Chapter 9. Economic and Social Impacts

9.1 Framework for Benefits and Costs

The net benefits of the proposed National Program consist of the effects of the program on:

- the engine and truck program costs
- fuel savings associated with reduced fuel usage resulting from the program
- greenhouse gas emissions,
- other air pollutants,
- noise, congestion, accidents resulting from truck use,
- refueling savings
- energy security impacts,
- increased driving due to the "rebound" effect.

At this time some impacts, such as the effects of the rule on public health, are not included in this analysis. We plan to address as many of these omitted impacts as possible for the final rule.

As discussed in Preamble Section VIII.A, this proposal identifies technologies that reduce fuel costs enough to pay for themselves over short periods of time. Assuming full information, perfect foresight, perfect competition, and financially rational vehicle producers and buyers, standard economic theory suggests that, under normal market operations, interactions between the buyers and producers would lead to incorporation into the vehicles of all cost-effective technology without government intervention. Unlike in the light-duty vehicle market, the vast majority of vehicles in the medium- and heavy-duty truck market are purchased and operated by businesses; for them, fuel costs may represent substantial operating expenses. Even in the presence of uncertainty and imperfect information – conditions that hold to some degree in every market – we generally expect firms to be cost-minimizing to survive in a competitive marketplace and to make decisions that are therefore in the best interest of the company and its owners and/or shareholders. In this case, the benefits of the rule would be due to external benefits. The analysis in Chapter 7 of this DRIA nevertheless is based on the observation that fuel savings that appear to be cost-effective in our analysis have not been generally adopted.

As discussed in Preamble Section VIII.A., several explanations have been offered for why there appear to be cost-effective fuel-saving technologies that are not generally adopted. In the original sales market, there appears to be poor information available about the effectiveness of fuel-saving technologies for new vehicles. The SmartWay program has helped to improve the reliability of information, but the technological diffusion process appears to be gradual even when information is well demonstrated. Similar issues arise in the resale market, where lack of trust in information about the effectiveness of fuel-saving technology may lead to lack of willingness to pay for fuel-saving technology. This inability to recover some of the value of fuel-saving technology in the resale market may contribute to the observed very short payback periods that original equipment buyers expect. It also appears that market coordination is incomplete. Different agents in the market, such as those who buy trucks and those who pay for operating costs, may not coordinate their activities; those who buy trucks may not fully consider the effects of their activities on those who incur fuel expenses. Finally, future fuel savings are uncertain due, among other factors, to fluctuating fuel prices, while technology costs are immediate and certain; risk-averse or loss-averse truck purchasers may put more emphasis on the immediate costs than the uncertain future benefits when deciding what vehicles to purchase.

Several of these explanations, including imperfect information and split incentives, imply problems in the markets for trucks. Uncertainty and loss aversion reflect buyers' preferences; requiring them to buy additional fuel-saving technology may affect the utility they receive from purchasing trucks. These factors could also influence the extent of any increases in VMT due to the "rebound effect" (discussed below), as well as any impacts on fleet turnover.

Preamble Section VIII.A. discusses these explanations in more detail. We seek comment on these and other explanations for why our analysis shows cost-effective fuel-saving technologies that truck purchasers have not adopted.

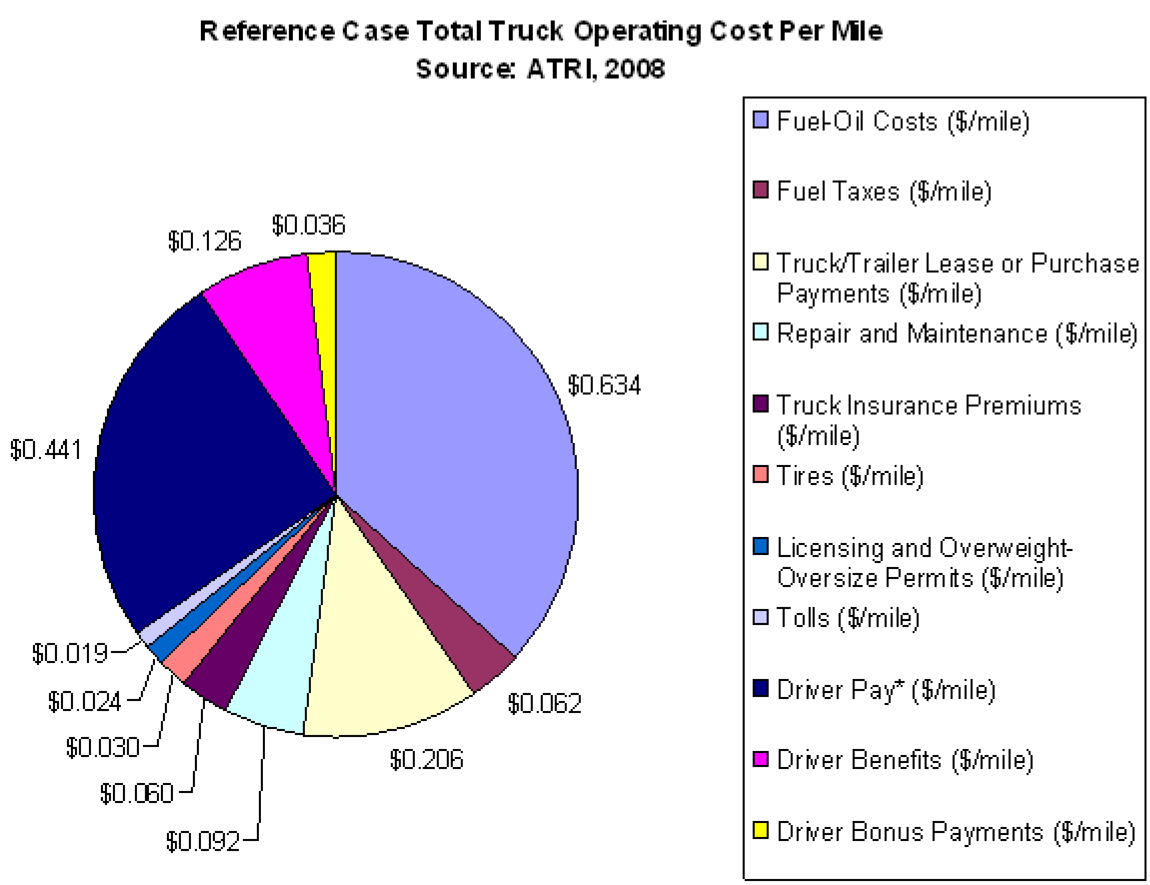
9.2 Rebound Effect

The VMT rebound effect refers to the fraction of fuel savings expected to result from an increase in fuel efficiency that is offset by additional vehicle use. If truck shipping costs decrease as a result of lower fuel costs, an increase in truck VMT may occur. Unlike the light-duty rebound effect, the medium-duty and heavy-duty rebound effect has not been extensively studied. Because the factors influencing the medium- and heavy-duty rebound effect are generally different from those affecting the light-duty rebound effect, much of the research on the light-duty is not likely to apply to the medium- and heavy- duty sectors. One of the major differences between the medium- and heavy-duty rebound effect and the light-duty rebound effect is that heavy-duty trucks are used primarily for commercial and business purposes. Since these businesses are profit driven, decision makers are highly likely to be aware of the costs and benefits of different shipping decisions, both in the near-term and long-term. Therefore, shippers are much more likely to take into account changes in the overall operating costs per mile when making shipping decisions that affect VMT.

Another difference from the light-duty case is that, as discussed in the recent NAS Report, when calculating the percentage change in trucking costs to determine the rebound effect, all changes in the operating costs should be considered. The cost of labor and fuel generally constitute the top two shares of truck operating costs, depending on the price of petroleum, distance traveled, type of truck, and commodity (see Figure 9-1).[12] In addition, the equipment costs associated with the purchase or leasing of the truck is also a significant component of total operating costs. Even though vehicle costs are lump-sum purchases, they can be considered operating costs for trucking firms, and these costs are, in many cases, expected to be passed onto the final consumers of shipping services on a variable basis. This shipping cost increase could help temper the rebound effect relative to the case of light-duty vehicles, in which vehicle costs are not considered operating costs.

When calculating the net change in operating costs, both the increase in new vehicle costs and the decrease in fuel costs per mile should be taken into consideration. The higher the net cost savings, the higher the expected rebound effect. Conversely, if the upfront vehicle costs outweighed future cost savings and total costs increased, shipping costs would rise, which would likely result in a decrease in truck VMT. In theory, other changes such as maintenance costs and insurance rates would also be taken into account, although information on these potential cost changes is extremely limited.

Figure 9-1 Average Truck Operating Costs



The following sections describe the factors affecting the rebound effect, different methodologies for estimating the rebound effect, and examples of different estimates of the rebound effect to date. According to the NAS study, it is "not possible to provide a confident measure of the rebound effect", yet NAS concluded that a rebound effect likely exists and that "estimates of fuel savings from regulatory standards will be somewhat misestimated if the rebound effect is not considered." While we believe the medium- and heavy- duty rebound effect needs to be studied in more detail, we have attempted to capture the potential impact of the rebound effect in our analysis. For this proposal, we have used a rebound effect for single unit trucks of 15%, a rebound effect for medium-duty (2b and 3) trucks of 10%, and a rebound effect for combination tractors of 5%. These VMT impacts are reflected in the estimates of total GHG and other air pollution reductions presented in Chapter 5 of the draft RIA.

9.2.1 Factors Affecting the Magnitude of the Rebound Effect

The heavy-duty vehicle rebound effect is driven by the interaction of several different factors. In the short-run, decreasing the fuel cost per mile of driving could lead to a decrease in end product prices. Lower prices could stimulate additional demand for those products, which would then result in an increase in VMT. In the long- run, shippers could reorganize their logistics and distribution networks to take advantage of lower truck shipping costs. For example, shippers may shift away from other modes of shipping such as rail, barge, or air. In addition, shippers may also choose to reduce the number of warehouses, reduce load rates, and make smaller, more frequent shipments, all of which could also lead to an increase in heavy-duty VMT. Finally, the benefits of the fuel savings could ripple through the economy and increase GDP, which would in turn increase overall demand for goods and services, and therefore increase truck VMT.

Conversely, if a fuel economy regulation leads to net increases in the cost of trucking because fuel savings do not fully offset the increase in upfront vehicle costs, then the price of trucking services could rise, spurring a decrease in heavy-duty VMT and shift to rail shipping. These effects would also ripple through the economy.

As discussed in Section 8 of the preamble, the magnitude of the rebound effect is likely to be determined by the extent of market failures that affect demand for fuel economy in medium- and heavy-duty fleets, such as split incentives and imperfect information, as well as rational firm responses to the tradeoff between higher certain upfront vehicle costs and lower but uncertain future expenditures on fuel.

9.2.2 Options for Quantifying the Rebound Effect

As described in the previous section, the fuel economy rebound effect for heavy-duty trucks has not been studied as extensively as the rebound effect for light-duty vehicles, and virtually no research has been conducted on the medium-duty truck rebound effect. In this proposal, we discuss four options for quantifying the rebound effect.

