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Executive Summary

Railroads have long been part of the very fabric of the United States, spurring the industrial revolution in the Northeast, inspiring the great migrations west, and symbolizing national progress. With its rich and complex history, the railroad industry offers a compelling subject for a study of productivity. The following report focuses on the freight rail industry, examining its evolution from several angles: competition, Congressional acts including deregulation, and the advent of technology. It also provides a detailed look at how this evolution brought about significant improvements in freight rail productivity, in the cases of labor, fuel, infrastructure, equipment, capital, and safety.

We begin by looking back at the period following World War II, when the railroad industry entered a cycle of decline, due in part to increased competition from trucks using the then-new Interstate Highway System, finally reaching a crisis point in the late 1960s. When Penn Central declared bankruptcy in June 1970, other smaller northeastern railroads followed suit, causing many freight rail carriers to threaten liquidation as well.

To help railroads adapt to this more competitive environment, the United States Congress passed several pieces of legislation that first reorganized bankrupt rail lines, and then, through the Staggers Rail Act in 1980, deregulated the railroads granting pricing freedom, authorizing contract rates, easing conditions for mergers and abandonments, and making other changes to reduce the regulatory burden on railroads.

Since deregulation, the railroad industry has made tremendous productivity improvements. Between 1979 and 2009, freight rail has seen impressive productivity gains in such categories as fuel consumption, where the rate of improvement reached 110 percent, and labor productivity, which achieved a 430 percent rate of improvement. Figure 1 provides a summary measure of rail productivity between 1966 and 2008 using revenue ton-miles (RTM) divided by operating

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1 Unless otherwise noted, data compiled for the metrics, analyses and graphs displayed in figures throughout this report were collected from annual editions of "Railroad Facts," a statistical reference book published by the Association of American Railroads.
expenses in constant dollars. Figure 2 illustrates that fewer resources in freight cars, employees, and track miles have yielded higher RTM.

In sum, the freight rail industry has encountered many challenges, but with the aid of new strategies, government policies, and innovative technologies, it has continued to make strong advances in productivity and competitive performance.
1 Industry Competition and Evolution

For nearly a century, the rail industry’s main competitor in the domestic freight segment has been trucks. From the advent of paved roads in the 1920s, and turnpikes between the 1930s and the early 1950s, to the development of interstate highways between the 1950s and 1991, trucks have benefited greatly from infrastructure improvements that have allowed them to:

- reduce transit times
- increase capacity (by increasing permitted truck size and weight)
- decrease operating costs, as road taxes have remained about one-third lower than required to cover the full costs large trucks have imposed on the highway system (Gallamore, 1999)

The trucking industry enjoys several other competitive advantages as well. For example, many truck carriers, especially owner-operators, can escape the Interstate Commerce Commission (ICC) “routes and rates” regulation. In addition, entry of new firms into the trucking industry is relatively easy compared with the rail industry, since firms only have to worry about equipment and operations, not about the right-of-way for tracks. In the trucking industry, all of the carriers vie for the same customers within a single highway system, which heightens the competitive atmosphere and leads to more efficiency (Martland, 2005). It should be noted that barges have presented formidable competition to rail freight as well, particularly between 1950 and 1980 (prior to the Waterways Revenue Act of 1978), when they were not required to pay any user fees and could operate at very low costs on federally aided inland waterways.

Intercity freight ton-miles represent a key metric of competitiveness between the rail and truck industries.

Before World War II, truck’s share of intercity freight ton-miles was less than 10 percent; at War’s end it was less than 5 percent. By 1951, however, truck’s share had risen to 16 percent and would exceed 20 percent by the end of the decade. As truck’s mode share rose, the rail industry’s share declined, leading to an excess of rail capacity. The track structure and resources needed to handle more than two thirds of all intercity ton-miles in 1944 (and more than 56 percent in 1950) were
far more than was necessary by 1960. The steady decline in traffic was exacerbated by recessions in 1958 and 1961, both of which caused more than a 10 percent year-to-year decline in rail tonnage (Martland, Lewis, Kriem, 2011).

