



**RESOURCES**  
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# POLICY BRIEF

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## How Do Low Gas Prices Affect Costs and Benefits of US New Vehicle Fuel Economy Standards?

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### Key Points

- In their initial benefit–cost analysis of the 2012–2016 standards, the agencies did not account for consumer or manufacturer behavioral responses to low gasoline prices.
- We augment the agencies' benefit–cost framework and use recent evidence on behavior and gasoline prices to estimate the effects of low gasoline prices on benefits and costs.
- The 25 percent reduction in future gasoline prices reduces the value of fuel savings by 22 percent, allowing for consumer changes in miles traveled and vehicle choice.
- Lower gasoline prices raise compliance costs by about \$0.5 billion per year, or about 9 percent of the total net benefits of the program.
- Accounting for these responses does not overturn the agencies' initial conclusions that benefits exceed costs.

### 1. Introduction

The new Corporate Average Fuel Economy (CAFE) and greenhouse gas (GHG) emissions standards will radically change the fuel economy and emissions of US light-duty vehicles. Beginning with new vehicles sold in model year 2012 and phasing in through the 2025 model year, the standards become increasingly stringent over time. These standards, which were jointly established by the National Highway Traffic Safety Administration (NHTSA) for fuel economy and the US Environmental Protection Agency (EPA) for GHG emissions, are forecast to reduce new vehicle fuel use and GHG emissions by about half by the model year 2025.

Surprisingly, in spite of the stricter requirements of the new standards, average new vehicle fuel economy has been falling since October 2015. Many observers attribute the declining fuel economy to the 50 percent decline in gasoline prices since their high in 2014.

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Falling gasoline prices lower consumer demand for high fuel economy vehicles. Compared with June a year ago, car sales are down 7.5 percent and truck sales are up 9.2 percent.<sup>1</sup>

Prior to the standards, EPA and NHTSA estimated that the benefits of the standards through 2016 would be about three times greater than the cost. Lower gasoline prices reduce the value of the fuel savings attributable to the standards. If low gasoline prices are reducing fuel economy and the value of the fuel savings to consumers, what are the implications for the actual benefits and costs of the standards?

The effects of low gasoline prices on the overall success of the standards and their costs and benefits are complex and depend on manufacturer and consumer responses to gasoline prices. Although the agencies noted the uncertainty of future gasoline prices, they did not assess the implications of low gasoline prices on the costs and benefits of the standards set for the 2012 to 2016 model year vehicles. Moreover, their benefit–cost analysis of those standards did not include behavioral responses to fuel prices, such as consumer choices of which vehicles to obtain and how much to drive. In this policy brief, we explain how fuel prices affect consumer and manufacturer behavior. We augment the agencies’ benefit–cost estimation framework and account for these behavioral responses to estimate the effects of lower gasoline prices on the benefits and costs of the standards.

To incorporate the effects of low gasoline prices on consumer behavior, we draw on recent estimates of the effects of both changes in fuel prices on vehicle sales mix and changes in the cost of driving on total vehicle miles traveled. We also include the response of manufacturers to lower fuel prices by accounting for the additional costs of new fuel economy technologies that will be required to meet the standards.

We estimate the effects of low gasoline prices on the costs and benefits of the standards, focusing on vehicles sold during the 2015 model year. If one ignores consumer and manufacturer responses to fuel prices, the value of fuel savings—a major component of the overall benefits—is proportional to fuel prices. However, in our analysis we find that a 25 percent fuel price decrease has a less than proportionate effect on fuel savings. The value of fuel savings falls by just 22 percent; consumer and manufacturer responses explain this difference.

Two other results also highlight the importance of including behavioral responses. First, lower gasoline prices raise the cost to manufacturers of achieving the standards, and second, lower prices result in larger GHG emissions reductions. The higher manufacturer costs arise because the level of fuel economy falls by more than the fuel economy requirement, and manufacturers have to make up the difference (for example, by adding more fuel-saving technology). This raises costs by about \$0.5 billion per year, or about 9 percent of the total net benefits of the program. Higher emissions reductions occur because lower gasoline prices cause people to drive more, so emissions fall by about 6 percent more under the standards (note that

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<sup>1</sup> *Wall Street Journal* Market Data Center; [www.motorintelligence.com](http://www.motorintelligence.com).

we assess the implications of low gasoline prices on the change in emissions caused by the standards, and not on the level of emissions).

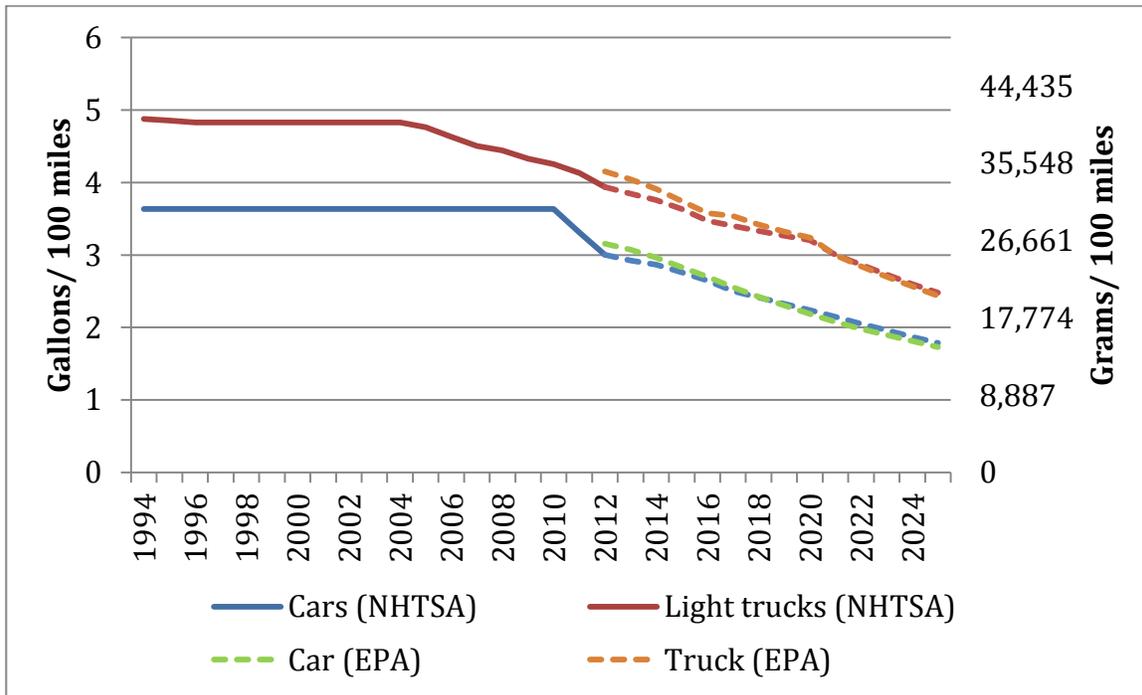
## **2. Background on the Standards and Overview of How Falling Fuel Prices Affect Their Costs and Benefits**

