US Railroad Efficiency: A Brief Economic Overview

By

Gerard J. McCullough, Ph.D.
Department of Applied Economics
University of Minnesota

The focus of U.S. transportation policy in the 19th and 20th centuries was on extending the benefits of transportation to more locales and to more citizens. The focus of policy in the 21st century must also be on reducing the costs of transportation. Current transportation costs associated with safety, congestion, sprawl, and pollution are large. Future costs associated with scarcity of petroleum could be cataclysmic.

The railroad network is a national asset that could be used to reduce the costs of transportation. This paper has two aims consistent with that possibility. The first is to describe the efficiency improvements that the railroad industry itself has made in the past few decades. The second is to describe the role that rail network could play in a more efficient overall national transportation system.

I. Economic Efficiency in Transportation

After the 1974 and 1978 oil shocks Congress explicitly recognized the importance of an efficient transportation system. The *Staggers Rail Act* of 1980, for example, was designed to promote “a safe and efficient rail transportation system.” (PL 96-448). Similarly, the *Intermodal Surface Transportation Efficiency Act* of 1991 had as its goal “a National Intermodal Transportation System that is economically efficient.” (PL 102-240).

There was less emphasis on efficiency in the 1990s. The *Transportation Equity Act* of 1998, for example, stressed fairness over efficiency (PL 105-178). With recent increases in oil prices, however, efficiency is back on the national agenda and is named in the title of the *Safe, Accountable, Flexible, Efficient Transportation Equity Act* of 2005 (PL 109-59).

There are two formal economic aspects of efficiency.

Productive efficiency occurs when an economy cannot produce more of one good or service without producing less of another. This generally occurs when firms produce at minimum average total cost.

Allocative efficiency occurs when the economy cannot raise one consumer's satisfaction without lowering another's. This occurs when price signals to consumers are based on marginal costs.

The focus of this conference is on techniques of improving rail network performance. We are concerned with the *productive efficiency* of railroad firms. We are asking what needs to be done to enable railroads to provide service at the minimum average cost that is technologically possible?

At the same time, however, everyone--including the manufacturers and distributors of most goods and services produced in our economy--consumes transportation services. The *allocative efficiency* of the transportation system within which railroads operate is also important. We must at least raise the question of whether the rail network is playing its proper role within our overall transportation system? Are we realizing the rail network's potential?[1]

II. Productive Efficiency of US Railroads

The Staggers Rail Act gave railroad managers discretion to use pricing and service levels (often reached through contract negotiations with shippers) to affect the composition of rail output. Changes in output composition, along with line abandonments and a significant degree of industry consolidation, have led to higher traffic densities, longer lengths of haul, and a significant shift in the train operations.[2]

