Institute *for*
Policy Integrity
NEW YORK UNIVERSITY SCHOOL OF LAW

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VIA ELECTRONIC SUBMISSION

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EPA Science Advisory Board (1400R)
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Re: January 2020 Meeting of the Chartered Science Advisory Board; The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, RIN 2060–AU09

The Institute for Policy Integrity ("Policy Integrity") at New York University School of Law[1] submits the following comments to the Environmental Protection Agency ("EPA") Chartered Science Advisory Board ("SAB"). These comments concern the SAB's draft report on the scientific and technical basis of the EPA's proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy (2060-AU09) ("Proposed Rule").[2] Policy Integrity commends the SAB for producing an important report on the technical and legal basis—including the flaws—underling the Proposed Rule. In these comments, we provide supplementary information to reinforce many of the key conclusions presented in the draft report, but also to encourage the SAB to reconsider its discussion of the social cost of carbon.

Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy. Policy Integrity has conducted a rigorous examination of the August 2018 joint EPA and National Highway Traffic Safety Administration ("NHTSA") (collectively "the agencies") Notice of Proposed Rulemaking, the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks ("Proposed

[1] This document does not purport to present New York University School of Law's views, if any.

[2] SAB Draft Report, Consideration of the Scientific and Technical Basis of the EPA's Proposed Rule Titled The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks (2019), https://yosemite.epa.gov/sab/sabproduct.nsf/ea5d9a9b55cc319285256cbd005a472e/3bd8a1aea4943223852584e1005463de!OpenDocument [hereafter "SAB Draft Report"].

Rule").[3] In October 2018, Policy Integrity submitted comments ("October comments") raising concerns with the economic analysis that the agencies used to support the Proposed Rule,[4] and, along with other organizations, comments on the agencies' failure to accurately and fully monetize the climate damages from greenhouse gas emissions.[5] In December 2018, Policy Integrity submitted supplemental comments ("December comments") highlighting concerns with an alternative economic analysis of the Proposed Rule presented in a report by NERA Economic Consulting and Trinity Consultants.[6] In May 2019, Policy Integrity submitted additional comments ("May comments") responding to a purported rebuttal from NERA of those critiques.[7]

The SAB's draft report has identified areas of significant weakness in the agencies' analysis supporting the Proposed Rule and areas where significant improvement in the Proposed Rule are feasible.[8] In particular the draft report focuses on NHTSA's Volpe CAFE Model and the agencies' sales and scrappage models. Policy Integrity's evaluation of these models as part of the public comment process reveals that they are inconsistent with basic economic theory, fail to conform to the best practices developed in the economic literature, and contain numerous econometric flaws, and, as a result, they produce anomalous outputs. Policy Integrity commends the SAB for highlighting these critical concerns in its draft report and urges the SAB to adopt a final report that does the same.

In order to aid the SAB in finalization of the draft report, Policy Integrity attaches the four sets of comments submitted to the agencies on the Proposed Rule, which describe the flaws in the agencies' analysis in greater detail. In addition, these comments highlight key areas of agreement with the draft SAB Report and provide additional technical detail to support or clarify the SAB's conclusions. Policy Integrity further urges the SAB to review the comments submitted to the agencies in October 2018 on the social cost of carbon—and the key points from those comments summarized below—and to adjust the draft report's discussion of uncertainty around the social cost of carbon to reflect the fact that the bulk of uncertainty, as well as omitted factors, point toward a *higher* and not a lower value for the benefits of reducing greenhouse gas emissions.

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[3] 83 Fed. Reg. 42,986 (Aug. 24, 2018).

[4] Comments of the Institute for Policy Integrity to EPA and NHTSA on The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA-2018-0067-12213 and EPA-HQ-OAR-2018-0283-5083 (Oct. 26, 2018), https://policyintegrity.org/documents/Emissions_Standards_EPA_NHTSA_Comments_Oct2018.pdf [hereafter "Policy Integrity October 2018 Comments"]

[5] *See* Policy Integrity et al., Comments on Quantifying and Monetizing Greenhouse Gas Emissions in the Safer Affordable Fuel-Efficient Vehicles Proposed Rule and Preliminary Regulatory Impact Analysis, EPA-HQ-OAR-2018-0283 and NHTSA-2018-006 (October 26, 2018), https://policyintegrity.org/documents/Emissions_Standards_PRIA_SCC_Comments_Oct2018.pdf [hereafter "Joint SCC Comments"].

[6] *See* Supplemental Comments by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12362 (Dec. 21, 2018) [hereafter "Policy Integrity December Comments"].

[7] Reply Comments of the Institute for Policy Integrity to EPA and NHTSA on The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA-2018-0067 and EPA-HQ-OAR-2018-0283 (May 31, 2019), https://policyintegrity.org/documents/Policy_Integrity_comments_to_NHTSA_and_EPA.pdf [hereafter "Policy Integrity May 2019 Comments"].

[8] SAB Draft Report at 1.

Finally, EPA has recently indicated that it has made substantial changes to the modeling that will be used to support a final rule.[9] Given the critical importance of the modeling to the agencies' conclusions, and the substantial flaws that underlie the modeling used in the Proposed Rule,[10] the SAB should review any substantially revised or newly developed models that the EPA intends to use to support a final rule. The SAB should request that EPA delay finalization of a final rule until such time as the SAB is able to offer a meaningful review of any substantially revised and new modeling.

A. Cost of Compliance.

Manufacturer Beliefs About Consumer Willingness to Pay for Efficiency. In Section 4.2, the draft report supports EPA's conclusion that manufacturers believe that consumers value 2.5 years of fuel savings when evaluating new vehicle purchases, and that, as a result, manufacturers will include the technology that would achieve such savings even without regulatory standards.[11] The economics literature does support a variety of estimates of consumers' observed willingness to pay for fuel efficiency improvements.[12] However, EPA's assumption about manufacturer behavior does not follow from consumers' observed willingness to pay for fuel efficiency improvements. As explained in Policy Integrity's October comments, the historical evidence shows that manufacturers have not improved fuel economy when not required to do so, even though consumers value fuel economy.[13] Policy Integrity's comments also explained how supply-side market failures, asymmetrical information, positional externalities, rational inattention, and a host of other influences can result in manufacturers not providing consumers with the amount of fuel efficiency they value.[14] Notwithstanding the draft report's statements,[15] EPA has consistently recognized that manufacturers would include *no* fuel economy technology improvements beyond what was required by standards, as reflected in the assumptions used both in the Draft Technical Assessment Report,[16] and in the 2012 rulemaking setting model year 2017-2025 standards.[17] As a result, Policy Integrity urges the SAB to revise this section of the draft report and to encourage EPA to adopt a more realistic assumption about manufacturer behavior in the absense of regulatory standards.

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[9] *See* Doug Obey & Lee Logan, *Citing Changes, Wheeler Rejects SAB Critique on Auto GHG Rollback*, INSIDEEPA (Jan. 6, 2020), https://insideepa.com/daily-news/citing-changes-wheeler-rejects-sab-critique-auto-ghg-rollback (quoting EPA Administrator Wheeler as stating that " a lot has changed in the proposed regulation").

[10] SAB Draft Report at 34 ("these issues are of sufficient magnitude that the estimated net benefit of the proposed revision may be substantially overstated. In fact, the weaknesses are sufficiently important that they could reverse the sign of result, indicating that the augural standards provide a better outcome than the proposed revision").

[11] *Id.* at 11.

[12] David Greene, Anushah Hossain, Julia Hofmann, Gloria Helfand & Robert Beach, *Consumer Willingness to Pay for Vehicle Attributes: What Do We Know?*, 118 TRANSP. RES. 258 (2018).

[13] *See* Policy Integrity October Comments at 40-46; *see also* ICCT Comments, Docket #EPA-HQ-OAR-2018-0283-5456, NHTSA-2018-0067-11741, Attachment 3, p. II-1.

[14] Policy Integrity October Comments. at 38-40, 47-51.

[15] SAB Draft Report at 11 (asserting agencies used an assumption of 3 years in the Draft TAR).

[16] *See* EPA 2016 Technical Support Document (November, 2016), EPA-420-R-16-021, at 4-15 to 4-16.

[17] EPA and NHTSA, 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed Reg 62,624, 62,915 (Oct. 15, 2012) (EPA stating that it did "not have a basis to expect that auto makers will go beyond the standards for [model year] 2016 in the absence of this rule").

Treatment of Flexibility Mechanisms. In Section 4.6, the draft report criticizes EPA for failing to fully account for the optimal use of available flexibility mechanisms by manufacturers when estimating the costs of compliance.[18] Policy Integrity supports this critique. EPA's failure to correctly consider flexibility mechanisms in the Proposed Rule leads to an overstatement of compliance costs and vehicle price increases, which in turn have a significant effect on other modeling components.

However, the SAB should revise its statement about the auto industry's historical use of flexibility mechanisms.[19] Flexibility mechanisms available to automakers under EPA's emission standards include credit banking, borrowing, trading and transferring between fleets, as well as air-conditioning and off-cycle credits/adjustments.[20] The flexibilities of the type that manufacturers were familiar with from the CAFE program have been heavily used, as documented in EPA's Automotive Trades Reports.[21] The other flexibility mechanisms have been steadily increasing in popularity and more recent studies suggest that they have been applied significantly. As reported by Resources for the Future, in 2016, tradeable credits represented around 33 percent of the additional required emissions reduction per vehicle from the regulations.[22] In 2017, the latest year with available data, the volume of trades has further increased by almost 40%.[23] This data shows that car manufacturers have become familiar and comfortable with the use of trading. The number of fleet-wide air-conditioning credits and off-cycle credits have also been increasing.[24] While we agree with the SAB that in the future, use of flexibility mechanisms will become even more prevalent in response to increases in regulation stringency, it is also important to acknowledge the *current* popularity of flexibility mechanisms. The preexisting use of such mechanisms implies that the Proposed Rule overestimates compliance costs in the early years—with the bias further compounding over time.

In addition, Policy Integrity encourages the SAB to discuss additional issues concerning the treatment of compliance flexibilities in the Proposed Rule. As discussed in Policy Integrity's October comments, modeling of banking bahavior that ignores strategic early overcompliance,

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[18] SAB Draft Report at 17-18.

[19] *Id.* at 17 ("Thus, even though economic models predict that extensive use of flexibility mechanisms would reduce compliance costs, the real-world use of flexibility mechanisms has been quite limited in the auto industry").

[20] For CAFE standards they also include the possibility of paying a penalty in lieu of compliance.

[21] EPA, THE 2018 AUTOMOTIVE TRENDS REPORT: GREENHOUSE GAS EMISSIONS, FUEL ECONOMY, AND TECHNOLOGY SINCE 1975 at ES9, ES11 (2018), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100W5C2.PDF?Dockey=P100W5C2.PDF [hereafter "2018 Automotive Trends Report"] (showing number of credits accumulated by large manufacturers an shown and industry-level credits report). While credit borrowing behavior cannot be easily inferred from the data, the experiences with CAFE show that manufacturers do use that option in practice for decreasing their compliance costs.

[22] Benjamin Leard & Virginia McConnell, *Agencies Should Account for Credit Trading in Estimating Costs of CAFE Compliance*, RESOURCES (Nov. 01, 2018), https://www.resourcesmag.org/common-resources/agencies-should-account-for-credit-trading-in-estimating-costs-of-cafe-compliance/.

[23] Benjamin Leard & Virginia McConnell, *Credit Trading Accelerates as Passenger Vehicle Fuel Economy and Greenhouse Gas Standards Tighten*, RESOURCES (Dec. 09, 2019), https://www.resourcesmag.org/common-resources/credit-trading-accelerates-passenger-vehicle-fuel-economy-and-greenhouse-gas-standards-tighten/.

[24] 2018 AUTOMOTIVE TRENDS REPORT at 106 (Table 5.6).

lack of borrowing, faulty modeling of credit transfers and imposing strong assumptions on the future off-cycle and air-conditioning efficiency technology are other areas that, in absence of adjustments, will lead to overestimated compliance costs.[25]

B. Fleet Size and Composition

Consumer Willingness to Pay for Fuel Efficiency. Section 5.1 of the draft report is critical of EPA for failing to use consistent assumptions about consumer willingness to pay for fuel efficiency throughout the Proposed Rule.[26] As explained in our October comments, Policy Integrity supports this critique of the Proposed Rule.[27] The draft report also presents evidence that there is an energy efficiency gap—that is, that consumers do not appear willing to pay for all of the fuel savings that would be rational to demand.[28] Policy Integrity supports this general conclusion. That said, the draft report's suggestion that behavioral factors and not information effects are the cause of the gap fails to account for the myriad market failures that the economics literature has identified as a cause of the energy efficiency gap.[29] As Policy Integrity outlined in detail in prior comments, there are a number of theorized and empirically measured market failures that may be the cause of the observed energy efficiency gap including consumer-side market failures (such as split incentives, inattention, salience, use of rules of thumb, consumer loss aversion, capital market failures, and positional externalities), as well as manufacturer-side market failures (such as market power and technology spillover effects).[30] One recent study is worth highlighting because it was released after the comment period for the Proposed Rule closed. Kenneth Gillingham, Sebastian Houde, and Arthur van Bentham have found significant empirical evidence of consumer myopia.[31] That study, which takes advantage of a sophisticated natural experiment, also finds empirical evidence that U.S. consumers substantially undervalue fuel economy and that a number of the studies that the agencies pointed in the Proposed Rule in order to claim consumers fully value fuel savings suffer from upward estimation bias.[32] The SAB should expand its discussion of market failures that cause the energy efficiency gap in its final report.

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[25] *See* Policy Integrity October Comments at 18-23.

[26] SAB Draft Report at 19-21.

[27] Policy Integrity October Comments at 33-35.

[28] SAB Draft Report at 21.

[29] *Id.* ("the undervaluation is unlikely to be attributable to a pure information effect . . . . A sustained program of behavioral economics research is necessary to fully understand consumer attitudes and decision making about vehicles").

[30] Policy Integrity October Comments at 47-51; Policy Integrity December Comments at 4; Policy Integrity May Comments at 11-12.

[31] Kenneth Gillingham, Sebastian Houde, & Arthur van Bentham, *Consumer Myopia in Vehicle Purchases: Evidence from a Natural Experiment* (Nat'l Bureau of Econ. Research, Working Paper No. 25845, 2019), https://www.nber.org/papers/w25845

[32] *Id.* at 16-17.

