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Report to the Subcommittee on Select Revenue Measures, Committee on Ways and Means, House of Representatives

January 2011

SURFACE FREIGHT TRANSPORTATION

A Comparison of the Costs of Road, Rail, and Waterways Freight Shipments That Are Not Passed on to Consumers

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Highlights

Highlights of GAO-11-134, a report to the Subcommittee on Select Revenue Measures, Committee on Ways and Means, House of Representatives

Why GAO Did This Study

Road, rail, and waterway freight transportation is vital to the nation's economy. Government tax, regulatory, and infrastructure investment policies can affect the costs that shippers pass on to their customers. If government policy gives one mode a cost advantage over another, by, for example, not recouping all the costs of that mode's use of infrastructure, then shipping prices and customers' use of freight modes can be distorted, reducing the overall efficiency of the nation's economy.

As requested, this report (1) describes how government policies can affect competition and efficiency within the surface freight transportation sector, (2) determines what is known about the extent to which all costs are borne by surface freight customers, and (3) discusses the use of the findings when making future surface freight transportation policy. GAO reviewed the transportation literature and analyzed financial and technical data from the Department of Transportation (DOT), the Army Corps of Engineers (Corps), and the Environmental Protection Agency to make cross-modal comparisons at a national level. Data limitations and assumptions inherent in an aggregate national comparison are noted in the report.

GAO is not making recommendations in this report. GAO provided a draft of this report to DOT and the Corps. DOT provided technical suggestions and corrections, which were incorporated as appropriate. The Corps had no comments.

View GAO-11-134 or key components.
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SURFACE FREIGHT TRANSPORTATION

A Comparison of the Costs of Road, Rail, and Waterways Freight Shipments That Are Not Passed on to Consumers

What GAO Found

Public spending, tax, and regulatory policies can promote economic efficiency in the freight transportation sector when they result in prices that reflect all marginal costs (the cost to society of one additional unit of service). These costs include private costs; public costs, such as infrastructure maintenance; and external costs, such as congestion, pollution, and accidents. When prices do not reflect all these costs, one mode may have a cost advantage over the others that distorts competition. As a consequence, the nation could devote more resources than needed to higher cost freight modes, an inefficient outcome that lowers economic well-being. Inefficient public investment decisions can result when all construction and other fixed costs are not passed on to the beneficiaries of that investment.

GAO's analysis shows that on average, additional freight service provided by trucks generated significantly more costs that are not passed on to consumers of that service than the same amount of freight service provided by either rail or water. GAO estimates that freight trucking costs that were not passed on to consumers were at least 6 times greater than rail costs and at least 9 times greater than waterways costs per million ton miles of freight transport. Most of these costs were external costs imposed on society. Marginal public infrastructure costs were significant only for trucking. Given limitations in the highway, rail, and waterway economic, financial, technical, and environmental data available for the analysis, GAO presents conservative estimates.

While freight costs are not fully passed on to consumers across all modes, a number of issues are important for decision makers to consider when proposing policy changes to align prices with marginal costs or reduce the difference between government fixed costs and revenues. Costs can vary widely based on the specific characteristics of an individual shipment, such as the geography and population density of the shipment's route, and the fuel-efficiency of the specific vehicle carrying it. Policy changes that align prices with marginal costs on a shipment-by-shipment basis would provide the greatest economic benefit, but precisely targeted policy changes can result in high administrative costs. By contrast, less targeted changes—such as charging user fees based on average costs, subsidizing more efficient alternatives, or broadly applying safety or emissions regulations—can change the overall distribution of freight across modes, but may provide fewer benefits. Although the current configuration of transportation infrastructure can limit the shifting of freight among modes, price changes can prompt other economic responses. Over the longer term, there is greater potential for responses that will shape the overall distribution and use of freight services.

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Abbreviations

BTS	Bureau of Transportation Statistics
CBO	Congressional Budget Office
CO2	carbon dioxide
Corps	U.S. Army Corps of Engineers
DOT	Department of Transportation
EPA	Environmental Protection Agency
FAF	Freight Analysis Framework
FHWA	Federal Highway Administration
NOX	nitrogen oxides
PM2.5	fine particulate matter with a diameter of 2.5 microns or less
Recovery Act	The American Recovery and Reinvestment Act of 2009
TIGER	Transportation Investment Generating Economic Recovery
TRB	Transportation Research Board
VMT	Vehicles Miles Traveled

United States Government Accountability Office
Washington, DC 20548

January 26, 2011

The Honorable Patrick J. Tiberi
Chairman
The Honorable Richard E. Neal
Ranking Member
Subcommittee on Select Revenue Measures
Committee on Ways and Means
House of Representatives

Freight shipments move over vast networks of highways, railroads, and waterways—often transported by more than one mode before reaching their final destination.[1] These networks connect and intersect, and play a critical role in providing the American public with the freight mobility needed to sustain national economic vitality and international competitiveness. According to the Department of Transportation (DOT), our surface freight transportation system connects an estimated 8 million businesses and 116 million households moving $12 trillion in goods.[2] The movement of goods involves both private and public interests from private trucking companies, railroads, and waterborne vessel operators to federal, state, and local governments. While the major freight railroad infrastructure is privately owned and operated, and port infrastructure is privately or publicly owned and operated, governments play a primary role in planning, building, maintaining, and operating highways and keeping our waterways navigable. This infrastructure is designed for multiple types of users, not just freight service providers. Governments collect taxes and tolls, which help offset transportation expenditures, but have a minimal role in the direct regulation of prices and rates. Governments also regulate various aspects of freight transportation across all modes, including pollution, safety, and, to a more limited degree, congestion.

How governments tax, regulate, and make investment decisions across modes could affect relative freight shipping prices. If government policy results in giving one mode of freight transportation a cost advantage over

[1]Pipelines are also a freight mode for transport of oil and gas, and can compete with other modes, but are not considered in the scope of this report.

[2]Department of Transportation, Bureau of Transportation Statistics, U.S. *Freight on the Move, Highlights from the 2007 Commodity Flow Survey Preliminary Data* (Washington, D.C.).

others—by, for example, ensuring that the wear and tear costs on infrastructure from users are fully recouped in one mode, but not in another mode—then shipping prices and choices made between alternative shipping options could be distorted. As a consequence, freight may be moved by a mode—for some portion or all of a trip—that imposes higher costs on the general public than might occur if such distortions did not exist. Because of your interest in the potential impact these policies can have on the freight transportation sector and beyond, you asked us to (1) describe how such policies can affect competition and efficiency within the surface freight transportation sector; (2) determine what is known about the extent to which costs are borne by surface freight users; and (3) discuss how our findings could be used when making future surface freight transportation policy.

To address these objectives, we reviewed reports issued by the Congressional Budget Office (CBO), DOT, the Transportation Research Board (TRB), and the Brookings Institution. We interviewed officials from DOT, the Army Corps of Engineers (Corps), the Environmental Protection Agency (EPA), representatives from professional research organizations and industry, members of academia, and individuals knowledgeable about freight transportation to obtain advice on economic concepts, appropriate and available data sources, methodological approaches, and views on government spending and regulatory policies. We obtained preliminary reviews about the scope, methodology, and analysis contained in this report from DOT, EPA, the Corps, as well as two members of the Comptroller General's Advisory Board—comprised of individuals with broad expertise in public policy.

We obtained, reviewed, and analyzed several datasets that can be used to estimate the revenues received from and costs imposed by users of the surface freight transportation system—federal, state, and local highways and roads; all classes of rail lines; and the inland, coastal, and Great Lakes waterways. Specifically, we identified data on federal, state, and local government revenues and expenditures on highways, railroads, and waterways from fiscal years 2000 through 2006, the time frame of Federal Highway Administration's (FHWA) ongoing highway cost allocation study. We also obtained available data on external costs associated with freight transport, including pollution, accidents, and congestion from EPA, related research from DOT, and the Texas Transportation Institute. We analyzed these data to estimate the costs at a national level that freight users impose on the public transportation infrastructure and society and the revenues collected to offset those costs. When multiple data sources were available for our analyses, we explain why we selected one over another.

To assess the reliability of the financial and technical data collected and published by various federal government agencies—such as DOT's Highway Statistics Series; the Department of the Treasury's statistics on income, debt, and tax expenditures; the Corps' Waterborne Commerce Statistics; and Census Bureau statistics, among others—we reviewed relevant documentation about the agencies' data collection and quality assurance processes, talked with knowledgeable officials from the agencies about these data, and compared these data against other sources of published information to determine data consistency and reasonableness. We determined that the data were sufficiently reliable for the purposes of providing high-level cost and revenue estimates by mode.

We used federal statistical databases to obtain federal, state, and local data for estimating government costs and revenues. We also used nationwide data to estimate external costs. We recognize several important limitations in our high-level analysis, such as discrepancies in ton-mile estimates and difficulties in allocating costs between freight and nonfreight users. However, we explain how we deal with such limitations throughout the report by, for example, conducting sensitivity analyses to understand changes in costs with respect to ton-miles. Further, this analysis of high-level data is limited in the sense that it can obscure variations in state spending and revenue policies, and external costs by geographical location or by type of truck, locomotive, or marine engine. Moreover, this type of high-level analysis does not consider how modes compete with one another or the services or operations within each mode that compete with one another (e.g., rail long-haul with long-distance trucking); nor does it consider the complementary nature of freight modes, wherein, freight moved by rail or waterways may also involve trucks for at least some portion of its overall journey. Consequently, the results should be viewed as representing averages across all of the marginal shipments that were made under a wide variety of different conditions in a wide variety of locations. The last section of this report discusses the limitations that such high-level analyses have on policy evaluations. Appendix I details our objectives, scope, and methodology.

We conducted our review from August 2009 to January 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Overview of the Surface Freight Transportation Sector

The nation's transportation infrastructure consists of over 4 million miles of public highways and roads; over 140,000 miles of national, regional, and local railroad networks; and 25,000 miles of commercially navigable waterways over which trillions of dollars worth of freight move annually. Public roads account for the majority of our nation's transportation infrastructure mileage, reaching nearly every corner of the United States, and as a result, enable trucks to move the greatest amount of freight on a tonnage basis. However, tonnage as a measure does not capture important aspects of freight mobility across the modes, such as the distances over which freight moves. For making comparisons across the modes throughout this report, we use ton-miles as a unit of measurement. Ton-miles measure the amount of freight moved, as well as the distance over which it moves.[3] Table 1 shows the estimates and sources for ton-miles of freight moved on each mode for 2007, the most recent year that data are available. Appendix I provides more detail on our methodology for determining ton-miles used for the estimates in this report.

Table 1: Estimated Ton-Miles of Domestic Surface Freight Shipped by Mode in 2007

Mode	Ton-miles (in millions)	Source
Trucking	2,040,000	Federal Highway Administration (FHWA), Freight Analysis Framework
Railroad	1,819,633	Bureau of Transportation Statistics, National Transportation Statistics
Waterways	553,151	U.S. Army Corps of Engineers, Waterborne Commerce of the United States

Sources: DOT and the Corps as indicated.

Freight shipments can also move by more than one mode before reaching their final destination. In particular, freight moved by rail or waterways

[3]Ton-miles are determined by multiplying the aggregate weight of freight by the distance that weight is carried.

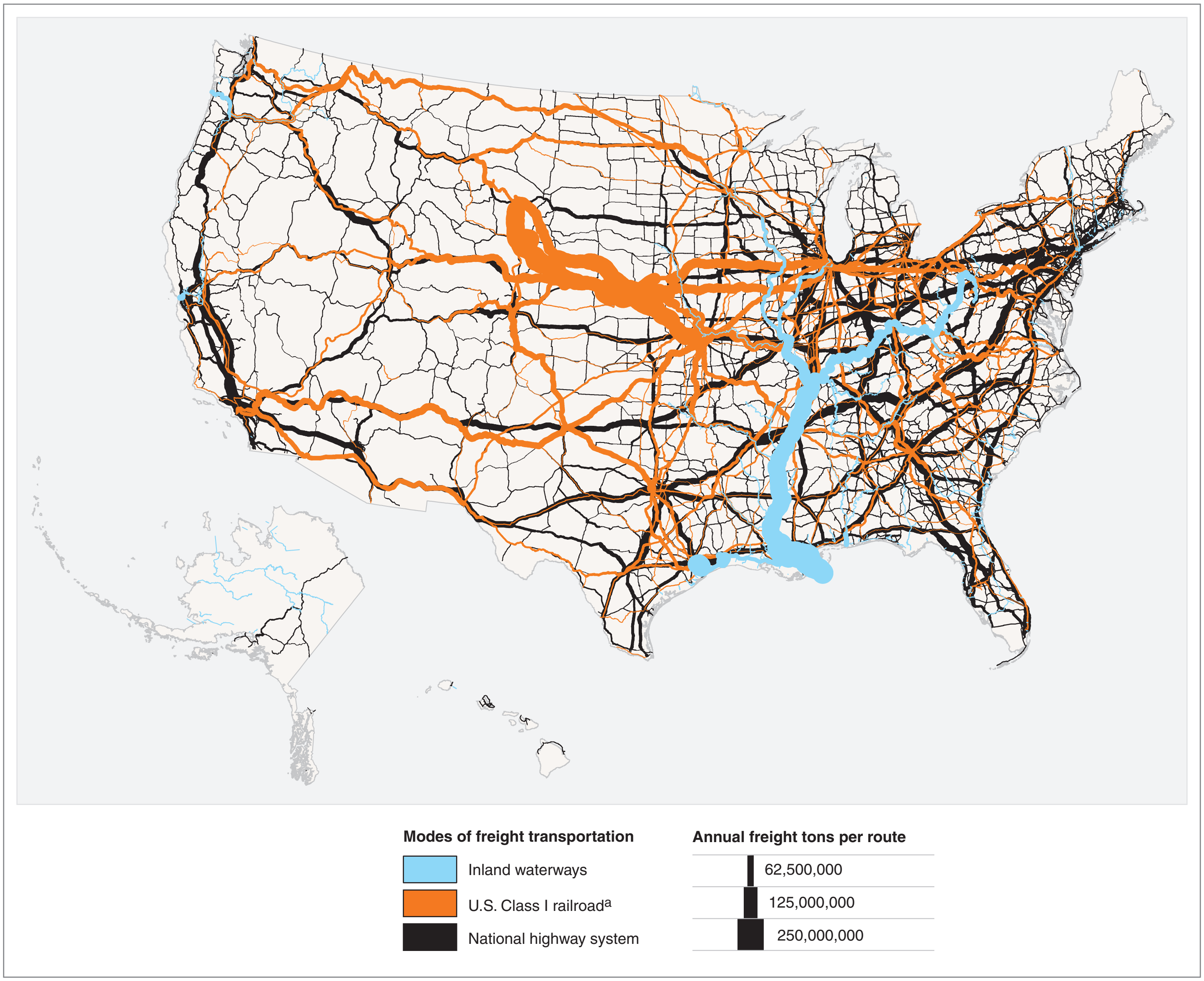
may also be moved by truck at some point to reach its final destination, as rail and waterways may not reach locations that can be reached by truck. On the other hand, trains and waterborne vessels typically have far greater capacity than does a single freight truck, so rail and waterways generally move large volumes of commodities (e.g., coal and grain) long distances that would not be feasible by truck alone. Modes often work as complements to complete a shipment. For example, a ton of grain may move from a grain elevator by rail, be transported to a port on an inland waterway, move by barge to another port on an inland waterway, and then be distributed by truck to its final destinations. A particular type of shipment known as "intermodal" is designed to move on multiple modes, using a container that can be moved from a truck to a train to a ship without handling any of the freight itself when changing modes. Such freight movements are growing and FHWA forecasts that intermodal freight will continue to increase in the future.[4]

In some cases, the modes may be substitutable for certain types of trips and will compete directly for shipments or for segments of shipments based on price and performance. For example, long-haul trucking and rail shipments may be substitutable, or short sea shipping legs can be a substitute for rail or truck shipments along coastal routes. The extent to which mode-shifting is possible in the United States is difficult to estimate and will largely be determined by the types of parameters discussed above, such as whether shipping is feasible by another mode (e.g., rail lines or waterways may not be available for some routes), or practical (e.g., sending heavy coal shipments by truck or time-sensitive shipments by rail or waterways are not practical), and by the relative prices and other service characteristics of shipping by different modes.[5] Figure 1 geographically depicts the national freight transportation infrastructure and tonnage of freight activity by mode, which provides a sense of the physical reach of each modal network.