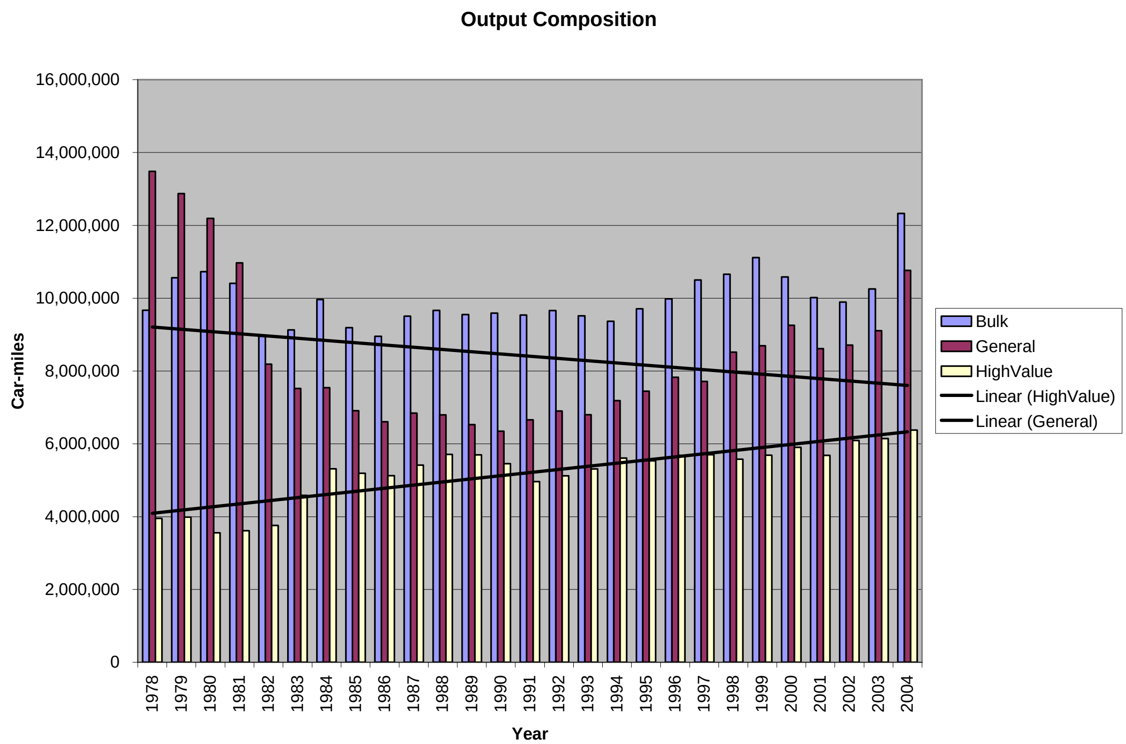
The changes in the composition of rail output are illustrated in Figure 1. [The data are from the Association of American Railroads *Analysis of Class I Railroads* published annually.] In 1978 the Class I industry generated about 13.5 billion loaded and empty general car-miles (defining "general" here as boxcar, gondola, reefer, general purpose flat car-miles), but by 2004 the number had dropped to 10.8 billion. In the high-value market, on the other hand, intermodal and multi-level auto carrier car-miles grew from 3.9 billion in 1978 to 6.4 billion in 2004. Loaded and empty bulk car-miles (open hopper, closed hopper and tank), meanwhile, grew from 9.7 billion to 12.3 billion.[3]

[1] It is also likely that an increase in the *allocative efficiency* of the transportation system will increase the *productive efficiency* of railroads. Econometric studies have shown that railroads exhibit increasing returns to density. This means that as the railroad share of the freight transportation market increases (*allocative efficiency*) railroads themselves will be able to produce at lower marginal cost (*productive efficiency*). See, for example, Ivaldi and McCullough (2001).

[2] Abandonments and consolidations were also facilitated by the Staggers Rail Act.

[3] The capacity of these bulk cars increased significantly as well.