In addition, the SAB should revise the report to clarify that observed estimates of consumer willingness to pay for efficiency is not the appropriate metric for the calculation of fuel saving benefits produced by fuel economy and emission standards. The need for such clarification is not merely speculative. In comments to the agencies, NERA Economic Consulting provided an economic analysis that calculated the economic benefits of fuel savings based only on purported measures of consumer willingness to pay for fuel efficiency improvements.[33] However, limiting the benefits of fuel economy to that level is incorrect and is a departure from the approach that the agencies have consistently taken for calculating the benefits of fuel savings since the first proposed fuel economy regulations over 40 years ago.[34] As Policy Integrity explained in its May comments, due to market failures, observed consumer willingness to pay for fuel economy may not reflect the full economic value of the future fuel savings consumers will experience over time.[35] But avoided fuel consumption represents real resource savings to the economy regardless of what consumers expected at the time of purchase. And, once those savings appear in their pocketbooks, consumers will fully value and use that money, regardless of the expectations for fuel savings that consumers had when they initially decided which car to buy.[36] Policy Integrity urges the SAB to revise its report to clarify that while the agencies should consistently apply consumer willingness to pay estimates when evaluating consumer decisionmaking regarding the purchase of vehicles, it would not be appropriate to use such a measure for calculating the social benefits of fuel savings.

Impact of Regulatory Alternatives on New Vehicle Sales. In Section 5.2 of the draft report, the SAB reviews the evidence regarding consumer willingness to pay for non-efficiency attributes and the effect such willingness to pay will have on vehicle sales. The draft SAB report concludes that "it is not yet feasible to quantify the impact on new vehicle sales of additional vehicle characteristics (beyond fuel economy) that are desired by consumers but restrained by federal standards."[37] Policy Integrity agrees that "it is not yet feasible to quantify the impact on new vehicle sales of additional vehicle characteristics (beyond fuel economy)" but does not believe that the evidence clearly supports the suggestion that "additional vehicle characteristics (beyond fuel economy) that are desired by consumers [are] restrained by federal standards."

The draft report's initial conclusion is consistent with long-standing EPA positions. In a study commissioned by EPA for the 2016 Technical Assessment Report, researchers concluded that "we have found very little useful consensus" regarding "estimates of the values of various

[33] *See* NERA Economic Consulting & Trinity Consultants, Evaluation of Alternative Passenger Car and Light Truck Corporate Average Fuel Economy (CAFE) Standards for Model Years 2021-2026 at 54 (Oct. 26, 2018) (attached to Comments of the Alliance of Automobile Manufacturers, NHTSA-2018-0067-12073 and EPA-HQ-OAR-2018-0283-6186 (Oct. 26, 2018)).

[34] Policy Integrity December Comments at 5-14.

[35] Policy Integrity May Comments at 11-13.

[36] Policy Integrity December Comments at 3-5.

[37] SAB Draft Report at 22.

vehicle attributes,"[38] and that the usefulness of willingness-to-pay estimates "encompasses such a wide range of values that is of little use for informing policy decisions."[39] In a follow-up paper, the author of EPA's commissioned study found "striking[ly]" high variation in willingness-to-pay estimates across the literature.[40] As such, Greene et al. (2018) concluded that focusing on any specific willingness-to-pay estimate is methodologically suspect.[41] The agencies themselves reached a similar conclusion in their economic analysis of the Proposed Rule:

> There are few empirical estimates of the[] values [that buyers of new cars and light trucks appear to attach to various attributes], and the range of estimates for the values of individual attributes reported in each study is very wide. Where the two studies included in the table report comparable measures, their estimates also differ widely.[42]

As Policy Integrity explained in its May comments, the available evidence does not clearly show that "vehicle characteristics (beyond fuel economy) that are desired by consumers [are] restrained by federal standards."[43] As a result of uncertainty in the tradeoff between vehicle characteristics and fuel economy, in their economic analysis of the Proposed Rule, the agencies found that "sufficiently detailed information on the potential improvements in car and light truck attributes . . . is not currently available,"[44] and that "the specific improvements in attributes other than fuel economy that producers are likely to make to their individual car and light truck models when they face less demanding fuel economy standards cannot be estimated."[45] In fact, the agencies modeling of compliance costs explicitly assumes that vehicle characteristics will be held constant.[46] As a result, in order to be consistent and non-arbitrary, the CAFE model would have to be substantially revised if the agencies made different assumptions regarding non-efficiency vehicle characteristics in their sales model.

Policy Integrity urges the SAB to finalize the report with language making clear that the economics literature does not yet support the agencies' reliance on estimates of consumer willingness to pay for non-efficiency attributes in a real-world policymaking context. However,

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[38] EPA, CONSUMER WILLINGNESS TO PAY FOR VEHICLE ATTRIBUTES: WHAT IS THE CURRENT STATE OF KNOWLEDGE? at 7-1 (2018) https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=OTAQ&dirEntryId=339388.

[39] *Id.*

[40] *See* David Greene, Anushah Hossain, Julia Hofmann, Gloria Helfand & Robert Beach, *Consumer Willingness to Pay for Vehicle Attributes: What Do We Know?*, 118 TRANSP. RES. PART A 258, 264, 273-74 (2018) (even after trimming outlines, "one standard deviation exceeds the mean of the [willingness to pay] estimates for most of the attributes...[and] the interquartile range also exceeds the median").

[41] *Id.* at 274.

[42] NHTSA & EPA, Preliminary Regulatory Impact Analysis: The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021-2026 Passenger Cars and Light Trucks 1095 (Aug. 23, 2018) [hereafter "Proposed Rule RIA"].

[43] Policy Integrity May Comments at 17-19.

[44] Proposed Rule RIA 1091 (Aug. 23, 2018).

[45] *Id.* at 1097.

[46] Policy Integrity May Comments at 24.

the final report should not inadvertently overstate the fact that the standards are restraining the availability of other vehicle characteristics that consumers desire.

In addition, Section 5.2 of the draft report is critical of the Proposed Rule's methodology for calculating the price elasticity of demand for new vehicles.[47] While Policy Integrity does not dispute the reasonableness of the estimated -0.2 to -0.3 elasticity estimate used in the Proposed Rule, Policy Integrity raised similar concerns regarding the sales model methodology that was used to derive these elasticity estimates.[48] However, Policy Integrity recommends that the SAB more clearly indicate that a return to the prior estimate of elasticity of -1 is not supported by the economics literature and so would not be appropriate in a final rule. As the draft report explains, that estimate "was not based on a particular analysis or study in the academic literature."[49] The inappropriateness of using a -1 value for price elasticity of demand for new vehicles is also supported by the peer review of the 2018 Volpe model commissioned by NHTSA.[50]

In Section 5.2, the draft report also states "[i]n the regulatory setting, it is assumed that all major vehicle manufacturers (Tesla is a notable exception) will raise prices since they are all incurring costs due to binding CAFE and GHG regulations."[51] Policy Integrity urges the SAB to revise this statement to more accurately reflect the fact that not all manufacturer cost increases will be passed through to consumers as price increases. As Policy Integrity explained in its October comments, the agencies' assumption that all cost increases will be passed on to consumers is unreasonable for three reasons:

- the existing level of market power in the vehicle industry means that firms may not pass on all of their costs to consumers;
- manufacturers can cross-subsidize the purchase of certain vehicles by adjusting prices across their fleet to optimally attract customers toward more fuel-efficient vehicles; and,
- historical price changes do not support an assumption of full passthrough.[52]

C. Fleet Utilization

Impact of Alternative Regulatory Policies on the Total Fleet Size, Older Vehicles, and Characteristics of the Vehicle Fleet; Use of Fixed Schedules for Vehicle Miles Traveled. In Section 5.3, the draft report recounts and concurs with the significant criticism that the agencies have received for their estimates of fleet size;[53] in Section 6.1, the draft report recounts and concurs with the criticisms that that agencies have received for their use of fixed schedules for vehicle miles traveled (VMT).[54] Policy Integrity strongly agrees with these criticisms of the

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[47] SAB Draft Report at 22-23.

[48] Policy Integrity October Comments at 33; *id.* at 57-59 (identifying general economic errors in the agencies' new modeling including the sales model).

[49] SAB Draft Report at 22.

[50] NHTSA, CAFE Model Peer Review Revised, at B-33, B035 (2019), https://www.regulations.gov/contentStreamer?documentId=NHTSA-2018-0067-0055&attachmentNumber=2&contentType=pdf (peer review of John Graham).

[51] SAB Draft Report at 22.

[52] Policy Integrity October Comments at 27-31.

[53] SAB Draft Report at 23-24.

[54] *Id.* at 25-26.

scrappage and VMT models that are used in the Proposed Rule. As Policy Integrity discussed extensively in October comments, the agencies' analysis of the implications of new vehicle price increases is fundamentally flawed for two critical reasons.[55] First, the agencies' estimates and modeling of the impact of price increases on total fleet size and VMT violate economic theory. Correcting the agencies' errors in this area will significantly reduce (or even reverse) the purported effect of the current standards on safety. Second, even if the agencies were right that increased new vehicle prices lead to an increase in the number and proportion of older vehicles in the market, the safety impact of those vehicles is overstated. The data supporting the agencies' conclusions are improperly inflated in ways that contradict the agencies' prior analyses and the available evidence. Given the magnitude of these errors and the importance of the scrappage, VMT, and safety models to the agencies' conclusions, the SAB should retain these discussions in any final report.

Magnitude of the Rebound Effect. In Section 6.2, the draft report correctly criticizes the agencies for moving from a 10 percent estimate of rebound to a 20 percent estimate.[56] In particular, the draft report explains that a 20 percent rebound estimate does not properly account for changes over time (and with income) in demand for driving, and is the result of the inappropriate use of simple averaging of studies rather than the more accurate use of quality and relevance metrics. Policy Integrity strong supports the SAB's conclusions. Policy Integrity provided substantial additional technical support for these conclusions, including analysis of the academic literature, in its October comments.[57]

D. Handling of Uncertainty

The draft SAB report includes a discussion of the social cost of carbon and climate sensitivity that significantly overstates the uncertainties involved in those estimates and appears to undermine their use in policymaking.[58]

To begin, it is incorrect for the draft report to say that using a "domestic value of $7 per ton" is "consistent with prior practices of the Interagency Working Group (IWG) when scaling global estimates to domestic value."[59] Though in 2010 the Interagency Working Group did report an "approximate, provisional, and highly speculative" domestic range, the 2010 technical support document also concluded that "[t]here is no a priori reason why domestic benefits should be a constant fraction of net global damages over time"; explained that the underlying models did "not account for how damages in other regions could affect the United States (e.g., global migration, economic and political destabilization"; and ultimately "concluded that using the global (rather than domestic) value . . . is the appropriate approach."[60] By 2015, the Interagency Working Group's clear position was that "a purely domestic measure is likely to understate

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[55] Policy Integrity October Comments at 59-98.

[56] SAB Draft Report at 26-27.

[57] Policy Integrity October Comments at 99-118.

[58] SAB Draft Report at 32-33.

[59] *Id.* at 32.

[60] Interagency Working Group on the Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866, at 11 (2010).

actual impacts to the United States"; that "from a technical perspective" there were few reliable estimates of a domestic social cost of carbon; that the prior "highly speculative" range was based on only 'two strands of evidence"; and that ultimately it would "continue to recommend the use of global SCC estimates in regulatory impact analyses."[61] In the Interagency Working Group's most recent guidance, from 2016, no range of domestic estimates is given, because instead "a global measure of the benefits from reducing U.S. emissions is appropriate" and is necessary to reflect foreign spillover effects on the United States, foreign reciprocal benefits to the United States, and the global nature of the climate problem.[62] And in the 2016 case *Zero Zone v. Department of Energy*, the Court of Appeals for the Seventh Circuit found, in response to petitioners' challenge that the Department of Energy's consideration of the global social cost of carbon in an appliance efficiency standard rulemaking was arbitrary, that the agency had acted reasonably in considering the global climate effects.[63]

It is also somewhat misleading for the draft report to suggest that "the National Academies observed . . . that further research is needed to develop a more comprehensive measure [of a domestic social cost of carbon]"[64]—a summary which seems to imply that the National Academies recommended more research on a domestic value and perhaps even endorsed the use of such a value. The National Academies did not endorse the use of a domestic value. Instead, the National Academies observed that existing methodologies could not accurately calculate a domestic value and then noted that *if* agencies were to undertake a more accurate estimate of a domestic value, they "would therefore need to" engage in more research on international spillover effects and foreign reciprocal actions.[65] Overall, the National Academies found reason to fundamentally reconsider what even "constitutes domestic impact in the case of a global pollutant" and endorsed the use of the global social cost of carbon values.[66] On these and other key issues, the recommendations from the National Academies supported the Interagency Working Group's methodology to date, while suggesting improvements for the future.

The SAB draft report refers to the social cost of carbon as "complex and highly uncertain," emphasizing the uncertainty around the climate sensitivity estimate, the damage function, and the discount rate.[67] The draft report further highlights a single paper from 2017 that argued for a dramatically lower valuation of the social cost of carbon, and refers vaguely to work by "others" to support the possibility that the social cost of carbon could even be negative (suggesting that increased emissions produce a net benefit to society).[68] This discussion overstates the uncertainties involved in calculating the social cost of carbon, seems to suggest that perhaps the current estimates are too high, and could even be read to cast doubt on the legitimacy of using

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[61] Interagency Working Group on the Social Cost of Carbon, *Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866*, at 32 (2015).

[62] Interagency Working Group on the Social Cost of Greenhouse Gases, *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866*, at 17 (2016).

[63] Zero Zone v. Dept. of Energy, 832 F.3d 654, 679 (7th Cir., 2016).

[64] SAB Draft Report at 32.

[65] NAS, VALUING CLIMATE DAMAGES: UPDATING ESTIMATION OF THE SOCIAL COST OF CARBON DIOXIDE, at 53 (2017).

[66] *Id*.

[67] SAB Draft Report at 32.

[68] *Id.*

social cost of carbon estimates in regulatory analysis. The SAB should therefore adjust this discussion to reflect instead the facts that the Interagency Working Group's estimates were vetted through hundreds of public rulemakings, that its methodologies were endorsed by the National Academies of Sciences and the Government Accountability Office, and that the values' use in regulatory analysis has been upheld by federal courts as reasonable. As our comments detail—along with their technical appendices on uncertainty, discounting, and damages[69]—though a few uncertainties might point in the direction of slightly lower social cost of greenhouse gas values, the models already account for such uncertainties around adaptation and carbon benefits; instead, on balance, most uncertainty *very strongly* point toward *higher*, not lower, social cost of greenhouse gas estimates—perhaps significantly higher. Indeed, many experts consider the Interagency Working Group's estimates to be conservative underestimates because the estimates currently omit many key damage categories, as well as tipping points, option value, and risk aversion.[70] On discount rates in particular, for example, both *Circular A-4* and the economic literature agree that uncertainty would point toward a lower discount rate,[71] or a declining discount rate framework,[72] which would almost certainly result in much higher estimates of the social cost of greenhouse gases than those used by the agencies in the Proposed Rule. Most importantly, uncertainty is not a reason to abandon the social cost of greenhouse gas metrics.