### ***2.1. The New CAFE and GHG Standards***

The new standards are a dramatic departure from previous policy. The standards, established in 2011 jointly by NHTSA and EPA, impose increasingly strict requirements on both fuel economy and GHG emissions for model years 2012 through 2025. CAFE standards set by NHTSA require each manufacturer's vehicle fleet to meet a minimum average miles per gallon (mpg), and the EPA standards require each manufacturer to meet a maximum emissions rate in grams of carbon dioxide (CO<sub>2</sub>) per mile. Cars and light trucks have separate standards, with trucks allowed to meet lower fuel economy and higher emissions requirements than cars. Three novel features of the standards are that the requirement that applies to a particular vehicle depends on its footprint (roughly, the area defined by the four wheels); manufacturers can trade compliance credits across their car and truck fleets; and manufacturers can also trade compliance credits with one another.

Figure 1 summarizes the required changes since 1994 in both the CAFE standards, read on the left axis, and the GHG standards, read on the right. The new standards are shown as dashed lines in the figure, beginning with model year 2012, and are projections made by the agencies prior to implementation. The CAFE standards are displayed as gallons per mile for consistency with the EPA standards. By the 2025 model year, the stricter standards are projected to reduce fuel consumption and GHG emissions rates by about half.

**FIGURE 1. PAST AND PROJECTED CAFE STANDARDS (GALLONS PER 100 MILES), AND EPA GHG STANDARDS (GRAMS CO<sub>2</sub> PER 100 MILES)**



Notes: Differences between the NHTSA fuel economy standards and the EPA greenhouse gas standards from 2012 to 2025 are due to differences in nontailpipe emissions accounted for by EPA but not by NHTSA. Grams of CO<sub>2</sub> per mile forecasts from EPA (2012).

## 2.2. How the Agencies Estimate Fuel Savings, GHG Emissions Reductions, and Overall Benefits and Costs of the New Standards

The agencies estimate benefits and costs of the standards relative to a reference case in which fuel economy is maintained at levels that existed prior to the tighter standards. In the agencies’ analyses, social benefits and costs include the following:

### Benefits:

- fuel cost savings to consumers due to higher fuel economy;
- value to consumers of higher vehicle miles traveled (VMT) due to rebound effect (standards reduce cost per mile driven, raising VMT);
- value of time savings for refueling due to lower fuel use;
- reduced petroleum market externality; and
- value of GHG reductions

### Costs:

- additional costs to the manufacturers to meet standards; and
- external costs due to more driving: higher air pollution, greater number of accidents, traffic congestion

Of these categories, the fuel cost savings and greenhouse gas emissions reductions account for most of the benefits, and costs to manufactures account for most of the costs. One important assumption the agencies made for the 2012-2016 standards is that the standards do not affect the mix of vehicles sold, both between cars and trucks and within a car or truck type. Their benefit–cost analysis for those standards used projections of the car-truck split from the Energy Information Administration’s 2010 Annual Energy Outlook (AEO), which depended on fuel prices and other factors, and included a steady shift toward cars and away from trucks over time. This shift has not actually occurred, and the car-truck mix has been more stable than the agencies projected. The agencies used the same fleet forecasts for their reference (“no standards”) case and their cases that include the standards, implicitly assuming that the standards themselves do not affect market shares of individual vehicles.

In their estimates of benefits and costs of the 2012-2016 standards, the agencies rely on the 2010 AEO’s forecast fuel prices. Although the agencies note the possibility that actual fuel prices may differ from the AEO projections, they do not perform any sensitivity analysis of the benefits and costs under alternative fuel price scenarios.<sup>2</sup>

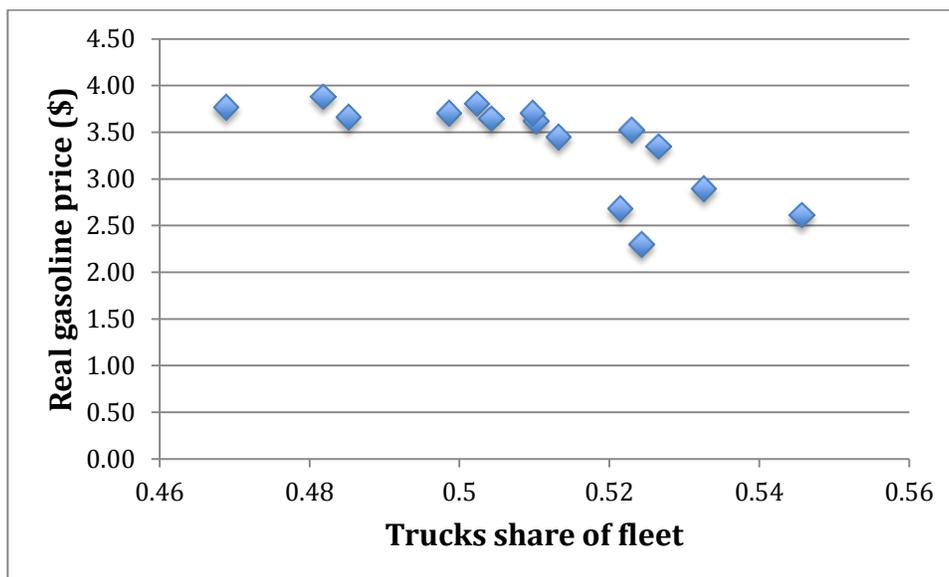
In the agencies’ benefit–cost analysis, benefits to consumers from fuel savings are calculated based on the change in fuel economy the standards cause, miles traveled over the vehicles’ lifetimes, and the price of fuel. The agencies assume that fuel prices do not affect fuel economy or miles traveled, which implies that a reduction in fuel prices proportionally reduces benefits of fuel savings to consumers. In their benefit–cost analysis for the 2012-2016 standards, falling fuel prices do not have any other implications for the agencies’ estimates of benefits or costs.