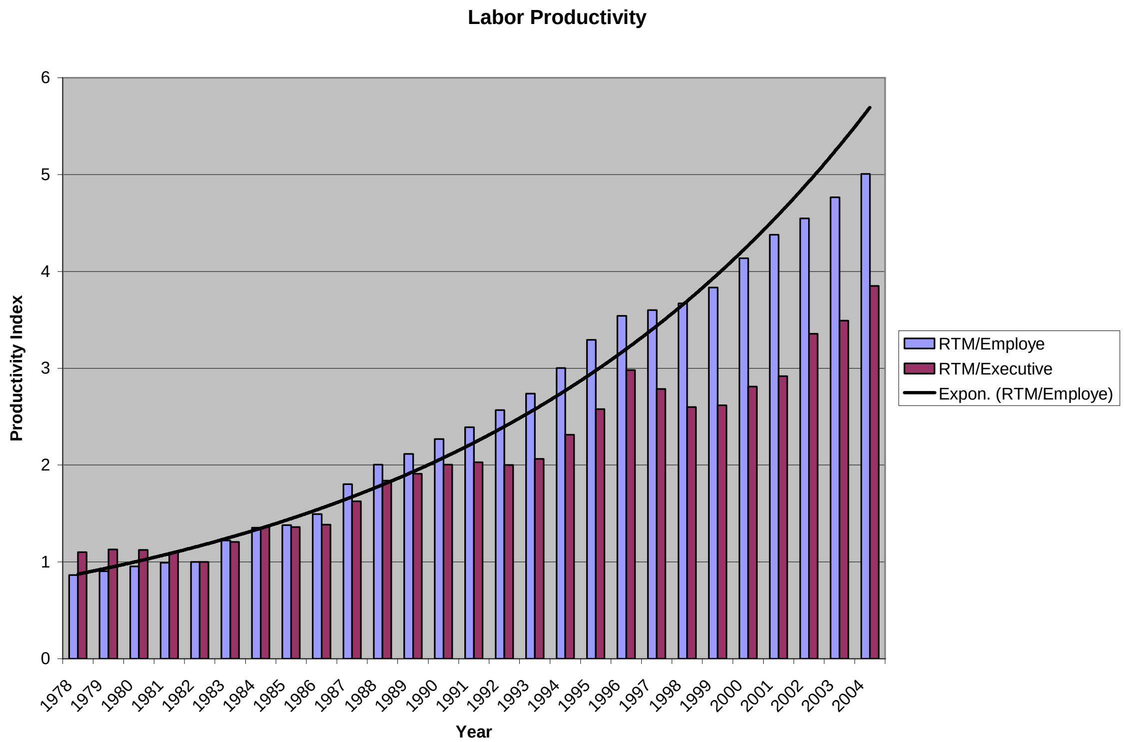
Figure 1. Car-miles by Car-type



The operational changes have been dramatic. The AAR *Analyses* show that between 1978 and 2004 revenue ton-miles per mile of road have grown from 4.5 million to 12.2 million, average lengths of haul have increased from 617 miles to 902 miles, and the percent of train-miles completed in unit trains has expanded from 7 percent to 37 percent.

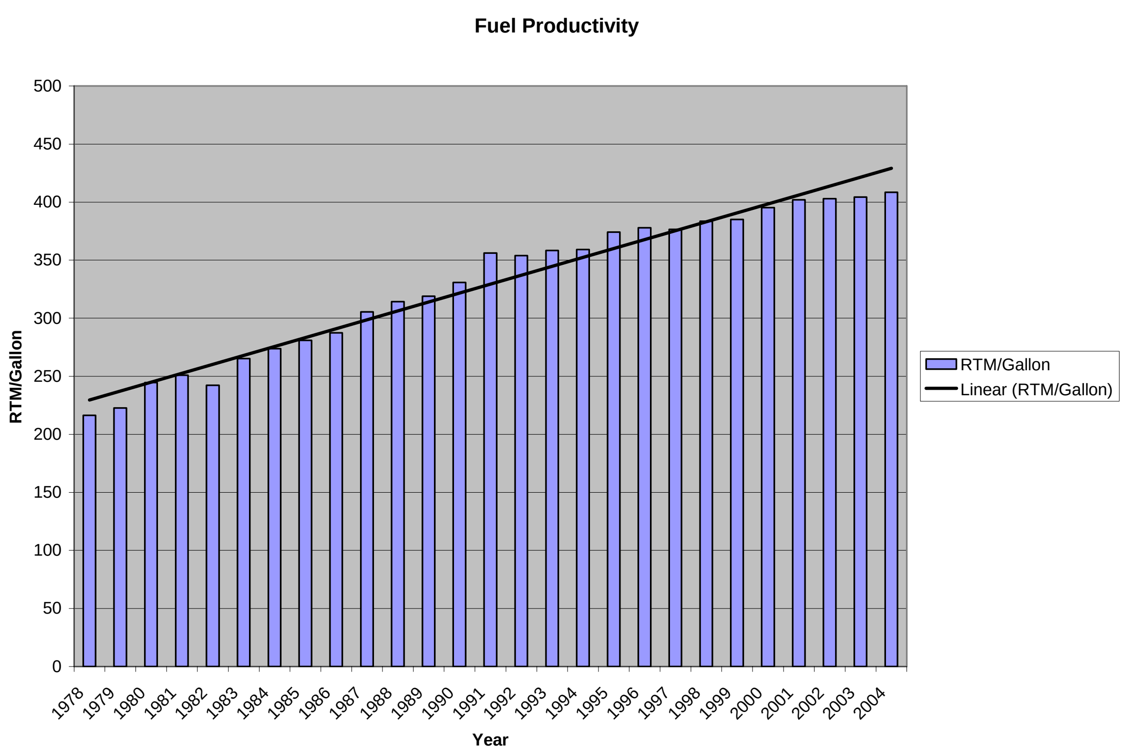
Operational changes have been accompanied by various technological improvements including higher adhesion locomotives, re-engineered rails and cars, better maintenance of way equipment, and automated inspection techniques. The overall effect has been a much higher level of *productive efficiency* in the rail industry. Labor output (Figure 2) has grown from 1.8 million revenue ton-miles per employee in 1978 to 10.5 million in 2004.

