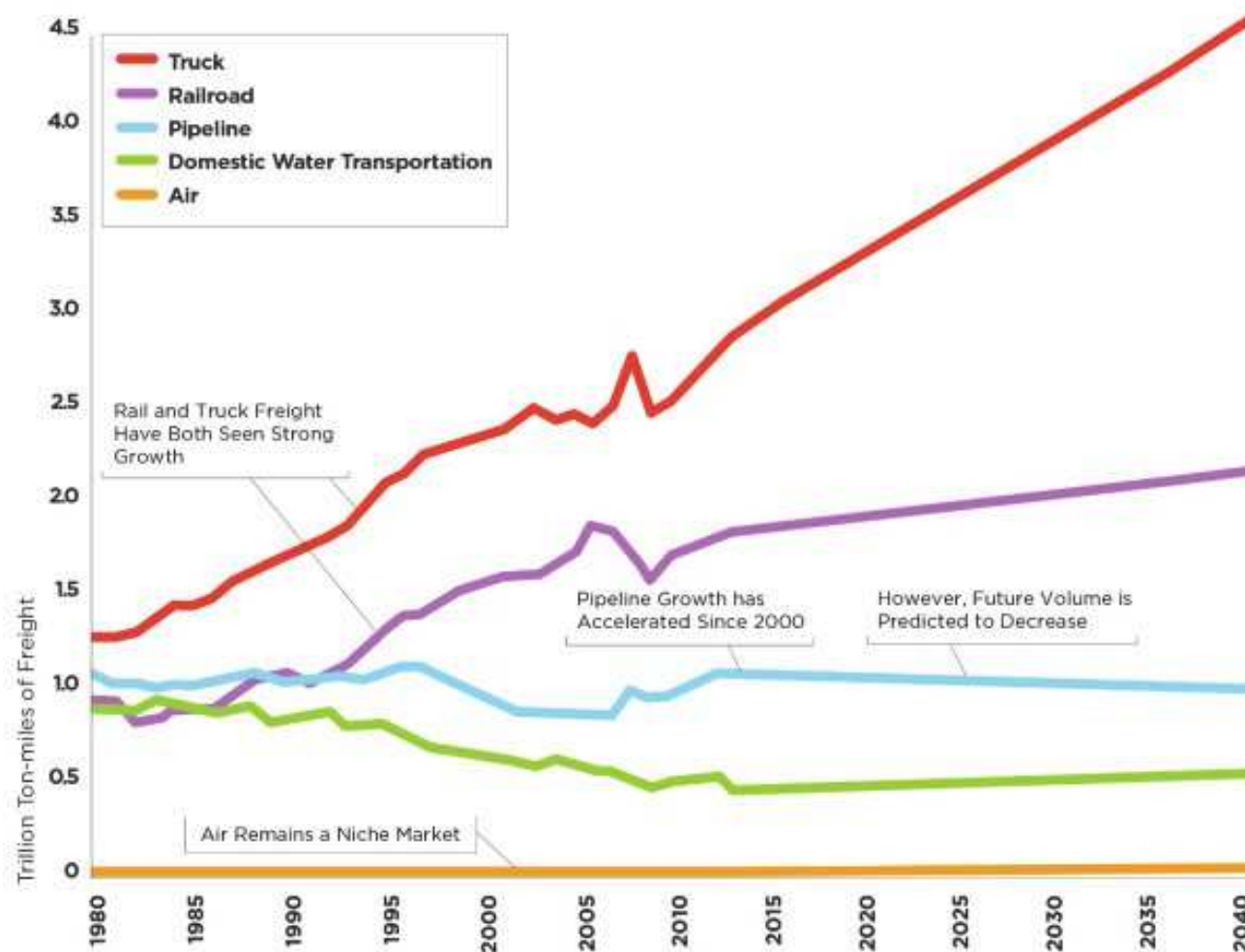
Three mode-shift scenarios were constructed on top of the ton-miles forecast recently published in the National Freight Strategic Plan. The data for this forecast came from a special tabulation of the Bureau of Transportation Statistics using the Freight Analysis Framework. This base scenario shown below predicts that rail will lose modal share in the future. Rail's modal share of freight ton-miles will decline from 29 percent in 2015 to 26 percent in 2040. Over this time period rail ton-miles will grow by 16 percent or 0.6 percent per year, while truck ton-miles will grow by 50 percent or 1.6 percent per year. These forecasts are based on forecast growth or shrinkage of the underlying commodities between freight markets. The base forecast does not account for relative performance of or investment in transportation modes. Rail's loss of mode share in these scenarios relates largely to coal. The Freight Analysis Framework (FAF-4) database estimates that coal accounts for 36 percent of the tonnage carried by rail, and that coal volumes will drop by about a third between 2015 and 2040. Thus, rail tonnage drops by 12 percent due to coal before any changes in other commodities are considered.

³³ Fender, K. J. and Pierce, D. A., 2013. An Analysis of the Operational Costs of Trucking: 2013 Update. American Transportation Research Institute.