### **2.3. How Lower Fuel Prices Influence Consumer Decisions**

Changes in fuel prices are likely to influence consumer decisions many ways. Lower fuel prices reduce the fuel costs of all vehicles, but a given fuel price decrease causes a larger fuel cost decline for vehicles with low fuel economy than for vehicles with high fuel economy. This reduces the relative cost of driving a low fuel economy vehicle, which affects purchase decisions (Klier and Linn 2010). For example, consumers may buy fewer cars and more trucks, or within any car or truck size, they may shift toward lower fuel economy options. Figure 2 shows a strong correlation between gasoline prices and the share of light trucks in total sales, and Leard et al. (2016a) conclude that recent gasoline price changes have had a strong effect on vehicle model market shares.

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<sup>2</sup> Later analyses of costs and benefits allow for a limited fleet mix response to vehicle prices. We discuss the more recent analyses by the Agencies in the conclusion.

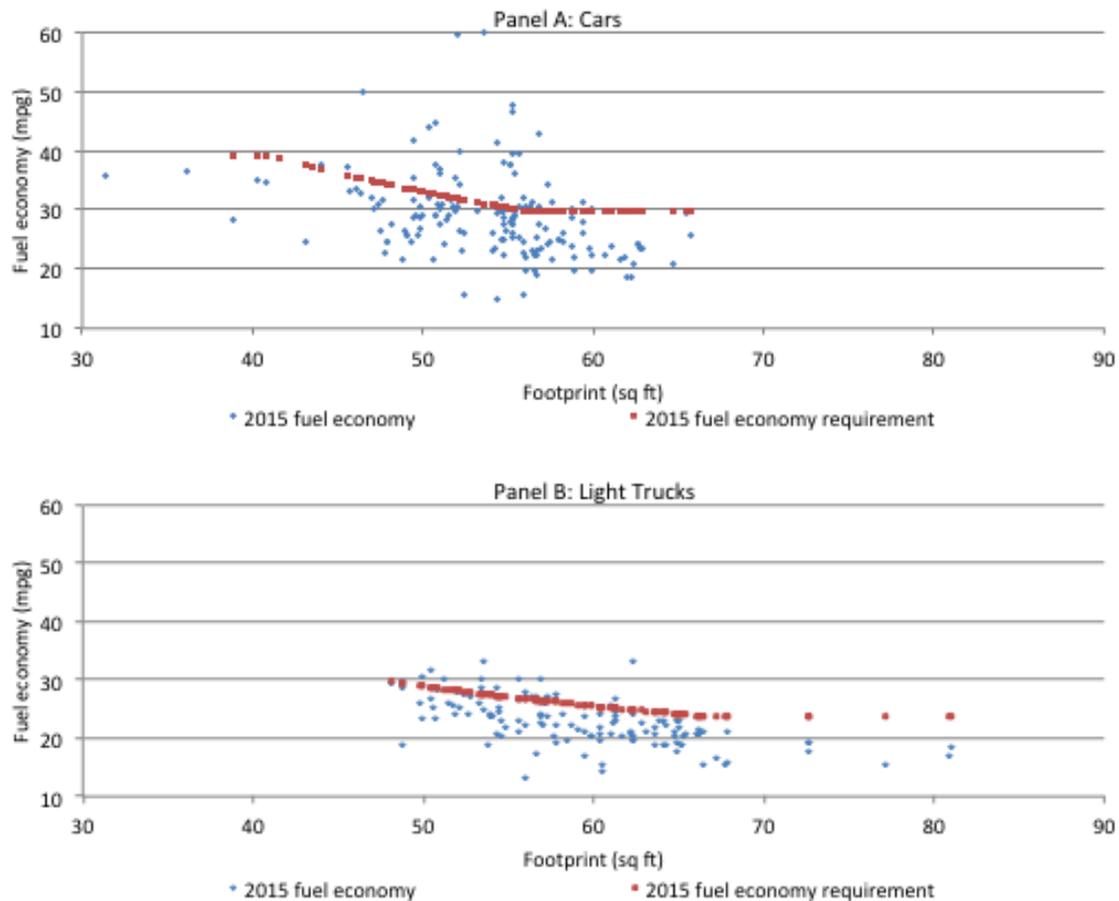
**FIGURE 2. QUARTERLY GASOLINE PRICES AND SHARE OF NEW TRUCKS SOLD, 2012–15**

Sources: EIA Short-Term Energy Outlook and Ward's Automotive Yearbook

Notes: Quarterly average motor gasoline, regular grade, retail price. Real gasoline prices in 2016\$.

Such changes in vehicle mix can also affect a manufacturer's fuel economy requirement (in either miles per gallon or grams of CO<sub>2</sub> per mile). Vehicles with low fuel economy tend to be larger than vehicles with high fuel economy, and larger vehicles are subject to lower fuel economy requirements under the standards. Leard et al. (2016a) show that low gasoline prices cause consumers to shift to larger vehicles, and that this effect reduces the level of fuel economy that manufacturers are required to attain.