The industry faced increasing challenges in the period following World War II, entering a period of decline that reached a nadir in the late 1960s. Many freight rail carriers threatened to go into liquidation after the country’s largest railway Penn Central went into bankruptcy in June 1970, followed by other smaller northeastern railroads.

In 1971, the federal government began responding to this crisis, first with the organization of Amtrak, a government-owned corporation providing intercity rail passenger service; then with the Regional Railroad Reorganization Act; and the Railroad Revitalization and Regulatory Reform Act (4R Act) of 1976. Finally, it created the Consolidated Rail Corporation (Conrail) in 1976, a government-funded private railroad incorporating under its banner the potentially profitable lines of bankrupt carriers (Morrison & Winston, 1999).

Hundreds of relatively small mergers occurred before the creation of Conrail. As the earlier merger that led to the creation of Penn Central was a failure, Conrail can be considered the launching point of the series of large mergers and acquisitions that followed and that led, more than 30 years later, to the current consolidated industry structure. Figure 3: Timeline of railroads’ mergers and acquisitions shows the principal mergers and acquisitions that occurred since the start of the freight rail industry.
### Timeline of railroads' mergers and acquisitions

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- **Norfolk Southern Railway (CSX)** 1890-today
- **Union Pacific (UP)** 1862-today
- **Burlington Northern and Santa Fe Railway (BNSF)** 1996-today
- **CSX Transportation (CSXT)** 1986-today

*SBD: Seaboard System Railroad 1983-1986

Source: Railroads' websites, backward historical analysis based on public data available online
2 Government Response and Deregulation

It is worthwhile taking a closer look at the government’s response to the disastrous Penn Central merger, because the set of legislative actions -- starting with Conrail’s creation -- established an entirely new regulatory and operational environment for freight rail.

From the start, Penn Central had various problems. Created on February 1, 1968 by the merger of the New York Central Railroad and Pennsylvania Railroad (and supplemented in 1969 by the New York, New Haven and Hartford Railroad), the new railroad suffered from a near-complete absence of advanced planning by its predecessors and soon was losing more than $1 million a day. A mismatch of corporate cultures and other problems led to this and many other difficulties.

After Penn Central collapsed into bankruptcy on June 21, 1970, the rest of the major Class I railroads in the region soon followed (except the Erie Lackawanna, which hung on until June 1972, when it fell victim to torrential hurricane floods). These regional railroads had not only been in precarious financial shape, but had relied almost exclusively on the Penn Central to through-ship their traffic.

A proposal by the Association of American Railroads sparked the creation of a government-funded private company, Conrail, which began operations on April 1, 1976. It consisted of lines from Penn Central and six other companies: the Ann Arbor Railroad (bankrupt 1973), Erie Lackawanna Railway (1972), Lehigh Valley Railroad (1970), Reading Company (1971), Central Railroad of New Jersey (1967) and Lehigh and Hudson River Railway (1972). In Conrail’s early years, it set about abandoning thousands of miles of track (a stipulation it was granted during its creation) to shed unprofitable lines. In addition, new management that took office at the beginning of 1981 reduced Conrail’s size by another 4,400 miles over the next two years. While this large reduction cost the railroad 1 percent of its traffic and 2 percent of its total profits, it more importantly brought about major cost efficiencies.

Further improvements to the railroad’s bottom line included centralized traffic control (CTC) to move trains more efficiently; job cuts approved by the unions; and courtesy of the Northeast Rail Services Act (NERSA), the opportunity to drop its money-draining commuter responsibilities.
By the end of 1981, Conrail was finally in the black and turning a profit, something not seen since the early days of Penn Central more than a decade earlier.

The creation of Conrail, entailing the consolidation and streamlining of a host of operations and services, laid the groundwork for additional government response to the railways’ financial predicament. The next phase took up regulator issues, with the Railroad Revitalization and Regulatory Reform Act (the 4-R Act) of 1976, which allowed railroads to set rates in regions where competition existed.

