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September 24, 2018

Chairman Mary Nichols and Board Members
California Air Resources Board
1001 I St
Sacramento CA, 95814

Re: Request for Public Input on the Proposed Amendments to the Low Emission Vehicle III Greenhouse Gas Emission Regulations

Dear Chair Nichols and Members of the Board:

The Union of Concerned Scientists (UCS) strongly commends the Air Resources Board for your continued efforts to reduce air pollution and climate change emissions from transportation sources in California and appreciate the opportunity to comment on the proposed amendments to the Low Emission Vehicle (LEV) III Greenhouse Gas Standards.

Our comments are summarized as follows:

(1) The proposed amendments to clarify the "deemed to comply" language are consistent with the intent of the originally adopted language. Therefore, while we believe the language and intent is already clear, we support ARB's proposed action.
(2) CARB has requested "comments on potential flexibilities" to the standards. UCS does not have specific proposals related to flexibilities. However, analysis performed by UCS of various current and proposed rule flexibilities demonstrates the potential for a significant loss in emissions benefits from the standards. Should CARB entertain additional flexibilities beyond what is already available to automakers, offsetting provisions must be included to ensure all emissions benefits of the standards are achieved and California stays on course to meeting state mandated 2030 climate targets.
(3) Finally, in reviewing the economic analysis performed on alternative scenarios for this rulemaking, we have found several areas where ARB should review and update its methodology for assessing the macroeconomic impacts of vehicle standards. While our comments related to the economic analysis do not affect the staff's assessment of the proposed language modification related to "deemed to comply", they are important for future regulatory assessments.

Comments on proposed "deemed to comply" language

This board's leadership has prevented thousands of premature deaths and other illnesses over several decades by reducing harmful air pollution from automobiles. More recently, the incentives and regulatory policies adopted by this board have set us on a path to tackle the pressing problem of climate change. These accomplishments have occurred due to the board's leadership and the unique authority provided under the Clean Air Act for California to push ahead of federal pollution standards in the interest of protecting the health and welfare of residents of the state of California.

In setting standards for climate pollution from passenger vehicles in 2004, CARB took the first step in regulating global warming emissions from vehicles. In early 2012, those standards were updated to extend through model year 2025. Federal emissions and fuel economy standards were finalized after CARB adoption of these standards. CARB chose to accept compliance with finalized federal standards as compliance with their own by adopting the "deemed to comply" language in recognition of the fact that these standards were materially equivalent.

Changes to the federal program which substantially weaken the standards, as currently proposed in the federal notice of proposed rulemaking[1], would mean they are no longer substantially similar to California's regulations and the "deemed to comply" provisions would no longer apply.

While the intent of current "deemed to comply" language is clear in that it only applies to current federal standards as written, we support the proposed language modifications as they do not constitute a change in policy or regulatory intentions by the board.

Comments on request for "Potential Flexibilities"

In the public hearing notice for this proposed regulatory change, CARB has requested "comments on potential flexibilities that might allow for continued compliance with the federal standards, or reward national actions to promote cleaner vehicles."[2] UCS is not proposing any flexibilities at this time. However, should CARB entertain new or expanded flexibilities in the advanced clean cars program, it is important that they do not result in a loss of emissions benefits or slow the advancement of clean vehicle technology deployment.

Analysis performed by UCS and presented to the National Academies of Sciences, Engineering, and Medicine earlier this year illustrates the significant impact to emissions benefits of various types of flexibilities when applied to current model year 2017-2025 standards.[3] UCS examined existing regulatory flexibilities (identified in the figure as "2010-2011 Early Credits" and "Electric Vehicle Incentives") as well as additional types of flexibilities that have been proposed at various points by automakers including: extension of the EV multiplier credits and 0 g/mile upstream emissions accounting, extending and expanding the hybrid pick-up truck credits, and reclassifying 2WD SUVs as light trucks instead of cars. If these flexibilities were applied to vehicle model years 2017 through 2025, they could amount to an estimated 37% reduction in lifetime emissions benefits of model year 2017 through 2025 vehicles.

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[1] Available online at: https://www.epa.gov/regulations-emissions-vehicles-and-engines/safer-affordable-fuel-efficient-safe-vehicles-proposed
[2] Available online at: https://www.arb.ca.gov/regact/2018/leviii2018/leviiinotice.pdf
[3] June 16, 2018 presentation to the National Academies of Sciences, Engineering, and Medicine. Available online at: http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188250.pdf

Reductions in U.S. Climate Benefits from Existing and Potential Flexibilities to Model Year 2017-2025 Standards.

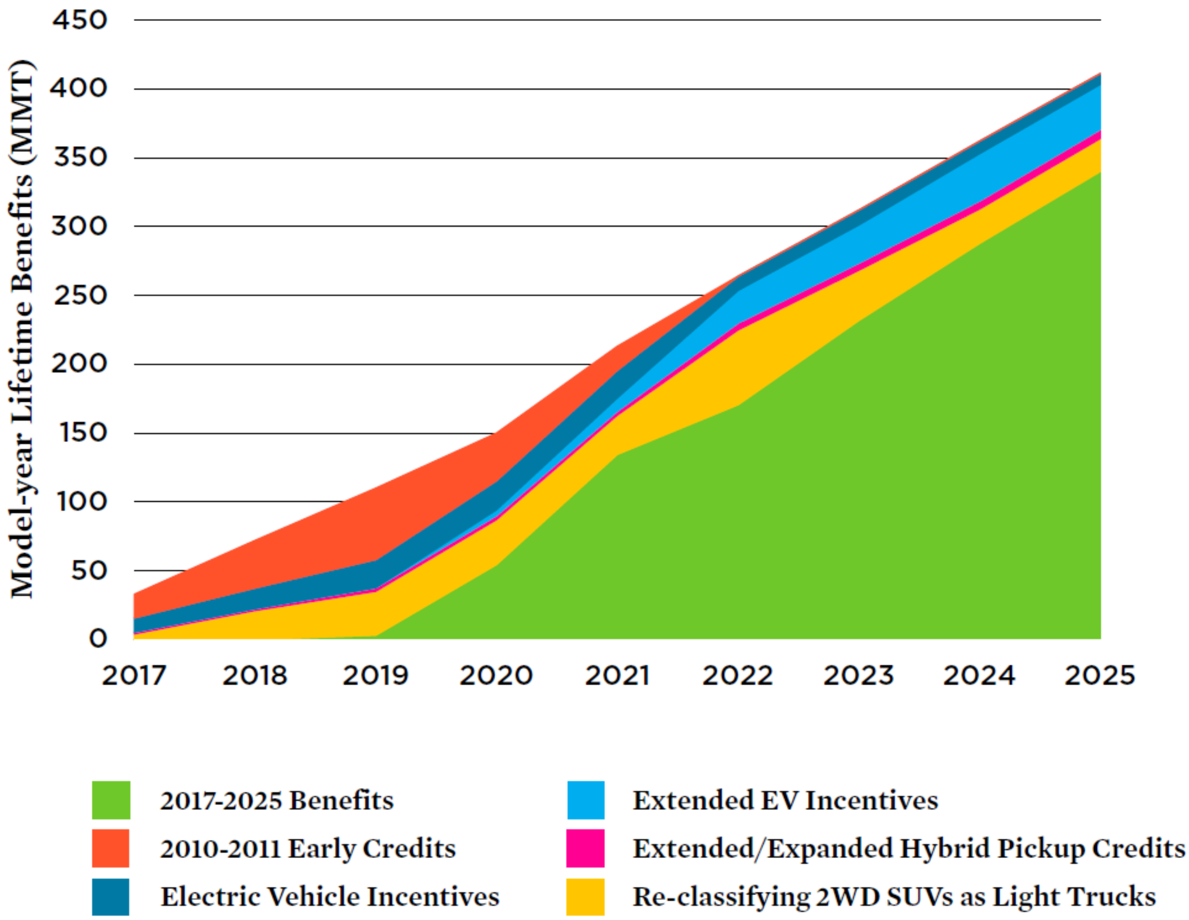

Figure 1: "2017-2025 Benefits" are the emission reductions remaining after all modeled flexibilities have been applied. "2010-2011 Early Credits" and "Electric Vehicle Incentives" are existing program flexibilities while the others are potential flexibilities. Total program benefits are reduced by 37% under these assumptions illustrating the significant impact of existing and potential flexibility provisions. Source: June 16, 2018 presentation by Dr. David Cooke to the National Academies of Sciences, Engineering, and Medicine. Available online at: http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188250.pdf

In its midterm evaluation finalized in 2017, CARB determined that the existing 2021-2025 standards are appropriate and should be maintained, while also recognizing that cost-effective technologies exist to meet even stronger standards that would further reduce emissions.[4] UCS supports this conclusion and therefore does not support adoption of further flexibilities to the advanced clean cars rules that would result in a loss in emissions benefits. Should the board consider additional compliance options, they must be accompanied by other changes designed to maintain the emission reductions of the standards.

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[4] California Air Resources Board Resolution 17-3 adopted March 24, 2017. Available online at: https://www.arb.ca.gov/msprog/acc/mtr/res17-3.pdf

Comment on economic assessment of vehicle standards

In reviewing the macroeconomic assessment of alternative scenarios to the proposed amendments (*Appendix D: Standardized Regulatory Impact Assessment Equivalent Document),* we identified several areas where improvements to the methodology or modeling tools is warranted to provide a more accurate assessment of near-term macroeconomic impacts from changes in vehicle costs and fuel consumption. The macroeconomic modeling performed to assess the alternative scenarios appears to share similarities with recent macroeconomic modeling carried out by researchers at Indiana University. A review of the Indiana University modeling by Synapse Energy Economics, Inc (Synapse) identified several modeling issues contributing to results showing negative near-term macroeconomic impacts of vehicle standards. [5] We urge CARB staff to review the Synapse report and to incorporate its findings into future vehicle standard economic assessments. A summary of the Synapse findings are described below.

Background

Modeling the economic impacts of changes in vehicle price and fuel consumption is an important part of assessing the overall benefits and costs to pollution standards for cars and trucks. UCS has carried out similar analysis in the past to perform assessments of light and heavy regulations and their projected impacts on gross domestic product (GDP) and employment.[6,7] These previous UCS analyses of vehicle standards found that the investment in the auto sector in new technologies and the resulting cost savings to consumers from using less gasoline and diesel result in net economic benefits in both GDP and employment.

In 2017, Sanya Carley and other researchers at Indiana University (IU) published a macroeconomic analysis (referred to below as the Carley study) of state and federal vehicle regulations through 2025.[8] To determine the macro economic impacts, the authors employed the use of the REMI model, the same model used by ARB to assess the economic impacts of alternatives scenarios in this rulemaking. The results from the Carley study demonstrated long-term trends similar to previous UCS analysis – namely positive net economic impacts in the long term as fuel savings more than offset increased vehicle costs. The IU study also concluded that vehicle standards had a negative near-term economic effect on employment. However, subsequent review by Synapse found several modeling issues which raise questions about the near-term results from the REMI modeling. These include failure to include vehicle financing, failure to account for consumer valuation of fuel economy, and use of a high price elasticity of demand. These are explained briefly below and covered in more detailed in the appended Synapse

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[5] Synapse Energy Economics comments to EPA. Available online at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2015-0827-8966

[6] *Delivering Jobs: The Economic Costs and Benefits of Improving the Fuel Economy of Heavy-Duty Vehicles*. 2010. Available online at: https://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_vehicles/The-Economic-Costs-and-Benfits-of-Improving-the-Fuel-Economy-of-Heavy-Duty-Vehicles.pdf

[7] *Creating Jobs, Saving Energy, and Protecting the Environment: An Analysis of the Potential Benefits of Investing in Cleaner Cars and Trucks.* 2007. Available online at: https://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_vehicles/fueleconomyjobs.pdf

[8] Carley et. al., *A Macroeconomic Study of Federal and State Automotive Regulations with Recommendations for Analysts, Regulators, and Legislators.* 2017. Available online at: https://spea.indiana.edu/faculty-research/research/working-groups/clean-vehicles.html

comments to EPA and in their subsequent report.[9,10] Similar modeling issues appear to exist in CARB's use of the REMI model.

