Economic Effects of Transportation: The Freight Story

Final Report

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reduced if inventory can be reduced. Inventory held in retail stores or warehouses can be reduced if replenishment is fast and reliable.

For manufacturers and distributors of goods, there is a constant tension between the pressure to have enough stock to satisfy customers and the pressure to reduce the cost of carrying inventory. Businesses often find that improved freight transportation provides a way to accommodate these conflicting pressures. And, when inventory costs can be reduced while maintaining or improving the level of customer service, that is an increase in productivity.

In many cases, firms actually find that spending more on transportation is profitable because there are offsetting reductions in inventory costs. But this can only be the case with an efficient and reliable transportation system. Firms that analyze their costs carefully sometimes find that inventory can be reduced and the number of warehouses reduced without loss of customer service by using more transportation and using it more effectively. Such changes in a firm's logistics set-up are sometimes referred to as a "reorganization effect." The reorganization effect occurs when a firm's managers decide that time-cost reductions, and other savings from freight improvements, are sufficient, for example, to increase length of haul and reduce the number of the firm's warehouses (see Exhibit 5). In this way, a firm takes advantage of reduced freight costs to realize scale economies in its warehouses and reduce inventory. The firm spends more on freight carriage, but the intended result is a reduction in total logistics costs.

Exhibit 5: How do Firms React to Improvements in Freight Transportation?

- Firms reduce stocking points, increase JIT processes, and increase shipping distances
- Firms react to reduced late-shipping-delays, valued highly by shippers, by investing more in logistics
- Inter-industry trading patterns are affected

There are good examples of cases where logistics reorganization, supported by a good transportation system, leads to lower total logistics costs and also to improved customer service. In the late 1980s, Polaroid, for example, decided to centralize its European inventories by buying more transportation and using fewer warehouses; a large number of warehouses were, in fact, closed. Polaroid's action resulted with: 1) estimated annual gross savings of $6.9 million and 2) net annual savings of $6.3 million after subtracting $0.6 million per year for increased costs resulting from computer system maintenance and increased warehouse personnel at headquarters (see Exhibit 6 on the following page).

When service can be improved while costs are cut, that is truly a gain in productivity. And the gains realized by Polaroid could not have been achieved without an efficient and reliable freight system in place.

Exhibit 6: Polaroid's Cost Savings from Reorganization—The Break-Down

- *warehousing personnel—$2.5 million;*
- *inventory carrying costs—$2.2 million;*
- *warehouse rental costs—$1.0 million;*
- *facilities and offices—$0.6 million;*
- *internal transportation between dealers and subsidiaries—$0.5 million; and*
- *insurance premiums—$0.1 million.*

Besides the savings that Polaroid could quantify, there were other gains that were not measured. Prior to centralizing inventory, 69 percent of orders could not be filled at the location that received them, so that items were backordered until they could be filled from other locations. This required significant internal transportation among dealers and subsidiaries to reposition inventory. Polaroid also achieved freight-cost savings based on volume discounts for consolidated (truckload) shipments to centralized warehouses.

Similarly, Ford Motor Company found a way to reduce transportation costs and inventory costs and improve service to its dealers by exploiting the lower cost of rail shipment of finished vehicles and introducing a new distribution system that sped the movement of vehicles from factories to dealers. Ford instituted a system of "mixing centers," essentially distribution centers, with predominantly rail shipment from factories to mixing centers and the final leg to the dealer by rail and highway or all highway according to the circumstances (see Exhibit 7). Ford's goal was to reduce order delivery times from 72 to 15 days from receipt of dealer order. The mixing centers replaced a system in which various types of vehicles ordered by a particular dealer were held at an assembly plant until there were enough vehicles for that dealer to fill an entire rail car (ten to twenty vehicles, depending on their size) or truck (five to ten vehicles, depending on their size). When a rail car or truck could be filled, the shipment moved to the dealer. Under the new system, each assembly plant ships daily to the mixing centers.

Exhibit 7: Ford's Mixing Centers--
Ford created four national mixing centers at Chicago; Shelbyville, Kentucky; Kansas City, Missouri; and Fostoria, Ohio.

At the mixing centers, vehicles are sorted and recombined to meet actual orders from dealers and moved on by rail or highway. Vehicles are held at the mixing center only as long as is needed for sorting and transloading, usually eight to 24 hours.

Through a major restructuring of its logistics operations and facilities, Ford was able to reduce both transportation and inventory costs while improving service to its customers. This resulted in an increase in productivity, and it required efficient and reliable freight systems, both rail and highway.

These cases, including that of Dell in the previous sub-section, illustrate a point that is at the heart of the freight story—businesses will increase expenditure on freight transportation, buy more freight service, and thereby achieve a reduction in total logistics costs because of savings in inventory and warehouses. And this is done in ways that improve customer service as well as reduce cost. Perhaps a central point is that firms are alert for opportunities to improve their logistics systems and will act when they find the price and quality of transportation that makes it feasible to do so.

These gains in logistics are gains in productivity. They may occur when a firm responds to a freight improvement, or, for whatever reason, analyzes its logistics arrangements and discovers that it is not taking full advantage of the freight transportation system's capabilities. Either way, these productivity gains will not occur unless a firm's management perceives that the freight system is robust and reliable enough to support its plans. These gains certainly will not occur if a firm's managers perceive that the quality of the freight system (as defined by speed and reliability) is deteriorating or will deteriorate (see Exhibit 8). This is the link between the quality of the freight system and national productivity gains.

