Assessment of Macroeconomic Impacts from Federal SAFE Proposal

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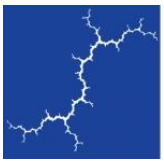

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EXECUTIVE SUMMARY

In August 2018, the U.S. Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) jointly issued a Notice of Proposed Rulemaking (NPRM) called the "Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks" (herein referred to as "Proposed Rollback"). The proposal would roll back existing Corporate Average Fuel Economy (CAFE) and tailpipe greenhouse gas (GHG) emission standards established by the Obama administration to model year (MY) 2020 levels for MYs 2021 through 2026. Under the existing CAFE and GHG standards, requirements grow increasingly stringent through MY 2025.

This report assesses the macroeconomic impacts of the Proposed Rollback. We find that the macroeconomic analysis included in the NPRM is incomplete because (1) it does not analyze the gross domestic product (GDP) impacts of the Proposed Rollback and (2) it provides only a partial analysis of the employment impacts of the Proposed Rollback. We further find that the analysis included in the NPRM is flawed due to its use of several key assumptions that do not comport with generally accepted values and expectations.

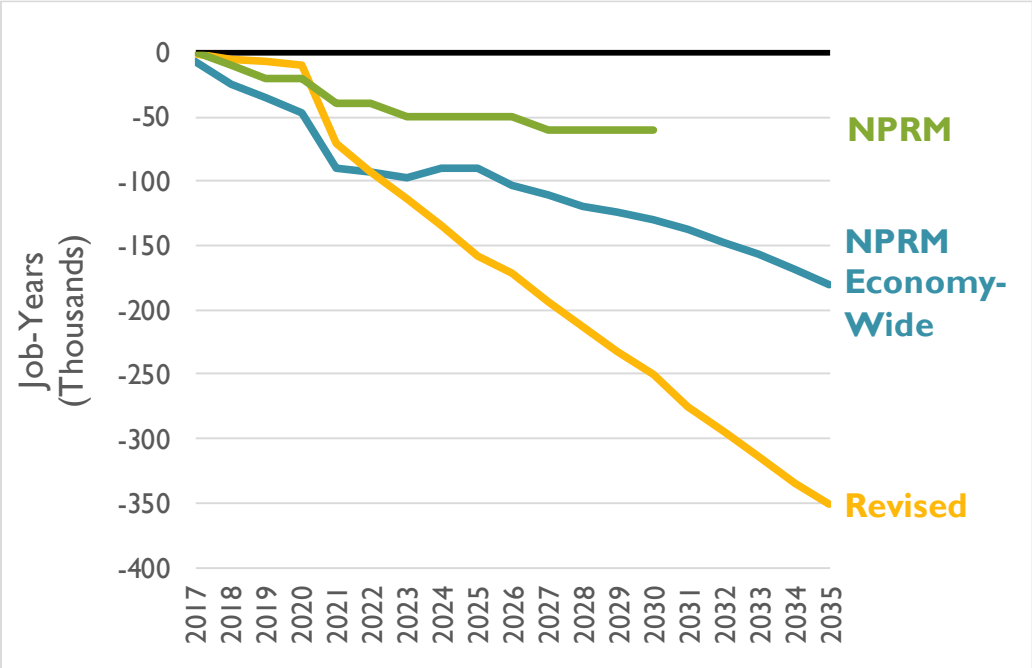
We therefore provide our own analysis of the macroeconomic impacts of the Proposed Rollback. Our analysis is grounded in the use of two related models: a total cost of ownership (TCO) model used to estimate the impacts of the existing standards on vehicle sales and an IMPLAN-based macroeconomic model used to analyze the GDP and employment impacts from the existing standards. We evaluate two scenarios: an NPRM Economy-Wide scenario, in which we attempt to replicate the inputs and assumptions included in the NPRM while expanding the analysis to include the full U.S. economy, and a Revised scenario, in which we update several key inputs and assumptions to more reasonable and defensible values. Our primary findings are the following:

- **The Proposed Rollback results in a reduction in vehicle sales for every year beginning in 2021.** Under our Revised scenario, we find that the Proposed Rollback will result in an increase in the perceived total cost of owning a car or truck for every year beginning in 2021. This increase in total ownership costs (accounting for fuel and insurance costs as well as up-front compliance costs) in turn drives a decrease in the number of vehicles sold. Our Revised scenario finds that car sales will decrease by more than 1 percent for MY 2025 and 2035 vehicles and light-truck sales will decrease by more than 2 percent for MY 2025 vehicles and MY 2035 vehicles.

- **The Proposed Rollback results in job losses in each year of our study period.** Like the NPRM analysis, both our NPRM Economy-Wide and Revised scenario analyses indicate that the Proposed Rollback will result in job losses. The NPRM's limited employment analysis indicated employment reductions of 50,000 in 2025 and 60,000 in 2030. Our NPRM Economy-Wide scenario shows losses of approximately 90,000 job-years in 2025

and over 180,000 job-years in 2035.[1] Under Revised scenario assumptions, the Proposed Rollback results in still greater employment reductions of nearly 160,000 in 2025 and 350,000 in 2035.

Figure ES-1. Employment Impacts of Proposed Rollback Under NPRM, NPRM Economy-Wide, and Revised Scenarios[2]



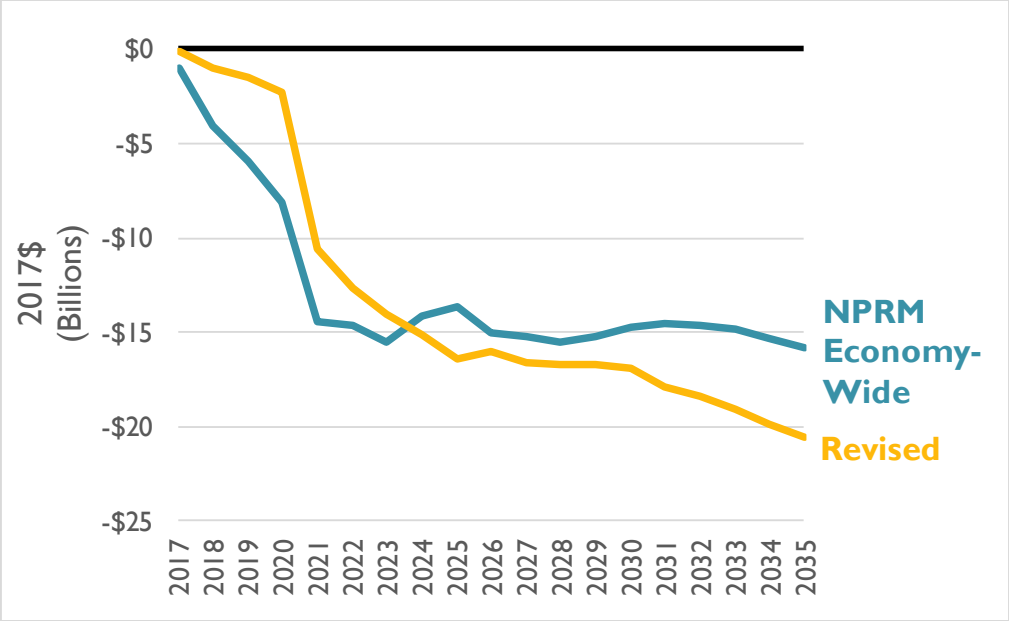
Note: The NPRM Economy-Wide scenario attempts to replicate the inputs and assumptions included in the NPRM while expanding the analysis to include the full U.S. economy, whereas the Revised scenario updates several key inputs (including compliance costs, gas prices, and the rebound effect) to more reasonable values.

- **The Proposed Rollback results in negative GDP impacts in each year of our study period.** As in our employment analysis, we find negative GDP impacts from the Proposed Rollback under both the NPRM Economy-Wide and Revised scenarios. Under the NPRM Economy-Wide scenario, annual GDP reductions amount to $14 billion in 2025 and $16 billion in 2035. Under the Revised scenario, annual GDP losses amount to $16 billion in 2025 and $21 billion in 2035.

[1] Throughout this report, we present employment impacts in terms of job-years. One job-year represents one job that lasts for one year. Because we only report employment impacts on an annual basis, these employment results can also be thought of in terms of the change in the average number of jobs in a given year.

[2] Here and throughout the rest of the report we provide inputs and results for MYs 2017 through 2035. We acknowledge that MY 2017 is a historical year but include it for consistency with the NPRM.

Figure ES-2. GDP Impacts of Proposed Rollback Under NPRM Economy-Wide and Revised Scenarios



Ultimately, we find that the Proposed Rollback will lead to increased gasoline expenditures, which will have negative repercussions for the U.S. economy as a whole. Any positive impacts experienced by the petroleum industry and its suppliers will be more than offset by GDP and employment reductions in the auto industry and the broader economy. We conclude that the Proposed Rollback is likely to have negative net impacts on the U.S. economy in terms of both employment and GDP.

1. BACKGROUND

In August 2018, the U.S. EPA and NHTSA jointly issued an NPRM proposing to implement a "Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks." Through this NPRM, NHTSA and EPA propose to revise certain CAFE and tailpipe GHG emission standards established by the Obama administration. Specifically, the agencies propose to hold these standards constant at MY 2020 levels through MY 2026.[3] This marks a departure from current regulations, under which CAFE and GHG standards grow more stringent through MY 2025.

The NPRM includes a variety of assumptions and analyses in support of the proposal, including an employment impact analysis and a cost-benefit analysis.[4] Through these analyses, NHTSA and EPA estimate that freezing CAFE and GHG standards will result in net present value benefits to the U.S. economy. They also find that rolling back existing standards will result in job losses in the auto sector.

This report provides an outside assessment of the likely macroeconomic impacts of the Proposed Rollback. Specifically, we:

1. Briefly review and evaluate the economic analyses presented in the NPRM;
2. Discuss certain key input assumptions to the NPRM analysis and identify specific assumptions that are vague and/or unreasonable; and
3. Present the results of a modeling exercise intended to capture the full range of macroeconomic impacts from the SAFE standards. This exercise deviates from the incomplete NPRM analysis by exploring economy-wide impacts (rather than just impacts within the automotive sector), evaluating GDP as well as employment impacts, and examining the effect of using an updated set of assumptions.

2. REVIEW OF EPA AND NHTSA EMPLOYMENT AND COST-BENEFIT ANALYSES

Two types of analyses that are commonly used to evaluate a policy decision are (1) cost-benefit analyses and (2) macroeconomic analyses. Cost-benefit analyses parse the costs and benefits of a proposal and

[3] NHTSA and EPA. *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks*, p. 42,989. Available at https://www.gpo.gov/fdsys/pkg/FR-2018-08-24/pdf/2018-16820.pdf.

[4] See NPRM, Section II-E-3, "New Vehicle Sales and Employment Assumptions," beginning on p. 43,070. Results from the cost-benefit analysis are presented in Tables II-25 through II-28 of the NPRM, pp. 43,062 to 43,066.

are used to identify whether the costs of the proposal outweigh the benefits. Macroeconomic analyses estimate the impacts of the proposal on economic indicators such as GDP and employment. While the NPRM presents a detailed cost-benefit analysis (albeit one that relies on a variety of questionable input assumptions), it provides little in the way of an assessment of impacts on GDP and employment from the Proposed Rollback.