Vehicle financing

Most vehicle purchases are financed rather than paid for with cash. However, macroeconomic modeling in REMI performed by Carley et. al. and modeling in REMI for this rulemaking do not appear to factor in vehicle financing effects.

Consumer valuation of fuel economy

Similar to the Carley study, REMI modeling by CARB does not appear to incorporate any effect of improved fuel efficiency on vehicle purchase behavior. The REMI modeling assumes a consumer only considers a higher upfront cost of a vehicle and does not put any value on future fuel savings from a more efficient vehicle. Fuel savings from vehicle efficiency can amount to thousands of dollars over the life of a vehicle, yet the modeling assumes consumers give these savings no consideration when making a vehicle purchase decision.

Price elasticity

Price elasticity of demand for vehicles used in the REMI modeling performed by Carley et. al. was significantly larger than published estimates in the literature as well as price elasticities used elsewhere in their own study. As a result, the sensitivity of vehicle sales to price changes in the REMI modeling is greater than is supported by the literature. It is unclear what price elasticity is used in the REMI modeling performed by CARB for this rulemaking but should be reviewed to ensure it is in line with current estimates in the published literature.

Results from Synapse Energy Economics macroeconomic assessment of vehicle standards

Synapse performed economic modeling using the IMPLAN model to reproduce the analysis by Carley et al. with corrections for the three issues identified above. The results show a significant difference in the timing of employment impacts as well as magnitude. The figure below compares the results for three scenarios. Results labeled *IU 2018* are the REMI model results from the Carley et. al. study as corrected by the authors in 2018 and results labeled *Improved IU* are the IMPLAN modeling results reported by Synapse using the same input assumptions as Carley et. al. except correcting for vehicle financing, consumer valuation of fuel economy, and price elasticity assumptions as described above. The Synapse IMPLAN results do not show the negative near-term employment impact (measured in job-years) as reported in the Carley study.

[9] Synapse Energy Economics comments to EPA. Available online at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2015-0827-8966

[10] *Cleaner Cars and Job Creation*. 2017. Available online at: http://www.synapse-energy.com/sites/default/files/Cleaner-Cars-and%20Job-Creation-17-072.pdf

Figure ES 1. Vehicle Standards Employment Impacts Under Improved IU and Synapse Scenarios, Compared to IU 2018 Results

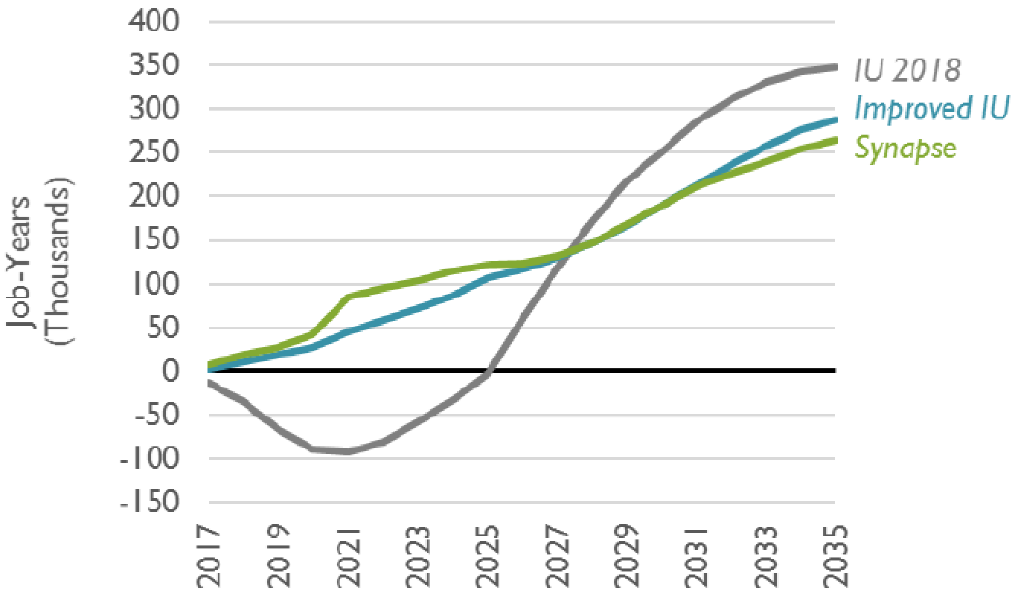

Figure 2: Macroeconomic modeling by Synapse Energy Economics, Inc. of state and federal vehicle standards, shows positive employment impacts from existing standards both in the near- and long-term. Source: Cleaner Cars and Job Creation. 2017. Available online at: http://www.synapse-energy.com/sites/default/files/Cleaner-Cars-and%20Job-Creation-17-072.pdf

While the magnitude of the macro economic impacts from vehicle standards are relatively small compared to overall U.S. employment, accurately assessing these impacts is important. Current economic assessment efforts by CARB using the REMI model should be reviewed and updated to address the issues raised by Synapse's review of REMI modeling performed by Carley et. al.

Thank you for the opportunity to comment. We urge the board to continue to move forward in addressing climate emissions from the transportation sector which now represents more than 40 percent of the state's greenhouse gas emissions. We ask for your support in adoption of the proposed regulatory language change to clarify "deemed to comply", ensure any consideration of further flexibilities in the standards maintain the expected emissions benefits from the current rules, and to review the macroeconomic modeling to ensure the most robust assessments of future vehicle standards.

Sincerely,

Don Anair
Research and Deputy Director - Clean Vehicles Program
Union of Concerned Scientists

Evaluating the Economics of Vehicle Standards

A critical review of a leading study

October 5, 2017

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CONTENTS

Thanks to the Union of Concerned Scientists for financial support and thoughtful feedback on an earlier draft of this report. All statements made here represent the views of the author alone.

1. INTRODUCTION

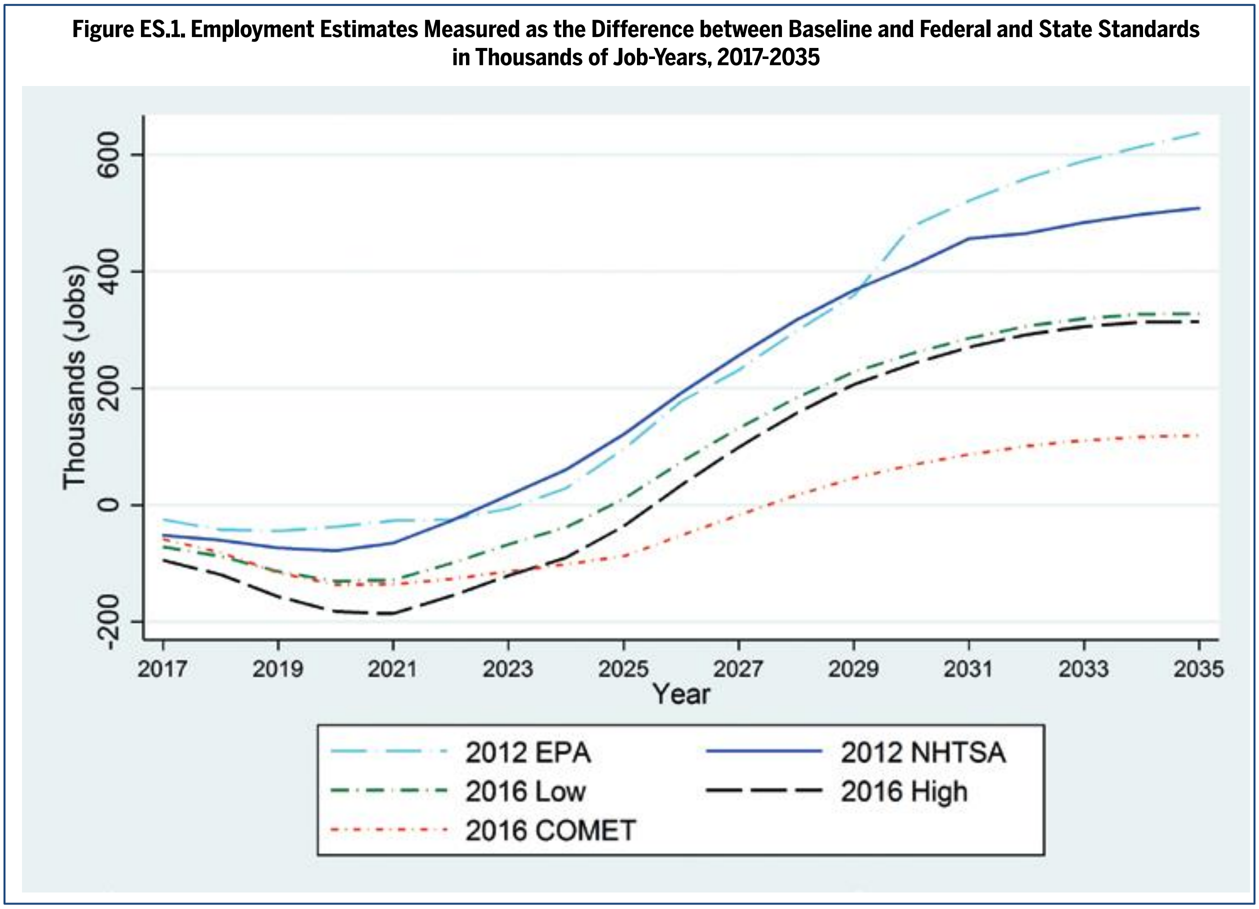
The United States Environmental Protection Agency (EPA) review of vehicle greenhouse gas (GHG) emission standards for 2022-2025, now underway, is likely to focus on the expected economic impacts of the existing standards. A detailed study sponsored by the Alliance of Automobile Manufacturers, from a group of authors at Indiana University (hereafter, "the IU study"), is noteworthy in that it addresses three major factors affecting employment impacts - vehicle price effects, supply chain innovations, and savings in gasoline expenditures. The study finds overall net economic long-run benefits from a combination of state and federal vehicle efficiency, greenhouse gas, and zero emissions vehicle (ZEV) programs. Despite these findings, the authors recommend consideration of delays to the federal standards and revisions to state ZEV standards, appearing to make an economic case for weakening vehicle standards based on estimates of a reduction in vehicle sales and short term job losses.[1] This report offers an evaluation and critique of the IU study, finding that modest corrections to the IU study's data and methodology should lead to the opposite conclusion: Existing vehicle standards provide strong economic gains and favorable cost-benefit ratios.

2. IGNORING LONG-TERM JOB GAINS

A basic finding of the IU study is that, under their assumptions, the long-run effects of vehicle regulations include large long-term increases in jobs (IU Study, Figure ES.1, p.4, reproduced below). Short-term job losses are small, and come close to zero under some scenarios. The study itself explains why the long-run outlook is so positive: Gains from innovation offset "at least half" of losses from higher vehicle prices; and consumer savings in gasoline use "have a much more positive impact on the economy" than the negative impacts of losses in the petroleum sector and its suppliers (IU study, p.3).