Exhibit 8: Some Findings from Interviews with Shippers and Carriers—*As part of FHWA's Freight BCA Study, twenty-one interviews have been conducted with shippers and carriers. This is some of what they show.*

Current service is good

- ➞ On-time rates often over 95%

Firms frequently revisit their logistics arrangements

- ➞ Of 13 shippers, 5 changed or were about to change logistics

Firms concerned if highway conditions get worse

Businesses revisit logistics under a variety of business pressures (cost and customer service)

- ➞ Freight-transport improvements affect the outcome of industry re-organizations
- ➞ Shippers revisit logistics in response to business pressures

1.3 The Business Reorganization Effect

We have seen that a good freight-transportation system allows and stimulates logistics improvements that, in turn, raise the productivity of businesses and, thus, the productivity of the nation. When the productivity of the nation is increased, the national economic welfare is enhanced; we are able to produce more or better goods and services than would otherwise have been the case.

While these concepts are intuitively valid, the analytical work to provide definite quantitative information on the link between improved freight transportation and national welfare is just beginning. Benefit-cost models have been developed for evaluation of highway investments, but none of them accords proper treatment to the benefits of freight improvements.[3] This is because the link between improved freight transportation and national welfare is complex; and hinges on how the cost of doing business is affected by improvements in freight transport and, in turn, how cost reductions translate into productivity gains in the economy.

In particular, previous models do not account for the benefits to the owners of the cargo and all they can mean in terms of more efficient logistics and greater productivity in manufacturing. Not treating the effects of road improvement (for example) on the owners of the cargo moving over the road is a major omission. Valuing a reduction in truck travel time (referred to as "transit time" for freight) only by the saving in drivers' wages

[3] In general, the sponsors and authors of these models have been heavily focused on user benefits for highway passengers and have not given thorough consideration to the economics of freight movement. In the standard models, the treatment of trucks is parallel to that of passenger cars. Benefits are reckoned on the basis of reduced travel time, reduced operating costs, and reduced costs from accidents, all in terms of benefit to the owner of the truck.

implicitly assumes there is no benefit to the shipper from getting goods to their destination more quickly. But it clearly must make at least some difference to the shipper if cargo is delivered earlier than it otherwise would be. This would mean, for example, that a larger number of warehouses could be reached in a day's drive from a factory, and a larger number of customers could be reached in a day's drive from a warehouse. As we have already noted, these extensions of the reach of a manufacturing or stocking facility can lead to gains from scale efficiencies and, possibly, provide opportunities for reducing total inventory.

The following classification scheme for benefits and other effects should facilitate understanding of the benefits associated with improvements in freight transportation.

Effects of Improved Freight Transportation	
First-order Benefits	Immediate cost reductions to carriers and shippers, including gains to shippers from reduced transit times[4] and increased reliability.
Second-order Benefits	Reorganization-effect gains from improvements in logistics[5]. Quantity of firms' outputs changes; quality of output does not change.[6]
Third-order Benefits	Gains from additional reorganization effects such as improved products, new products, or some other change.
Other Effects	Effects that are not considered as benefits according to the strict rules of benefit-cost analysis, but may still be of considerable interest to policy-makers. These could include, among other things, increases in regional employment or increases in rate of growth of regional income.

FHWA's Freight BCA Study focuses on the first and second-order benefits of improved freight transportation. It looks at demand for freight carriage from the viewpoint of the consumer of freight transportation (i.e., the shipper). A shipper's response to the change in freight-movement cost is determined by the conditions of its demand for freight transportation. A shipper's demand for freight transportation reflects both the market's

[4] Carrier effects include reduced vehicle operating times and reduced costs through optimal routing and fleet configuration. Transit times may affect shipper in-transit costs such as for spoilage, and scheduling costs such as for inter-modal transfer delays and port clearance. These effects are non-linear and may vary by commodity and mode of transport.

[5] Improvements include rationalized inventory, stock location, network, and service levels for shippers.

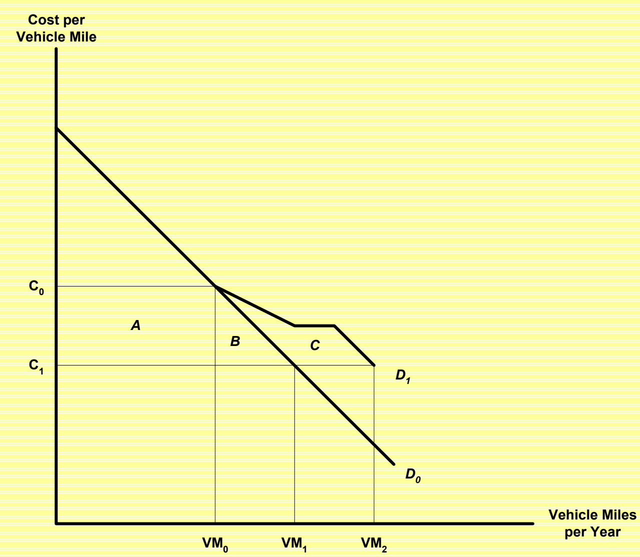
[6] In the first-order case, nothing changes for shippers except the cost of freight movement (including time cost). They continue to ship the same volume of goods the same distance between the same points. Their costs are less, but they make no response to the cost reduction other than to keep the extra income thus realized. In order to estimate the first-order benefits, it is necessary to find the value of the time-cost reductions and then add this amount to those that are calculated in a standard analysis—reductions in operating costs, cost savings from reductions in accidents, and drivers' wages—all assuming no change in volumes or distances shipped.

In the second-order case, firms respond to the cost reduction. They may reduce prices to gain additional revenue by selling more goods; they may ship longer distances; they may close some warehouses; they may do some combinations of these things; or they may do something else altogether. Cost reductions of a certain magnitude occur; firms respond in ways that lead to both greater output and lower cost per unit of output.

demand for the firm's products and the way in which it uses freight transportation as an input to its production and/or distribution processes.