[4]FHWA, *Freight Transportation: Improvements and the Economy*, (June 2004).

[5]A recent study estimates that about 12 percent of truck ton-miles can potentially shift to rail or waterways; see James J. Winebrake and James J. Corbett, "Improving the Energy Efficiency and Environmental Performance of Goods Movement," in *Climate and Transportation Solutions: Findings from the 2009 Asilomar Conference on Transportation and Energy Policy*, edited by Daniel Sperling and James S. Cannon (Institute of Transportation Studies, University of California, Davis, 2010).

Figure 1: Tonnage of Freight on Highways, Railroads, and Inland Waterways (2007)



Sources: Highways: U.S. Department of Transportation, Federal Highway Administration, Freight Analysis Framework, Version 3.1, 2010. Rail: Based on SurfaceTransportation Board, Annual Carload Waybill Sample and rail freight flow assignments done by Oak Ridge National Laboratory. Inland Waterways: U.S. Army Corps of Engineers (Corps), Annual Vessel Operating Activity and Lock Performance Monitoring System data, as processed for Corps by the Tennessee Valley Authority; and Corps, Institute for Water Resources, Waterborne Foreign Trade Data, Water flow assignments done by Oak Ridge National Laboratory. U.S. Department of Transportation (map).

[a]In 2008, Class I railroads in the United States are defined as having annual carrier operating revenues of $401 million or more; Class II railroads are those with revenues greater than $32 million but less than $401 for at least 3 consecutive years; and Class III railroads are those with less than $32 million.

Government Plays a Key Role in the Surface Freight Transportation Infrastructure

Federal, state, and local governments each play a crucial role in planning, designing, constructing, and maintaining the highways and waterways infrastructure, as well as raising revenues for the highway and waterway portions of the surface transportation system. Governments also play a role in regulating the freight industry, which we address in the next section. FHWA, state departments of transportation, and local transportation organizations plan and fund new highway infrastructure and maintain existing highways. The Corps has the responsibility for construction, operation, and maintenance of the nation's waterway system. There is limited public sector funding for rail infrastructure. All Class I railroads, which comprise about 91 percent of all railroad revenues, are privately owned and, as one of the most capital-intensive industries in the United States, make considerable investments in their own transportation networks.

- *Highway infrastructure.* The federal government authorized over $190 billion for the federal-aid highway program for fiscal years 2005 through 2009.[6] A small portion of this funding was specifically identified for surface freight transportation projects, including $25 million for the freight Truck Parking Facilities program and $30 million for the Freight Intermodal Distribution Pilot Grant program.[7] For the most part, however, funding is provided for construction, reconstruction, restoration, and rehabilitation of roads that serve both freight and nonfreight users. Because the federal government's expenditures for highways are based, in part, on the user pay principle, the government collects taxes and fees, which flow into the Highway Trust Fund—historically, the principal mechanism for funding federal highway programs. The fund's highway account reported revenues of about $34 billion in fiscal year 2007—mainly from fuel (diesel and gasoline) tax that constitutes the majority of revenues from both freight and nonfreight users, as well as a variety of taxes imposed on trucks used in freight movement, including a truck and trailer sales tax, a heavy vehicle use tax, and a tire tax.[8] In the following

[6]The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, Pub. L. No. 109-59, § 1101, 119 Stat. 1144, 1153 (August 10, 2005).

[7]Pub. L. No. 109-59, §§ 1305(d)(1) and 1306(d)(3), 119 Stat. 1214-1217.

[8]Tax rates are as follows: fuel tax rate of 24.4 cents per gallon for diesel and 18.4 cents per gallon for gasoline; sales tax rate of 12 percent of retailer's sales price for tractors and trucks over 33,000 pounds gross vehicle weight and trailers over 26,000 pounds gross vehicle weight; heavy vehicle use tax rate varies for vehicles 55,000 pounds or more, and a tire tax rate, depending on tire size and weight, of 9.45 cents (4.725 cents for biasply or super single tires) for each 10 pounds of the maximum rated load capacity over 3,500 pounds.

year, 2008, the Highway Trust Fund held insufficient amounts to sustain the authorized level of funding, and partly as a result, we placed it on our list of high-risk programs.[9] To cover the shortfall, from fiscal years 2008 through 2010 Congress transferred a total of $34.5 billion in additional general revenues into the Highway Trust Fund, including $29.7 billion into the highway account.[10] Consequently, highway funding shifted away from the contributions of highway users, breaking the link between highway taxes paid and benefits received by users. The American Recovery and Reinvestment Act of 2009 (Recovery Act) further augmented transportation spending using general fund revenues of about $48 billion, of which about 57 percent was identified for federal highway projects.[11]

State and local governments also invest in public highways and roads. Within the federal-aid highway program, the federal government is responsible for funding 80 to 100 percent of highway project costs, and state and local governments are responsible for the remainder of the costs. State governments spent about $36 billion on capital outlays and about $21 billion more on maintenance of state-administered highways in 2007, while local governments spent approximately $69 billion on public roads. According to FHWA, state governments collected about $61 billion in user revenue, and local governments collected about $4 billion from a combination of fuel taxes, vehicle taxes and fees, and tolls. State and local governments supplement user revenue with general fund appropriations to support highway and road activities.

- *Railroad infrastructure.* The federal government has helped improve public safety on freight railroad infrastructure by providing limited funds to states for railroad-highway grade crossings and grants for relocating railroad tracks away from urban centers. Since January 1, 2007, freight railroads no longer pay federal fuel taxes, and there is no federal user fee specific to freight railroads. However, the federal government pays freight

[9]GAO, *High-Risk Series: An Update*, GAO-09-271 (Washington, D.C.: January 2009).

[10]For fiscal year 2008, about $8 billion was transferred from the general fund to the highway account (Pub. L. No. 110-318, § 1(a)(4), 122 Stat. 3532 (September 15, 2008); in fiscal year 2009 the transfer was $7 billion (Pub .L. No. 111-46, §§1, 123 Stat 1970 (August 7, 2009); and $14.7 billion was transferred to extend highway programs to December 31, 2010 (Pub. L. No. 111-147, § 442, 124 Stat. 71, 94 (March 18, 2010). See GAO, *Highway Trust Fund: Improved Solvency Mechanisms and Communication Needed to Help Avoid Shortfalls in the Highway Account*, GAO-09-316 (Washington, D.C.: Feb. 6, 2009).

[11]Pub. L. No. 111-5, Title XII, 123 Stat, 115, 206 (February 17, 2009). See app. II for more details on the Recovery Act.

rail companies for intercity passenger train usage of the companies' railroad tracks to the extent that these costs are not recovered through passenger fares. Recently, the Recovery Act funded two discretionary grant programs, the Transportation Investment Generating Economic Recovery (TIGER) grant program at $1.5 billion and the High-Speed Intercity Passenger Rail program at $8 billion, both of which can provide capital investment in railroad infrastructure.[12] Additional funding for these programs were made available through the 2010 appropriations for DOT,[13] nearly $600 million for TIGER grants and $2.5 billion for the high speed rail program. Because these programs are new, they are not included in the scope of our analysis of government spending on freight transportation.

Little systematic information is available about state programs and financial assistance for the freight railroad industry. A 1997 survey of state departments of transportation found 10 states with dedicated freight railroad budgets exceeding $1 million annually.[14] A few states (e.g., Alabama, North Dakota, and Tennessee) tax fuel for locomotives, but this revenue is not always used for rail projects. Railroads also pay state and local property taxes on their infrastructure; the nation's major railroads paid $625 million in property taxes in 2008, according to the Association of American Railroads.[15]

- *Waterway infrastructure.* The Corps, under its civil works program, is responsible for planning, constructing, operating, and maintaining the nation's waterways used primarily by commercial vessels, as well as recreational and commercial passenger boats along some sections of the waterways. For fiscal year 2007, the Corps spent about $1.2 billion to operate and maintain the inland waterways, as well as the nation's coastal harbors and channels (deep and shallow draft), and $686 million more for a variety of construction projects along inland waterways and coastal harbors and channels. For the same year, the Saint Lawrence Seaway

[12]TIGER grant funds are available for all freight modes. See appendix II for additional information.

[13]Consolidated Appropriations Act, 2010, Pub. L. No. 111-117, Div. A, title I, 123 Stat 3034, 3035-3037 (December 16, 2009).

[14]See American Association of State Highway and Transportation Officials, *Freight Rail Bottom Line Report* (Washington, D.C., 2003).

[15]Association of American Railroads, *Great Expectations: Railroads and the U.S. Economic Recovery* (Washington, D.C., February 2010).

Development Corporation budgeted about $33 million for operations and maintenance activities and $1 million for construction activities. Much of these funds are from the Harbor Maintenance Trust Fund.[16]

The general fund pays for all of the Corps' operations and maintenance activities and one-half of the inland waterway construction costs for rehabilitating, modernizing, or replacing locks and dams.[17] The other half comes from commercial waterway users that pay fuel taxes which flow into the Inland Waterways Trust Fund. The Inland Waterways Users Board and the National Academy of Public Administration have both reported on inefficiencies in the delivery of construction projects which have led to delays and cost escalation that have strained the trust fund and resulted in fewer and less-beneficial projects being funded.[18] Some waterborne vessels are exempt from the fuel tax, including oceangoing ships, passenger boats, recreational craft, or government vessels. Receipts totaled about $101 million, including excise taxes and interest on investments, in fiscal year 2007. In contrast, revenue for the Harbor Maintenance Trust Fund comes largely from an excise tax on imports imposed on commercial users of certain ports. The tax applies a second time to cargo that has already arrived at a U.S. port, but is transferred by barge or short-sea route to another U.S. port. Importers or shippers pay an amount equal to 0.125 percent of the value of the commercial cargo involved at the time of unloading. Exporters are exempted from the excise tax. In fiscal year 2007, this trust fund received about $1.4 billion from tax collections—including $68 million from domestic shippers, which is relevant to the scope of this study—and $154 million from interest on investments in U.S. treasury bonds. Harbor Maintenance Trust Fund revenues exceed expenditures, and in 2007 the Fund was carrying a

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[16]The Saint Lawrence Seaway Development Corporation, a government-owned corporation, develops, operates, and maintains that part of the St. Lawrence Seaway within the territorial limits of the United States.

[17]The Water Resources Development Act of 1986, Pub. L. No. 99-662, § 102, 100 Stat. 4082, 4088 (November 17, 1986) codified at 33 U.S.C. § 2212, established the cost-sharing ratios. Fifty percent of the costs associated with construction and major rehabilitation of inland waterways is paid with funds appropriated from the Inland Waterways Trust Fund; 50 percent is paid from funds appropriated from the general fund. Operation and maintenance costs of the inland waterway system are paid from funds appropriated from the general fund.

[18]See Inland Waterways Users Board, 23rd Annual Report to the Secretary of the Army and United States Congress (August 2009); and National Academy of Public Administration, *Prioritizing America's Water Resources Investments: Budget Reform for Civil Works Construction Projects at the U.S. Army Corps of Engineers* (Washington, D.C., February 2007).

balance of nearly $4 billion, which has continued to grow. The federal government levies other fees, such as customs and agricultural quarantine inspection fees, on waterborne vessel operators and shippers to cover the costs of the inspection programs.

State and local governments also provide funding to publicly owned ports and dock facilities on waterways for the purposes of construction, operation, and maintenance of commercial port facilities, including warehouses, cranes, and terminals; canals; harbors; and other public waterways, in addition to dredging of those waterways. State and local governments also impose a variety of fees, such as canal tolls, rents from leases, concession rents, and other charges for use of commercial or industrial water transport and port terminal facilities and related services.

Government Plays a Key Role in Regulating the Surface Freight Transportation Sector

In addition to constructing, operating, and maintaining the infrastructure, governments regulate various aspects of the surface freight transportation sector. Federal regulations across all modes are focused on safety and the environment rather than economic regulation. For example, truck safety regulations include truck size and weight limits and restrictions governing interstate freight operations.[19] For rail, Congress has recently directed the Secretary of Transportation to require that Class I railroads, and commuter or regularly scheduled intercity transportation providers, install positive train control systems to help reduce the risk of crashes.[20] Freight railroads continue to be subject to pricing regulation in areas where shippers do not have an alternative mode for shipping goods. Waterways freight carriers and their employees must comply with federal regulations. Indeed, all three modes—trucks, railroads, and waterway vessels—are expected to comply with federal drug testing,[21] security,[22] and environmental regulations, including measures imposing new pollution standards to reduce sulfur in diesel fuel.[23] Except as preempted by federal

[19] 23 C.F.R. Part 658.

[20] Rail Safety Improvement Act of 2008, Pub. L. 110-432, § 104, 122 Stat. 4848, 4856 (October 16, 2008) codified as positive law at 49 U.S.C. § 20157.

[21] 49 C.F.R. Parts 40, 382 (motor carriers) and 219 (rail carriers), and 33 C.F.R. Part 95 (watermen).

[22] *See*, *e.g.*, 49 C.F.R. § 1572, dealing with transportation credentialing and security threat assessments for maritime and land transportation workers.

[23] 40 CFR parts 86, 92 and 94.

law, state and local governments may also establish regulations that affect freight transportation.

Compliance with these regulations can impose costs on the freight industries. For example, new emissions regulations may result in costlier investments in new vehicles than would otherwise have occurred. At the same time, government regulations are often intended to help reduce the costs of freight movements on society by reducing emissions and improving safety.

Public Policies That Encourage Pricing Freight Transport at Levels That Reflect Social Costs Would Maximize Economic Well-Being, but Other Objectives Also Matter

In a market economy, resources are allocated to their most efficient uses (meaning they produce the greatest net benefits to society) when the prices of goods and services reflect all of the costs entailed in producing those goods and services. More specifically, economic efficiency requires that the price of a good or service equals the marginal social cost (the cost to society of consuming one additional unit of the good or service). Governments can best promote economic efficiency in the freight transportation sector by minimizing subsidies that produce gaps between prices and marginal social costs and by correcting price gaps that can occur naturally in the market. However, policies that promote efficiency can conflict with other objectives of policymakers, such as covering the costs of government services and satisfying certain concepts of equity.

Government Subsidies and External Costs Can Result in Differences between the Costs of Freight Transportation Services and the Prices Charged to Shippers

The total social costs of providing freight transportation services can be divided into three categories on the basis of who bears them. First, there are private costs, such as labor, equipment, and fuel that are typically paid directly by freight service providers. Freight rail infrastructure falls into this category, as it is mainly funded privately by the rail companies. Second, there are the costs of public investments and services, such as the construction, maintenance, and operations of highways and waterways.[24] These public costs are paid out of government budgets and can be funded through a variety of general or targeted taxes and fees. Finally, there are "external" costs, such as congestion, accidents, and health and environmental damage caused by pollution that are generated while transporting freight, that are not paid for directly by either the service providers or by government. These external costs are imposed on other

[24]Some waterway infrastructure, such as terminal infrastructure, is often privately owned.

members of society who are directly affected by these externalities.[25] Each of these cost categories can be divided further between marginal costs and fixed costs. As noted earlier, marginal costs are those associated with the production of additional units of service. In contrast, fixed costs, such as those associated with the initial construction of infrastructure, are incurred before any service can be provided; however, the production of additional units of service does not add to these costs.