Figure 1: National Freight Plan Modal Forecast

U.S. Ton-Miles of Freight (in Millions)

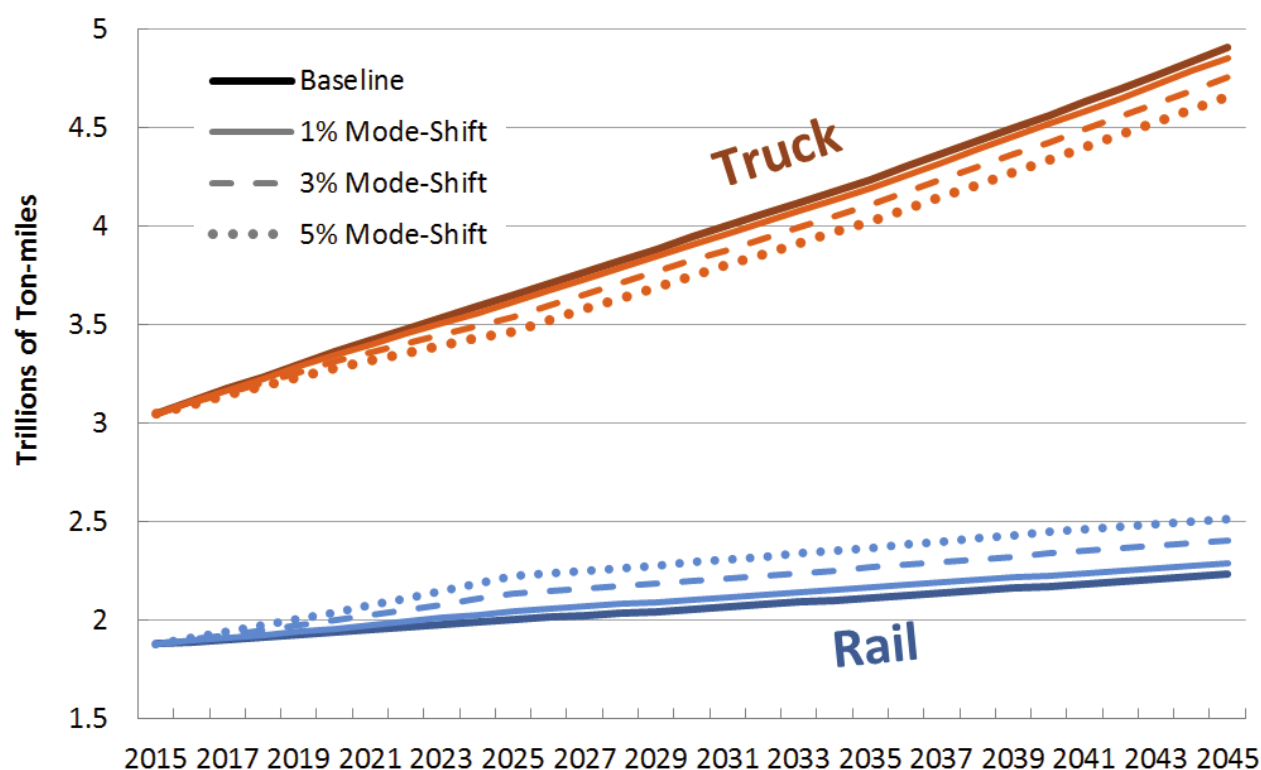
BTS Special Tabulation



Source: National Freight Plan

In order to assess the benefits of railroad transportation, three scenarios have been generated. They represent a shift to rail of one percent, three percent, and five percent of truck ton-miles to rail. Mode shifts are assumed to occur at a constant rate from the start of 2016 to 2025. One tenth of the shift is assumed to occur each year during the 10-year period. Figure 2 shows the resulting mode-shift scenarios.

Figure 2: Mode-Shift Scenarios from Truck to Rail



* Baseline Data from BTS

Impacts of Mode-Shifts

The impacts of the mode shift are summarized in Table 13. A one percent mode shift would eliminate 65 billion truck miles off U.S. roads between 2016 and 2045. This would translate to 79,313 fewer property damage only accidents, 17,512 fewer injury accidents, and, 737 fewer accidents resulting fatalities, translating to at least 25 avoided fatalities per year.

A one percent mode shift reduces greenhouse gas emissions by 64.3 million Metric Tons CO₂ over the next 30 years, representing on average two million Metric Tons of CO₂ per year, as well as substantial reductions of NO_x and PM emissions. Mode shifts of three or five percent bring higher proportion benefits.

Table 13: Impacts of Mode Shifts over 30 Years

	1% Mode-shift	3% Mode-shift	5% Mode-shift
Truck miles (billions)	-65	-195	-325
Fatal accidents/crashes (number)	-737	-2,211	-3,685
Injury accidents/crashes (number)	-17,512	-52,535	-87,559
Property damage only accidents (number)	-79,313	-237,938	-396,564
CO2 Emissions (thousand metric tons)	-64,300	-192,899	-321,499
NOX emissions (metric tons)	-101,369	-304,107	-506,846
PM (metric tons)	-2,441	-7,322	-12,203
VOC (metric tons)	-26,018	-78,053	-130,089

Source: WSP/PB Analysis, 2015

When the impacts as shown in Table 13 are assigned monetary values and then discounted by seven percent per USDOT guidance, a one percent mode-shift was found to generate \$19.3 billion in benefits. Of these, 44 percent accrued to shippers in lower transportation costs and 66 percent to the rest of society in cleaner air, less roadway congestion, and improvements in safety.