Exhibit 9: How the Business Reorganization Effect Can be Captured Under a Benefit-Cost Framework—*The shipper's demand curve reflects the benefits the shipper gets from buying freight transportation. The cost the shipper is willing to incur to obtain freight transportation is what managers believe the freight movement is worth to the firm. They will not incur a cost higher than what they think it is worth (although they will willingly take it at a lower cost if that is possible). Thus, the change in the demand curve reflects the greater benefits the shipper can get from the freight-carriage improvement, once the firm has reorganized its logistics set-up.*

A freight improvement's full benefit is reflected in the sum of areas A, B, and C.



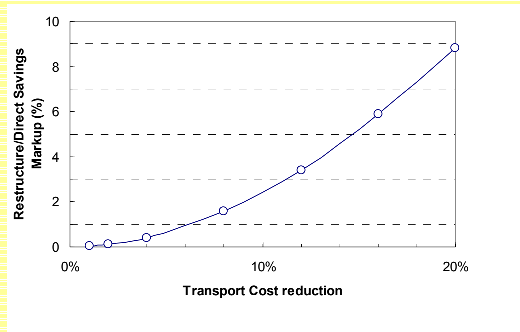
As developed under the Freight BCA Study and presented in Exhibit 9, the shipper's demand curve for freight transportation takes two forms, D_0 and D_1. D_0 shows a shipper's demand for freight transportation before an improvement to the freight system (in particular a highway improvement). The new curve, D_1, shows the change in demand that follows the improvement. The shipper's reaction to the cost reduction can be thought of as occurring in three phases. In the very short run, the shipper makes no response and continues to buy the same number of vehicle miles of freight, VM_0. The benefit to the shipper is the area A, the cost reduction with the existing volume of freight. In the next phase of response, the shipper takes advantage of the lower cost and buys more freight movement, VM_1. This adds the area B to the benefit. But this still reflects the shipper's original demand curve, D_0. The shipper has not made any changes in the firm's basic logistics.

But, after managers have had time to consider the cost reduction, they may, as already noted, make changes in their logistics. This is when the shipper's demand for transportation would change, and there would be the new freight transportation demand curve, D_1. The additional benefit from the reorganization is area C, the area between the old and new demand curves. The freight improvement's full benefit is reflected in the sum of areas A, B, and C.[7]

[7] Note that, as shown in "Benefit-Cost Analysis of Highway Improvements in Relation to Freight Transportation: Microeconomic Framework", this captures all benefits without double counting.

Although the extent of logistics reorganizations is not well known, case studies and interviews conducted under the Freight BCA Study have confirmed that it can and does occur. With the best parameter estimates to date (albeit based on limited data), the mark-up factor for reorganization over conventional benefits follows the pattern shown in Exhibit 10.

Exhibit 10: Mark-up Factor for Reorganization Over Conventional Benefits—*For any level of transport cost reduction, a risk analysis allows us to assign a probability range to the dependent variables. For instance, based on assumed ranges of uncertainty in parameters and with a 20% transport cost reduction, the analysis shows that we can be confident at the 90% level that the true mark-up factor is between 7.5% and 10%.*



It is reasonable to expect that the mark-up factor will level off as transport cost reductions increase.

2. Trends in Freight Transportation

Based on the above, we now can see how improvements in freight transportation generate economic benefits that can improve the productivity of the national economy. In particular, an efficient and reliable freight system is a necessary condition for ensuring that transport costs remain low and foster increases in productivity. The following question remains, however: what affects the reliability and efficiency of the freight system?

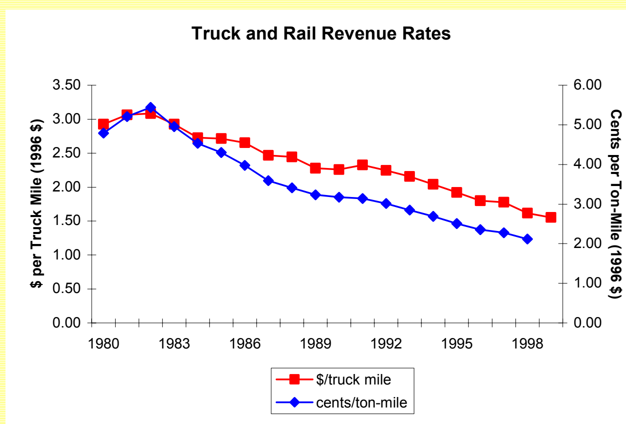
In this Section, we will develop a picture of changes in the freight system and how well it has been performing—keeping in mind that the performance of the freight system is important since it not only affects economic productivity, but is itself a function of public policy. We will look briefly at the history of freight transportation since deregulation, recent trends in investment in freight transportation, especially highway freight, and consider the implications of investment trends.

2.1 Historic Perspective on Freight Transportation in the Post-deregulation Period

Changes in transportation and logistics, and especially changes in the trucking industry, came about as a consequence of trucking deregulation (Motor Carrier Act of 1980) and partial rail deregulation (Staggers Rail Act of 1980). Deregulation led to declines in trucking rates (see Exhibit 11), and, more importantly, a new, responsive, and flexible trucking industry emerged that has become more sophisticated in its operations and has made possible much of the improvement in the logistics system that has subsequently evolved.

Exhibit 11: Deregulation led to a decrease in trucking rates.