The primary justification offered by NHTSA and EPA for the NPRM is the agencies' conclusion that the Proposed Rollback will result in hundreds of billions of dollars in net societal benefits. In its presentation of the benefits and costs of its proposal, NHTSA estimates that freezing CAFE regulation will result in net present value benefits of $176 billion, at a 3 percent discount rate.[5] EPA estimates net benefits of $201 billion from revising the GHG standards, at a 3 percent discount rate.[6] These findings of large benefits arise primarily from the following analytic conclusions:

1. That increased compliance costs associated with more stringent standards outweigh any associated fuel savings.

2. That the compliance costs associated with more stringent standards would lead to a decrease in new vehicle sales and an increase in the number of used vehicles on the road. This increased use of older, less safe vehicles would in turn result in greater personal injury and property damage.

3. That more stringent standards would create more negative externalities associated with increased driving than they would eliminate by reducing fuel usage.

The agencies' employment analysis exclusively focuses on automotive labor, accounting for changes in labor in auto dealerships, at auto assembly plants, and in the construction of fuel saving technologies. The agencies unconvincingly argue that employment effects related to other industries are too uncertain and difficult to attempt to predict.[7] By focusing exclusively on automotive labor, the agencies present incomplete results. Their employment analysis does not account for the following:

1. Effects on automotive supply chains;

2. Impacts on the petroleum sector and its supply chains; and

3. Economy-wide impacts as changes in consumer spending on automobiles and fuel affect the remaining income left to spend on other goods and services.

These are major oversights. Reductions in fuel costs constitute one of the core benefits of the CAFE and GHG standards. To conduct an employment analysis of a fuel economy regulation that does not in any way account for the ramifications of gasoline savings on the petroleum sector or on the wider economy

[5] NPRM, Table II-25, p. 43,062.

[6] NPRM, Table II-27, p. 43,065.

[7] NPRM, p. 43,436.

is to conduct an insufficient analysis. Similarly, the failure to include supply chain effects indicates an incomplete analysis. Conducting a more complete employment analysis is clearly feasible, as there are a variety of input-output models designed specifically to account for these broader societal impacts.[8] Other recent analyses of the employment impacts of CAFE regulations have explicitly accounted for these effects.[9]

Even the agencies' limited employment analysis finds negative impacts on the auto sector from the Proposed Rollback. Their analysis estimates that the Proposed Rollback will result in an employment decrease of approximately 50,000 by 2025 and 60,000 by 2030.[10] This amounts to a 5 percent reduction in automotive industry employment.

The agencies do not provide an analysis of the estimated GDP impacts from the Proposed Rollback in the NPRM. Therefore, the agencies do not present a full picture of macroeconomic impacts from the Proposed Rollback.

3. REVIEW OF EPA AND NHTSA KEY ASSUMPTIONS

The NPRM identifies several assumptions that are critical both to a cost-benefit analysis and to a full-scale economic impact analysis. However, the NPRM presents some assumptions in a vague or confusing manner. Specifically, the following inputs lack clarity:

- **Compliance costs.** These represent the average, per-vehicle, incremental cost of a vehicle that complies with the Proposed Rollback standards for a given MY relative to the baseline of a vehicle that complies with the existing standards. The NPRM provides two separate sets of compliance costs in Tables VII-4 and VII-5. The compliance costs differ for MYs 2022, 2024, and 2025 through 2030, and the NPRM does not state which set of compliance costs are used in the analysis.

[8] Popular examples include the IMPLAN and REMI models. These models are used by academics, consultants, government agencies, and nonprofits. They are used to inform policy decisions, to analyze the impacts of policy on regional and/or national output and employment, and to evaluate the effects of business relocation, to name a few general uses. We discuss IMPLAN in greater depth in Appendix A: Modeling Details.

[9] Carley, S., D. Duncan, J. D. Graham, S. Siddiki, N. Zirogiannis. March 2017. *A Macroeconomic Study of Federal and State Automotive Regulation*s. Available at https://spea.indiana.edu/faculty-research/research/working-groups/clean-vehicles.html; McAlinden, S., Yen Chen, Michael Schultz, and David J. Andrea. 2016. The Potential Effects of the 2017-2025 EPA/NHTSA GHG/Fuel Economy Mandates on the U.S. Economy. Prepared by the Center for Automotive Research. Available at https://www.cargroup.org/publication/the-potential-effects-of-the-2017-2025-epanhtsa-ghgfuel-economy-mandates-on-the-u-s-economy/; Allison, A., J. Hall, F. Ackerman. 2018. *Cleaner Cars and Job Creation: Macroeconomic Impacts of Federal and State Vehicle Standards*. Synapse Energy Economics for UCS, NRDC, ACEEE. http://www.synapse-energy.com/sites/default/files/Cleaner-Cars-and%20Job-Creation-17-072.pdf.

[10] NPRM, Table VII-26, p. 43,291.

- **Consumer valuation of savings.** The NPRM states that buyers of new cars and light trucks likely value between half of and all future fuel savings, rather than the 32 percent the agencies previously assumed.[11] However, the NPRM does not appear to identify the exact consumer valuation assumptions used in the estimation of vehicle sales and scrappage impacts. In fact, the discussion of the sales model in the Preliminary Regulatory Impact Analysis (PRIA) suggests that the agencies do not account for any consumer valuation of fuel savings when estimating the change in vehicle sales from the Proposed Rollback. Table 8-1 provides coefficient estimates for the sales model, and neither a consumer valuation of fuel savings nor a net price premium variable is included.[12]

Additionally, some of the assumptions used in the NPRM analyses do not comport with generally accepted values and expectations:

- **Compliance costs.** While the NPRM does not present internally consistent compliance cost assumptions, it is clear that the NPRM assumes vehicle standard compliance costs that are far higher than the agencies' previous estimates.[13]

- **Rebound effect.** The NPRM relies on a 20 percent assumed rebound effect, rather than the 10 percent value previously used by the agencies.[14] This higher value has several important effects, including reducing the estimate of fuel savings from more stringent standards, increasing the estimate of on-road fatalities under more stringent standards, and all but eliminating agency estimates of local pollution benefits from more stringent standards. As detailed in a recent report by Professor Kenneth Gillingham, the existing literature supports a rebound effect estimate of approximately 10 percent but does not support a central estimate as high as the 20 percent value used in the NPRM.[15]

- **Impact of gas price changes on the U.S. economy.** The PRIA acknowledges that, by increasing global demand for oil, the Proposed Rollback will likely result in an increase in the price of oil and, ultimately, of gasoline.[16] However, the PRIA claims that, because a growing fraction of U.S. oil consumption is being supplied by U.S. oil producers, any change in the price of oil effectively amounts to an internal transfer payment and is irrelevant to an economic analysis.[17] This argument is belied by the agencies' emphasis on the impact of recent decreases in projected fuel prices on their assessment of fuel

[11] NPRM, p. 43,073.

[12] PRIA, Table 8-1, p. 953.

[13] NPRM, p. 42,994.

[14] NPRM, p. 43,107.

[15] Gillingham, K. 2018. *Comments on the Rebound Effect from Fuel Economy Standards*.

[16] PRIA, p. 1,071.

[17] PRIA, p. 1,073.

economy standards.[18] As the NPRM acknowledges elsewhere, fuel price assumptions affect a variety of factors relevant to an economic assessment of the Proposed Rollback, ranging from consumer propensity to purchase fuel-efficient vehicles to the typical distance driven by light-duty vehicles. To the extent that the Proposed Rollback will raise gas prices in ways not captured by the agencies' analysis, it will have more harmful effects than presented in the NPRM, as there will be a greater increase in fuel costs.

4. SYNAPSE MODELING METHODOLOGY

We used two separate models to conduct our analysis of the impacts of the Proposed Rollback. First, we used a spreadsheet-based TCO model to assess the vehicle sales and fuel savings impacts from the Proposed Rollback. Our TCO model accounts for a range of factors considered by a typical prospective purchaser of a new vehicle to determine the change in the perceived lifetime vehicle ownership costs resulting from the Proposed Rollback. Second, we used an IMPLAN-based macroeconomic impact model to analyze employment and GDP impacts. These two sets of models are complementary, as the macroeconomic impact model relies on outputs from the TCO model to produce results regarding the impact of the Proposed Rollback on the macroeconomy.[19]

4.1. TCO Methodology and Assumptions

We used a TCO model to assess the impacts of the Proposed Rollback on vehicle sales. A TCO model is distinguished by its accounting for factors beyond compliance costs when evaluating the impact of a change in fuel economy standards on vehicle ownership costs and vehicle sales. Our TCO model incorporates such key factors as financing options, insurance costs, and consumer valuation of fuel savings. In general, the relationship between vehicle standards and vehicle sales depends on two primary factors: (1) the perceived total incremental cost of a new rollback-compliant vehicle relative to a vehicle that complies with existing standards (referred to as "net price premiums" because they are compliance costs net of, e.g., consumer valuation of fuel savings) and (2) the responsiveness of the demand for new vehicles to changes in net price premiums (known as the price elasticity of demand).

We evaluated the effects of the Proposed Rollback on sales of cars and light trucks from 2017 through 2035. We measured all vehicle sales impacts of the Proposed Rollback relative to a baseline in which the tighter existing standards remain in place.

[18] See NPRM, pp. 42,992-42,993 ("If fuel prices are high, the value of those gallons may be enough to offset the cost of further fuel economy improvements, but … the most recent reference case projections in the Energy Information Administration's (EIA's) Annual Energy Outlook … do not indicate particularly high fuel prices in the foreseeable future … In 2012, the agencies projected fuel prices would rise significantly…Things have changed significantly since 2012, with fuel prices significantly lower than anticipated, and projected to remain low through 2050.")

[19] Both of these models are discussed further in Appendix A: Modeling Details.

We modeled two separate scenarios. First, we evaluated an "NPRM Economy-Wide" scenario in which we attempted to replicate all inputs and assumptions documented in the NPRM while also expanding the analysis to include the full U.S. economy. Key assumptions for the NPRM Economy-Wide scenario include:

- **Gross price premiums (also known as compliance costs).** In these analyses, the gross price premium is a negative value, as the Proposed Rollback is expected to reduce the average vehicle price. We used the gross price premiums from Table VII-26 in the NPRM.[20] Under these assumptions, the gross price premium from the Proposed Rollback begins at approximately -$100 per vehicle in 2017 and drops to -$2,500 per vehicle in 2025.

- **Gas prices.** The NPRM notes that the analysis uses estimates of fuel prices from the U.S. Energy Information Administration's Annual Energy Outlook (AEO) 2017.[21]

- **Vehicle miles traveled (VMT) schedules.** The PRIA includes new base VMT schedules for passenger cars and light trucks, which we rely on.[22]

- **Baseline vehicle sales.** The NPRM presents a baseline light-duty vehicle sales projection from the CAFE model through 2029.[23]

- **Consumer valuation of fuel savings.** The Proposed Rollback reduces the upfront cost of a vehicle but increases the amount spent on gasoline throughout the life of the vehicle. Consumers are thought to consider not only the upfront costs of a new vehicle, but also a stream of expected future gas savings. In line with one approach suggested in the NPRM, we assumed consumers value 100 percent of lifetime vehicle fuel savings.[24]

- **Consumer financing.** We used the NPRM assumption that 70 percent of new vehicle costs will be financed and only 30 percent will be paid up front. We used additional financing assumptions from the NPRM which state that those who finance will do so at an annual interest rate of 4.25 percent over a loan term of 68 months.[25]

- **Price elasticity of demand.** The NPRM does not explicitly state the value that is used for the price elasticity of new vehicle demand. Instead, it provides a range of coefficients from its econometric model between -0.2 to -0.3. We therefore used the average of these two values, -0.25.

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[20] Throughout our analysis, we use assumptions taken from the GHG standard analysis conducted by EPA. These assumptions are similar to, but not identical to, the assumptions associated with NHTSA's CAFE analysis.