9.2.2.1 Aggregate Estimates

The aggregate approximation approach quantifies the overall change in truck VMT as a result of a percentage change in truck shipping prices. This approach relies on estimates of aggregate price elasticity of demand for trucking services, given a percentage change in trucking prices, which is generally referred to as an "own price elasticity." Estimates of trucking own-price elasticities vary widely, and there is no general consensus on the most appropriate values to use. A 2004 literature survey cited in the recent NAS report found aggregate elasticity estimates in the range of -0.5 to -1.5.[3] In other words, given an own price elasticity of -1.5, a 10%

decrease in trucking prices leads to a 15% increase in demand for truck shipping demand. However, this survey does not differentiate between studies that quantify change in tons shipped or ton-miles. In addition, most of the studies find that these elasticity estimates vary substantially based on the length of the trip and the type of cargo. For example, one study estimated an own-price elasticity of -0.1 for the lumber sector and -2.3 for the chemical sector.[4]

The increase in overall truck VMT resulting from the rebound effect implicitly includes some component of mode shifting. Since there are differences in GHG emissions per ton of freight moved by different modes (e.g., rail, barge, air) compared to truck, any potential shifting of freight from one mode to the other could have GHG impacts. Although the total demand for freight transport is generally determined by economic activity, there is often the choice of shipping by either truck or other modes when freight is transported. This is because the United States has both an extensive highway network and extensive rail, waterway and air transport networks; these networks often closely parallel each other and are often viable choices for freight transport for many origin and destination pairs within the continent. If rates go down for one mode, there will be an increase in demand for that mode and some demand will be shifted from other modes. This "cross-price elasticity" is a measure of the percentage change in demand for shipping by another mode (e.g., rail) given a percentage change in the price of trucking. Aggregate estimates of cross-price elasticities also vary widely, and there is no general consensus on the most appropriate value to use for analytical purposes. The NAS report cites values ranging from 0.35 to 0.59.[5] Other reports provide significantly different cross-price elasticities, ranging from 0.1[6] to 2.0. See Figure 9-2.[7]

Figure 9-2 Examples of Road Elasticity and Cross Elasticity Estimates

Reference	Road freight elasticities	Cross elasticities (rail)	Comments
[Quinet, 1994]	[-0.9; -0.7]	1.3	Long distance
[UBA, 2007]		1.9	*Assuming a 20% cost reduction*
[TRL, 2008]		0.29 [0.4-0.9]	Rail bulk markets *Assuming a 20% cost reduction*
[Oxera, 2007]	-1.2	0.74	Tonne-km
[Beuthe, 2001]	SD: -1.06 SD: -0.58	SD: 0.11 SD: 0.08	Tonne-km Tonne-volume *Assuming a 5% cost reduction*
	LD: -1.31 LD: -0.63	LD: 0.67 SD: 0.14	Tonne-km Tonne-volume *Assuming a 5% cost reduction*
[Bonilla, 2008]	-1.42 (foodstuffs) -1.75 (building materials) -0.43 (oil and coal)		Tonne-km (for Denmark)
Setra[f]	SD: -0.7		Tonne-km
	LD: -1.0		Tonne-km
[TML, 2008]	-0.416 (TRANSTOOLS model) [-1.2; -0.3] (analytical approach)		Tonne-volume Tonne-km
[Graham, 2004]	Typically [-1.5; -0.5]		Range from literature review. But it highly depends on commodity groups, trip length, etc.

Table 1: Example of elasticity range estimates

Source: Christidis and Leduc, 2009

When considering intermodal shift, one of the most relevant kinds of shipments are those that are competitive between rail and truck modes. These trips include long-haul shipments greater than 500 miles, which weigh between 50,000 and 80,000 pounds (the legal road limit in many states). Special kinds of cargo like coal and short-haul deliveries are of less interest because they are generally not economically transferable between truck and rail modes, and they would not be expected to shift modes except under an extreme price change. However, the total volume of ton-miles that could potentially be subject to mode shifting has also not been studied extensively.

9.2.2.2 Sector-Specific Estimates

Given the limited data available regarding the medium- and heavy- duty rebound effect, the aggregate approach greatly simplifies many of the assumptions associated with calculations of the rebound effect. In reality, however, responses to changes in fuel efficiency and new vehicle costs will vary significantly based on the commodities affected. A detailed, sector specific approach, would be expected to more accurately reflect changes in the trucking market given these standards. For example, input-output tables could be used to determine the trucking cost share of the total delivered price of a product or sector. Using the change in trucking prices described in the aggregate approach, the product-specific demand elasticities could be used to calculate the change in sales and shipments for each product. The change in shipment increases could then be weighted by the share of the trucking industry total, and then summed to get the total increase in trucking output. A simplifying assumption could then be made that the increase in output results in an increase in VMT. This type of detailed data has not yet been collected, therefore we do not have any calculations available for the proposal. While we hope to have this data available for the final rulemaking, gathering high quality data may take a longer time frame. We invite the submission of comments or data that could be used as part of this methodology.

9.2.2.3 Econometric Estimates

Similar to the methodology used to estimate the light-duty rebound effect, the heavy-duty rebound effect could be modeled econometrically by estimating truck demand as a function of economic activity (e.g., GDP) and different input prices (e.g., vehicle prices, driver wages, and fuel costs per mile). This type of econometric model could be estimated for either truck VMT or ton-miles as a measure of demand. The resulting elasticity estimates could then be used to determine the change in trucking demand, given the change in fuel cost and truck prices per mile from these standards.

9.2.2.4 Other Modeling Approaches

Regulation of the heavy-duty industry has been studied in more detail in Europe, as the European Commission (EC) has considered allowing longer and heavier trucks for freight transport. Part of the analysis considered by the EC relies on country-specific modeling of changes in the freight sector that would result from changes in regulations.[8] This approach attempts to explicitly calculate modal shift decisions and impacts on GHG emissions. Although similar types of analysis have not been conducted extensively in the U.S., research is currently underway that explores the potential for intermodal shifting in the U.S. For example, Winebrake and Corbett have developed the Geospatial Intermodal Freight Transportation (GIFT) model, which evaluates the potential for GHG emissions reductions based on mode shifting, given existing limitations of infrastructure and other route characteristics in the U.S.[9] This model connects multiple road, rail, and waterway transportation networks and embeds activity-based calculations in the model. Within this intermodal network, the model assigns various economic, time-of-delivery, energy, and environmental attributes to real-world goods movement routes. The model can then calculate different network optimization scenarios, based on changes in prices and policies.[10] However, more work is needed in this area to determine whether this type of methodology is appropriate for the purposes of capturing the rebound effect. We invite comment on this approach, as well as suggestions on alternative modeling frameworks that could be used to assess mode shifting, fuel consumption, and the GHG emission implications of these proposed regulations.

9.2.3 Estimates of the Rebound Effect

The aggregate methodology was used by Cambridge Systematics, Inc. (CSI) to show several examples of the magnitude of the rebound effect.[11] In their paper commissioned by the NAS in support of the recent medium- and heavy-duty report, CSI calculated an effective rebound effect for two different technology cost and fuel savings scenarios associated with an example Class 8 combination tractor. Scenario 1 increased average fuel economy from 5.59 mpg to 6.8 mpg, with an additional cost of $22,930. Scenario 2 increased the average fuel economy to 9.1 mpg, at an incremental cost of $71,630 per vehicle. Both of these scenarios were based on the technologies and targets from a recent Northeast States Center for a Clean Air Future (NESCCAF) and International Council on Clean Transportation (ICCT) report.[12] The CSI examples provided estimates using a range of own price elasticities (-0.5 to -1.5) and cross-price elasticities (0.35 to 0.59) from the literature. For these calculations, CSI assumed 142,706 million miles of truck VMT and 1,852 billion ton-miles were affected. The truck VMT was based on the Bureau of Transportation Statistics (BTS) highway miles for combination trucks in 2006, and the rail ton-miles were based on the 2006 BTS total railroad miles. This assumption may overstate the potential rebound effect, since all highway miles and rail ton miles are not in direct competition. However, this assumption appears to be reasonable in the absence of more detailed information on the percentage of total miles and ton-miles that are subject to mode shifting.

For CSI's calculations, all costs except fuel costs and vehicle costs were taken from the 2008 ATRI study. It is not clear from the report how the new vehicle costs were incorporated into the per mile operating costs calculations. For example, in both the ATRI report and the CSI report, assumptions about depreciation, useful life, and the opportunity cost of capital are not explicitly discussed.

Based on these two scenarios, CSI found a rebound effect of 11-31% for Scenario 1 and 5-16% for Scenario 2 when the fuel savings from rail were not taken into account ("First rebound effect"). When the fuel savings from reduced rail usage were included in the calculations, the overall rebound effect was between 9-13% for Scenario 1 and 3-15% for Scenario 2 ("Second Rebound Effect"). See Table 9-1.

CSI included a number of caveats associated with these calculations. Namely, the elasticity estimates derived from the literature are "heavily reliant on factors including the type of demand measures analyzed (vehicle-miles of travel, ton-miles, or tons), geography, trip lengths, markets served, and commodities transported." Furthermore, the CSI example only focused on Class 8 trucks and did not attempt to quantify the potential rebound effect for any other truck classes. Finally, these scenarios were characterized as "sketches" and were not included in the final NAS report. In fact, the NAS report asserted that it is "not possible to provide a confident measure of the rebound effect", yet concluded that a rebound effect likely exists and that "estimates of fuel savings from regulatory standards will be somewhat misestimated if the rebound effect is not considered."

Table 9-1 Range of Rebound Effect Estimates from Cambridge Systematics Aggregate Assessment

	Scenario 1 (6.8 mpg, $22,930)	Scenario 2 (9.1 mpg, $71,630)
"First Rebound Effect" (increase in truck VMT resulting from decrease in operating costs)	11-31%	5-16%

"Second Rebound Effect" (net fuel savings when decreases from rail are taken into account)	9-13 %	3-15%

As an alternative, using the econometric approach, NHTSA has estimated the rebound effect in the short-run and long run for single unit (Class 4-7) and combination (Class 8) trucks. As shown in Table 9-2, the estimates for the long-run rebound effect are larger than the estimates in the short run, which is consistent with the theory that shippers have more flexibility to change their behavior (e.g., restructure contracts or logistics) when they are given more time. In addition, the estimates derived from the national data also showed larger rebound effects compared to the state data.[a] One possible explanation for the difference in the estimates is that the national rebound estimates are capturing some of the impacts of changes in economic activity. Historically, large increases in fuel prices are highly correlated with economic downturns, and there may not be enough variation in the national data to differentiate the impact of fuel price changes from changes in economic activity. In contrast, some states may see an increase in output when energy prices increase (e.g., large oil producing states such as Texas and Alaska), therefore the state data may be more accurately isolating the individual impact of fuel price changes.

Table 9-2 Range of Rebound Effect Estimates from NHTSA Econometric Analysis

Truck Type	National Data		State Data	
	Short Run	Long Run	Short Run	Long Run
Single Unit	13-22%	28-45%	3-8%	12-21%
Combination	N/A	12-14%	N/A	4-5%

As discussed throughout this section, there are multiple methodologies for quantifying the rebound effect, and these different methodologies produce a large range of potential values of the rebound effect. However, for the purposes of quantifying the rebound effect for this rulemaking, we have used a rebound effect with respect to changes in fuel costs per mile on the lower range of the long-run estimates. Given the fact that the long-run state econometric estimates are generally more consistent with the aggregate estimates, for this proposal we have chosen a rebound effect for single unit trucks of 15% that is within the range of estimates from both methodologies. Similarly, we have chosen a rebound effect for combination tractors of 5%.

[a] NHTSA's estimates of the rebound effect are derived from econometric analysis of national and state VMT data reported in Federal Highway Administration, *Highway Statistics*, various editions, Tables VM-1 and VM-4. Specifically, the estimates of the rebound effect reported in Table 9-2 are ranges of the estimated short-run and long-run elasticities of annual VMT by single-unit and combination trucks with respect to fuel cost per mile driven. (Fuel cost per mile driven during each year is equal to average fuel price per gallon during that year divided by average fuel economy of the truck fleet during that same year.) These estimates are derived from time-series regression of annual national aggregate VMT for the period 1970-2008 on measures of nationwide economic activity , including aggregate GDP, the value of durable and nondurable goods production, and the volume of U.S. exports and imports of goods, and variables affecting the price of trucking services (driver wage rates, truck purchase prices, and fuel costs), and from regression of VMT for each individual state over the period 1994-2008 on similar variables measured at the state level.

To date, no estimates of the medium-duty (2b and 3) rebound effect have been cited in the literature. Since medium-duty vehicles are used for very different purposes than heavy-duty vehicles, it does not necessarily seem appropriate to apply one of the heavy duty estimates to the 2b and 3 classes. Class 2b and 3 vehicles are more similar in use to large light-duty vehicles, so for the purposes of our analysis, we have chosen to apply the light duty rebound effect of 10% to this class of vehicles.

