Quick Facts

- Transportation-related activity – including the movement of people and goods as well as the purchase of transportation-related products and services – accounted for over 10 percent of Gross Domestic Product (GDP) in the United States in 2002 with a value of over $1 trillion. That same year, over 19 billion tons of freight, with a value of $13.3 trillion, was carried over 4.4 trillion ton-miles in the United States.[1]
- Inefficiencies and poor maintenance throughout the transportation sector hurt the economy. According to the Federal Highway Administration (FHWA), bottlenecks for trucks on America's highways caused 226 million hours of delay and cost $7.3 billion in 2006.[2] Almost half of the locks on inland waterways maintained by the Army Corps of Engineers are more than 60 years old, even though the planned design life of these locks was 50 years.[3]
- Trucks transport 70 percent of all goods by weight in the United States and emit 75 percent of greenhouse gas (GHG) emissions from freight transportation.[4] GHG emissions from freight trucks increased by 80 percent from 1980 to 2007 while the amount of freight shipped in trucks measured in ton-miles has grown by over 100 percent in that same period.[5]

Background

Freight transportation is a critical component of the American economy. According to the U.S. Department of Transportation, the movement of goods played a significant role in U.S. economic growth in the past two decades. The relative importance of international merchandise trade, and thus the movement of goods, to the overall U.S. economy increased from 12 percent in 1990 to 23 percent in 2008.[6]

Public policy that affects freight transportation must reflect the sensitivity of the national economy to these policies' effects on freight. The players in freight transportation span the full spectrum of private enterprise from sole proprietors to very large international corporations. The relative importance of freight transportation within the overall U.S. economy is likely to continue growing, given current transportation trends and the policies of the Obama Administration. For example, President Obama hopes to double exports by 2015 though his Administration's National Export Initiative (NEI).[7]

Freight transportation is a complex mix of publicly and privately managed systems – the roads and rivers used by trucks and barges, respectively, are almost entirely managed by the government while the railroads are managed by the private sector. Trucks must share the road with passenger vehicles, and freight rail companies sublease their tracks to passenger rail companies to offset maintenance costs.

This overview will focus mostly on truck and rail transport, as they account for nearly 60 percent of freight transport in ton-miles and 80 percent of the sector's greenhouse gas (GHG) emissions. For more details about aviation and marine, see the Climate TechBook sections on *Aviation Emissions Mitigation Strategies* and *Marine Shipping Emissions Mitigation*,

Freight Travel by Mode

There are many modes of transportation for the movement of goods including truck, rail, water, air, and pipeline. By weight and value, most goods are moved on trucks, but the amount of freight moved by rail is comparable when one considers the amount multiplied by distance as measured in ton-miles (see Figure 1).

Because the freight transportation industry is highly competitive, the private sector chooses the most cost-effective mode for transportation. For instance, intermodal transport (using more than one mode) handled less than 11 percent of goods by value in 2008, likely due to the cost of transferring goods between modes. There is evidence that some of the transfer costs are offset by low-cost, long-distance hauls. The Federal Highway Administration (FHWA) estimates intermodal transport's share of goods will increase to over 21 percent by 2035.[8]

Each mode of freight transportation offers advantages and disadvantages. Some useful metrics to compare and contrast freight transportation modes are energy efficiency, convenience, and cost.