[21] NPRM, p. 43,069.

[22] PRIA, pp. 971 and 973.

[23] NPRM, Table II-32, p. 43,076.

[24] NPRM, p. 43,074.

[25] NPRM, pp. 42,994 and 43,080.

- **Rebound effect.** The rebound effect describes how VMTs respond to a change in vehicle operational costs resulting from a change in fuel efficiency. The NPRM assumes a rebound effect of 20 percent.

In addition to our NPRM Economy-Wide scenario, we modeled a "Revised" scenario in which we modified the NPRM scenario to incorporate more recently available data and revised assumptions. The updated assumptions associated with our Revised scenario include:

- **Revised compliance costs** provided by the California Air Resources Board (CARB). The compliance costs included in the NPRM are notably larger than those included in the agencies' 2016 Draft Technical Assessment Report (TAR).[26] CARB has reviewed the compliance costs included in the NPRM and has concluded that they are not valid; instead, it proposes relying on the most recent reasonable compliance cost numbers put forth by the agencies—i.e., those based on the modeling conducted for the agencies' 2016 Draft TAR reviewing existing GHG and CAFE standards. Comparisons between the revised compliance costs and those included in the NPRM are provided in Figure 1 and Figure 2 below.

- **Updated gas prices based on EIA's AEO 2018 Reference case**.[27] Under this latest forecast, gas prices are expected to be somewhat higher than forecasted under AEO 2017 (see Figure 3 below).

- **Use of a rebound effect of 10 percent** rather than the 20 percent value used in the NPRM. A 10 percent rebound effect is consistent with the value used in previous agency filings and is consistent with the latest literature on the rebound effect.[28]

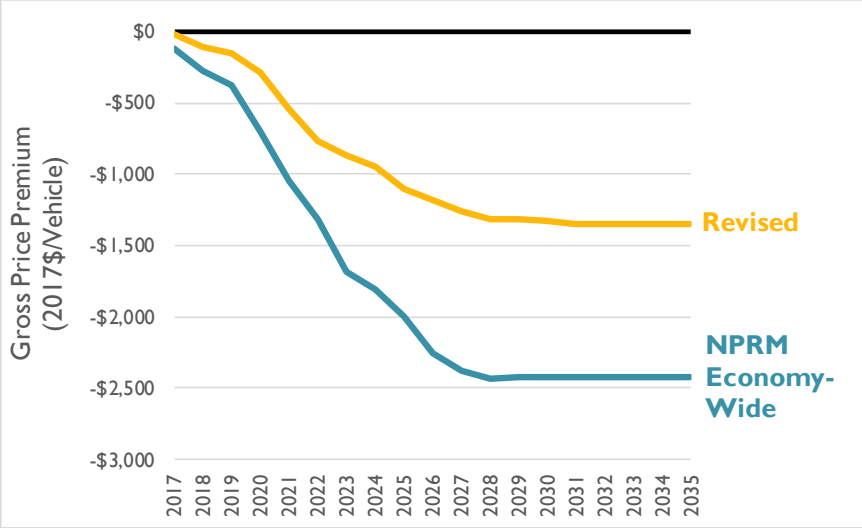
- **Achieved fuel economy levels that meet but do not exceed the standards.** In this Revised scenario, we assume that new vehicles will meet the relevant CAFE and GHG standards but will not exceed them. This differs from the NPRM Economy-Wide scenario, as the NPRM assumes that new vehicles will over-comply with the standards in many years.

[26] EPA, CARB, &NHTSA. July 2016. *Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025*.

[27] U.S. Energy Information Administration. AEO 2018. Table 12: Petroleum and Other Liquids Prices. Available at https://www.eia.gov/outlooks/aeo/excel/aeotab_12.xlsx.

[28] NHTSA, EPA, and California Air Resources Board. *Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025*, pp. 10-20; Gillingham, K. 2018. *Comments on the Rebound Effect from Fuel Economy Standards*.

Figure 1. Passenger Car Gross Price Premiums Under NPRM Economy-Wide and Revised Scenarios



Note: Here and throughout the rest of the report we provide inputs and results for MYs 2017 through 2035. We acknowledge that MY 2017 is a historical year but include it for consistency with the NPRM.

Figure 2. Light-Truck Gross Price Premiums Under NPRM Economy-Wide and Revised Scenarios

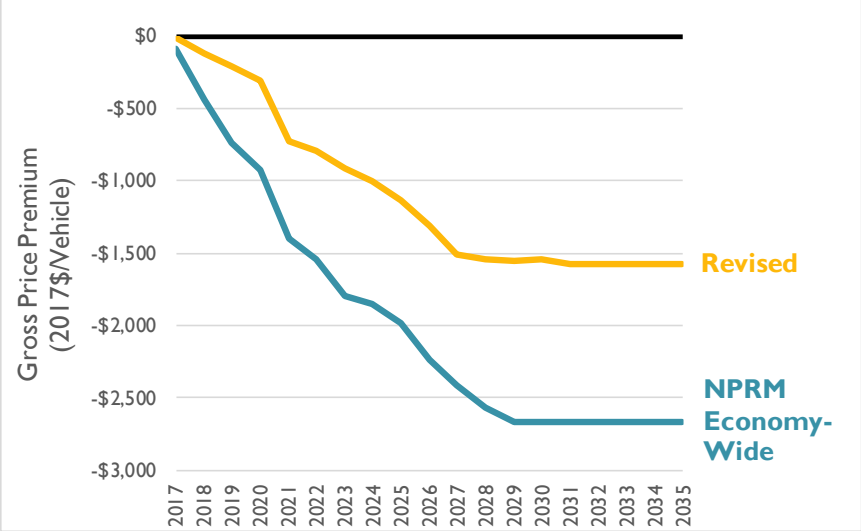
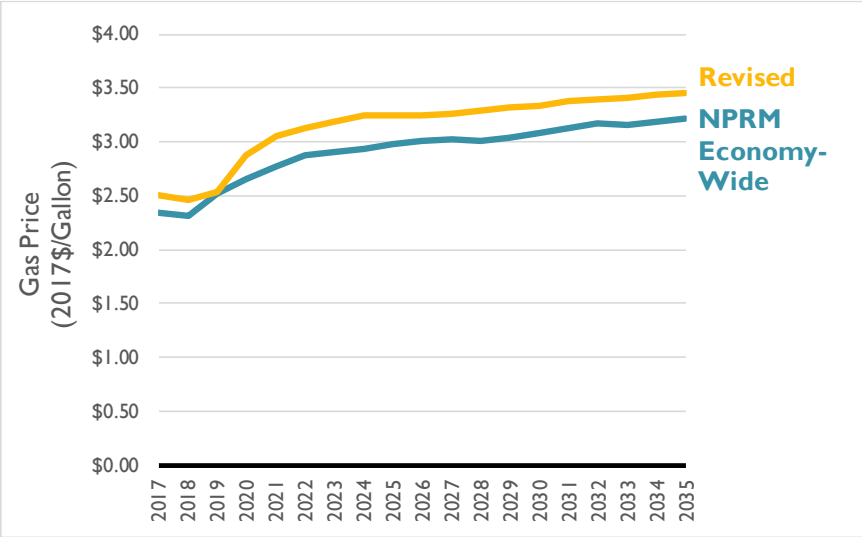


Figure 3. Gas Prices Under NPRM Economy-Wide and Revised Scenarios



Other than these modifications, the two scenarios maintain the same set of assumptions. A summary of the key assumptions included in the NPRM Economy-Wide and Revised scenarios is presented in Table 1 below. We provide many of these inputs in tabular format in Appendix A: Modeling Details.

Table 1. TCO Modeling Assumptions, NPRM Economy-Wide Scenario and Revised Scenario

Input	NPRM Economy-Wide Scenario	Revised Scenario
Gross Price Premium	Taken from NPRM, Table VII-26	Provided by CARB
Gas Prices	AEO 2017	AEO 2018
Vehicle Miles Traveled	Taken from PRIA, Figures 8-6 and 8-9	Taken from PRIA, Figures 8-6 and 8-9
Baseline Vehicle Sales	Taken from NPRM, Table II-32	Taken from NPRM, Table II-32
Consumer Valuation of Fuel Savings	Full valuation	Full valuation
Consumer Financing	70% of purchases financed; 68-month loan term, 4.25% loan rate	70% of purchases financed; 68-month loan term, 4.25% loan rate
New Vehicle Price Elasticity	-0.25 (the average of the range presented in the NPRM)	-0.25 (the average of the range presented in the NPRM)
Rebound Effect	20%	10%
Fuel Economy Compliance	Meets and exceeds standards	Meets but does not exceed standards

4.2. Macroeconomic Analysis Methodology and Assumptions

We used the IMPLAN input-output model to project GDP and employment impacts of the Proposed Rollback standards relative to a baseline of the tighter existing standards over MYs 2017 through 2035.

IMPLAN is a malleable, industry-standard model that is based on historical economic structures and relationships.[29]

We modeled three different mechanisms by which the Proposed Rollback will affect the macroeconomy. Each mechanism represents a separate pathway through which the Proposed Rollback impacts U.S. employment and GDP. The three mechanisms are:

Mechanism 1: Compliance Costs. This mechanism accounts for the economic impacts from the change in vehicle sales resulting from the Proposed Rollback.

Mechanism 2: Auto Sector Investment. This mechanism accounts for the employment and GDP impacts of decreased investment in auto technologies due to the Proposed Rollback.

Mechanism 3: Fuel Spending Impacts. This mechanism accounts for the economic impacts from the increase in fuel expenditures due to the proposed lower fuel economy standards, as well as the re-spending impacts from increased consumer spending on fuel.

For each of the three mechanisms, we account for three types of economic impacts:

- **Direct impacts.** These are changes in employment and GDP in sectors immediately impacted by the Proposed Rollback. These sectors include, for example, the auto manufacturing sector, as it will be directly impacted by the dampened need to incorporate new fuel-saving technologies in future cars.
- **Indirect impacts.** These are changes in employment and GDP in sectors that act as suppliers to directly affected industries. Examples of these sectors include the steel industry and other suppliers to automakers.
- **Induced impacts.** These are changes in employment and GDP associated with shifts in economy-wide consumer spending from the Proposed Rollback. These effects account for the decrease in disposable income resulting from increased fuel spending under the Proposed Rollback. They also incorporate changes in the consumer spending of employees in directly and indirectly impacted industries.

The inputs to our IMPLAN modeling are largely the same as those used in our TCO analysis. In both the NPRM Economy-Wide and Revised scenarios, we used the same inputs across both models for key assumptions such as gross price premiums, consumer valuation of fuel savings, consumer financing, price elasticity, and other relevant parameters. In addition, we used the changes in car and truck sales calculated in the TCO model as an input to our IMPLAN modeling. We also used TCO fuel spending outputs to determine changes in spending on gasoline for the IMPLAN analysis.

[29] This report uses the 2016 IMPLAN nationwide dataset, which is the most recently available national dataset at the time of writing.

Other key inputs to our macroeconomic modeling include:

- **Allocation of auto sector spending across IMPLAN industries.** We allocated changes in spending on the auto sector such that about 8 percent of spending on vehicle standards compliance for new vehicles goes directly to auto industry labor, 32 percent goes to materials and parts, 39 percent goes to overhead, 10 percent goes to dealers, 7 percent goes to shareholders, and 4 percent goes to research and development.[30]

- **Allocation of re-spending.** We assumed that 80 percent of new vehicles are purchased by households, 19 percent are purchased for corporate fleets, and 1 percent are purchased for government fleets.[31]

- **Consumer savings rates.** We relied on data from the U.S. Bureau of Labor Statistics Consumer Expenditure survey to calculate an average savings rate for purchasers of new vehicles.[32] Using these data, we assumed a savings rate of approximately 13 percent for households purchasing new cars. In other words, when a household saves $100, it will re-spend approximately $87 on other consumer expenditures and put the remaining $13 into a savings account where it is not immediately put back into the wider economy.