The fact that deregulation led to a striking decline in truck rates is shown below. After adjusting for inflation, revenue per truck-mile in 1999 was approximately 53% of the 1980 level. We see a similar pattern for rail rates. Revenue per ton-mile in 1998 was just over 44% of the figure for 1980.



The elimination of regulatory barriers to entry, and particularly the requirement for route and commodity-specific operating authority, permitted the rise of efficient truckload (TL) operations. Prior to deregulation, some TL firms existed, but the regulatory barriers kept them out of any significant markets. The less-than-truckload (LTL) firms were, for most practical purposes, the trucking industry. Insulated from competitive pressures, they generally offered one-size-fits-all service. There were no contracts for specific bundles of services and few arrangements for truckload pick-up and delivery at customer-specified times. And, of course, there was little door-to-door truckload service.

Things changed when TL carriers could approach shippers and offer door-to-door services, tailored to customer specifications, at rates much lower than those demanded by the LTL firms. It was this development that allowed guaranteed just-in time (JIT) deliveries and all the other features that brought the evolution of advanced logistics systems and supply-chain management (see Exhibit 12A). And, as we have seen, improvements in logistics generate business reorganization effects that help to enhance productivity.

More specifically, the phenomenon of lower freight rates and better service led to substitution of transportation spending for inventory spending. As shown in Exhibit 12B, actual spending on freight transport was rising much faster than inventory costs—businesses took advantage of cheaper and better freight transport to restrain growth in their inventory costs.

As businesses substituted transportation spending for inventory spending, and the business reorganization effect began to take a foothold, the demand for trucking services increased significantly. In particular, since 1990 (10 years post-deregulation) growth in trucking ton-miles has accelerated significantly (see Exhibit 13, below) and at a faster

Exhibit 12A: The advent of TL carriers allowed for significant efficiency improvements in logistics systems.

The increased efficiency of the logistics system is manifest in the reduction of logistics cost as a share of Gross Domestic Product (GDP). Total logistics costs peaked as a share of GDP at 16.0 percent in 1981. By 1992 the share had dropped to 10.1 percent and has since remained close to that level over the last few years, being at 9.9 percent in 1999. This trend is shown in below.

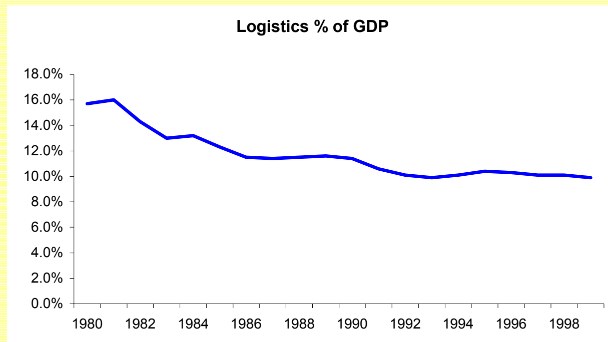
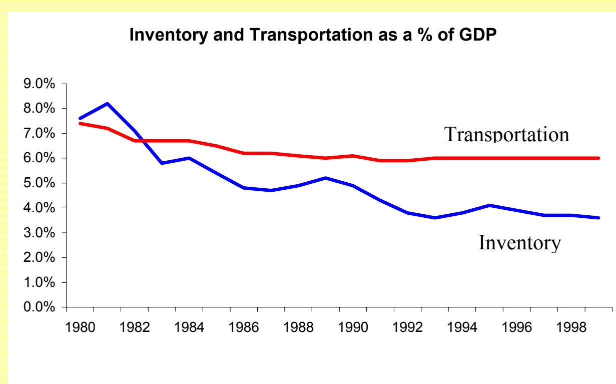


Exhibit 12B: Firms began to substitute transportation spending for inventory spending.

Relative to GDP, freight costs were at 7.4 percent in 1980 and have fallen since. Since 1988 the national freight bill has been an almost constant share, 6.1 or 6.0 percent, of GDP while the relative share of inventory costs has continued to fall—from a post-1980 high of 8.2 percent in 1981 to 3.6 percent in 1999.



rate than GDP, but in line with growth rates in manufacturing.[8]

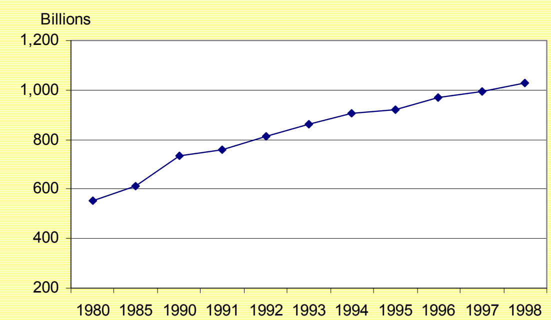
As with the development of TL carriers, the growth of intermodal rail traffic has improved the freight system's efficiency. In 1980, the Interstate Commerce Commission exempted intermodal rail transport from all economic regulation without waiting for the Staggers Act. Railroads could quote whatever rates they thought best and were free to enter into contracts with customers. (Before 1980 contracts were not allowed.)

As a result, while total rail tonnage has grown slowly since 1980 (an average of 0.6 percent per year from 1980 to 1998), intermodal traffic (measured by number of trailers and containers moved by rail) has increased an average of 6.0 percent per year over the same period. The attraction of lower rail rates is part of the reason for this rapid growth. But the ability to develop contracts in which railroads could tailor service to the specific requirements of large customers was also important.

Exhibit 13: The demand for trucking services has grown rapidly in the 1990s, partly reflecting the business reorganization effect.