Figure 2. Revenue Ton-miles per Employee



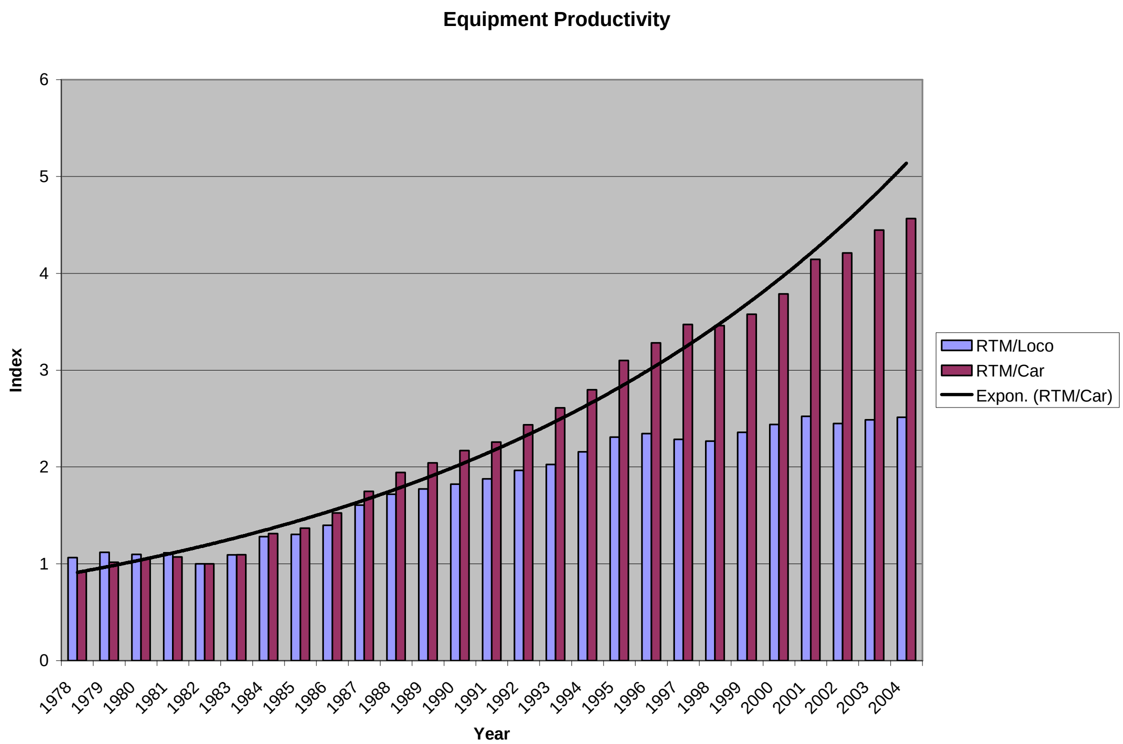
Fuel productivity (Figure 3) has increased from 216.4 revenue ton-miles per gallon to 408.5 revenue ton-miles per gallon.

Figure 3. Revenue Ton-miles per Gallon



Equipment productivity (Figure 4) has increased as well: revenue ton-miles per locomotive increased by about 250 percent, and revenue ton-miles per freight car has increased by about 450 per cent.[4] [All of the data are from the *Analyses of Class I Railroads*.]

Figure 4. Revenue Ton-miles per Unit of Equipment



The economic effect of these changes has been a significant reduction in railroad operating costs. These are illustrated by the bottom line in Figure 5--operating expenses per revenue ton-mile--which dropped from 2.46 cents (current) in 1978 to 2.11 cents (current) in 2004. (Operating revenue per revenue ton-mile, the top line in Figure 5, is treated below as a dimension of allocative efficiency.)