On the draft report's reference in particular to a single paper by Dayaratna et al., as the SAB knows, the work by the Intergovernmental Panel on Climate Change represents the gold standard for determining the equilibrium climate sensitivity distribution. Crucially, the National Academies fully reviewed the literature available through 2017 (note that Dayaratna et al.'s work was available on SSRN in April 2016 and as a discussion paper by July 2016[73]) and concluded that changing the Interagency Working Groups' approach to climate sensitivity was not necessary in the short term.[74] Finally, singling out a single study to cast doubt on whether the social cost of carbon may be too high is strange given the SAB's failure to similarly identify other literature that might strongly point toward much higher estimates of the social cost of carbon, such as Nobel Prize winner William Nordhaus's recent choice to increase the ECS from 2.9 to 3.1 from the DICE-2013 mode to the DICE-2016R2 model. Overall, the SAB should explain both that most uncertainties surrounding the social cost of carbon would point toward a higher value, and also that uncertainty is not a reason to abandon use of the metrics.

Finally, the draft report observes that the 2018 Proposed Rule used a deterministic sensitivity analysis by changing the values of uncertain inputs one at a time, and the SAB recommends either an even "more systematic exploration of alternative scenarios" or else moving "toward

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[69] *See* Joint SCC Comments, *supra*.

[70] *See generally id.*; *see also*, *e.g.*, Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014) (coauthored with Kenneth Arrow, Lawrence H. Goulder, Rober E. Kopp, Michael Oppenheimer, & Thomas Sterner) .

[71] *Id.* at 24.

[72] *Id.* at 27.

[73] http://www.uoguelph.ca/economics/repec/workingpapers/2016/2016-08.pdf.

[74] NAS, *supra*, at 34 (summarizing findings of the Phase 1 report and "recommend[ing] against a near-term update to the social cost of carbon based simply on a recalibration of the probability distribution of the equilibrium climate sensitivity).

comprehensive probabilistic analysis."[75] However, the regulatory impact analysis for the Proposed Rule failed to conduct even a minimally acceptable sensitivity analysis on the social cost of carbon. As explained in our October 2018 comments, not only do the agencies fail to consider a global number even in a sensitivity analysis (let alone focusing on the global estimate as the Interagency Working Group would recommend),[76] but the agencies' reports on their alleged run of a 2.5% discount rate as a sensitivity analysis is "incomplete and inapplicable to this proceeding," as the language was clearly cut-and-pasted from an entirely different regulatory impact analysis.[77] The agencies' also failed to give proper consideration to a 95th percentile "high-impact" estimate that the Interagency Working Group intended to serve a tool to address uncertainty over catastrophic damages, tipping points, option value, and risk aversion.[78] In a similar kind of oversight, the agencies also ignored entire categories of significant upstream emissions;[79] and since, as the draft report acknowledges, "higher emissions" would change the rule's ultimate climate impacts,[80] it is crucial to accurately estimate emissions. The SAB should make clear that a proper analysis of climate effects would first more accurately quantify all upstream and downstream emissions, and then would apply the full range of estimates from the Interagency Working Group's 2016 technical support document, including a focus on the central values based on a 3% discount rate, as well as sensitivity analysis using a 2.5% discount rate and a high-impact 95th percentile number to account for uncertainty.

Thank you for the opportunity to comment on the draft SAB report. For additional information, please feel free to contact Avi Zevin at (949) 302-6179 or avi.zevin@nyu.edu.

Respectfully,

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Sylwia Bialek
Peter Howard
Jason Schwartz

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[75] SAB Draft Report at 33.

[76] Joint SCC Comments at 6-20.

[77] *Id.* at 28; *see also id.* at 20-27 (explaining why the choice of a 7% discount rate for the main analysis is not justified).

[78] *Id.* at 28-32.

[79] Joint SCC Comments at 2-3.

[80] SAB Draft Report at 33.

Attachments:
Comments of the Institute for Policy Integrity to EPA and NHTSA on The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA-2018-0067-12213 and EPA-HQ-OAR-2018-0283-5083 (Oct. 26, 2018)

Policy Integrity et al., Comments on Quantifying and Monetizing Greenhouse Gas Emissions in the Safer Affordable Fuel-Efficient Vehicles Proposed Rule and Preliminary Regulatory Impact Analysis, EPA-HQ-OAR-2018-0283 and NHTSA-2018-006 (October 26, 2018)

Supplemental Comments by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12362 (Dec. 21, 2018)

Reply Comments of the Institute for Policy Integrity to EPA and NHTSA on The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA-2018-0067 and EPA-HQ-OAR-2018-0283 (May 31, 2019)

ATTACHMENT A

Comments of the Institute for Policy Integrity to EPA and NHTSA on The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA-2018-0067-12213 and EPA-HQ-OAR-2018-0283-5083 (Oct. 26, 2018)

Institute *for*
Policy Integrity
NEW YORK UNIVERSITY SCHOOL OF LAW

October 26, 2018

VIA ELECTRONIC SUBMISSION

Attn: Christopher Lieske, Office of Transportation and Air Quality, Assessment and Standards Division, Environmental Protection Agency (EPA)

Re: The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, EPA–HQ–OAR–2018–0283; FRL–9981–74–OAR; RIN 2127–AL76; RIN 2060–AU09

The Institute for Policy Integrity ("Policy Integrity") at New York University School of Law[1] submits the following comments on The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 42986 (Aug. 24, 2018) ("Proposed Rule").

In the Proposed Rule, the Environmental Protection Agency ("EPA") proposes to reverse course on its final greenhouse gas emissions standards for 2021-2025 ("GHG Standards") and the National Highway Traffic Safety Administration ("NHTSA") proposes to reverse course on the Corporate Average Fuel Economy standards for 2021 as well as the augural standards for 2022-2025 ("CAFE standards") (collectively the "baseline standards").[2]

Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy. We write to make the following comments, as more fully described herein:

1. The agencies' approach to weighing their statutory factors is unreasonable.

[1] This document does not purport to present New York University School of Law's views, if any.

[2] In 2012, EPA set standards for cars and light trucks sold in model years 2017 to 2025. 2017 and Later Model Year Light-Duty vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards 77 Fed. Reg. 62,624 (Oct. 12, 2012) [hereafter "baseline standards"]. NHTSA set final fuel economy standards for model years 2017 to 2021 and non-final "augural" standards for model years 2022 to 2025, meaning that those standards represented the agencies' "best estimate" of the appropriate level of stringency for those model years, based on the information available in 2012. *Id.* at 62,627.

2. The agencies have arbitrarily inflated the costs of the baseline standards through several unreasonable assumptions about compliance costs and the extent to which manufacturers pass those costs through to consumers.
3. The agencies have arbitrarily ignored consumer valuation of fuel savings and the welfare benefits of the baseline standards.
4. The agencies' analysis is riddled with econometric errors.
5. The agencies' assumptions about the impact of the baseline standards on fleet composition, vehicle travel, and safety arbitrarily disregard basic economic theory.
6. The agencies' choice of rebound estimate is arbitrary and capricious.
7. Potential changes in the mass of vehicles caused by the baseline standards do not support the Proposed Rule.
8. The agencies' employment analysis is incomplete.
9. The agencies' emissions analysis is inaccurate and incomplete.
10. The agencies' have arbitrarily failed to provide missing information necessary for meaningful public review of the Proposed Rule.

In addition, Policy Integrity is submitting the following three sets of comments under separate cover, which are incorporated herein:[3]

1. Comments explaining that EPA cannot legally withdraw the Clean Air Act preemption waiver granted to California in 2013 for the greenhouse gas and zero emission vehicle requirements of its Advanced Clean Cars program.
2. Comments, submitted together with several other organizations, explaining how the agencies' analysis of the social cost of carbon in the Proposed Rule is inconsistent with best available science, best practices for economic analysis, and legal standards for rational decisionmaking.
3. Comments, submitted together with several other organizations, explaining how NHTSA's analysis of the social cost of carbon in the Draft Environmental Impact Statement for the Safer Affordable Fuel-Efficient Vehicles Rule for Model Year 2022-2026 Passenger Cars and Light Trucks is inconsistent with best available science, best practices for economic analysis, and legal standards for rational decisionmaking.

The references cited herein are provided in a bibliography at the end of these comments.

[3] All three sets of comments are available here: https://policyintegrity.org/what-we-do/update/3190.

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In their justification for the Proposed Rule,[4] the National Highway Traffic Safety Administration ("NHTSA") and the Environmental Protection Agency ("EPA") (collectively the "agencies") rely heavily on the argument that the baseline standards will substantially increase costs which, in turn, will translate into higher prices faced by new car purchasers. NHTSA estimates that vehicle prices will be approximately $2,700 higher by 2029 under the baseline standards.[5] EPA similarly estimates that vehicle prices will be $2,800 higher in 2030, including maintenance and other costs.[6] Discouraged by the price surge, so the agencies argue, used car scrappage will decrease as consumers increasingly rely on used cars for their transportation needs and retain and drive those cars more. This analysis is the core of the agencies' decision to roll back the baseline standards.

In our comments, we show that the agencies' analysis produced biased and irrational results at each of the steps in that causal chain, leading to a Proposed Rule that vastly overstates the benefits of the rollback and understates the benefits society foregoes with the rollback. The agencies should not finalize the Proposed Rule.

I. THE AGENCIES' APPROACH TO WEIGHING THEIR STATUTORY FACTORS IS UNREASONABLE

In attempting to carry out their statutory mandates to conserve energy[7] and protect public welfare,[8] the agencies have unreasonably interpreted their statutory factors, arbitrarily overlooked important parts of the problem, and fixated on a subset of issues in ways that Congress did not intend. They have misidentified the market failures and problems that their proposed rollback intends to address, and have relied on a biased and manipulated cost-benefit analysis to justify their proposal. A full and balanced analysis of all the costs and benefits that the agencies are charged with considering would reveal—as the midterm review recently confirmed—that the baseline standards will deliver massive net social benefits, and the proposed rollback is unjustified.

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[4] The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 42986 (Aug. 24, 2018) [hereafter "Proposed Rule"].

[5] 83 Fed. Reg. at 42,994; *see also id.* at 43,263-64, Table VII-4 (see last two rows for MY2025).

[6] *Id.* at 43,229 (explaining that these costs "could be passed on to consumers").

[7] 83 Fed. Reg. at 42,995, 43,015, 43,205 (conceding that EPCA ultimately requires NHTSA to set standards to conserve energy).

[8] 42 U.S.C. § 7521(a)(1).

A. Standards of rationality for regulatory decisionmaking

Agencies are constrained by the standards of rationality both in interpreting statutory factors[9] and in exercising their regulatory decisionmaking.[10] Agencies may not rely on factors that Congress did not intend for them to consider, fail entirely to consider an important aspect of the problem, or offer an explanation for their decision that runs counter to the evidence before them. Additionally, when agencies propose to reverse course from a prior reasoned decisionmaking—as the agencies propose to do here—they must provide a "reasoned explanation" for dismissing the "facts and circumstances that underlay" the original rule.[11] Finally, agencies' regulatory decisions must stay within the overarching bounds of their statutory mandate.[12]

B. NHTSA's approach to its statutory factors is unreasonable

The Energy Policy and Conservation Act (EPCA) requires NHTSA to set the maximum feasible fuel economy standards after considering technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy.[13] NHTSA admits that the overarching mandate under EPCA is to conserve energy.[14]

Need to Conserve Energy: NHTSA has unreasonably defined the "need . . . to conserve energy" factor and has unreasonably ignored aspects of this issue.

To start, the agencies falsely and inconsistently argue that the need to conserve energy has diminished because U.S. reliance on foreign oil has decreased.[15] At the most extreme, the agencies claim that the rollback will result in zero monopsony costs and zero national security costs because the United States is so close to self-sufficiency in its petroleum supply that it is

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[9] Chevron U.S.A. Inc. v. NRDC, 467 U.S. 837 (1984).

[10] Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Ins. Co., 463 U.S. 29, 43, 48 (1983).

[11] *F.C.C. v. Fox Television Stations*, 556 U.S. 502, 515-16 (2009).

[12] *See, e.g., Center for Biological Diversity v. NHTSA*, 538 F.3d 1172, 1195 (9th Cir. 2008) (noting that NHTSA's balancing of statutory factors cannot undermine the "fundamental purpose" of the EPCA); *Clean Air Council v. Pruitt*, 862 F.3d 1, 9 (D.C. Cir. 2017) ("It is 'axiomatic' that 'administrative agencies may act only pursuant to authority delegated to them by Congress.'") (quoting *Verizon v. FCC*, 740 F.3d623, 632 (D.C. Cir. 2014)).

[13] 49 U.S.C. § 32902(f).

[14] 83 Fed. Reg. at 42,995, 43,015, 43,205 (conceding that EPCA ultimately requires NHTSA to set standards to conserve energy).

[15] 83 Fed. Reg. at 43,214-15.

"unlikely" that imports would increase as a consequence of the proposed rollback.[16] That assumption is wrong for several reasons, and is inconsistent with other parts of the analysis:

- The latest *Annual Energy Outlook* from the Energy Information Administration projects that the United States will continue to import crude oil through 2050 and "remains a net importer of petroleum and other liquids on an energy basis."[17]
- But even assuming that the United States will soon become a net exporter of petroleum, there are still foreign suppliers in the meantime, and there would continue to be foreign suppliers even after the United States achieves net-export status.[18] Petroleum prices are set in a global market. And because oil is a global market, how much we produce is irrelevant to U.S. exposure to price shocks; the United States will remain vulnerable.[19]
- Moreover, the assumption that the increased petroleum consumption caused by the proposed rollback will be met through 0% imports[20] is also wildly inconsistent with the assumptions made elsewhere in the analysis. For the purposes of calculating the energy price shock effect, the agencies assume that—through the year 2050—75% of the increase in fuel consumption resulting from lower CAFE and CO_2 emissions standards will be reflected in increased U.S. imports."[21] For calculating upstream emissions effects, the agencies assume that—through the year 2050—50% of increased gasoline consumption would be supplied by increased domestic refining and that 90% of this additional refining would use imported crude petroleum."[22] In total, the upstream emission calculations assume that 95%[23] of increased consumption will either be from foreign refining or from foreign crude imports. The agencies inconsistently and opportunistically assume 0% imports when it serves their purposes, but

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[16] NHTSA & EPA, Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021-2026 Passenger Cars and Light Trucks Preliminary Regulatory Impact Analysis 1068, 1077 (Aug. 23, 2018) [hereafter "PRIA"].

[17] EIA (2018a), at 24 (showing projections for the reference case); *cf. id.* at 53-54 (showing that the United States is a "modest net export of petroleum *on a volume basis* from 2029 to 20245," as compared to on an energy basis; and showing that under certain oil price scenarios, the United States remains a net importer even on a volume basis; and showing that in the reference case, "the United States returns to being a net petroleum importer in 2045 on a volume basis"). Notably, the AEO2018 assumes that all "current laws and regulations . . . are unchanged throughout the projection period," *id.* at 8, meaning it assumes that the current standards under the 2012 rule will stay in force. Under the proposed rollback, as U.S. demand for petroleum increases, projections for imports could change. *See* EIA (2018b), at 26 ("CAFE standards are increased . . . to meet augural CAFE standards for model year 2022 to 2025," after which "CAFE standards are held constant" at MY2025 levels "through the end of the projection.").