However, the effect of gasoline prices on the level that fuel economy manufacturers must attain may differ from the effect on the level of fuel economy that consumers choose. In fact, consumers have a range of fuel economy choices even within a vehicle size or footprint, as Figure 3, panels A and B, suggest. Facing lower fuel prices, consumers may opt for powerful engine sizes or more "loaded" versions of vehicles of the same size. The figures illustrate the fuel economy variation, and in many cases vehicles have similar footprint to one another but different levels of fuel economy. If low fuel prices cause consumers to shift to vehicles that have lower fuel economy but similar footprint to the vehicles they would have purchased under high fuel prices, low fuel prices can lead to a larger decrease in the fuel economy consumers choose than in the fuel economy requirement. In fact, Leard et al. (2016a) show that the decrease in fuel prices between mid-2014 and mid-2015 caused fuel economy that consumers chose to fall by 0.3 mpg and caused the fuel economy requirement to fall by only 0.1 mpg. This gap affects producers' decisions, as we discuss in the next section.

**FIGURE 3. FUEL ECONOMY, ACTUAL AND REQUIRED**

*Notes:* The samples include all car models and power types in panel A and all light truck models and power types in panel B for the 2015 model year. For each model and power type, the figure plots its actual fuel economy (blue) and 2015 fuel economy requirement (red) in miles per gallon (mpg) against the corresponding footprint in square feet (sq. ft.).

Another effect of low fuel prices on consumer behavior is that they lower the cost per mile of driving and cause people to drive more. This effect is conceptually distinct from the rebound effect, which refers to the increase in driving caused by the fuel economy increase that the standards induce; the rebound effect occurs regardless of the level of fuel prices. The agencies recently reviewed the rebound literature and note that many recent studies report elasticities of driving to fuel costs between  $-0.1$  and  $-0.3$ . An elasticity of  $-0.1$  implies that a 10 percent decrease in fuel prices raises VMT by 1 percent.

In short, observations of consumer behavior suggest that fuel prices affect market shares and VMT, but the agencies' framework for estimating the benefits and costs of the 2012–16 standards ignored these responses.

## **2.4. How Low Fuel Prices Affect Benefits and Costs of the Standards**

The preceding discussion shows that lower fuel prices reduce the fuel economy consumers choose, reduce the fuel economy requirement, and increase VMT. These effects have complex implications for overall benefits and costs of the standards, which we discuss next.

We follow the agencies and estimate benefits and costs by comparing a scenario with the new standards and a scenario that holds the standards fixed at their 2011 level. Then we assess the effects of low gasoline prices by comparing benefits and costs under high and low gasoline price scenarios. This yields four scenarios: high and low gasoline prices, each without and with standards.

How do gasoline prices affect fuel and GHG savings? A large component of the benefits derives from the lower fuel consumption caused by higher fuel economy under the standards. The fuel savings are equal to VMT multiplied by the change in fuel economy caused by the standards. Lower fuel prices reduce driving costs and increase VMT, which increases the first component of fuel savings. That is, if we suppose that fuel prices do not change fleet-wide average fuel economy, the higher VMT increases the fuel savings. There is a second effect, however, which is that fuel prices can affect the fleet-wide fuel economy increase caused by the standards. Leard et al. (2016a) suggest that this effect is small relative to the change in VMT, however (the calculations in the next section demonstrate this point). Consequently, because total driving is higher with lower fuel prices, the overall effect is likely to increase the fuel economy gains caused by the standard. Because GHG reductions are (approximately) proportional to the fuel savings, lower fuel prices are also likely to raise the GHG reductions.

Next, we discuss the effects of gasoline prices on the overall benefits and costs of tighter standards. The value of the fuel savings depends on the reduction in fuel use caused by the standards and the price per gallon of fuel. Lower gasoline prices therefore create two opposing effects on the value of fuel savings: on the one hand, the price per gallon decreases, but as just described, lower gasoline prices increase the fuel savings. The net effect of low fuel prices on the value of fuel savings therefore depends on the size of the behavioral responses.

Lower gasoline prices also affect the costs of compliance with the standards. Above, we discussed how a decrease in fuel prices may create a gap between the fleet-wide average level of fuel economy consumers choose and the fleet-wide average level of fuel economy that manufacturers must attain. In the short term, manufacturers may adjust vehicle prices or use compliance credits to make up this shortfall, but in the long term, manufacturers have to make up this fuel economy gap to comply with the standards and are likely to do so by adding to their vehicles' fuel-saving technology—that is, more technology than they would add if fuel prices were high. The added technology raises the costs of complying with the standards.<sup>3</sup>

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<sup>3</sup> A manufacturer could respond to the standards themselves and to lower fuel prices by increasing the size (and footprint) of a particular vehicle, which would change its fuel economy requirement. Whitefoot and Skerlos (2012) discuss this possibility but we are not aware of any research analyzing the extent to

### 3. The Effects of Falling Prices on Effectiveness, Costs, and Benefits of the Standards: An Application to Model-Year 2015 Vehicles

The agencies projected that benefits would exceed costs by about three times in their benefit–cost analysis. Their assumptions imply that value of fuel savings fall in proportion to fuel price change, and there are no other implications of low fuel prices for costs and benefits. In this section, we relax those assumptions and estimate effects of low fuel prices on benefits and costs.

As we showed above, declining fuel prices are likely to affect the mix of vehicles sold, fuel and GHG savings, and benefits and costs. We illustrate these effects in this section by assessing the effects of the 2014–15 fuel price decline on the fuel and GHG savings, benefits, and costs for vehicles sold in the 2015 model year. The analysis is based on recent estimates of the effects of fuel prices on VMT and market shares (Leard et al. (2016).

We compare outcomes of the standards under two different assumptions about gasoline price forecasts. The first is the projection used by the agencies in their assessment of costs and benefits of the 2012–16 standards. This analysis used the fuel prices projected in the 2010 AEO. The second is the 2015 AEO projected fuel prices, which are about 25 percent lower than the 2010 projections (see Appendix Figure A1).