Table 14: Social and Private Benefits of Mode Shifts over 30 Years Discounted @ 7% (Millions)

	1% Mode-shift (M\$ Discounted @ 7%)	3% Mode-shift (M\$ Discounted @ 7%)	5% Mode-shift (M\$ Discounted @ 7%)
Shipper Savings	\$8,573	\$25,720	\$42,867
Pavement maintenance savings	\$3,145	\$9,435	\$15,725
Marginal congestion savings	\$1,125	\$3,375	\$5,625
Environmental Savings			
- CO2 emissions savings	\$2,496	\$7,488	\$12,479
- NOX emissions savings	\$284	\$853	\$1,422
- PM emissions savings	\$422	\$1,267	\$2,112
- VOC emissions savings	\$19	\$57	\$94
Subtotal Environmental	\$3,222	\$9,665	\$16,109
Safety Savings			
- Injury crash savings	\$888	\$2,664	\$4,439
- Fatality crash savings	\$2,286	\$6,859	\$11,432
- Damage crash savings	\$103	\$308	\$514
Subtotal Safety	\$3,277	\$9,831	\$16,385
Total Discounted Benefits	\$19,342	\$58,026	\$96,710
Total Undiscounted Benefits	\$51,749	\$165,870	\$276,450

Comparison to 2002 Freight Rail Bottom Line Report

This update provides current best practice methodologies that are substantially different from the 2002 Freight Rail Bottom Line Report. The key differences are as follows:

- The previous study generated a series of scenarios. Under the Constrained Investment scenario, railroads would be able to expand capacity to accommodate 50 percent of expected volume increases. Under the Aggressive Investment scenario, railroads provide enough investment to not only keep up with expected volume but to also seize market share. By year 20 of the analysis (2020), the annual freight rail ton-miles were estimated to be 48 percent higher under the Aggressive Investment scenario than under the Constrained Investment scenario. By contrast the assumed reallocation of five percent of truck ton-miles to rail in the current update increases rail ton-miles by 12 percent in year 20 (2035). In other words, the amount of diversion to rail in the current update is more conservative.
- The previous Freight Rail Bottom Line Report estimated that rail service was priced in the year 2000 at around \$0.024/ton-mile and truck priced at \$0.080/ton-mile (in 2000 dollars). In today's dollars this would represent rail being priced at \$0.033/ton-mile and trucking priced at \$0.11/ton-mile. The estimate of the price of trucking used in this report was similar to the one used in the previous report, at \$0.108/ton-mile. On the other hand, the estimate used for rail was considerably higher at \$0.083/ton-mile (adjusting for circuitry). This higher cost estimate can be attributed to only considering commodities and rail segments that could reasonably shift to truck. Bulk commodities transported by unit train were not considered. The current update offers a more conservative estimate of per-unit rail benefits, based on current best practice data.
- The sources of data for estimating road impacts of rail differ between the 2002 Freight Rail Bottom Line Report and the current update. The former relied on FHWA Highway Economic Requirements System (HERS) model, while the latter relies on the FHWA Highway Cost Allocation Study. The previous Freight Rail Bottom Line report did not include the quantification of safety and environmental benefits, whereas the current report does. The current analysis includes a 30 year analysis period, whereas the 2002 Freight Rail Bottom Line Report had a 20 year analysis period. Some differences are summarized in Table 15 below.

Table 15: Comparison between 2002 Freight Rail Bottom Line Report and Current Update

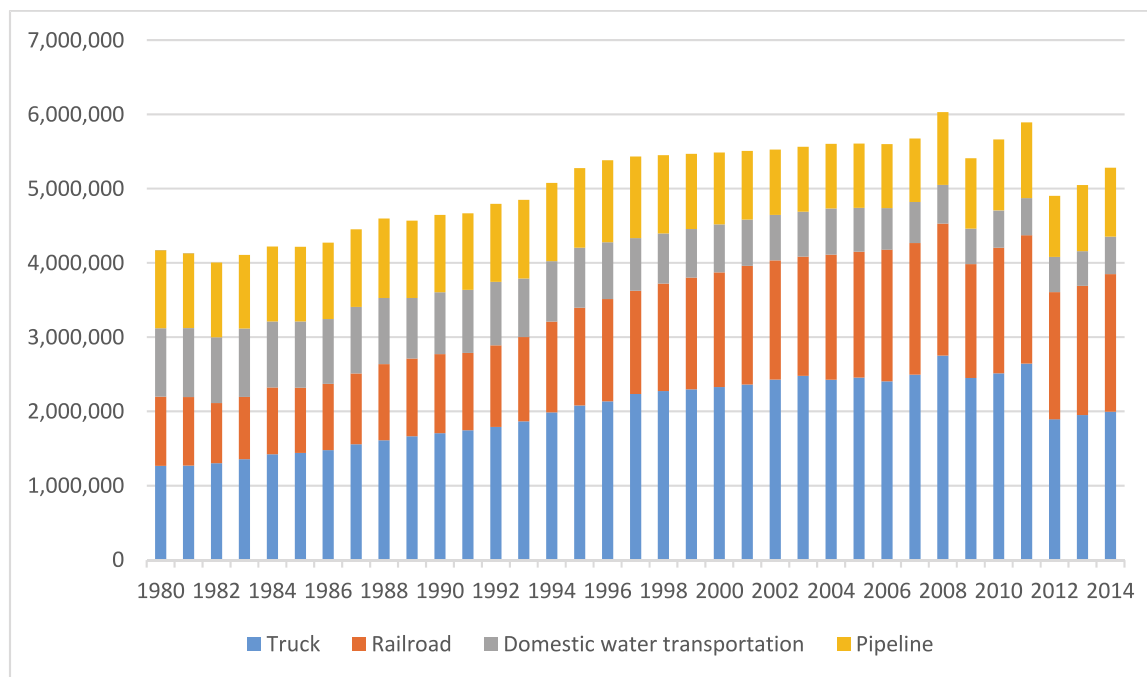
	2002 Freight Rail Bottom Line Report— Difference between Constrained Investment and Aggressive Growth Scenarios	Current Update Difference between Base Case and 5 Percent Diversion to Rail
Change in Year 20 Rail Ton-Miles (Billions)	734	252
Percentage Change in Year 20 Rail Ton-Miles	48%	12%
Change in Year 20 Truck VMT (Billions)	–40	–13
Change in Hwy Costs (2015 \$Billions)	\$1,251	\$65
Change in Shipper Costs (2015 \$Billions)	\$774	\$131
Shipper Savings per Ton-Mile (2015 \$s)	\$0.077	\$0.025
Change in Environmental Costs (2015 \$Billions)		\$30
Change in Safety Costs (2015 \$Billions)		\$50