- **Industry import fractions.** We relied on IMPLAN's calculations of local purchase percentages to identify the percentage of import purchases from a given industry. As an example, IMPLAN assumes that approximately 81 percent of American spending on automobile manufacturing goes to American facilities and the remaining 19 percent goes to imports. We assumed that the same local spending percentages apply to ancillary industry categories such as management of automobile companies.

5. SYNAPSE MODELING RESULTS

5.1. TCO Results

Our TCO model estimates the change in vehicle sales due to the Proposed Rollback. It also generates two primary sets of results which then flow into the IMPLAN macroeconomic model. The first is a series of net price premiums for cars and light trucks (MYs 2017 through 2035). The net price premium represents the change in the consumer-perceived total cost of ownership for new cars and trucks due to the Proposed Rollback. This incorporates calculations related to the gross price premiums as well as

[30] These assumptions are based on federal compliance cost calculations as reported in a prior macroeconomic analysis of fuel economy standards conducted by authors based at Indiana University. Carley, S., D. Duncan, J. D. Graham, S. Siddiki, N. Zirogiannis. March 2017. *A Macroeconomic Study of Federal and State Automotive Regulations with Recommendations for Analysts, Regulators, and Legislators*. Available at https://spea.indiana.edu/faculty-research/research/working-groups/clean-vehicles.html

[31] *Id*.

[32] U.S. Bureau of Labor Statistics. Consumer Expenditure Survey. https://www.bls.gov/cex/tables.htm#avgexp.

consumer valuation of fuel savings. The second is the change in car and truck sales due to the net price premiums. The development of the change in car and truck sales is dependent on the net price premium as well as the price elasticity of demand. We assume the same price elasticity of demand for cars and trucks.

Figure 4 presents the passenger car net price premiums for both the NPRM Economy-Wide and the Revised scenarios. Under the NPRM Economy-Wide scenario, the passenger car net premium is negative for all model years (that is, the Proposed Rollback is perceived as reducing the total cost of ownership of new cars, which therefore increases sales). The net premium reaches a minimum value of almost -$700 for MY 2028 cars before becoming more positive in the years between 2028 and 2035, as compliance costs level off while gas prices continue to rise. In contrast, under the Revised scenario the passenger car net premium is positive for all model years starting in 2021 and reaches a maximum value of nearly $1,400 per vehicle for MY 2035 cars. This indicates that the Proposed Rollback increases the total cost of ownership of new cars and will therefore decrease new car sales for MYs 2021 through 2035 relative to a scenario in which the existing standards are left in place. The differences in results between the two scenarios is driven primarily by the differences in assumed compliance costs. Under the NPRM Economy-Wide scenario, the compliance costs are large enough that they outweigh the consumer valuation of fuel savings and result in a perceived net negative price premium from the Proposed Rollback. In contrast, the compliance costs used in the Revised scenario are outweighed by the impact of consumers' valuation of fuel savings and result in a positive perceived net price premium from the Proposed Rollback for most model years.

Figure 4. Car Net Price Premiums Under NPRM Economy-Wide and Revised Scenarios

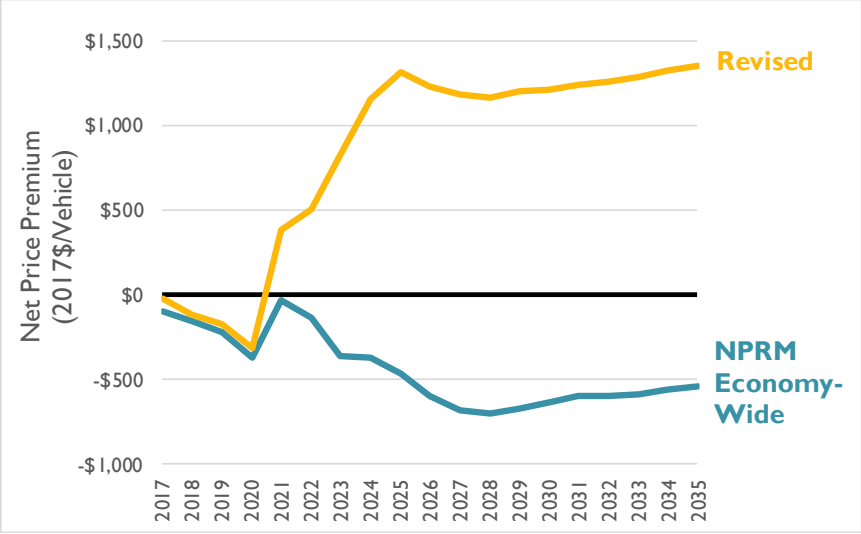


Figure 5 presents a different picture for light-truck net premiums. Under the NPRM Economy-Wide scenario, the net premium is initially slightly negative for MYs 2017 through 2020. It then becomes positive for the remainder of the study period, reaching values of over $500 per vehicle in MYs 2025 and 2035. Under the Revised scenario the net premium is positive for all model years beginning in 2021 and

reaches a maximum of over $3,300 in MY 2035. Under both scenarios, in the long run consumers perceive new rollback-compliant light trucks as being more expensive on a total ownership cost basis, largely because of increased fuel costs from the less fuel-efficient vehicles. As with passenger cars, the difference in these two sets of results is driven primarily by differences in assumed compliance costs.

Figure 5. Light-Truck Net Price Premiums Under NPRM Economy-Wide and Revised Scenarios

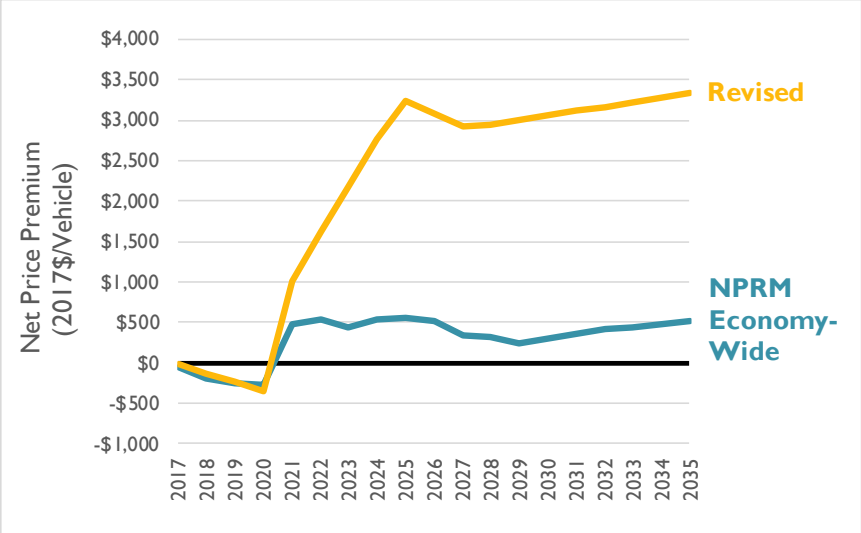
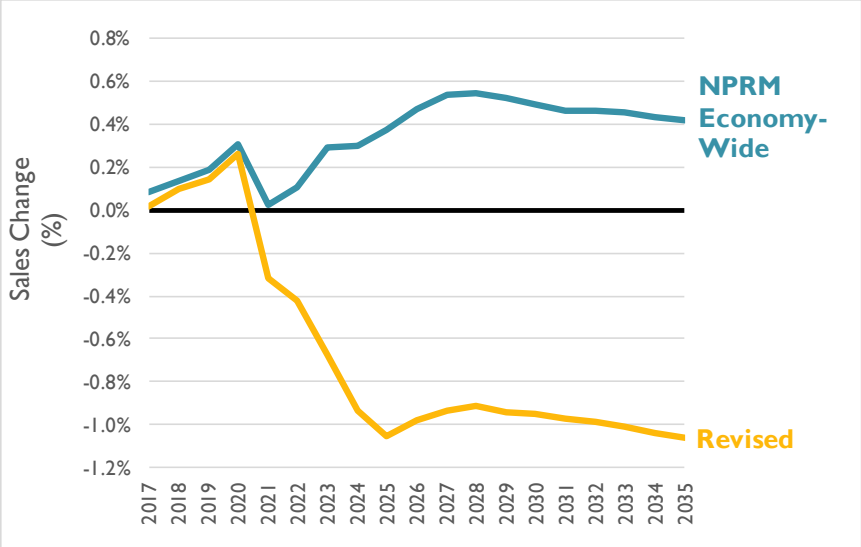


Figure 6 presents the effect of the Proposed Rollback on car sales for both the NPRM Economy-Wide and the Revised scenarios. Under the NPRM Economy-Wide scenario, the negative net price premiums result in an increase in vehicles sold, as more consumers decide to purchase new vehicles at lower perceived total cost of ownership levels. The maximum change in car sales under the NPRM Economy-Wide scenario is 0.55 percent for MY 2028 cars. In contrast, under the Revised scenario we estimate positive net price premiums from the Proposed Rollback beginning in 2021, which results in reduced car sales, as consumers decide not to purchase a new vehicle with a perceived higher cost. The change in car sales under the Revised scenario reaches a maximum effect of -1.06 percent for MY 2025 and 2035 cars.

Figure 6. Impact of Proposed Rollback on Number of New Cars Sold Under NPRM Economy-Wide and Revised Scenarios

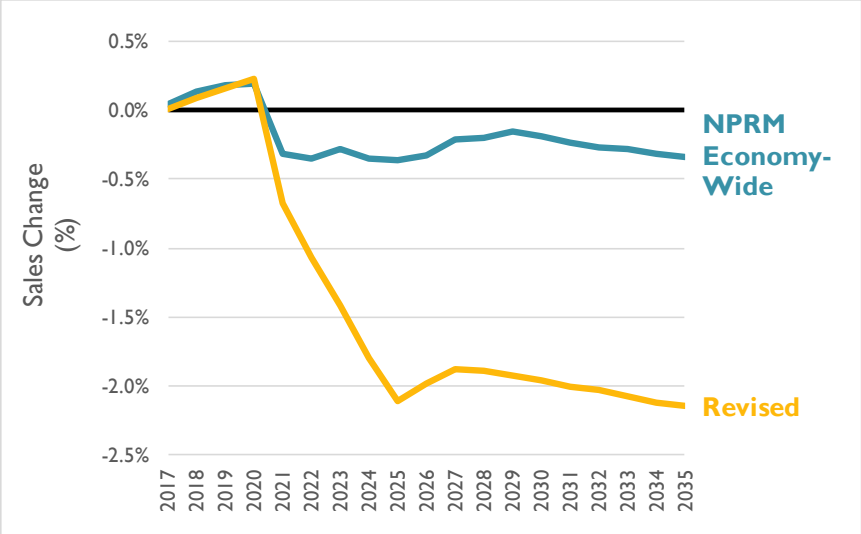


The difference between the NPRM Economy-Wide and Revised scenario TCO results is again primarily driven by the difference in assumed compliance costs.

Still, the impacts on total car sales in both scenarios are relatively modest. The increase in sales estimated under the NPRM Economy-Wide scenario never reaches 0.6 percent, and the change in sales estimated under the Revised scenario never reaches -1.1 percent. These impacts could be dwarfed by many other economic factors and changes in vehicle offerings.