During the first decade following deregulation (1980 to 1990), intercity ton-miles grew at an average annual rate of 2.8 percent per year, somewhat slower than the 3.2 percent rate experienced during the pre-deregulation decade. Ton-miles between 1990 and 1998 grew at an annual rate of 4.3 percent, faster than GDP's growth of 3.0 percent, but in line with manufacturing growth.

Intercity Trucking Ton-Miles



Intermodal freight transport has generated benefits that have further fostered productivity growth in manufacturing and the overall economy. For instance, the benefits of low-cost double-stack service were fully realized because the trans-Pacific container lines were able to contract with rail carriers for fast and reliable service—service that adheres to the

[8] The following table shows the annual growth in ton-miles compared with manufacturing growth. The two growth rates are virtually the same over the period 1980-1998. It should be noted, however, that, in the last few years, growth in highway freight ton-miles has fallen somewhat below growth in manufacturing output.

	1980-1990	1990-1998
Annual Growth in Intercity Trucking Ton-Miles	2.8%	4.3%
Annual Growth in Manufacturing	2.7%	4.3%

Longer truck hauls (which partly determine ton-mileage) reflect, in part, the greater "reach" of factories and warehouses as businesses have reorganized and optimized their logistics arrangement in light of improved performance of the freight system. On the other hand, lighter products and packing materials may have restrained the growth of tonnage relative to production. This explains why trucking ton-miles has not grown at a faster rate than manufacturing output.

precise schedules set by the steamship companies. Because of this, and because of competition between railroads, large volumes of imported consumer goods move speedily and reliably from West-coast ports to the Midwest at low rates (e.g., railroads are hauling containers from Los Angeles to Chicago at a rate of 30 cents a mile, while the average truckload rate is currently somewhat in excess of $1.00 a mile). Freight service of this quality and price allows major distributors and retailers to keep a tight rein on their logistics costs to the benefit of their customers and the overall economy.

TL carriers and intermodal transportation services exemplify the types of changes that have led to improvements in the reliability and quality of this nation's freight system. As shippers have changed their logistics practices to take advantage of a more flexible and demand-responsive freight system, carriers have also improved their operations—as suggested by the development of TL and intermodal services. Improvements in trucking productivity, for example, are important to ensure that efficiency gains in the freight system are sustainable. So, how has productivity in the trucking industry fared since deregulation?

Exhibit 14: Productivity Trends in the Trucking Industry

Based on available sources, labor productivity improved significantly from 1975 to the mid-1990s, but appears to have leveled off and may be possibly declining. The chart below presents two labor productivity indexes: one from the Bureau of Labor Statistics (BLS) and the other a calculation using ton-miles and BLS labor data.

Trends in Trucking Labor Productivity

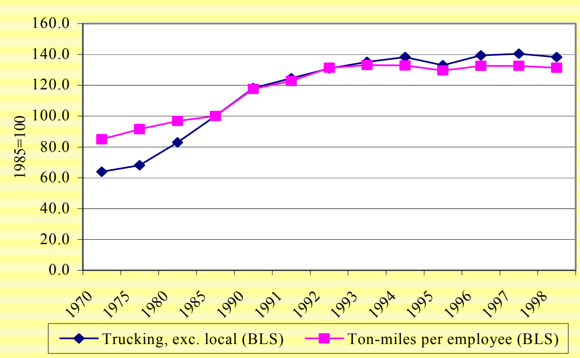


Exhibit 14 shows the recent trends in trucking labor productivity. The flattening, and even recent decline, in productivity suggests that the trucking industry may have difficulty in meeting short-term transportation demands from the manufacturing and service sectors over the next several years.[9] If that occurs, productivity losses in the transportation sector can lead to higher intermediate costs to the manufacturing sector in the form of increased operating costs. This, in turn, can exert downward pressure on manufacturing productivity, as transportation and warehousing costs rise relative to output. In the longer term, decreases in manufacturing productivity result in an overall weakening of the U.S. economy.

[9] Note that it is possible that quality improvements (e.g., on-time performance) are not fully reflected in the BLS measure for labor productivity. That measures uses inflation-adjusted revenue as the measure of trucking output.

Although there has been a recent decline, capital (equipment) utilization has also improved since deregulation. The average length of haul has increased and the number of trips made by the average tractor-trailer combination has also increased over the last two decades. More trips, and more miles per trip, means the average combination vehicle is moving more ton-miles.

2.2 Freight Productivity and System Performance

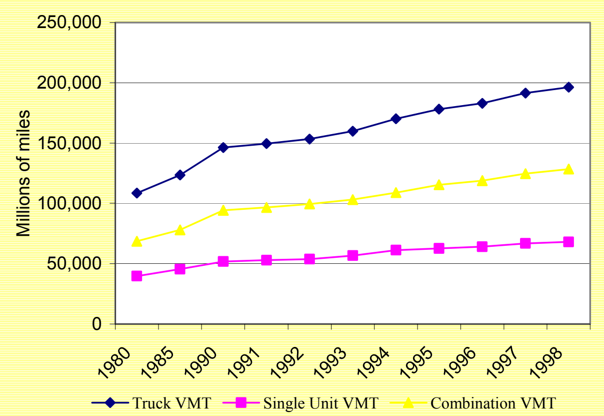
It is not entirely clear what has caused the slowdown in the productivity of the trucking industry. Labor productivity is affected by various factors including traffic congestion, the reliability of the transportation system, regulation (such as the hours of service rule and size and weight regulations), and the availability of qualified and experienced drivers or operators. However, although deregulation has led to important efficiency gains in carrier services and logistics practices, increasing traffic levels on our nation's highways may be beginning to take their toll on the productivity of the freight system (see Exhibit 15).