In order to remain in business, private companies need to set prices that not only will cover their private marginal costs, but that will also include a margin that provides a sufficient rate of return to be able to obtain needed investment funds from capital markets. In a competitive market economy, only private costs will be passed on in prices to the final consumers of freight services, unless government policies are designed to pass the public and external costs on to those consumers as well. Governments can recover the public costs that support freight transportation by imposing taxes or fees on freight service providers. Competitive market forces should lead service providers to pass the cost of these payments on to their customers in the same manner that private costs are passed on. If competitive pricing prevents a particular business from passing such costs on to its customers, it may not earn a sufficient rate of return to remain in business.[26] To the extent that public costs are not covered by taxes or fees levied on freight providers or consumers, governments would be providing a subsidy to the industry, which is paid by other taxpayers. Governments can also attempt to make freight service consumers bear the external costs generated by service providers by imposing taxes or fees on those providers in proportion to the external costs that they generate. Again, these costs should be passed on to the customers or noncompetitive businesses will drop out of the market. Government regulation of pollution and other factors that generate external costs can be used in conjunction with taxes and fees to address those costs.

[25]External benefits can also occur in a market. External benefits occur when someone not involved in a particular transaction receives some benefit which they did not have to pay compensation to receive.

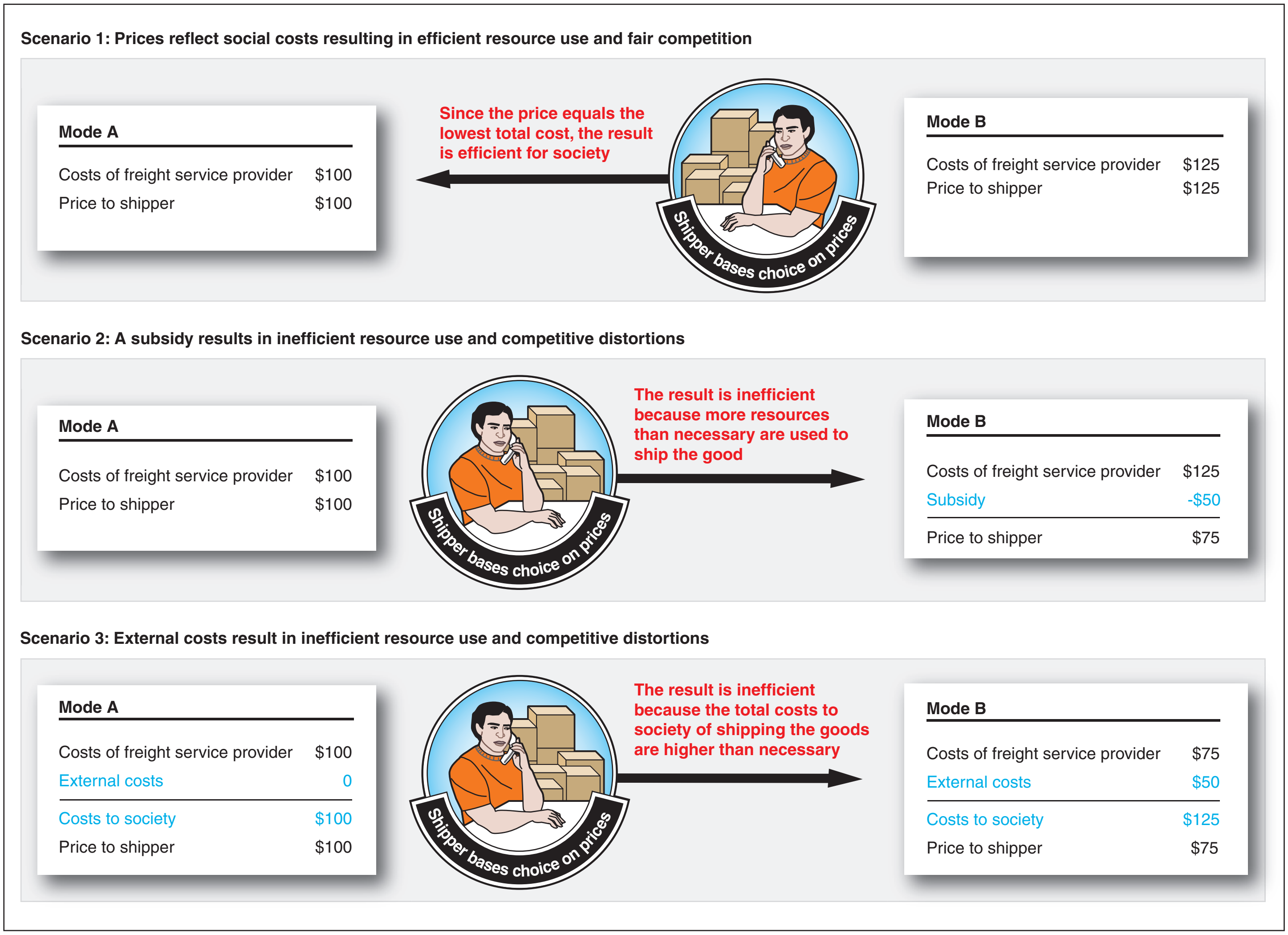
[26]Some government tax policies, such as the proposed federal tax credit for railroad track maintenance, can work in the opposite manner to shift the burden of certain private costs from service providers to general taxpayers.

When Prices Do Not Reflect All Marginal Costs, Competition Can Be Distorted and Economic Efficiency Reduced

The hypothetical scenarios in figure 2 illustrate how discrepancies between marginal social costs (plus a competitive return on investment) and prices, whether caused by government subsidies or by external costs, can distort competition and cause inefficient allocations of resources in the freight transportation sector.[27] In the scenarios, a shipper has to choose between two transportation modes to ship a package. Except for price, the services provided by the two modes are equal in all respects, such as timeliness and reliability. In the first scenario, Mode B uses $125 in resources to ship the package; Mode A uses $100 in resources. Price accurately reflects costs incurred to provide the freight service for both modes. Looking to minimize expenses, the shipper makes the logical decision and chooses the less expensive option (Mode A). The freight service provider represented by Mode A is rewarded for providing service more efficiently than the competitor, and the $25 of resources that otherwise would have been used if the product were shipped by Mode B can be used more efficiently in other ways to produce benefits for society.

[27]In the scenarios, the competitive rate of return is not shown separately, but is included in the cost figure.

Figure 2: Hypothetical Scenarios Illustrating How Prices That Do Not Reflect Social Costs Affect Resource Use and Competition



Source: GAO.

The second scenario in figure 2 shows the detrimental effects of a subsidy.[28] In this scenario, the government provides a subsidy to Mode B, enabling it to charge a price that is $50 below its marginal costs. As in the first scenario, the shipper selects the lower-priced option; however, in this case the subsidy results in the service being provided by the higher-cost producer. As a result, $25 of resources that otherwise could have been used to provide other societal benefits are not used efficiently.

The third scenario in figure 2 shows how external costs can distort competition and reduce economic efficiency in a manner similar to government subsidies. In this scenario, Mode B generates $50 in external costs that are not reflected in the price charged to the shipper. The fact that these costs are not passed on to the shipper makes Mode B more competitive than it would be if it had to include those costs in the price. Consequently, the shipper chooses Mode B, despite the fact that society bears $25 more in costs than if the other mode had provided the service.

When prices do not reflect marginal social costs, investment decisions are also distorted, potentially resulting in a misallocation of resources. Much like a freight service shipper whose primary concern is price, an investor that is primarily concerned with profit potential is not concerned with the social costs that a freight service provider generates if they do not affect the provider's net profit. Therefore, an investor looking to maximize his or her return will invest resources in the more profitable provider regardless of social costs. From an economywide perspective, this is a misallocation of resources because those investment resources could be used more efficiently if applied to another area in the economy that is more efficient.

[28]A subsidy is a form of financial assistance provided to a business or economic sector. There are reasons for providing a subsidy, such as to provide assistance to low-income individuals or to correct market failures. For example, in the context of freight transportation, there are situations where subsidizing more fuel-efficient shippers may result in increased economic efficiency because it might shift demand from a high external cost alternative to a lower-cost alternative. However, not all subsidies arise from intentional government policies, and from an economic perspective, subsidies that result in lower economic efficiency relative to other alternatives would be considered less desirable.

There Can Be a Tradeoff between Recovering Fixed Public Infrastructure Costs and Promoting the Efficient Use of Existing Infrastructure

Certain freight transportation costs, such as the construction of new infrastructure, are considered to be "fixed" (rather than marginal) in the sense that they do not increase as use of the infrastructure increases. As an example, the construction cost of a bridge is a fixed cost, but pavement wear is a marginal cost. In freight transportation, fixed costs to build infrastructure are generally large relative to the marginal costs of an additional vehicle trip on an uncongested highway. Consequently, if governments were to charge users only for the marginal costs of their use, they usually would not be able to recover the full costs of building much of the infrastructure. As private companies that own and invest in their own infrastructure, freight railroads must pass on fixed costs to customers in order to remain in business.[29] However, once the infrastructure is in place, charging users a portion of the fixed costs each time they use the infrastructure (on top of a charge for any marginal costs they impose) can result in underutilization of the infrastructure. Appendix V outlines a number of different ways that governments can address this tradeoff between efficiency and cost recovery.[30] The choice among these alternatives involves a political, rather than a strictly economic judgment. Table 2 categorizes how the various types of costs in the freight transportation sector can be passed on to freight service consumers.

[29]Freight railroads are allowed to charge differential rates—up to a certain point—to shippers depending on whether those shippers have other modal alternatives, and thus can recover more of their costs from what are known as "captive shippers" to allow them to offer lower prices and pass on less of their costs where there is more competition. For more on captive shippers and rail rates see GAO, *Freight Railroads: Updated Information on Rates and Other Industry Trends*, GAO-08-218T (Washington, D.C.: Oct. 23, 2007).

[30]One option, known as "Ramsey pricing" would be to charge a higher price to users who are less likely to respond by reducing their use of the infrastructure than would other users. This approach would be similar to the practice just described for railroads.

Table 2: Categories of Total Social Costs in the Freight Transportation Sector

Category	Examples	Circumstances under which the costs would be passed on to freight service consumers
Marginal social costs (increase with each freight shipment)		
Private	• Fuel • Labor of truck drivers and rail and vessel operators • Vehicle and tire wear	These costs that are paid directly by freight service providers will generally be passed on to consumers in competitive markets. Where monopoly conditions exist (as is the case in certain rail corridors), effective government price regulation can ensure that excessive rates are not charged.
Public	• Pavement wear • Wear on waterway locks and dams as vessels pass	Government taxes or fees that are based on factors associated with infrastructure wear (e.g., vehicle miles traveled, loaded vehicle weight, and axle configuration) and levied on service providers would be passed on to consumers in the same manner that private costs are.
External	• Health and environmental damage due to pollution • Time costs due to congestion (in certain places, at certain times)	Government taxes or fees based on volumes of pollutants produced by specific freight vehicles under specific conditions and time-variant tolls charged for specific routes would be passed on to consumers in the same manner that private costs are. Government regulations can also be used in conjunction with taxes and fees to reduce the amounts of external costs generated to begin with.
Fixed social costs (exist regardless of whether an additional shipment is made)		
Private	• Initial construction of warehouses, depots, and rail lines	The cost of financing this construction will be incorporated in the prices that providers charge to consumers under the same conditions as described for private marginal costs above.
Public	• Construction of new highway capacity and maintenance of current highway stock • Construction of locks and dredging of waterway channels	Several alternative types of taxes or fees can be used to pass these costs on to consumers, including those that allocate the costs across all freight providers based on the extent of their use of the infrastructure.
External	• Health and environmental damage due to pollution from construction equipment	Charges based on the volumes of pollutant could be included in the construction costs that the government allocates across freight providers in the manner described above.

Source: GAO.

Policies That Promote Economic Efficiency Can Conflict with Other Government Objectives

Government policies aimed at reducing gaps between prices and social costs in the freight transportation sector also support the benefit principle of equity—a widely accepted economic principle—but they can conflict with the "ability-to-pay" principle of equity (which holds that people should contribute to the cost of government in line with their financial resources) and other objectives important to policymakers. The benefit principle holds that government services should be financed by those who benefit from those services. In the case of transportation funding, motor fuel taxes adhere more closely to the benefit principle than does the income tax because fuel consumption is correlated with road use. However, motor fuel taxes are regressive, meaning that lower income individuals pay a greater share of their income toward these taxes than do higher income individuals. This regressivity can conflict with the ability-to-pay principle, unless compensating relief to lower income individuals is provided in other parts of the tax system.

Other objectives may be important to policymakers, such as whether or not a policy can be administered cost effectively. For example, attempts to achieve a high level of precision in marginal cost pricing through taxes and fees carry with them an administrative burden, as we discuss later in this report. The administrative costs of implementing finely calibrated versions of a tax may outweigh any efficiency gains achieved through increased precision. Efficiency in the freight transportation sector depends on prices fully reflecting marginal costs on a shipment-by-shipment basis; however, subsidies and external costs can vary considerably from one shipment to another based on the geographic origin and destination, time of day, and other factors. Moreover, as we discuss below, considerable uncertainty exists in the valuation of many types of costs.

Available Data Indicate That Consumers Do Not Pay the Full Costs of Transporting Freight, Particularly Freight Moved by Truck

The combination of tax, spending, and regulatory policies in the United States does not result in consumers of all three surface freight transportation modes bearing the full costs they impose on society, particularly truck freight. Available data indicate that each of the modes, in the aggregate, generates marginal costs in excess of their marginal revenue. [31] Specifically, we estimate that freight trucking costs that were not passed on to customers were at least 6 times greater than rail costs and at least 9 times greater than waterways costs per million ton miles of freight transport. Most of these costs were external costs imposed on society. In particular, the modes generate external costs related to accidents and pollution that are not reflected in prices. Furthermore, available data also indicate that at the national level, the infrastructure costs (both marginal and fixed) attributable to commercial freight transported by trucks and over waterways exceed the revenue that these freight transportation providers pay governments to fund that infrastructure. The available data for the freight transportation networks and vehicles we examined show that both the marginal and fixed social costs that are not passed on to freight service consumers are greatest (per million ton miles of freight carried) for freight trucks and lowest for railroads.

Consumers of Freight Services Pay Less of the Marginal Costs Associated with Trucking than with Railroads or Waterways

Although certain data limitations and difficulties in valuing important categories of costs prevent us from making definitive quantitative estimates of the nonprivate (i.e., public and external) marginal costs generated by an additional million ton-miles of freight service provided by each of the three transportation modes, we are able to present at least lower bound estimates of those costs and to compare the magnitudes of these costs across the three modes.[32] In a competitive economy, private costs such as payments for labor and fuel are generally passed on in prices

[31] The estimates are based on aggregated data in order to compare the modes on a nationwide basis. This level of aggregation obscures considerable variations in costs and tax payments across individual shipments within each mode. For example, for any rail or waterway shipment, truck movement may also be involved at either origination or destination points. Consequently, the results should be viewed as representing averages across all of the marginal shipments that were made under a wide variety of different conditions in a wide variety of locations.