[1] Sanjay Carley, Denvil Duncan, John D. Graham, Saba Siddiki, and Nikolaos Zirogiannis. "A Macroeconomic Study of Federal and State Automotive Regulations," Indiana University School of Public and Environmental Affairs, March 2017. Automotive industry sponsorship is recognized in the acknowledgments on the study's title page. Minor corrections to some calculations, released by the authors after the March 2017 publication, do not affect their overall conclusions, or this critique.

Figure 1. IU study summary of employment impacts



Source: IU study, p.4.

For more detail, a summary of cumulative macroeconomic impacts (IU study, Table 8.1, p.105) shows five variations on impacts, both for a nine-year period, 2017-2025, and for a 19-year period, 2017-2035. Losses are greater in the shorter period, reflecting higher new car prices, while additional benefits of fuel economy far outweigh the losses in the longer period. The greatest projected loss for the shorter period, across the study's five variants, is a cumulative $111.9 billion. Even if GDP stays unchanged at today's level of about $19 trillion, this cumulative multi-year loss represents an average of 0.066 percent of annual GDP—about 1/15 of one percent per year. The greatest projected gain for the longer period, $332.6 billion over 19 years, similarly amounts to 0.092 percent of annual GDP—close to 1/10 of one percent per year. Employment effects are not similarly summarized, but will likely be roughly proportional to changes in GDP.

It is difficult to see how these calculations of small short-term losses and much larger long-term gains could support a recommendation to delay or roll back the existing regulations. As the IU study says, "The net economic impacts of the gasoline savings are favorable, large in absolute magnitude, and dominate the long-run results" of their macroeconomic modeling (p.106).

In its separately developed estimates of vehicle sales, with even more variants (12 each for cars and trucks, see section 9.6, p.120), a similar pattern emerges in most scenarios: small, if any, short-term losses followed by steady gains in sales thereafter.

Despite the evidence that overall long-term impacts are positive, the IU study calls for a reconsideration of current standards, apparently based on findings of net short-term vehicle sales decreases and job losses.

In an analysis finding long-run benefits but short-term losses, the details of data and methods determine whether the net economic impact of emission standards is projected to be positive or negative. And a look at those details reveals many ways in which arbitrary and unsupported choices have biased the IU study toward concluding that there are negative impacts of fuel economy regulations. Failure to include vehicle financing effects and ignoring any consumer valuation of fuel economic in the macro-economic modeling undermines the validity of the national and regional jobs results (see Section 3). The use of excessively high interest rates and discount rates (see Sections 4 and 5) devalue the long run and privilege short-run costs over even medium-run benefits, biasing the results of the IU study's separate vehicle sales analysis. And finally, the failure to value, or even measure, GHG reduction (see Section 6) obscures one of the crucial pathways by which our long-run economic health is affected by our short-run economic actions.

3. Clashing Models: Why the Disagreement?

In its literature review of earlier studies, the IU study points out that many assessments of fuel economy and emissions standards have used separate, potentially inconsistent methods for evaluating different aspects of the problem (IU study section 6.4, "Limitations of Existing Studies", pp.66-69). Yet the IU analysis suffers from the same problem, using a macroeconomic model, REMI, for an overview of employment and GDP impacts, and an unnamed total cost of ownership (TCO) model for a more detailed analysis of vehicle sales.

The IU study itself discusses the differences between the models, and their lack of coordination (p.124). For example, REMI assumes a larger[2] price elasticity of demand for new vehicles (-1.65, vs. -1.0 in TCO). REMI also "does not incorporate any consumer demand for fuel economy" or estimates of resale value, whereas TCO includes both (p.124). Vehicle financing, which affects consumer cash flow, also appears in the IU study's modeling with TCO but not REMI.

On all these points, the TCO model assumptions appear more realistic. Regarding price elasticity, a literature review from Lawrence Berkeley National Laboratory finds that the range of estimated

[2] Following standard usage in the field, this means "larger in absolute value." Price elasticities are almost always negative.

elasticities for automobile purchases is from -0.30 to -1.28.[3] The TCO value falls within that range; the REMI value does not.

Regarding consumer interest in fuel economy, high-resale-value cars, and vehicle financing, there is no obvious justification for ignoring these factors, as in REMI, except for software limitations. It seems much more sensible to include these factors, as in TCO.

And on all these points, the less appropriate REMI assumptions seem likely to lead to forecasting fewer purchases of more fuel-efficient vehicles. Yet the IU study highlights the REMI results, introducing the TCO projections almost as an afterthought, and then fails to incorporate the TCO findings into the REMI modeling.[4]

REMI is a well-known, sophisticated model of the U.S. economy and is well suited to forecasting macroeconomic interactions and impacts in many situations. However, it is no better than its inputs: it requires skillful translation of real-world policies into expected impacts on its rigidly defined key sectors and stylized policy options. What the IU study has found, with its extensive use of REMI, is that the model cannot directly incorporate many effects that could boost purchases of fuel-efficient new cars. Ignoring those effects biases the model toward finding net negative effects, at least in the short run, on the auto industry, employment, and the economy as a whole.

An alternative modeling strategy could have used TCO's more detailed projections of changes in auto sales and costs per vehicle as key inputs to REMI, along with TCO's more reasonable price elasticity. This would have tied the two models together and would have produced more positive forecasts of economic impacts.

The TCO price elasticity of -1.0 for new vehicle purchases, adopted to match government agency analyses,[5] has an interesting property which should simplify the evaluation of vehicle standards and sales. Recall that price elasticity of demand is the percent change in sales resulting from a 1 percent change in price. At an elasticity of -1.0, total dollar spending is not affected by price changes. If the price of a new vehicle goes up by 2 percent, the number of new vehicles purchased goes down by 2 percent, leaving total dollar expenditure on new vehicles unchanged.

Employment and other economic impacts of vehicle production depend primarily on the dollar expenditure, not on the number of vehicles. Job creation in models such as REMI is calculated per million dollars of expenditure, not per car. At a price elasticity of -1, implying constant expenditure, the economic impacts of production should be unchanged. So, for example, at a 2 percent price increase, workers in the auto industry and its supply chain are producing 2 percent fewer vehicles, each of which requires 2 percent more labor and material inputs. The result should be roughly zero net change in auto

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[3] K. Sydny Fujita. 2015. "Estimating Price Elasticity using Market-Level Appliance Data," Lawrence Berkeley National Laboratory. Available at https://ees.lbl.gov/sites/all/files/lbnl-188289.pdf.

[4] The REMI projections are presented first, and at greater length, in both the executive summary and the report itself.

5 As described on IU study, p.155.

sector jobs. This is what one might expect to happen if the REMI model was run with a price elasticity of -1 instead of -1.65.

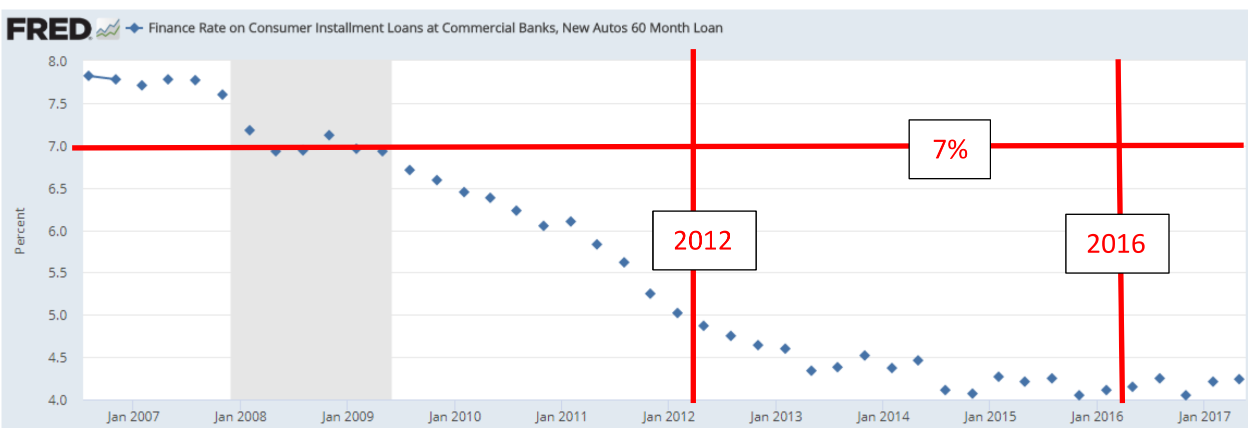
Yet although the IU study's TCO modeling makes less unreasonable choices on many questions than their REMI modeling, that does not mean that the TCO analysis is problem-free. It repeatedly exaggerates interest rates and uses excessively high discount rates, as discussed in the next two sections. These choices systematically devalue the future benefits of fuel economy, relative to the short-term costs of more expensive vehicles, biasing the IU study results against the existing standards.

4. Car Loan Rates Have Gone Down, not Up

The IU study focuses on the contrast between what was known in 2012, at the time of important studies by regulatory agencies, and in 2016, when the IU analysis was performed. It is clearly the case that the price of gasoline, and hence the monetary value of fuel savings, has declined since 2012. This is cited repeatedly (and reasonably) as a cause of reduced estimates of monetary savings from fuel efficiency standards.

Yet in another case, the cost of new car loans, the IU study assumes that costs have increased, raising their estimate of the interest rate on car loans from 5 percent in the "2012 perspective" to 7 percent in the "2016 perspective" (IU study, pp. 117-120). While 5 percent was roughly correct for 2012, an increase to 7 percent bears no relationship to more recent experience, as shown by data from the Federal Reserve Board of St. Louis (Figure 2):

Figure 2. Interest rate on 60-month new auto loans



Source: FRED (Federal Reserve Economic Data), Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/graph/?id=RIFLPBCIANM60NM, (except added lines and labels)

In fact, the interest rate on new car loans has been below 7 percent since early 2009, below 5 percent since early 2012, and has lately been below 4.5 percent. Consistent updating to a "2016 perspective" should involve lowering, not raising, the interest rate on car loans—which, according to the IU study, are used to finance 70 percent of new car purchases.

The IU study asserts that the interest rate on new-car loans has little effect on purchases (p.120), but does not present data or results to support that claim. (And if it has little effect, why change it in the wrong direction?) In general, loan payments on a 60-month loan are 6 percent higher at an annual rate of 7 percent, compared to 4.5 percent.[6] A 6 percent change in consumer costs, for 70 percent of new car buyers, seems well within the magnitude of effects examined in the IU study and other research on this topic; there is no reason to ignore it.

5. High Discount Rates: Dismissing Future Benefits

Evaluation of vehicle standards involves several multi-year calculations, where the present value of the stream of costs and benefits is the crucial number. A higher discount rate means that a lower value is placed on future benefits, compared to current costs. The IU study chooses, with little support, to use high discount rates, above those that have become standard in federal regulatory analyses.

A longstanding Office of Management and Budget (OMB) standard, applied to EPA and other agency analyses, calls for use of 3 percent and 7 percent discount rates, followed by reporting of results calculated both ways (as acknowledged in the IU study, p.156). In at least four instances, the IU study uses (different) higher discount rates.

First, in Appendix I, Figures I.2, I.3, and I.4 all use the four options of 3 percent, 5 percent, 7 percent, and 10 percent discount rates, without explanation (IU study, pp. 151-152).