[18] EIA (2018a), at 24 (2018) (explaining that even if the United States becomes a net energy exporter, "both imports and exports continue through the projection period").

[19] *See* Letter to the Agencies from Jason Bordoff (Oct. 22, 208), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-3906

[20] PRIA at 1068, 1077

[21] PRIA at 1073.

[22] PRIA at 1291.

[23] 50% + (50% * 90%) = 95%.

elsewhere in the Proposed Rule, when a different estimate suits them, they instead assume 95% imports. This is patently arbitrary.

- The agencies wrongly conclude that national security costs are zero based on the fact that the "size" of the Strategic Petroleum Reserve (SPR) has not historically varied in response to the level of U.S. petroleum consumption or imports.[24] However, "the budgetary costs for maintaining [the size of] the SPR" is only one possible effect of changes in the level of petroleum consumption or imports. Regardless of whether the United States actually changes the *size* of the SPR in real time to respond to changing levels of U.S. petroleum consumption, the *protective value* that the SPR offers given its size does automatically change as total U.S. petroleum consumption changes.[25] The agencies have failed to assess how much the relative protective value of the SPR will change as total U.S. consumption rises following the proposed rollback, and therefore have failed entirely to consider one important element of the national need to conserve energy.

The agencies also wrongly argue that assessing how environmental considerations create a need to conserve energy is "complicated,"[26] that the 2012 standards may not "sufficiently address climate change to merit their costs,"[27] and that increasing the standards is not "necessary to avoid destructive or wasteful use of energy."[28] The agencies attempt to belittle the standards' effect on climate as "small" by focusing on temperature degree effects rather than on economic impacts.[29] In fact—as detailed in separate comments that Policy Integrity submitted jointly with other organizations—assessing the climate effects of the proposed rollback versus the 2012 standards is not "complicated"; it is quite easily accomplished by monetizing climate damages using the social cost of greenhouse gas metrics. Once climate damages are more fully monetized (as the agencies are required to do[30]), it will become apparent that the proposed rollback will cause billions of dollars in climate damages. Billions of dollars lost to avoidable climate damages is not a small effect, and it very clearly is a "destructive and wasteful" effect. This approach in no way

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[24] PRIA at 1077.

[25] Dept. of Energy, *Long-Term Strategic Review of the U.S. Strategic Petroleum Reserve: Report to Congress* 64 (2016), https://www.energy.gov/sites/prod/files/2016/09/f33/Long-Term%20Strategic%20Review%20of%20the%20U.%20S.%20Strategic%20Petroleum%20Reserve%20Report%20to%20Congress_0.pdf ("The value of the SPR over the coming decades will be affected by the evolution of future world crude oil markets in terms of future oil price levels and quantities of oil produced and consumed globally.").

[26] 83 Fed. Reg. at 43,215.

[27] *Id.*

[28] *Id.*

[29] *Id.* at 43,216.

[30] See our separate Joint Comments on the Social Cost of Greenhouse Gases, available at https://policyintegrity.org/what-we-do/update/3190 (explaining how the agencies have improperly manipulated and undervalued the climate damage calculations).

places "an outsized emphasis"[31] on this consideration; to the contrary, it simply uses monetization to translate effects into the same metric of dollars that the agencies use to value all other costs and benefits in the proposed rollback. As the agencies explained in the 2012 rule, monetization is an "appropriate[ ]" tool to put climate benefits "in context in the rule."[32] An apples-to-apples comparison of more fully monetized costs and benefits would show—just as the agencies concluded in the 2012 rule—that the climate benefits of the 2012 standards alone offset a significant portion of the technology costs, and together with the other significant private and social benefits, the benefits well justify the costs of the 2012 standards.[33] In addition, if anything, the need to conserve energy to prevent climate and other environmental externalities is only more urgent now than it was during the 2012 rulemaking.[34]

NHTSA's discussion of the "need to conserve" factor also gives short shrift to non-climate environmental externalities, only briefly mentioning the possible effects on other emissions without detailing any of the myriad non-climate public health and welfare consequences from pollution associated with petroleum production and combustion for motor vehicles.[35]

The agencies also wrongly concludes that consumers' need to save money is now "less urgent" and no longer supports a strong overall need to conserve energy.[36] The agencies assert that past

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[31] 83 Fed. Reg. at 43,216.

[32] 77 Fed. Reg. at 62,898. Far from giving monetized climate benefits outsized weight in the 2012 rule, the agencies did not select more stringent standards that would have had even larger net benefit figures. If anything, the agencies gave "outsized" weight in the 2012 rule to economic practicability in selecting a standard that did not maximize net benefits. *Id.* at 63,055 ("We recognize that higher standards would help the need of the nation to conserve more energy . . . [but] [w]e conclude that the correct balancing recognizes economic practicability concerns . . . and sets standards at the [less stringent] levels that the agency is promulgating.").

[33] NHTSA, *Final Regulatory Impact Analysis: Corporate Average Fuel Economy for MY 2017-MY 2025 Passenger Cars and Light Trucks* at 51 (2012) [hereafter "NHTSA 2012 FRIA"] (showing cost and benefit estimates at a 7% discount). Note that even these monetizations of climate damages are almost certainly a severe underestimate. Consideration of unquantified benefits further justifies the 2012 standards. *See* 77 Fed. Reg. at 63,079-80 ("Similarly, the agency's estimate of the value of reduced climate-related economic damages from lower emissions of GHGs excludes many sources of potential benefits from reducing the pace and extent of global climate change. For example, none of the three models used to value climate-related economic damages includes those resulting from ocean acidification or loss of species and wildlife. The models also may not adequately capture certain other impacts, including potentially abrupt changes in climate associated with thresholds that govern climate system responses, interregional interactions such as global security impacts of extreme warming, or limited near-term substitutability between damage to natural systems and increased consumption. Including monetized estimates of benefits from reducing the extent of climate change and these associated impacts would increase the agency's estimates of benefits from adopting higher CAFE standards.").

[34] *See* Intergovernmental Panel on Climate Change, *Global Warming of 1.5°C: Summary for Policymakers* at SPM-4, SPM-11 (2018), http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf (reporting with high confidence that warming could likely reach 1.5 degrees by 2030, and detailing the associated risks to health, livelihoods, food security, water supply, human security, and economic growth).

[35] 83 Fed. Reg. at 43,211.

[36] 83 Fed. Reg. at 43,216.

rulemakings were overly and paternalistically focused on "myopia."[37] This statement ignores all the other pathways through which the 2012 standards benefit consumers' need to save money, including by correcting informational asymmetries, attention costs, and other informational failures; positional externalities; and various other supply-side and demand-side explanations for consumers' inability to achieve in an unregulated market the level of fuel economy that they desire. These components of the national need to conserve energy are discussed at length throughout these comments, and were specifically considered by the agencies in the 2012 rule.[38]

Indeed, more broadly, NHTSA has failed to adequately explain its shift since 2012 in its interpretation and application of the need to conserve energy factor. In the 2012 Clean Car Standards, NHTSA noted that the fuel savings of the rule allowed it to comply with the purposes of the statute, estimating that the rule's "fuel economy increases would lead to fuel savings totaling a range from 180 billion to 184 billion gallons."[39] Actual fuel savings, and the associated benefits to consumers, the environment, and society, were at the heart of NHTSA's analysis of the need to conserve energy factor back in 2012.[40] Now the agency ignores those conclusions from 2012 and relies on mistaken and inconsistent interpretations of petroleum import projections and the urgency of climate change to justify ignoring this statutory factor and giving primacy instead to economic practicability and safety effects. The failure to explain this shift in approach is arbitrary.

Economic Practicability: NHTSA discusses consumer valuation, price effects, sales effects, and job impacts in the context of its economic practicability factor. These comments discuss at length how NHTSA has inappropriately analyzed many of these elements of the economic practicability test.

NHTSA additionally claims that economic practicability also encompasses "harm to the nation's economy caused by highway fatalities,"[41] even as the agency also counts safety as its own separate factor.[42] First, NHTSA has miscalculated the safety impacts, as discussed throughout these comments. But second, it is arbitrary to fully include the alleged "harm to the nation's economy caused by highway fatalities" as part of economic practicability even while the agency ignores and undercounts various harms to the nation's economy caused by climate- and pollution-related fatalities, illnesses, and other welfare impacts. Neither under the need to

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[37] Id.

[38] 77 Fed. Reg. at 62,914.

[39] 77 Fed. Reg. at 63,059.

[40] *E.g.*, 77 Fed. Reg. 63,077 (stating that the rule's fuel economy savings offset any rebound-related costs of the rule, producing "significant benefits to society.").

[41] 83 Fed. Reg. at 43,209.

[42] 83 Fed. Reg. at 43,226.

conserve energy factor, as noted above, nor under the economic practicability factor does NHTSA fully weigh the monetized damages associated with such climate impacts[43] as:

- property lost or damaged by sea-level rise, coastal storms, flooding, and other extreme weather events, as well as the cost of protecting vulnerable property and the cost of resettlement following property losses;
- changes in energy demand, from temperature-related changes to the demand for cooling and heating;
- lost productivity and other impacts to agriculture, forestry, and fisheries, due to alterations in temperature, precipitation, CO_2 fertilization, and other climate effects;
- human health impacts, including cardiovascular and respiratory mortality from heat-related illnesses, changing disease vectors like malaria and dengue fever, increased diarrhea, and changes in associated pollution;
- changes in fresh water availability;
- ecosystem service impacts;
- impacts to outdoor recreation and other non-market amenities; and
- catastrophic impacts, including potentially rapid sea-level rise, damages at very high temperatures, or unknown events.

It is arbitrary for NHTSA to count alleged safety costs as support for its propose rollback both under the economic practicability factor and as its own separate "bolster[ing]" factor,[44] and yet never fully monetize climate- and pollution-related deaths and other welfare impacts under either the need to conserve energy factor nor under the economic practicability factor.[45]

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[43] These impacts are all included to some degree in the three integrated assessment models (IAMs) used by the IWG (namely, the DICE, FUND, and PAGE models), though some impacts are modeled incompletely, and many other important damage categories are currently omitted from these IAMs. *Compare* Interagency Working Group on the Social Cost of Carbon (2010), at 6-8, 29-33; *with* Howard (2014). For other lists of actual climate effects, including air quality mortality, extreme temperature mortality, lost labor productivity, harmful algal blooms, spread of west nile virus, damage to roads and other infrastructure, effects on urban drainage, damage to coastal property, electricity demand and supply effects, water supply and quality effects, inland flooding, lost winter recreation, effects on agriculture and fish, lost ecosystem services from coral reefs, and wildfires, *see* EPA, *Multi-Model Framework for Quantitative Sectoral Impacts Analysis: A Technical Report for the Fourth National Climate Assessment* (2017); U.S. Global Change Research Program, *Climate Science Special Report: Fourth National Climate Assessment* (2017); EPA, *Climate Change in the United States: Benefits of Global Action* (2015); Union of Concerned Scientists, *Underwater: Rising Seas, Chronic Floods, and the Implications for U.S. Coastal Real Estate* (2018).

[44] 83 Fed. Reg. at 43,226.

[45] See our separate comments on NHTSA's failure to fully monetize the social cost of greenhouse gases. https://policyintegrity.org/what-we-do/update/3190.

C. EPA's approach to its statutory factors is unreasonable

EPA acknowledges that it must consider public health and welfare under Section 202 of the Clean Air Act,[46] and yet claims authority to give "particular consideration" to costs and safety.[47] EPA never explains why it may give outsized consideration to costs and safety, even as it devalues important climate and pollution effects. After all, the "primary goal" of the entire Clean Air Act is to advance "pollution prevention."[48] It is therefore arbitrary and inconsistent with the statute for EPA to instead give primacy to cost and safety factors in justifying the proposed rollback, to fixate on alleged traffic deaths avoided without also clearly reporting the climate- and pollution-related deaths, illnesses, and welfare losses that the proposed rollbacks will cause. In its discussion of its statutory factors, EPA specifically highlights the alleged avoided highway fatalities,[49] and yet only reports volume estimates for greenhouse gas changes, without detailing any of the real-world impacts from the increase in greenhouse gas emissions, criteria pollutant emissions, and toxic pollutant emissions, which will include: climate-related deaths and illnesses from excessive heat, excessive cold, extreme weather events, diarrhea, vector-borne diseases, food- and water-borne diseases, cardiovascular and respiratory effects, food scarcity, water scarcity, and conflict;[50] as well as mortalities and morbidities from increases in particulate matter and other pollutants, including premature adult and infant mortality, acute bronchitis, respiratory emergency room visits, non-fatal heart attacks, asthma exacerbations, strokes, reproductive and developmental effects, cancer and genotoxicity effects, and work-loss days.[51] EPA never sufficiently discusses these important aspects of the regulatory problem, and does not explain their connection to its statutory factors. EPA certainly may consider a range of effects, including

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[46] 83 Fed. Reg. at 43,228.

[47] 83 Fed. Reg. at 43,231.

[48] 42 U.S.C. § 7401(c) (defining the goal for "this chapter," which includes § 7521 in subchapter II); *Air Alliance Houston v. EPA*, No. 17-1155 (D.C. Cir., Aug. 17, 2018), 2018 WL 4000490 (citing § 7401(c) as describing congressional intent in enacting the Clean Air Act). "Pollution prevention" is often distinguished from strictly technologically-based end-of-pipe pollution controls, to include process changes that reduce the amount of pollution generated in the first place. S. Rep. No. 101-228, pt. 2, at 168 (1989), 1990 U.S.C.C.A.N. 3385, 3553 ("The technologies, practices or strategies which are to be considered . . . go beyond the traditional end-of-the-stack treatment or abatement system. The Administrator is to give priority to technologies or strategies which reduce the amount of pollution generated through process changes or the substitution of materials less hazardous. Pollution prevention is to be the preferred strategy wherever possible."). Increasing fuel economy of vehicles is precisely the kind of pollution prevention strategy that Congress had in mind.

[49] 83 Fed. Reg. at 43,231.

[50] Carleton et al. (2018); Howard (2014); NHTSA, Draft Environmental Impact Statement at S-21 (2018) [hereafter "SAFE Rule Draft EIS"].

[51] SAFE Rule Draft EIS at S-9, 2-27, 4-24 (listing the human health and welfare impacts from the increased particulate matter emissions under the proposed rollbacks).

safety, energy security, and national security, but there is no statutory basis for giving safety more attention than other important effects such as public "health" and "welfare."[52]

In the 2012 rulemaking, EPA focused on its charge to protect public health and welfare, and spoke at length about the standards' effects on "atmospheric concentrations of CO2, global climate warming, ocean acidification, and sea level rise."[53] The agency also devoted in 2012 a long discussion to the health and air-quality effects of non-GHG pollutants.[54] The Proposed Rule meanwhile, notably lacks any meaningful reference to ocean acidification or sea level rise.[55] EPA now fails to explain its lack of attention to important parts of the problem that the agency previously assessed under its statutory mandate back in 2012.