Chapter 2: Changes to the Rail Industry since the 2002 Freight-Rail Bottom Line Report

Rail Traffic Trends

The base year of data presented in the 2002 Report was 2000. The 2002 Report was prepared following a long period of growth in freight rail traffic. For example, rail ton-miles had grown by 45 percent since 1990 and by 66 percent since 1980. To some extent, increases in rail traffic resulted from overall growth in U.S. freight movements, but rail had also increased its market share, particularly at the expense of domestic water transportation.

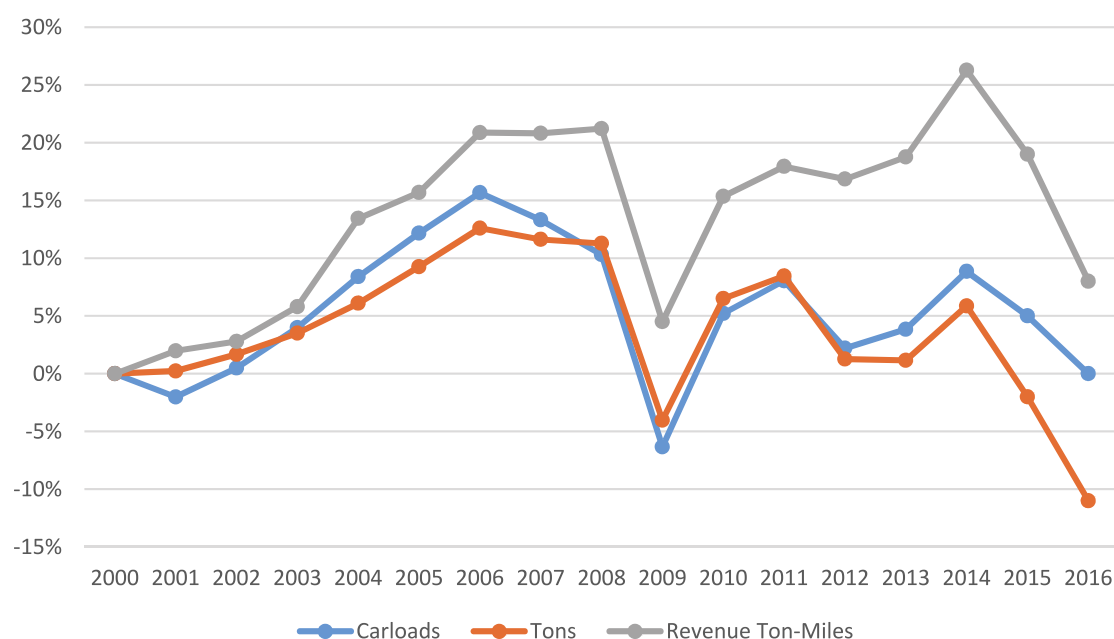
Figure 3: Ton-Miles of U.S. Freight by Mode (Millions)



Source: U.S. Bureau of Transportation Statistics (Air Freight is excluded because it is a small number)

Since 2000, overall freight traffic has not entirely recovered from the Great Recession, and rail freight growth has been inconsistent. Freight rail traffic grew significantly between 2000 and 2006, but then it plummeting during the Great Recession, began to recover through 2014, and then declined again through 2016. Because average length of haul increased, ton-miles have been positive, whereas carloads have not grown over the past 16 years and tonnage transported by rail has declined.

Figure 4: Cumulative Percent Change in Rail Traffic since 2000



Source: AAR (AAR), Parsons Brinckerhoff Analysis

Tonnage declines to some extent have been driven by coal as shown in Table 16, which was 43 percent of rail tonnage in 2000, but other commodities declined as well. These have been partially counteracted by growth in commodities that were not transported by rail in 2000, such as crude oil and ethanol. Intermodal has also been a source of traffic growth for railroads. In Table 16, most intermodal shipments are listed as “Miscellaneous Mixed Shipments.”