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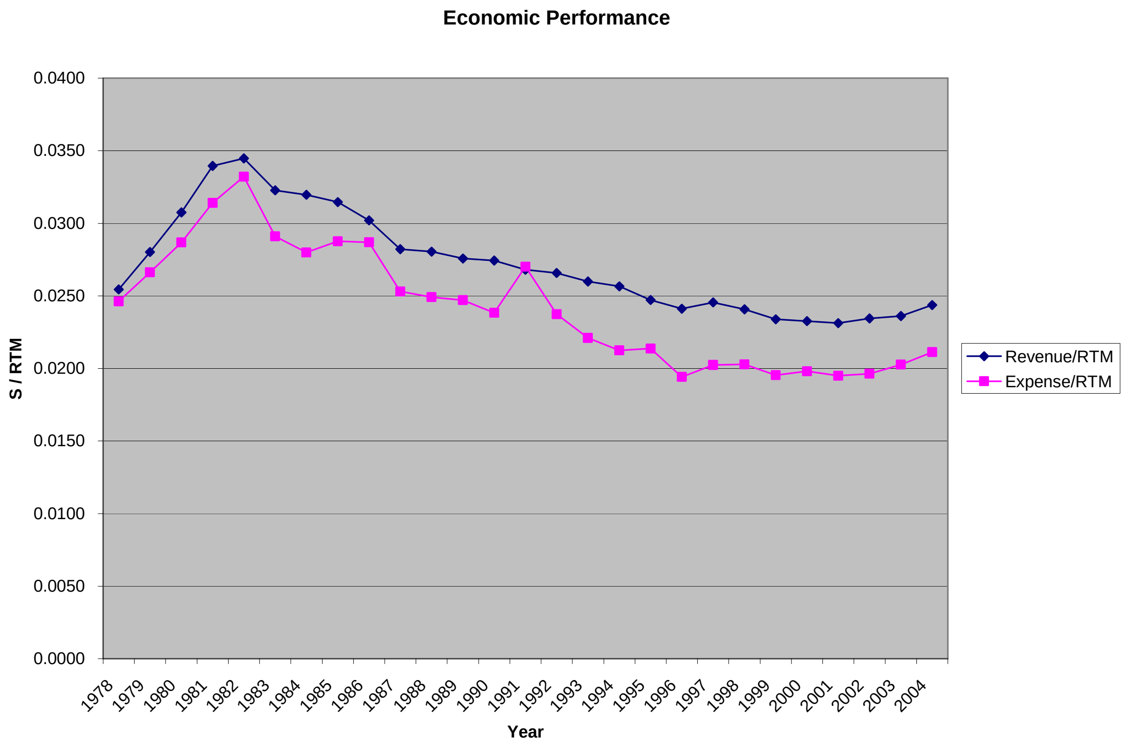
[4] What we have reported here are "partial" productivity measures in which outputs (e.g. revenue ton-miles) are divided by a specific input (e.g. labor hours). Other "total factor" productivity measures are available which take into account not only the relative increases of outputs and inputs but the residual effect of "technological progress" i.e. more efficient combinations of factors such as capital and labor. Most recent econometric studies of rail costs show total factor productivity gains in the rail industry of about three to four percent annually. See, for example, Ivaldi and McCullough (2004).