D. The agencies define the market failure too narrowly

The regulatory impact analysis far too narrowly defines the market failures that fuel economy and greenhouse gas emission standards are intended to address. The regulatory impact analysis claims that, "in the case of the CAFE standards," the market failure is limited to protecting consumers who do not "voluntarily purchase enough fuel economy" to protect themselves "if gasoline prices suddenly rise significantly."[56] With the CO2 standards, the market failure is to protect "the planet from the risks of unchecked climate change."[57]

Under both the statutory mandate from EPCA and best practices for economic analysis,[58] the problems that NHTSA is charged with addressing are not so restricted to only protecting consumers from gas price spikes. As explained above in this section as well as throughout these comments, NHTSA is more broadly charged to address: externalities relating to energy security, national security, positional goods, global climate change, and air and water pollution associated with fuel production and consumption; asymmetric information, attention costs, and other

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[52] 42 U.S.C.A. § 7521(a)(1) ("The Administrator shall by regulation prescribe . . . standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare."); *Massachusetts v. E.P.A.*, 549 U.S. 497, 528-29 (2007).

[53] 77 Fed. Reg. at 62,895.

[54] *See* 77 Fed. Reg. at 62,899, 62,910-12.

[55] The lone exceptions occur in footnote 477, where the agencies note that the 2012 rule measured sea level rise, but does not mention any sea level effects from this proposed rollback, 83 Fed. Reg. at 43,230; and at page 43,248, discussing California's reasons for a waiver. EPA also mentions that it has estimated sea-level rise under the Executive Order on environmental justice, *id.* at 43,474, but fails to connect such climate impacts to its statutory mandate.

[56] PRIA at 110.

[57] *Id.*

[58] *See* Office of Mgmt. & Budget, *Circular A-4* (2003) [hereafter "OMB Circular A-4"] (defining various market failures, including environmental externalities and informational failures).

information failures; internalities, including myopia; and various supply-side market failures, including first-mover disadvantage.

Similarly, while EPA's primary focus when regulating greenhouse gas emissions should remain the need to protect the planet from unchecked climate change, EPA must not ignore other related market failures that cause harm to public health and welfare, including the issues and market failures listed in the previous paragraph.

In defining the market failures too narrowly, the agencies not only violate the instructions of Executive Order 12,866,[59] but also evince their fundamental misunderstanding of the purposes of the original 2012 standards. The proposed rollback fails to consider important aspects of the problem set before the agencies by Congress, and also fails to consider discussions of these market failures from the 2012 rulemaking, and so the proposed rollback is arbitrary and capricious.

E. The agencies should balance their statutory factors using a full and balanced cost-benefit analysis, not a biased and manipulated cost-benefit analysis

In the past, the agencies have relied on cost-benefit analysis to inform their balancing of their statutory factors. And the agencies should do the same here, after conducting a full, balanced cost-benefit analysis. As we have explained throughout these comments, such as analysis would not support the Proposed Rule.

Past Reliance on Cost-Benefit Analysis: Both agencies have relied on cost-benefit analysis in previous rulemakings to provide an explanation and context for their chosen standards. For example, in the 2012 rule, both NHTSA and EPA cited the costs and benefits in discussing the statutory balancing process. EPA stated that "given the technical feasibility of the standard, the cost per vehicle in light of the savings in fuel costs over the lifetime of the vehicle, the very significant reductions in emissions and in oil usage, and the *significantly greater quantified benefits compared to quantified costs*, EPA is confident that the standards are an appropriate and reasonable balance of the factors to consider under section 202(a)."[60] NHTSA similarly used a marginal cost-benefit analysis to set the 2012 CAFE standards. The agency explained that while the agency is not required to conduct a cost-benefit analysis, "[r]egardless of what type of analysis is or is not used, considerations relating to costs and benefits remain an important part of CAFE standard setting."[61] Similarly, in setting the CAFE standards for MY 2008-2011, NHTSA used a marginal cost-benefit analysis to determine the maximum feasible standards.[62] The U.S.

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[59] Exec. Order 12,866 § 1(b)(1) (1993).

[60] 77 Fed. Reg. at 62,777 (emphasis added).

[61] 77 Fed. Reg. at 62,623, 63,020.

[62] *Center for Biological Diversity*, 538 F.3d at 1186.

Court of Appeals for the Ninth Circuit affirmed the agency's use of cost-benefit analysis to balance the statutory factors of EPCA, explaining that the balancing was appropriate so long as the agency does not balance the factors in such a way that conflicts with the statute's energy conservation mandate, and so long as the agency does not "put a thumb on the scale" by undervaluing or overvaluing particular effects.[63]

In the current rule, the agencies turned their back on these principles and their prior practice without providing a reasoned explanation. Instead, the agencies have balanced the factors in a way that conflicts with their controlling statutes and weighed the statutory factors without regard for the accuracy of the accompanying cost-benefit analysis.

Errors and Oversights in Balancing the Factors: The agencies acknowledges that the proposed rollback will increase fuel usage by about 500,000 barrels per day by the early 2030s.[64] The agencies nonetheless claim that the increased consumption and emissions are justified by the cost savings and safety concerns (in rebound, fleet composition, and mass).[65] But that analysis is severely flawed.[66] First, the increased emissions that will result from the proposed action need to be properly incorporated into the cost-benefit analysis. There are significant health and safety issues associated with the increased greenhouse gas emissions which the agencies are ignoring. See Sections I and IX of these comments, and our separate comments on the social cost of greenhouse gases, for a discussion of the treatment of emissions in the agencies' cost-benefit analysis. Second, the safety considerations have been incorrectly calculated in the cost-benefit analysis. See sections V-VII of these comments for an in-depth discussion of the treatment of scrappage, rebound, and mass effects. The agencies cannot duck their requirements to conserve energy and protect public health and safety by citing automobile safety without an adequate discussion of the health and safety impacts of the Proposed Rule's increased emissions or without an accurate estimate of the actual safety impact of the rollback versus the 2012 standards.

NHTSA claims that it is allowed to use feasibility concerns to deviate from the regulatory standards that would maximize net benefits.[67] Yet if a standard truly were not feasible, then its costs would be prohibitively high, and a full and fair cost-benefit analysis would reflect that. After correcting their currently inaccurate estimations of costs and benefits, in the ways we have laid out in these comments, the agencies should rely on a full and balanced cost-benefit analysis. Such a full and fair analysis will reveal that the proposed rollback is not justified, that the 2012

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[63] *Id.* at 1197.

[64] 83 Fed. Reg. at 42,995, 43,254.

[65] 83 Fed. Reg. 42,995-96, 43,067, 43,230.

[66] *National Ass'n of Home Builders v. EPA*, 682 F.3d 1032, 1040 (D.C. Cir. 2012).

[67] 83 Fed. Reg. at 43,209.

standards remain massively benefit-cost justified, and that, if anything, an increase in stringency is warranted.

Misleading Fatalities Statistics: The agencies' reliance on fatality statistics that include alleged rebound-related traffic fatalities to justify its proposed rollback is arbitrary because the agency's own cost-benefit analysis finds that the rebound effect will have no net welfare impact.[68] The agencies repeatedly cite as justification for the proposed rollback that it will allegedly "reduce highway fatalities by 12,700 lives."[69] Half of this figure comes from fatalities allegedly attributed to the rebound effect.[70] Yet the agencies acknowledge that the increase in driving is "freely chosen" and not "imposed by" the standards,[71] and their analysis reflects this fact by showing that the private welfare gained by consumers from driving more due to the rebound effect will offset any fatalities allegedly caused by the rebound effect. As a result, the agencies are misrepresenting the effects of the proposed rollback by claiming 12,700 lives saved. Compounding this error, the accident related costs associated with the increase in driving that results from the scrappage and dynamic fleet share models—which is also "freely chosen"—are inexplicably and unjustifiably not offset by countervailing mobility benefits in the benefit cost analysis—and the agencies inappropriately claim that these traffic fatalities—which comprise the other half of the 12,700 projection[72]—also justify the roll back. Indeed, the agencies entire "safety" justification for the roll back rests solely on their prediction that by rolling back the standards, people will drive less and this will reduce traffic fatalities. The agencies discussion of the "safety" effects of the standards is thus deeply misleading. Furthermore, the projected traffic fatalities figure is never offset by the significant increase in climate- and pollution-related fatalities from the proposed rollback's increase in greenhouse gas emissions and other pollution. Consequently, the agencies' justification for the proposed rollback runs counter to the evidence before the agencies.

Inconsistent Claims on Net External Costs versus Net External Benefits: In Tables II-25 through II-28, the agencies list positive sums for "net external benefits."[73] Yet, immediately following those tables, the agencies instead report that the proposed rollback will generate net external *costs*: "less stringent . . . standards will produce *net external economic costs*, as the increase in environmental and energy security externalities outweighs external benefits from

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[68] 83 Fed. Reg. at 43, 212, 43, 231; *Id.* at 43,105 (discussion of mobility benefits accompanying the rebound effect).

[69] 83 Fed. Reg. at 42,986, 42,995, 43,152; *see also id.* at 43,231-43,232 (where EPA inconsistently refers instead to either 15,680 fatalities or 12,903 fatalities).

[70] *See id.* at 43,153, tbl. II-74.

[71] *Id.* at 43,148.

[72] Leaving aside the small number of mass reduction related fatalities, which the agencies concede are not statistically significant. NPRM at 43,111

[73] *E.g.*, 83 Fed. Reg. at 43,065.

reduced driving and higher fuel tax revenue (line 19)."[74] Adding to the inconsistency, the regulatory impact analysis reports on the exact same figures from line 19 but instead writes "the reduction in external costs imposed by vehicle use combines with higher fuel tax revenue to more than offset the increase in environmental and energy security externalities (line 19)."[75] The summaries from the Proposed Rule and the PRIA are mirror opposites. Given the wording, this discrepancy cannot have resulted from a mere typographical error. Rather, it seems more likely that, at some point in the agencies' analysis of the proposed rollback, the agencies had calculated that the rollback would result in a net external economic cost, but then different numbers were used for the tables. Tellingly, EPA's June 18, 2018 review of the proposed rollback, as shared with OIRA, found that the proposed rollback would cause $83 billion in net social costs.[76] If the agencies do calculate a net external cost for the proposed rollback, then the agencies have not explained why the proposed rollback is justified; if the agencies do not calculate a net external cost despite the statement in the Proposed Rule, the agencies have failed to explain what changed in their analysis to completely switch the sign and magnitude of the calculation of net external effects, from a significant cost to an alleged benefit. Either way, as presented currently, the Proposed Rule and its justification are arbitrary.

II. THE AGENCIES HAVE ARBITRARILY INFLATED THE COSTS OF THE BASELINE STANDARDS

The agencies' estimates of the relative effects on vehicle buyers of the Proposed Rule versus the baseline standards is riddled with errors. First, the agencies have overestimated compliance costs by failing to appropriately model how manufacturers will efficiently deploy flexible compliance options and make fuel economy improvements to reduce their costs. Second, the agencies have overstated the share of vehicle prices that will be passed on to consumers—in particular, to consumers of lower-price vehicles. And third, the agencies have arbitrarily relied on "relatively low" fuel prices to justify the need for the Proposed Rule.

The premise of the Proposed Rule is that, under the baseline standards, vehicle prices will otherwise increase enough to cause a substantial drop in sales, thus allegedly affecting the ability of manufacturers to comply with the standards as well as the relative safety of the cars driven by consumers.[77] That price analysis rests on the assumption that manufactures will pass all of their

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[74] 83 Fed. Reg. at 43,067 (emphasis added).

[75] PRIA at 1085.

[76] EPA, *Further Review of CAFE Model & Inputs* at 2 (June 18, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (see Email 5, page 11 of PDF).

[77] 83 Fed. Reg. at 42,993-994

compliance costs on to buyers, a feature known as full "pass-through."[78] Thanks to this pass-through assumption, NHTSA estimates that vehicles will be approximately $2,700 higher by 2029 under the baseline standards.[79] EPA similarly estimates that vehicle prices will be higher by $2,260 in 2030.[80] Additional costs from maintenance, financing, insurance, taxes, and other fees brings the agencies' estimates to a total of $2,810.[81] But those price estimates are inflated, because the agencies incompletely model the use of cost-saving flexibilities, wrongly model the decisions about fuel economy improvements and unreasonably assume a full pass-through of costs to consumers, among other reasons. Additionally, those estimates are offset by the lifetime fuel savings of the baseline standards, which the agencies have underestimated.

Correcting these mistakes, together with other errors in calculating the Proposed Rule's costs and benefits, will show that the baseline standards continue to be benefit-cost justified, and that the Proposed Rule is not justified.

A. The agencies fail to model efficient deployment of all compliance options, including flexibilities, and thus overestimate the baseline standards' costs

The baseline standards incorporate a number of cost-minimizing flexible compliance options. Manufacturers can reduce their costs of compliance by averaging the efficiency levels of vehicles within a fleet, by generating excess compliance credits in one year and banking them for future use, by promising to over-comply in future years and borrowing those credits to make up for an existing deficit, by transferring credits between fleets, by trading credits with other manufacturers, by generating offset credits (or "adjustments" as NHTSA calls them) through off-cycle technologies and other opportunities, and by efficiently relying on penalties as an upper-bound safety valve on compliance costs, among other things.

Studies show that for both fuel economy standards and EPA's history with averaging, banking, and trading (ABT) programs, the expected cost savings from employing these kinds of market-based flexible compliance options relative to uniform standards can be as high as 50%.[82] These compliance flexibilities are especially beneficial given how heterogeneous the car manufacturers

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[78] *Id.* at 43,071; *see also id.* at 43,135 ("CAFE standards force manufacturers to apply fuel saving technologies to offered vehicles and then pass along the cost of those technologies (to the extent possible) to buyers of new vehicles.").

[79] 83 Fed. Reg. at 42,994; *see also id.* at 43,263-64, Table VII-4 (see last two rows for MY2025).

[80] *Id.* at 43,229

[81] *Id.* at 43,229.

[82] *See* Rubin et al. (2009), at 315–328 (2009) (showing the huge potential of cost savings associated with credit trading between firms for the CAFE program); Newell & Stavins (2003), at 56 (estimating the potential cost savings associated with market-based policies); Carlson et al. (2000) (showing gains from trade in transferable sulfur dioxide emission allowances among electric utilities).

are and how diverse individual manufacturers' product lines are.[83] And indeed, with companies as different in their fuel efficiency profiles as Tesla and Porsche, one can expect substantial cost savings from credit trading and other flexible compliance options.[84] The agencies are well aware of the cost-minimizing potentially of these flexibilities.[85] In the proposal, the agencies explain that, "well-functioning banking and trading provisions increase market efficiency and reduce the overall costs of compliance with regulatory objectives."[86] Moreover, as the agencies acknowledge, the introduction of trading has changed the decisions made by manufacturers: "Since NHTSA introduced trading and transferring, manufacturers have largely traded or transferred credits in lieu of paying civil penalties."[87] The agencies also acknowledge "that buying and selling credits is a more cost-effective strategy for manufacturers than paying civil penalties" and quote the decrease in civil penalties paid annually.[88]

By failing to model the most efficient deployment of all these cost-minimizing compliance flexibilities, both NHTSA and EPA have overestimated the costs of complying with the baseline standards.