The impact of increasing traffic levels on the quality and reliability of freight transportation can be magnified if concomitant investments in our highways, ports, railroads, and intermodal facilities do not keep pace—in economics jargon, if the supply of infrastructure does not keep pace with increases in demand, the cost of moving freight will increase. Have we been investing enough on our nation's highways to ensure that the productivity of the freight sector is maintained?

Exhibit 16A (below) shows the trend in highway investment since 1980, adjusted for inflation. The amounts shown are capital outlays on State-administered highways.[10] The annual growth rate in investment over this period was 4.0 percent, compared to inflation-adjusted growth in GDP of

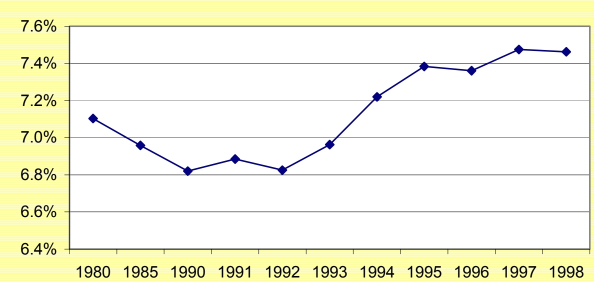
Exhibit 15: Growth in Truck Traffic

Growth in truck vehicle-miles accelerated in the 1990-1998 period by an average annual compound growth rate of 3.8 percent from 3.0 percent experienced during the 1980s. Combination truck vehicle-miles have grown at a faster rate than single-unit truck vehicle miles, reflecting an increasing average length of haul.



Even more striking is the fact that the share of truck VMT to total VMT has markedly increased in recent years. The share of truck VMT rose rapidly between 1993 and 1995 and appears to be leveling off at 7.5% of total highway VMT.

Share of Truck VMT



[10] State roads were chosen so as to leave out the local network that is less important for line-haul freight movement.

3.2 percent per year.[11] Although capital outlays on highways have grown steadily since 1980 and outpaced growth in GDP, highway congestion has worsened significantly over this same period, as shown in Exhibit 16B.[12]

Congestion is especially problematic for freight transportation. As noted earlier, evidence gathered in discussions with shippers and carriers indicates that shippers have been getting a high level of highway-freight service. Those shippers that demand it have obtained a high degree of schedule reliability (e.g., deliveries consistently arriving in time windows of 15 or fewer minutes even on runs of ten hours or longer). Whole systems of inventory control and supply-chain management have been built around the expectation that this kind of reliability is a permanent feature of freight service. Also, siting of warehouses and terminals has been based on current levels of speed and reliability on the highway network. All of these features of total logistics system are important for national productivity and welfare, and all could be threatened if the reliability of the highway system continues to deteriorate.[13]

Exhibit 16A: Highway Investment Since 1980

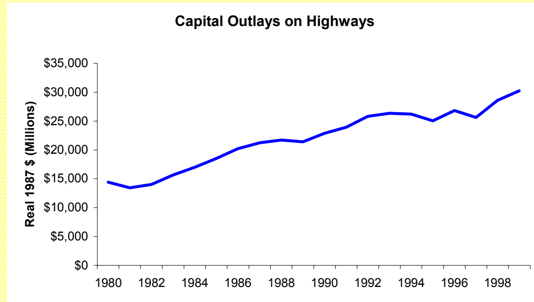
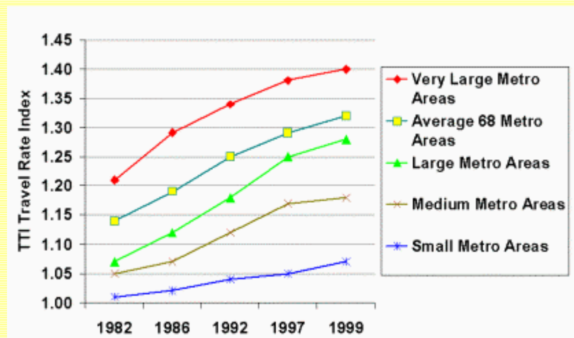


Exhibit 16B: Travel Rate Congestion Index

Congestion has increased rapidly since 1980, as both passengers and freight compete to improve mobility and productivity.



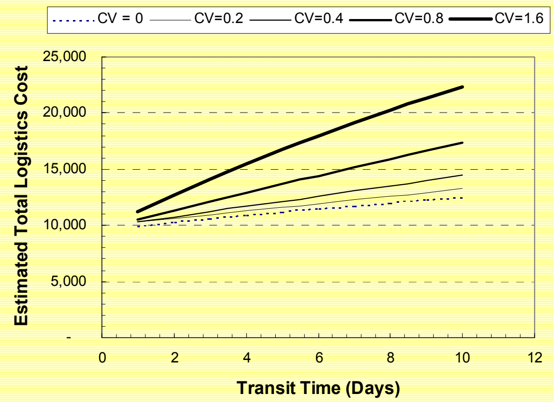
Specifically, logistics costs are shown to be highly dependent on both transit time and transit time variability, which are directly affected by congestion. The sensitivity to transit times increases significantly for higher values of variability. The same can be said for service levels. The relationships between estimated total logistics costs and transit time and variability are illustrated in Exhibit 17 (below).

[11] In this same period, railroad capital expenditures grew relatively slowly, at an annual rate of 1.0 percent after adjusting for inflation. This is slightly faster than the growth of rail tonnage in the same period (0.6 percent per year).

[12] The TTI travel rate congestion index measures how much longer it takes you to make trip in a congested peak travel period (e.g., 8AM or 9AM) compared to an uncongested off-peak period (e.g., midday or late night). In 1982, it took about 20 percent more time to make a trip in a very large metropolitan area during the peak period. In 1997, it took over 40 percent more time.