[32] Difficulties in estimating the health and mortality costs associated with a ton of specific pollution emissions are a key source of uncertainty surrounding our estimates. Nevertheless, available studies identify values that we can reasonably characterize as conservative. Moreover, we can draw conclusions about the relative magnitudes of pollution costs.

to the final consumers of freight services; therefore, those costs did not need to be included in our estimation of costs that are not passed on. We are also able to estimate the amount of revenue that governments collect from highway taxes and fees, such as those on motor fuels and tires that are associated with marginal activity.[33] (We use the payment of such taxes and fees as a measure of the extent to which governments have passed some of the nonprivate costs on to final consumers). The extent to which the nonprivate marginal costs exceed tax and fee payments indicates the extent to which some nonprivate marginal costs are not reflected in prices charged to freight consumers. We refer to this difference as "unpriced costs." The available evidence suggests that, on average, an additional million ton-miles of freight service provided by trucking[34] generates significantly more unpriced costs than an additional million ton-miles of either freight rail or waterways service generates.[35] We estimate that over

[33]Each mile of driving consumes fuel and reduces a tire's tread life and, thereby, increases the taxes a driver pays. Toll payments typically are not as directly related to each mile driven; however, a driver's total toll payments in a given year are likely to be correlated with the number of miles driven.

[34]Our estimates of infrastructure costs, subsidies, and tax payments for the trucking mode are based on data for all single-unit and combination trucks (excluding pickup trucks). This population of trucks will include a variety of trucks that are not used for freight services. Data from the 2002 Vehicle Inventory and Use Survey suggests that between 64 percent and 83 percent of total vehicle miles traveled (VMT) for single-unit trucks and between 94 percent and 100 percent of total VMT for combination trucks was attributable to freight providers (depending on whether concrete mixers, dump, and trash and recycling trucks are included as freight trucks). In total, between 83 percent and 94 percent of VMT for all trucks was attributable to freight providers.

[35]To adjust for the large differences in tonnage moved by different modes, we use 1 million ton-miles as our unit of measure for marginal increases in services and also as a basis for comparing fixed costs across modes. This marginal unit represents an increase in service provided by entirely new trips as opposed to increases attained by adding tonnage to each trip. In the rail and waterway modes, this margin could represent one additional trip, whereas in trucking, it would represent many additional trips. Given that our data on marginal costs and revenues are averaged across all types of freight truck trips, the ratio of marginal costs to marginal revenue for trucks would be the same, whether our marginal unit is 1 ton-mile or a million ton-miles. However, a truck ton-mile does not necessarily represent the same unit of service as a rail or waterway ton-mile. Rail and waterway networks allow for less flexibility in shipping routes than does the highway system; therefore, it may take more ton-miles to ship a ton of freight between points A and B by rail or waterway than it does by truck. To the extent that rail and waterway shipments travel more miles between two given points than do truck shipments, the trucking costs in table 3 are overstated relative to the other modes on a constant-unit-of-service basis. We could not find evidence to suggest that these differences are large enough to change the direction or the order of magnitude of our findings. Although VMT has been used as the marginal unit in some freight trucking analyses, this unit is not useful for cross-mode comparison given the huge differences in vehicle sizes across modes.

$55,000 per million ton-miles of service in unpriced freight trucking costs were not passed on to consumers. In contrast, freight rail and waterways services imposed over $9,000 and over $7,000 in unpriced costs per million ton–miles, respectively.

Table 3 summarizes the estimates of marginal social costs attributable to each freight mode not passed on to consumers, per million ton miles. The estimates we present for pollution and other external costs are based on conservative volume estimates and valuation approaches from the available literature. Moreover, we do not include cost estimates for carbon dioxide (CO2) emissions because of the considerable uncertainty surrounding such estimates. For these reasons, our bottom-line estimates for marginal social costs not passed on to consumers are likely to represent minimum values for those costs.[36]

Table 3: Estimates of Marginal Social Costs Attributable to Each Freight Mode Not Passed on to Consumers, per Million Ton-Miles

Monetary values (in thousands of constant 2010 dollars)			
	Trucking	**Railroad**	**Waterways**
Marginal social costs			
Marginal private costs	[a]	[a]	[a]
Marginal public infrastructure costs (e.g., pavement preservation costs)[d]	$7	-[b]	-[c]
Other public subsidies—federal tax subsidies and financing programs[e]	-	-	-
Marginal external costs[f]			
Emissions of particulate matter and nitrogen oxide	44	8	6[g]
Accidents	8	1	-
Congestion	7	-	Unknown
Marginal taxes and fees			
Taxes and fees associated with marginal freight activity	11	-	-[c]

[36]Because of uncertainties surrounding truck freight ton-mile estimates, we present alternative truck ton-mile estimates in appendix I. The sensitivity analysis shows that the comparison across modes would not change fundamentally with those alternative values; a change in the ton-mile estimate changes both the costs and revenues per ton-mile in the same direction.

Monetary values (in thousands of constant 2010 dollars)	Trucking	Railroad	Waterways
Marginal social costs not passed on to consumers[f]			
Unpriced costs—marginal social costs minus taxes and fees associated with marginal freight activity	Over 55	Over 9 (but less than trucking costs that are not passed on)	Over 6 (but less than trucking costs that are not passed on)

Source: GAO analysis of DOT and EPA data, except as noted.

[a]As explained above, private costs are generally passed on to consumers, so they do not need to be added into the estimation of costs that are not passed on.

[b]"-" means less than .5.

[c]Transportation Research Board, Paying Our Way, Estimating Marginal Social Costs of Freight Transportation, (1996), shows 0.03 cents per ton-mile plus 3 cents per ton per lock passage, converted to 2010 dollars by GAO. Also, Congressional Budget Office, Paying for Highways, Airways, and Waterways: How Can Users Be Charged? (May 1992), shows 0.06 per ton-mile, converted to 2010 dollars by GAO.

[d]Infrastructure costs and taxes and fees represent averages of data from fiscal years 2000 through 2006.

[e]We did not include any state or local government tax subsidies or financing program targeted at the freight modes.

[f]These estimates likely understate total external costs because they do not cover all types of external costs—for example, we did not calculate costs for CO2 emissions—and the estimates for the included costs are likely to be conservative. The conclusion that unpriced costs for rail and waterways are lower than those for trucking is based on data relating to emission, accident, and congestion volumes. The data in table 4 indicate that the excluded costs are larger for trucking than for the other modes.

[g]This estimate is for inland waterways freight only because comprehensive data were not available for other types of waterways.

Marginal Public Infrastructure Costs

Marginal public infrastructure costs—the second cost item in table 3—relate to public highway spending attributable to miles driven by freight trucks (i.e., pavement preservation costs per million ton-miles). We estimate from recent FHWA data that trucks imposed an average marginal cost to pavement of $7,000 per million ton-miles.[37] We also estimate from FHWA data that pavement preservation costs borne by all levels of government attributable to all single-unit and combination trucks

[37]We did not consider bridge costs. According to TRB, bridge cost generally is regarded to be small relative to other highway costs of increased traffic. In contrast to a pavement, which is designed to fail eventually as a result of fatigue after a specified number of loads pass, a bridge is designed for an extended life span, provided that it is not exposed to a single load greater than its load-bearing capacity. Our pavement cost estimates were based on government spending, rather than on actual pavement damage. To the extent that governments did not attempt to repair all pavement damage, these estimates understate the actual costs.

(excluding pickup trucks) averaged about 6.1 cents per vehicle miles traveled (VMT).[38] The cost per ton-mile would increase with truck weight and decrease with the number of axles. The costs also varied by location (urban or rural), type of road surface, temperature, and other factors. When we compared single-unit and combination trucks using DOT data, we found that marginal revenues exceeded the marginal infrastructure costs by 4.8 cents per VMT for single-unit trucks and by 3.5 cents per VMT for combination trucks, meaning that both types of trucks pay more than their share of pavement preservation costs.[39] Although marginal costs are difficult to estimate from available data, CBO along with TRB and the Brookings Institution have undertaken this effort and reported their results. Their reports, although dated by at least 15 years, remain the most pertinent and relevant to our study.

Because railroads generally pay for their own infrastructure, governments spend little on railroad infrastructure. For waterways freight, marginal public infrastructure costs, as estimated by TRB and CBO, are relatively low because the costs of dredging channels are predominantly fixed, rather than marginal, and vary little with the amount of tonnage that passes through. Because the Recovery Act (2009) was enacted after the time frame of our analysis and was a one-time funding source, our analysis does not consider these funds. Appendix II contains more details on the Recovery Act funds identified for freight transportation infrastructure by mode.

Other Public Subsidies

Federal tax and financing programs subsidize the surface freight transportation infrastructure used by trucks, railroads, and waterborne

[38]FHWA provided us with updated data (representing costs averaged over the years 2000 through 2006) for costs funded by the federal government. We updated the truck share of state and local government costs by applying percentage share estimates from the 1997 FHWA Cost Allocation Study to more recent cost data from Highway Statistics (see app. I for methodology details). The average cost per ton mile should be close to the cost per marginal ton-mile because each ton-mile driven by a particular type of vehicle over a specific stretch of road under similar conditions imposes approximately the same pavement cost. All of the cost estimates—both average and marginal—cited here are averaged across all ton-miles driven by trucks nationwide in a given year.

[39]We did not have separate ton-mile data for single-unit or combination trucks. However, we estimated from VMT data by different weight classes of trucks that combination trucks carried, on average, about three times the load of single units resulting in marginal revenues exceeding marginal public infrastructure costs by $12,000 per million ton-miles for single unit $3,000 for combination trucks. The revenues cover the pavement preservation costs when they are allocated to these costs rather than being used to address the marginal external costs.

vessels. Although we could not determine what portion of these benefits is associated with marginal activity, trucking and waterways freight received indirect, public subsidies through infrastructure improvements financed by certain state and local government bonds, which earned interest that was not subject to federal income tax. Trucking, railroads, and waterways also benefited from federal loan and loan guarantee financing programs for infrastructure improvements at attractive terms.[40] However, we determined that the subsidies from federal financing programs for each of the three modes were negligible on a per-million-ton-mile basis. See appendix III for additional information on federal income tax subsidies and the federal financing programs.

While each of the modes may benefit from certain provisions of the federal corporate income tax, the effects of these benefits on the three modes are not included in table 3 because they relate to fixed costs, rather than marginal costs. For example, eligible Class II and III railroads may take federal business tax credits for rail track maintenance, eligible shipping companies may make tax deferred deposits into a capital construction fund, and all of the modes can benefit from accelerated depreciation for tax purposes (as do many other industries). CBO's estimates of federal corporate effective tax rates for 2002[41]—the best available evidence of whether the overall corporate income tax system favors one mode relative to another, or relative to other industries—suggest that the federal corporate income tax may provide a slight advantage to waterways freight over the other two modes.[42] CBO estimated that the effective tax rate on the category of assets that includes heavy trucks, truck trailers, and buses—the category closest to freight trucks investments—to be 18.2

[40]Although only 20 percent of the program's funding is reserved for projects benefiting freight railroads other than Class I railroads, for fiscal years 2003 through 2007, borrowers have all been Class II and III railroads.

[41]See Congressional Budget Office, *Taxing Capital Income: Effective Rates and Approaches to Reform* (October 2005), table 2.

[42]An effective tax rate measures the share that taxes take out of the return earned on a specific investment. An effective tax rate and a statutory tax rate differ in several ways. The effective rate applies to the economic income earned over the life of an investment and takes account of several factors beyond just the statutory tax rate, including differences between tax depreciation and economic depreciation, inflation, and differences in the tax treatment of income from debt-financed versus equity-financed investments.

percent.[43] Further, CBO estimated the effective tax rate on investments in railroad infrastructure to be 20.1 percent and the rate on investments in railroad equipment to be 11.4 percent. When weighted by the amounts of assets in railroad infrastructure and railroad equipment, these two rates combine for an average effective tax rate on railroad investments of 18.1 percent. The closest asset category for waterways freight includes all investments in ships and boats. CBO estimated the effective tax rate on these investments to be 16.5 percent. These relative effects are on top of any benefits due to public infrastructure investments that trucking and waterways receive over railroads. The effective tax rates for all three modes are below the 26.3 percent average effective tax rate for all corporations, indicating that all three modes are receiving better than average tax rates.

Marginal External Costs

For all of the freight modes, external costs are large relative to public infrastructure costs. Our analysis of available data to quantify the levels of externalities in table 4 shows that freight trucking produces more air pollution, accidents, and congestion per million ton-miles than do the other modes. However, we recognized that there are many difficulties in estimating the monetary costs associated with these external effects. Consequently, the estimates we presented previously in table 3 should be considered a rough order of magnitude estimate for these external costs.[44]

[43]In 2006 CBO estimated that about 37 percent of assets in the trucking industry are owned by businesses that are not subject to the corporate income tax. CBO did not make a separate effective tax rate estimate for these types of businesses in this category. CBO did indicate that the average statutory rate for unincorporated businesses was 27 percent, compared to the 35 percent for corporations. We assume that the effective tax rates for the average unincorporated trucking firm is no greater than 18.2 percent, based on CBO's analysis and our belief that smaller unincorporated businesses are likely to use the most generous capital allowances available in the tax code (expensing of capital expenditures under section 179) for a larger proportion of their investments than are corporations.

[44]Appendix IV contains external cost estimates from the literature. Although noise costs are relevant to freight transportation, the available information indicates that under most conditions noise costs are a fraction of total estimated freight costs, and roughly equal for truck, rail, and waterborne freight. The evidence also indicates external costs that are not well documented, such as water pollution and hazardous material releases, would not alter the observed overall imbalance between the modes.

Table 4: Cross-Modal Comparisons of Externalities[a]

Category	Type	Trucking	Railroad	Waterways	Trucking to rail ratio[b]	Trucking to waterways ratio
Air pollution[c]	Tons of particulate matter per million ton-miles, 2002	0.1191	0.0179	0.0116[d]	6.7	10.2
	Tons of nitrogen oxide per million ton-miles, 2002	3.0193	0.6747	0.4691[d]	4.5	6.4
	Tons of CO2 equivalents per million ton-miles, 2007	229.8	28.96	17.48	7.9	13.1
Accidents[e]	Fatalities per billion ton-miles, avg. 2003-2007	2.54	0.39	0.01	6.4	208.8
	Injuries per billion ton-miles, avg. 2003-2007	55.98	3.32	0.05	16.9	1,239.6
Congestion[f]	Cost of delay to road users in 2000, (in billions of constant 2010 dollars)	$10.86	$0.58	Not available	18.6	Not available

Source: GAO analysis of data from DOT, EPA, and the Texas Transportation Institute.

[a]Federal Highway Administration, *Freight Facts and Figures 2009; and Bureau of Transportation Statistics, National Transportation Statistics*.

[b]A ratio of 1.0 indicates equal amounts of negative effect per unit of freight moved. For example, the ratio of 6.7 in the table indicates that truck freight produces, on average, six and seven-tenths times the particulate matter emissions as movement of the same unit of freight by rail.

[c]Environmental Protection Agency, *National Emissions Inventory*, data provided to GAO by correspondence, and Inventory of *U.S. Greenhouse Gas Emissions and Sinks*: 1990 – 2008.

[d]Estimate is for inland waterways freight only because comprehensive data were not available. Emissions data for waterways freight are for 2005 and were obtained from the Texas Transportation Institute, *A Modal Comparison of Domestic Freight Transportation Effects on the General Public*.