Second, in Appendix VI, the COMET model of technologies and regulatory costs (an input to the TCO modeling) uses a 15 percent discount rate, described as "a discount rate which is meant to replicate credit banking behavior" (IU study, p.163; see also Table V.1, p.164). No further explanation is offered, and it is not clear what banking behavior is being replicated. A 15 percent rate is quite high for the recent past. Average loan rates have remained well below 5 percent since the 2008-2009 recession (see Figure 3). Even commercial bank interest rates on credit cards have been below 15 percent since early 2010.[7]

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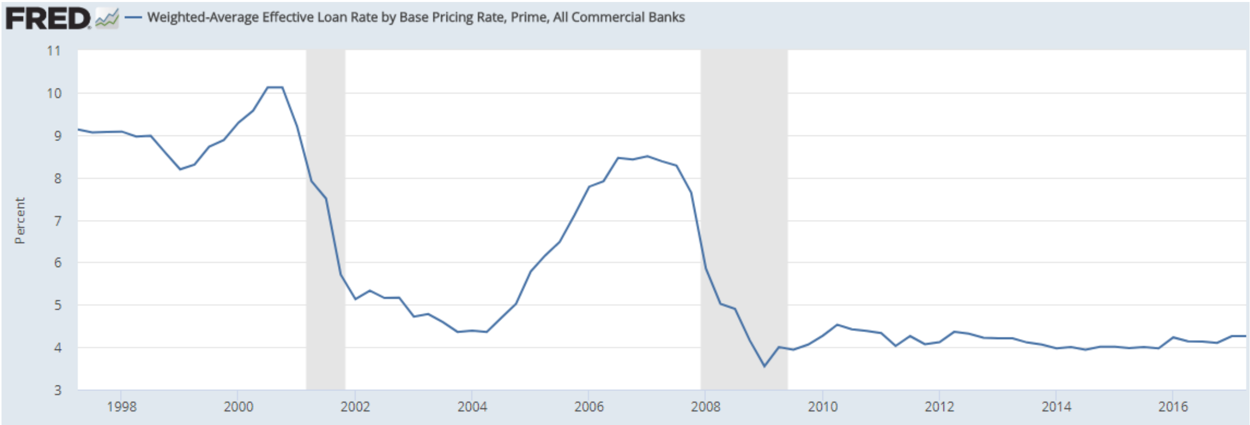
[6] Calculated using the Excel PMT() function.

[7] See https://fred.stlouisfed.org/categories/33059.

Figure 3. Average loan rates, all commercial banks



Source: Federal Reserve Economic Data (FRED), Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/EERPRNQ.

Third, another appendix discussion of the TCO modeling says that it uses a 7 percent discount rate alone (p.171).

Finally, several presentations of TCO results use 5 percent, 7 percent (referred to as "baseline"), and 13 percent discount rates (p.173, 175)

Regarding OMB's longstanding recommendation of 3 percent and 7 percent, the IU study says, without additional explanation, "We do not present results at 3% because, while 3% is an appropriate social discount rate for some applications of cost-benefit analysis, it is not relevant to modeling impacts of regulation on new vehicle sales in the automotive industry" (p. 117).

Some of the higher rates are justified as approximations of real-world decision-making. Consumers may be myopic in some respects, and/or acting like they have high individual discount rates. Is the purpose of the analysis to mimic myopia, or to look past it at social costs and benefits? Lower discount rates, such as 3 percent, value future benefits more highly, making break-even come much sooner for investment in fuel-efficient automobiles. Reducing GHG emissions, as a climate mitigation strategy, is a principal goal of EPA's standards; many have argued that even 3 percent is too high for climate policy analyses.

How much difference does it make? Imagine a program that requires a cost of $1,000 in year 0, and yields benefits of $200 per year starting in year 1 and continuing indefinitely. Table 1 shows its present value at years 5 and 10, and the year when it breaks even in present value, at each of the discount rates mentioned in the IU report. The higher the discount rate, the longer it takes to reach break-even on this, or any initiative with costs first and benefits later. The scattering of inconsistent but high discount rates in the IU study suggests a bias against investing now to reap benefits in the medium- to long-term future, without any clear theoretical rationale for one or another rate.

Table 1. Present value of $1000 cost followed by $200 annual benefit

Discount rate	3%	5%	7%	10%	13%	15%
NPV at year 5	-$84	-$134	-$180	-$242	-$297	-$330
NPV at year 10	$706	$544	$405	$229	$85	$4
Years to breakeven	5.5	6	7	8	9	10

Source: Author's calculations.

6. The Importance of Externalities

The word "externality," singular or plural, appears only once in the IU report (outside the bibliography), in a discussion of how an externality-based rationale for CAFE standards "is a source of consternation among libertarians and some rational-choice economists" (IU study, p.15). GHG emissions and climate policy get only occasional mentions in this 200-page report, and there appear to be no data whatsoever on the size of the emission reductions expected under any of the numerous scenarios and variants of the analysis.

But employment and GDP are not the only macro-level impacts of emissions and fuel economy standards. EPA's GHG reduction policy is explicitly aimed at one category of emissions—not at job creation or GDP growth.

There are multiple externalities from vehicle emissions—that is, unpriced impacts on third parties who are neither the buyers nor sellers of vehicles, vehicle fuels, and other commodities in the automotive supply chain. There are societal costs and benefits from these emissions, and from corresponding pollution reduction efforts, that must be accounted for. Conventional monetary valuations of emissions have been developed and used in many regulatory analyses.

Multiple externalities from vehicle emission could be valued; the easiest is carbon dioxide (CO_2) emissions, which could be valued at the 2013 federal estimate of the social cost of carbon (the latest available). This would have a dramatic effect on the overall, societal assessment of emissions and fuel-economy standards. Using the latest calculation from the federal Interagency Working Group on the Social Cost of Carbon, the social benefit of emission reduction is worth $49 per metric ton of CO_2-equivalent in 2020, rising to $54 in 2025, $59 in 2030, and $65 in 2035 (all in 2017 dollars).[8]

To weigh the costs and benefits of the regulations evaluated by the IU study, it is necessary to correct the biased inputs, such as high interest rates and discount rates, used in that study. To match past

[8] See https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf. Published amounts, in 2007 dollars, multiplied by 1.1752 to account for inflation from mid-2007 to mid-2017 (from the BLS CPI Inflation Calculator).

standards of regulatory analysis, it is also necessary to include some measure of the value of emission reduction that result from those regulations. These changes would decisively demonstrate that there is a large net social gain from maintaining strict emission standards.

Cleaner Cars and Job Creation

Macroeconomic Impacts of Federal and State Vehicle Standards

Prepared for Union of Concerned Scientists, Natural Resources Defense Council, and American Council for an Energy-Efficient Economy

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) are currently reconsidering federal greenhouse gas and corporate average fuel economy (CAFE) standards set for light-duty vehicles through model year 2025. As part of this process, EPA and NHTSA are examining a range of factors, including the potential economic impacts of fuel economy standards.

In March 2017, a group of researchers from Indiana University (IU) released a report concluding that the combination of currently planned federal CAFE and greenhouse gas standards and state zero-emission vehicle standards (we refer to these collectively as the "vehicle standards") will result in long-term macroeconomic benefits. However, their analysis also concluded that the vehicle standards will result in short-term macroeconomic losses. In 2018, IU released revisions to its modeling that corrected for two analytical errors that had biased its 2017 results against the vehicle standards. Nonetheless, IU's general conclusions remained the same.

A previous Synapse Energy Economics (Synapse) report identified questionable inputs and methodological inconsistencies in the IU report that further biased its results against the vehicle standards. To understand the impacts of these inputs and inconsistencies, Synapse used the IU analysis as a starting point to conduct an independent assessment of the macroeconomic impacts of the vehicle standards. Our analysis relied on two related modeling exercises: a total cost of ownership (TCO) analysis used to estimate the impact of the vehicle standards on vehicle sales, and an IMPLAN-based input-output analysis used to assess impacts on U.S. employment and gross domestic product (GDP).

We evaluated two scenarios: (1) an "Improved IU" scenario, which uses inputs and assumptions from IU's most up-to-date scenario from February 2018, with corrections to observed analytical inconsistencies; and (2) a "Synapse" scenario that uses alternative input assumptions derived primarily from recent federal government sources.

The Improved IU scenario corrects for a lack of synchronization between IU's own TCO and macroeconomic modeling. The IU authors discarded many of the assumptions from their more carefully researched TCO model, replacing them with less appropriate assumptions in their macroeconomic modeling. For example, IU's macroeconomic modeling assumed that consumers ignore future fuel savings when buying a vehicle, are extremely sensitive to changes in vehicle prices, and never finance their vehicle purchases. The Improved IU scenario corrects for this lack of consistency by incorporating IU's TCO modeling assumptions and results into the macroeconomic modeling, while keeping all other IU input assumptions.

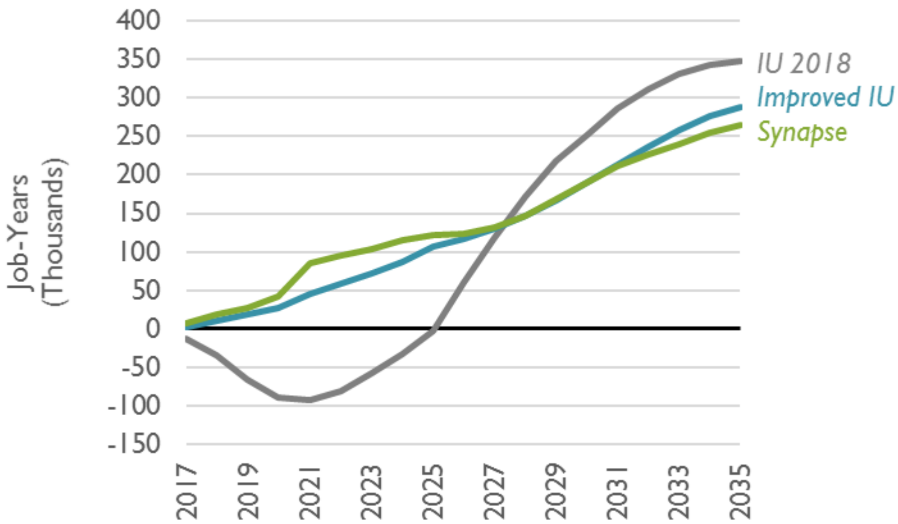
The Synapse scenario uses the latest EPA technology cost estimates available, includes updated gas price projections and vehicle financing rates, and assumes that consumers value five years of fuel savings when making vehicle purchase decisions.

Throughout our analysis, we compared the impact of implementing the vehicle standards for model years 2017–2025 to a baseline in which the vehicle standards remain fixed at 2016 levels. We evaluated impacts over the period from 2017 through 2035.

Our primary findings include the following:

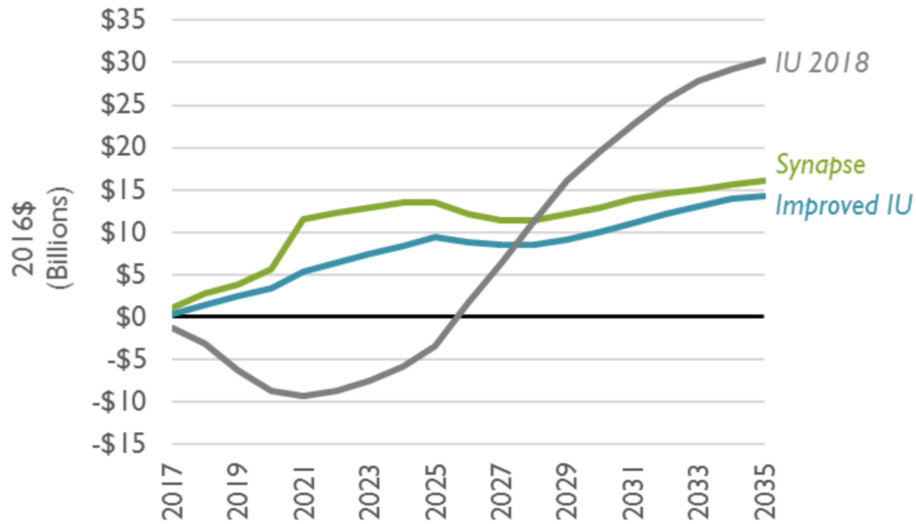
- **Federal and state vehicle standards result in positive employment impacts in both the short term and the long term.** Under both scenarios we modeled, the vehicle standards result in positive employment impacts throughout the study period. This is a key difference from IU's finding of short-term job losses (see Figure ES 1). Our results indicate nationwide employment increases of more than 100,000 in 2025 and more than 250,000 in 2035 under both scenarios. To put our results in perspective, these increases represent less than 0.2 percent of current U.S. employment levels.