Following this phase of centralization and consolidation came a time of great regulatory reform, capped by the Staggers Rail Act in 1980, considered the major turning point in the history of U.S. railroad regulation. The Staggers Act brought or strengthened the following measures:

- railroads could base their rates on market demand, (in recognition of their need to earn adequate revenues)
- carriers and shippers could enter into confidential negotiated contracts
- railroads could merge and benefit from economies of scale
- Class I railroads could abandon unprofitable lines or to sell them to other non-Class I railroads

Additionally, under the Staggers Act, shippers who believed carriers were charging them excessive rates could now seek the arbitration of a regulator -- if the shipper was served by one carrier in a monopolistic position and when the carrier’s ratio of revenue to variable cost was found to exceed 180 percent (Laurits R. Christensen, 2009).

3 Unit Trains

Railroad operations were once dominated by traditional carload services, in which general freight trains carried all kinds of freight, and cars moved from origin to destination via a series of trains and classification yards.

Since 1980, the railroad industry has made operational changes and tremendous productivity improvements. Railroads try to maximize their productivity in terms of revenue ton-miles (RTM) or revenue car mile per input factor. This has meant focusing on unit trains, where all
freight cars are shipped from the same origin to the same destination, usually bearing the same commodity. This saves major costs associated with assembling and disassembling trains at rail yards. There has been a large increase in the proportion of rail traffic handled by unit trains. Rail management has used pricing to encourage this trend.

A great spur to rail productivity has been the increased shipping of certain kinds of commodities that are most suited to rail, including:

- bulk commodities, such as coal, grain, and ores that can be shipped in unit trains
- intermodal traffic that can move in dedicated trains between modern intermodal terminals
  traffic that requires specialized equipment and specialized handling, such as chemicals, which benefit from the low risks associated with rail traffic, and automotive material, including auto parts and finished automobiles, both of which move in specially-designed equipment to and from high volume facilities
  (Martland, Lewis, Kriem, 2011).

**Rail Intermodal**

An important advance within the modern freight rail industry, rail intermodal involves the long-distance movement of shipping containers by rail and utilizing another mode of transportation, normally trucking, for short movements at the origin and destination. The freight rail industry borrowed the concept of using shipping containers from the marine industry, and it has proved to be a very efficient method for long distance shipments. Moreover, transferring international containers from ocean freighters and transporting them to their final destination through the Double-Stack container train service (DST), which consists of stacking containers two-high on rail flatcars, offers many advantages in comparison with the long-haul truck shipment including reduced fuel consumption. To be particularly cost effective and competitive, however, the process needs to include a return trip, i.e., backhauling domestic products in the emptied containers that have brought the imported goods to the domestic market (Gallamore, 1999).

Among freight categories, rail intermodal represents the highest growth over the past two decades, with the number of trailers and containers expanding from 3 million in 1980 to more
than 12 million in 2006 (a 400 percent increase). Indeed, in fewer than 20 years, rail intermodal has become the second largest of all the freight categories, just behind coal. Nevertheless, a decline has been observed starting in 2007 (due in part to the economic recession); in line with the overall decline in the U.S. freight rail traffic (Figure 4: U.S. Rail Intermodal Traffic).

![U.S. Rail Intermodal Traffic: 1980-2009](image)

**Coal Unit Trains**

Excluding the introduction of intermodal freight, the types of goods that railroads handle now does not differ greatly from those transported 30 years ago. In 2008, five categories of goods (coal, intermodal, chemicals, farm products, and food and kindred products) represented 74% of total tons shipped. Nevertheless, the shares represented by these different types of commodities have changed. Most notably, the share of coal increased from 36% in 1981 to 45% in 2008 (Railroad Facts).

In the U.S., coal is produced in three major areas: the Appalachian region (Pennsylvania, Maryland, Virginia, Tennessee, Alabama, and Ohio); the interior region (Illinois, Indiana, Missouri, Texas, and Kentucky); and the western region (Wyoming, Utah, Montana, Colorado,
North Dakota, and Arizona). Most of the western coal originates in the Powder River Basin (PRB) of northeast Wyoming and southeast Montana and enjoys low sulfur content. Its consumption has surged due to increasingly strict clean air laws. As seen in Figure 5, in the past 60 years, coal production west of the Mississippi River has increased. In 2009, approximately 58% of U.S. coal was produced west of the Mississippi (U.S. Energy Information Administration, 2010).