9.2.4 Application of the Rebound Effect to VMT Estimates

It should be noted that the NHTSA econometric analysis attempts to isolate the rebound effect with respect to changes in the fuel cost per mile driven. As described previously, the rebound effect should be a measure of the change in VMT with respect to the change in overall operating costs. Therefore, NHTSA's rebound estimates with respect to fuel costs per mile must be "scaled" to apply to total operating costs. For example, we assumed the elasticity of class 8 truck use with respect to fuel cost per mile driven is -0.05 (which corresponds to a 5% fuel economy rebound effect), and fuel costs are on average 45% of total truck operating costs, therefore the elasticity of truck use with respect to total operating costs is -0.05/0.43 = -0.116. This calculation would correspond to an "overall" rebound effect value of -11.6%. In other words, cutting fuel costs per mile by 10% would correspond to only a 4.3% decline in total truck operating costs, so the elasticity of truck use with respect to total operating costs would have to be 2.3 times (100%/43%) larger than the elasticity of truck use with respect to fuel cost alone, in order to produce the same response in truck VMT (4%* -0.116 = 10%*-0.05). We conducted similar calculations for 2b/3 trucks assuming fuel costs are on average 25% of total operating costs, and for vocational trucks assuming fuel costs are on average 21% of total operating costs. Furthermore, we assumed an "average" incremental technology cost of $9,500 for class 8 combination tractor, $2,000 for class 2b and 3 trucks, and $300 for vocational trucks.[b]

For the purposes of this proposal, we made several additional simplifying assumptions when applying the overall rebound effect to each class of truck. For example, we assumed that per mile vehicle costs were based on the new vehicle cost (e.g., $100,000 for the reference case Class 8 combination tractor) divided by the total lifetime number of expected vehicle miles (e.g., 1.26 million miles for a Class 8 combination tractor, 288,000 miles for 2b/3 trucks, and 334,000 miles for vocational trucks). We recognize that this calculation implicitly assumes that truck depreciation is strictly a function of usage and does not take into account the opportunity cost of alternative uses of capital. As a result, the new vehicle cost per mile assumptions used in these calculations are a smaller percentage of total operating costs compared to the ATRI and CSI examples. We expect to refine this assumption between the proposal and final rulemakings, and invite submission of data on how truck owners and operators incorporate new vehicle costs into their operating cost per mile calculations.

In the costs and benefits summarized in Chapter 9.5, we have not taken into account any potential fuel savings or GHG emission reductions from the rail, air or water-borne shipping

[b] These cost estimates include indirect costs. Due to timing constraints, preliminary estimates were used to calculate the rebound effect, which differ slightly from the costs presented in Chapter 7. For the final rulemaking, we plan to use more consistent cost assumptions in our analyses.

sectors due to mode shifting. However, we have provided CSI's example calculations in Table 9-1 and request comment on these values. In addition, the rebound effect values used in the cost and benefit analysis fall within the range of the "second rebound effect", which does account for savings from reduced rail.

In addition, we have not attempted to capture how current market failures might impact the rebound effect. The direction and magnitude of the rebound effect in the medium- and heavy-duty truck market are expected to vary depending on the existence and types of market failures affecting the fuel economy of the trucking fleet. If firms are already accurately accounting for the costs and benefits of these technologies and fuel savings, then these regulations would increase their net costs, because trucks would already include all the cost-effective technologies. As a result, the rebound effect would actually be negative and truck VMT would decrease as a result of these proposed regulations. However, if firms are not optimizing their behavior today due to factors such as lack of reliable information (see Preamble Section VIII.A. for further discussion), it is more likely that truck VMT would increase. If firms recognize their lower net costs as a result of these regulations and pass those costs along to their customers, then the rebound effect would increase truck VMT. This response assumes that trucking rates include both truck purchase costs and fuel costs, and that the truck purchase costs included in the rates spread those costs over the full expected lifetime of the trucks. If those costs are spread over a shorter period, as the expected short payback period implies, then those purchase costs will inhibit reduction of freight rates, and the rebound effect will be smaller.

As discussed in more detail in Preamble Section VIII.A, if there are market failures such as split incentives, estimating the rebound effect may depend on the nature of the failures. For example, if the original purchaser cannot fully recoup the higher upfront costs through fuel savings before selling the vehicle nor pass those costs onto the resale buyer, the firm would be expected to raise shipping rates. A firm purchasing the truck second-hand might lower shipping rates if the firm recognizes the cost savings after operating the vehicle, leading to an increase in VMT. Similarly, if there are split incentives and the vehicle buyer isn't the same entity that purchases the fuel, than there would theoretically be a positive rebound effect. In this scenario, fuel savings would lower the net costs to the fuel purchaser, which would result in a larger increase in truck VMT.

If all of these scenarios occur in the marketplace, the net effect will depend on the extent and magnitude of their relative effects, which are also likely to vary across truck classes (for instance, split incentives may be a much larger problem for class 7 and 8 combination tractor than they are for heavy duty pickup trucks).

9.3 Other Economic Impacts

9.3.1 Noise, Congestion, and Accidents

Section 9.2 discusses the likely sign of the rebound effect. If net operating costs of the vehicle decline, then we expect a positive rebound effect. Increased vehicle use associated with a positive rebound effect also contributes to increased traffic congestion, motor vehicle accidents, and highway noise. Depending on how the additional travel is distributed over the day and on where it takes place, additional vehicle use can contribute to traffic congestion and delays by increasing traffic volumes on facilities that are already heavily traveled during peak periods. These added delays impose higher costs on drivers and other vehicle occupants in the form of increased travel time and operating expenses. Because drivers do not take these added costs into account in deciding when and where to travel, they must be accounted for separately as a cost of the added driving associated with the rebound effect.

Increased vehicle use due to a positive rebound effect may also increase the costs associated with traffic accidents. Drivers may take account of the potential costs they (and their passengers) face from the possibility of being involved in an accident when they decide to make additional trips. However, they probably do not consider all of the potential costs they impose on occupants of other vehicles and on pedestrians when accidents occur, so any increase in these "external" accident costs must be considered as another cost of additional rebound-effect driving. Like increased delay costs, any increase in these external accident costs caused by added driving is likely to depend on the traffic conditions under which it takes place, since accidents are more frequent in heavier traffic (although their severity may be reduced by the slower speeds at which heavier traffic typically moves).

Finally, added vehicle use associated with a positive rebound effect may also increase traffic noise. Noise generated by vehicles causes inconvenience, irritation, and potentially even discomfort to occupants of other vehicles, to pedestrians and other bystanders, and to residents or occupants of surrounding property. Because these effects are unlikely to be taken into account by the drivers whose vehicles contribute to traffic noise, they represent additional externalities associated with motor vehicle use. Although there is considerable uncertainty in measuring their value, any increase in the economic costs of traffic noise resulting from added vehicle use must be included together with other increased external costs from the rebound effect.

EPA and NHTSA rely on estimates of congestion, accident, and noise costs caused by pickup trucks and vans, single unit trucks, buses, and combination trucks developed by the Federal Highway Administration to estimate the increased external costs caused by added driving due to the rebound effect.[13] The FHWA estimates are intended to measure the increases in costs from added congestion, property damages and injuries in traffic accidents, and noise levels caused by automobiles and light trucks that are borne by persons other than their drivers (or "marginal" external costs). EPA and NHTSA employed estimates from this source previously in the analysis accompanying the Light Duty GHG final rule. The agencies continue to find them appropriate for this analysis after reviewing the procedures used by FHWA to develop them and considering other available estimates of these values.

FHWA's congestion estimates for trucks already consider that trucks account for a lower percent of peak period traffic on congested freeways because they try to avoid peak periods when possible. The FHWA congestion costs are a weighted average based on the estimated percent of peak and off-peak freeway travel for each of the classes of trucks. FHWA focused congestion costs on freeways because non-freeway effects are less serious because of lower traffic volumes and opportunities to re-route around the congestion. The agencies, however, applied the congestion cost to the overall VMT increase, though the fraction of VMT on each road type used in MOVES range from 27 to 29 percent of the vehicle miles on freeways for vocational trucks and 53 percent for combination trucks. The results of this analysis potentially overestimate the costs and provide a conservative estimate.

EPA and NHTSA aggregated the vocational truck segment costs by weighting of 15 percent of the bus cost and 85 percent of the single unit costs to reflect the vehicle make-up of this segment. The low, mid, and high cost estimates from FHWA updated to 2008 dollars are included in Table 9-3.

Table 9-3: Low-Mid-High Cost Estimates ($/mile)

Noise			
	High	**Middle**	**Low**
Pickup Truck, Van	$0.002	$0.001	$0.000
Vocational Truck	$0.024	$0.009	$0.003
Combination Truck	$0.052	$0.020	$0.006
Accidents			
	High	**Middle**	**Low**
Pickup Truck, Van	$0.082	$0.026	$0.014
Vocational Truck	$0.058	$0.019	$0.010
Combination Truck	$0.069	$0.022	$0.010
Congestion			
	High	**Middle**	**Low**
Pickup Truck, Van	$0.144	$0.049	$0.013
Vocational Truck	$0.324	$0.110	$0.029
Combination Truck	$0.316	$0.107	$0.028

The agencies are proposing to use FHWA's "Middle" estimates for marginal congestion, accident, and noise costs caused by increased travel from trucks.[14] This approach is consistent with the current methodology used in the Light Duty GHG rulemaking analysis. These costs are multiplied by the annual increases in vehicle miles travelled from the rebound effect to yield the estimated increases in congestion, accident, and noise externality costs during each future year.

EPA and NHTSA use the aggregate per mile costs, as shown in Table 9-4. Table 9-5 presents total monetized estimates of external costs associated with noise, accidents, and congestion.

Table 9-4 $/mile Inputs used for External Costs (2008$)

COMBINED COSTS	
Pickup Truck, Van	$0.076
Vocational Truck	$0.138
Combination Truck	$0.149

Table 9-5: Annual External Costs Associated with the Heavy Duty Vehicle Program (Millions of 2008 dollars)

YEAR	Class 2b&3	Vocational	Combination	ACCIDENTS, NOISE, CONGESTION
2012	$0	$0	$0	$0
2013	$0	$0	$0	$0
2014	$8	$10	$18	$36
2015	$16	$19	$35	$70
2016	$23	$30	$52	$104
2017	$30	$39	$68	$137
2018	$37	$48	$83	$168
2019	$44	$56	$98	$198
2020	$50	$64	$111	$225
2021	$55	$71	$123	$249
2022	$60	$78	$133	$271
2023	$65	$84	$143	$292
2024	$70	$90	$153	$312
2025	$74	$96	$161	$331
2026	$77	$101	$169	$348
2027	$81	$107	$176	$364
2028	$84	$112	$182	$378
2029	$86	$117	$188	$391
2030	$89	$122	$193	$404
2031	$91	$128	$198	$417
2032	$94	$134	$202	$430
2033	$96	$141	$206	$443
2034	$98	$147	$210	$455
2035	$101	$153	$214	$467
2036	$103	$159	$218	$480
2037	$105	$164	$222	$491
2038	$107	$170	$226	$503
2039	$109	$176	$230	$515
2040	$112	$182	$233	$527
2041	$114	$188	$237	$539
2042	$116	$194	$241	$551
2043	$118	$200	$245	$562
2044	$120	$206	$248	$575
2045	$122	$212	$252	$586
2046	$124	$219	$256	$598
2047	$126	$225	$259	$610
2048	$128	$231	$263	$623
2049	$131	$238	$267	$635
2050	$133	$245	$271	$648
NPV, 3%	$1,606	$2,407	$3,439	$7,452
NPV, 7%	$746	$1,070	$1,614	$3,429

9.3.2 Less Frequent Refueling due to Improved Fuel Consumption

Reducing the fuel consumption of heavy duty trucks may either increase their driving range before they require refueling, or motivate truck manufacturers to offer, and truck purchasers to buy, smaller fuel tanks. Keeping the fuel tank the same size allows truck operators to reduce the frequency with which drivers typically refuel their vehicles; it thus extends the upper limit of the range they can travel before requiring refueling. Alternatively, if truck purchasers and manufacturers respond to improved fuel economy by reducing the size of fuel tanks, the smaller tank will require less time in actual refueling.

Because refueling time represents a time cost of truck operation, these time savings should be incorporated into truck purchasers' decisions over how much fuel-saving technology they want in their vehicles. The savings calculated here thus raise the same questions discussed in Preamble VIII.A and DRIA Section 9.1: does the apparent existence of these savings reflect failures in the market for fuel economy, or does it reflect costs not addressed in this analysis? The response to these questions could vary across truck segment. See those sections for further analysis of this question.

No direct estimates of the value of extended vehicle range or reduced fuel tank size are readily available. Instead, this analysis calculates the reduction in the annual time spent filling the fuel tank; this reduced time could come either from fewer refueling events, if the fuel tank stays the same size, or less time spent refueling, if the fuel tank is made proportionately smaller. The fuel savings are calculated as the time not spent putting fuel into the vehicle, based on the amount of time that would have been necessary to pump the fuel. The calculation does not include time spent searching for a fuel station or other time spent at the station; it is assumed that the time savings occur only when truck operators would otherwise be refueling, and it incorporates additional driving due to the rebound effect. EPA and NHTSA request comment on whether reduced refueling time will result from greater fuel efficiency and how it may vary by truck segment.

The calculation applies DOT-recommended values of travel time savings to convert the resulting time savings to their economic value. The DOT-recommended value of travel time per vehicle-hour for truck drivers is \$22.15 in 2008\$ (converted from \$18.10 in 2000\$).[15] The inputs used in the analysis are included Table 9-3.