[13] Note that the share of truck VMT to total VMT on the nation’s highways has increased markedly in recent years. Consequently, increases in delay resulting from congestion have had an increasing impact on the productivity of trucking.

Exhibit 17: Minimum Logistics Cost Versus Transit Time for Various Levels of Reliability*



Lower logistics costs are achieved principally through smaller safety stocks. Improvements in achievable service levels are also made possible by a reliable and fast transportation system.

* Transit time reliability is expressed using the coefficient of variation CV. CV is defined as the ratio of the standard deviation to the mean.

Non-recurrent, or unanticipated, congestion is even more problematic to the productivity of the freight transport system. Congestion contributes not only to making transit times longer, but also more unpredictable. This unpredictability can hinder JIT inventory management and even hinder some production processes. As a result, shippers attach a dollar value to predictability and speed. A study by HLB Decision-Economics indicated that carriers on average value savings in transit time at between $144 – $192 per hour. Savings in non-scheduled delay were valued at $371 per hour. In addition to value-of-time savings, there would also be vehicle operating cost savings from more efficient and reliable speeds. Although these results are based on a small sample, they indicate the magnitude of savings that can be generated by improving the performance of the highway system (which can be measured by congestion levels). It is interesting to note that time late was valued at roughly twice the rate of transit time.[14]

Consequently, reduced transit time variability (which can be generated by decreases in congestion) allows for gains in scheduling and routing of transport resources. Increased competitiveness as a result of improved service levels may translate into higher sales and increased demand for both products and transport services.

2.3 Implications of Investment and Performance Trends

In commenting on the condition of the system, shippers and carriers tend to stress two themes. One is that they are, to a large degree, satisfied with the highway network as it now performs. They have designed their schedules and logistics systems around the current level of performance. But many of these people also emphasize that they would have a low level of tolerance for any deterioration in performance. For instance, there are choke points and problem areas, areas where speeds are markedly lower than in the rest of the country.

[14] The value of direct time savings in freight transportation provides a lower bound for the overall value of such time savings from a total logistics perspective. As a logistics input, transportation efficiency gains might alter the optimal balance between inventory holdings, warehousing and transportation. In the long run, some firms may be able to utilize improved transportation delivery to reduce safety stocks, improve service levels and lessen warehousing needs. A business reorganization effect could reduce total logistics costs well beyond the value of direct time savings.

In the absence of improvements, the speed and reliability of the freight system can be expected to worsen as vehicle traffic grows and congestion increases. Such a development could force shippers and carriers into costly redesign and restructuring of their systems with higher logistics costs and a consequent drop in productivity. It is reasonable to suppose that, if such costs are to be minimized, the current level of investment must be, at least, maintained. However, improvement in the performance of the freight system, with concomitant gains in national productivity, will require gains in the battle against congestion.

Take, for example, the impact that congestion has on productivity growth stemming from information technology. Economic research is proving what has been suspected for a few years—that the sustained economic expansion of the late 1990s reflects a powerful link between information technology and the growth rate in U.S. productivity. [15] The link is important because more than 80 percent of any improvement in people's real incomes and living standards can come only from productivity growth.[16] Productivity growth due to advanced logistics in the freight transportation sector is a microcosm of the IT revolution.

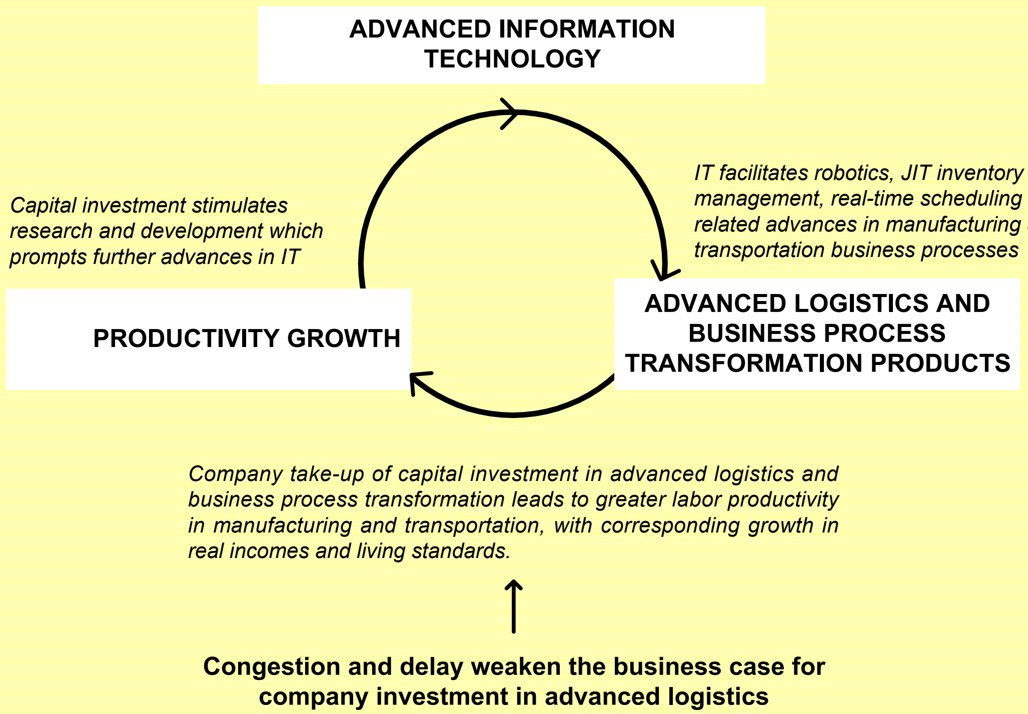
Exhibit 18 (below) illustrates how the relationship between IT-productivity growth in the economy at-large is mirrored in the freight transportation sector. Innovation in information technology facilitates development of new products in robotics, just-in-time inventory control programs, networked dispatching, real-time schedule management, and other manifestations of intelligent production and transportation logistics. When manufacturers and transportation firms invest in such products, their labor productivity improves (as proven by Stiroh) and peoples' real wages improve accordingly. And, since capital investment itself triggers faster technological advance, a circle is established which drives the rate of growth higher still.[17]