Figure 5: Coal Production by Location, 1949-2009
U.S. Energy Information Administration, 2010

This increase in the consumption of PRB coal helped the rail share in coal transportation increase as production sites moved westward, away from the major electricity generation plants.

4 Productivity Trends

Several factors have had an impact on the productivity and competitive position of the freight railroad industry during the past several decades. We offer and define the following set of productivity metrics that can be organized in categories and analyzed over a 30-year period:

**Labor:**
- Revenue ton-miles (RTM) / Employee-hours
- Revenue ton-miles (RTM) / Number of employees by labor category
- Operating revenues (adjusted) / Total compensation (adjusted)

**Fuel:**
- Revenue ton-miles (RTM) / gallons of fuel consumed

**Infrastructure:**
- Revenue ton-miles (RTM) / Miles of track (route) owned
- Revenue ton-miles (RTM) / maintenance of way (MOW) expenditures (adjusted)

**Equipment:**
- Revenue ton-miles (RTM) / Number of locomotives in service
- Carloads / Number of freight cars in service by type of car
- Revenue ton-miles (RTM) / maintenance of equipment (MOE) expenditures (adjusted)

**Capital:**
- Net railway operating income / Net investment = Return on investment

**Safety (indicators rather than productivity metrics):**
- Accidents / Train-miles
- Injuries & Illnesses / Number of employees

**Labor productivity**

Labor productivity, expressed in terms of revenue ton-miles (RTM) per employee-hour (Figure 6), has increased 430 percent in the three decades between 1979 and 2009. This sustained increase was only interrupted twice, between 1996 and 1998, when productivity stabilized for two years, and after 2008, when a small drop was observed for the first time in 30 years.
A major question arises with respect to these results: What has caused this significant improvement in labor productivity during the past 30 years?

The overall improvement in labor productivity has to do, of course, with both with the increase in demand and the major changes in labor rules and staffing in the freight rail industry. The industry reduced its number of employees from 483,000 in 1979 to 152,000 in 2009 (Class I RR only), without compromising the overall growth in traffic. The negotiation of new labor agreements allowed for a reduction in force. The adoption by railroads of computers, starting from the 1980s resulted in the automation of several tasks that were previously labor intensive. Both operational (e.g. train dispatch) and administrative functions (e.g. accounting) became increasingly automated, contributing significantly to the 68 percent reduction in labor force.

Figure 7 displays the evolution of labor productivity by labor classification. It shows that among all categories of employees, it is the professional and administrative staff whose productivity has increased the most, confirming the impact of computerization on the clerical functions.
Another metric of interest is the operating revenues divided by labor compensation, after adjustments using respectively the Federal Reserve Implicit Price Deflator and the RR Labor Cost Recovery Index. It shows that while a dollar spent in labor compensation in 1979 generated $1.80 of operating revenues, productivity in 2009 increased by 192 percent to $5.25 of revenue for $1 of labor cost. In Figure 8, the effect on compensation productivity of the increase in rates after 2004 is clearly observable, as is the effect of the traffic loss that occurred after 2008.
Fuel productivity

Fuel productivity, expressed in terms of RTM or car-miles per gallon of fuel consumed, has been steadily increasing since 1979 as the result of improvements in both locomotive technology and traffic management techniques.

Indeed, research and development in the field of diesel-electric technology have led to continual reductions in diesel engines’ fuel consumption, made possible by the general improvements in diesel technology (e.g., turbo compressors, improved injectors and lubricants, low friction transmissions), but also by a series of more recent innovations such as:

- the new generation of hybrid locomotives that capture the energy dissipated during braking and store it in batteries for re-use
- fuel monitoring systems that measure and report fuel levels and allow for real-time fuel management
- start-stop systems that shut down idle diesel engines, while keeping them able to restart on demand
In addition to the advances achieved in locomotive technology, new management tools such as trip optimizers have helped reduce railroads’ fuel bills by reducing the number of unprofitable miles, just as Centralized Traffic Control and better signaling have helped reduce the fuel-consuming train stops and slowdowns.