Table 16: Changes in Freight Rail Tonnages 2000–2015

Commodity	2000	2015	Tonnage Change	% Change	Annual % Change
Farm Products	135.7	145.5	9.8	7%	0.5%
Metallic Ores	31.6	59.4	27.8	88%	4.3%
Coal	757.8	638.1	–119.7	–16%	–1.1%
Crude Petroleum/Natural Gas	0.0	41.6	41.6	NA	NA
Nonmetallic Minerals	125.9	159.8	33.9	27%	1.6%
Food & Kindred Products	93.9	101.0	7.1	8%	0.5%
Lumber & Wood Products	48.9	27.2	–21.7	–44%	–3.8%
Pulp, Paper, & Allied Products	36.1	32.7	–3.4	–9%	–0.7%
Chemicals & Allied Products	155.0	178.0	23.0	15%	0.9%
Petroleum & Coal Products	42.2	51.5	9.3	22%	1.3%
Stone, Clay & Glass Products	48.3	42.8	–5.5	–11%	–0.8%
Primary Metal Products	59.8	44.6	–15.2	–25%	–1.9%
Transportation Equipment	41.5	27.0	–14.5	–35%	–2.8%
Waste & Scrap Material	40.1	36.7	–3.4	–8%	–0.6%
Miscellaneous Mixed Shipments	101.0	120.0	19.0	19%	1.2%
Other	48.9	25.5	–23.4	–48%	–4.2%
Total	1,766.7	1,731.4	–35.3	–2%	–0.1%

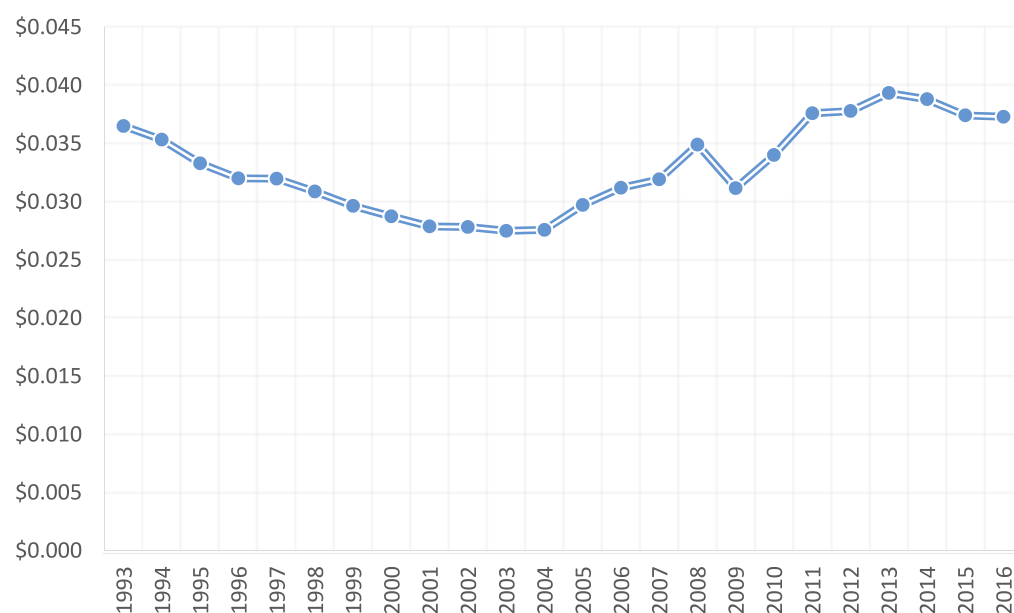
Source: AAR, Parsons Brinckerhoff Analysis

One issue with trend analysis is that trends can appear very different depending on the time-period analyzed. Furthermore, what appears to be a consistent trend could be interrupted at any time. However, freight volume trends have implications for the findings of the *2002 Report* in 2018. Because the report was written after a period of steady freight rail growth, capacity was a major concern at the time. Rail freight levels appeared to be increasing relentlessly, and it was thought that major capacity additions would be necessary to accommodate all of the additional rail freight. Rail freight may continue its upward trajectory. Capacity is always an issue, and certain portions of the U.S. rail network have been under capacity in recent years. However, the growth of U.S. rail freight has been negligible over the past 16 years, or negative, depending upon which statistic one chooses to consider. Mainline capacity is important but perhaps not as preeminent a concern as in 2002.

Financial Performance

The *2002 Report* described the railroad industry as operating under “intense price pressure.” To some extent this reflected the timing of the report, which prepared right around a nadir of railroad revenue per ton-mile. For example, between 1993 and 2000, railroad revenue per ton-mile declined by 21 percent in constant dollars. Since that time, revenue per ton-mile has increased. Measured in constant dollars, railroad revenue per ton-mile has increased by 35 percent between 2000 and 2014.