Energy Efficiency by Mode

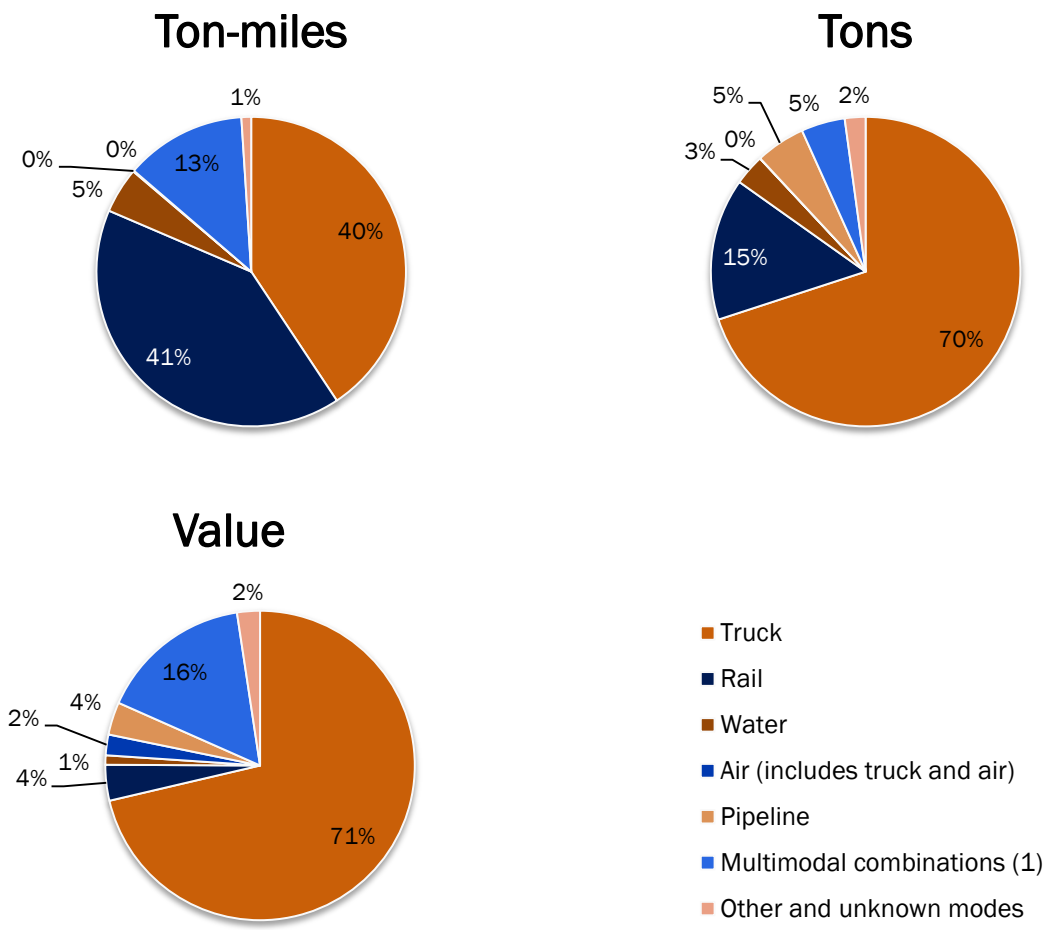
When measuring the movement of goods in units of energy consumed per ton-mile, rail is the most energy-efficient form of freight transportation (see Table 1). Using this metric, rail is twelve times more efficient than trucks and almost twice as efficient as ships. According to the Association of American Railroads (AAR), trains transported a ton of freight 457 miles on one gallon of diesel fuel on average in 2008, a 94 percent increase since 1980.[9] However, fuel efficiency is not a comprehensive metric. For instance, the road infrastructure within the United States is so extensive that in many cases goods delivered by trucks can travel fewer miles than goods moved by competing modes.

Table 1: Energy intensity of domestic transportation modes in the U.S. from 1980 to 2006.

	1980	1990	2000	2006	Percent Change from 1980-2006
Trucks (Btu per vehicle mile)	24,757	22,795	23,448	23,340	-5.7%
Trucks (Btu per ton mile)	4,266	3,928	4,040	4,074	-4.5%
Rail (Class I) (Btu per freight car mile)	18,742	16,619	14,917	14,990	-20.0%
Rail (Class I) (Btu per ton mile)	597	420	352	330	-44.7%
Ships (Btu per ton mile)	358	387	473	571	59.5%
Note: Class I railroads are the largest freight railroad companies based on operation revenue					

Source: U.S. Department of Energy, *Transportation Energy Data Book*. 2008. U.S. Department of Transportation, *National Transportation Statistics*, 2009.