Figure 5. Revenue and Expenses per Revenue Ton-mile

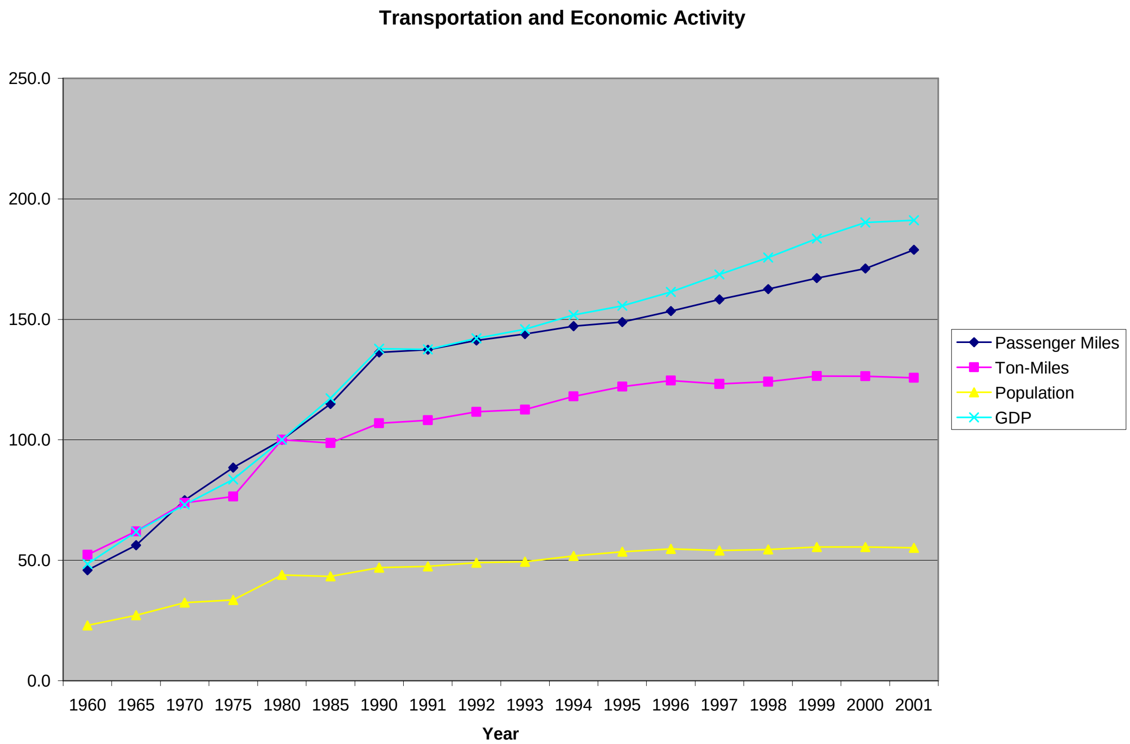


III. US Railroads and Allocative Efficiency

The role of transportation in fostering economic growth may have been exaggerated by highway builders and others who benefit directly from transportation spending. It is analytically difficult to disentangle the extent to which transportation investment generates economic activity or economic activity spurs transportation investment.

Nevertheless, there is a close connection between transportation activity and economic activity. Figure 6 based on the U.S. Department of Transportation's *National Transportation Statistics* illustrates how activity in national passenger and freight transportation markets (measured by VMT) are correlated to real GDP and population. Clearly, transportation is an important constituent of economic activity.

Figure 6. Transportation and Economic Activity



Various independent studies have shown that railroads have a definite *allocative efficiency* advantage over other modes in providing some transportation services. When all costs are taken into consideration—internal costs absorbed by firms and external costs such as pollution and congestion--railroads often generate lower marginal costs than the other modes. An efficient economy would favor railroads in these cases. One reason this may not happen is that it is difficult for political authorities to impose these external costs on truckers and shippers in the form of user fees for congestion/pollution/safety.

TRB Special Report 246 compares the full marginal cost of freight transportation by truck and rail in representative corridors. Table 1 (from *Special Report 246*, p. 90) compares the marginal cost of a truckload movement of grain some 215 miles from Walnut Grove, MN to Winona, MN. The rail movement has significantly lower overall costs when the external effects are taken into account.[5]

[5] One calculation missing in the TRB report is the total logistics cost that the shipper faces when he or she uses rail versus truck. Truck transit times are usually better and this lowers time-related total logistics costs.

Table 1. Freight Marginal Costs		
Category	**Truck**	**Rail**
Congestion	6.25	0.00
Accident	26.11	9.19
Pollution	6.75	1.43
Energy Security	3.63	0.39
Noise	0.00	0.78
Public Infrastructure	61.02	0.00
Carrier Cost	427.94	113.00
TOTAL	531.70	124.87

One allocative concern is that rail industry consolidation has not only helped to increase traffic densities and lengths of haul; it has also increased rail market power. The Herfindahl-Hirschman Index (HHI) is the standard measure that the U.S. Department of Justice uses to measure market concentration.[6] As the number of Class I railroads dropped from 36 firms in 1978 to 7 in 2004, the HHI (Figure 7)--calculated here from the AAR *Analyses* on the basis of carloads originated grew--from 589 to 2263 . This is well above 1000 HHI trigger-point at which the Justice Department begins to carefully scrutinize mergers.