Figure ES 1. Vehicle Standards Employment Impacts Under Improved IU and Synapse Scenarios, Compared to IU 2018 Results



- **Federal and state vehicle standards result in positive GDP impacts in both the short term and the long term.** Under both scenarios we modeled, the vehicle standards result in positive GDP impacts throughout the study period. Under the Improved IU scenario, annual GDP increases add up to $9.5 billion in 2025 and $14.3 billion in 2035. Under the Synapse scenario, annual GDP benefits amount to $13.6 billion in 2025 and $16.1 billion in 2035. Again, note that these large absolute numbers are small in perspective, representing less than 0.1 percent of 2017 U.S. GDP.

Figure ES 1. Vehicle Standards GDP Impacts Under Improved IU and Synapse Scenarios, Compared to IU 2018 Results



Our findings of positive GDP and employment impacts from vehicle standards throughout the study period differ from IU's results, which show negative near-term impacts. The inconsistencies between IU's TCO modeling and macroeconomic modeling, which have been corrected in our analysis, appear to be the major factor contributing to IU's near-term findings.

We conclude that the planned vehicle standards are likely to have positive impacts on the U.S. auto sector and on the wider U.S. economy.

1. CONTEXT

The U.S. Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) are currently reconsidering federal greenhouse gas and corporate average fuel economy (CAFE) standards set for light-duty vehicles through model year 2025. As part of this process, EPA and NHTSA are examining a range of factors, including the potential economic impacts of these standards.[1]

In March 2017 a group of researchers from Indiana University (IU) released a study, sponsored by the Alliance of Automobile Manufacturers, examining the aggregate impacts on employment and gross domestic product (GDP) of federal greenhouse gas and CAFE standards and state zero-emission vehicle (ZEV) standards.[2] The IU report found that these vehicle standards result in long-term economic gains, but short-term losses. These alleged short-term losses have been used as an argument for delaying or weakening federal vehicle standards.[3]

A previous Synapse Energy Economics (Synapse) report identified implausible inputs in the IU report that biased its results against vehicle standards.[4] In this report, we discuss the findings of Synapse's own modeling of the state and federal vehicle standards. Our analysis began with the same general modeling framework and input assumptions used in the IU study. In the process of examining IU's analysis, we discovered two errors; these were subsequently corrected by the IU study authors.[5] Our work is based on IU's revised analysis, which corrected for those two errors. However, IU's corrected version of its modeling did not address all inconsistencies. We corrected for these remaining inconsistencies in our "Improved IU" scenario, while holding all other IU assumptions the same. Finally, we adjusted certain key assumptions to be consistent with the latest federal government projections of vehicle standard compliance costs, gasoline prices, and related parameters, resulting in our "Synapse" scenario.

Under both modeled scenarios we found that the vehicle standards have employment and GDP impacts that are positive throughout the forecast period and grow more favorable over time. We find that the

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[1] U.S. Environmental Protection Agency. *Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emissions Standards for Model Years 2022-2025*. https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas.

[2] Carley, Sanya, Denvil Duncan, John D. Graham, Saba Siddiki, and Nikolaos Zirogiannis. March 2017. *A Macroeconomic Study of Federal and State Automotive Regulations*. [Hereinafter "IU Report"]

[3] IU Report, p. 147; King, Danny. 2017. "Automakers say CAFE compliance will cost jobs and make cars more expensive." https://www.autoblog.com/2017/03/10/automakers-cafe-compliance-report/.

[4] Ackerman, Frank. October 2017. *Evaluating the Economics of Vehicle Standards: A Critical Review of a Leading Study*.

[5] Both errors biased the original IU report's results against the vehicle standards. In one error, the IU authors mistakenly used a set of regulatory compliance costs that were higher than intended. In the other, the IU analysis substantially under-counted fuel savings from more fuel-efficient light trucks. See IU SPEA. January 2018. COMET Corrected. https://spea.indiana.edu/doc/research/working-groups/comet-022018.pdf; IU SPEA. February 2018. COMET Corrected. https://spea.indiana.edu/doc/research/working-groups/comet-022018.pdf

positive impacts of the vehicle standards on the auto sector and on consumer fuel savings outweigh negative impacts of reduced spending in the petroleum sector.

2. Total Cost of Ownership Modeling

Following IU's method, we used two separate models to evaluate the impacts of the vehicle standards: a total cost of ownership (TCO) model to assess impacts on vehicle sales; and a macroeconomic model to analyze employment and GDP impacts. Using these models in combination, we evaluated two scenarios: (1) an "Improved IU" scenario, which makes use of the assumptions from IU's 2016 COMET scenario (as revised in 2018), with corrections to observed analytical inconsistencies;[6] and (2) a "Synapse" scenario that uses alternative input assumptions derived from recent federal government sources. Essentially, the Improved IU scenario indicates how IU's macroeconomic results might change had IU incorporated its own TCO calculations and assumptions into its macroeconomic modeling. The Synapse scenario demonstrates how the results of both the TCO analysis and the macroeconomic modeling change when using alternative assumptions about technology costs, fuel prices, financing costs, and consumer valuation of fuel savings.

The TCO model evaluates the impact of the vehicle standards on vehicle sales. This relationship depends on two factors: the perceived total incremental cost of a new standards-compliant vehicle relative to a baseline vehicle, and the responsiveness of demand for new vehicles to changes in perceived cost.

2.1. TCO Inputs

Our initial TCO modeling made use of the same set of inputs and structure as IU used in its 2016 COMET Scenario. We evaluated the effects of the vehicle standards on sales of cars and light trucks from 2017 through 2035, matching IU's framework.[7] All impacts were measured relative to a baseline of compliance with the 2016 vehicle standards. For the Improved IU scenario, our TCO modeling assumptions were identical to those used in IU's revised COMET modeling. Key assumptions for this scenario include:

- **Gross price premium:** This represents the average, per-vehicle, incremental cost of a vehicle that complies with the vehicle standards for a given model year, relative to the baseline of a vehicle that complies with the 2016 vehicle standards. For our Improved IU scenario, we used the gross price premium from IU's 2016 COMET scenario. Under

[6] The IU report included several different scenarios. We selected the COMET 2016 scenario as our point of departure both because it was the only scenario that incorporated IU's own updated compliance cost modeling and because it was the IU scenario that resulted in the most pessimistic set of economic impacts.

[7] Of course, 2017 is now a past year with historical data; we maintain the focus of analysis on 2017–2035 for compatibility and comparability to the IU study, which was initially performed in 2016–2017.

these assumptions, the gross price premium rises from approximately $100 per vehicle in 2017 to $2,000 per vehicle in 2025.[8] Note that these costs include estimates of costs related to state ZEV standards and are therefore not reflective of federal standards alone. Beyond 2025, the gross premium gradually declines, as the vehicle standards are assumed to hold steady at model year 2025 levels while technological innovation decreases the cost of complying with those standards.

- **Gas prices:** In our Improved IU scenario, we used the Reference Case gasoline price assumptions from the U.S. Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2016, consistent with IU's assumptions.

- **Consumer valuation of fuel savings:** The vehicle standards increase the upfront cost of a vehicle but decrease the amount spent on gasoline throughout the life of the vehicle. If consumers only consider upfront costs, they will view a more fuel-efficient new vehicle as more expensive and will be less likely to buy one. If, on the other hand, consumers value the entire stream of future gas savings, they may view a more fuel-efficient vehicle as less expensive from a total cost perspective. Our Improved IU scenario assumed that consumers value three years of anticipated gas savings when they decide whether to purchase a car.

- **Resale value:** The Improved IU scenario assumed that consumers expect that they will be able to re-sell a new vehicle for 35 percent of the original purchase price five years after purchase.

- **Consumer financing:** Our Improved IU scenario assumed that 70 percent of consumers will finance their purchases of new vehicles, while 30 percent will pay up front. This scenario also assumed that those who finance will do so at an annual interest rate of 7 percent and a loan term of five years.

- **Price elasticity:** Our Improved IU scenario assumed a price elasticity of demand of -1.0 for new vehicle purchases. That is, we assumed that when the cost of a new vehicle increases by 1 percent, demand for new vehicle purchases will decrease by 1 percent. In the context of the TCO model, the relevant cost increase is the net premium, which accounts for discounted fuel savings, insurance costs, and resale value, in addition to the gross price premium.

- **Rebound effect:** The rebound effect describes how energy consumption increases in response to an increase in fuel efficiency that causes operational energy costs to decrease. Our Improved IU scenario followed IU and EPA in assuming a rebound effect of 10 percent with respect to vehicle travel. That is, we assumed that for a 10 percent decrease in the price of fuel, consumers increase the number of miles they drive by 1 percent.

[8] Here and throughout this report, all dollar figures are in constant 2016 dollars, unless otherwise noted.

In our Synapse scenario we modified IU's TCO analysis to incorporate certain updates and revised assumptions. These revisions included:

- Revised compliance costs (gross premiums) and fuel economy levels based on EPA documentation.[9] Synapse scenario compliance cost assumptions are slightly higher than the Improved IU assumptions over the short term and slightly lower over the longer term, but are generally not radically different (as shown in Figure 1). In 2025, Synapse scenario compliance costs are 10 percent lower than Improved IU costs for cars and 7 percent lower for light trucks.

- Updated gas prices based on EIA's AEO 2018 Reference case.[10] As shown in Figure 2, AEO 2018 gas price projections are fractionally higher than AEO 2016 projections for the early 2020s but converge around 2030.

- Use of a consumer fuel savings horizon of five years rather than three, consistent with prior EPA analyses and other research;[11] and

- Updated auto loan interest rate of 5 percent rather than 7 percent, based on recent federal data.[12]

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[9] U.S. EPA. November 2016. Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under Midterm Evaluation: Technical Support Document. Data from this document were supplemented by data derived from EPA's underlying OMEGA model.

[10] 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.

[11] U.S. EPA. April 2010. Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis. P. 8-2. Available at https://nepis.epa.gov/Exe/ZyPDF.cgi/P1006V2V.PDF?Dockey=P1006V2V.PDF. See also Consumers Union. August 15, 2017. Consumers Union Comments on NHTSA's Notice of Intent to Prepare an Environmental Impact Statement for Model Year 2022–2025 Corporate Average Fuel Economy Standards. P. 4. Available at http://consumersunion.org/wp-content/uploads/2017/08/Consumers-Union-NHTSA-EIS-Comment.pdf.

[12] Federal Reserve Bank of St. Louis. Finance Rate on Consumer Installment Loans at Commercial Banks, New Autos 60 Month Loan. Accessed March 21, 2018. https://fred.stlouisfed.org/graph/?id=RIFLPBCIANM60NM.