Table 9-3: Inputs to Calculate Refueling Time Savings

	HD PICKUP TRUCK AND VAN	VOCATIONAL TRUCK	TRACTOR
Fuel Economy Baseline (mpg)	15.3	9.7	5.0
Fuel Economy Scenario (mpg)	17.4	10.5	5.6

Fuel Dispensing Rate (gallon/minute)[16]	10	10	20

The savings per vehicle through its lifetime are listed in Table 9-4.

Table 9-4: Aggregate Refueling Savings (2008$)

	PICKUP TRUCKS AND VANS	VOCATIONAL TRUCKS	TRACTORS
3% Discount Rate	$64	$220	$294
7% Discount Rate	$50	$176	$235

The aggregate savings of the vehicles sold in 2014 through 2050 are listed in Table 9-5.

Table 9-5 Estimated Refueling Savings due to the Proposed Standards (dollar values in Millions of 2008 dollars)

	Class 2b&3		Vocational		Combination		
Year	# of refills avoided	Savings	# of refills avoided	Savings	# of refills avoided	Savings	Total Savings
2012	0	$0.0	0	$0.0	0	$0.0	$0.0
2013	0	$0.0	0	$0.0	0	$0.0	$0.0
2014	301,003	$0.3	1,583,798	$1.8	1,756,743	$4.9	$6.9
2015	757,125	$0.6	3,096,205	$3.4	3,462,356	$9.6	$13.6
2016	1,931,986	$1.6	4,717,981	$5.2	5,102,279	$14.1	$21.0
2017	3,823,122	$3.2	7,705,952	$8.5	7,435,028	$20.6	$32.3
2018	7,212,535	$6.0	10,525,339	$11.7	9,691,806	$26.8	$44.5
2020	13,614,967	$11.3	15,657,235	$17.3	13,862,079	$38.4	$67.0
2030	36,499,842	$30.3	33,746,377	$37.4	26,202,604	$72.5	$140.2
2040	49,399,292	$41.0	51,815,351	$57.4	32,036,289	$88.7	$187.1
2050	59,561,334	$49.5	69,941,600	$77.5	37,222,096	$103.1	$230.0
NPV, 3%		$521		$728		$1,267	$2,516
NPV, 7%		$225		$315		$584	$1,123

9.4 The Effect of Safety Standards and Voluntary Safety Improvements on Vehicle Weight

Safety regulations developed by NHTSA in previous regulations may make compliance with the proposed standards more difficult or may reduce the projected benefits of the program. The primary way that safety regulations can impact fuel efficiency and GHG emissions is through increased vehicle weight, which reduces the fuel efficiency of the vehicle. Using MY 2010 as a baseline, this section discusses the effects of other government regulations on model year (MY) 2014-2016 medium and heavy duty vehicle fuel efficiency. At this time, no known safety standards will affect new models in MY 2017 or 2018. The agency's estimates are based on cost and weight tear-down studies of a few vehicles and cannot possibly cover all the variations in the manufacturers' fleets. National Highway Traffic Safety Administration (NHTSA) requested, and various manufacturers provided, confidential estimates of increases in weight resulting from safety improvements. Those increases are shown in subsequent tables.

We have broken down our analysis of the impact of safety standards that might affect the MY 2014-16 fleets into three parts: 1) those NHTSA final rules with known effective dates, 2) proposed rules or soon to be proposed rules by NHTSA with or without final effective dates, and 3) currently voluntary safety improvements planned by the manufacturers.

9.4.1 Weight Impacts of Required Safety Standards

NHTSA has undertaken several rulemakings in which several standards would become effective for medium and heavy duty (MD/HD) vehicles between MY 2014 and MY 2016. We will examine the potential impact on MD/HD vehicle weights for MY 2014-2016 using MY 2010 as a baseline.

1. FMVSS 119, Heavy Truck Tires Endurance and High Speed Tests
2. FMVSS 121, Air Brake Systems Stopping Distance
3. FMVSS 214, Motor Coach Lap/Shoulder Belts
4. MD/HD Vehicle Electronic Stability Control Systems

9.4.1.1 FMVSS 119, Heavy Truck Tires Endurance and High Speed Tests

The data in the large truck crash causation study (LTCCS) and the agency's test results indicate that J and L load range tires are more likely to fail the proposed requirements among the targeted F, G, H, J and L load range tires.[c] As such the J and L load range tires specifically need to be addressed to meet the proposed requirements since the other load range tires are likely to pass the requirements. Rubber material improvements such as improving rubber compounds would be a countermeasure that reduces heat retention and improve the durability of the tires. Using high tensile strength steel chords in tire bead, carcass and belt would enable a weight reduction in construction with no strength penalties. The rubber material improvements and using high tensile strength steel would not add any additional weight to the current production heavy truck tires. Thus there may not be an incremental weight per vehicle for the period of MY 2014-2016 compared to the MY 2010 baseline. This proposal could become a final rule with an effective date of MY2016.

9.4.1.2 FMVSS No. 121, Airbrake Systems Stopping Distance

The most recent major final rule was published on July 27, 2009 and became effective on November 24, 2009 (MY2009) with different compliance dates. The final rule requires the vast majority of new heavy truck tractors (approximately 99 percent of the fleet) to achieve a 30 percent reduction in stopping distance compared to currently required levels. Three-axel tractors with a gross vehicle weight rating (GVWR) of 59,600 pounds or less must meet the reduced

[c] "Preliminary Regulatory Impact Analysis, FMVSS No. 119, New Pneumatic Tires for Motor Vehicles with a GVWR of More Than 4,536 kg (10,000 pounds), June 2010.

stopping distance requirements by August 1, 2011 (MY2011). Two-axle tractors and tractors with a GVWR above 59,600 pounds must meet the reduced stopping distance requirements by August 1, 2013 (MY2013). There are several brake systems that can meet the requirements in the final rule. Those systems include installation of larger S-cam drum brakes or disc brake systems at all positions, or hybrid disc and larger rear S-cam drum brake systems.

According to the data provided by a manufacturer (Bendix), the heaviest drum brakes weigh more than the lightest disc brakes while the heaviest disc brakes weigh more than the lightest drum brakes. For a three-axle tractor equipped with all disc brakes, the total weight could increase by 212 pounds or could decrease by 134 pounds compared to an all drum braked tractor depending on which disc or drum brakes are used for comparison. The improved brakes may add a small amount of weight to the affected vehicle for MY2014-2016 resulting in a slight increase in fuel consumption.

9.4.1.3 FMVSS No. 208, Motor coach Lap/Shoulder Belts

Based on preliminary results from the agency's cost/weight teardown studies of motor coach seats, [d] it is estimated that the weight added by 3-point lap/shoulder belts ranges from 5.96 to 9.95 pounds per 2-person seat. This is the weight only of the seat belt assembly itself and does not include changing the design of the seat, reinforcing the floor, walls or other areas of the motor coach. Few current production motor coaches have been installed with lap/shoulder belts on their seats, and the number could be negligible. Assuming a 54 passenger motor coach, the added weight for the 3-point lap/shoulder belt assembly is in the range of 161 to 269 pounds (27 * (5.96 to 9.95)) per vehicle. This proposal could become a final rule with an effective date of MY2016.

9.4.2 Electronic Stability Control Systems (ESC) for Medium and Heavy Duty (MD/HD) Vehicles

The ESC is not currently required in MD/HD vehicles and could be proposed to be required in the vehicles by NHTSA. FMVSS No. 105, Hydraulic and electric brake systems, requires multipurpose passenger vehicles, trucks and buses with a GVWR greater than 4,536 kg (10,000 pounds) to be equipped with an antilock brake system (ABS). All MD/HD vehicles have a GVWR of more than 10,000 pounds, and these vehicles are required to be installed with an ABS by the same standard.

The ESC incorporates yaw rate control into the ABS, and yaw is a rotation around the vertical axis. The ESC system uses several sensors in addition to the sensors used in the ABS, which is required in MD/HD vehicles. Those additional sensors could include steering wheel angle sensor, yaw rate sensor, lateral acceleration sensor and wheel speed sensor. According to the data provided by Meritor WABCO, the weight of the ESC for the model 4S4M tractor is estimated to be around 55.494 pounds, and the weight of the ABS only is estimated to be 45.54

[d] Cost and Weight Analysis of Two Motorcoach Seating Systems: One With and One Without Three-Point Lap/Shoulder Belt Restraints, Ludkes and Associates, July 2010.

pounds. Then the added weight for the ESC for the vehicle is estimated to be 9.954 (55.494 – 45.54) pounds.

9.4.3 Summary – Overview of Anticipated Weight Increases

Table Table 9-6 summarizes estimates made by the agency regarding the weight added by the above discussed standards or likely rulemakings. The agency estimates that weight additions required by final rules and likely NHTSA regulations effective in MY 2016 compared to the MY 2010 fleet will increase motorcoach vehicle weight by 171-279 pounds and will increase other heavy duty truck weights by a minor 10 pounds.

Table 9-6 Weight Additions Due to Final Rules or Likely NHTSA Regulations: Comparing MY 2016 to the MY 2010 Baseline Fleet

Standard Number	Added Weight in pounds MD/HD Vehicle	Added Weight in kilograms MD/HD Vehicle
119	0	0
121	0 (?)	0 (?)
208 Motorcoaches only	161-269	73-122
MD/HD Vehicle Electronic Stability Control Systems	10	4.5
Total Motorcoaches	171- 279	77.5-126.5
Total All other MD/HD vehicles	10	4.5

9.4.4 Effects of Vehicle Mass Reduction on Safety

NHTSA and EPA have been considering the effect of vehicle weight on vehicle safety for the past several years in the context of our joint rulemaking for light duty vehicle CAFE and GHG standards, consistent with NHTSA's long-standing consideration of safety effects in setting CAFE standards. Combining all modes of impact, the latest analysis by NHTSA for the MYs 2012-2016 final rule[e] found that reducing the weight of the heavier light trucks (LT > 3,870) had a positive overall effect on safety, reducing societal fatalities.

In the context of the current rulemaking for HD fuel consumption and GHG standards, one would expect that reducing the weight of medium-duty trucks similarly would, if anything, have a positive impact on safety. However, given the large difference in weight between light-duty vehicles and medium-duty trucks, and even larger difference between light-duty vehicles

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[e] "Final Regulatory Impact Analysis, Corporate Average Fuel Economy for MY 2012 - MY 2016 Passenger Cars and Light Trucks", NHTSA, March 2010, (Docket No. NHTSA-2009-0059-0344.1).

and heavy-duty vehicles with loads, the agencies believe that the impact of weight reductions of medium- and heavy-duty trucks would not have a noticeable impact on safety for any of these classes of vehicles.

However, the agencies recognize that it is important to conduct further study and research into the interaction of mass, size and safety to assist future rulemakings, and we expect that the collaborative interagency work currently on-going to address this issue for the light-duty vehicle context may also be able to inform our evaluation of safety effects for the final HD vehicle rule. We seek comment regarding potential safety effects due to weight reduction in the HD vehicle context, with particular emphasis on commenters providing supporting data and research for HD vehicle weight reduction.

9.5 Petroleum and energy security impacts

9.5.1 Impact on U.S. petroleum imports

In 2008, U.S. petroleum import expenditures represented 21 percent of total U.S. imports of all goods and services.[17] In 2008, the United States imported 66 percent of the petroleum it consumed, and the transportation sector accounted for 70 percent of total U.S. petroleum consumption. This compares roughly to 37 percent of petroleum from imports and 55 percent consumption of petroleum in the transportation sector in 1975.[18] It is clear that petroleum imports have a significant impact on the U.S. economy. Requiring lower GHG-emitting heavy duty vehicles and improved fuel economy in the U.S. is expected to lower U.S. petroleum imports.

9.5.2 Background on U.S. energy security

U.S. energy security is broadly defined as protecting the U.S. economy against circumstances that result in significant short- and long-term increases in energy costs. Most discussion of U.S. energy security revolves around the topic of the economic costs of U.S. dependence on oil imports. The U.S.'s energy security problem is that the U.S. relies on imported oil from potentially unstable sources. In addition, oil exporters have the ability to raise the price of oil by exerting monopoly power through the formation of a cartel, the Organization of Petroleum Exporting Countries (OPEC). Finally, these factors contribute to the vulnerability of the U.S. economy to episodic oil supply shocks and price spikes. In 2008, U.S. net expenditures for imports of crude oil and petroleum products were $336 billion (in 2008$, see Figure 9-3).