[e]Federal Motor Carrier Safety Administration, *Large Truck and Bus Crash Facts 2007*; Federal Railroad Administration, Office of Safety Analysis online accident/incident data; and Federal Highway Administration, *Freight Facts and Figures 2009*. Trucks are defined as over 10,000 gross vehicle weight, which can include some non-freight activity. For example, in 2007, 12.3 percent of large trucks involved in a fatal accident and 13.2 percent in accidents with injuries were dump, garbage, or concrete-mixer trucks.

[f]Federal Highway Administration, 1997 Federal Highway Cost Allocation Study Final Report.

Emissions and Air Pollution

EPA and DOT have not produced recent estimates of the economic costs of air pollution on a ton-mile basis for any of the freight modes.[45] Therefore, we applied EPA's estimates for the human health benefits of

[45]Available external cost estimates from other sources shown in appendix IV indicate that air pollution and climate change from all surface freight transportation could be as high as 7.6 cents per ton-mile of freight.

reducing one ton of fine particulate matter and one ton of nitrogen oxide to the emissions data. We estimated for freight trucking an emissions cost of $44,000 per million ton-miles, as shown in table 3.[46] Given the even greater uncertainty surrounding the economic costs of CO2 emissions, we did not produce our own estimate. The omission of these costs, as well as the omission of other nonhealth costs associated with emissions of nitrogen oxide and particulate matter, means that the estimates in table 3 are likely to understate the extent to which some marginal costs are not passed on to final consumers. This understatement would be the greatest for trucking.

According to our synthesis of EPA's latest national emissions inventory data (2002), freight trucks produced over six times more fine particulate matter and over four times more nitrogen oxide on a ton-mile basis than freight locomotives,[47] and over 10 and six times more of each type of emission, respectively, on a ton-mile basis than inland waterway vessels.[48] And, according to our analysis of EPA data on greenhouse gases, trucks emitted the highest levels of greenhouse gas (CO2 equivalents) among the freight modes—about eight times more per unit of freight than freight rail, and thirteen times more than waterways freight, as shown in table 4.[49,50]

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[46]The EPA's benefit estimates are from EPA, *Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis*, EPA-420-R-10-009 (April 2010). See appendix I for more detail on GAO's computations.

[47]According to EPA, fine particulate matter can lodge in the lungs, aggravate respiratory conditions such as asthma and bronchitis, cause lung damage and premature death, and may even be a cause of cancer. Nitrogen oxide is a precursor of ground-level ozone, which can contribute to health problems similar to those caused by fine particulate matter, although less acute. In addition to physical health risks, these pollutants also contribute to haze and reduced visibility, and a variety of other environmental impacts.

[48]Ocean-going vessels involved in coastwise freight movements have significantly different performance with respect to emissions than do inland waterways vessels. However, data are not available to isolate the differences, and thus we do not provide separate estimates in this report.

[49]For more information about estimating freight air pollution, see Transportation Research Board, *Representing Freight in Air Quality and Greenhouse Gas Models*, NCFRP Report No. 4 (Washington, D.C., 2010); and GAO, *Climate Change: The Quality, Comparability, and Review of Emissions Inventories Vary Between Developed and Developing Nations*, GAO-10-818 (Washington, D.C.: July 30, 2010).

[50]Greenhouse gases trap the sun's heat within the earth's atmosphere and contribute to climate change. The dominant greenhouse gas emission for the transport sector is CO2, but other important manmade greenhouse gases include methane, nitrous oxide, and fluorinated gases.

Recent EPA regulatory changes require that freight carriers for all the modes upgrade to technologies that reduce particulate matter and nitrogen oxide emissions.[51] EPA expects these standards to reduce diesel engine emissions of particulate matter and nitrogen oxide by 80 and 90 percent, respectively, for locomotives and waterborne vessels and 90 and 95 percent, respectively for heavy duty trucks over the next 20 to 30 years as older engines are taken out of service. While these regulations are expected to reduce the overall level of air pollution external costs, overall emissions will not be reduced to the estimated levels until 2030 or later because older, more polluting diesel engines will still be in use for years to come as each mode's fleet converts to the new technology.

Accidents

According to our analysis of DOT data shown in table 4, nationwide between 2003 and 2007, large trucks were involved in about six times more accidents with fatalities and 17 times more accidents with injuries, per billion ton-miles, than freight rail. Rates of fatalities and injuries involving a waterways vessel were much lower than those involving both trucks and freight rail.[52] The economic costs of transportation accidents reflect the value assigned to the loss of a human life and the reduced productive life and pain and suffering related to serious injuries.[53] The external portion of those costs excludes any amounts borne by the freight service providers (e.g., through insurance premiums or court settlements). Available cost estimates from the literature, shown in appendix IV, indicate that truck external accident costs could be as much as 2.15 cents per ton-mile, almost nine times higher than rail external accident costs. However, these estimates are dated and do not reflect the reduced rate of truck and rail accidents in recent years, or the much higher economic value now assigned to loss of human life. To obtain our conservative estimate of $8,000 per million ton-miles in table 3, we started with the number of fatalities in table 4, multiplied by the latest value for human life used by DOT in guidance for its own analysts, and then assumed that carriers are

[51] 40 C.F.R. parts 80, 86, 92, 94, 1033, and 1042.

[52] Our accident data for freight trucking covers trucks of over 10,000 pounds gross vehicle weight, and may include dump trucks, cement mixers, and garbage/refuse haulers. We selected freight vessels that were defined as tows, tugs, ships, or barges as representing domestic waterborne freight.

[53] Economists and other researchers have worked to establish specific values for the loss of life and serious injuries. Currently DOT uses $6 million in its analysis when determining the Value of a Statistical Life, which is defined as the value of improvements in safety that result in a reduction by one in the expected number of fatalities that a regulatory action provides.

already compensated for 50 percent of these costs (see app. I for details on our scope and methodology). We identified four studies that attempted to determine the extent to which accident costs were compensated through insurance premiums, payments, and other compensation.[54] These studies ranged from 50 to 62 percent in uncompensated or external costs. We chose to use 50 percent of the portion of costs that were not compensated as a reasonably conservative estimate since our calculations do not include estimates for uncompensated costs for injuries and property damage.

Congestion

Most of the available information on road congestion, in particular the costs of delay for all highway users, does not specify external costs associated with freight traffic.[55] We found only one study that provides a cross-modal estimate of freight congestion costs nationally, indicating that in 2000, congestion delay costs from intercity freight trucking were approximately five times those of intercity rail freight, per ton-mile.[56] In its 1997 Highway Cost Allocation Study, FHWA estimated that in 2000 trucks were responsible for $10.9 billion (constant 2010 dollars) in congestion costs to other highway users nationwide. We used that figure in computing our conservative estimate (given that the costs associated with road congestion have grown since 2000) of $7,000 per million ton-miles shown in table 3. We found no national estimates of the external congestion costs waterways freight causes to passenger, recreational, and other nonfreight

[54]See Jason D. Lemp and Kara M. Kockelman (2008). "Quantifying the External Costs of Vehicle Use: Evidence from America's Top-selling Light-duty Models," *Transportation Research Part D*,; 'Transportation Research Board, *Paying Our Way, Estimating Marginal Social Costs of Freight Transportation*, (1996); Forkenbrock, David J. (1999). "*External Costs of Intercity Truck Freight Transportation*," Transport Research part A 33, 505-526; and David J. Forkenbrock, "Comparison of external costs of rail and truck freight transportation," *Transport Research*, Part A, 35 (2001): 321-337.

[55]See, for example, Congressional Research Service, *Surface Transportation Congestion: Policies and Issues*, RL33995 (Feb. 6, 2008); and Federal Highway Administration, *Estimated Cost of Freight Involved in Highway Bottlenecks* (Nov. 12, 2008). Congestion can also add to air pollution and other secondary costs, but we did not find separate estimates for these types of effects.

[56]Beyond estimating the external costs of road freight, this study also estimates the congestion costs imposed on highway users by freight rail at road crossings. See Michael F. Gorman, "Evaluating the public investment mix in US freight transportation infrastructure," *Transportation Research*, Part A 42 (2008): 1-14.

waterways users.[57] There is no national policy to charge transportation infrastructure users for their contribution to congestion.

Taxes and Fees Associated with Marginal Freight Activity

Federal, state, and local governments levy certain taxes and user fees on road users that increase with the payers' use. These levies include taxes on motor fuels and tires, as well as tolls. FHWA provided us with underlying data from its forthcoming highway cost allocation study that estimates how much of the various federal highway user taxes and fees are attributable to trucks. We combined this data with our own estimates for state and local fuel taxes and tolls in order to obtain our estimate of the total tax and fee payments that trucks make for their marginal use of highways, which amounts to about $11,000 per million ton-miles.[58] In comparison, estimates by TRB and CBO suggest that marginal fees paid by waterways freight service providers are less than $500 per million ton-miles. Railroads do not pay taxes or fees for the marginal use of their own infrastructure.

Consumers of Freight Services Pay Less of the Fixed Costs Associated with Trucking than with Railroads or Waterways

We examined the extent to which fixed costs are not passed on to final consumers separately from our table 3 comparison of marginal costs and marginal taxes and fees because unpriced fixed costs will not cause inefficient use of existing infrastructure as unpriced marginal costs do; however, unpriced fixed costs can lead to inefficient investment decisions (as discussed in the following section). Fixed public infrastructure costs are those, such as investments in new roads or the dredging of a waterway, which would exist regardless of whether an additional shipment is made on the route. Fixed taxes and fees, such as excise taxes on vehicle purchases and registration fees, do not vary with the number of VMT. Our estimates in table 5 indicate that the unpriced fixed social costs per ton-mile are largest for trucking—$7,000 per million ton-miles—and smallest for waterways freight—$2,000 per million ton-miles. Railroad

[57]Truck and waterborne freight carriers may add to congestion that affects other carriers within the same mode. However, we do not consider congestion costs borne by other carriers within the mode as external costs for that mode. Nevertheless, there still may be misallocation of freight services or resources, even if these costs are not considered an external cost.

[58]We estimated the state and local revenues attributed to freight trucks using yearly share ratios compared to a 2000 ratio. The revenue estimate is an average across VMT from 2000 to 2006. See appendix I for details.

infrastructure is, for the most part, privately owned and thus has negligible fixed public infrastructure costs.[59]

Table 5: Estimates of Fixed Social Costs Attributable to Each Freight Mode That Are Not Passed on to Consumers, per Million Ton-Miles

Monetary values (in thousands of constant 2010 dollars)			
	Trucking	**Railroad**	**Waterways**
Fixed social costs			
Fixed private costs	[a]	[a]	[a]
Fixed public infrastructure costs	$14	-[c]	$4
Other public subsidies—federal tax subsidies and financing programs[b]	Unknown on a per-ton-mile basis but varies little across modes	Unknown on a per-ton-mile basis but varies little across modes	Unknown on a per-ton-mile basis but varies little across modes
Fixed external costs	Unknown, but likely small	Unknown, but likely small	Unknown, but likely small
Fixed taxes and fees			
Taxes and fees targeted at the freight modes but not on marginal freight activity	7	Unknown, but likely small	2
Fixed social costs not passed on to consumers			
Unpriced costs—Fixed social costs minus taxes and fees (excluding other public subsidies)	7	-	2

Sources: GAO analysis of DOT, Department of the Treasury, Census Bureau, and Corps data.

[a]As explained above, private costs are generally passed on to consumers, so they do not need to be added into the estimation of costs that are not passed on.

[b]This category does not include any state or local government tax or financing subsidies. The costs of the financing programs and tax exempt bonds would be negligible per ton-mile. We could not estimate the cost of preferential treatment under the corporate income tax on a per-ton-mile basis; however, as explained above, this treatment varies little across modes.

[c]"-" means less than .5.

Within the freight trucking mode, we also compared single-unit and combination trucks. Our analysis suggests that fixed costs exceeded the share of fixed taxes and fees for both types of trucks, and that the amount of these unpriced fixed costs was higher for single-unit trucks than for

[59]Fixed private costs are mostly likely passed on fully to consumers under competitive conditions.

combination trucks: 7.7 cents versus 5.2 cents per VMT.[60] In contrast, the marginal revenues exceeded the marginal costs for each type of truck, with the difference larger for single-unit than for combination trucks: 4.8 cents versus 3.5 cents per VMT.

Formulating Policy Responses to Address Unpriced Social Costs Raises Complex Issues

In this report we have pointed out that the efficiency of our economy is decreased in several ways when marginal and fixed costs are not reflected in prices, and that the available evidence at a national level indicates that there are unpriced marginal and fixed social costs across the three surface freight transportation modes. Policy responses that attempt to more closely align prices with marginal social costs (including a competitive rate of return on capital) or attempt to reduce gaps between fixed costs and revenues will confront a number of complex issues that are important for policymakers to consider, particularly when considering national-level policies. We also noted that the extent to which modes are substitutable is difficult to estimate and will largely be determined by whether shipping is feasible or practical by another mode, and by the relative prices and other service characteristics of shipping by different modes. In addition to mode-shifting, price changes can prompt other economic responses in the short run, such as the use of lighter-weight materials; over the longer term there is greater potential for responses that will shape the overall distribution and use of freight services.

Costs can vary widely based on the specific characteristics of an individual shipment, such as the geography and population density of the shipment's route, and the fuel-efficiency of the specific vehicle carrying it. Ideally, policy that is able to align marginal prices with marginal costs on a shipment-by-shipment basis would provide the greatest economic benefit. However, achieving this in practice would typically result in high administrative costs. For example, freight carriers may have to purchase new technologies or be required to maintain more complex and detailed records. Similarly, government agencies would likely have to devote more resources to enforcement efforts. As a result, economic efficiency could be reduced because the costs to administer the policy may actually exceed the benefits achieved.

[60] If, on average, combination trucks carried about three times the load of single units, then the unpriced fixed costs would be about $20,000 per million ton-miles for single-unit trucks and $4,000 for combination trucks.

Less targeted interventions (e.g., charging fees or taxes based on average costs, subsidizing more efficient alternatives, or broadly applying safety or emission regulations) can have impacts on users and potentially change the overall distribution of freight across modes or demand for freight overall, but provide fewer benefits. Further, more general policy interventions can push too much of the cost onto users who previously had below-average unpriced costs and too little of the cost onto users who previously had above-average unpriced costs. For example, a policy that charges freight providers on the amount of their emissions would result in an overcharge for those traveling in rural areas where few people live and an undercharge for those traveling in more densely populated urban areas. External costs from the same amount of emissions would be higher in more densely populated urban areas because more people are exposed to the pollutants.

Other complexities arise when attempting to align fixed costs and revenues. In general, our current system is set up as a user pay system, wherein the costs of building and maintaining the system are to be borne by those who benefit. However, available data suggest that in the trucking and waterways modes, current government mechanisms to recover the fixed costs associated with public infrastructure do not achieve full recovery. Aligning fixed costs and revenues for public infrastructure—whose multiple users include passenger cars and recreational boats along with freight trucks and vessels—is a complex task requiring detailed cost allocation studies, which are expensive and time-consuming, and are not done regularly.[61] Furthermore, policies designed to recover fixed costs can conflict with policies designed to address gaps between marginal social costs and revenues. As discussed previously, if governments were to charge users only for the marginal costs of their use, in many cases they would not be able to recover the costs of building the infrastructure to begin with. However, once the infrastructure is in place, charging users a portion of the fixed costs each time they use the infrastructure (on top of a charge for any marginal costs they impose) would likely result in underutilization of the infrastructure because some potential users would not be willing to bear the higher cost. Appendix V provides options that governments can take to address this tradeoff between efficiency and cost recovery.

[61]The last federal highway cost allocation study was issued in 1997, with an update in 2000. FHWA has a new cost allocation study ongoing.