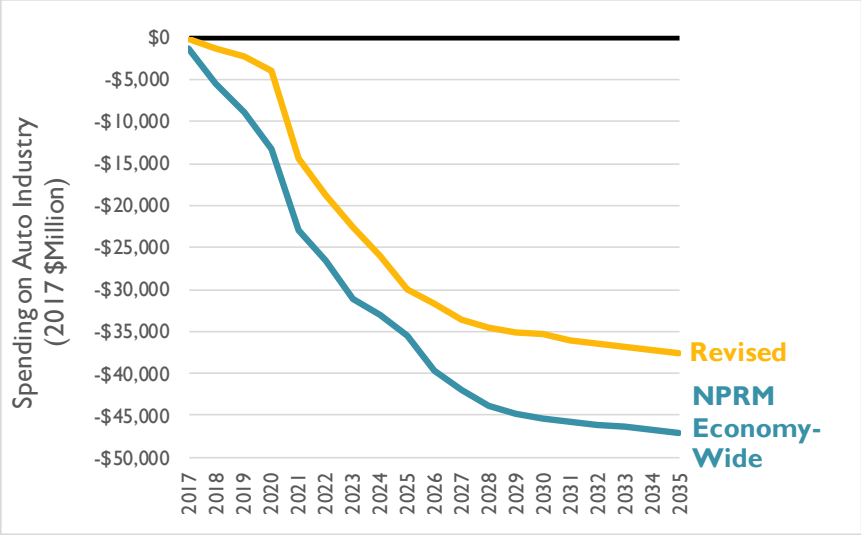
Figure 7 below shows the impact of the Proposed Rollback on truck sales under the NPRM Economy-Wide and Revised scenarios. In the case of light trucks, the NPRM Economy-Wide scenario shows an initial increase in sales from the Proposed Rollback before shifting to a negative change in sales for MYs 2021 through 2035. It reaches its largest absolute effect in MY 2025 when the estimated impact on sales of light trucks is -0.36 percent. Under the Revised scenario, the Proposed Rollback drives a decrease in vehicle sales in every year beginning in MY 2021, with the impact reaching -2.15 percent for MY 2035 light trucks.

Figure 7. Impact of Proposed Rollback on Number of New Light Trucks Sold Under NPRM Economy-Wide and Revised Scenarios



Under both the NPRM Economy-Wide and the Revised scenarios, the dollar value of vehicle sales decreases in every year, regardless of the change in the quantity of vehicle sales. Therefore, the amount of money going into the auto sector decreases. Figure 8 below presents the change in auto sector spending due to the Proposed Rollback and shows that the amount of money spent on the auto sector decreases in every year in the study period. Under the Revised scenario, the annual decrease in auto sector spending is over $37 billion for MY 2035. Under the NPRM Economy-Wide scenario, the maximum decrease in auto sector spending is over $45 billion for MY 2035.

Figure 8. Impact of Proposed Rollback on Auto Sector Spending Under NPRM Economy-Wide and Revised Scenarios



We provide these results in tabular format in Appendix A: Modeling Details.

5.2. Macroeconomic Modeling Results

Figure 9 presents the employment results from the NPRM Economy-Wide and Revised scenarios for MYs 2017–2035 compared with the employment impacts identified in the NPRM for MYs 2017–2030.[33] The employment analysis contained in the NPRM shows employment impacts that are negative, but less negative than those in the NPRM Economy-Wide and Revised scenarios. This is because the employment analysis in the NPRM only accounts for jobs within the automotive sector.

The results from the NPRM Economy-Wide scenario and the Revised scenario, presented in Figure 9, capture economy-wide employment impacts from the Proposed Rollback. We find a reduction in employment from the rollback in both scenarios. The NPRM Economy-Wide scenario shows employment reductions of 90,000 job-years in 2025 and over 180,000 job-years in 2035.[34] When we use revised assumptions for compliance costs, rebound effect, and fuel prices in our Revised scenario, we find employment reductions of nearly 160,000 in 2025 and over 350,000 in 2035. [35] The employment impacts in the NPRM Economy-Wide scenario are approximately half those in the Revised scenario.

The greater job losses under our Revised scenario are primarily a result of lower assumed compliance costs and a lower assumed rebound effect. Under the Revised scenario, estimated consumer savings on new vehicles are more moderate than under the NPRM Economy-Wide scenario, which assumes higher compliance costs for existing standards. As a result, under the Revised scenario, consumers save less on automotive vehicle expenditures and therefore have less disposable income to spend on other, more labor-intensive industries. Under a lower rebound effect, the Proposed Rollback leads to greater increases in consumer spending on gasoline and an associated reduction in consumer spending on other goods and services.

Under both scenarios, the Proposed Rollback leads to net job losses largely because the Proposed Rollback would increase the transfer of money to the petroleum industry, which is both more import-intensive and less labor-intensive than most consumer-facing industries.

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[33] NPRM, Table VII-26, pp. 43,291-43,292.

[34] Throughout this report, we present employment impacts in terms of job-years. One job-year represents one job that lasts for one year. Because we only report employment impacts on an annual basis, these employment results can also be thought of in terms of the change in the average number of jobs in a given year.

[35] We note that the results from this macroeconomic modeling exercise differ somewhat from the results presented in a recent report we prepared for Union of Concerned Scientists (UCS), "Giving Back Half the Gains: Macroeconomic Impacts of the Proposed Rollback in Federal Vehicle Standards." This is for two reasons. First, the analysis in the UCS report explores a separate scenario; that is, the report explores the macroeconomic impacts of the Proposed Rollback relative to a 2016-technology baseline. Second, the analysis in the UCS report relies on a separate set of assumptions – assumptions that are in line with a prior report we had prepared for UCS. These assumptions include a price elasticity of demand of -1, VMT schedules from the Draft TAR, and compliance costs developed by UCS in a modified version of the Volpe model. Nevertheless, both analyses arrive at the same general conclusion, which is that the Proposed Rollback will result in increasingly negative GDP and employment impacts relative to the existing standards.

Figure 9. Employment Impacts of Proposed Rollback Under NPRM, NPRM Economy-Wide, and Revised Scenarios

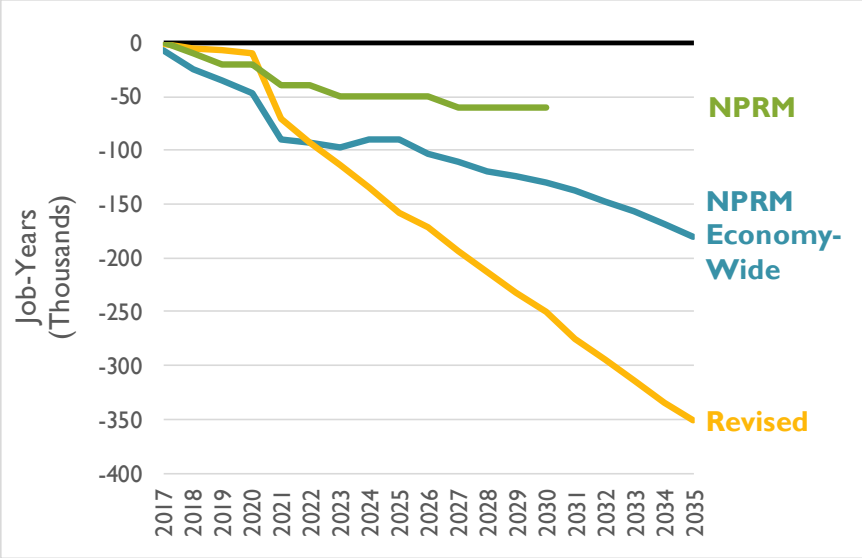
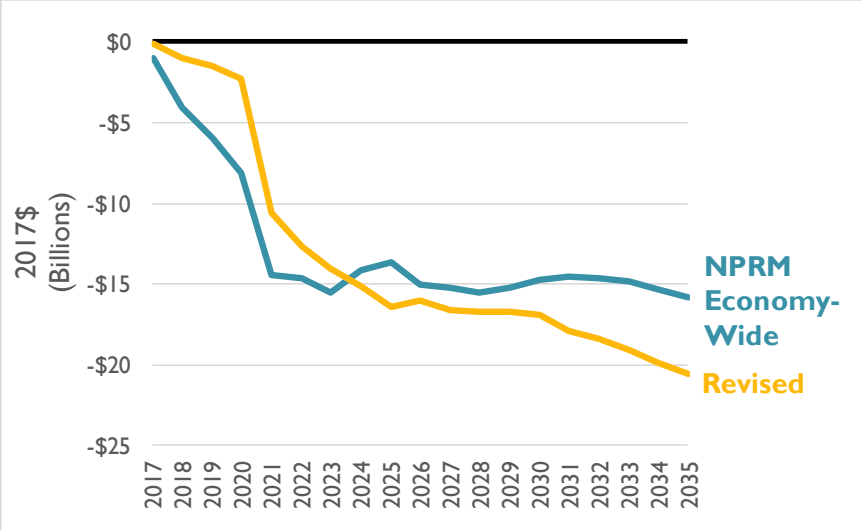


Figure 10 presents the GDP results of our macroeconomic modeling for the NPRM Economy-Wide and Revised scenarios.[36] We find that the Proposed Rollback would result in modest decreases in GDP relative to the baseline of the existing standards. GDP impacts are similar across the NPRM Economy-Wide and Revised scenarios. Under the NPRM Economy-Wide scenario, annual GDP reductions amount to $14 billion in 2025 and $16 billion in 2035. Under the Revised scenario, we find annual GDP reductions of $16 billion in 2025 and $21 billion in 2035.

[36] Unlike in Figure 9, we do not include a line representing the impacts under an NPRM scenario as the NPRM did not estimate GDP impacts.

Figure 10. GDP Impacts of Proposed Rollback Under NPRM Economy-Wide and Revised Scenarios



Under both the NPRM Economy-Wide and Revised scenarios, we find initial steep reductions in GDP for years 2017 through 2020 and a steadier decline for years 2021 through 2035. This is largely due to the NPRM assumptions about consumer financing that we included in our modeling. Because the upfront cost of a new vehicle is spread over nearly six years for 70 percent of consumers, there is a reduction in auto sector spending in the initial years that is much greater than the corresponding increase in consumer spending. By the fifth year of our analysis, the consumer spending effects begin to balance out the auto investment effects.

Notably, we see a much smaller deviation in GDP impacts between the NPRM Economy-Wide and Revised scenario than we see in employment impacts. This is largely due to the job intensity of the auto sector relative to the job intensity of generic consumer re-spending. In general, the auto sector—particularly the auto manufacturing industry—is capital-intensive and generates an unusually high level of GDP per job when additional spending is directed towards it. Generic consumer spending, on the other hand, often goes toward labor-intensive industries such as retail stores, and therefore generates more jobs than spending on the auto industry. Under the NPRM Economy-Wide scenario, the Proposed Rollback causes a larger reduction in spending on the auto sector than under the Revised scenario as it assumes higher compliance costs. This greater shift in spending from the auto sector to generic consumer goods has a positive effect on employment that offsets some of the losses associated with reduced fuel savings. However, this shift in spending has very little impact on GDP, since a dollar spent on the auto sector has a GDP impact similar to that of a dollar spent on a typical set of consumer goods and services.