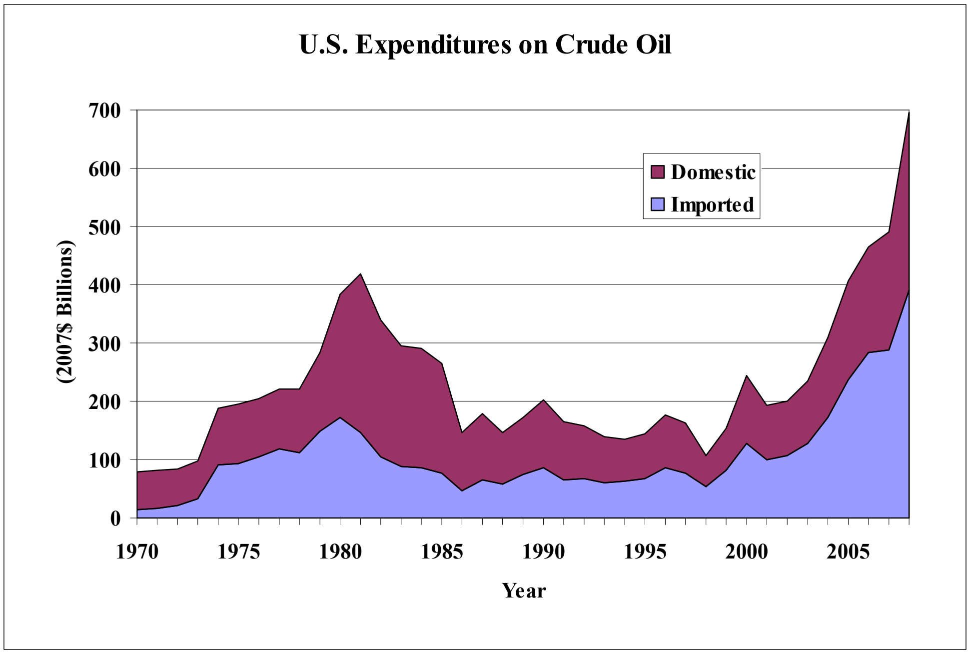

Figure 9-3: U.S. Expenditures on Crude Oil from 1970 through 2008[f]

One effect of the EPA/NHTSA joint heavy duty vehicle rule is that it promotes more efficient use of transportation fuels in the U.S. The result is that it reduces U.S. oil imports, which reduces both financial and strategic risks associated with a potential disruption in supply or a spike in the cost of a particular energy source. This reduction in risks is a measure of improved U.S. energy security. For this rule, an "oil premium" approach is utilized to identify those energy security related impacts which are not reflected in the market price of oil, and which are expected to change in response to an incremental change in the level of U.S. oil imports.

9.5.2.1 Methodology used to estimate U.S. energy security benefits

In order to understand the energy security implications of reducing U.S. oil imports, EPA has worked with Oak Ridge National Laboratory (ORNL), which has developed approaches for evaluating the social costs and energy security implications of oil use. The energy security estimates provided below are based upon a methodology developed in a peer-reviewed study entitled, "*The Energy Security Benefits of Reduced Oil Use, 2006-2015*," completed in March 2008. This recent study is included as part of the docket for this rulemaking.[19] This ORNL study is an update version of the approach used for estimating the energy security benefits of U.S. oil import reductions developed in an ORNL 1997 Report by Leiby, Paul N., Donald W.

[f] For historical data through 2006: EIA Annual Energy Review, various editions.
For data 2006-2008: EIA Annual Energy Outlook (AEO) 2009 (Update Reference (Stimulus) Base Case).
See file "aeostimtab_11.xls" available at http://www.eia.doe.gov/oiaf/servicerpt/stimulus/aeostim.html

Jones, T. Randall Curlee, and Russell Lee, entitled "*Oil Imports: An Assessment of Benefits and Costs.*" [20]

When conducting this recent analysis, ORNL considered the full cost of importing petroleum into the U.S. The full economic cost is defined to include two components in addition to the purchase price of petroleum itself. These are: (1) the higher costs for oil imports resulting from the effect of U.S. import demand on the world oil price and on OPEC market power (*i.e.*, the "demand" or "monopsony" costs); and (2) the risk of reductions in U.S. economic output and disruption to the U.S. economy caused by sudden disruptions in the supply of imported oil to the U.S. (*i.e.*, macroeconomic disruption/adjustment costs). Maintaining a U.S. military presence to help secure stable oil supply from potentially vulnerable regions of the world was not included in this analysis because its attribution to particular missions or activities is difficult (as discussed further below).

The literature on the energy security for the last two decades has routinely combined the monopsony and the macroeconomic disruption components when calculating the total value of the energy security premium. However, in the context of using a global value for the Social Cost of Carbon (SCC), the question arises: how should the energy security premium be determined when a global perspective is taken? Monopsony benefits represent avoided payments by the U.S. to oil producers in foreign countries that result from a decrease in the world oil price as the U.S. decreases its consumption of imported oil. Although there is clearly a benefit to the U.S. when considered from a domestic perspective, the decrease in price due to decreased demand in the U.S. also represents a loss to other countries. Given the redistributive nature of this monopsony effect from a global perspective, it is excluded in the energy security benefits calculations for this rule. In contrast, the other portion of the energy security premium, the U.S. macroeconomic disruption and adjustment costs that arise from U.S. petroleum imports, does not have offsetting impacts outside of the U.S., and, thus, are included in the energy security benefits estimated for this rule. Section 8.I of the preamble contains more discussion of how the monopsony and macroeconomic disruption/adjustment components are treated for this analysis.[g]

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[g] However, even when the global value for greenhouse gas reduction benefits is used, an argument can be made that the monopsony benefits should be included in net benefits calculation for this rule. Maintaining the earth's climate is a global public good and as such requires that a global cooperative perspective be taken on the benefits of GHG mitigation by all nations, including the U.S. Given that a cooperative global approach is required to address the climate change issue, each country (and market participant) should face the global SCC. In other words, using the global SCC does not transform the calculation from a domestic (i.e., U.S.) to a global one. Energy security, on the other hand, is broadly defined as protecting the U.S. economy against circumstances that threaten significant short- and long-term increases in energy costs. Energy security is inherently a domestic benefit. However, the use of the domestic monopsony benefit is not necessarily in conflict with the use of the global SCC, because the global SCC represents the benefits against which the costs associated with our (i.e., the U.S.'s) domestic mitigation efforts should be judged. In addition, the U.S. values both maintaining the earth's climate and providing for its own energy security. If this reasoning holds, the two benefits—the global benefits of reducing greenhouse gas emissions and the full energy security premium, including the monopsony benefits—should be counted in the net benefits estimates of the rule. In the final analysis, the Agency determined that the first argument, that the monopsony benefits "net out" from a global perspective, is more appropriate and therefore is using only the macroeconomic adjustment/disruption component of the energy security benefit for this rule.

As part of the process for developing the ORNL energy security estimates, EPA sponsored an independent, expert peer review of the 2008 ORNL study. A report compiling the peer reviewers' comments is provided in the docket.[21] In addition, EPA has worked with ORNL to address comments raised in the peer review and to develop estimates of the energy security benefits associated with a reduction in U.S. oil imports for this heavy duty vehicle rule. In response to peer reviewer comments, ORNL modified its model by changing several key parameters involving OPEC supply behavior, the responsiveness of oil demand and supply to a change in the world oil price, and the responsiveness of U.S. economic output to a change in the world oil price.

For this rule, ORNL further updated the energy security premium by incorporating the most recent oil price forecast and energy market trends in AEO 2010 into its model. In order for the energy security premium to be used in EPA's MOVES model, ORNL developed energy security premium estimates for a number of different years; *i.e.*, 2020, 2030, and 2040.

For 2020, ORNL has estimated that the total energy security premium associated with a reduction of imported oil is \$19.66/barrel. On a dollar per gallon basis, energy security benefits for 2020 are \$0.47/gallon. Table 9-6 provides estimates for energy security premium for the years 2020, 2030 and 2040,[h] as well as a breakdown of the components of the energy security premium for each year. The components of the energy security premium and their values are discussed below.

Table 9-6 Energy Security Premium in 2020, 2030 and 2040 (2008$/Barrel)

YEAR	MONOPSONY (RANGE)	MACROECONOMIC DISRUPTION/ADJUSTMENT COSTS (RANGE)	TOTAL MID-POINT (RANGE)
2020	$12.28 ($4.16 - $23.74)	$7.39 ($3.39 – $11.92)	$19.66 ($10.27 - $30.90)
2030	$12.69 ($4.43 – 23.80)	$8.54 ($4.10 – $13.60)	$21.23 ($11.30 - $32.88)
2040	$12.68 ($4.41 – $23.41)	$8.99 ($4.48 – $14.08)	$21.67 ($11.54 - $31.10)

9.5.2.2 Effect of oil use on long-run oil price, U.S. import costs, and economic output

The first component of the full economic costs of importing petroleum into the U.S. follows from the effect of U.S. import demand on the world oil price over the long-run. Because the U.S. is a sufficiently large purchaser of foreign oil supplies, its purchases can affect the world oil price. This monopsony power means that increases in U.S. petroleum demand can cause the

[h] AEO 2010 forecasts energy market trends and values only to 2035. The energy security premia post-2035 are assumed to be the 2035 estimate.

world price of crude oil to rise, and conversely, that reduced U.S. petroleum demand can reduce the world price of crude oil. Thus, one benefit of decreasing U.S. oil purchases, due to the increased availability and use of other transportation fuels, is the potential decrease in the crude oil price paid for all crude oil purchased.

The demand or monopsony effect can be readily illustrated with an example. If the U.S. imports 10 million barrels per day at a world oil price of $50 per barrel, its total daily bill for oil imports is $500 million. If a decrease in U.S. imports to 9 million barrels per day causes the world oil price to drop to $49 per barrel, the daily U.S. oil import bill drops to $441 million (9 million barrels times $49 per barrel). While the world oil price only declines $1, the resulting decrease in oil purchase payments of $59 million per day ($500 million minus $441 million) is equivalent to an incremental benefit of $59 per barrel of oil imports reduced, or $10 more than the newly-decreased world price of $49 per barrel. This additional $10 per barrel "import cost premium" represents the incremental external benefits to the U.S. for avoided import costs beyond the price paid oil purchases. This additional benefit arises only to the extent that reduction in U.S. oil imports affects the world oil price. ORNL estimates this component of the energy security benefit in 2020 to be $12.28/barrel, with a range of $4.16/barrel to $23.74/barrel of imported oil reduced.

It is important to note that the decrease in global petroleum prices resulting from the proposed rule could spur increased consumption of petroleum in other sectors and countries, leading to a small uptick in GHG emissions outside of the United States. This global fuel consumption increase could offset some portion of the GHG reduction benefits associated with the rule. EPA has not quantified this increase in global GHG emissions in the draft RIA and requests comment on whether to do so for the final RIA.

9.5.2.3 Short-run disruption premium from expected costs of sudden supply disruptions

The second component of the oil import premium, "macroeconomic disruption/adjustment costs," arises from the effect of oil imports on the expected cost of disruptions. A sudden increase in oil prices triggered by a disruption in world oil supplies has two main effects: (1) it increases the costs of oil imports in the short run and (2) it can lead to macroeconomic contraction, dislocation and Gross Domestic Product (GDP) losses. ORNL estimates the composite estimate of these two factors that comprise the macroeconomic disruption/adjustment costs premium to be $7.39/barrel in 2020, with a range of $3.39/barrel to $11.92/barrel of imported oil reduced.

9.5.2.3.1 Macroeconomic disruption adjustment costs

There are two main effects of macroeconomic disruption/adjustment costs. The first is the short-run price increases with an oil shock. The oil price shock results in a combination of real resource shortages, costly short-run shifts in energy supply, behavioral and demand adjustments by energy users, and other response costs. Unlike pure transfers, the root cause of the disruption price increase is a real resource supply reduction due, for example, to disaster or war. Regions where supplies are disrupted, such as the U.S., suffer very high costs. Businesses' and households' emergency responses to supply disruptions and rapid price increases consume real economic resources.

While households and businesses can reduce their petroleum consumption, invest in fuel switching technologies, or use futures markets to insulate themselves in advance against the potential costs of rapid increases in oil prices, when deciding how extensively to do so, they are unlikely to account for the effect of their petroleum consumption on the magnitude of costs that supply interruptions and accompanying price shocks impose on others. As a consequence, the U.S. economy as a whole will not make sufficient use of these mechanisms to insulate itself from the real costs of rapid increases in energy prices and outlays that usually accompany oil supply interruptions. Therefore, the ORNL estimate of macroeconomic disruption and adjustment costs that the EPA uses to value energy security benefits includes the increased oil import costs stemming from oil price shocks that are unanticipated and not internalized by advance actions of U.S. consumers.