Analogously to the agencies, we estimate benefits and costs by a “before” and “after” comparison. We use 2010 as the before or reference case, because the new standards were not in effect at that time. The analysis is based on a disaggregated data set in which a vehicle model and power type constitutes a unique observation. For example, the data distinguish the gasoline, hybrid, and plug-in hybrid versions of the 2015 Honda Accord. For the high gasoline price scenario, we compare the sales-weighted average fuel economy of the vehicles actually sold in 2010, with the sales-weighted average fuel economy of the vehicles actually sold in 2015 fleet. We renormalize total 2015 vehicle sales so that total sales in 2010 and 2015 equal one another (the renormalization is for consistency with the agencies, which assume that the standards do not affect total sales). We adjust the 2015 market shares using results from Leard et al. (2016a), assuming that fuel prices in 2015 had remained at the (higher) levels from 2014.<sup>4</sup> We compute fuel savings and greenhouse gas reductions based on fuel prices and market shares. To evaluate the low fuel price scenario, we again compare the 2010 and 2015 fleets, except that we use estimates from Leard et al. (2016a) to compute the 2010 market shares that

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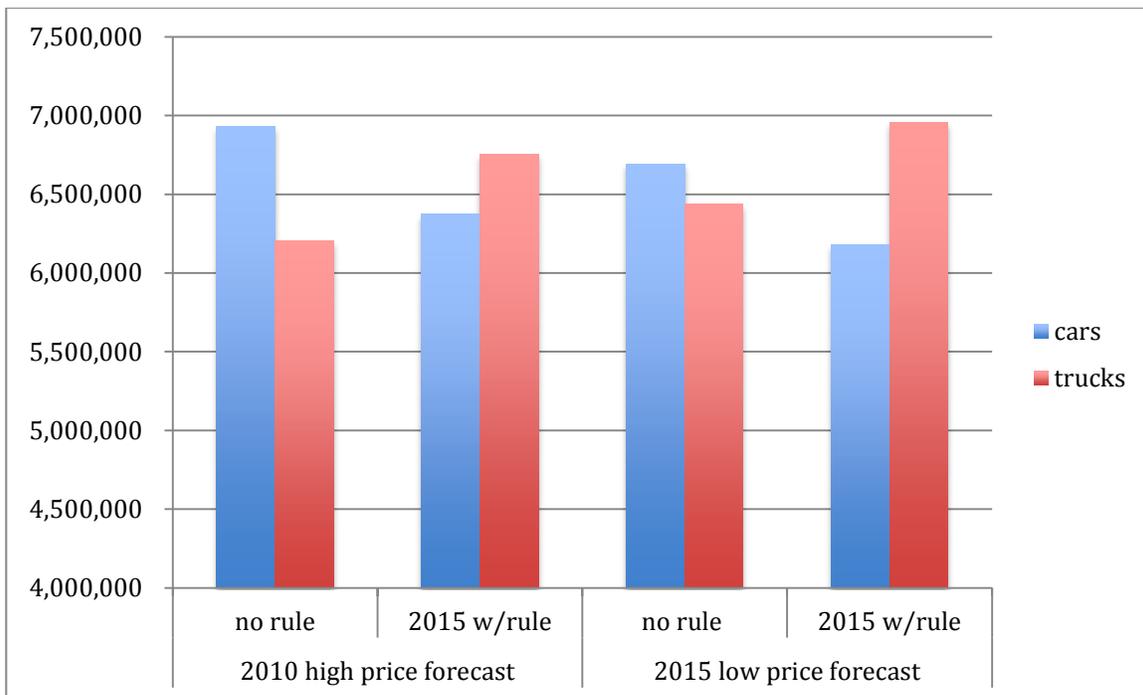
which manufacturers have actually done this. Consequently we omit this potential behavioral response from our analysis.

<sup>4</sup> The market share adjustment is based on a statistical model that links a vehicle’s fuel costs to its market share, where a vehicle is defined as a unique model and power type. The statistical model allows for the possibility that a change in fuel prices affects not only the overall shares of cars and light trucks in total sales, but also the market shares of individual vehicle models and power types within the car and light truck classes. We estimate the relationship between fuel costs and market shares using monthly sales data. We use the estimates reported in column 3 from Table 3 in Leard et al. (2016a) to predict sales shares resulting from the high gasoline assumption of the AEO (see Appendix).

would have occurred if fuel prices in 2010 had been lower (we use the observed 2015 market shares for the low fuel price scenario with the standards).

We account for fuel savings and GHG emissions reductions over the life of the 2015 vehicles, assuming the same average vehicle lifetimes as the agencies assume in their analyses. The forecasts for sales of cars and trucks are shown in Figure 4. Total sales for each scenario are normalized to the actual level in 2010.

**FIGURE 4. RELATIVE VEHICLE SALES UNDER REFERENCE CASE AND IN 2015 WITH STANDARDS IN PLACE, CARS AND TRUCKS**



Source: Estimated from Leard et al. (2016a) under alternative price forecasts.

Notes: Reference case is the “no standards” case. Total sales in each period are normalized to the initial 2010 total in the 2010 high price forecast.

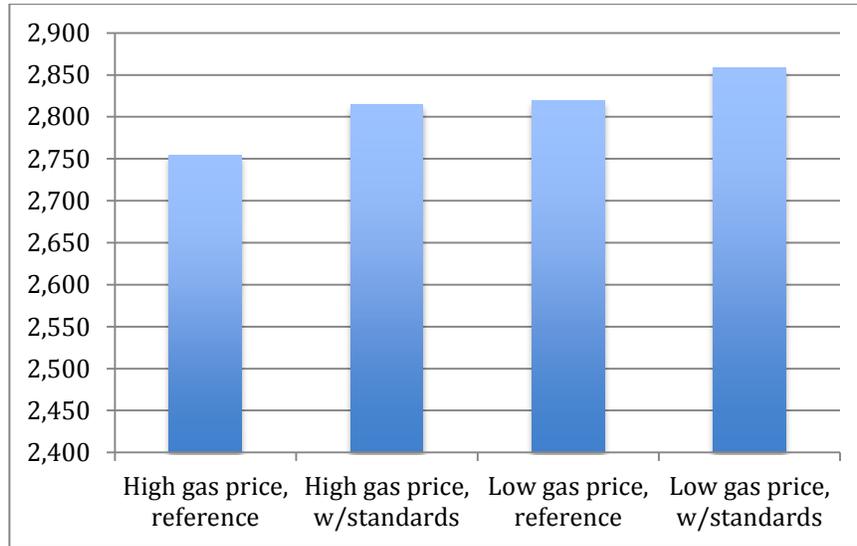
### 3.1. Fuel Consumption and Emissions

Figure 5 shows the results for total VMT for both cars and trucks for the 2015 model year, for both high and low gasoline prices, and with and without the CAFE/GHG standards in place. Because of the rebound effect, the standards increase VMT in both gasoline price cases. Comparing the two cases with the standards, low fuel prices cause people to drive more.