Figure 9 above shows the evolution of fuel productivity for Class I railroads in terms of RTM per gallon of fuel consumed. It appears that productivity has increased almost linearly over the past three decades, but increased more sharply starting in 2006, which may correspond to an increased management focus on fuel consumption (freight traffic decreased by only 13.5 percent between 2006 and 2009, while fuel consumption decreased by almost 24 percent during the same period).

**Infrastructure productivity**

In the assessment of infrastructure productivity, the distinction between miles of route and miles of track is not significant. Indeed, the average number of tracks per route did not change significantly during the past 30 years, remaining in the range of 1.6-1.7.
As shown in Figure 10, infrastructure productivity as the ratio of RTM to miles of track owned increased by almost 190 percent in the past 30 years. It has generally followed the evolution of the demand, especially during the past 15 years when network down-sizing slowed in comparison with the years of network rationalization immediately following deregulation. Indeed, the miles of track owned were reduced by 34 percent between 1979 and 1994, and by only 12 percent between 1994 and 2009. This reduction is known as network rationalization because the reduction in the network size was generally at the expense of the less profitable routes and was accompanied by a more intelligent use of the remaining network. Through network rationalization, railroads effectively exercised the abandonment provisions of the Staggers Rail Act.

Additionally, improvements in track technology and better maintenance methods allowed for longer infrastructure life and fewer traffic interruptions on portions of the network.

![Figure 10: RTM per mile of track owned (Thousand)](image-url)
The author of this study notes that in the assessment of infrastructure productivity, the use of maintenance-of-way (MOW) and structure expenditures (excluding labor) as an input helps overcome the issue of track being only one of the components of the infrastructure category. The productivity of each dollar spent on MOW and structure expenditure is shown in Figure 11 below².

![Figure 11: RTM per MOW expenditures excl. labor](image)

**Equipment productivity**

As discussed earlier, this study focuses on locomotives and freight cars, as the main categories of equipment. Locomotive productivity expressed in terms of RTM per locomotive in service shows two different periods of evolution: the first period from the early 1980s to mid-1990s, when productivity increased by almost 150 percent, and the second period from mid-1990s to 2008, during which productivity was stable, just before a drop in 2009 (Figure 12).

² Data for MOW labor compensation relative to years from 1989 to 1992, 1994, 1996, 1997, 2008, and 2009 are missing. Therefore, the figures have been interpolated and might differ from the real ones.
The large increase in locomotive productivity during the first period is due to a reduction in the number of locomotives in service (most likely the non-renewal of units at the end of life or their replacement by fewer but more powerful units) without affecting traffic growth. In 1979, the industry utilized 28,097 locomotives, and by 1994, total locomotives had been reduced to 18,505, a 34% reduction. The ability of the rail industry to maintain traffic growth while reducing the number of locomotives, even supported by the improvements in tractive technology, is evidence of the large productivity gains that resulted from better management and equipment maintenance.

Following such tremendous gains, the freight rail industry experienced a period of productivity stabilization. It was eventually determined that further traffic growth would require an increase in the size of the size of the locomotive fleet. The freight rail industry responded, increasing the number of locomotives in service by 30 percent between 1994 and 2008 from 18,505 to 24,003 locomotives, while freight traffic increased by 48 percent.

The assessment of freight car productivity should take into account the fact that, under negotiated contracts, Class I railroads operate larger numbers of freight cars provided by shippers.
seeking to secure freight capacity. Hence, Figure 13 below takes into account both railroad-owned and shipper-owned freight cars. It appears that freight car productivity has not increased as significantly as the productivity of other inputs such as labor, fuel, and infrastructure. Freight car productivity increased by 40 percent between 1979 and 2009, with a peak in 2006 that was 2.1 times higher than the lowest value in 1982.