The second main effect of macroeconomic disruption/adjustment costs is the macroeconomic losses during price shocks that reflect both aggregate output losses and "allocative" losses. The former are a reduction in the level of output that the U.S. economy can produce fully using its available resources; and the latter stem from temporary dislocation and underutilization of available resources due to the shock, such as labor unemployment and idle plant capacity. The aggregate output effect, a reduction in "potential" economic output, will last so long as the price is elevated. It depends on the extent and duration of any disruption in the world supply of oil, since these factors determine the magnitude of the resulting increase in prices for petroleum products, as well as whether and how rapidly these prices return to their pre-disruption levels.

In addition to the aggregate contraction, there are "allocative" or "adjustment" costs associated with dislocated energy markets. Because supply disruptions and resulting price increases occur suddenly, empirical evidence shows they also impose additional costs on businesses and households which must adjust their use of petroleum and other productive factors more rapidly than if the same price increase had occurred gradually. Dislocational effects include the unemployment of workers and other resources during the time needed for their intersectoral or interregional reallocation, and pauses in capital investment due to uncertainty. These adjustments temporarily reduce the level of economic output that can be achieved even below the "potential" output level that would ultimately be reached once the economy's adaptation to higher petroleum prices is complete. The additional costs imposed on businesses and households for making these adjustments reflect their limited ability to adjust prices, output levels, and their use of energy, labor and other inputs quickly and smoothly in response to rapid changes in prices for petroleum products.

Since future disruptions in foreign oil supplies are an uncertain prospect, each of the disruption cost components must be weighted by the probability that the supply of petroleum to the U.S. will actually be disrupted. Thus, the "expected value" of these costs – the product of the probability that a supply disruption will occur and the sum of costs from reduced economic output and the economy's abrupt adjustment to sharply higher petroleum prices – is the relevant measure of their magnitude. Further, when assessing the energy security value of a policy to reduce oil use, it is only the change in the expected costs of disruption that results from the policy that is relevant. The expected costs of disruption may change from lowering the normal (i.e., pre-disruption) level of domestic petroleum use and imports, from any induced alteration in the likelihood or size of disruption, or from altering the short-run flexibility (e.g., elasticity) of petroleum use.

In summary, the steps needed to calculate the disruption or security premium are: 1) determine the likelihood of an oil supply disruption in the future; 2) assess the likely impacts of a potential oil supply disruption on the world oil price; 3) assess the impact of the oil price shock on the U.S. economy (in terms of import costs and macroeconomic losses); and 4) determine how these costs change with oil imports. The value of price spike costs avoided by reducing oil imports becomes the oil security portion of the premium.

9.5.2.3.2 Cost of existing U.S. energy security policies

The last often-identified component of the full economic costs of U.S. oil imports are the costs to the U.S. taxpayers of existing U.S. energy security policies. The two primary examples are maintaining the Strategic Petroleum Reserve (SPR) and maintaining a military presence to help secure a stable oil supply from potentially vulnerable regions of the world. The SPR is the largest stockpile of government-owned emergency crude oil in the world. Established in the aftermath of the 1973-74 oil embargo, the SPR provides the U.S. with a response option should a disruption in commercial oil supplies threaten the U.S. economy. It also allows the U.S. to meet part of its International Energy Agency obligation to maintain emergency oil stocks, and it provides a national defense fuel reserve. While the costs for building and maintaining the SPR are more clearly related to U.S. oil use and imports, historically these costs have not varied in response to changes in U.S. oil import levels. Thus, while SPR is factored into the ORNL analysis, the cost of maintaining the SPR is excluded.

U.S. military costs are excluded from the analysis performed by ORNL because their attribution to particular missions or activities is difficult. Most military forces serve a broad range of security and foreign policy objectives. Attempts to attribute some share of U.S. military costs to oil imports are further challenged by the need to estimate how those costs might vary with incremental variations in U.S. oil imports.

9.5.2.4 Modifications to analysis based upon peer reviewer comments

As part of the peer review process, the EPA commissioned ORNL to conduct a number of sensitivity analyses to address the comments of the peer reviewers. Based upon the peer reviewer comments, key parameters that influence the "oil import" premium were assessed. Since not all the comments were in agreement with each other, several ranges of different parameters were developed for the analyses. These sensitivities used the most recent price forecasts and energy market trends available at the time the peer review was being conducted and completed, the AEO 2007 Reference Case. Thus, the results presented below are suggestive of how the energy security premium is influenced by alternative assumptions of key parameters that influence world oil markets but are not directly comparable to the oil security premiums used for the heavy duty vehicle rule. A summary of the results of the sensitivity analyses conducted for the peer review process are shown in Table 9-7.

Three key parameters were varied in order to assess their impacts on the oil import premium: (1) the response of OPEC supply, (2) the combined response of non-U.S., non-OPEC demand and supply and (3) the GDP response to a change in the world oil as a result of reduced U.S. oil imports. The cases used updated supply/demand elasticities for non-U.S./non-OPEC region after considering more recent estimates than those used in 1997 study. As a result, the total market responsiveness is greater than previous ORNL estimates. Only relatively small changes to the world oil price are anticipated from a substantial reduction in U.S. demand, on average, about $0.70/barrel for every million barrels per day reduction in demand. In the ORNL framework, OPEC-behavior is treated parametrically, with a wide range of possible responses represented by a range of supply elasticities. Case One in **Error! Reference source not found.**Table 9-7 below refers to the AEO 2007 estimates of energy market trends and uses the elasticity parameters from the original 1997 ORNL study. In Case Two, the OPEC supply elasticities range from 0.25 to 6.0 with a mean elasticity of 1.76. Case Three alters the distribution of the OPEC supply elasticities so that the mean elasticity is 2.2 instead of 1.76. With the more elastic OPEC oil supply in Case Three, the oil premium is lower. Alternatively, a candidate rule for OPEC strategic response behavior, adapted from a lead article on what behavior maximizes OPEC's long run net revenue in a robust way,[22] would have OPEC responding to preserve its worldwide oil market share. This is presented as Case Seven. Application of this rule instead of the range of OPEC supply responses used leads to an estimate of the oil import premium that is between Case Two and Case Three.

The second key parameter that was varied based upon peer reviewer comments was non-OPEC, non-U.S. demand and supply responsiveness to a change in the U.S. oil import demand and, hence, the world oil price. In Case Four, the mean non-U.S./non-OPEC demand and supply elasticities are taken to each be 0.3 in absolute value terms. When combined together, the net elasticity of import demand from the non-U.S./non-OPEC region is approximately 1.6. Case Five takes the Case Four assumptions of a more elastic OPEC supply behavior and combines those assumptions with the 1.6 net elasticity of import demand for the non-U.S./non-OPEC region. Case Six looks at the consequences of a yet higher net elasticity of import demand — 2.28 — for the non-U.S./non-OPEC region. The impact on the oil import premium is relatively modest.

Cases Eight and Nine consider a reduced GDP elasticity, the parameter which summarizes the sensitivity of GDP to oil price shocks. Several reviewers suggested a lower estimate for this parameter. In response to their comments, a couple of cases were examined where the GDP elasticity was lowered to 0.032 in comparison to the original ORNL estimate of 0.0495. As anticipated, this change lowered the oil import premium modestly. For example, compared with Case Four where OPEC supply is more elastic, lowering the GDP elasticity with respect to the world oil price reduced the oil import premium by roughly $0.40/barrel. This is because the GDP-dislocation component is only about one-quarter of the total premium, and there are offsetting changes in other components. The last case examined, Case Nine, looks at the consequences for the oil import premium with a reduced elasticity of GDP if OPEC attempts to maintain its share of the world oil market.

Clearly there is an unavoidable degree of uncertainty about the magnitude of marginal economic costs from the U.S. importation of petroleum, and the size of the oil import premium. ORNL sought to reflect this with probabilistic risk analysis over key input factors, guided by the available literature and the best judgment of oil market experts. Cases shown in Table 9-7 explore some reasonable variations in the ranges of input assumptions and the mean oil premium estimates vary in a fairly moderate range between roughly $11 and $15/barrel of imported oil. On balance, Case Eight suggested a reasonable and cautious assessment of the premium value to ORNL, and is ORNL's recommended case. This is based on a review of important driving factors, the numerical evaluations and simulations over major uncertainties, and taking into consideration the many comments and suggestion from the reviewers, the EPA and other Agencies. This recommended case, and the premium range resulting from 90 percent of the simulated outcomes, encompasses a wide array of perspectives and potential market outcomes in response to a reduction of U.S. imports.

As mentioned previously, this recommended case relied on the most recent available projections of the U.S. and world oil market for the next ten years based upon the AEO 2007 Reference Case. OPEC behavior was treated parametrically, with a wide range of possible responses represented by a wide range of supply elasticities, from small to quite large. This recommended case recognized that the OPEC response is the most uncertain single element of this analysis. It could vary between inelastic defense of output levels, or market share, or could be highly elastic in defense of price, probably at the expense of longer run cartel power and discounted net profits. The balance between possible elastic and inelastic OPEC response was essentially even over a fairly wide range of elasticities. ORNL concluded that this is the best way to estimate OPEC behavior until greater progress can be made in synthesizing what insights are available from the evolving strategic game-theoretic and empirical research on OPEC behavior, and advancing that research. An alternative would have been to use OPEC strategic response behavior to maximize long-run net revenue, which may well correspond to market-share preservation behavior (e.g., Case Seven), and a somewhat higher premium value.

Finally, ORNL's recommended case used a GDP elasticity range, the parameter which summarizes the sensitivity of GDP to oil price shocks, which is reduced compared to earlier estimates, and compared to the full range of historically-based estimates. This helped address the concerns of those who either question the conclusions of past empirical estimates or expect that the impacts of oil shocks may well be declining.

Table 9-7 Summary Results – Oil Import Premium Under Various Cases ($2007/BBL)

Component	Statistic	1) AEO2007 Base Outlook, 1997 Study Elasticities	2) AEO2007 Base Outlook, Wider Range of OPEC Supply Elasticities	3) Case 2 with Revised Wider Range of OPEC Supply Elasticities	4) Case 2 with Updated Non-OPEC Supply/Demand Elasticities	5) Case 4 plus Revised Wider Range of OPEC Supply Elasticities	6) Case 4 Variant with Wider, Higher Range of Non-U.S./Non-OPEC Supply/Demand Elasticities	7) Case 6 with Applied Strategic Rule: Maintain Market Share	8) Case 4 with Reduced GDP Elasticity	9) Case 7 with Reduced GDP Elasticity
Monopsony Component	Mean	$5.57	$10.26	$8.16	$7.77	$6.52	$6.44	$9.36	$7.86	$9.42
	Range	($3.60 - $8.19)	($3.10 - $21.22)	($3.12 - $19.30)	($2.94 - $13.75)	($2.90 - $13.06)	($2.69 - $11.33)	($6.69 - $12.42)	($2.94 - $13.89)	($6.72 - $12.54)
Disruption Import Costs	Mean	$2.36	$2.33	$2.34	$1.92	$1.94	$1.93	$1.89	$2.20	$2.16
	Range	($0.51 - $4.66)	($0.58 - $4.57)	($0.66 - $4.61)	($0.39 - $3.75)	($0.38 - $3.84)	($0.42 - $3.70)	($0.44 - $3.66)	($0.63 - $4.07)	($0.62 - $3.96)
Disruption Dislocation Costs	Mean	$3.83	$3.70	$3.76	$3.42	$3.45	$3.47	$3.41	$2.67	$2.64
	Range	($1.06 - $6.69)	($1.04 - $6.57)	($1.06 - $6.74)	($0.92 - $6.23)	($0.94 - $6.10)	($0.92 - $6.13)	($0.87 - $6.26)	($0.90 - $4.84)	($0.87 - $4.87)
	Mean	$6.19	$6.03	$6.10	$5.34	$5.39	$5.40	$5.30	$4.87	$4.81
Costs	Range	($2.94 - $10.01)	($2.94 - $9.75)	($2.91 - $9.85)	($2.53 - $8.69)	($2.60 - $8.62)	($2.58 - $8.92)	($2.54 - $8.74)	($2.23 - $7.85)	($2.25 - $7.77)
Total Mid-Point	Mean	$11.75	$16.29	$14.27	$13.11	$11.90	$11.86	$14.65	$12.71	$14.23
	Range	($8.04 - $15.96)	($8.10 - $27.42)	($7.90 - $25.49)	($7.26 - $19.59)	($6.96 - $18.62)	($6.79 - $17.23)	($11.03 - $18.61)	($7.07 - $19.02)	($10.76 - $18.25)
Total Premium, in $/Gallon	Mean	$0.28	$0.39	$0.34	$0.31	$0.28	$0.28	$0.35	$0.30	$0.34
Price Reduction ($/MMBD)	Mean	$0.52	$1.04	$0.81	$0.75	$0.61	$0.60	$0.90	$0.75	$0.90

Cases

1) Based on AEO2007. Updated oil market outlook from AEO1994 Base Case to AEO2007 Base Case. Among other things, this means average crude price rises from $20.33 to $48.34. All elasticities match 1997 values. Non-U.S. elasticity of import demand = -0.