Figure 6 shows the average fuel consumption rate under the four cases (fuel consumption rate is defined as gallons per mile, or the reciprocal of mpg). The fuel consumption rate differs between the reference and standards cases because of the standards’ requirements for better fuel economy. With the standards imposed, the fuel consumption rate differs between the high and low gas prices because fuel prices affect the mix of vehicles and the sales-weighted level of fuel economy required by the standards. As we would expect, the standards reduce the fuel consumption rate in both the high and low gasoline price cases. And

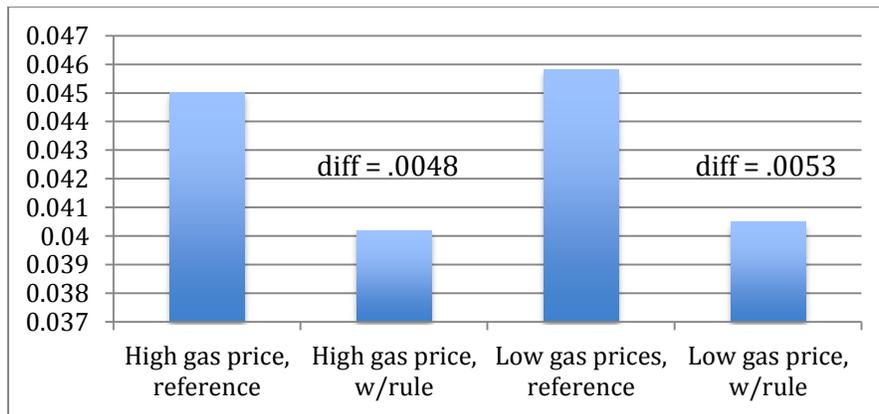
also as expected, the fuel consumption rate is slightly higher when gas prices are lower, both with and without the standards in place.

**FIGURE 5. TOTAL VEHICLE MILES TRAVELED (VMT), 2015 (BILLIONS OF MILES)**



Note: See Table 1 below for exact differences with and without standards.

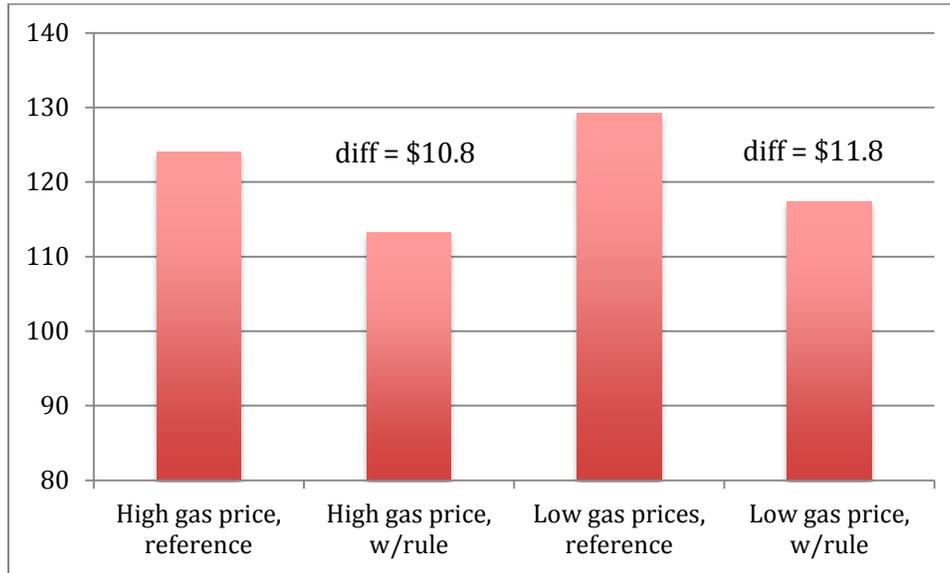
**FIGURE 6. AVERAGE FUEL CONSUMPTION RATE, 2015 (GALLONS PER MILE)**



Taken together, VMT and the fuel consumption rate determine total fuel use. Figure 7 shows that in both the high fuel price and low fuel price cases, the effect of the standards in reducing the fuel consumption rate offsets the effects of higher VMT, and total fuel consumption falls. And as Table 1 shows, the standards reduce total fuel consumption more when gasoline prices are low than when they are high. This is primarily because fuel savings under the standards are proportional to VMT, and lower fuel costs increase VMT.

Table 1 also shows the change in CO<sub>2</sub> emissions due to the standard. Because there are larger reductions in fuel use when gasoline prices are low, emissions reductions are also larger.