1. Manufacturers would not automatically apply all technologies defined by the agencies as "cost-effective"

Figure 9 below, copied from NHTSA's Draft CAFE Model Documentation, illustrates how the agencies simulate the manufacturer's compliance decisions in every model year.[89] As shown in Figure 9, the agencies assume that manufacturers apply all technologies considered "cost-effective" in the first step, regardless of how much compliance is needed or how many credits

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[83] More formally, the more the marginal costs of compliance differ between the producers, the more costs are saved when trade is introduced. *See* Administrative Conference of the United States, *Recommendations 2017-4 on Marketable Permits* 3 (2017), *available at* 82 Fed. Reg. 61,728, 61,730 (Dec. 29, 2017) (reporting that marketable permit programs are more beneficial when "Regulated parties have sufficiently differing compliance costs, such that the savings from trading are likely to be greater than transaction costs.").

[84] *See, e.g.*, Stranlund (2017); 74 Fed. Reg. 14,196, 14206 (Mar. 30, 2009) ("Under Part 536, credit holders . . . will have credit accounts with NHTSA, and will be able to hold credits, apply them to compliance with CAFE standards, transfer them to another 'compliance category' for application to compliance there, or trade them."); *id.* at 14,218 ("In the event that a manufacturer does not comply with a CAFE standard, even after the consideration of credits, EPCA provides for the assessing of civil penalties."); 81 Fed. Reg. at 95,489 ("[S]ince the introduction of credit trading and transfers for MY 2011 and after, many manufacturers have taken advantage of those flexibilities rather than paying civil penalties for non-compliance.").

[85] 83 Fed. Reg. at 43,231.

[86] *Id.* at 42,999.

[87] *Id.* at 43,451.

[88] *Id.* at 43,451.

[89] Draft CAFE Model Documentation, July 2018, Figure 9, at 69, available at ftp://ftp.nhtsa.dot.gov/CAFE/2021-2026_CAFE_NPRM/CAFE_Model/CAFE_Model/CAFE_Model_Documentation_NPRM_2018.pdf (last accessed 10/19/2018) [hereafter "CAFE Model Documentation"]; see also 83 Fed. Reg. at 43,161, 43,174.

they have available. The problem with this assumption lies in the definition of "cost-effective technologies." According to the agencies, cost-effective technologies are the technologies that cost less than the sum of compliance costs that the technology avoids[90] plus the value of 2.5 years of fuel savings achieved by the technology.[91] Given those numbers, some manufacturers could be predicted to over-comply in every year on a technological basis, even as available credits are left to expire.

If consumers are demanding these cost-effective technologies such that manufacturers can earn a profit by including them, that assumption may make some sense. However, the assumption clashes directly with the contradictory assumption that the agencies rely on in the model's sales module, where they implicitly assume that customers entirely disregard fuel efficiency in their purchasing decisions.[92] In that model, the failure to include any estimate for consumer valuation leads the agencies to overestimate how the baseline standard's alleged price increases will depress sales of new vehicles (The problematic assumptions of the sales module, and the inconsistency with the agencies' other assumptions on consumer valuation of fuel economy, are discussed in Section III.)

At the same time, the agencies' schematic of manufacturers' compliance decisions in Figure 9 assumes that manufacturers think that consumers value fuel economy enough that they will demand every technological option with a 2.5-year payback period, even if it causes the manufacturer to over-comply with the standards year after year.

Those positions are inconsistent. The agencies cannot have it both ways. Like under Figure 9's 2.5-year payback assumptions, the agencies' sales module should also assume that consumers do value fuel savings, as explained in Section III, thus changing the estimates of new vehicle sales under the baseline standards.

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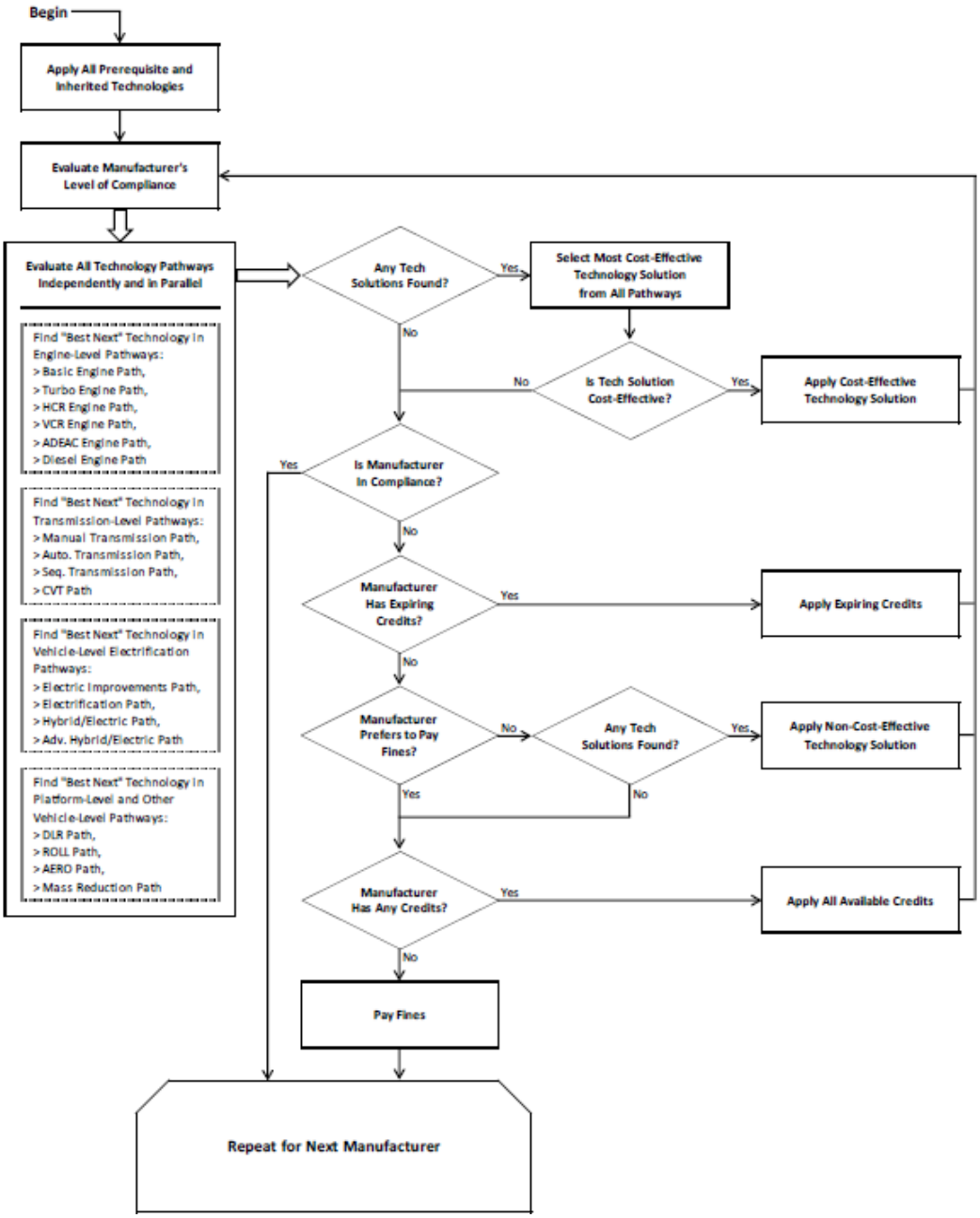
[90] In the case of the CAFE program, this value represents the change in CAFE civil penalties (or fines).

[91] *See* CAFE Model Documentation at 72-75 (explaining cost-effective technologies); 83 Fed. Reg. at 43,179, 43,225.

[92] The assumption that customers do not value fuel efficiency is irrational. *See* Section III.

Figure 9. Compliance Simulation Algorithm



Furthermore, it is unreasonable to assume, that manufacturers will only use their expiring credits or other compliance flexibilities after they have applied all cost-effective technologies, as seen in Figure 9. A manufacturer would not let a credit expire while using costly fuel efficiency technologies. They would be even less likely to do that if customers did not value the technology, as the agencies assume in the sales model. These unreasonable assumptions lead to an overestimation of fuel economy costs and thus bias the findings.

Perhaps a manufacturer would apply cost-effective technologies before using all available credits if the manufacturer is able to transfer or trade any credits about to expire. Yet, as explained more below, the agencies have not fully modeled the trading of excess credits, even when permitted to by statute. This failure further leads to a biased overestimate of total compliance costs for the entire industry.

2. Many of the agencies' failures to consider efficient deployment of banking, borrowing, trading, and offsets are not mandated by the statute

The proposed rollback explains that the agencies' model reflects banking as well as transfers between car and truck fleets, but not borrowing or trading.[93] Yet banking and transferring are not accurately modeled. While NHTSA has some limits on what flexibilities it can consider when setting standards, many of the omissions of compliance flexibilities from the model are not dictated by limits in NHTSA's statutory authority; moreover, EPA does not even face such limits.

Banking: The model's default assumption is that manufacturers will hold on to banked credits "for as long as possible," applying credits only after all technological options have been exhausted, and even applying expiring credits only after all "cost-effective" technological options have been exhausted.[94] The model also does not fully capture that manufacturers may strategically over-comply in some years to bank more credits. These assumptions are incorrect and will lead to an overestimation of costs. In reality, manufacturers will take a long-range view to planning their compliance and will identify the most cost-efficient times to generate credits, bank credits, and use credits. Sometimes a manufacturer will be able to save money by over-complying in early years when standards are less stringent, banking those credits, and then applying those credits in later years before installing costlier technologies. The model ignores these potential cost savings.

The model also only incompletely counts credits banked in years before the Proposed Rule would take effect. NHTSA claims that its statutory instructions prohibit it from considering credit availability in setting standards, and so only models credits that are already banked or will be banked and used through "the last year for which new standards are not being considered (MY 2019 in this analysis)."[95] First of all, because the Proposed Rule starts in MY 2021, that means MY 2020—not MY 2019—is the last year for which new standards are not being considered. This difference matters, especially because ignoring a full year of early banked credits will make it seem like manufacturers are further behind in meeting their compliance than they really are, which will affect the agencies' assumptions about the compliance costs

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[93] 83 Fed. Reg. at 43,181.

[94] *Id.* at 43,181.

[95] *Id.* at 43,183.

manufacturers will face from MY 2021 and on. Second, it is not clear that the statutory prohibition on considering credit availability was intended to apply to banked credits. The statutory limit on considering "trading, transferring, or availability of credits," 42 U.S.C. § 32902(h)(3), was added in 2007 as a "conforming amendment" to the Energy Independence and Security Act, which was the statute that gave NHTSA authority to allow credit trading and transferring;[96] meanwhile, banking and borrowing have been part of NHTSA's authority since the original Energy Policy and Conservation Act of 1975.[97] In 1989, for example, NHTSA explicitly relied on the availability of "credit banks" to justify maintaining the MY 1990 standard at 27.5 mpg instead of lowering its stringency.[98] NHTSA has not explained why it now believes it may not more fully consider banking. Third, whatever statutory limit may apply to NHTSA does not apply to EPA under the Clean Air Act. And yet, not only has EPA not separately modeled the cost-saving potential of banking more thoroughly, but the model does not even fully reflect the availability of already-banked CO_2 credits, because the "CAFE model was not modified to allow exceptions to the [assumed five-year] life-span of compliance credits" even though EPA credits for MY 2009-2011 may be used through MY 2021.[99]

All of these errors and unnecessary omissions result in the agencies overestimating total compliance costs, by failing to capture the full cost-saving potentials of banking. The agencies have made similar errors and omissions for all the other flexible compliance options: borrowing, transferring, trading, offsets, and penalties.

Borrowing: The agencies acknowledge that manufacturers have, in the past, sometimes made use of the cost-savings afforded by borrowing, but they chose not to include borrowing in the model because they assume manufacturers would not want to accept the "risk" of this flexible compliance strategy.[100] The agencies do not explain why they believe manufacturers would be particularly risk averse to the use of this compliance flexibility. The fact that manufacturers have, in fact, used borrowing in the past to help save on compliance costs indicates that the agencies should not be so quick to omit borrowing from the model. The result of that omission is likely an overestimation of compliance costs.

Transferring: Just as the model does not fully capture how manufacturers will strategically over-comply in order to bank credits, the model also does not fully capture how manufacturers may

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[96] Pub. L. 110-140 § 104, 121 Stat. 1503 (Dec. 19, 2007).

[97] Pub. L. 94-163 § 301 (amending the Motor Vehicle Information and Cost Savings Act §§ 503(a)(1) (on averaging) and § 508 (on banking)).

[98] 54 Fed Reg. 21,985, 21,994 (May 22, 1989) ("given their credit banks, both GM and Ford can easily comply with the MY 1990 standard of 27.5 mpg by use of carryforward credits, i.e., ones that have already been earned").

[99] 83 Fed. Reg. at 43,183.

[100] Id.

save on total costs by over-complying in one fleet to transfer credits to another fleet.[101] Furthermore, "[t]he model prefers to hold on to earned compliance credits within a given fleet," because that is the behavior the agencies have observed from the manufacturers going back to 2009.[102] Yet historical compliance behavior under less stringent standards is not necessarily a useful template for how manufacturers would respond in the future under more stringent standards. As the agencies acknowledge, under the CO_2 standards, given the availability of more early compliance credits, manufacturers have been more strategic about transferring credits between fleets to minimize their costs.[103] The agencies' failure to more realistically model the efficient use of transferring results in an overestimation of total compliance costs.

Trading: The agencies say they have "not attempted" to model trading.[104] Though NHTSA may have some statutory limits on its ability to consider the cost-saving potentials of credit trading, EPA does not face any such statutory limits under the Clean Air Act. The agencies do include a sensitivity analysis that, by pretending all cars and trucks were manufactured by a single company, imperfectly approximates the conditions of trading.[105] Even this imperfect exercise suggests the cost savings afforded by trading could be substantial: by the agencies' own estimates, costs drop by over 12%.[106] Yet in relegating this consideration to a single scenario in the sensitivity analysis, EPA has failed to consider how a model of the cost-savings of trading—combined with other necessary corrections to misestimates of costs and benefits and with other plausible assumptions also buried in sensitivity analysis—could further confirm what the agencies already know from the 2016 midterm evaluation: that compliance with the baseline standards is feasible and affordable, especially compared to the baseline standard's massive benefits. Instead, by relegating any consideration of trading to an imperfect sensitivity analysis, EPA has overestimated compliance costs.

Air-Conditioning and Off-Cycle Credits/Adjustments: The model "does not attempt to project how future off-cycle and A/C efficiency technology use will evolve . . . . Rather, this analysis uses the off-cycle credits submitted by each manufacturer for MY 2017 compliance and carries these forward to future years with a few exceptions."[107] For some manufacturers, that means the agencies assume zero or low[108] use of off-cycle adjustments in perpetuity, just because of their

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[101] *Id.*

[102] *Id.* at 43,185.