2) AEO2007 Base Outlook, with wider range of OPEC supply elasticities, 0.25 to 6.0 and a mean elasticity of 1.76.

3) Revise Case 2, with OPEC behavior distributed over elasticities 0 to 6, so that 25% of response is inelastic (< 1.0), mode elasticity is 2.0 (mean elasticity is 2.2 rather than 1.76)

4) Updated Case 2 supply/demand elasticities for non-OPEC region with more recent estimates. Elasticity of non-U.S. demand -0.2 to -0.4, with mean and mode -0.3, non-U.S. Supply = 0.2 to 0.4, with mean and mode 0.3, implying (mode) net elasticity of impo

5) Revise Case 4, with OPEC behavior distributed over elasticities 0 to 6, so that 25% of response is inelastic (< 1.0), mode elasticity is 2.0 (mean elasticity is 2.2 rather than 1.76). Net elasticity of import demand is -1.6 for the non-U.S./non-OPEC r

).3

non-U.S. supply = 0.2 to 0.6, mode 0.3 and m

7) Applied Strategic OPEC Behavioral Rule to Case 6: Maintain Market Share (Gately 2004 paper best strategy). This rule implies that OPEC Supply elasticity matches that of all non-OPEC supply. As a result non-U.S. elasticity of import demand ranges from

8) Variant on version Case 4, considered reduced GDP elasticity for future disruptions (range -0.01 to -0.054; midcase value -0.032; mean value is -0.032, reduced from mean value of -0.0495). OPEC-behavior treated parametrically.

9) Revise Case 7 (which applied Strategic OPEC Behavioral Rule to Case 6: Maintain Market Share (Gately 2004 paper best strategy)) with reduced GDP elasticity for future disruptions (range -0.01 to -0.054; midcase value -0.032; mean value is -0.032, reduc

9.5.2.5 The impact of fuel savings on U.S. petroleum imports

EPA used the MOVES model to estimate the reduced consumption in fuel due to this Proposal. A detailed explanation of the MOVES model can be found in Chapter 5 of this draft RIA.

Based on a detailed analysis of differences in fuel consumption, petroleum imports, and imports of refined petroleum products and crude oil among the Reference Case, High Economic Growth, and Low Economic Growth Scenarios presented in AEO 2009, NHTSA and EPA estimate that approximately 50 percent of the reduction in fuel consumption resulting from adopting improved fuel GHG standards and fuel economy standards is likely to be reflected in reduced U.S. imports of refined fuel, while the remaining 50 percent would be expected to be reflected in reduced domestic fuel refining. Of this latter figure, 90 percent is anticipated to reduce U.S. imports of crude petroleum for use as a refinery feedstock, while the remaining 10 percent is expected to reduce U.S. domestic production of crude petroleum. Thus, on balance, each gallon of fuel saved as a consequence of improved fuel heavy duty GHG standards and fuel economy standards is anticipated to reduce total U.S. imports of crude petroleum or refined fuel by 0.95 gallons.[i]

Based upon the fuel savings estimated by the MOVES model and the 95 percent oil import factor, the reduction in U.S. oil imports from this rule are estimated for the years 2020, 2030 and 2040 (in millions of barrels per day (MMBD)) in Table 9-8 below.

Table 9-8 U.S. Oil Import Reductions Resulting from the Heavy Duty Vehicle Rule in 2020, 2030 and 2040 (in MMBD)

2020	2030	2040
0.177	0.357	0.463

For comparison purposes, Table 9-9 shows the U.S. imports of crude oil in 2020 and 2030 as projected by DOE in the Annual Energy Outlook 2010.[j]

Table 9-9 Projected U.S. Imports of Crude Oil in 2020 and 2030 (in MMBD)

2020	2030
8.54	8.69

[i] This figure is calculated as 0.50 + 0.50*0.9 = 0.50 + 0.45 = 0.95.
[j] AEO 2010, EIA, Table 127, Projected United States Imported Liquids by Source to 2030.

9.5.2.6 Energy security benefits of this rule

Using the same methodology as the peer reviewed model, but updating the analysis using AEO 2010 world oil price values and the estimated fuel savings from the rule using the MOVES model, EPA has calculated the energy security benefits of the rule for the years 2020, 2030 and 2040. Since the Agency is taking a global perspective with respect to valuing greenhouse gas benefits from the rule, only the macroeconomic adjustment/disruption portion of the energy security premium is used in the energy security benefits estimates present below. These results are shown below in Table 9-10.

Table 9-10 U.S. Energy Security Benefits of the Heavy-Duty Vehicle Rule in 2020, 2030 and 2040 (in millions of $2008)

2020	2030	2040
$477	$1,113	$1,520

9.6 Summary of Benefits and Costs

In this section, EPA presents a summary of costs, benefits, and net benefits of the proposal. Table 9-10 shows the estimated annual monetized costs of the proposed program for the indicated calendar years. The table also shows the net present values of those costs for the calendar years 2012-2050 using both a 3 percent and a 7 percent discount rate.[k] In this table, fuel savings are calculated using pre-tax fuel prices.

Table 9-10 Estimated Monetized Costs of the Proposed Program (Millions of 2008 dollars)[a]

	2020	2030	2040	2050	NPV, YEARS 2012-2050, 3% DISCOUNT RATE	NPV, YEARS 2012-2050, 7% DISCOUNT RATE
Truck/Tractor Costs	$2,100	$2,000	$2,300	$2,600	$43,800	$23,500
Fuel Savings (pre-tax)	-$8,000	-$18,900	-$28,000	-$35,200	-$351,100	-$152,100
Quantified Annual Costs	-$5,900	-$16,900	-$25,700	-$32,600	-$307,300	-$128,600

[a] Technology costs and fuel savings for separate truck segments can be found in Chapter 7.

Table 9-11 presents estimated annual monetized benefits for the indicated calendar years. The table also shows the net present values of those benefits for the calendar years 2012-2050 using both a 3 percent and a 7 percent discount rate. Note that fuel savings shown here result from fleet-wide reductions in fuel use. Thus they grow over time, as an increasing fraction of the fleet meets the 2018 standards. The table also shows the benefits of reduced CO_2 emissions—and consequently the annual quantified benefits (i.e., total benefits)—for each of four SCC values considered by EPA. As discussed in Section 8.5, there are some limitations to the SCC

[k] For the estimation of the stream of costs and benefits, we assume that after implementation of the proposed MY 2014-2017 standards, the 2017 standards apply to each year out to 2050.

analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion.

In addition, these monetized GHG benefits exclude the value of reductions in non-CO_2 GHG emissions (CH_4, N_2O) expected under this proposal. Although EPA has not monetized the benefits of reductions in non- CO_2 GHGs, the value of these reductions should not be interpreted as zero. Rather, the net reductions in non-CO_2 GHGs will contribute to this rule's climate benefits, as explained in Section III.F of the preamble.

Table 9-11 Monetized Benefits Associated with the Proposed Program (Millions of 2008 dollars)

	2020	2030	2040	2050	NPV, YEARS 2012-2050, 3% DISCOUNT RATE[A]	NPV, YEARS 2012-2050, 3% DISCOUNT RATE[A]
Reduced CO2 Emissions at each assumed SCC value[b]						
5% (avg SCC)	$200	$700	$1,200	$1,800	$8,900	$8,900
3% (avg SCC)	$900	$2,400	$3,700	$5,100	$45,300	$45,300
2.5% (avg SCC)	$1,500	$3,600	$5,500	$7,400	$76,800	$76,800
3% (95th percentile)	$2,900	$7,200	$11,200	$15,400	$138,100	$138,100
Energy Security Impacts (price shock)	$500	$1,100	$1,500	$1,800	$19,800	$8,700
Accidents, Noise, Congestion	-$200	-$400	-$500	-$600	-$7,500	-$3,400
Refueling Savings	$100	$100	$200	$200	$2,500	$1,100
Non-CO_2 GHG Impacts and Non-GHG Impacts [c,d]	n/a	n/a	n/a	n/a	n/a	n/a
Total Annual Benefits at each assumed SCC value[b]						
5% (avg SCC)	$600	$1,500	$2,400	$3,200	$23,700	$15,300
3% (avg SCC)	$1,300	$3,200	$4,900	$6,500	$60,100	$51,700
2.5% (avg SCC)	$1,900	$4,400	$6,700	$8,800	$91,600	$83,200
3% (95th percentile)	$3,300	$8,000	$12,400	$16,800	$152,900	$144,500

[a] Note that net present value of reduced CO_2 emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SCC at 5, 3, 2.5 percent) is used to calculate net present value of SCC for internal consistency. Refer to the SCC TSD for more detail.
[b] Section 8.5 of the RIA notes that SCC increases over time. Corresponding to the years in this table, the SCC estimates range as follows: for Average SCC at 5%: $5-$16; for Average SCC at 3%: $22-$46; for Average SCC at 2.5%: $36-$66; and for 95th percentile SCC at 3%: $66-$139. Section VIII.F also presents these SCC estimates.
[c] The monetized GHG benefits presented in this analysis exclude the value of changes in non-CO_2 GHG emissions expected under this proposal (see RIA Chapter 5). Although EPA has not monetized changes in non-CO_2 GHGs, the value of any increases or reductions should not be interpreted as zero.
[d] Non-GHG-related health and welfare impacts (related to $PM_{2.5}$ and ozone exposure) were not estimated for this proposal, but will be included in the analysis of the final rulemaking.

Table 9-12 presents estimated annual net benefits for the indicated calendar years. The table also shows the net present values of those net benefits for the calendar years 2012-2050 using both a 3 percent and a 7 percent discount rate. The table includes the benefits of reduced CO2 emissions (and consequently the annual net benefits) for each of four SCC values considered by EPA.

Table 9-12 Monetized Net Benefits Associated with the Proposed Program (Millions of 2008 dollars)

	2020	2030	2040	2050	NPV, 3%	NPV, 7%
Annual Costs[a]	-$5,900	-$16,900	-$25,700	-$32,600	-$307,300	-$128,600
Monetized Annual Benefits at each assumed SCC value						
5% (avg SCC)	$600	$1,500	$2,400	$3,200	$23,700	$15,300
3% (avg SCC)	$1,300	$3,200	$4,900	$6,500	$60,100	$51,700
2.5% (avg SCC)	$1,900	$4,400	$6,700	$8,800	$91,600	$83,200
3% (95th percentile)	$3,300	$8,000	$12,400	$16,800	$152,900	$144,500
Monetized Net Benefits at each assumed SCC value						
5% (avg SCC)	$6,500	$18,400	$28,100	$35,800	$331,000	$143,900
3% (avg SCC)	$7,200	$20,100	$30,600	$39,100	$367,400	$180,300
2.5% (avg SCC)	$7,800	$21,300	$32,400	$41,400	$398,900	$211,800
3% (95th percentile)	$9,200	$24,900	$38,100	$49,400	$460,200	$273,100

[a] Note that negative costs represent savings rather than costs.

EPA also conducted a separate analysis of the total benefits over the model year lifetimes of the 2014 through 2018 model year trucks/tractors. In contrast to the calendar year analysis presented in Table 9-9 through Table 9-12, the model year lifetime analysis shows the lifetime impacts of the program on each of these MY fleets over the course of their lifetime. Full details of the inputs to this analysis can be found in RIA Chapter 5. The net societal benefits of the full life of each of the five model years from 2014 through 2018 are shown in Table 9-13 and Table 9-14 at both a 3 percent and a 7 percent discount rate, respectively.