**FIGURE 7. TOTAL FUEL CONSUMPTION, 2015 (BILLIONS OF GALLONS)**



**TABLE 1. CHANGES DUE TO THE CAFE/GHG STANDARDS, UNDER DIFFERENT FUEL PRICE CASES**

Due to the CAFE/GHG standard	High gasoline prices	Low gasoline prices
Change in VMT	69 billion miles	78 billion miles
Change in fuel consumption	-10.8 billion gallons	-11.4 billion gallons
Change in CO <sub>2</sub> emissions	-95 million tons	-100 million tons

**3.2. Benefits and Costs of the Standards**

The values of fuel savings and the CO<sub>2</sub> emissions reductions constitute most of the benefits of the standards. To estimate fuel savings, we first estimate the fuel consumption for vehicles sold in model year 2015 for each year the vehicles are expected to remain on the road after 2015. We monetize fuel consumption using gasoline prices net of taxes,<sup>5</sup> and we compute the present discounted value (PDV) of the stream of expenditures. These are shown as the first column in Table 2. The value of fuel savings due to the standards is shown as the difference in the PDV of expenditures in the reference and standards cases using a 3 percent discount rate. As discussed above, the effect of low gasoline prices on the value of fuel savings depends on two opposing effects: the change in the price per gallon of fuel (negative) and the change in fuel savings (positive). On balance, the lower fuel prices dominate the higher fuel savings, and

<sup>5</sup> The price net of taxes is the best estimate of the social cost of fuel. Taxes are considered a transfer and not a cost.

the value of fuel savings is quite a bit lower under the low fuel price case—almost \$6 billion, or 22 percent. The decline in gasoline prices is forecast to be about 25 percent over the period, which, as we expect, is greater than the percentage decrease in the value of fuel savings. The difference between 22 percent and 25 percent reflects the increase in fuel savings caused by low fuel prices. Overall, the lower cost of fuel more than offsets the greater fuel savings.

Table 2 also shows the CO<sub>2</sub> reductions in the high and low gasoline price cases. We do not account here for changes in emissions of non-CO<sub>2</sub> GHGs or for other air pollutants that also contribute to the external costs of driving. The CO<sub>2</sub> benefits are proportional to the fuel savings. We convert gallons of fuel to tons of CO<sub>2</sub> emissions, and the resulting total CO<sub>2</sub> emissions are shown in the second column. Total tons of CO<sub>2</sub> emissions are lower under the standards, but they are higher with low gasoline prices because of the increase in travel. The difference in tons reduced under the standards is greater with low prices, which is consistent with the fuel savings results in Table 1. We monetize the CO<sub>2</sub> reductions according to the US government estimates of the social cost of carbon throughout the life of the vehicles (IWG 2015). We take the PDV of these benefits using a 3 percent discount rate. The dollar value of the CO<sub>2</sub> benefits of the standards is larger in the low fuel price case.

**TABLE 2. EFFECT OF LOW FUEL PRICES ON FUEL SAVINGS AND CO<sub>2</sub> REDUCTIONS OF THE CAFE/GHG STANDARDS (INCLUDING BOTH CARS AND TRUCKS)**

	PDV of total fuel expenditures (3%, millions 2007\$)	CO <sub>2</sub> emissions (billions of tons)	PDV of CO <sub>2</sub> benefits (3%, millions 2007\$)
High gas price, reference case	\$296,050	1,085	
High gas price, w/ standards	\$270,024	990	
Difference between low and high price cases	-\$26,025	-95	\$3,316
Low gas price, reference case	\$223,957	1,100	
Low gas price, w/standards	\$203,667	1,000	
Difference between low and high price cases	-\$20,290	-100	\$3,599

As we discussed above, low fuel prices increase the costs to manufacturers of meeting the requirements. This is because low gasoline prices cause consumers to shift to larger vehicles, but the level of fuel economy consumers want decreases more than the fuel economy the manufacturers must attain. Therefore, in the long run the manufacturer will have to add further fuel-saving technologies to meet the standards (as noted above, because of a lack of empirical evidence we do not allow for the possibility that low gasoline prices cause manufacturers to increase the size of their vehicles).

As in Leard et al. (2016b), we first estimate the marginal costs of additional improvements to the fuel economy of each manufacturer's fleet. The agencies report the costs to manufacturers of achieving various levels of stringency. Using these data, we fit a linear function for each manufacturer for the several levels of stringency the agencies consider.<sup>6</sup> This yields an estimate of the cost per mpg improvement for each manufacturer, which we refer to as marginal costs. A graph of these costs by manufacturer is shown in the Appendix in Figure A2.

We use these estimates to determine the costs of the needed improvements for each manufacturer to reach its requirement. In Leard et al. (2016a), we estimate the effect of fuel prices on the fuel economy consumers would choose in the absence of the standards and the fuel economy manufacturers must attain, separately for each manufacturer and car/truck class. On average, low fuel prices create a 0.2 mpg gap between fuel economy consumers choose and fuel economy manufacturers must attain across the fleet. We multiply the manufacturer and class-specific gaps by the corresponding marginal costs and sum across manufacturers and classes.

The first two rows of Table 3 show costs for cars and trucks separately, and the third row shows costs for the fleet as a whole. The table reports sales-weighted averages, thereby accounting for the effects of fuel prices on market shares. The first column shows that marginal costs are higher for trucks than for cars. But the decrease in fuel prices creates a greater gap for cars than for trucks, and the second column shows that the cost per vehicle turns out to be higher for cars than for trucks. The third column shows the increase in the total costs of getting to the standard caused by low gasoline prices.

**TABLE 3. THE ADDITIONAL COSTS OF MEETING THE STANDARDS WHEN GASOLINE PRICES FALL**

	Sales weighted marginal costs (costs per mpg per vehicle, 2007\$)	Average additional cost per vehicle of getting to the standards (2007\$)	Change in costs of getting to standards (millions 2007\$)
Cars	\$198	\$44	\$323
Trucks	\$531	\$28	\$232
Cars and trucks combined	\$374	\$35	\$555

<sup>6</sup> We use three levels of stringency, 3 percent, 4 percent, and 5 percent improvement, for this analysis. The agencies' preferred level is in the middle of these three estimates.

Table 4 summarizes our findings of the effects of lower fuel prices on the costs and benefits of the standards. The table shows how lower fuel prices affect the estimated costs and benefits for the 2015 model year cars and trucks.