[103] *Id.*

[104] *Id.* at 43,181.

[105] *Id.* at 43,367.

[106] Id.

[107] *Id.* at 43,159.

[108] *Id.* at 43,160, tbl. II-79.

compliance choices for MY 2017. That is an illogical and arbitrary assumption. Rather, the agencies should assume that manufacturers will efficiently deploy all cost-saving offset opportunities, especially in the face of increasingly stringent standards.

EPA Is Not Constrained by EPCA: To whatever extent EPCA may limit NHTSA's ability to consider credit trading and transferring, such limits do not extend to EPA. EPA is *not* statutorily prohibited from taking credit trading and transferring into account in setting its standards, and it thus has no excuse not to consider them in analyzing the costs of the standards. To the contrary, EPA is required to "giv[e] appropriate consideration to the cost of compliance,"[109] and by failing to consider the availability of a cost-minimizing compliance strategy, the agency fails to consider an important element of its statutory factors.

If EPA fully models the rational use of credits while NHTSA does not, it is possible that the two agencies would reach somewhat different conclusions about what level of standards are justified. EPA might be tempted to ignore such analytical results and, instead of adopting the standards shown to be cost-benefit justified, just continue to match NHTSA's standards. Yet EPA is not allowed to set lower standards just for the sake of harmonization; to the contrary, full harmonization may be inconsistent with EPA's statutory responsibilities. Harmonization would have very real costs in terms of forgone emissions reductions and consumer savings and would go against EPA's statutory mandate. In addition, EPA would have to assess those costs and explain why the alleged benefits of harmonization would justify those very real costs. The Proposed Rule fails to satisfy this standard.

How the Agencies Considered Compliance Flexibilities in 2012: In prior rules, the agencies discussed and analyzed the impact of various compliance flexibilities when assessing whether new standards were feasible.[110] For example, in 2012, EPA embraced credit trading as a mechanism that allows manufacturers to comply with the standards in the most cost-effective way and took compliance flexibilities such as trading into account.[111] And despite NHTSA's statutory restriction, NHTSA acknowledged in 2012 that credit trading would reduce the cost of complying with the standards to a meaningful extent."[112] In fact, in 2012 NHTSA provided an estimate of the impact that those flexibilities have on the costs and found that compliance flexibilities would reduce the cost of additional technology needed for compliance by $20 billion, or about 15% of the total estimate.[113]

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[109] 42 U.S.C. § 7521(a)(2).

[110] 77 Fed. Reg. at 62,776.

[111] *Id.* at 62,649, 62,776.

[112] *Id.* at 63,082-83.

[113] *Id.* at 63,084.

Importantly, the 2012 analysis found the standards were beneficial even without these savings. Currently, since the agencies now assert that the costs of the original standards exceed their benefits, accounting for credit trading might change the outcome of the analysis and show that the proposed rollback is not justified.

In order to satisfy the requirement to provide a reasoned explanation, this issue must be addressed. When an agency reverses course through a repeal, it must provide a "reasoned explanation" for dismissing the "facts and circumstances that underlay" the original rule.[114] EPA has given no reason for not taking these flexibilities into account now in deciding to roll back its standards. And both NHTSA and EPA have failed to provide a reasoned explanation for ignoring the impact of credits and trading on compliance costs. At minimum, EPA needs to fully incorporate credit trading into its model for the years 2016-2030.

Risk Aversion: As a justification for disregarding credit trading, the agencies claim that "long-term planning is an important consideration for automakers," and that "firms may be reluctant to base their future product strategy on an uncertain future credit availability."[115] But the industry has a well-known track record of using trading and it is unlikely that the market would dry up. The manufacturers face uncertainty that will affect any compliance strategy: uncertainty from steel tariffs and technological innovation and so forth. There is no reason to think that vehicle manufacturers would be particularly risk averse to these particular types of compliance flexibilities. Averaging, banking, and borrowing have been part of the CAFE program since 1975.[116] While trading and transferring were added to the CAFE program later, vehicle manufacturers have been familiar with trading since EPA finalized rules for heavy-duty truck emissions in 1990.[117] Vehicle manufacturers have been comfortable with these compliance flexibilities for decades, and activity in the credit trading markets has increased in recent years.[118] The assumption that industry would be reluctant to use a proven tool that could save it money is arbitrary.

Additionally, there are a variety of ways to structure a credit market, through futures and liability schemes and banking, which can minimize many potential uncertainties.[119] Not only have manufacturers not been calling for such tools, suggesting perhaps a lack of particularized risk here, but also the agencies have failed to explore such tools if they do indeed perceive a risk. In

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[114] *Fox Television Stations*, 556 U.S. at 515-16.

[115] 83 Fed. Reg. at 43,231.

[116] Energy Policy and Conservation Act of 1975, Pub. L. 94-163 § 301 (amending the Motor Vehicle Information and Cost Savings Act §§ 503(a)(1) (on averaging) and 508 (on banking)).

[117] 55 Fed. Reg. 30,584 (July 26, 1990).

[118] Leard & McConnell (2017).

[119] Schwartz (2017).

any event, uncertainty applies to almost all businesses and there is no reason to believe that the vehicle industry is particularly risk averse. For instance, the supply of many "rare earth elements," rare minerals or elements needed to build products in the high tech industry, is legitimately uncertain.[120] But many high tech companies nonetheless operate under on the assumption that those materials will be available in developing their technologies.[121] The availability of trading here is much more certain than the availability of rare earths, and manufacturers are very likely to assume that trading will continue to be available.

3. NHTSA's assumption about which manufacturers are willing to pay penalties leads to an overestimate of compliance costs

The CAFE penalties work like safety valves because they allow car manufacturers to either comply with the standards or pay the penalty if compliance costs are too high.[122] Consequently, when the marginal cost of compliance is lower than the penalty, companies comply with the standards. But when the marginal costs of compliance with the standards exceed the penalty, companies tend to choose to pay penalties.

In assessing the costs of the baseline standards, NHTSA assumes that manufacturers consider paying penalties as a form of compliance only when all cost-effective technologies have already been deployed, and even then assumes that any manufacturer without historic evidence of willingness to pay penalties will instead opt for any non-cost-effective technologies before using any available credits. Ultimately, NHTSA assumes that most manufacturers are not willing to pay penalties beginning in 2020.[123] This effectively inflates the aggregate compliance costs. Combined with NHTSA's disregard for usage of credits after 2020, this assumption implies that each fleet needs to reach at least the fuel efficiency level prescribed by the standards in the given year through technology alone. Such modeling is equivalent to modeling a command-and-control regulation without any flexibilities and, by definition, will result in overstated compliance costs.

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[120] See for instance http://www.airforcemag.com/MagazineArchive/Pages/2018/February%202018/Rare-Earth-Uncertainty.aspx; https://www.wsj.com/articles/SB10001424052748704049904575553792429346772

[121] https://www.osa-opn.org/home/articles/volume_22/issue_7/features/rare_earth_elements_high_demand,_uncertain_supply

[122] NHTSA, CAFE Pub. Info. Ctr., Civil Penalties, https://one.nhtsa.gov/cafe_pic/CAFE_PIC_Fines_LIVE.html ("Manufacturers that do not meet the applicable standards in a given model year can pay a civil penalty."); NHTSA, CAFE Overview, https://one.nhtsa.gov/cafe_pic/CAFE_PIC_home.htm (describing the penalties as one option among several "compliance flexibilities"); *See also* Stranlund (2017), at 238 (describing the economics of compliance); Jacoby & Ellerman (2004) (describing the use of the safety valve principle to limit the cost of emissions restrictions); Roberts & Spence (1976) (describing the benefits of a penalty system enhancing the emission licensing when the abatement costs are unknown; Pizer, (2002) (describing the welfare benefits of enhancing quantity controls by using price controls like penalties when the compliance costs are unknown to the regulator).

[123] The assumptions regarding manufacturer behavior with respect to civil penalties is presented in Table–II–86, 83 Fed. Reg. at 43,180.

The assumptions NHTSA makes about which manufacturers are unwilling to pay penalties are arbitrary. NTHSA claims to base them on the historic data, but that data comes from a time when regulation stringency was much lower as compared to future standards.[124] Under such circumstances, there is no reason to assume—and NHTSA has not explained—that past compliance behavior provides enough relevant information to reliably predict manufacturers' future compliance strategies. With an increased penalty and more stringent fuel economy standard, historic compliance levels are likely to change going forward.[125]

Historical observations cannot explain all of the assumptions made by the agencies. The arbitrariness of NHTSA's penalty assumption is visible in its treatment of FCA (Fiat Chrysler Automobiles), for which NHTSA assumes willingness to pay penalties until year 2025 but never afterwards. NHTSA provides no justification for that arbitrary assumption.[126]

NHTSA assumes that most manufacturers will be unwilling to pay penalties based in part on the fact that most manufacturers have not paid penalties in recent years. The Proposed Rule cites the statutory prohibition on NHTSA considering credit trading as a reason to assume manufacturers without a history of paying penalties will comply through technology alone, whatever the cost.[127] But this is an arbitrary assumption and is in no way dictated by the statute. NHTSA knows as much, since elsewhere in the proposed rollback, the agency explains "EPCA is very clear as to which flexibilities are not to be considered" and NHTSA is allowed to consider off-cycle adjustments because they are not specifically mentioned.[128] But considering penalties are not mentioned as off-limits for NHTSA in setting the standards either. Instead, the prohibition focuses on credit trading and transferring. The penalty safety valve has existed in EPCA for decades, and Congress clearly would have known how to add penalties to the list of trading and transferring. The fact that Congress did not bar NHTSA from considering penalties as a safety valve means that NHTSA must consider manufacturer's efficient use of penalties as a cost-minimizing compliance option. Besides, NHTSA does consider penalties for some of the manufacturers making its statutory justification even less rational.

The agencies also explain that, since the Clean Air Act does not contain a specific civil penalty provision, the model does not assume that manufacturers will choose non-compliance with the CO_2 standards. To the extent it may be true that few manufacturers have a history of failing to comply with EPA's CO_2 standards, it is only because of the existence of useful compliance

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[124] *See* Union of Concerned Scientists, Response to Automaker Comments Regarding Raising CAFE Fines at 5 (Dec. 21, 2017), https://www.regulations.gov/document?D=NHTSA-2017-0059-0019.

[125] *See id.*

[126] "The notable exception to this is FCA, who we expect will still satisfy the requirements of the program through a combination of credit application and civil penalties through MY 2025 before eventually complying exclusively through fuel economy improvements in MY 2026." 83 Fed. Reg. at 43,181.

[127] *Id.* at 43,181.

[128] *Id.* at 43,212.

flexibilities like trading and borrowing. And yet the model does not capture trading and borrowing for CO_2 credits, nor does it accurately model other compliance flexibilities. The lack of a civil penalty provision in the Clean Air Act only highlights the need for EPA to fully model all available compliance flexibilities. Otherwise, EPA will overestimate compliance costs, as it has done in the proposed rollback.

4. Credit use does not show that the baseline standards are unaffordable

The agencies' justification for the Proposed Rule also misrepresents how manufacturers make their compliance credit decisions. According to the agencies, further proof that consumers do not sufficiently value fuel efficient vehicles lies in the fact that manufacturers have begun using credits to comply with the baseline standards.[129] This conclusion, however, gets the logic of credit use wrong.

Though automakers have indeed used banked credits to meet some of their compliance obligations under the baseline standards in the last couple of years,[130] there are at least two other reasons to explain that use, which are more likely than the argument that manufactures think they will not be able to comply with the standards in the future.

First, automakers have an incentive to use their banked credits if they are about to expire.[131] Credits earned in a given year can be banked for only a limited number of years,[132] and it would be a waste of money on the part of automakers to fail to use banked credits (or sell for usage) before they expire.

Second, automakers have an incentive to use banked credits when they expect that the future standards will be easier to achieve—not when they expect future standards to be more costly, as EPA asserts. A bank of credits is similar to a "rainy day fund." With a rainy day fund, if a person expects to need the fund in the near future, it would be foolish to use it today. If that person were to use the funds in such a case, the funds would be unavailable when they are really needed in the future. Similarly, if automakers expected compliance to be even more costly in the future, it would not make sense for them to use up their bank of credits right now.

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[129] *Id.* at 43,217; *id.* at 16,079.

[130] EPA, Manufacturer Performance Report for the 2016 Model Year iv (2018) [hereafter "EPA (2018) Manufacturer Performance Report"], available at https://www.epa.gov/regulations-emissions-vehicles-and-engines/greenhouse-gas-ghg-emission-standards-light-duty-vehicles#2016MY; see also 83 Fed. Reg. at 16,079.

[131] Credits can be banked and carried forward for up to five years. NHTSA, CAFE 2017-2015 Fact Sheet at 8, https://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2017-25_Fact_Sheet.pdf.

[132] Credits are usually available for five years, but some credits are available for different periods of time. See 40 CFR § 86.1865-12(k)(6)(ii).

Given this logic, the use of credits over the last couple of years (starting before the election of President Donald Trump, and so starting before promises began to be made about a rollback),[133] indicates that automakers may believe compliance will be less costly in the future than now. Given that the standards are scheduled to go up from 2022 through 2025, why might automakers expect compliance to be easier in the future? Three factors likely explain this belief.

First, rising consumer demand for fuel efficient vehicles caused by increasing fuel prices, as discussed in Section II.C. below, will make compliance easier. Second, increasing availability—and the lower cost—of low-emission vehicle technology will also make compliance less costly. An industry group released a recent analysis of electrified vehicle sales,[134] showing that sales of electrified vehicles have grown for the last two years, both in absolute terms and as a fraction of overall new vehicle sales.[135] This continues a long-running trend of growth in electrified vehicle sales that began when mass-market hybrid vehicles were released in the late 1990s.

Focusing in particular on sales of fully electric cars and trucks, sales growth is even stronger: 2017 was a record year for sales of fully electric vehicles. There were 199,826 fully electric vehicles sold in 2017, an increase of 25% relative to 2016, substantially outpacing growth in sales of vehicles overall.[136] In 2017, fully electric vehicles constituted just over 1% of all new vehicles sold in the United States.[137] In 2016, EPA found that the 2022–2025 standards would be achievable if even 2% of new vehicle sales are electric by 2025.[138] If sales continue to grow at their current rate, then fully electric vehicle sales will be at least double this amount by 2025. Current projections from the EIA show that fully electric vehicles are predicted to be 5.5% of new car sales by 2025.[139]

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[133] *See* EPA (2018) Manufacturer Performance Report at iv (reporting that "[u]nlike the previous four years, in which generating credits was the norm, most large manufacturers (with sales greater than 150,000 vehicles) generated deficits in the 2016 model year" and reported sufficient credits available from prior model years to be able to offset that deficit).