Table 9-13 Monetized Costs, Benefits, and Net Benefits Associated with the Lifetimes of 2014-2018 Model Year Trucks (Millions of 2008 dollars; 3% Discount Rate)

	2014MY	2015MY	2016MY	2017MY	2018MY	SUM
Monetized Costs						
Technology Costs	-$1,400	-$1,400	-$1,600	-$1,700	-$2,100	-$8,200
Monetized Benefits at each assumed SCC value						
Pre-tax Fuel Savings	$6,100	$6,400	$7,200	$10,700	$11,800	$42,200
Energy Security	$400	$400	$400	$600	$700	$2,500
Accidents, Noise, Congestion	-$300	-$300	-$300	-$300	-$300	-$1,400
Refueling Savings	$200	$200	$200	$200	$200	$1,100
Non-CO_2 GHG Impacts and Non-GHG Impacts [a,b]	n/a	n/a	n/a	n/a	n/a	n/a
Reduced CO2 emissions at each assumed SCC value						
5% (avg SCC)	$200	$200	$200	$300	$300	$1,200
3% (avg SCC)	$600	$700	$700	$1,100	$1,200	$4,300
2.5% (avg SCC)	$1,000	$1,000	$1,100	$1,700	$1,800	$6,600
3% (95th percentile)	$1,900	$2,000	$2,200	$3,200	$3,600	$12,900
Monetized Net Benefits at each assumed SCC value						
5% (avg SCC)	$5,200	$5,500	$6,100	$9,800	$10,600	$37,400
3% (avg SCC)	$5,600	$6,000	$6,600	$10,600	$11,500	$40,500
2.5% (avg SCC)	$6,000	$6,300	$7,000	$11,200	$12,100	$42,800
3% (95th percentile)	$6,900	$7,300	$8,100	$12,700	$13,900	$49,100

[a]

The monetized GHG benefits presented in this analysis exclude the value of changes in non-CO_2 GHG emissions expected under this proposal (see RIA Chapter 5). Although EPA has not monetized changes in non-CO_2 GHGs, the value of any increases or reductions should not be interpreted as zero.

[b] Non-GHG-related health and welfare impacts (related to $PM_{2.5}$ and ozone exposure) were not estimated for this proposal, but will be included in the analysis of the final rulemaking.

Table 9-14 Monetized Costs, Benefits, and Net Benefits Associated with the Lifetimes of 2014-2018 Model Year Trucks (Millions of 2008 dollars; 7% Discount Rate)

	2014MY	2015MY	2016MY	2017MY	2018MY	SUM
Monetized Costs						
Technology Costs	-$1,400	-$1,400	-$1,600	-$1,700	-$2,100	-$8,200
Monetized Benefits at each assumed SCC value						
Pre-tax Fuel Savings	$4,500	$4,500	$4,900	$7,000	$7,400	$28,300
Energy Security	$300	$300	$300	$400	$400	$1,700
Accidents, Noise, Congestion	-$200	-$200	-$200	-$200	-$200	-$900
Refueling Savings	$200	$200	$200	$200	$200	$900
Non-CO_2 GHG Impacts and Non-GHG Impacts [a,b]	n/a	n/a	n/a	n/a	n/a	n/a
Reduced CO2 emissions at each assumed SCC value						
5% (avg SCC)	$200	$200	$200	$300	$300	$1,200
3% (avg SCC)	$600	$700	$700	$1,100	$1,200	$4,300
2.5% (avg SCC)	$1,000	$1,000	$1,100	$1,700	$1,800	$6,600
3% (95th percentile)	$1,900	$2,000	$2,200	$3,200	$3,600	$12,900
Monetized Net Benefits at each assumed SCC value						
5% (avg SCC)	$3,600	$3,600	$3,800	$6,000	$6,000	$23,000
3% (avg SCC)	$4,000	$4,100	$4,300	$6,800	$6,900	$26,100
2.5% (avg SCC)	$4,400	$4,400	$4,700	$7,400	$7,500	$28,400
3% (95th percentile)	$5,300	$5,400	$5,800	$8,900	$9,300	$34,700

[a] The monetized GHG benefits presented in this analysis exclude the value of changes in non-CO_2 GHG emissions expected under this proposal (see RIA Chapter 5). Although EPA has not monetized changes in non-CO_2 GHGs, the value of any increases or reductions should not be interpreted as zero.

[b] Non-GHG-related health and welfare impacts (related to $PM_{2.5}$ and ozone exposure) were not estimated for this proposal, but will be included in the analysis of the final rulemaking.

9.7 Economy Wide Impacts

EPA has undertaken an analysis of the economy-wide impacts of the medium- and heavy-duty truck fuel economy and GHG standards. The results presented in this section were not used to determine the GHG or fuel economy standards. However, this analysis provides more insight into some of the potential impacts of this rule.

It is anticipated that the GHG tailpipe standards would have impacts on the U.S. economy that extend beyond the transportation sector. The price of medium- and heavy-duty trucks would increase with this rule. This rule would also lower the demand for transportation fuels, resulting in fuel savings to vehicle users and a lower overall world oil price. This combination of effects—price increases for trucks and lower demand and world oil prices—would impact all sectors of the economy that use medium- and heavy-duty trucks and fuels as intermediate inputs to produce final goods. Households would also be impacted indirectly as consumers of final goods. Furthermore, as discussed in earlier in this chapter, truck VMT is largely driven by changes in economic activity.

It is important to note, however, that these potential impacts do not represent additional benefits or costs from the regulation. Instead, they represent the effects on the U.S. economy as its direct benefits and costs are transmitted through changes in prices in the affected markets, including those for vehicles and their components, fuel, and the various resources used to supply them. In addition, this analysis assumes that the fuel savings modeled here would not have taken place in the absence of this rule. As discussed in Preamble Section VIII.A., this assumption is based on what appear to be imperfections in the market for fuel-saving technology in the trucking industry.

To estimate the impacts of this rule on U.S. Gross Domestic Product (GDP) and personal consumption, EPA has used an economy-wide, computable general equilibrium (CGE) model. The economy-wide model used in this analysis is the Intertemporal General Equilibrium Model (IGEM).[23] IGEM is a model of the U.S. economy with an emphasis on the economy's energy and environmental aspects. IGEM is a dynamic model which depicts growth of the economy due to capital accumulation, technical change and population change. The model utilizes a unified accounting framework consistent with the National Income and Product Accounts and the Industry Classification System. It is a detailed multi-sector model covering thirty-five industries, consisting of five energy and thirty non-energy sectors. The model ensures market balances (supply equals demand) in value and quantity terms, including limits placed on private investment dictated by domestic and foreign saving behavior and by the fiscal policies of federal, state and local governments.

Capital accumulation in the model arises from the saving and investment behavior of households and businesses and provides an essential input to production and consumption. Households in the model make choices regarding present and future consumption (i.e., saving) and make choices regarding the allocation of time between labor and leisure. The model covers all aspects of long-run growth including the supply of capital, labor, imported and intermediate inputs to production; the rates and directions of exogenous and endogenous technical change for each producing sector; and the degrees of substitutability among inputs and commodities in production and final demand (consumption, investment, governments and foreign trade). The substitution possibilities for both producers and consumers in IGEM are driven by model parameters that are based on observed market behavior revealed over the past forty to fifty years.

In order to model the effects of this rule, the CGE model uses outputs of the transportation sector models as inputs to determine the economy-wide impacts of this rule. Specifically, the model uses information from other models on incremental costs of vehicle technologies, reduction in fuel consumption, and impacts on the world oil price. The incremental cost of vehicle technologies is used to generate a percentage change in vehicle cost that is applied to the IGEM motor vehicles sector. However, since the cost and fuel savings vary significantly across truck classes, we have used a weighted average cost and fuel saving in this analysis. In addition, medium- and heavy-duty trucks make up approximately XXX% of the motor vehicles sector; therefore the cost increases represented here only apply to that portion of the IGEM sector. The data on reduction in fuel consumption are used as inputs to IGEM in order to reduce the amount of refined petroleum sector output required by the transportation sector and other sectors in the model. Finally, the estimates of reductions in the world oil price are directly used to reduce the oil price in the model. The changes in world oil price are estimated using the

Energy Security Oil Premium Model maintained by Oak Ridge National Laboratory, which is discussed in more detail in Chapter 9.4.

9.7.1.1 Impacts on U.S. GDP

In order to use IGEM to estimate the real U.S. GDP impacts of this rule, we analyzed the impact of changes in the costs of medium- and heavy-duty trucks, changes in fuel consumption from the shift to a lower GHG-emitting vehicle stock, and the impacts of changes in the demand for motor fuels on fuel prices. See the RIA Chapter 7.1 for additional information on the change in vehicle technology costs, RIA Chapter 7.2 for details on changes in fuel demand, and RIA Chapter 9.4 for a discussion on the monopsony effect. It is important to note that the economy-wide analysis does not include a representation of a number of additional benefits (e.g. reducing greenhouse gas and non-GHG emissions), and thus the GDP impacts presented here do not incorporate the results of a complete cost benefit analysis. Table 9-15 and Figure 1 show the Reference Case GDP and GDP with this rule from 2015 through 2050.

Table 9-15 Annual GDP Impacts Associated with This Rule (Billions of 2008 dollars)

YEAR	REFERENCE CASE GDP	GDP WITH RULE	% CHANGE FROM REFERENCE CASE
2015	$XXX	$XXX	XXX%
2020	$XXX	$XXX	XXX%
2030	$XXX	$XXX	XXX%
2040	$XXX	$XXX	XXX%
2050	$XXX	$XXX	XXX%

In the Reference Case, GDP rises from approximately $XXX trillion in 2015 to $XXX trillion in 2020, $XXX trillion in 2030, $XXX trillion in 2040, and $XXX trillion in 2050. With this rule, GDP rises from approximately $XXX trillion in 2015 to $XXX trillion in 2020, $XXX trillion in 2030, $XXX trillion in 2040, and $XXX trillion in 2050.

The fuel savings and lower world oil prices that result from this rule lead to lower prices economy-wide, even when the impact of higher vehicle costs are factored into this analysis. Lower prices allow for additional purchases of investment goods which, in turn, lead to a larger capital stock. These price reductions also allow higher levels of real government spending while improving U.S. competitiveness thus promoting increased exports relative to the growth driven increase in imports. As a result, GDP is expected to increase as a result of this rule.

9.7.1.2 Impacts on U.S. Consumption

In addition to showing the impacts of the GHG vehicle rule on U.S. GDP, EPA also shows the impacts on real U.S. personal consumption expenditures. Table 9-16 and Figure 2 show the Reference Case consumption and consumption with this rule from 2015 through 2050.

Table 9-16 Consumption Impacts of the Rule (Billions of 2008 dollars)

YEAR	REFERENCE CASE CONSUMPTION	CONSUMPTION WITH RULE	% CHANGE FROM REFERENCE CASE
2015	$XXX	$XXX	XXX%
2020	$XXX	$XXX	XXX%
2030	$XXX	$XXX	XXX%
2040	$XXX	$XXX	XXX%
2050	$XXX	$XXX	XXX%

In the Reference Case, consumption rises from approximately $XXX trillion in 2015 to $XXX trillion in 2020, $XXX trillion in 2030, $XXX trillion in 2040, and $XXX trillion in 2050. With this rule, consumption rises from approximately $XXX trillion in 2015 to $XXX trillion in 2020, $XXX trillion in 2030, $XXX trillion in 2040, and $XXX trillion in 2050.

The consumption impacts on a per household basis are presented in Table 9-17 and Figure 3. Higher vehicle costs are projected to reduce household consumption slightly in the first few years of the rule implementation. Over time, fuel savings increase and the price of world oil decreases, which leads to lower prices economy-wide. As a result, household consumption increases over the long term.

Table 9-17 Consumption Impacts of This Rule per Household (2007$)

YEAR	REFERENCE CASE CONSUMPTION	CONSUMPTION WITH RULE	% CHANGE FROM REFERENCE CASE
2015	$XXX	$XXX	XXX%
2020	$XXX	$XXX	XXX%
2030	$XXX	$XXX	XXX%
2040	$XXX	$XXX	XXX%
2050	$XXX	$XXX	XXX%

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[14] *See* Federal Highway Administration, 1997 *Federal Highway Cost Allocation Study*, http://www.fhwa.dot.gov/policy/hcas/final/index.htm, Tables V-22, V-23, and V-24 (last accessed July 21, 2010).

[15] See Table 4. Last viewed on August 4, 2010 at http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf. Note that we assume the value of travel time is constant out to 2050, which is a conservative assumption since it is likely this value will increase due to income growth in the future.

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