The bottom two rows summarize the effects of lower fuel prices on net benefits. Both the higher costs of the additional technology (first row) and the change in fuel savings reduce the net benefits. The change in costs is the same as that shown for all vehicles in Table 3. The changes in benefits include two components: the change in the value of fuel savings and the change in CO<sub>2</sub> benefits (second and third rows). The value of fuel savings declines with the lower fuel prices, as discussed above. The CO<sub>2</sub> benefits increase with lower prices because fuel use increases. However, the magnitude of the CO<sub>2</sub> benefits is small compared with the fuel savings. Overall, net benefits fall by about \$6 billion.

These estimates of benefits and costs differ from the approach to benefits and costs used by the agencies in their 2011 analysis. The higher costs in the first row would not be included if one were to use the agencies' framework for estimating benefits and costs. If this estimate of costs is not included, the estimated change in net benefits due to low gas prices would be about 9 percent lower. In calculating fuel savings, we account for the effect of low fuel prices on fuel consumption, including changes in the vehicle mix and in total miles driven. The agencies' framework does not include either response. We find that these effects are important and that the fuel price decline dominates the benefits. To examine the effect of including the elasticity of VMT to lower fuel prices, we reestimate our model using an elasticity of zero (no VMT response). We find that the benefits of the standards would be 10.5 percent lower, as shown in the last row in of Table 4. In summary, omitting the behavioral responses understates the costs but also understates the benefits. In this example, the two errors roughly cancel out, but that need not be the case in other situations.

**TABLE 4. SUMMARY OF EFFECTS OF LOWER GASOLINE PRICES ON COSTS AND BENEFITS OF THE STANDARDS**

	Effects of lower gas prices on 2015 vehicles (cars and trucks combined, millions of 2007\$)
Change in costs	
Change in costs of getting to standard due to lower prices	\$555
Changes in benefits	
Change in fuel savings from standards due to lower prices	-\$5,736
Change in CO <sub>2</sub> benefits due to lower fuel prices	\$283
Change in net benefits (change in benefits less change in costs)	-\$6,008
Change in net benefits if there were no VMT response to lower gasoline prices	-\$6,645

## 4. Conclusions

In this paper, we have characterized the consumer and manufacturer responses to falling gasoline prices that should be considered when assessing the costs and benefits of the CAFE and GHG standards. To illustrate the responses, we have used data and our own estimates of behavioral responses, including the change in vehicle mix both with and without the lower fuel prices, miles traveled, and how much manufacturers must increase fuel economy to meet the standards. We have also drawn on available evidence from the agencies for the underlying costs of additional improvements to fuel economy and from the economics literature for the elasticity of VMT to changes in the price of fuel.

The recently released EPA and NHTSA Draft Technical Assessment Report (EPA and NHTSA 2016) does include estimates of benefits and costs of the 2021–25 standards that are based on the gasoline price forecast released by the EIA in 2015. This forecast is the same one we use here for the low gasoline price case. In chapters 12 and 13 of the report, this new price forecast with the associated vehicle car and truck mix is used to assess costs and benefits. The car and truck mix is much closer to the observed mix in 2015, suggesting that this captures one of the important behavioral responses we identify here—changes in the shares of cars and trucks that consumers buy. But it does not include other responses to lower prices, such as changes in the mixes within the car and truck classes, costs to manufacturers, or the additional driving. We show that these behavioral responses can be important for the overall net benefits of the program.

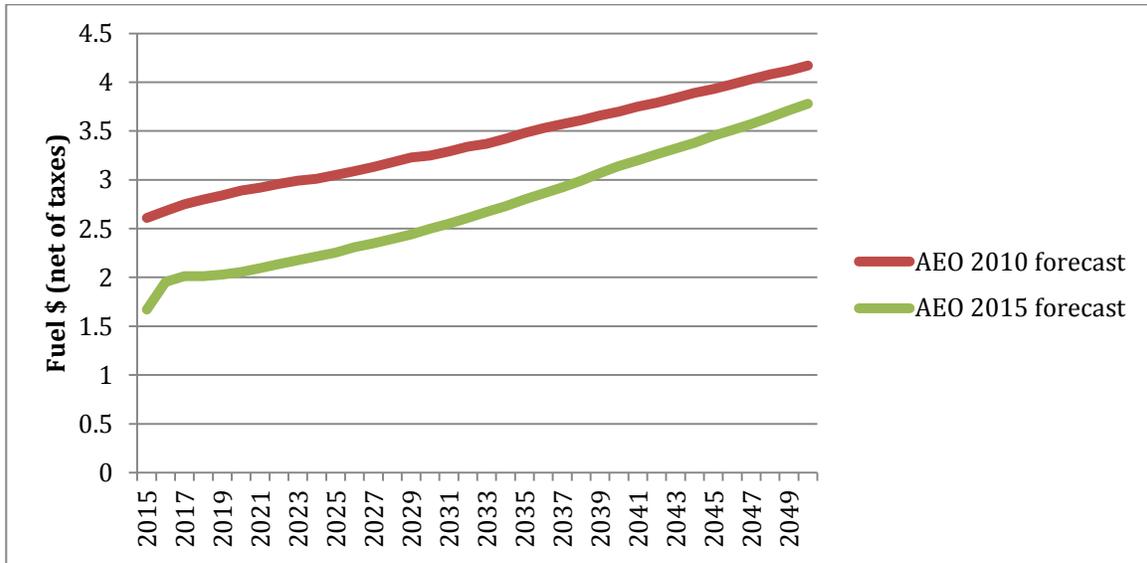
Our analysis focuses on one model year for which we have complete data. The analysis reflects behavioral responses to lower fuel prices between 2014 and 2015. Implications of lower fuel prices for benefits and costs could differ if low prices continue and if consumer and manufacturer responses are greater in the long run than the short run. Nevertheless, our analysis illustrates the importance of including behavioral responses to market conditions in benefit–cost analysis.

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## Appendix

**FIGURE A1. GASOLINE PRICE FORECASTS BY AEO 2010 AND AEO 2015, NET OF FEDERAL AND STATE TAXES**



Source: US Department of Energy

**FIGURE A2. MARGINAL COSTS: CHANGE IN PER-VEHICLE COSTS/CHANGE IN MPG BY MANUFACTURER**