Figure 1: Freight distribution among modes by ton-miles, tons, and value in 2007.



Note that the Commodity Flow Survey is for domestic shipments only; it does not include movements such as ship-to-land imported intermodal transfers.

(1) Multimodal includes the traditional intermodal combination of truck and rail plus truck and water; rail and water; parcel, postal, and courier service; and other multiple modes for the same shipment.

Source: U.S. Department of Transportation, *2007 Commodity Flow Survey*, 2009.

Convenience by Mode

Which transportation mode is most convenient for moving a good depends on the good itself and the good's source, destination, and time requirements for delivery. Industrial goods like coal as well as other large and heavy goods tend to be moved by rail and ships. Coal is the good moved second most by weight and the good moved the most by ton-miles, and more than 70 percent of coal is moved by rail.[10]

Rail's share of freight increases as trip length increases; goods travel 691 miles on average with rail.[11] This

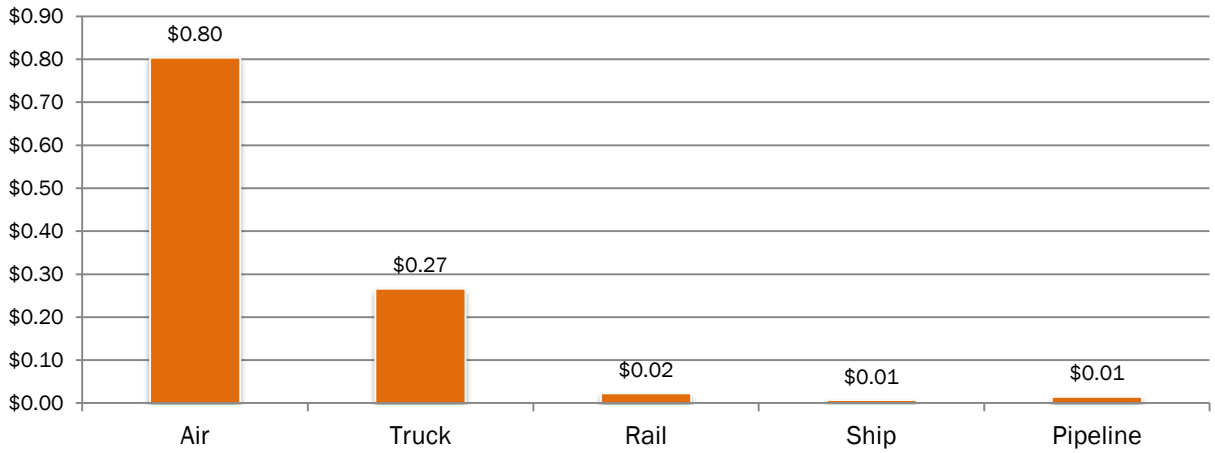
explains why rail's share of freight transport is almost equal to truck's when the metric is ton-miles, while it carries less than 12 percent of the total tons moved.

Infrastructure constraints limit both ship and rail freight volume. It is simply not possible for many trips to be accommodated solely by rail or ship and the cost of transferring goods from one mode to another is often prohibitive. For many short trips (known as short haul), trucks are the only mode available. Furthermore, in many cases trucks must also be used for the last mile of freight distribution. This helps explain why trucks have such a dominant share of the tons of goods moved (nearly 70 percent in 2007).

One of the most significant advantages for trucks over other modes is the extensiveness of the highway system. The Dwight D. Eisenhower System of Interstate and Defense Highways is an engineering feat that was recognized as one of the "Seven Wonders of the United States" by the American Society of Civil Engineers (ASCE) in 1994.[12] The nation's rail and water freight transportation networks are much less extensive geographically than the network of highways and roads, making trucks a faster and more convenient delivery mode for most short- and many long-distance freight trips than these other modes or intermodal options. In fact, the miles of infrastructure for rail actually decreased by 24 percent between 1980 and 2007, while the road infrastructure increased by 5 percent.[13]

Another factor affecting each mode's convenience is a recently developed inventory strategy known as Just-In Time (JIT). JIT attempts to minimize the amount of goods businesses hold at any given time. Holding goods can entail substantial costs, including the cost of storage. Thus JIT helps the bottom line for many companies, and frees up more capital to spend on other business needs. This strategy puts increased time pressure on freight transportation, however. There is less tolerance for shipping delays because the receiver's on-site inventory of goods is not as large. As a result, goods must arrive on time, when expected, and reliably.