Figure 1. Car Gross Price Premiums Under Improved IU and Synapse Scenarios

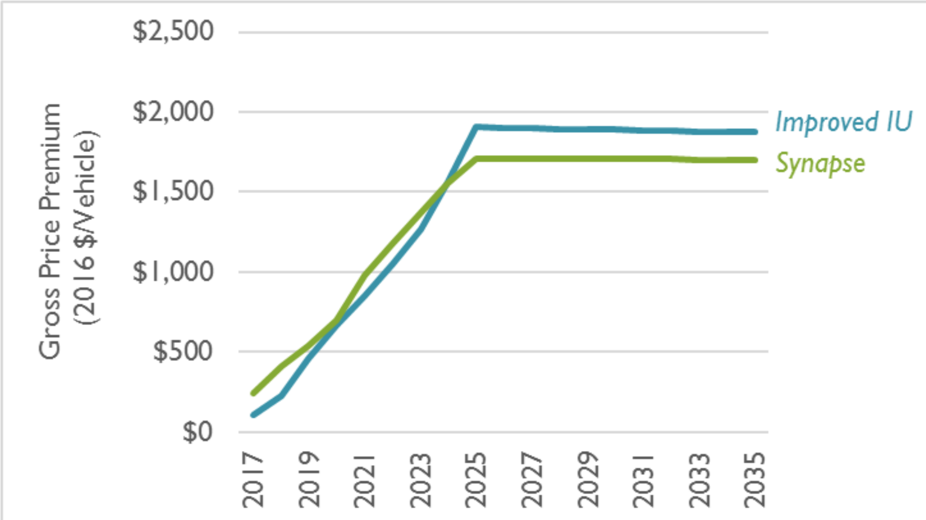
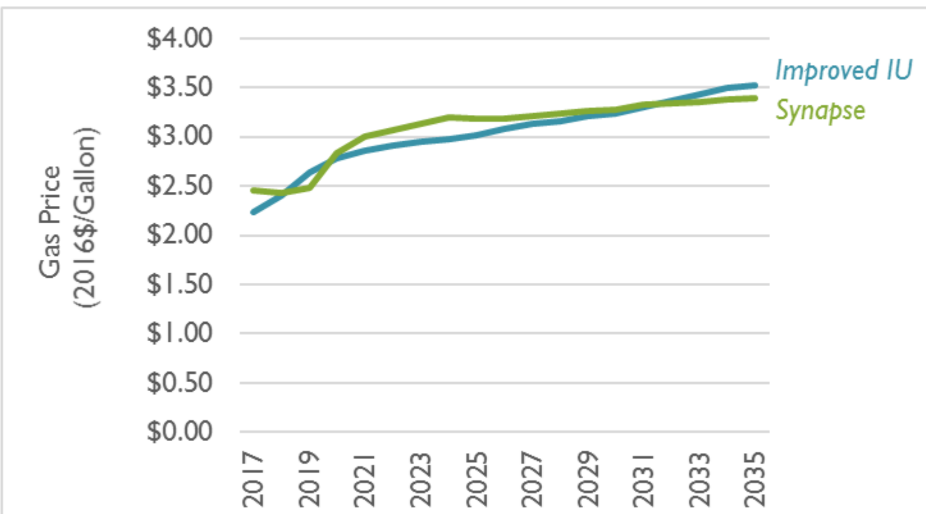


Figure 2. Gas Prices Under Improved IU and Synapse Scenarios



Other than these modifications, our Synapse scenario maintained the same set of assumptions as those used in IU's 2016 COMET scenario and our Improved IU scenario. Table 1 summarizes the key TCO assumptions across the Improved IU and Synapse scenarios.

Table 1. TCO Modeling Assumptions, Improved IU Scenario and Synapse Scenario

Input	Improved IU Scenario (Consistent with IU 2016 COMET Scenario)	Synapse Scenario
Gross Price Premium	Taken from IU COMET modeling as revised in 2018	Based on EPA Proposed Decision TSD
Gas Prices	AEO 2016	AEO 2018
Consumer Valuation of Fuel Economy	3 years	5 years
Discount Rate	7%	7%
Resale Value	35% after 5 years	35% after 5 years
Consumer Financing	70% of purchases financed. 5-year loan term, 7% interest rate	70% of purchases financed. 5-year loan term, 5% interest rate
New Vehicle Price Elasticity	-1.0	-1.0
Rebound Effect	10%	10%

2.2. TCO Results

Our TCO calculations are used to estimate changes in vehicle sales for purposes of economic modeling and yield two primary sets of results. The first is a series of net price premiums for cars and light trucks for model years 2017 through 2035. This represents the change in the consumer-perceived total cost of owning new cars and trucks due to the vehicle standards. The second is the change in car and truck sales resulting from the perceived net premium.

We note that all Improved IU scenario TCO results are virtually identical to IU's 2018 revision to its 2016 COMET results, as our Improved IU scenario relied entirely on IU's TCO assumptions. This fact is reflected in the labeling of the figures in this section.

Under the Improved IU scenario, the car net premium is slightly negative, though close to zero, in 2017 and 2018 (that is, the vehicle standards are perceived as slightly reducing the total cost of ownership, thus tending to increase sales). The net premium is then increasingly positive (discouraging sales) from 2019 through 2025, reaching a maximum value of $512 for model year 2025 cars before declining in the years between 2025 and 2035. In contrast, under the Synapse scenario the car net premium is initially slightly positive but becomes increasingly negative (thus increasing car sales) over time (see Figure 3).

Figure 3. Car Net Price Premiums Under Improved IU and Synapse Scenarios

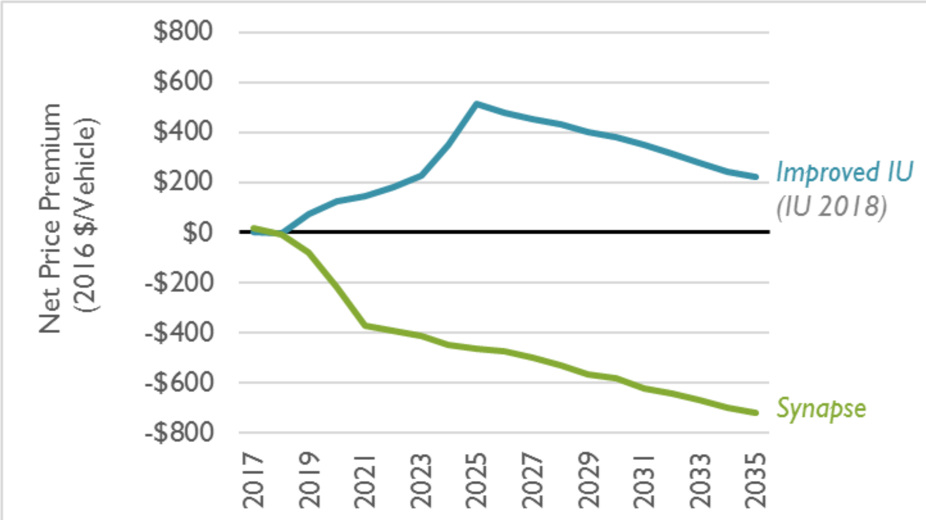


Figure 4 presents a similar picture for truck net premiums. Under the Improved IU scenario, the net premium is positive in all years (that is, the vehicle is perceived as increasing the total cost of owning a truck), though it remains below $500 in every year. Under the Synapse scenario the net premium is initially positive but is negative by model year 2020. It then becomes increasingly negative over time. Under this scenario, consumers generally perceive new vehicles as less expensive on a total ownership cost basis, largely because they value five years of fuel savings rather than three. Of course, consumers purchasing these vehicles will ultimately realize fuel savings beyond three or five years, regardless of how they view those savings at the time of vehicle purchase.[13]

[13] Those who sell a vehicle before the third or fifth year of ownership will indirectly recover future fuel savings via the increased resale value of the vehicle.

Figure 4. Light Truck Net Price Premiums Under Improved IU and Synapse Scenarios

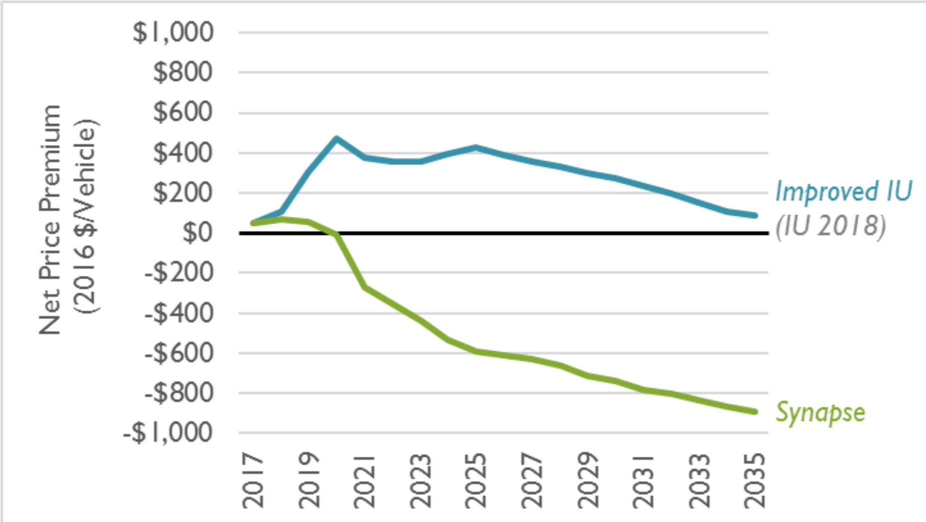
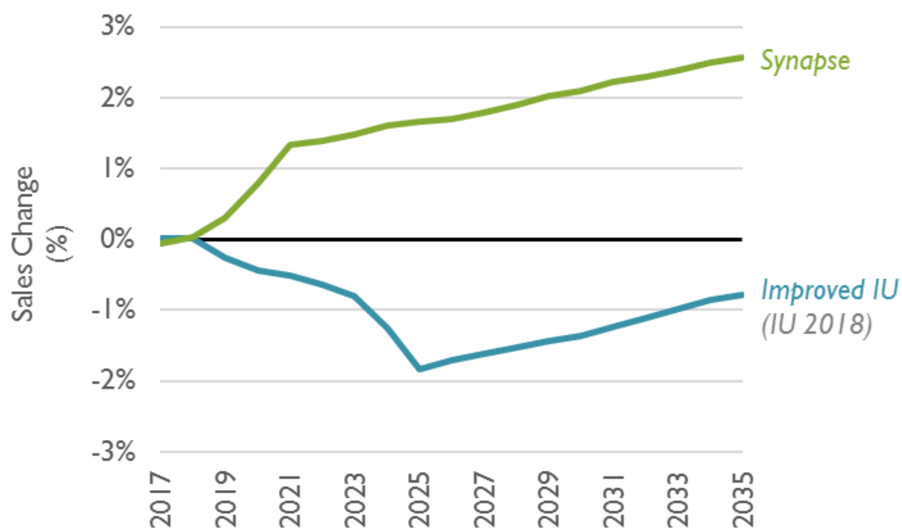


Figure 5 displays the effect of the vehicle standards on car sales under each scenario. Under the Improved IU scenario, positive net price premiums result in a decrease in sales, as some consumers decide not to purchase a new vehicle to avoid paying a higher price. In contrast, under the Synapse Scenario we estimate negative price premiums which lead to increased car sales, as a perceived decrease in lifecycle vehicle costs entices consumers to buy more.