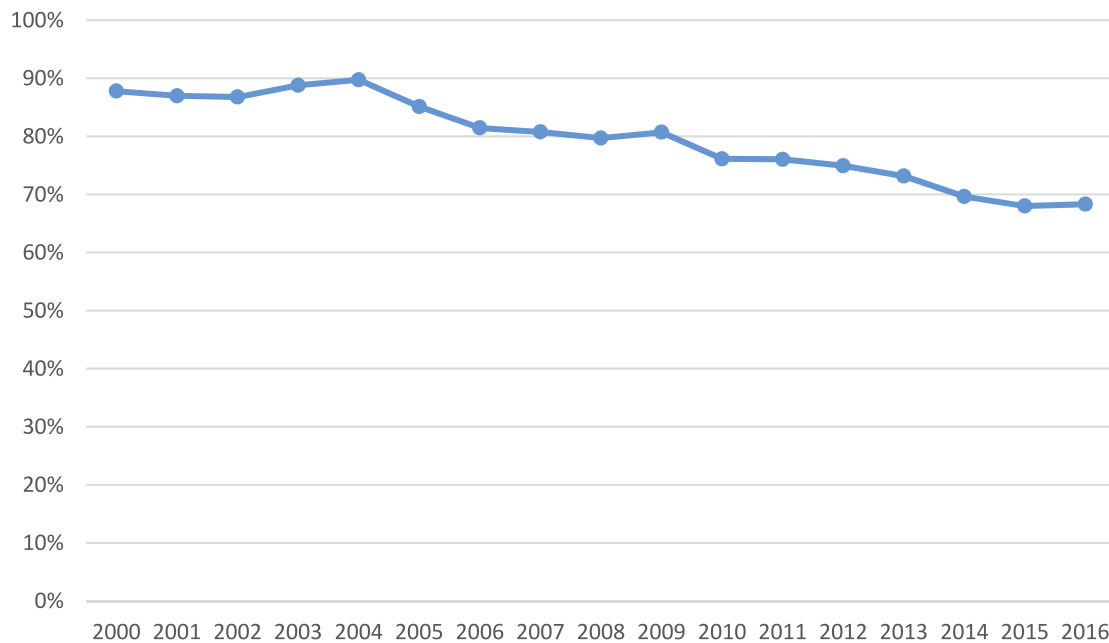
Figure 5: Railroad Revenue per Ton-Mile in Constant 2011 Dollars



Source: AAR

A common measure of railroad profitability is railroad operating ratio, which equals operating expenses divided by operating revenues. This metric is an expression of operating profit margins. As shown in Figure 6, starting in 2004, average railroad operating ratios have improved on a regular basis, declining from 88 percent in 2000 to about 68 percent in 2016.

Figure 6: Railroad Operating Ratio



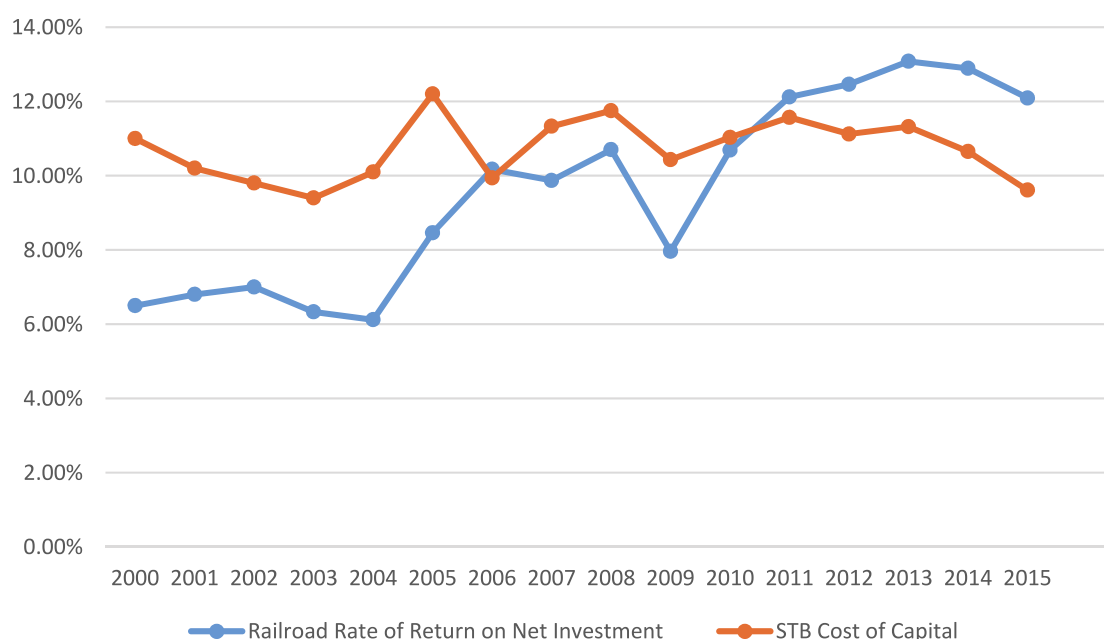
Source: AAR, Parsons Brinckerhoff Analysis

The *2002 Report* noted a gap between the railroad industry's cost of capital and its return on investment. The U.S. Surface Transportation Board (STB) is charged with determining revenue levels that "(A) provide a flow of net income plus depreciation adequate to support prudent capital outlays, assume the repayment of a reasonable level of debt, permit the raising of needed equity capital, and cover the effects of inflation; and (B) attract and retain capital in amounts adequate to provide a sound transportation system in the United States."³⁴ As of the *2002 Report*, the STB had almost never considered railroads to be revenue adequate. As an example, between 1980 and 2005, railroads were found to be revenue inadequate 413 out of 445 determinations (number of railroads times the number of years) or 93 percent of the time.³⁵ The frequency with which railroads have been found to be revenue adequate has increased. In 2013, the STB found that five of seven Class I railroads had achieved a rate of return equal to or greater than the STB's calculation of the railroad industry cost of capital. Three of seven railroads were determined to be revenue adequate in 2012. Figure 7 below represents a comparison of the STB cost of capital determination and a composite of Class I railroads' return on investment. As can be seen, the industry was found to be revenue adequate since 2011.