Figure 2: Average freight revenue per ton-mile (2006 $)



Source: U.S. Department of Transportation, *National Transportation Statistics*, 2009.

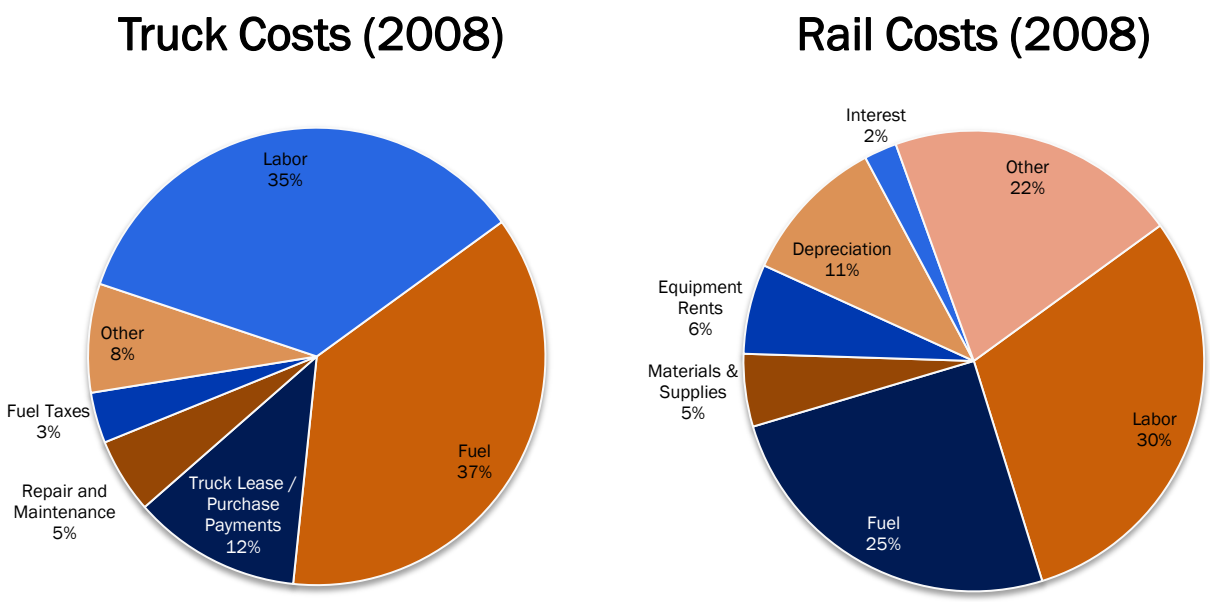
Cost by Mode

The cost of freight transportation varies greatly by mode and is an important factor in determining which mode is appropriate. Figure 2 shows the revenue per ton-mile by mode. The cost of moving goods by airplane and truck is significantly more expensive than by rail or ship.

As mentioned previously, the two most competitive modes are truck and rail, both of which spend most of their revenue on fuel and labor (Figure 3). Rail must pay the complete costs of maintaining the railroad tracks while trucks share road maintenance cost with other vehicles, principally through fuel excise taxes.

Estimating costs for both rail and truck is very complex. Figure 3 is provided for illustrative purposes and should not be treated as a definitive breakdown of the costs for either mode. The costs for any movement of goods depend on the current fuel prices, the distance traveled, the level of congestion, and other factors. These cost shares may all vary considerably and thus the cost breakdown by mode is difficult to quantify in the general case.

Figure 3: The cost of shipping goods by truck and rail in 2008.