Figure 7. Herfindahl Index

[6] Let S_i be the percent of output that a firm provides in a given market. The HHI is given by the formula

$$H = \sum_i S_i$$

Until recently, however, railroads have to some extent shared the cost reductions brought about by efficiency increases with shippers.[7] Figure 5 shows that despite increases in market power operating revenue per ton-mile declined from 2.54 cents (current) per revenue ton-mile in 1978 to 2.44 cents (current) per revenue ton-mile in 2004.[8] The pricing discipline enabled railroads to maintain a significant share of the freight market Table 2, based on data from the *National Transportation Statistics*) shows that railroads now carry about 40 percent of U.S. freight ton-miles--intercity and intracity.

Table 2. Freight Market Shares (ton-miles x 10^9)				
Mode	**1993**	**1997**	**2002**	**Percent Δ**
Truck	869.5	1023.5	1311.1	50.8
Rail	942.6	1022.5	1199.4	27.2
Water	272.0	261.7	323.1	18.8
Air	4.0	6.2	5.6	38.7

Railroads may also have an allocative efficiency advantage in some passenger markets as well though this is influenced by ridership levels as well as vehicle performance. Table 3 based on the Oak Ridge National Laboratory's *2000 Transportation Energy Data Book* (Table 2.12) compares the fuel intensity of competing intercity passenger modes. Both Amtrak intercity service and rail transit have energy efficiency advantages over intercity auto, transit buses and air but not over intercity bus. The report does not evaluate commuter rail services where railroads probably perform even better in energy efficiency terms.

Table 3. Energy Efficiency (Passenger Modes 1998)	
Mode	**Btu / Pass-mi**
Auto	3,671
Transit bus	4,238
Intercity bus	713
Air carriers	3,999
Intercity rail	2,460
Rail transit	3,216

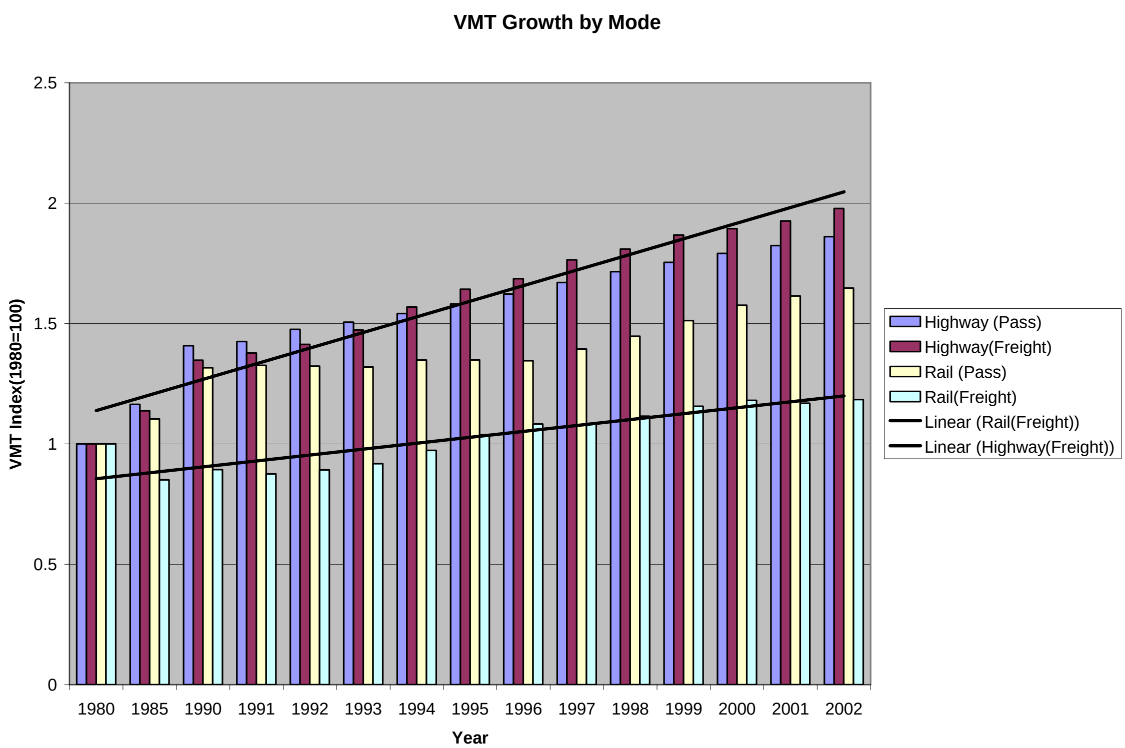
[7] The dynamics of railroad pricing behavior are beyond the scope of this brief paper. Intermodal, intramodal, product and geographic competition, the bargaining power of large shippers, and potential intervention by the Surface Transportation Board (STB), are all possible elements which affect prices.