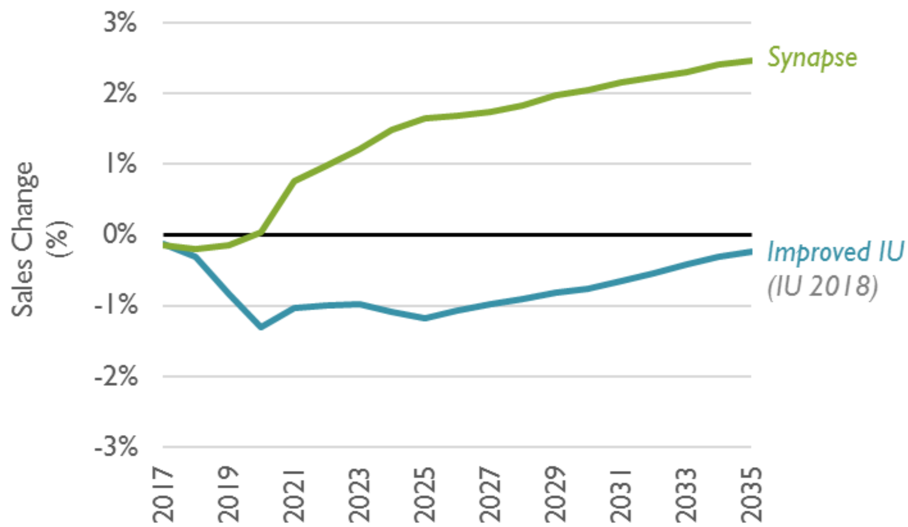
Figure 5. Vehicle Standards Impacts on Number of Cars Sold under Improved IU and Synapse Scenarios



The difference in TCO results is largely driven by a difference in the number of years of fuel savings accounted for by consumers making car purchase decisions. The additional two years of valued savings are enough to fully offset compliance costs in the Synapse scenario. Still, the impacts on total sales are relatively modest under either scenario and could easily be dwarfed by a host of economic factors and changes in vehicle offerings that influence sales volumes from year to year; these factors are not considered in our (or IU's) analysis.[14] Negative impacts never reach 2 percent of sales in any year under the Improved IU scenario, and positive impacts remain below 3 percent of sales under the Synapse Scenario.

Figure 6 below shows the impact of the vehicle standards on truck sales under the Improved IU and Synapse Scenarios. These impacts are smaller in magnitude, but in the same direction as the impacts on car sales. Under the Improved IU scenario, truck sales never drop by more than 1.3 percent, and by the end of the study period the impact is less than 0.25 percent. Under the Synapse scenario, truck sales decrease slightly relative to the baseline in the near term but increase over the medium to long term, reaching a nearly 2.5 percent increase by 2035.

Figure 6. Vehicle Standards Impacts on Number of Light Trucks Sold under Improved IU and Synapse Scenarios



Even under the Improved IU scenario, when the vehicle standards cause the total number of vehicles sold to decrease, the *dollar value* of vehicle sales increases in every year. Thus, the amount of money going into the auto sector increases.[15] Figure 7 below shows that the vehicle standards increase the amount of money spent on the auto sector by more than $20 billion annually in every year between 2024 and 2035 under the Improved IU scenario. Under the Synapse scenario, auto sector spending increases in every year, with annual increases exceeding $30 billion in every year from 2023 onwards.

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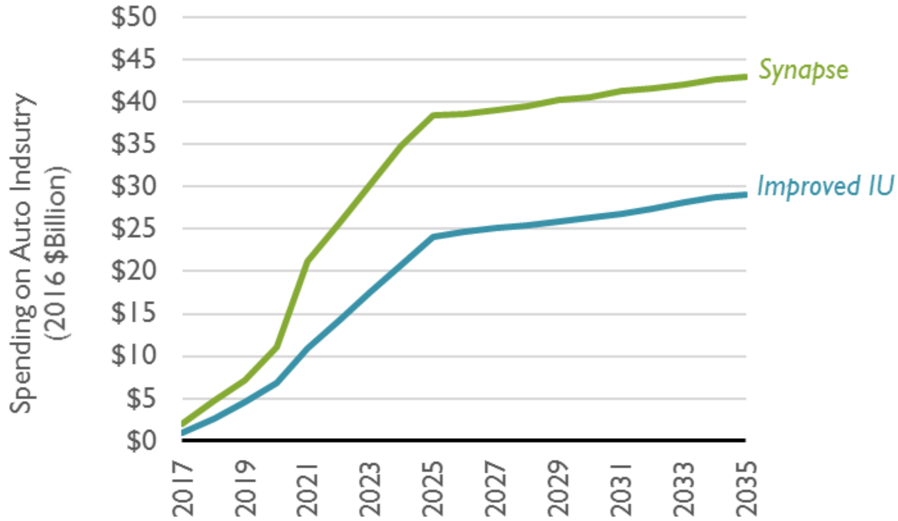
[14] Furthermore, note that including only the cost of federal standards, as is appropriate for the current federal agency reconsideration, would likely result in modest positive sales impacts throughout for both scenarios, given the lower cost of compliance.

[15] With a price elasticity of -1.0, one might expect total auto spending to be constant. A 1 percent increase in price is associated with a 1 percent decrease in quantity, and vice versa. In fact, the total value of sales increases because the perceived total cost of fuel-efficient cars is lower than the upfront cost, due to fuel savings.

Figure 7. Vehicle Standards Impact on Auto Sector Spending Under Improved IU and Synapse Scenarios



3. Macroeconomic Modeling

We used the IMPLAN model to project the GDP and employment impacts of the vehicle standards over the period from 2017 through 2035, relative to the baseline of compliance with the 2016 vehicle standards. IMPLAN is an industry-standard economic input-output model that uses historical data to assess the economy-wide impact from an initial change in economic activity.[16] Our use of IMPLAN represents one important methodological difference from the IU study. IU used the REMI model, a more complex (and much more expensive) model that incorporates general equilibrium relationships in addition to input-output calculations.[17]

We followed IU in modeling three different mechanisms by which the vehicle standards affect the macroeconomy:

1. **Compliance Costs.** This mechanism traces economic impacts related to the effects of net compliance costs on auto industry sales.
2. **Auto Sector Investment.** This mechanism accounts for employment and GDP impacts resulting from increased investment in technologies to comply with the proposed standards.

[16] This study used the 2015 IMPLAN national data set.

[17] See IU Report, pp. 86-87.

3. **Fuel Spending Impacts.** This mechanism traces the impacts of reductions in fuel expenditures due to increased fuel economy levels, and the re-spending of most of the resulting consumer savings.

Within each mechanism, we accounted for three different types of economic impacts:

- **Direct impacts.** These are changes in employment and GDP in sectors immediately impacted by the vehicle regulations. For example, these include changes in employment in the auto manufacturing sector resulting from the need to incorporate additional fuel-saving technologies in future cars.
- **Indirect impacts.** These are changes in employment and GDP within industries that serve as suppliers to the directly affected industries. For example, these include effects on the steel industry and other suppliers to the auto industry.
- **Induced impacts.** These are changes in employment and GDP associated with shifts in consumer spending in the wider economy. Induced effects arise when consumers re-spend most of their fuel savings resulting from the use of more fuel-efficient vehicles. Induced effects also result from changes in consumer spending by employees in directly and indirectly impacted industries who have more (or less) disposable income.

Under our modeling framework, every direct impact is offset to at least some degree by an induced impact that goes in the opposite direction. If the vehicle standards result in decreased spending on the petroleum industry, they also result in increased spending on other industries, as consumers re-spend their gas savings elsewhere. Similarly, if the vehicle standards result in increased spending on the auto industry, consumers have less money left to spend on other industries.[18]

3.1. IMPLAN Modeling Inputs

Many inputs to our IMPLAN modeling were the same as those used in our TCO analysis. In each of our scenarios, we used the same assumptions for gross price premiums, consumer financing, gas prices, price elasticity, and other relevant parameters across both models. In addition, we used the percentage changes in car and truck sales as calculated in the TCO model to determine the change in spending on the auto sector within our IMPLAN modeling. We similarly used TCO calculations to determine changes in spending on gasoline for the IMPLAN analysis.

Synchronization of inputs and outputs across our TCO and macroeconomic modeling is a critical difference between our analysis and the IU study. The IU authors discarded many of the assumptions from their TCO model, substituting less appropriate assumptions in their macroeconomic modeling. Most importantly, IU's macroeconomic modeling assumed that consumers do not value any future fuel

[18] We note that the IU study explicitly accounted for impacts from consumer re-spending of fuel savings, but it is not clear to us whether the IU study accounted for re-spending impacts associated with changes in spending on the auto industry.

savings at the time of vehicle purchase, respond to changes in vehicle price with an elasticity of -1.65 rather than -1.0, and never finance their vehicle purchases.[19]

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 in a manner consistent with the IU study's assumptions. Like IU, we assumed that about 8 percent of spending on vehicle standards compliance for new gasoline-powered 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.[20]

- **Allocation of re-spending:** We followed IU in assuming 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.[21]

- **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.[22] Based on this data, we assumed a savings rate of 14.6 percent for households purchasing new cars. That is, we assumed that when a household with a new standards-compliant vehicle saves $100 on gas expenditures, it will re-spend $85.40 on other consumer expenditures. The rest will go into a savings account, where it is not immediately recycled into the wider economy.

- **Industry import fractions**: Generally, we relied on IMPLAN's calculations of local purchase percentages to determine the percentage of purchases from a given industry that go to imports. For example, IMPLAN assumes that about 75 percent of American spending on automobile manufacturing goes to American facilities, while 25 percent goes to imports. We assumed that this same local spending percentages applies to ancillary industry categories, such as management of automobile companies.

3.2. IMPLAN Modeling Results

Figure 8 summarizes the GDP results of our macroeconomic modeling, in comparison to IU's results. We found that, under both the Improved IU and Synapse Scenarios, the existing 2017-2025 state and federal vehicle standards result in increased U.S. GDP in all years of our study period. This is a notable difference from IU's finding of near-term negative impacts. Under the Improved IU scenario, annual GDP increases

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[19] IU Report, p. 124.

[20] See IU Report, p. 168. IMPLAN industries used to represent these categories include "Scientific research and development services," "Management of companies and enterprises," "Automobile manufacturing," "Light truck and utility vehicle manufacturing," "Labor Income," "Proprietor Income," and "Retail - Motor vehicle and parts dealers."

[21] IU Report, pp. 87-88.

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

add up to $9.5 billion in 2025 and $14.3 billion in 2035. Under the Synapse scenario, annual GDP benefits amount to $13.6 billion in 2025 and $16.1 billion in 2035.