Note that truck costs are based on a survey conducted by the American Transportation Research Institute while rail costs are calculated using data from Schedules 410 and 210 of the R-1 annual report filed with the Surface Transportation Board by the Class I railroads.

Source: American Association of Railroads, *Rail Cost Adjustment Factor*, 2009. American Transportation Research Institute, *An Analysis of the Operational Costs of Trucking*, 2008.

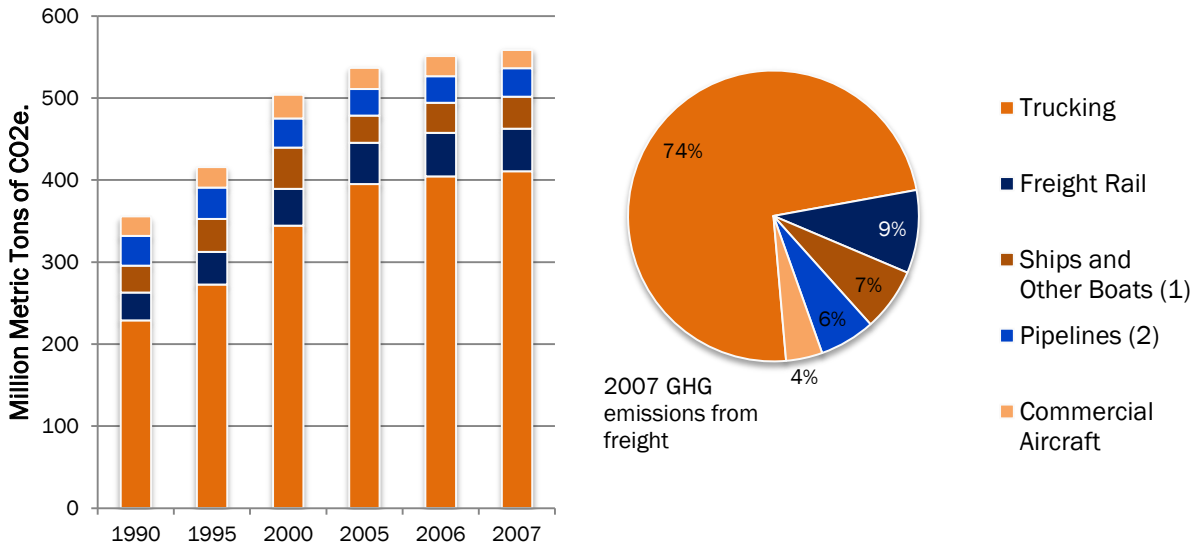
Greenhouse Gas Emissions from Freight

Freight contributed 27.9 percent of the U.S. GHG emissions from transportation, or 7.8 percent of total GHG

emissions in 2007. This share has grown from 23 percent of transportation GHG emissions in 1990 due to the increased emissions from trucking (see Figure 4).

It is clear from Figure 4 that the key challenge to reducing GHG emissions from freight transportation is to reduce the amount of emissions from truck transport. At a high level, there are two ways to accomplish this goal: reduce GHG emissions from trucks or shift more freight transport to less GHG-intensive forms of transport such as rail. The latter option is referred to as modal shift.

Figure 4: GHG Emissions from Transportation from 1990 to 2007 in Million Metric Tons of CO_2e.



(1) Fluctuations in emissions estimates reflect data collection problems. (2) Includes only CO_2 emissions from natural gas used to power pipelines.

Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2007*, 2008.

Reducing Emissions from Trucks

The U.S. Environmental Protection Agency (EPA) is taking the lead in reducing GHG emissions from transportation through its rulemaking authority. In April of 2010, the EPA in partnership with the National Highway Traffic Safety Administration (NHTSA) promulgated the first federal GHG standard for passenger vehicles and light trucks, which together accounted for over 60 percent of GHG emissions from transportation in 2007.[14] The agency is currently working on a similar standard for heavy-duty trucks; the EPA expects to issue a notice of proposed rulemaking by October of 2010.[15] In May of 2010, President Obama issued a Presidential Memorandum indicating the standards should consider the recommendations in a report released by the National Research Council's report detailed below.[16] It is unclear how stringent the EPA's standard will be.