Table 2 presents the macroeconomic results of our Revised scenario by category of initial expenditure for MYs 2025 and 2035. The impacts are broken out by those related to changes in spending on new vehicle purchases, those related to changes in spending on fuel purchases, and those related to changes in generic consumer spending. These impact breakouts can be thought of as analogues to the

mechanisms and IMPLAN effect types described above in Section 4.2. The impacts related to changes in spending on new vehicle purchases correspond to the direct and indirect effects of Mechanisms 1 and 2; the impacts related to changes in spending on fuel purchases correspond to the direct and indirect effect of Mechanism 3; and the impacts related to changes in generic re-spending correspond to the total consumer-related induced effects of all three mechanisms.

Table 2. Changes in Direct Spending and Associated GDP and Employment Impacts, Revised Scenario

	Spending Change (2017 $Billion)		GDP Impact (2017 $Billion)		Employment Impact (Thousand Job-Years)	
Spending Category	2025	2035	2025	2035	2025	2035
New Vehicle Purchase	-$30	-$38	-$37	-$47	-291	-366
Fuel Purchase	$33	$91	$28	$78	215	600
Generic Re-spending	-$6	-$40	-$7	-$52	-83	-585
Total	***-$3***	***$13***	***-$16***	***-$21***	***-159***	***-351***

In every year of our analysis, we find negative macroeconomic impacts driven by reduced spending in the auto sector. We find slightly positive impacts related to generic consumer re-spending for MYs 2017 through 2022, but those impacts become negative by MY 2023 and grow increasingly so through MY 2035 as the loss of fuel savings increasingly outweighs the reduced spending on new vehicles. On the other hand, we see increasingly positive impacts related to fuel purchases, as less fuel-efficient vehicles lead to greater consumer spending on fuel. In aggregate, we see negative macroeconomic impacts from the Proposed Rollback relative to the existing standards in every year of our study period.

6. DISCUSSION

6.1. Contribution of Findings

Our results indicate that the Proposed Rollback is likely to result in consistently and increasingly negative net employment and GDP impacts in the United States. Notably, this finding is consistent with the employment impact results presented in the NPRM. Our contribution is to expand the macroeconomic impact analysis contained within the NPRM and assess how that analysis is affected when conducted with more defensible input assumptions. Our key findings include that:

1. When examined on an economy-wide scale, the employment impacts of the Proposed Rollback are likely to be more negative than suggested in the limited NPRM analysis, even if NPRM input assumptions are assumed to hold;

2. The use of updated gas price assumptions and more reasonable assumptions for regulatory compliance costs and the rebound effect yields employment impacts that are consistently worse than those implied by the NPRM assumptions; and

3. The Proposed Rollback is likely to have negative GDP impacts in addition to negative employment impacts.

6.2. Basis for Findings

Our findings of increasingly negative macroeconomic impacts from the Proposed Rollback are largely rooted in the net economic benefits associated with gas savings and, conversely, the negative repercussions of increased spending on gasoline. When consumers spend more on gas, they have less left to spend on other consumer goods and services. And those other goods and services tend to be more labor-intensive and less import-intensive than gasoline. According to IMPLAN data, spending one million dollars on a typical basket of consumer goods ultimately supports about 16 jobs, whereas the same money spent on the petroleum refining sector supports only five jobs.[37] At the same time, about 90 percent of generic consumer spending goes toward domestic industries, whereas only slightly more than half of U.S. spending on crude oil goes toward domestic industry.[38]

Together, these differences in labor intensity and import intensity explain why positive domestic employment and GDP effects arise when consumers save on gas and re-spend those savings elsewhere. Since the Proposed Rollback results in increased gas expenditures, it has net negative impacts. As increased gas expenditures accumulate, their net impacts become increasingly negative, ultimately overwhelming any effects associated with changes in spending on the auto sector.

6.3. Comparison to Other Studies

This study is not the first to evaluate the macroeconomic impacts of CAFE and GHG standards for light-duty vehicles. Here, we briefly discuss our findings in comparison to three other studies that have addressed this topic: the NPRM itself, a 2017 report by a group of academics from Indiana University (IU),[39] and a 2016 report from the Center for Automotive Research (CAR).[40]

As discussed previously, the NPRM did not assess GDP impacts and limited its employment analysis to effects within the auto sector.[41] The NPRM analysis did not make use of an input-output model, and it ignored effects associated with the automotive supply chain, changes in spending on gasoline, and changes in spending on the wider economy. The NPRM found that decreasing the stringency of

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[37] IMPLAN 2016 national dataset.

[38] *Id*.

[39] Carley, S., D. Duncan, J. D. Graham, S. Siddiki, N. Zirogiannis. 2017. *A Macroeconomic Study of Federal and State Automotive Regulations*. Available at https://spea.indiana.edu/faculty-research/research/working-groups/clean-vehicles.html

[40] McAlinden, S., Y. Chen, M. Schultz, D. J. Andrea. 2016. *The Potential Effects of the 2017-2025 EPA/NHTSA GHG/Fuel Economy Mandates on the U.S. Economy*. Conducted by the Center for Automotive Research. Available at https://www.cargroup.org/publication/the-potential-effects-of-the-2017-2025-epanhtsa-ghgfuel-economy-mandates-on-the-u-s-economy/.

[41] NPRM, p. 199.

standards would have small but increasingly negative effects on automotive employment. Our broader analysis indicates that accounting for impacts on other sectors yields even more negative employment effects from the Proposed Rollback, as the depressing effects of reduced consumer gas savings and reduced spending throughout the automotive supply chain outweigh the positive impacts from increased employment across the gasoline supply chain.

The 2017 IU report used the REMI macroeconomic impact model to evaluate the employment and GDP impacts of CAFE, GHG, and zero-emission vehicle standards for MYs 2017–2025. IU's analysis accounted for impacts on the automotive supply chain, the petroleum sector, and the wider economy. It concluded that increasingly stringent vehicle standards would result in long-term GDP and employment benefits but short-term macroeconomic losses. However, our review of the IU study revealed that it failed to make use of its own stated assumptions regarding such critical input parameters as compliance costs, price elasticity of demand for new vehicles, consumer valuation of fuel savings, and consumer financing. When we conducted an updated macroeconomic analysis using IU's stated assumptions, we found that increasingly stringent CAFE and GHG standards would likely result in positive employment and GDP impacts across all years of the study period.[42]

The 2016 CAR report also evaluated the likely impacts of CAFE and GHG standards for MYs 2017–2025 but focused exclusively on the automotive sector and its supply chain. The CAR study found that more stringent standards were likely to have negative impacts on the auto sector. However, this finding was driven by two sets of unreasonable input assumptions. First, the CAR study assumed CAFE compliance costs ranging from $2,000 per vehicle to $6,000 per vehicle. Even the lowest of these values is above generally accepted compliance cost values. The higher end of $6,000 per vehicle has no support whatsoever, and CAR made no attempt to justify such a value despite using it in one-third of its scenarios. Second, CAR assumed that increased vehicle prices will not only reduce the number of vehicle sales but will also reduce the revenues of auto manufacturers. This assumption implies a consumer responsiveness to vehicle price increases that is well beyond generally accepted estimates.[43] The combination of these unreasonable assumptions and the lack of accounting for consumer re-spending of savings from reduced expenditures on gas and automobiles led to CAR's finding of negative employment impacts. The NPRM, the IU report, and our own analysis all indicate that under a reasonable range of assumptions the CAFE standards can be expected to positively affect auto sector revenues and employment.

[42] *See* Allison, A., J. Hall, F. Ackerman. 2018. *Cleaner Cars and Job Creation: Macroeconomic Impacts of Federal and State Vehicle Standards*. Synapse Energy Economics for UCS, NRDC, ACEEE. Available at http://www.synapse-energy.com/sites/default/files/Cleaner-Cars-and%20Job-Creation-17-072.pdf.

[43] The NPRM estimated a price elasticity of demand for vehicle sales of between -0.2 and -0.3. The IU authors assumed a price elasticity of -1.0. The CAR analysis implies an elasticity well below -1.5.

7. CONCLUSION

Our analysis leaves us confident that the Proposed Rollback is likely to have negative impacts on both the auto sector and the broader U.S. economy. The rollback of fuel economy standards will lead to greater spending on gasoline, which will on balance negatively impact the U.S. economy. Any benefit experienced by the petroleum industry and its suppliers will be more than offset by GDP and employment reductions in the auto industry and the broader economy.

In addition, our TCO modeling indicates that the Proposed Rollback will likely increase total vehicle ownership costs and reduce the number of new vehicles sold in the United States, as the impacts of reduced fuel savings outweigh decreased compliance costs. If this is true, many of the NPRM's claimed benefits relating to the effects of increased vehicle sales would in fact be costs.

This study focuses only on vehicle sales and macroeconomic indicators. We do not account for social and economic impacts associated with public health and environmental impacts. However, we would expect the negative impacts of the rollback to be even greater when accounting for these public health and environmental impacts. We therefore conclude that the Proposed Rollback is likely to have detrimental impacts on the U.S. economy.

APPENDIX A: MODELING DETAILS

Modeling Framework

Our modeling exercises for this report incorporate two related models: a spreadsheet-based TCO model and an IMPLAN-based macroeconomic model. We used the TCO model to assess the impact of the Proposed Rollback on vehicle sales and gasoline expenditures. The TCO model takes as inputs a variety of assumptions related to the impact of the Proposed Rollback on the costs of owning and operating a vehicle. These include direct regulatory compliance costs, ancillary costs such as increased sales tax and insurance costs, and fuel savings.[44] Fuel savings in turn depend on a variety of factors, including assumed on-road fuel economy levels, fuel prices, and VMTs under both existing standards and the proposed standards. VMTs are determined separately for each set of standards, reacting to changes in both fuel prices and fuel economy, as mediated by the rebound effect.

Ultimately, the TCO model calculates the net present value of the perceived change in ownership costs resulting from the Proposed Rollback, relying on set assumptions for private discount rates and consumer valuation of fuel savings. In this study, we assumed a 7 percent private real discount rate[45] and examined a variety of fuel saving valuation assumptions, ranging from zero valuation to full consumer accounting for future fuel savings under the expectation that future gas prices will remain as they are today. Once the net present value change in ownership costs, or net premium, is calculated, it is multiplied by an assumed price elasticity of demand for new vehicle sales to arrive at an expected change in new vehicle sales.

Our macroeconomic modeling is rooted in the use of IMPLAN, an industry-standard input-output model that relies upon historical economic relationships to model the effects of changes in direct economy-wide spending patterns on employment and GDP. IMPLAN captures indirect supply chain effects and induced effects from employees re-spending their wages and consumers re-spending savings, in addition to immediate, direct effects. Importantly, IMPLAN accounts for not only which types of industries purchase goods and services from each other but also the degree to which purchases from and by a given industry go to domestic versus foreign industries. IMPLAN captures only effects within a given study area, in this case the United States. Our analysis relies on the IMPLAN 2016 national dataset.

[44] In line with the NPRM, we model the deregulatory SAFE proposal as resulting in negative compliance costs and negative fuel savings.

[45] That is, we assume that consumers discount expected future fuel savings at a rate of 7 percent when making their vehicle purchase decisions. This private discount rate is distinct from the social discount rate typically used in regulatory cost-benefit analyses.

Direct inputs to our economic modeling include vectors of changes in spending by and on various industries. For spending on gasoline, we followed IMPLAN's assumption that approximately 13 percent of gas expenditures go to margin for gas stations and the remainder flows through to petroleum refiners and producers. For spending on the automotive sector, we allocated expenditures on new vehicle investments based on government data as summarized in a report by IU academics.[46] Under these assumptions, about 8 percent of spending on vehicle standards compliance for new vehicles goes directly to auto industry labor, 32 percent goes to materials and parts, 39 percent goes to overhead, 10 percent goes to dealers, 7 percent goes to shareholders, and 4 percent goes to research and development.[47] For consumer re-spending of fuel savings, we used Consumer Expenditure Survey data to estimate that private vehicle owners put about 13 percent toward savings accounts[48] and assumed that consumers spend the remaining 87 percent in line with IMPLAN's calculated household spending patterns.