³⁴ 49 U.S. Code 10704(a)(2).

³⁵ *Determining Revenues Adequate to Maintain and Improve Service and Capacity*, presentation by Robert D. Rosenberg of Slover & Loftus, LLP and Timothy J. Stafford of AAR to the Association of Transportation Law Professionals Fall Forum XI, November 10, 2014.

Figure 7: Comparison of Class I Railroad Industry Rate of Return on Net Investment and STB Cost of Capital



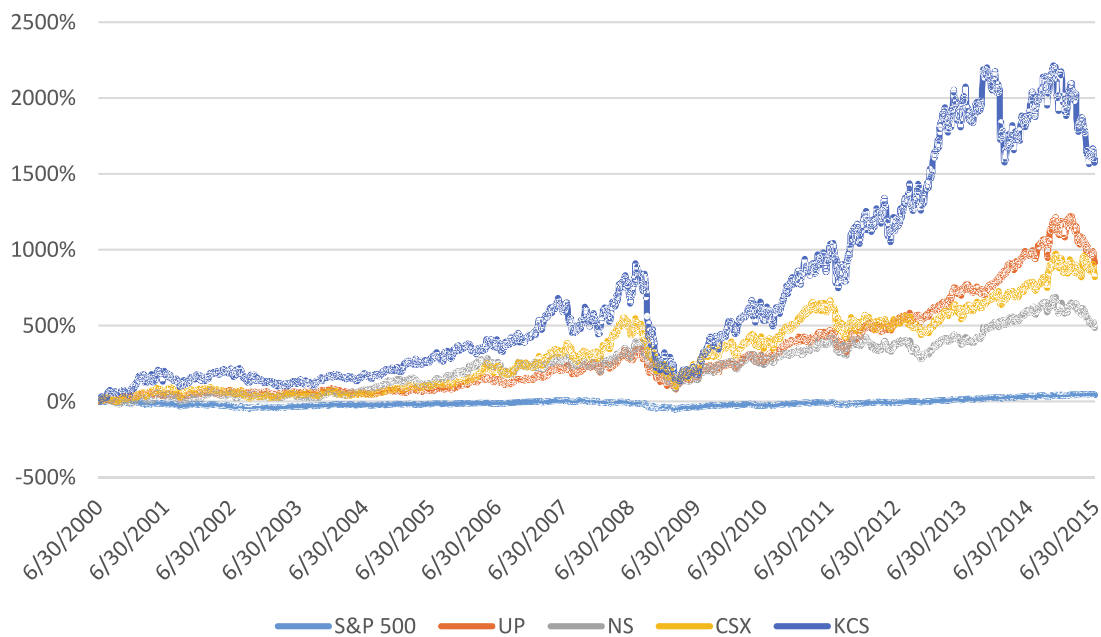
Source: AAR

Revenue adequacy is also determined by which of the STB’s methodology is employed. Methodologies have been evolving over the past decade. By one approach the STB has considered, all of the four largest (BNSF, CSX, NS, UP) Class I railroads would have been found to be revenue adequate in 2010, 2011, and 2012.³⁶

Between 2000 and 2015 railroad stock prices reflected the “railroad renaissance,” far outpacing the broader market. Figure 8 shows rail stock performance measured against the Standard & Poor’s 500 (S&P 500) index.

³⁶ Ibid. The STB uses two models to determine the cost of equity, a multi stage discounted cash flow model and the capital asset planning model. The capital asset planning model yield a lower cost of equity.

Figure 8: Cumulative Percent Change in Railroad Stock Prices and S&P 500 since June 30, 2000