Modal Shift

As mentioned above, convenience and cost determine which mode of transportation is appropriate for the distribution of goods. At least one of these factors must be addressed in order to cause a modal shift – i.e., to change which mode is used to transport a good.

The market for freight transportation is highly competitive in the United States, so most changes will likely come from the private sector. The optimizations or enhancements necessary to cause any modal shift would require significant increases in fuel prices to send a strong signal to freight shippers. Another necessary condition for modal shift is the further containerization of freight; this enables quick transport from one mode to another, encouraging intermodal transport such as truck-to-rail or truck-to-ship movements.[17]

National Research Council Report on Medium- and Heavy-Duty Trucks

The Energy Independence and Security Act of 2007 required the U.S. DOT to enact a first-ever fuel economy standard for medium- and heavy-duty vehicles (MHDV). In order to assist in developing this new standard, the National Research Council (NRC) assembled a committee to assess fuel economy technologies for MHDVs.

The final report, released in April of 2010, recommends that a load-specific fuel consumption standard be adopted for medium- and heavy-duty trucks instead of an absolute fuel efficiency standard, as has been done in the past by the EPA with passenger vehicles and light-duty trucks. Such a standard would acknowledge that trucks are designed as load-carrying vehicles. Thus, the standard would measure the performance of the vehicle against its intended purpose. The following are other recommendations from the report:

- The federal government should continue to support R&D to develop MHDV technologies for reducing fuel consumption.
- An economic/payback analysis should be done based on fuel usage by application and different fuel price scenarios.
- Congress should consider raising fuel taxes as an alternative to a fuel efficiency mandate for MHDVs.
- Congress should consider increasing weight and size restrictions on MHDVs.
- The federal government should encourage the sharing of information related to improved driving techniques.
- Vehicle regulation should come at the final stage of manufacturing.
- Congress should help implement a field test for new standards in order to validate them.

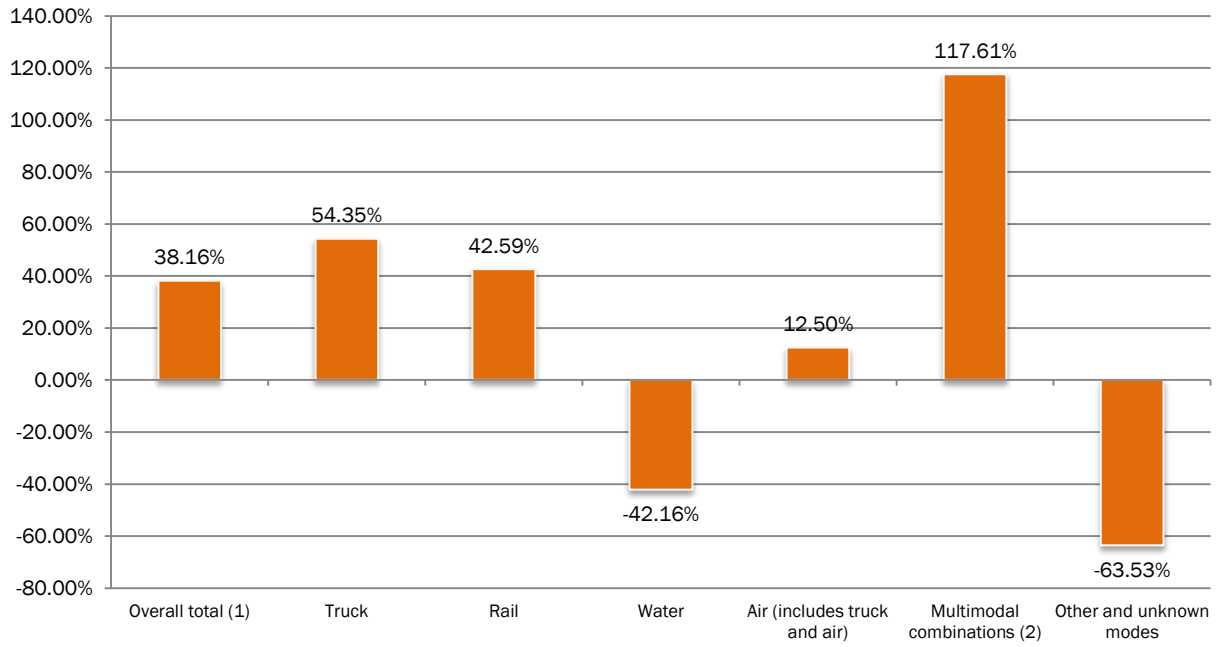
[18,19]