As with locomotives, the freight car fleet (Class I RR + shippers and car companies) was significantly reduced during the first period: the number of freight cars in service decreased from 1.6 million in 1979 to 1.1 million in 1994 (-31 percent). During the same period, demand dropped by 23 percent between 1979 and 1982 but recovered steadily to regain its original 1979 level in 1994. This essentially flat demand, coupled with the freight car fleet reduction led to the observed improvement in productivity. The trend was reversed in the following 12 years as demand took off while equipment down-sizing slowed down, allowing for continued productivity growth. Freight car productivity could not withstand the sudden and significant traffic losses that occurred after 2006, however, dropping by more than 20 percent in three years.

These improvements in car productivity can be attributed, as with locomotives, to better equipment management (scheduling) and maintenance, but also to more efficient
loading/unloading operations, and to the use of unit trains. As mentioned previously in this study, the latter consist of trains composed of a single type of car, carrying one commodity and linking the same origin with the same destination on a regular basis without making on-route stops or splits.

Maintenance of equipment (MOE) expenditures (excluding labor) can also be used as an input. This provides a measure of the productivity of every dollar spent in equipment maintenance as shown in Figure 14 below³:

![Figure 14: RTM per MOE expenditures excl. labor](image)

**Capital productivity**

The Return On Investment (ROI) is a financial measure of how well a company uses capital to generate profits. It is therefore the ratio of an output to an input and can be seen as a capital productivity measure. For railroads, the ROI is the ratio of the Net Railway Operating Income (NROI) to the Net Investment in transportation property (infrastructure and equipment).

³ Data for MOE labor compensation relative to years from 1989 to 1992, 1994, 1996, 1997, 2008, and 2009 are missing. Therefore, the figures have been interpolated and might differ from the real ones.
Figure 15 shows the evolution of the ROI during the past 30 years. If one ignores the periodic fluctuations and focuses on the general trends as illustrated by the black trend line, three trends emerge:

- a “divestment phase” from 1979 to 1991 where the ROI has increased as the result of massive industry down-sizing (reductions in the equipment and the size of the network) and modest but overall improving results (in current dollars)
- an “investment phase” between 1992 and 2003 where the ROI has stabilized as results kept improving but were accompanied by an increase in the investment, partly in equipment acquisition and track modernization
- a “profitability phase” from 2004 to 2009 where the investment maintained its uptrend, but during which higher profits caused the ROI improvement

![Figure 15: Return On Investment](image)

**Safety**

It would not be correct to present safety indicators as productivity metrics even if they consist generally of an industry output divided by an input (e.g. the number of accidents per train-mile). They deserve attention, however, because the rail industry has made notable improvements in the
past 30 years. Figure 16 shows the number of derailments and collisions per million train-miles excluding grade crossing accidents.

5 Conclusions

In the past 40 years, there have been major changes in the U.S. freight rail industry including bankruptcies, reduction of crew size and computerization. As a result of the Regional Rail Reorganization Act of 1973 and the Staggers Rail Act of 1980, railroads abandoned unprofitable lines and set their own rates.

Between 1979 and 2009, all the inputs of the U.S. freight rail industry saw their productivity increased by rates ranging from 110% in the case of fuel to 430% in the case of labor. Productivity growth has slowed in recent years, raising the issue of the sustainability of the significant improvements achieved during the past three decades. Although shipping rates decreased right after deregulation, railroads have reversed their downward trend, allowing companies to capture some of the positive outcomes of these productivity improvements.
Future improvements in operations productivity are likely to be conditioned by the evolution of shipping rates for the most strategic commodities. Also, the contributions of fuel, infrastructure, and equipment productivity will gain importance as a result of the limited incremental improvements still possible in labor productivity.
REFERENCES


Federal Railroad Administration, Office of Safety Analysis. 2.02 Train Accident Rates. http://safetydata.fra.dot.gov/


"Railroad Facts.” by the Association of American Railroads (AAR). Railroad Facts is the AAR’s annual publication of railroad financial, traffic, and operating data. Carl D. Martland has assembled data from many of these reports into a comprehensive database covering most of the period between 1965 and 2010.