Input Assumptions

In Table 3 and Table 4 below, we present the main input assumptions used in our modeling under the NPRM Economy-Wide and Revised scenarios, respectively. Table 5 presents the financing assumptions used in both scenarios.

[46] Carley, S., D. Duncan, J. D. Graham, S. Siddiki, N. Zirogiannis. 2017. *A Macroeconomic Study of Federal and State Automotive Regulations with Recommendations for Analysts, Regulators, and Legislators*. Available at https://spea.indiana.edu/faculty-research/research/working-groups/clean-vehicles.html

[47] The specific IMPLAN industry categories used include Labor Income, Automobile manufacturing, Light-truck and utility vehicle manufacturing, Management of companies and enterprises, Retail – motor vehicle and parts dealers, Proprietor income, and Scientific research and development services.

[48] U.S. Bureau of Labor Statistics. 2017 Consumer Expenditure Survey. Table 1101. Available at https://www.bls.gov/cex/tables.htm#avgexp

Table 3. Input Assumptions, NPRM Economy-Wide Scenario

Model Year	Gas Prices	Existing Car Compliance	Existing Truck Compliance	Rollback Car Compliance	Rollback Truck Compliance	Car Compliance Costs	Truck Compliance Costs	Baseline LDV Sales	Baseline Car Price	Baseline Truck Price
	2017$/gal	Mpg	Mpg	Mpg	Mpg	2017$/vehicle	2017$/vehicle	Vehicles	2017$/vehicle	2017$/vehicle
2017	$2.34	42.32	29.72	42.12	29.62	-$116	-$87	16,830,000	$28,512	$36,702
2018	$2.31	44.66	31.85	43.56	30.97	-$272	-$441	17,190,000	$28,925	$36,995
2019	$2.52	46.05	33.79	44.66	32.08	-$374	-$735	17,480,000	$29,335	$37,133
2020	$2.65	48.83	35.55	45.81	33.16	-$702	-$928	17,660,000	$29,703	$37,416
2021	$2.77	51.97	38.81	43.78	32.20	-$1,046	-$1,399	17,750,000	$30,209	$37,836
2022	$2.88	53.86	39.85	44.21	32.55	-$1,320	-$1,547	17,760,000	$30,487	$38,071
2023	$2.91	55.54	40.58	44.44	32.67	-$1,682	-$1,796	17,740,000	$30,808	$38,271
2024	$2.93	56.97	41.33	44.66	32.79	-$1,812	-$1,856	17,730,000	$30,926	$38,565
2025	$2.98	57.71	41.72	44.66	32.79	-$1,995	-$1,979	17,710,000	$31,150	$38,563
2026	$3.01	58.85	42.52	44.66	32.79	-$2,250	-$2,234	17,700,000	$31,449	$38,780
2027	$3.02	59.64	42.93	44.88	33.04	-$2,378	-$2,411	17,740,000	$31,622	$38,916
2028	$3.01	60.05	43.56	44.88	33.04	-$2,428	-$2,565	17,810,000	$31,758	$38,989
2029	$3.04	60.05	43.78	44.88	33.16	-$2,424	-$2,671	17,870,000	$31,849	$39,006
2030	$3.08	60.05	43.78	44.88	33.16	-$2,424	-$2,671	17,959,514	$31,845	$38,915
2031	$3.12	60.05	43.78	44.88	33.16	-$2,424	-$2,671	18,049,477	$31,880	$38,885
2032	$3.17	60.05	43.78	45.11	33.16	-$2,424	-$2,671	18,139,891	$31,917	$38,853
2033	$3.16	60.05	43.78	45.11	33.16	-$2,424	-$2,671	18,230,757	$31,959	$38,818
2034	$3.19	60.05	43.78	45.11	33.16	-$2,424	-$2,671	18,322,078	$31,999	$38,784
2035	$3.21	60.05	43.78	45.11	33.16	-$2,424	-$2,671	18,413,857	$32,038	$38,751

Note: We calculate the existing and rollback compliances using results from modeling of the CO_2 standards. We convert the CO_2 results to miles per gallon using a conversion factor of 8,887 grams of CO_2 per gallon of gasoline.

Table 4. Input Assumptions, Revised Scenario

Model Year	Gas Prices	Existing Car Compliance	Existing Truck Compliance	Rollback Car Compliance	Rollback Truck Compliance	Car Compliance Costs	Truck Compliance Costs	Baseline LDV Sales	Baseline Car Price	Baseline Truck Price
	2017$/gal	Mpg	Mpg	Mpg	Mpg	2017$/vehicle	2017$/vehicle	Vehicles	2017$/vehicle	2017$/vehicle
2017	$2.50	40.40	30.23	40.40	30.23	-$18	-$12	16,830,000	$28,512	$36,702
2018	$2.47	42.32	31.29	42.32	31.29	-$102	-$115	17,190,000	$28,925	$36,995
2019	$2.53	44.21	32.08	44.21	32.08	-$153	-$208	17,480,000	$29,335	$37,133
2020	$2.88	46.53	33.04	46.53	33.04	-$287	-$312	17,660,000	$29,703	$37,416
2021	$3.05	49.10	35.69	43.56	31.29	-$538	-$722	17,750,000	$30,209	$37,836
2022	$3.13	51.37	37.50	43.56	31.29	-$762	-$798	17,760,000	$30,487	$38,071
2023	$3.18	54.19	39.32	43.56	31.29	-$868	-$912	17,740,000	$30,808	$38,271
2024	$3.25	56.97	41.33	43.56	31.29	-$943	-$1,002	17,730,000	$30,926	$38,565
2025	$3.25	59.64	43.56	43.56	31.29	-$1,099	-$1,139	17,710,000	$31,150	$38,563
2026	$3.24	59.64	43.56	43.56	31.29	-$1,186	-$1,311	17,700,000	$31,449	$38,780
2027	$3.26	59.64	43.56	43.56	31.29	-$1,257	-$1,505	17,740,000	$31,622	$38,916
2028	$3.29	59.64	43.56	43.56	31.29	-$1,310	-$1,539	17,810,000	$31,758	$38,989
2029	$3.33	59.64	43.56	43.56	31.29	-$1,310	-$1,555	17,870,000	$31,849	$39,006
2030	$3.34	59.64	43.56	43.56	31.29	-$1,324	-$1,546	17,959,514	$31,845	$38,915
2031	$3.38	59.64	43.56	43.56	31.29	-$1,345	-$1,571	18,049,477	$31,880	$38,885
2032	$3.40	59.64	43.56	43.56	31.29	-$1,346	-$1,571	18,139,891	$31,917	$38,853
2033	$3.41	59.64	43.56	43.56	31.29	-$1,346	-$1,571	18,230,757	$31,959	$38,818
2034	$3.44	59.64	43.56	43.56	31.29	-$1,346	-$1,571	18,322,078	$31,999	$38,784
2035	$3.46	59.64	43.56	43.56	31.29	-$1,346	-$1,571	18,413,857	$32,038	$38,751

Note: We calculate the existing and rollback compliances using results from modeling of the CO_2 standards. We convert the CO_2 results to miles per gallon using a conversion factor of 8,887 grams of CO_2 per gallon of gasoline.

Table 5. Financing Assumptions

Parameter	Value
Loan Term (Years)	5.67
Share of Consumers Financing	70%
Loan Rate	4.25%

Results Tables

In Table 6 and Table 7 below, we present the results from the NPRM Economy-Wide and Revised scenarios, respectively.

Table 6. Results of Proposed Rollback, NPRM Economy-Wide Scenario

Model Year	Car Sales Change	Truck Sales Change	Car Net Premium	Truck Net Premium	Car Fuel Spending	Truck Fuel Spending	Auto Sector Spending	Employment Impact	GDP Impact
	Vehicles	Vehicles	2017$/vehicle	2017$/vehicle	2017$ (Billions)	2017$ (Billions)	2017$ (Billions)	Job-years (thousands)	2017$ (Billions)
2017	6,809	3,647	-$98	-$60	$0.04	$0.05	-$1.37	-6	-$1.04
2018	10,568	12,522	-$154	-$200	$0.22	$0.49	-$5.47	-24	-$4.02
2019	14,923	16,785	-$220	-$262	$0.45	$1.33	-$8.90	-35	-$5.96
2020	24,848	18,291	-$370	-$283	$0.95	$2.45	-$13.17	-47	-$8.13
2021	1,879	-30,775	-$28	$478	$2.34	$5.59	-$23.02	-90	-$14.47
2022	8,688	-34,644	-$132	$542	$3.88	$8.88	-$26.60	-93	-$14.69
2023	23,465	-27,868	-$361	$439	$5.52	$12.15	-$31.22	-98	-$15.54
2024	24,469	-33,716	-$371	$543	$7.29	$15.39	-$33.00	-90	-$14.18
2025	30,229	-34,277	-$463	$553	$9.15	$18.66	-$35.47	-90	-$13.68
2026	38,604	-31,406	-$597	$509	$11.08	$21.98	-$39.60	-103	-$14.99
2027	44,096	-20,793	-$684	$338	$12.85	$24.83	-$41.88	-111	-$15.28
2028	44,871	-19,680	-$696	$319	$14.46	$27.51	-$43.86	-120	-$15.55
2029	42,971	-14,965	-$666	$242	$16.05	$30.14	-$44.88	-126	-$15.33
2030	40,785	-18,757	-$629	$301	$17.59	$32.72	-$45.30	-132	-$14.83
2031	38,548	-22,543	-$592	$360	$19.00	$35.08	-$45.73	-140	-$14.65
2032	38,869	-26,636	-$595	$422	$20.24	$37.37	-$46.10	-152	-$14.83
2033	38,563	-27,497	-$588	$433	$21.13	$39.04	-$46.37	-161	-$15.02
2034	36,692	-30,828	-$558	$483	$22.14	$40.96	-$46.78	-175	-$15.58
2035	35,409	-33,245	-$536	$518	$23.00	$42.64	-$47.13	-188	-$16.09

Table 7. Results of Proposed Rollback, Revised Scenario

Model Year	Car Sales Change	Truck Sales Change	Car Net Premium	Truck Net Premium	Car Fuel Spending	Truck Fuel Spending	Auto Sector Spending	Employment Impact	GDP Impact
	Vehicles	Vehicles	2017$/vehicle	2017$/vehicle	2017$ (Billions)	2017$ (Billions)	2017$ (Billions)	Job-years (thousands)	2017$ (Billions)
2017	1,329	826	-$19	-$14	$0.00	$0.00	-$0.18	-1	-$0.13
2018	7,673	7,918	-$112	-$127	$0.00	$0.00	-$1.36	-5	-$0.98
2019	11,443	14,613	-$168	-$228	$0.00	$0.00	-$2.32	-7	-$1.49
2020	21,168	22,161	-$315	-$342	$0.00	$0.00	-$3.86	-9	-$2.28
2021	-25,315	-65,506	$382	$1,018	$1.24	$2.89	-$14.49	-71	-$10.57
2022	-33,680	-104,117	$512	$1,628	$2.82	$6.63	-$18.73	-92	-$12.63
2023	-53,847	-137,435	$828	$2,163	$4.88	$11.25	-$22.52	-113	-$14.08
2024	-76,418	-171,597	$1,160	$2,763	$7.43	$16.68	-$25.96	-135	-$15.16
2025	-86,067	-201,311	$1,317	$3,245	$10.18	$22.47	-$29.90	-159	-$16.41
2026	-79,904	-189,872	$1,235	$3,080	$12.81	$27.86	-$31.65	-171	-$15.98
2027	-76,517	-179,784	$1,187	$2,920	$15.41	$33.02	-$33.64	-193	-$16.63
2028	-74,996	-181,762	$1,164	$2,946	$17.91	$37.86	-$34.55	-213	-$16.68
2029	-77,699	-185,729	$1,205	$3,001	$20.28	$42.35	-$35.03	-232	-$16.73
2030	-78,751	-190,486	$1,215	$3,056	$22.33	$46.16	-$35.37	-251	-$16.94
2031	-80,655	-195,275	$1,240	$3,114	$24.33	$49.90	-$36.15	-275	-$17.87
2032	-82,587	-199,327	$1,264	$3,161	$25.93	$52.98	-$36.49	-295	-$18.44
2033	-84,799	-203,795	$1,294	$3,212	$27.38	$55.85	-$36.86	-314	-$19.14
2034	-87,694	-209,447	$1,333	$3,282	$28.78	$58.70	-$37.29	-334	-$19.93
2035	-89,764	-213,677	$1,359	$3,329	$29.95	$61.15	-$37.64	-351	-$20.56

APPENDIX B: SENSITIVITIES

Below we present the results from two sensitivities: first, a series of sensitivities in which we modify the NPRM Economy-Wide scenario by one input at a time, and second, a sensitivity in which we assume consumers do not value any amount of fuel savings when determining the perceived incremental cost of a new vehicle.