Trends in Freight Transportation

From 1993-2007, freight transportation grew by over 35 percent (see Figure 5). Much of this growth came from trucks, which now lead other modes of transportation in the three main measures of goods movement: tons, ton-miles, and value.

These trends can be explained by cost competitiveness and the advent of just-in-time (JIT) inventory management. Low fuel prices throughout the 1990s and much of the 2000s made modes of transportation most dependent on fuel prices (i.e., trucks) more attractive. The rise in popularity of JIT inventory management made businesses more reliant on timely delivery, favoring trucks since they have access to an expansive network of roads and can move product quickly. As a result, trucks gained more and more market share throughout the 1990s and into the 2000s.

Figure 5: Percent change in ton-miles from 1993-2007.



(1) CFS plus out-of-scope estimates. (2) Multimodal includes the traditional intermodal combination of truck and rail plus truck and water; rail and water; parcel, postal, and courier service; and other multiple modes for the same shipment.

Source: U.S. Department of Transportation, *Freight Shipments in America*, 2006.

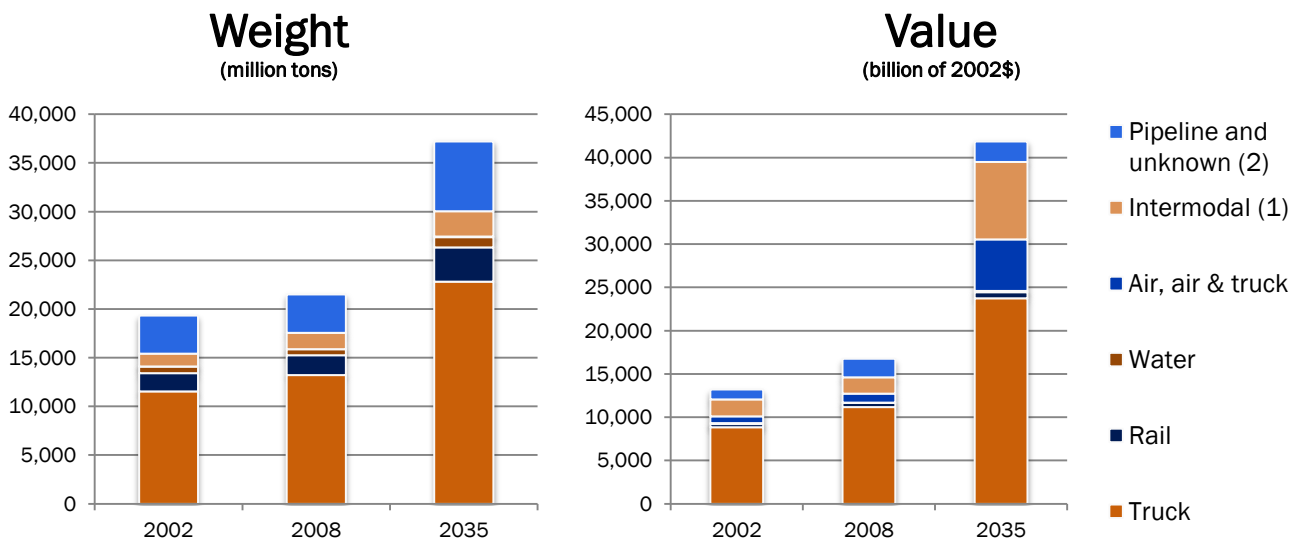
Current trends will likely continue into the future. Figure 6 shows an estimate of the goods by weight and value from 2002-2035. The U.S. DOT estimates that trucks will continue to increase their share of freight transportation.