Finally, marginal social costs can vary widely across jurisdictions, and have varying levels of impact, which has implications for the level of government that is best suited to administer a policy response. For example, congestion costs are local in nature, thus cities, counties, or local authorities are in the best position to develop interventions that reduce those costs, or attempt to price those costs. On the other hand, some air pollution costs can be imposed on multiple states, the entire nation, or other countries. State or local governments may not be equipped or institutionally capable of implementing policies that are regional in nature and affect multiple states. National policy responses to pollution and emissions must also consider that air pollution reductions can be achieved across a number of different industries, potentially at lower cost than in the transportation sector. Furthermore, although considerable research has gone into estimating the effects of climate change, there is uncertainty around how increases in atmospheric concentrations of greenhouse gases and temperature within ecosystems and economic growth will vary across regions, countries, and economic sectors, and therefore, appropriate policy responses require international coordination.[62]

Agency Comments

We provided copies of a draft of this report to DOT and the Corps for review and comment. DOT responded with suggestions to consider additional data sources and methods for calculating infrastructure and external costs. We accepted some of DOT's suggestions and incorporated those changes into our report, but for others, we believe that our data sources and methods are appropriate. DOT also provided technical corrections, which we incorporated in the report. The Corps indicated that we had adequately incorporated or footnoted its comments made to a preliminary draft of this report and had no further comment.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the Secretary of Transportation, the Secretary of Defense, the Commanding General and Chief of Engineers of the U.S. Army Corps of Engineers, and interested

[62]See GAO, *Climate Change: Expert Opinion on the Economics of Policy Options to Address Climate Change*, GAO-08-605 (Washington, D.C.: May 9, 2008) for a broader and more detailed discussion of this issue.

congressional committees. In addition, the report will also be available at no charge on the GAO Web site at http://www.gao.gov.

If you have any questions about this report, please contact our offices at (202) 512-2843 or (202) 512-9110 or at herrp@gao.gov or whitej@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix VI.

Phillip R. Herr
Director, Physical Infrastructure

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Director, Tax Issues

Appendix I: Objectives, Scope, and Methodology

The objectives of this report are to (1) describe how public policies can affect competition and efficiency within the surface freight transportation sector; (2) determine what is known about the extent to which costs are borne by surface freight users; and (3) discuss how our findings could be used when making future surface freight transportation policy.

To describe the effects of public policy on the freight sector, we conducted a review of the transportation and economic literature and interviewed transportation policy experts to identify how government, academic, and professional research organizations apply economic concepts to determine the efficiency of the surface freight transportation system in the United States. We identified the types of data that can be used to evaluate the costs imposed by users of the surface freight transportation system on the economy and the factors to consider when determining the effect of government intervention.

To determine the extent to which costs are borne by users of freight trucking, freight rail, and waterways freight services, we obtained, reviewed, and analyzed several datasets. We used federal highway cost and revenue data provided by the Federal Highway Administration's (FHWA) Office of Policy for allocating costs imposed by and estimating revenue received from the freight trucking industry—specifically, single-unit and combination trucks. For allocating similar costs and revenues to the same classes of trucks at the state and local government levels, we used several tables reported by *FHWA's Highway Statistics Series*. To estimate domestic waterways costs at the federal level, we used construction costs reported by the U.S. Army Corps of Engineers (Corps), and used operations and maintenance costs obtained from the Corps' Operations and Maintenance Business Information Link system. For estimating state and local governments' financial assistance to waterways, we used the Census Bureau's State and Local Government Finance data. In terms of revenue, inland waterways and the harbor maintenance trust fund revenue estimates were based on financial information reported by the Department of the Treasury's Bureau of Public Debt. We used available cost and revenue information on railroads published by the Association of American Railroads. To assess the reliability of finance and technical data, largely gathered from federal statistical agencies' databases, we reviewed relevant documentation about the agencies' data collection and quality assurance processes, talked with knowledgeable officials from several agencies about these data, and compared these data against other sources of published information to determine data consistency and reasonableness. We determined that the data were sufficiently reliable for the purposes of this report.

We reviewed marginal and fixed costs from the literature, including (1) the 1997 *FHWA Highway Cost Allocation Study*, its addendum published in 2000, and unpublished supporting documentation; (2) the Transportation Research Board's 2008 National Cooperative Highway Research Program, Synthesis 378, on State Highway Cost Allocation Studies; (3) the 1996 Transportation Research Board (TRB) report entitled *Paying Our Way, Estimating Marginal Social Costs of Freight Transportation*; (4) the 1992 Congressional Budget Office (CBO) report entitled *Paying for Highways, Airways, and Waterways: How Can Users Be Charged*; (5) the American Association of State Highway and Transportation Officials publications; and (6) *Road Work, A New Highway Pricing and Investment Policy*, published by the Brookings Institution in 1989.

To understand available financial and technical data on freight, we conducted interviews with and obtained data from officials in the following organizations:

- Department of Transportation's Chief Economist, Federal Highway Administration's Freight Management of Operations, and Transportation Infrastructure and Finance Innovation Act program office;
- Federal Railroad Administration's Railroad Rehabilitation and Improvement Financing program office;
- Research and Innovation Technology Administration's Bureau of Transportation Statistics;
- Maritime Administration's ship financing program office;
- Army Corps of Engineers' Institute for Water Resources; and
- Environmental Protection Agency's (EPA) Office of Air and Radiation.

We also interviewed Department of Transportation (DOT), Corps, and EPA officials to obtain advice on economic concepts related to surface freight transportation, appropriate and available data sources, and methodological approaches. We obtained preliminary reviews about the scope, methodology, and analysis contained in this report from DOT, EPA, the Corps, as well as two members of the Comptroller General's Advisory Board—comprised of individuals with broad expertise in public policy.

We also spoke with industry representatives to discuss their views on government spending and regulatory policy. Specifically, we interviewed representatives from the American Trucking Association, the Association of American Railroads, the American Waterways Operators, and the American Association of Port Authorities. In addition to industry representatives, we also interviewed individuals who were involved in previous federal and state highway cost allocation studies or authored research papers on external costs.

Cost Estimation Methodology

We estimated federal, state, and local government costs for the surface freight transportation infrastructure, including the publicly owned highways and domestic, commercial inland waterways by examining government-reported spending data. Freight railway infrastructure, on the other hand, is, for the most part, privately owned and operated. Private railroad investment costs and revenues are proprietary, and therefore, we did not attempt to produce estimates of private costs and limited our analysis to government expenditures associated with rail, where appropriate. Further, we did not consider in our study (1) pipeline freight because pipelines carry specific liquid commodities, such as natural gas and oil products or (2) air freight because air freight constitutes a fraction of commercial freight moved by value, ton, and ton-miles and is typically used to move high-value, time-sensitive freight which would generally not be moved by the other modes. Where possible, we adjusted all figures to constant 2010 dollars using the fiscal year gross domestic product price index.

In compiling our results for freight trucking, we could only approximate the freight truck population by using available data for all single-unit and all combination trucks—any vehicle consisting of a power unit pulling at least one trailer that does not have a power unit—but excluded light trucks, which are generally passenger vehicles and delivery vans. In using this population to represent freight trucks, we include some trucks that are involved in nonfreight purposes, such as municipal waste disposal trucks and utility trucks, which account for a small percentage of the total vehicle miles traveled (VMT) of this population.[1] Some of the nonfreight trucks are likely to have marginal costs and tax payments that are lower

[1]Data from the 2002 Economic Census—Vehicle Inventory and Use Survey: Geographic Area Series— suggests that, in total, between 83 percent and 94 percent of VMT for all trucks was attributable to freight providers (depending on whether concrete mixers, dump, and trash and recycling trucks are included as freight trucks). Between 64 and 83 percent of total VMT for single-unit trucks and between 94 and 100 percent of total VMT for combination trucks was attributable to freight providers.

than those for the average freight truck, while other nonfreight trucks will have higher costs and tax payments. While the population of freight trucks could also have been defined based on the number of axles on a truck, FHWA's 1997 *Highway Cost Allocation Study*—the basis for some of our spending and revenue projections—reported costs and revenues by various weights of single-unit and combination trucks.

Our estimates of external costs—the costs imposed on society, such as the cost of lost time resulting from traffic congestion or the health consequences related to pollution—reflect activities that can be attributed to domestic freight activity for all single-unit and combination trucks, rail carriers, and waterborne vessels. In several instances, we made adjustments to national data in an effort to remove nondomestic or nonfreight activity from our calculations. For example, as shown in table 9 in this appendix, we adjusted EPA data to more accurately report emissions attributable to domestic freight activity for all three modes.

Both our estimates of government costs and revenues and external costs are based on high-level data in order to compare the modes on a nationwide basis. Variations in costs and revenue across individual shipments within each mode may be obscured by this level of aggregation. Because these are comparisons between modes on an aggregate, national basis, and we are not able to compare specific shipments, the estimates associated with railroads and waterways do not consider the costs associated with the truck ton-miles necessary to complete a shipment on those modes (for an analysis that attempts to compare marginal costs across the modes on a shipment-by-shipment basis, see Transportation Research Board, *Paying Our Way, Estimating Marginal Social Costs of Freight Transportation* (1996)). The results should be viewed as representing averages across all of the marginal shipments that were made under a wide variety of different conditions in a wide variety of locations.

Federal Highway Marginal and Fixed Costs and Revenues

FHWA has conducted highway cost allocation studies—the most recent being in 1997, which superseded its 1982 study—that attempted to determine whether all highway users are paying their fair share of federal highway costs and to ensure that it and Congress have up-to-date information when making future decisions affecting federal highway user fees. According to FHWA officials, sections of the 1997 report were peer-reviewed by TRB, and based on TRB's comments, FHWA issued an addendum in 2000. According to FHWA officials, an update to this study is forthcoming. To the extent possible, we developed cost and revenue categories similar to those used in FHWA's 1997 study.

For this review, we obtained FHWA's Office of Policy data on average spending from 2000 through 2006 on highways by improvement type and vehicle class—specifically single-unit and combination trucks. Improvement types included new construction, preservation, minor widening, bridge work, safety and traffic operations, and environmental, among others. We also obtained federal revenue data by vehicle class and revenue type—fuel, retail, heavy vehicle use, and tire taxes. We used this FHWA data to estimate total federal highway costs and revenues attributed to freight trucks.

We separated the federal costs and revenues into two categories—the first included costs and revenues associated with marginal use of the highways by freight trucks. We considered highway system preservation costs to be the closest available approximation of the wear-and-tear costs associated with road use.[2] However, we did not include (1) bridge-related costs because bridges are built to withstand a specific design load[3] or (2) enhancement or new capacity costs because these costs do not directly vary with repeated truck usage. All other federal spending was considered to be fixed costs. Our use of spending data to represent marginal costs may result in an understatement of those costs if that spending was not sufficient to repair all of the damage caused by road use. We considered marginal revenue to be receipts from fuel and tire taxes—receipts directly related to the use of the highway infrastructure. We assumed the retail tax had little relationship to highway use, and therefore, did not include it in our marginal revenue category.

State Highway Marginal and Fixed Costs and Revenues

Because FHWA efforts to update the 1997 study will not address state and local government costs, we produced our own estimates of state and local government costs and revenues allocated to freight trucks for the same time period as the federal-level data that FHWA had provided to us. For our state estimates, we summarized state expenditures on highways from fiscal years 2000 through 2006 using table SF-12A, State Highway Agency Capital Outlay, from FHWA's Highway Statistics Series. With assistance from FHWA officials, we categorized these costs into four improvement

[2]Highway system preservation costs include pavement resurfacing, rehabilitation, and reconstruction.

[3]Although bridges are designed to withstand the load of the bridge itself, the load of the heaviest vehicle using the bridge, plus a safety factor—and thus have a negligible marginal cost—usage by heavy trucks exceeding the bridge weight limit can cause considerable wear and tear.

types—new capacity, system preservation, enhancements, and other—consistent with cost categories identified in the 1997 Highway Cost Allocation Study and in federal costs reported in the Highway Statistics Series. Because state expenditures reported in table SF-12A included federal funds that states received, we adjusted the expenditures to reflect strictly state spending on highways. First, we converted federal obligations reported in highway statistics table FA-6A (Obligation of Federal Funds) to expenditures using factors provided by an official from FHWA.[4] Second, for each of the four improvement types, we subtracted the estimated federal expenditures from state expenditures to obtain states' spending of their own funds. Third, for each improvement type, we estimated the expenditure amounts attributable to freight trucks using proportions that we derived from supporting documentation related to the 1997 study. State and local governments are generally responsible for maintaining the nation's highways, and therefore, we again used a proportion derived from data from the 1997 study and applied it to Highway Statistics Series table SF-2 (State Disbursements for Highways) containing maintenance and services figures to estimate operations and maintenance costs attributed to freight trucking at the state level.[5] As with the federal spending data, we considered system preservation expenditures to be the best available approximation of costs associated with marginal highway use. We consider all other costs, such as new construction, system enhancements, and routine maintenance to be fixed costs.[6]

[4]According to the FHWA official, historically, the annual rate at which obligations were expended were as follows: 27 percent in year 1, 41 percent in year 2, 16 percent in year 3, 5 percent in year 4, 3 percent in year 5, 3 percent in year 6, 2 percent in year 7, 2 percent in year 8, and 1 percent in year 9.

[5]Federal highway spending is generally used for capital investments. Some federal highway spending is identified for maintenance of roads on federal lands, such as National Park Service and Bureau of Land Management roads. Spending includes FHWA activities funded through the general fund and all other federal agencies, such as the Forest Service, Bureau of Indian Affairs, Bureau of Land Management, as well as the Highway Trust Fund Mass Transit account. We do not estimate federal maintenance spending attributable to freight trucking, as the FHWA *Highway Cost Allocation Study* did not include funds directly appropriated from general funds. However the amount of freight trucking on special federal roads (i.e., roads in national parks) is likely to be minimal.

[6]See appendix A of FHWA's *Guidelines For Conducting A State Highway Cost Allocation Study Using the State HCAS Tool* for examples of routine maintenance costs, including roadway surfacing patching and scraping, maintenance of signs, painting, and winter plowing, which, for the most part, are the responsibility of state and local governments.

To estimate marginal state revenues attributable to freight trucks from fiscal years 2000 through 2006, we first determined the average, annual total receipts from motor fuels receipts (minus penalties and fines) reported in table MF-1 (State Motor Fuel Taxes and Related Receipts) and tolls from bridge, tunnel, and road crossings receipts reported in table SF-3B (State Administered Toll Road and Crossing Facilities). We then determined what shares of these revenues were attributed to freight trucks as follows: except for tolls, the revenue shares from fuel for freight trucks were based on results from the 1997 *Highway Cost Allocation Study*.[7] The revenue shares for each year after 2000 were adjusted for changes in VMT, motor fuels consumed, and vehicle registrations. Since the 1997 study did not allocate tolls, we assumed that for each freight truck category, the share of tolls was equal to its share of total VMT in a given year. For fixed revenues, we also included registration, drivers license, and weight-distance receipts, as reported in table MV-2 (State Motor-Vehicle and Motor-Carrier Tax Receipts), in our calculations.