Input-Specific Impacts

In our Revised scenario, we changed three inputs in the NPRM Economy-Wide scenario: compliance costs, fuel prices, and rebound effect. In Figure 11, we present the employment impacts resulting from sensitivities in which we modified the NPRM Economy-Wide scenario by changing the compliance costs and the rebound effect in isolation. We present these results next to the results from the NPRM Economy-Wide and Revised scenarios for comparison.

- **Rebound effect.** When updating the rebound effect from 20 percent (per the NPRM) to 10 percent, we see a larger negative impact on employment than in the NPRM Economy-Wide scenario, though a smaller negative impact than in the Revised scenario. Revising the rebound effect downward results in a greater increase in gasoline expenditures under the Proposed Rollback, and therefore a greater reduction in employment associated with consumer re-spending of gas savings. This sensitivity results in losses of 104,000 job-years in 2025 and 214,000 job-years in 2035.

- **Compliance costs.** When updating the compliance costs from those presented in the NPRM to estimates based on the modeling conducted for the agencies' 2016 Draft TAR, we similarly find an employment impact from the Proposed Rollback that is more negative than the impact in the NPRM Economy-Wide scenario, but less negative than the impact in the Revised scenario. Under the lower compliance costs the Proposed Rollback shifts less money away from the auto sector into more labor-intensive economic sectors. This sensitivity results in employment losses of 116,000 in 2025 and 234,000 in 2035.

When both the rebound effect and the compliance costs are changed at the same time, as in the Revised scenario, the negative impacts are greater than the impacts from the input-specific sensitivities. Both changes have the effect of causing employment impacts to be more negative.

Figure 11. Input-Specific Employment Impacts of Proposed Rollback

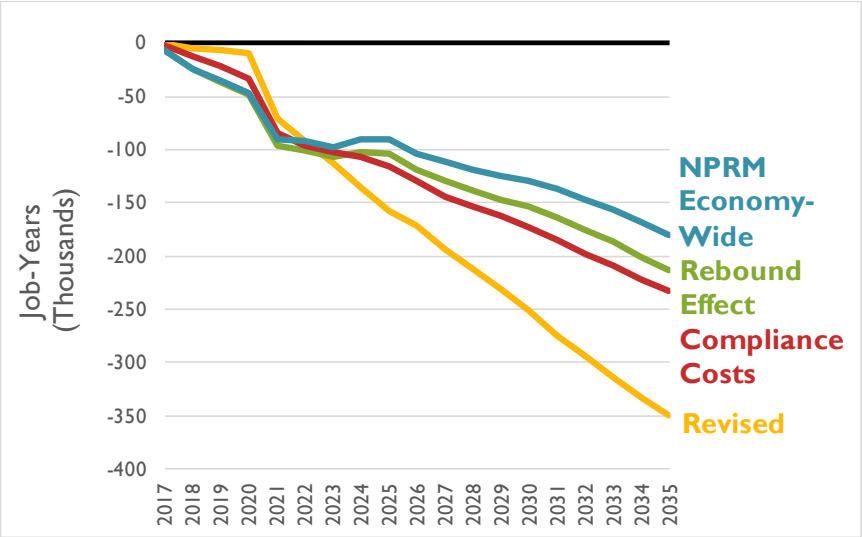
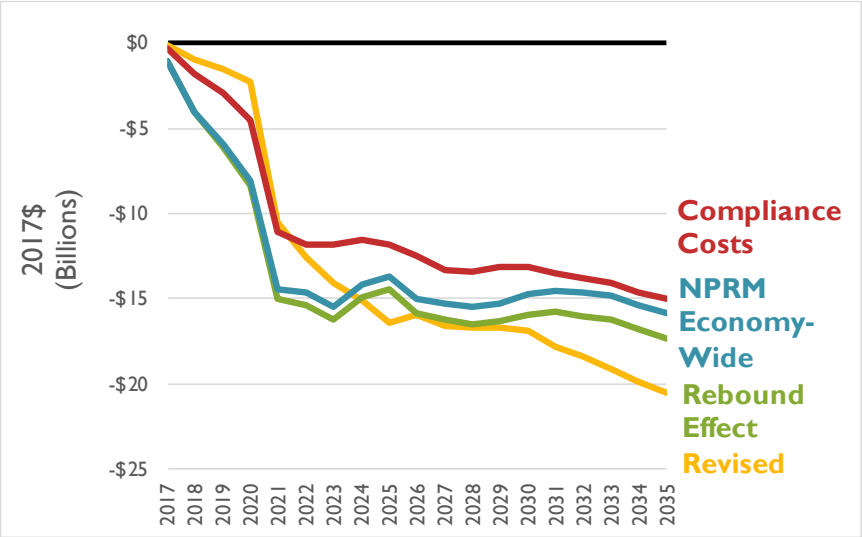


Figure 12 presents the GDP impacts of the Proposed Rollback when we modify the NPRM Economy-Wide scenario by changing the compliance costs and the rebound effect separately. Like the employment impacts, we present these results next to the results from the NPRM Economy-Wide and the Revised scenarios for comparison.

- **Rebound effect.** When updating the rebound effect from 20 percent to 10 percent, we see a larger negative impact on GDP than in both the NPRM Economy-Wide and Revised scenarios in the early years. This is because under a lower rebound effect the Proposed Rollback shifts a greater amount of expenditures toward gasoline and away from generic consumer goods, which tend to be more locally based and drive greater domestic GDP impacts per dollar of expenditure. This sensitivity results in GDP losses of $14 billion in 2025 and $17 billion in 2035.

- **Compliance costs.** When updating the compliance costs from those presented in the NPRM to estimates based on the modeling conducted for the agencies' 2016 Draft TAR, we find that the GDP impact is smaller than the results in both the NPRM Economy-Wide and the Revised scenarios. This sensitivity results in GDP losses of $12 billion in 2025 and $15 billion in 2035.

Figure 12. Input-Specific GDP Impacts of Proposed Rollback



No Consumer Valuation of Fuel Savings

As discussed previously, the NPRM does not clearly identify the agencies' preferred assumption regarding consumer valuation of fuel savings. Based on a statement in one section of the NPRM, our NPRM Economy-Wide scenario assumed full consumer valuation of fuel savings. However, we explored one additional sensitivity in which we assumed consumers do not value fuel savings whatsoever when deciding whether to purchase a new vehicle. This sensitivity nonetheless still accounts for the impact of actual achieved reductions in fuel savings from the Proposed Rollback when analyzing the estimated employment and GDP impacts presented below.

Figure 13 presents the employment impacts of the Proposed Rollback using the modeling inputs from the NPRM Economy-Wide scenario but assuming consumers do not account for future fuel savings at the time of purchase. In the early years, we see employment impacts that are slightly less negative than those in the NPRM Economy-Wide scenario. This is expected; if we assume consumers do not value fuel savings (as we do in this sensitivity), the Proposed Rollback is likely to increase vehicle sales because the negative gross price premium is not outweighed by consumers' valuation of fuel savings. Therefore, we see a reduced initial employment impact on the auto sector, as the Proposed Rollback has less negative auto sector revenue repercussions than under the NPRM Economy-Wide scenario. However, in the later years this reduced negative impact on the auto sector translates into reduced positive impacts on generic consumer spending. As consumers finance increased new vehicle purchases they have less left to spend on more labor-intensive consumer goods industries. In the long-run, this sensitivity estimates greater employment losses than under the NPRM Economy-Wide scenario. It results in employment losses of nearly 100,000 in 2025 and 207,000 in 2035.

Figure 13. Employment Impacts of Proposed Rollback, No Consumer Valuation of Fuel Savings

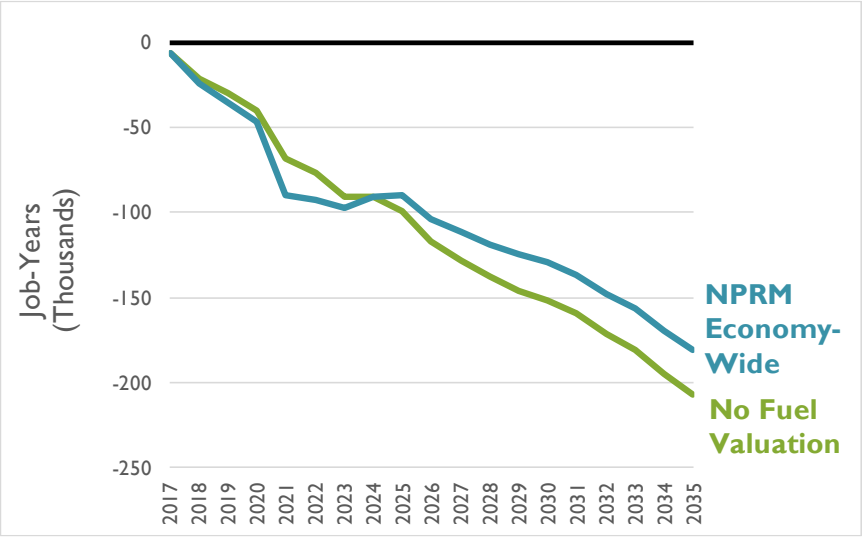


Figure 14 presents the GDP impacts of the Proposed Rollback for the same sensitivity in which we assume vehicle purchasers do not value fuel savings at all. It shows less negative GDP impacts than the NPRM Economy-Wide scenario for every model year. There are less negative GDP impacts related to the auto sector in this sensitivity because there are more vehicle sales relative to the NPRM Economy-Wide scenario, which makes it such that the aggregate GDP impacts are consistently less negative than those in the NPRM Economy-Wide scenario. This sensitivity results in GDP losses of $11 billion in 2025 and $14 billion in 2035. Our primary conclusion from this sensitivity exercise is that the Proposed Rollback's net economy-wide employment and GDP impacts are likely to be negative regardless of one's assumption regarding the extent to which consumers value future fuel savings at the time of vehicle purchase.

Figure 14. GDP Impacts of Proposed Rollback, No Consumer Valuation of Fuel Savings