Mitigation Strategies

Both the private and public sectors play a role in the effort to reduce GHG emission from freight

transportation. As mentioned in above, reducing emissions from trucks and encouraging modal shift are the two most effective strategies. Since freight is a highly competitive market, incentives to improve technology and the efficiency of freight transportation already exist and play a major role in both approaches to reduce GHG emissions. However, the government can also influence the market by pricing GHG emissions.

Figure 6: Trends for freight transportation by weight and value.



(1) Intermodal includes U.S. Postal Service and courier shipments and all intermodal combinations, except air and truck. Intermodal also includes oceangoing exports and imports that move between ports and interior domestic locations by modes other than water. (2) Pipeline and unknown shipments are combined because data on region-to-region flows by pipeline are statistically uncertain.

Source: U.S. Department of Transportation, *Freight Facts and Figures 2009*, 2009.

The following are a list of some policy options that will reduce GHG emissions from freight transportation:

- **Government support:** funding research and development, providing financial assistance for environmentally friendly logistics practices such as freight containerization, and EPA's SmartWay program.
- **Trucks:** engine standards, speed limit reduction, increasing size constraints, anti-idling policies including the electrification of rest stops, eco-driving to optimize fuel consumption, the advanced technologies such as use of hybrid electric engines or waste heat recovery, and alternative fuel support, such as support for biodiesel.
- **Logistics**: support for a more efficient organization of supply-chain networks, including optimal location of trans-shipment points and freight consolidation and distribution centers.

Related Business Environmental Leadership Council (BELC) Company Activities

Alcoa

Alstom

Boeing

Cummins

Daimler

GE

Lockheed Martin

Rio Tinto

United Technologies

Related Pew Center Resources

Climate TechBook. *Transportation Overview*

Climate TechBook. *Aviation Emissions Mitigation Strategies*

Climate TechBook. *Marine Shipping Emissions Mitigation*

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Further Reading / Additional Resources

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[2] Cambridge Systematics, Inc., *Estimated Cost of Freight Involved in Highway Bottlenecks*, 2008.

[3] American Society of Civil Engineers. *Statement Of The American Society of Civil Engineers Before the Subcommittee on Energy and Water Development On the Budget for The U.S. Army Corps of Engineers and Bureau of Reclamation For the Fiscal Year 2010.* Washington: American Society of Civil Engineers, 2009.

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[10] Government Accountability Office, *Freight Railroads: Industry Health Has Improved, but Concerns about Competition & Capacity Should Be Addressed*, 2006. U.S. Department of Transportation, *2007 Commodity Flow Survey*, 2009.

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[15] U.S. Environmental Protection Agency, *Control of Greenhouse Gas Emissions from Heavy-Duty Vehicles - Rulemaking Gateway | Laws Regulations | US EPA*., 2009, http://yosemite.epa.gov/opei/RuleGate.nsf/byRIN/2060-AP61

[16] Office of the Press Secretary. Presidential Memorandum Regarding Fuel Efficiency Standards | The White House. May 21, 2010. http://www.whitehouse.gov/the-press-office/presidential-memorandum-regarding-fuel-efficiency-standards (accessed May 27, 2010).

[17] Containerization is the use of standard intermodal containers as defined by the International Organization for Standardization (ISO).

[18] National Research Council, *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles,* 2010.

[19] Load-specific fuel consumption (LSFC) is measured in gallons of fuel per payload tons per 100 miles. This metric includes the extra weight of a truck when it is carrying a payload; the lower the fuel consumption of the vehicle and the higher the payload the vehicle carries, the lower the LSFC.