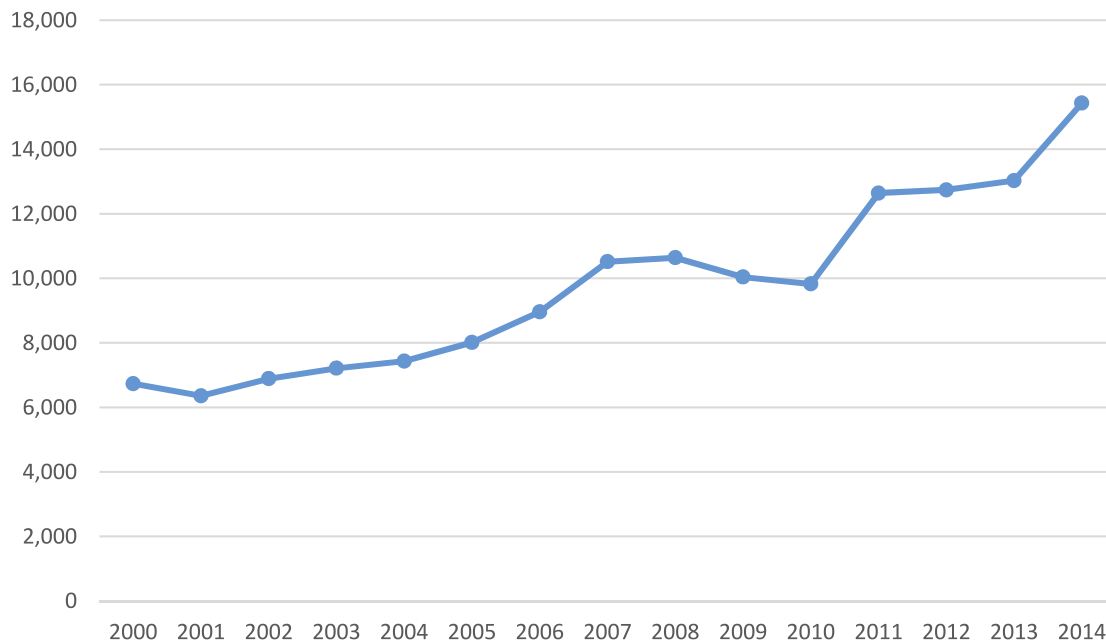


Source: finance.yahoo.com

Capital Expenditures

The improved financial condition of the railroad industry has enabled railroads to dramatically increase capital spending. Because investment in infrastructure, freight cars, and locomotives are providing better returns to shareholders, railroads have increased investment in their asset bases. In constant dollars, the level of railroad capital investment has doubled in the short period since 2010.

Figure 9: Railroad Capital Expenditure (Millions 2011 Dollars)



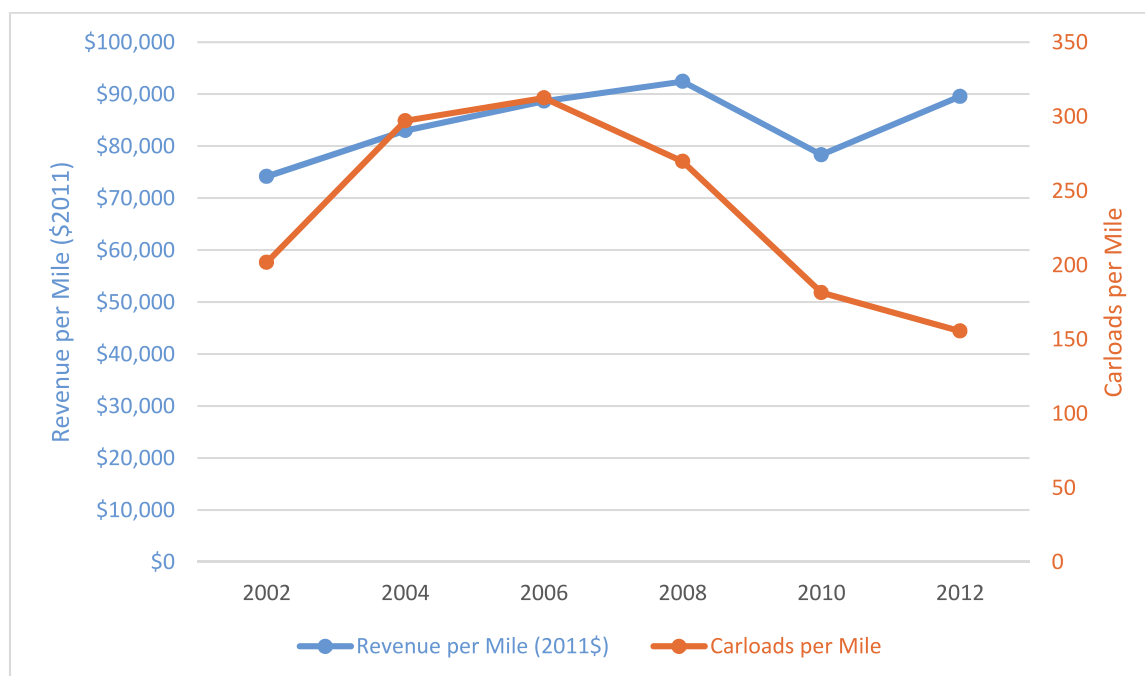
Source: AAR

The railroad industry's financial performance has been particularly impressive, since it occurred with the backdrop of the Great Recession. For example, average annual railroad revenue per ton-mile increased every year, excepted between 2008 and 2009, but this decline was erased within two years, reaching a new high in 2011. Industry capital expenditures also increased each year, except for a seven percent drop between 2008 and 2010. Capital expenditures then reached a new high in 2011.

Short Line Railroad Trends

The performance of the short line and regional railroad industry since the *2002 Plan* has been mixed. Short line company financial health is often considered to be a function of density. The more freight per miles, the better short line railroads will be able to covered the fixed costs of maintaining their lines. Figure 10 below displays the short line industry average revenue per mile operated (owned or leased), and the average number of annual carloads handled per mile operated. Both statistics improved between 2002 and 2006. But carloads per mile have since declined. On the other hand, revenue per mile has remained high.

Figure 10: Short Line and Regional Railroad Revenue per Mile in Constant 2011 Dollars, Carloads per Mile



Source: American Short Line and Regional Railroad Association, Parsons Brinckerhoff Analysis