Local Highway Infrastructure Marginal and Fixed Costs and Revenues

We also developed marginal and fixed cost estimates for local highway spending and revenues attributed to freight trucks. For local expenditures, we summarized local disbursements on highways, averaged from 2000 through 2006 using table LGF-2 from the Highway Statistics Series. The table grouped data by capital outlays, maintenance and traffic services, administration and miscellaneous, and law enforcement, among other categories. We grouped the data as closely as we could into categories approximating those that FHWA used in their 1997 study and then allocated these disbursements to single-unit and combination trucks based on those trucks' shares of the 1997 categories. Given that capital construction and system preservation was reported as a single category, the only option we had for estimating the amount spent on pavement rehabilitation (which we used to benchmark marginal costs) was to assume that pavement rehabilitation accounted for the same share of total capital costs as it did in 2000. On the revenue side, we again used tables from the *Highway Statistics Series*: table LDF (Local Government Receipts from State and Local Highway User Revenue) and table LGF-3B (Receipts of Local Toll Facilities). Table LDF reported motor fuel and motor vehicle revenues combined as a single number. Using data from the 1997 cost study, we estimated that motor fuel accounted for 45 percent of

[7]We used the study's projections for 2000 as the basis for the shares for state revenues from registrations, licenses, and weight-distance taxes. FHWA advised against using the 2000 projections for motor fuels taxes, so we used its 1994 data as our starting point for those taxes instead.

combined motor fuel and motor vehicle revenue in 1994. We used the trucks' shares of local motor fuel and motor vehicle taxes from the 1997 study to allocate our updated revenue amounts to trucks. For tolls, we used the same allocation assumption as we did for state toll revenues. Local revenues account for less than 3 percent of the marginal revenue and fixed revenue amounts that we report in tables 3 and 5 respectively. Table 6 summarizes expenditures and revenues by mode by government per million ton-miles.

Table 6: Estimated Average Infrastructure Expenditures and Revenue (per Million Ton-Miles) by Level of Government by Mode

Monetary values (in thousand of constant 2010 dollars)

Mode	Federal	State	Local	All levels of government[a]
Costs				
Trucks—related to marginal costs	$3	$2	$1	$7
Trucks—related to fixed costs	4	4	5	14
Railroads	Not estimated; freight rails receive limited government assistance	Not estimated; freight rails receive limited government assistance	Not estimated; freight rails receive limited government assistance	Not estimated; freight rails receive limited government assistance
Waterways	2	3 (State and local)		4
Revenues				
Trucks—related to marginal revenues	6	5	-[b]	11
Trucks—related to fixed revenues	2	5	-[b]	7
Railroads	Not estimated; freight rails pay some taxes	Not estimated; freight rails pay some taxes	Not estimated; freight rails pay some taxes	Not estimated; freight rails pay some taxes
Waterways	-[b]	2 (State and local)		2

Sources: GAO calculations based on DOT, Corps, and Census data.

[a]Federal, state, and local expenditures may not total the all level of government expenditures due to rounding.

[b]"-" means less than .5.

Freight Rail Costs and Revenues

All Class I railroad infrastructure is privately owned, and most other classes of railroads are also privately owned. However, the federal government provides some limited assistance to privately owned railroads, but it was negligible for the purposes of our analysis. The federal government no longer levies any federal excise tax on railroads.[8] There is little available evidence on the extent to which railroads receive financial assistance from states or local governments, but this evidence suggests that these amounts are negligible. Railroads are subject to state and local property taxes on their infrastructure and the nation's major railroads paid at least $625 million in 2008.

Waterways Freight Costs

The nation's waterways are used for many purposes, such as navigation, flood control, irrigation, and recreation. According to literature we reviewed, the marginal infrastructure costs associated with freight on the waterways are negligible.[9] To estimate the overall fixed cost to the federal government for waterway infrastructure investments, as well as operations and maintenance in support of freight transportation, we obtained budgeting and expenditure data by waterway (deep and shallow draft coastal harbors and channels, Great Lakes, and inland waterways) from fiscal years 2000 through 2006 from the Corps and the Saint Lawrence Seaway Development Corporation.

- *Coastal harbors and channels operations and maintenance, investments, and nonfuel taxed waterways investments.* We allocated the Corps' total operations and maintenance harbors and channels (deep and shallow draft) expenditures by year to each state based on the Harbor Maintenance Trust Fund expenditures by state.[10] We also obtained waterway infrastructure investment costs by project by state from the Corps. We allocated the expenditures to domestic freight based on tonnage—specifically, the percent of total tonnage moved through each state that is domestic waterways freight—as reported by Corps data supporting table 4-1, Waterborne Commerce by States, Waterborne Commerce of the United States, National Summaries. Such allocation may

[8]Freight rails were subject to a federal fuel tax between fiscal years 2000 through 2006 for deficit reduction purposes. Freight rails paid 4.3 cents per gallon for diesel in 2000 and 2004; 3.3 cents from January 1, 2005 through June 30, 2005; 2.3 cents from July 1, 2005 through December 31, 2006; and nothing after December 31, 2006. Railroad companies are subject to the 0.1 cent per gallon Leaking Underground Storage Tank tax on motor fuels. 26 U.S.C. § 4041(a)(C)(ii)(III).

[9]Transportation Research Board, *Paying Our Way, Estimating Marginal Social Costs of Freight Transportation* (1996) shows 0.03 cents per ton-mile plus 3 cents per ton per lock passage, converted to 2010 dollars by GAO. Congressional Budget Office, *Paying for Highways, Airways, and Waterways: How Can Users Be Charged?* (May 1992) shows 0.06 cents per ton-mile, converted to 2010 dollars by GAO.

[10]See Congressional Research Service, *Harbor Maintenance Trust Fund Expenditures* (January 25, 2010).

overstate costs attributable to domestic freight operations for at least two reasons. First, CRS reports that a significant amount of harbor spending is directed toward harbors that handle little cargo, and therefore the primary beneficiaries of the spending will be nonfreight users of the harbors and channels. Second, dredging at U.S. ports may be done primarily to accommodate ever-larger container ships involved in oceanic trade, and therefore costs attributable to domestic trade may be negligible in those cases. However, without a waterways cost allocation study, little more is known about how costs may be distributed among the various users of harbors, channels, and other waterways, and thus tonnage appears to be the most reasonable method to allocate costs.

- *Inland waterways operations, maintenance, and construction costs.* After consultations with a Corps official, we allocated 50 percent of the Corps' inland waterways operations, maintenance, and construction spending from fiscal years 2000 through 2006 to freight. We used 50 percent because federal law establishes a 50/50 federal/nonfederal cost-share arrangement for construction. We could not definitively determine the extent to which waterways freight activity accounted for all waterway activity. Two studies provide a wide range of possibilities. A 1980 Corps study indicated that for selected waterways (the Ohio, Allegheny, Monongahela, Lower and Upper Mississippi, among others) within the boundaries of three Corps districts—St. Paul, St. Louis, and Pittsburgh—the average waterways freight activity accounted for 75 percent.[11] More recently, however, a 2010 preliminary report concluded that a wide range of consumers benefit from the pools of water created and operated to facilitate commercial navigation and other uses, but commercial navigation itself appears to be a relatively small beneficiary of this system. This finding was based on a limited scope of work, and without further research, allocating costs or revenues to commercial freight has limitations.

State and local governments spend their own funds for investments in state-owned port facilities involved in domestic freight transportation. For our state and local government analysis, we used expenditure and revenue data on "sea and inland port facilities" from the U.S. Census Bureau's, Government Finance Statistics, *State and Local Government Finances by Level of Government*. States and local governments provide funding to

[11]U.S. Army Corps of Engineers, Navigation *Cost Allocation Study* (1980). The purpose of this study was to determine the feasibility of specifically identifying expenditures made exclusively for commercial navigation and, where multipurpose features are involved, allocating costs among various beneficiaries.

publicly owned ports and dock facilities on waterways for the purposes of construction, operation, and maintenance of commercial port facilities, canals, harbors, and other public waterways; dredging of those waterways; and maintenance of commercial docks, piers, wharves, warehouses, cranes, and associated terminal facilities, among other things. To determine the portion of this spending that may be allocated to domestic waterways freight transportation, we used factors based on tonnage—specifically, the percent of total tonnage moved through the port that is domestic waterways freight, as reported by Corps data supporting table 4-1, Waterborne Commerce by States, Waterborne Commerce of the United States, National Summaries.

Ton-Mile Adjustments

We used ton-miles to normalize our data across modes. Multiple ton-mile estimates are available for domestic freight activity. To the extent possible, we attempted to use ton-mile data that most accurately reflects the total domestic freight activity within each mode.

- *Freight trucks.* We used truck ton-mile estimates based on DOT's Freight Analysis Framework (FAF).[12] According to DOT officials, the 2007 ton-mile estimate derived from the FAF are the most comprehensive representation of domestic truck freight activity available. DOT has another series of ton-mile estimates produced by the Bureau of Transportation Statistics (BTS); however, according to DOT officials the BTS series does not capture as much domestic truck freight activity as the FAF estimate.[13] We determined that the FAF data were more appropriate for the purpose of presenting our cost and revenue data on a per-ton-mile basis because the cost and revenues data we used were for the broadest definition of truck freight traffic.[14] One difficulty in using the FAF

[12]The Freight Analysis Framework (FAF) integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation. With data from the 2007 Commodity Flow Survey and additional sources, FAF version 3 provides estimates for tonnage and value, by commodity type, mode, origin, and destination for 2007, the most recent year, and forecasts through 2040.

[13]DOT officials could not provide a definitive explanation as to why the BTS data do not capture the full complement of domestic truck freight activity. One official said he thought that part of the explanation is because the BTS figures do not fully capture the movement of some imported commodities. Another DOT official said that the BTS figures undercount retail-to-retail or other intercompany movements for large retailers that manage their own fleet of truck freight vehicles. This official also thinks that BTS undercounts freight movements in the 50- to 200-mile range when moving from origin to destination.

[14]In fact, as previously mentioned, some cost and revenue data were derived from populations that slightly exceeded all freight trucks.

estimates is that 2007 is the only recent year for which DOT has applied the current FAF methodology. DOT in previous years applied a different methodology to estimate ton-miles based on 2002 data. However, given that the methodology for estimating these figures changed significantly between 2002 and 2007, DOT cautions that the estimates from the 2 years should not be combined in the same time series.[15] In order to produce ton-mile estimates for all of the years that we needed, we multiplied the BTS figure for each year by the ratio of the FAF estimate to the BTS estimate for 2007. Given the unavoidable imprecision of this approach, we report error bounds of plus and minus 5 percent for all of our per-ton-mile results. These ton-mile data are shown in table 7.

Table 7: Estimated Truck Ton-Miles of Domestic Surface Freight, 2000 – 2007

Ton miles (in millions)

Ton-mile source	2000	2001	2002	2003	2004	2005	2006	2007
Freight Analysis Framework (FAF)	-	-	-	-	-	-	-	2,040,000
GAO estimate based on 2007 FAF/BTS ratio (1.55)	1,847,273	1,878,839	1,928,914	1,958,696	1,984,713	2,000,110	2,000,011	-
Plus 5 percent	1,939,636	1,972,781	2,025,359	2,056,631	2,083,949	2,100,115	2,100,012	-
Minus 5 percent	1,754,909	1,784,897	1,832,468	1,860,762	1,885,477	1,900,104	1,900,011	-
Bureau of Transportation Statistics (BTS)	1,192,633	1,213,013	1,245,342	1,264,570	1,281,367	1,291,308	1,291,244	1,317,061

Source: GAO analysis of DOT data.

- *Freight rail.* We used freight ton-miles reported in table 1-46b from BTS's 2009 National Transportation Statistics report.

- *Waterways freight.* We used ton-miles for all domestic waterways, including the inland waterways (internal or intraport), coastal waterways (coastwise), and Great Lakes (lakewise), as reported in table 1-4 of the Corps' 2008 *Waterborne Commerce of the United States, National Summary.* When estimating the marginal external costs for particulate matter and nitrogen oxide, we strictly used the ton-miles along the inland waterways because the available data included only the pollution along the inland waterways system.

[15]DOT plans to release revised estimates for years 1997 and 2002 based on the new methodology in 2011.

External Costs

To determine what is known about freight external costs and how government policies shift costs to freight users, we analyzed and synthesized cost estimates reported for each transportation mode and calculated accident and pollution incident rates. We reviewed reports and studies issued by federal agencies, transportation research organizations, and academia, as well as our past work in surface and freight transportation and the environment. We also discussed freight transportation externalities and policies with a number of knowledgeable government and non-government officials.

To describe freight accident external costs among modes, we reviewed the available estimates. We found significant variation across study methodologies, such as what segments of freight transportation were included, whether freight operator accidents or injuries were included, and whether they estimated average or marginal costs. Additionally, all of the estimates were dated (based on freight activities from 2000 or earlier). To determine whether recent rates were consistent with previous cost estimates. We calculated more recent national rates of accident fatalities and injuries involving a freight carrier, in ton-mile terms, for each mode during calendar years 2003 to 2007. Table 8 depicts our approach to calculating these rates.

Table 8: Methodology for Estimating Average Annual Accident Fatalities and Injuries, per Billion Ton-Miles, Average of 2003 to 2007

Mode	Fatalities	Injuries	Estimated billion ton-miles	Fatalities per billion ton-miles	Injuries per billion ton-miles
Trucks[a]	5,069	111,800	1,997	2.54	56.05
Trains[b]	683	5,747	1,739	0.39	3.32
Waterborne vessels[c]	7	26	587	0.01	0.05

Source: GAO analysis of DOT 2010 data.

[a]Fatalities and injuries reported in Federal Motor Carrier Safety Administration's Federal Motor Carrier Safety Administration Large Truck and Bus Crash Facts 2007 (table 1 and table 4). Trucks are defined as over 10,000 gross vehicle weight, which can include some nonfreight activity. For example, in 2007, 12.3 percent of large trucks involved in a fatal accident and 13.2 percent involved in accidents with injuries were dump, garbage or concrete mixer trucks.

[b]Fatalities and injuries reported in Federal Railroad Administration Office of Safety Analysis's accident/incident online data reporting system, table 1.07

[c]Fatalities and injuries reported in FHWA's Freight Facts and Figures, tables 5-1 and 5-2. We selected freight vessels listed as tows, tugs, or barges to use in our analysis.

We report these computations as the nonmonetized indicators of relative freight external accident costs among the modes. They can be considered reliable indicators of external costs, since these are accident consequences that result despite regulation and other safety measures. Available estimates used different methods and assumptions for determining what portion of total accident costs is external, and estimates varied from 48 to 62 percent of total accident costs. We concluded that none of the available evidence about the external costs portion would significantly change the disparity in accident costs between truck freight and the other two modes that is depicted by the overall accident rates.

To describe freight pollution external costs among modes, we reviewed the existing literature and estimates. Other studies estimated average external costs for intercity truck and rail freight, and found that intercity truck freight could be as high as 1.67 cents per ton-mile and rail freight could be as high as .38 cents per ton-mile in constant 2010 dollars. Other related publications variously report emissions information for one or more of the three modes, but not economic costs.

Table 9 depicts our approach to estimating national rates of emissions for two key regulated emissions typically comprising the majority of estimated air pollution external costs—nitrogen oxide (NOX) and fine particulate matter with a diameter of 2.5 microns or less (PM2.5)—in ton-mile terms for each mode.

Table 9: Methodology for Estimating Tons of Freight-Related PM2.5 and NOX Emissions, per Million Freight Ton-Miles for Trucks and Locomotives in 2002 and for Waterborne Vessels in 2005

Mode	Estimated tons of PM2.5 emissions	Estimated tons of NOX emissions	Estimated millions of ton-miles	Estimated tons of PM2.5 per million ton-miles	Estimated tons of NOX per million ton-miles
Trucks[a]	229,754	5,824,060	1,928,914	0.1191	3.0193
5 percent ton-mile increase	229,754	5,824,060	2,025,359	0.1134	2.8756
5 percent ton-mile decrease	229,754	5,824,060	1,832,468	0.1254	3.1783
Rail locomotives[b]	28,690	1,083,320	1,605,532	0.0179	0.6747
Waterborne vessels[c]	3,520	141,865	274,367	0.0116	0.4691

Source: GAO analysis of EPA and Texas Transportation Institute data.