[15] Kevin J. Stiroh of the Federal Reserve Bank of New York reports that IT-intensive industries experience significantly larger productivity gains than other industries and a wide variety of his econometric tests show a strong correlation between IT capital deepening and productivity growth. Stiroh's results indicate that virtually all of the aggregate productivity acceleration of the late 90s is due to industries that either produce IT or use it intensively, with essentially no contribution from industries that are less involved in the IT revolution. From *Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?* Federal Reserve Bank of New York, January 12, 2001

[16] Dale W. Jorgenson, *Information Technology and the U.S. Economy,* The American Economic Review, March 2001

[17] David Lewis, *The Role of Public Infrastructure in the 21st Century,* Special Report 220, Transportation Research Board, National Research Council, 1988

Exhibit 18: The relationship between IT-productivity growth in the economy at-large is mirrored in the freight transportation sector.



But linkages can be weakened, even severed, by congestion and delay on the nation's highways. It is one thing for new robotics and intelligent logistics products to come on the market; it is quite another for manufacturing and transportation firms to invest in them. Such investment is costly. Threats to the effectiveness of such products are threats to the business case for investing in them. Wide-spread testimonials are not at hand, but analytic and anecdotal evidence indicates that congestion and delay is viewed in some sectors as a barrier to obtaining satisfactory pay-back from investment in just-in-time logistical products. Take-up of advanced logistics may be waning already, in part due to the economic slowdown, but also to mounting congestion in some strategic corridors around the country.

3. Future Growth in Freight Transportation

As discussed in earlier sections of this report, an efficient and reliable freight transportation system helps to sustain growth in economic productivity. However, recent trends in the performance of the highway system, as measured by congestion and system reliability, likely have adversely impacted the system's productivity. As congestion has worsened, system reliability has been compromised. Moreover, decreases in carrier productivity, can lead to increases in the relative cost of moving goods, dampening growth in the economy.

It can be argued that the problems that are generated by congestion will be difficult to mitigate because of projected growth in the demand for highway travel and concomitant constraints in the development of additional highway infrastructure (e.g., constraints stemming from funding availability, environmental considerations, community opposition, etc.). For instance, the Federal Highway Administration (FHWA) estimates that by 2020 freight volume in the US will nearly double in some sectors (see Exhibit 19). Consequently, maintaining (not to mention improving) the productivity of our freight transportation system will be challenging.

Exhibit 19: *According to a recent FHWA presentation, US domestic freight traffic is expected to grow by 2.9 percent by 2020. "Freight Trends/Issues, Multimodal System Flows and Forecasts, and Policy Implications" shows that US domestic freight will rise by 3.4 percent between 1998 and 2010, and another 2.4 percent from 2010 to 2020. US international freight traffic is expected to grow by 3.4 percent between 1998 and 2020, including an increase of US/Canada traffic by 3.1 percent, US/Mexico traffic by 3.5 percent. In 1998, domestic and international US freight traffic totaled approximately 9.8 billion tons and $9.1 trillion.*

The private sector's ability to generate the types of economic benefits that stem from productivity increases depends on how well our transportation facilities are maintained, operated, or expanded (for highways, these activities fall predominantly within the responsibility of the public sector). Likewise, through regulation and investment decisions, public policy affects the manner in which shippers and carriers operate and make logistics decisions.

However, transportation policy and planning is not as robust as it should be in relation to the freight sector. For instance, project analysis tools do not appropriately recognize how and why infrastructure design and capacity problems drive down the productivity of freight transportation and drive up the cost of industrial production. Likewise, transportation planners and decision-makers cannot anticipate readily how infrastructure improvements would make freight carriers, their industrial customers, and the economy at large better off. With a significant portion of the focus of transportation policy and planning shifting to freight-related matters, filling the planning gap is essential.

Clearly, highway investments that increase capacity and/or speed and reduce accidents will improve the performance of trucks, as will improvements in operations planning. Improvements in intermodal connections will also have an effect. Furthermore, Intelligent Transportation Systems (ITS) can be particularly important, especially when they reduce incident-based congestion. It is clear that transportation agencies at all levels of government can bring about improvement in highway freight-carriage. For instance,

- Targeted capacity expansion projects that alleviate high-frequency bottlenecks in the freight system can improve transit time variability.
- Freight planning can help to make sure that freight movement needs are appropriately considered by decision-makers by providing state and local transportation planners with the necessary tools to better account for the impacts of alternative investments on the efficiency of the freight system.
- Programs that strive to improve operations planning (or the interaction of planning and operations functions within a transportation agency) can improve system performance.
- ITS deployment can enhance the efficiency of the highway system through operational improvements, better user information, and incident management (which is particularly problematic from the perspective of system reliability).
- Federal grant programs that provide financing mechanisms for freight transportation improvements can help to generate the types of investments needed to improve the productivity of the freight system.

In a nutshell, future (and to some extent current) challenges will center on 1) squeezing as much efficiency as possible out of available transportation resources (in particular infrastructure) and 2) finding scarce resources to implement efficiency-enhancing programs and projects.