Figure 8. Vehicle Standards GDP Impacts Under Improved IU and Synapse Scenarios, Compared to IU 2018 Results

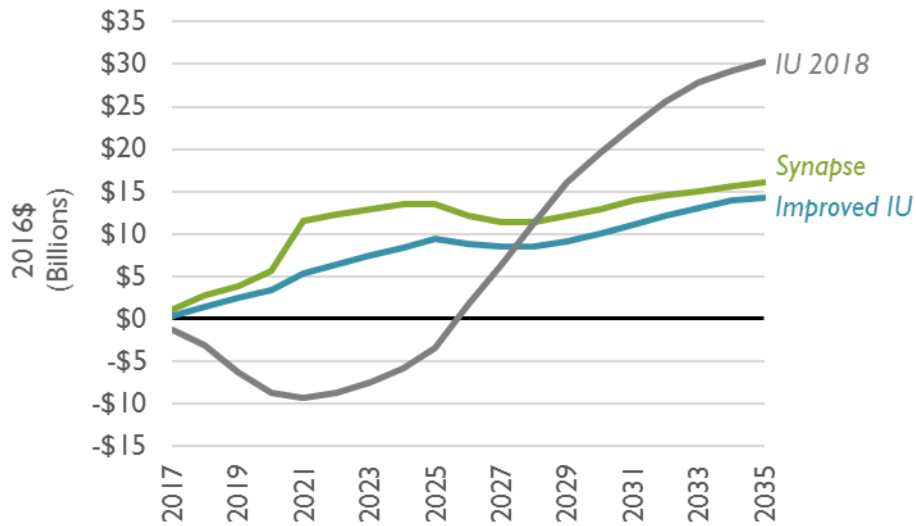

Figure 9 presents our aggregate employment results alongside IU's revised results. We again find positive net benefits in all years. In both the Improved IU and Synapse scenarios, the vehicle standards result in national employment increases of more than 100,000 in 2025 and more than 250,000 in 2035.[23]

[23] Throughout this report, employment impacts are reported in terms of job-years, where one job-year represents one job that lasts for one year. Since we exclusively report employment impacts on an annual basis, these results can also be thought of in terms of a change in the average number of jobs in a given year.

Figure 9. Vehicle Standards Employment Impacts Under Improved IU and Synapse Scenarios, Compared to IU 2018 Results

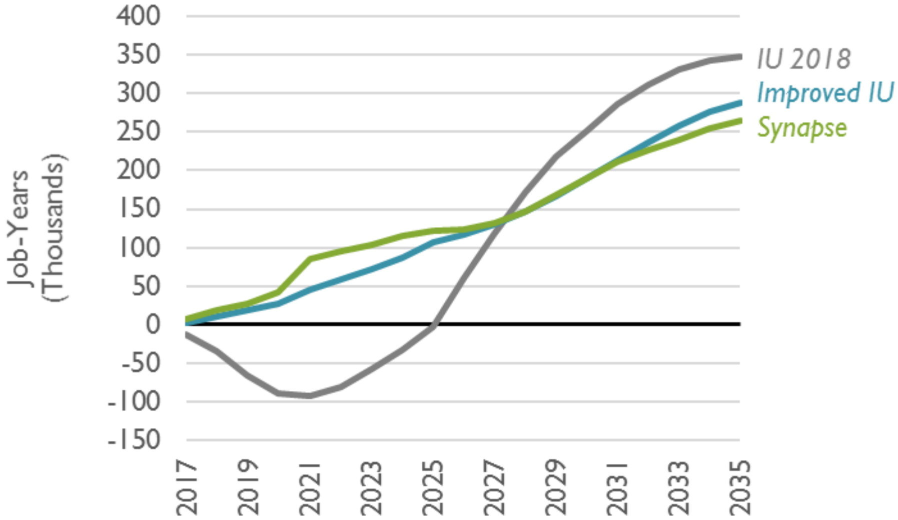

Table 2 presents our Synapse scenario macroeconomic results broken out by category of initial expenditure for 2025 and 2035. We divide impacts into those related to changes in spending on new vehicles, changes in fuel expenditures, and changes in general consumer spending on all sectors of the economy. This breakout can also be thought of in terms of the mechanisms and IMPLAN effect types described above. Impacts related to new vehicle purchases correspond to the direct and indirect effects of Mechanisms 1 and 2. Fuel purchase-related impacts correspond to the direct and indirect effects of Mechanism 3. And generic re-spending impacts correspond to the aggregate consumer-related induced effects of all three mechanisms.[24]

Table 2. Changes in Direct Spending[25] and Associated GDP and Employment Impacts, Synapse Scenario

	Spending Change (2016 $Billion)		GDP Impact (2016 $Billion)		Employment Impact (Thousand Job-Years)	
Spending Category	**2025**	**2035**	**2025**	**2035**	**2025**	**2035**
New Vehicle Purchase	$38	$43	$43	$48	347	385
Fuel Purchase	-$39	-$89	-$33	-$75	-256	-590
Generic Re-spending	$2	$33	$3	$43	32	470
Total	***$2***	***-$13***	***$14***	***$16***	***122***	***265***

[24] Induced effects associated with re-spending by employees in the auto and petroleum sectors are captured within the results for those sectors. Those induced impacts are generally small relative to both the direct and indirect effects of those sectors and the induced effects associated with consumer re-spending.

[25] Direct spending includes purchases of imports as well as domestic products. The spending change is greater than the GDP impact for fuel purchases, because a significant fraction of fuel purchases goes to imports.

In all years of our analysis we find positive impacts related to enhanced spending in the auto sector and negative impacts related to reduced spending in the petroleum sector. Consumer re-spending impacts are negative but small in the early years, and then increasingly positive in the later years, as the consumer benefits of fuel savings outweigh the costs of increased spending on new vehicles. Beyond 2025, impacts related to vehicle sales flatten out as vehicle standards are assumed to remain constant for all model years after 2025. However, impacts related to fuel purchases and re-spending grow steadily between 2025 and 2035, as more and more fuel-efficient cars come onto the roads. Positive impacts associated with increased spending on new vehicles and generic consumer goods outweigh negative impacts associated with decreased spending on fuel.

4. Discussion: Why Such Strong Results?

Our results indicate that the federal and state vehicle standards covering model years 2017–2025 are likely to result in consistently positive net employment and GDP impacts in the United States. Here we briefly discuss the underlying basis for these results.

4.1. General Explanations for Results

Fundamentally, we modeled a combination of two tradeoffs:

1. Spending on new vehicles vs. generic consumer spending; and
2. Spending on gasoline vs. generic consumer spending.

IMPLAN data indicates that generic consumer spending results in slightly more jobs and GDP per million dollars spent than auto sector spending, and far more jobs and GDP than spending on gasoline. This is a result of two factors: First, most industries on which consumers spend money are less import-intensive than the automotive and gasoline industries. As of 2015, about 90 percent of generic household spending goes toward U.S. output. In contrast, 75 percent of U.S. spending on automobile manufacturing stays within the country, and only 52 percent of U.S. spending on crude oil goes toward domestic industry.[26]

Second, generic spending generally goes to sectors that are more labor-intensive than the automobile and petroleum sectors. According to IMPLAN data, one million dollars of annual spending on generic consumer goods results in about 15 total jobs. For the automobile manufacturing sector, that figure is eight jobs. For the petroleum refining sector, it is five jobs.

[26] The domestic share of oil production has been increasing since 2015. However, it is likely to remain below the domestic share of retail industries.

Of course, part of the spending on automobiles and gasoline goes to entirely local and relatively labor-intensive retail dealerships and gas stations. Nonetheless, the aggregate impacts of spending on gasoline remain far lower than those from generic spending.

Thus, we find that total employment and GDP impacts are relatively insensitive to modest increases or decreases in spending on new vehicles. However, gasoline savings—moving dollars from the gasoline pump to generic consumer spending—are sure to cause net job creation. Increases in the number of new, fuel-efficient vehicles that are purchased, and in the fuel savings per new vehicle, lead to better macroeconomic outcomes.

4.2. Comparison to IU Results

The main high-level difference between our results and those reported in the IU study is that IU found that the vehicle standards are likely to result in negative near-term impacts (even in its 2018 updates), while we find positive impacts in both the near term and the long term. This is in part because the IU report found that the vehicle standards would have negative impacts on the auto sector, whereas both of our scenarios indicate positive impacts on the auto sector.

As shown by our Improved IU scenario, parts of IU's macroeconomic results are contradicted by its TCO results. That is, if IU believes its own TCO results, it should also believe that the vehicle standards result in increased spending on the auto sector, and therefore increased economic activity within the auto sector. The IU study only found negative impacts on the auto sector because it did not make use of its TCO results in its macroeconomic analysis. Instead, it relied upon alternative, poorly justified assumptions regarding such critical parameters as the net price premium perceived by consumers and the price elasticity of demand for new vehicles.

Our Improved IU scenario incorporated two types of corrections to IU's original 2016 COMET scenario: First, we corrected for the two calculation errors that IU acknowledged and corrected in its 2018 revisions. Second, we corrected for the methodological error of not incorporating TCO assumptions and results into macroeconomic modeling. After making these two corrections, we found positive impacts on the auto sector, and positive net nationwide macroeconomic impacts, in all years.

One point that is relevant to our finding of macroeconomic benefits across all years is that of timing. As mentioned above, we assume that increased spending on the auto sector is offset by a reduction in generic consumer spending. However, in keeping with IU's TCO assumptions, we also assume that most new vehicle owners finance their vehicle purchases. Thus, while any increased economic activity in the auto sector happens in the year that a new vehicle is manufactured and sold, negative impacts on generic consumer spending power are spread across the subsequent five years, as the consumer pays off the auto loan. So, in the first year of our analysis, increases in auto sector spending outweigh decreases in generic consumer spending by a factor of about 5 to 1.

The result is that in the early years of our analysis, in which gas savings remain relatively small, positive auto sector employment impacts outweigh negative impacts on generic spending. In the 2020s, negative generic spending impacts associated with increased automobile expenditures grow to fully offset the positive impacts of increased auto sector spending.[27] But by that time, consumer re-spending of gas savings from several years' worth of new fuel-efficient vehicles is sufficient to ensure that aggregate employment and GDP impacts remain positive. In the later years of our analysis, the positive impacts of shifting from spending on gasoline to generic consumer spending increasingly dominate our aggregate results.

5. CONCLUSION

The existing federal and state vehicle standards for model years 2017-2025 are likely to result in positive net macroeconomic benefits at the national level across all time horizons. Note, however, that the GDP and employment effects discussed here are not large in the context of the national economy. The largest of our annual GDP impact results amounts to less than 0.1 percent of 2017 U.S. GDP.[28] Our largest modeled annual employment impacts are less than 0.2 percent of current U.S. employment levels.[29] In addition, our results, like all forecasts, are necessarily uncertain, especially farther out in the modeling period.

Nonetheless, it is significant that we consistently find positive impacts in all years of both scenarios we modeled. This is particularly noteworthy given that one of our scenarios involved only a few corrections to a prior analysis that reported negative near-term impacts. Our findings leave us confident that the vehicle standards are likely to have modest positive impacts on both the auto sector and the broader U.S. economy. Fuel economy standards will lead to less spending on fuel; that is the intended result of such standards. This contributes to energy independence, reduction of greenhouse gas emissions, and other social goals. But cutbacks in the petroleum sector will be more than offset by gains in the rest of the economy, ensuring overall growth in employment.

Importantly, this study, like the IU study, focuses exclusively on macroeconomic indicators, and only examines three core mechanisms by which vehicle standards impact those indicators. This study does not account for social or economic impacts associated with the public health and environmental

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[27] Since we assume loan payments are spread over five years, it is in 2021, the fifth year of our analysis, that total annual consumer vehicle payments begin to add up to payments received by the auto sector.

[28] Under the Synapse Scenario, net GDP impacts reach $16 billion in 2035. In 2017, the U.S. GDP was greater than $19 trillion. See U.S. Bureau of Economic Analysis. National Income and Product Accounts, Gross Domestic Product: Fourth Quarter and Annual 2017. https://www.bea.gov/newsreleases/national/gdp/gdpnewsrelease.htm.

[29] Under the Improved IU scenario, employment impacts reach 289,000 in 2035. Total U.S. employment is currently around 155 million. U.S. Bureau of Labor Statistics. Labor Force Statistics from the Current Population Survey. Data as of March 21, 2018. https://data.bls.gov/timeseries/LNS12000000

benefits of the vehicle standards. Our findings lead us to conclude that the emission reduction benefits associated with the vehicle standards can be achieved while strengthening the U.S. economy.