[a]Estimated emissions data are obtained directly from EPA and are based on the current MOVES2010 model for estimating on-road vehicle emissions. The estimate assumes that nearly all on-road diesel emissions are freight-related and 15 percent of gasoline powered vehicle emissions are freight-related.

[b]Estimated emissions data are derived by subtracting 3.17 percent from total emissions from the locomotive category in EPA table 3-95 and table 3-96 of EPA's Assessment and Standards Division Office of Transportation and Air Quality, Regulatory Impact Analysis: Control of Emissions of Air Pollution from Category 3 Marine Diesel Engines, Chapter 3 Emission Inventory, EPA-420-R-09-019. According to EPA documentation we reviewed 3.17 percent of total estimated locomotive emissions can be attributed to nonfreight activities.

[c]The estimate is for inland waterways freight only because of insufficient data for other domestic waterways freight. Emissions data for waterways freight are for 2005 and were obtained from the Texas Transportation Institute, A Modal Comparison of Domestic Freight Transportation Effects on the General Public (2009).

Table 10 depicts our approach to monetizing the negative health effects associated with NOX and PM2.5 surface freight emissions. To monetize these effects for each freight mode, we used EPA's estimate of the benefits-per-ton of reducing NOX and PM2.5 emissions for 2015. Though EPA's benefits-per-ton estimates were intended to value improvements in air quality associated with emissions reductions, we believe that they also serve as a close approximation of the monetized impact of emissions increases that occur on the margin. The monetized value of emissions increases is referred to here as estimated damages.[16] To make our calculations, we adjusted these estimates for both NOX and PM2.5 to 2010 dollars and then multiplied them by the total amount of emissions for each mode for 2002. Then, we divided this total by the estimated total number of ton-miles for each mode in 2002. (Total emissions and ton-miles are both reported in table 9).

[16]According to an EPA official, the estimated damages (or "disbenefits" in EPA's usage) should not be considered completely synonymous with costs because part of the estimate was determined by surveying the population on what they would be willing to pay in order to extend their health and life by reducing pollution. It is plausible that if these respondents were asked how much these pollutants were costing them in health and quality of life costs, then they would likely have a different response.

Table 10: Methodology for Estimating Damages of Freight-Related PM2.5 and NOX Emissions, per 2002 Ton–Miles for Trucks and Locomotives and 2005 Ton-Miles for Waterborne Vessels

Monetary values (in constant 2010 dollars)[a]

Mode	Estimated damages per ton of NOX emissions (2010 dollars)	Estimated damages per ton of PM2.5 emissions (2010 dollars)	Estimated damages from NOX per million ton-miles (thousands of 2010 dollars)	Estimated damages from PM2.5 per million ton-miles (thousands of 2010 dollars)	Total estimated damages from NOX and PM2.5 per million ton-miles (thousands of 2010 dollars)
Trucks	$4,610	$251,466	$13.92	$29.95	**$43.87**
5 percent ton-mile increase	4,610	251,466	13.26	28.53	**41.78**
5 percent ton-mile decrease	4,610	251,466	14.65	31.53	**46.18**
Locomotives	4,610	251,466	3.11	4.49	**7.60**
Waterborne vessels	4,610	251,466	2.38	3.23	**5.61**

Source: GAO calculations based on DOT and EPA data.

[a]We adjusted to constant 2010 dollars the benefit estimates (in 2007 dollars) for each ton reduction in NOX and PM2.5 emissions for 2015 (with a discount factor of 7 percent) from EPA, Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards Regulatory Impact Analysis, EPA-420-R-10-009 (April 2010).

Manmade greenhouse gases include CO2, methane, nitrous oxide and fluorinated gases, and the dominant greenhouse gas emission for the transport sector is CO2. We calculated tons of CO2 equivalent emissions per million ton-miles of transported freight for 2007. Table 11 depicts our approach to calculating these rates.

Table 11: Methodology for Estimating Freight-Related CO2 Emissions, per 2007 Ton-Miles for Trucks and Locomotives and 2005 Ton-Miles for Waterborne Vessels

Mode	Estimated tons of emissions	Estimated ton-miles (in millions)	Estimated tons of emissions per million ton-miles
Trucks	468,702,769	2,040,000	229.76
Locomotives	52,690,481	1,819,633	28.96
Waterborne vessels[a]	5,286,614	274,367	19.27

Source: GAO calculations based on EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007, table A-101 and Texas Transportation Institute data.

[a]Estimate is for inland waterways freight only because sufficient data were not available for other domestic waterways freight. Emissions data for waterways freight are for 2005 and were obtained from the Texas Transportation Institute, A Modal Comparison of Domestic Freight Transportation Effects on the General Public (2009).

We conducted our review from August 2009 to January 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Recovery Act Funds for Freight Transportation Infrastructure

The American Recovery and Reinvestment Act of 2009 (Recovery Act)[1] provided one-time funding to promote job preservation and creation and infrastructure investments, among other things. Since a portion of these funds were targeted for transportation infrastructure projects, generally, they may benefit both passenger and freight users. For example, where freight and passenger trains share tracks, the High-Speed Intercity Passenger Rail program may also enhance capacity for freight rail lines. In this appendix, we report funds identified for infrastructure projects and do not attempt to identify funding to freight or nonfreight users of the infrastructure. We also report Recovery Act funds identified for the EPA's Clean Diesel Program which helps reduce emissions for freight vehicles across all modes and for Army Corps of Engineers waterway projects that we identified as pertaining to freight transportation.

In addition, the Build America Bonds program, created by the Recovery Act, [2] allowed state and local governments to obtain financing at lower borrowing costs for new capital projects such as the development and construction of transportation infrastructure by having the Department of the Treasury make a direct payment to the state or local governmental issuer in an amount equal to 35 percent of the interest payment on the bonds. We summarize this information in table 12.

Table 12: Summary of Recovery Act Funds for Transportation Infrastructure Projects That Might Benefit Specific Modes

Trucking	Railroad	Waterways
FHWA for pavement restoration, repair, or construction of highways that could benefit freight and nonfreight users. $27.5 billion or 57 percent of DOT's total Recovery Act funding of $48.1 billion.	Federal Railroad Administration for the High-Speed Intercity Passenger Rail program. Such assistance could also enhance freight rail where freight and passenger trains share tracks.[a] • $8.0 billion or 17 percent of DOT's total $48.1 billion.	Corps for waterways and harbor projects that could benefit both freight and nonfreight waterways users. The Corps received approximately $4.6 billion in Recovery Act funds. • Construction: $637 million.[b] Operations and maintenance: $956 million.[c]
We also identified around $762 million in TIGER grant funding that could benefit freight transportation.[d]		

[1]Pub. L. No. 111-5, 123 Stat. 115 (February 17, 2009).

[2]Recovery Act, Div. B, title I, § 1531.

Trucking	Railroad	Waterways
EPA Clean Diesel Program funding—$55 million identified for multimodal purposes		
To acquire idle reduction and aerodynamic technologies that help reduce truck diesel emissions, among other things. • $88 million or 30 percent of the total $289 million.	To repower locomotives with emissions reducing technologies. • $27 million or 9 percent of the total $289 million.	To repower or retrofit tugboats, marine engines, and vessels with emission reducing technologies. • $25 million or 9 percent of the total $289 million.
Build America Bond Program—state and local bonds for 61 infrastructure projects totaling $18.4 billion		
• For 34 highway improvement projects (bond amounts totaled $9.9 billion). • For 19 multipurpose projects including highways (bond amounts totaled $7.8 billion).	NA	For 8 port related projects (bond amounts totaled $782 million).

Sources: Federal Highway Administration, Army Corps of Engineers, Environmental Protection Agency, and Department of the Treasury.

[a]Although sharing of tracks with passenger operations can result in benefits for freight railroad, it may also impose additional costs if the freight railroad is not compensated through cost-sharing agreements.

[b]Amount as of January 2010.

[c]Amount approved as of August 2009.

[d]TIGER grants are the Transportation Investment Generating Economic Recovery grants. We identified 10 highway grants totaling $188 million, 4 railroad grants totaling $171 million, and 3 waterways grants totaling $48 million that could benefit both freight and nonfreight users. We also identified eight intermodal grants totaling $355 million that benefited more than one transportation mode. In October 2010, DOT awarded nearly $600 million in subsequently appropriated (FY 2010) funds to over 70 projects in a second round of TIGER grants.

Appendix III: Federal Tax Subsidies and Financing Programs

Tax expenditures are revenue losses to the federal government resulting from tax provisions, such as federal tax (1) exemptions or deductions of the interest earned from certain state and local government bonds or (2) credits provided by the Department of the Treasury for infrastructure projects.

We obtained estimates of fiscal years 2003 through 2007 tax expenditures from the yearly Analytical Perspectives, Budget of the United States Government. The Office of Management and Budget aggregates tax expenditures for state and local government bonds used to finance government operations, facilities, and services, and also identifies the general purpose of the bonds. Thus, we could identify the specific transportation mode for which these bonds were used, but not necessarily whether the bonds were used for domestic freight or nonfreight use. We also used the Statistics of Income's Tax-Exempt Bonds articles from the Internal Revenue Service to estimate the proportion of state and local government bonds used for transportation purposes.

In addition, three federal financing programs administered by DOT provided some subsidies to the freight industry through either interest rates or terms that were more favorable than might be available in the commercial credit markets. These three programs include FHWA's Transportation Infrastructure Finance and Innovation Act program,[1] the Federal Railroad Administration's Railroad Rehabilitation and Improvement Financing program,[2] and the Maritime Administration's ship financing program.[3] We obtained cost estimates from these program offices for fiscal years 2003 through 2007 for 28 infrastructure projects that we identified as being available for use by freight trucks, freight rail, and waterways freight. Table 13 summarizes this information.

[1]Transportation Infrastructure Finance and Innovation Act of 1998, Pub.L. 105–178, Title I, Subtitle E, Ch. 1, §§ 1501 to 1504, 112 Stat. 241 (June 9, 1998; codified as positive law at 23 U.S.C. chapter 6).

[2]Pub.L. 94-210, Title V, § 502, as added Pub.L. 105-178, Title VII, § 7203(a)(1), 112 Stat. 473 (June 9,1998; codified at 45 U.S.C. chapter 17).

[3]46 U.S.C Chapter 537.

Table 13: Summary of Federal Tax Subsidies and Financing Programs, Fiscal Years 2003-2007

Trucking	Railroad	Waterways
Federal tax expenditures (totals for fiscal years 2003 through 2007)		
Exemption from federal taxes on interest earned from state and local government bonds for general transportation purposes totaled $13.5 billion for 5 fiscal years. We were unable to estimate specific amounts for freight and nonfreight usage or by transportation mode.		
The exclusion of interest for financing highway projects and rail-truck transfer facilities was $65 million.	The 50 percent tax credit to Class II and III railroads for maintenance on their railroad tracks was $340 million.	The tax deferral on capital construction of shipping companies was $100 million. Exemption on state and local government-issued private activity bonds for docks and wharves—including freight and nonfreight as well as those for international use—was $681 million.
Federal financing programs (totals for fiscal years 2003 through 2007)[a]		
The Transportation Infrastructure Finance and Innovation Act credit assistance program provided $938 million in credit assistance to five highway projects available for use by freight and nonfreight users at a subsidy cost of about $51 million. TIFIA borrowers also obtained other monetary benefited that could not be estimated.	The Railroad Rehabilitation and Improvement Financing Program loan and loan guarantee program provided $573 million in credit assistance for 18 rail projects.[b] While borrowers paid $17 million in credit risk premiums to offset the risk of default, additional monetary benefits may accrue, but could not be estimated.	The ship financing program provided loan guarantees to 3 freight waterway shipping companies for ship construction or reconditioning at a subsidy cost of $13 million on guarantees totaling $302 million.

Sources: Department of Transportation; President's Budget; and Internal Revenue Service, Statistics of Income Bulletin.

[a]We use the term subsidy here to refer to any form of financial assistance provided to a business or economic sector (see footnote 24) and not the subsidy costs of the federal financial programs as defined by the Office of Management and Budget. OMB Circular A-11 defines subsidy cost as the "estimated present value of the cash flows from Government (excluding administrative expenses) less the estimated present value of the cash flow to the Government resulting from a direct loan or loan guarantee, discounted to the time when the loan is disbursed."

[b]Twenty percent of the program's funding is reserved specifically for projects benefiting Class II and III railroads; however, from fiscal year 2003 through 2007 all borrowers have been Class II and III railroads.

Appendix IV: Freight External Cost Estimates from the Literature

Cost per ton-mile (in 2010 cents)			
Type	**Trucking[a]**	**Railroads**	**Waterways**
Congestion delay	0.24 to 0.58	0.03	Not estimated
Accident	0.11 to 2.15	0.24	Not estimated
Air pollution, health	0.11 to 1.67	0.01 to 0.38	0.09 to 1.87
Climate change	0.03 to 2.95	0.01 to 0.51	0.00 to 0.25
Noise	0.05	0.05	Not estimated

Source: Data reproduced primarily from Mark Delucchi and Don McCubbin, "External Costs of Transport in the U.S.", Handbook of Transport Economics, eds. by A. de Palma, R. Lindsey, E. Quinet, and R. Vickerman (Edward Elgar Publishing Ltd., forthcoming).

[a]Data are largely representative of intercity freight portion, not necessarily local freight.

Appendix V: Policy Options for Addressing Tradeoffs between Efficiency and Cost Recovery

The following cost recovery options have been identified in the economics literature:[1]

- *General subsidy.* Infrastructure users could be charged for the marginal public and external costs they impose, and any shortfall in the coverage of total costs could be paid out of general government funds. This policy would promote efficient use of existing infrastructure; however, it would require higher general fund taxes (which cause their own economic distortions) than would otherwise be necessary and taxpayers who make little use of infrastructure may consider this to be unfair.

- *Ramsey pricing.* If infrastructure users can be classified into different groups depending on the strength of their demand for infrastructure use, then those individuals who would not reduce their use significantly, even if they were charged an amount that exceeded the marginal costs they impose, could be charged a higher price to cover fixed costs. Users with weaker demands could be charged prices equal to their marginal costs. Under these conditions, infrastructure would be utilized up to an efficient level, even though some users are charged more than their marginal costs. The principal impediment to implementing this approach is the difficulty of estimating the strength of various users' demand. In addition, users with high demands may consider it unfair to be charged higher fees than other users solely on that basis.

- *Two-part tariffs.* Infrastructure users could be charged two types of fees. One could be a flat-rate fee to cover fixed costs that everyone could pay to gain access to the infrastructure. The second fee could be a per-use charge designed to cover the marginal costs arising from each use. This policy option could lead to less-than-efficient levels of infrastructure use because some who would have used the infrastructure if only the per-use fee were charged may not use it if the additional access fee were charged. This approach might be made more attractive to and be perceived as more equitable by different types of users if they were given a choice between (1) a high access fee with a low per-use charge and (2) a lower access fee with a higher per-use charge.

- *Average-cost pricing.* Charging users for the average, rather than marginal, costs that they impose would raise sufficient revenue to cover all costs; however, this policy would reduce efficiency because some users who would use the infrastructure if they were charged only for their

[1]See, for example, Congressional Budget Office, *Paying for Highways, Airways, and Waterways: How Can Users Be Charged?* (May 1992).

marginal costs may not be willing to use it if they were charged the higher amounts needed to cover average costs.

Appendix VI: GAO Contacts and Staff Acknowledgments

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