[8] The operating revenue per ton-mile measure is only a proxy for average prices. It does not measure the degree to which railroads charge different prices to different customers.

IV. Conclusions

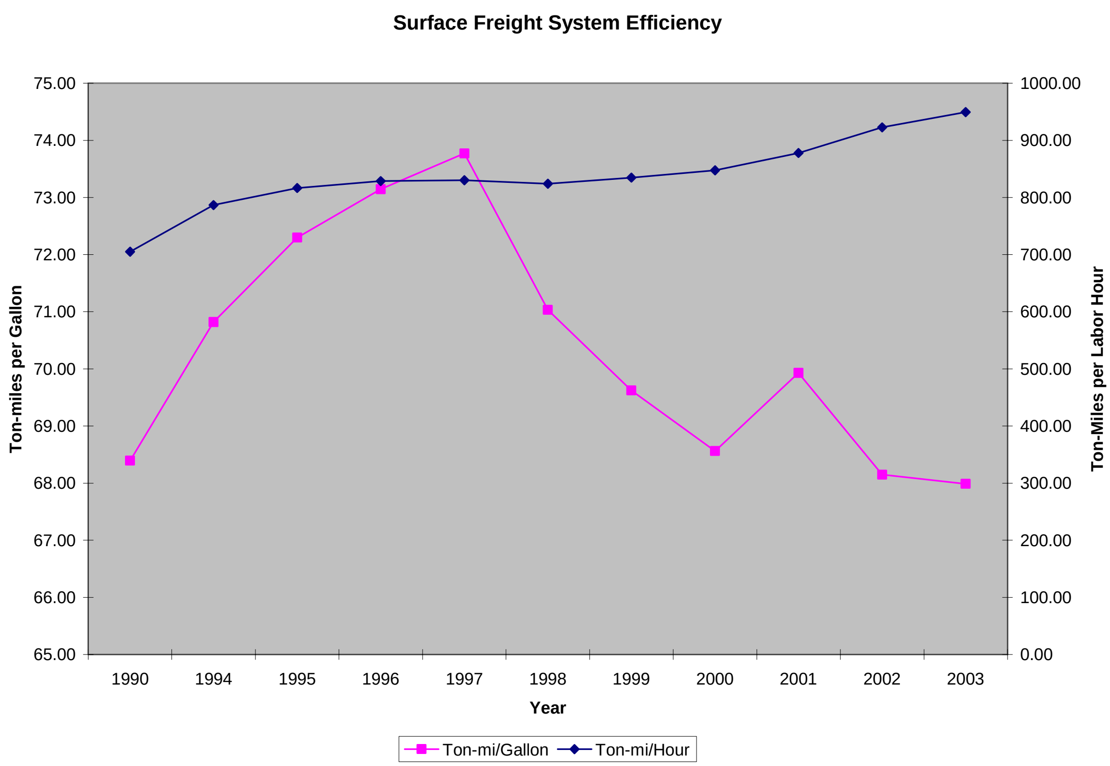
We still lack the data necessary to define the proper role of rail passenger service in the U.S., but it is clear that freight railroads have an *allocative efficiency* advantage in various markets. Though freight railroads have made significant gains in *productive efficiency*, rail freight is still one of the slowest growing modes of transportation in the U.S. Figure 8, based on National Transportation Statistics from BTS, shows that since 1980 rail freight vehicle-miles-traveled (VMT) has actually grown less rapidly than highway freight VMT or even rail passenger VMT.

Figure 8. VMT Growth by Mode



One interesting outcome, shown in Figure 9 based on the *National Transportation Statistics*, is that the freight system has become more labor efficient since 1978 but not more energy efficient. This should lead to a serious consideration of whether our national transportation policies are moving us away from allocative efficiency.

Figure 9. Surface Freight System Efficiency



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