[134] This figure appeared as early as December 2017 in a Center for Automotive Research presentation. Chen (2017), at 18.

[135] Bailo et al. (2018), at 9.

[136] Jonathan M. Gitlin, *2017 was the best year ever for electric vehicle sales in the US*, ARSTECHNICA (Jan. 4, 2018), https://arstechnica.com/cars/2018/01/2017-was-the-best-year-ever-for-electric-vehicle-sales-in-the-us/.

[137] *Id*.

[138] EPA, NHTSA, & California Air Resources Board ("CARB"), 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 at 12-22 (2016), at https://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/Draft-TAR-Final.pdf [hereafter "Draft TAR"].

[139] EIA, Light-Duty Vehicle Sales by Technology Type (thousands), United States, https://www.eia.gov/opendata/qb.php?category=2642004 (last visited Apr. 26, 2018) (data found at "Light-Duty Vehicle Sales: Alternative-Fuel Cars: 100 Mile Electric Vehicle," "Light-Duty Vehicle Sales: Alternative-Fuel Cars: 200 Mile Electric Vehicle," and "Light-Duty Vehicle Sales: Alternative-Fuel Cars: 300 Mile Electric Vehicle").

Third, the generous electric vehicle credits available under the baseline standards may explain why automakers have expected compliance to be less costly. Since 2017, electric vehicles have allowed automakers to earn credits that can be used to meet compliance shortfalls due to sales of less-efficient vehicles. The credits earned by electric vehicles are especially valuable, because they also earn a "multiplier incentive" from EPA. Any credit earned for sale of an electric vehicle in 2017 through 2019 is doubled. Credits earned in 2020 are worth 1.75 traditional credits, and in 2021, they will be worth 1.5 traditional credits.[140] In addition to using these credits to meet their own compliance obligations, automakers can also sell these credits to other automakers or bank them (for up to five years) for use in the future.[141] The electric-vehicle credits give automakers substantial flexibility when meeting the standards. Given the significant benefits that electric-vehicle sales provide to manufacturers seeking to comply with the standards, the recent high projections of sales of electric vehicles indicate that automakers will have an easier time meeting the standards than EPA could have expected in 2012 or even when analyzing the Final Determination in 2016 and 2017.

B. The agencies' assumption that manufacturers will pass all compliance costs through to consumers is unreasonable

The agencies' full pass-through assumption[142] is unreasonable for two further reasons having to do with the structure of the vehicle markets.

1. Market power

First, the existing level of market power in the vehicle industry means that firms may not pass on all of their costs to consumers. When an industry is perfectly competitive, manufacturers cannot charge consumers more than their marginal cost of production, because competitors are ready and waiting to lure away their customers. Thus, with perfect competition, prices equal the marginal costs of production. In such a case, if production costs increase, the prices rise correspondingly. But the vehicle industry is still characterized by some degree of market power,[143] which means that manufacturers are less constrained in what they chose to pass on to consumers. In other words, firms in a market that is not perfectly competitive likely have a profit margin that is bigger than their marginal cost of production, and they can choose not to pass the

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[140] Draft TAR at 11-6. The multiplier for fully electric vehicles ends in 2021, but the credits earned until that point will be available for use for five years after the year in which they were earned.

[141] *Id.* at 11-4.

[142] 83 Fed. Reg. at 43,071.

[143] The market has become increasingly competitive. But strong product differentiation and huge fixed costs of entry have shielded the industry from becoming fully competitive. As a result, only four firms hold 58.1% of the market. Calculations of CR4 based on data from https://www.statista.com/statistics/249375/us-market-share-of-selected-automobile-manufacturers/. Because of this consolidation, the sector has some monopolistic competition, if not an oligopolistic structure.

full cost increases on to consumers through price increases, because they have the ability to absorb costs into their profit margin.[144] The agencies acknowledge that manufacturers have some ability to absorb costs into their profit margin,[145] thus supporting the assumption that manufacturers may choose to do so.

2. Mix shifting

Second, in their pursuit of profits, manufacturers can be expected to use any available means of reducing compliance costs.[146] And as the agencies acknowledge in the proposal, when deciding how to meet the standards, vehicle manufacturers can and do take into account consumers' demand for individual vehicle models and their attributes.[147] Using that information, manufacturers adjust prices across their fleet to optimally attract customers toward more fuel-efficient vehicles—a practice called *mix-shifting*.[148] As the agencies admit, this practice allows manufacturers to cross-subsidize the prices of entry-level vehicles to keep monthly payments low and attract new and young consumers to their brand.[149] It also allows manufacturers to shift the cost of fuel efficiency and emissions control improvements to categories of vehicles where consumers are less price-sensitive, such as luxury vehicles. This approach minimizes the total compliance cost, and in particular minimizes the pass through of costs to consumers of lower-price vehicles. As a result, economic studies tend to point to less than 100% pass though.[150]

While the agencies acknowledge cross-subsidization in the Proposed Rule,[151] in their price analysis, the agencies claim that "it is reasonable to assume that all incremental technology costs

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[144] *See* Hourcade et al. (2007).

[145] 83 Fed. Reg. at 43,085.

[146] *See* Anne C. Mulkern, *Economists see errors in government claims on pricing*, E&E NEWS (August 6, 2018), https://www.eenews.net/climatewire/2018/08/06/stories/1060092785 (quoting economist Mark Jacobsen, associate professor of economics at the University of California, San Diego as saying that "'Automakers don't always raise the price of cars relative to the costs of meeting fuel economy standards" but that instead automakers have "price points they're trying to meet for specific markets.").

[147] 83 Fed. Reg. at 43,186.

[148] *See* Luk et al. (2016), at 154–171; *see also* Goldberg (1998); Austin & Dinan (2005).

[149] 83 Fed. Reg. at 43,224; *see also* i*d.* at 43,083 (acknowledging that technology costs could, among other options, be paid for by manufacturers or dealers rather than be passed onto consumers in their entirety).

[150] Gron & Swenson, (2000), at 316 (rejecting the hypothesis of full cost pass-through and constant markup).

[151] "All of this is paid for through cross subsidization by increasing prices of other vehicles not just in California and other States that have adopted California's ZEV mandate, but throughout the country." 83 Fed. Reg. at 42,999. In addition: "If the body-style level average price change is used, then the assumption is manufacturers do not cross-subsidize across body styles, whereas if the average price change is used then the assumption is they would proportion costs equally for each vehicle. These are implementation questions to be worked out once NHTSA has a historical data source separating price series by body styles, but these do not matter in the current model which only considers the average price of all light-duty vehicles. 83 Fed. Reg. at 43,095.

can be captured by the average price of a new vehicle."[152] This approach completely overlooks vehicle and customer heterogeneity and ignores the profit-maximization idea behind mix-shifting.[153]

In 2012, the agencies acknowledged mix-shifting and pointed to its importance going forward.[154] However, because mix-shifting can only decrease costs compared to baseline standards and the agencies had already found the rule to be beneficial, there was no need for mix-shifting modeling in 2012. But now, the agencies claim that the benefits of the baseline standards no longer outweigh the costs.[155] Yet the agencies cannot possibly reach such a conclusion before they have considered the impact of mix-shifting. Given that the agencies currently find the baseline standards to be detracting from welfare, they should ensure that their results are not driven by biased methodology that inflates the costs of the regulation.

Moreover, evidence of the industry's recent performance, cited in the Proposed Rule, shows that manufacturers have been able to comply with the standards over the past ten years without detriment to their fleets.[156] For example, the agencies explain that manufactures have been able to reduce fleet-wide CO2 emissions while continuing to produce a diverse fleet.[157] This was likely helped in part by the ability to shift any increase in costs due to the standards to models, such as luxury vehicles, where consumers are less likely to react to the price difference and thus continue to keep prices at a competitive level. The agencies now argue that the Proposed Rule is justified on the ground that something different "may" happen with compliance levels than was assumed in the baseline standards.[158] But that conjecture is insufficient to show that "there are good reasons for the new policy."[159]

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[152] 83 Fed. Reg. at 43,186.

[153] *See* Anne C. Mulkern, *Economists see errors in government claims on pricing*, E&E NEWS (August 6, 2018), https://www.eenews.net/climatewire/2018/08/06/stories/1060092785 (quoting economist Christopher R. Knittel, professor of economics at MIT as saying in the context of mix-shifting that "They [the agencies] add up what those technologies would cost, and then that is the change in prices of the vehicles. The EPA and NHTSA analysis, I think, is missing a major part of how the markets operate in the presence of fuel economy standards,").

[154] 77 Fed. Reg. at 63,068 ("We recognize, however, that many manufacturers do in fact cross-subsidize to some extent, and take losses on some vehicles while continuing to make profits from others. NHTSA has no evidence to indicate that manufacturers will inevitably shift production plans in response to these final standards, but nevertheless believes that this issue is worth monitoring in the market going forward.").

[155] As these comments explain, the agencies' analysis is fundamentally flawed.

[156] 83 Fed. Reg. at 43,231.

[157] *Id.* at 43,230.

[158] *Id.* at 43,231.

[159] *Fox Television Stations, Inc.*, 556 U.S. at 515; *see also NetCoalition v. SEC*, 615 F.3d 525, 539 (D.C. Cir. 2013) (holding that the court would not "defer to the agency's conclusory or unsupported suppositions" (internal quotation marks omitted)).

3. The agencies provide no evidence for their claim of past price increases due to the baseline standards

The agencies' suggestions that evidence of full pass-through lies in recent vehicle price increases are also incorrect.

According to the agencies, there have been "tremendous increases" in vehicle prices over the last decade, making vehicles "increasingly unaffordable."[160] But historical prices do not support the agencies' conclusions. As independent surveys show, over the last ten years, the price of lower-cost vehicles has remained constant despite recent increases in the stringency of standards. A study by Synapse Economics shows that the range of prices of new vehicles has increased, but those increases occurred because the price of high-end vehicles has gone up as more features have been added.[161] The price of more affordable vehicles, on the other hand, has not changed in real terms.

Moreover, the agencies' narrative about the average vehicle becoming unaffordable for the median household is ill-conceived and misleading.[162] By definition, the median household does not buy an average vehicle, but rather a median vehicle. To illustrate why that matters, assume that the price of only the most expensive makes (e.g., only Mclaren vehicles) increases. For the median household, this will have no implications: as the median household never buys the most expensive makes, the price of the vehicles it buys has not changed. However, the average price would increase, so using the agencies' logic, we would deduce that the increase of Mclaren car price would make the cars less affordable for the median household. That is obviously unreasonable.

In addition, in its discussion of affordability, the agencies also disregard the fact that the recent changes in average vehicle price can be, and in fact are, demand-driven and thus reflect the shift in consumer preferences, and not a financial burden for customers. For example, the agencies claim that "new vehicles become increasingly unaffordable—with the average new vehicle transaction price recently exceeding $36,000—up by more than $3,000 since 2014 alone."[163]

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[160] 83 Fed. Reg. at 42,993-94 (citing Average New-Car Prices Rise Nearly 4 Percent for January 2018 On Shifting Sales Mix, According To Kelley Blue Book, https://mediaroom.kbb.com/2018-02-01-Average-New-Car-Prices-Rise-Nearly-4-Percent-For-January-2018-On-Shifting-Sales-Mix-According-To-Kelley-Blue-Book (last accessed Jun. 15, 2018).

[161] Tyler Comings & Avi Allison, Synapse Energy Economics, Inc., *More Mileage for Your Money: Fuel Economy Increases While Vehicle Prices Remain Stable* 5 (2017), https://consumersunion.org/wp-content/uploads/2017/03/Synapse-CU-Affordability-Report-3-15-corrected-1.pdf.

[162] ("In fact, a recent independent study indicated that the average new car price is unaffordable to median-income families in every metropolitan region in the United States except one: Washington, DC. Figure I-2 with the average new vehicle transaction price recently exceeding $36,000—up by more than $3,000 since 2014 alone. 83 Fed. Reg. 42,993-42,994.

[163] *Id.* at 42,993.

However, as the quoted article explains: "shifting sales mix to trucks and SUVs has been particularly extreme lately, and as volume shifts away from cars, the average vehicle price ticks up."[164] Clearly, in that context, the agencies' concern about decreasing affordability is misplaced—it is the consumers that have been choosing, on average, the more expensive types of cars.

C. The agencies' reliance on "relatively low" fuel prices is arbitrary and capricious

The agencies' conclusions about the need for the Proposed Repeal also rest on the claim that fuel prices are "relatively low" when compared to fuel prices in 2012.[165] According to the agencies, because of these lower prices, consumers have chosen to buy vehicles that do not improve manufacturers' compliance positions.[166] For example, according to the agencies, because of the new fuel prices, consumers are not interested in hybrids.[167] And according to the agencies, because of these "new facts and circumstances," the agencies are justified in rejecting the 2012 facts and analyses.[168]

But the agencies have arbitrarily ignored EPA's analysis in 2016 and the 2017 Final Determination, which show that the baseline standards were still achievable and justified even though fuel prices had dropped since 2012. For the 2017 Final Determination, EPA's central analysis used the EIA Annual Energy Outlook 2016 ("2016 AEO") forecast of gasoline prices, and analyzed scenarios that included a low estimate of $1.97, up to a high estimate of $4.94. After analyzing those scenarios, EPA found that even with the lowest prices projected in AEO 2016 of close to $2, the "lifetime fuel savings significantly outweigh the increased lifetime costs" of the GHG Standards.[169] In ignoring the 2017 analysis, the Proposed Rule has failed to provide a "reasoned explanation" for dismissing the "facts and circumstances that underlay" the original rule rendering its analysis arbitrary and capricious.[170]

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[164] *Average New-Car Prices Rise Nearly 4 Percent for January 2018 On Shifting Sales Mix, According To Kelley Blue Book*, Kelley Blue Book https://mediaroom.kbb.com/2018-02-01-Average-New-Car-Prices-Rise-Nearly-4-Percent-For-January-2018-On-Shifting-Sales-Mix-According-To-Kelley-Blue-Book.

[165] 83 Fed. Reg. at 42,993; *id.* at 43,069 (explaining that both the high and low fuel prices from 2017 are lower than they were in 2011); *id.* at 42,993 ("Things have changed significantly since 2012, with fuel prices significantly lower than anticipated, and projected to remain low through 2050.").

[166] *Id.* at 43,217.

[167] *Id.* at 43,222.

[168] *Id.* at 43,226.

[169] EPA, Final Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation at 8 (2017, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100QQ91.pdf [hereafter "Final Determination"].

[170] *Fox Television Stations*, 556 U.S. at 515-16.

Moreover, even if fuel prices are slightly lower than in 2012, for the last several years, fuel prices have been rising again. Fuel prices have been rising steadily since 2016, and as of October 6, 2018, are at $2.866.[171] In the last year, fuel prices have risen by more than 10%.[172] With oil prices reaching currently around $83 per barrel of Brent crude, some analysts and commodity traders predict that 2019 might see prices above $100 per barrel.[173]

If fuel prices rise in line with these forecasts, those rising fuel prices will give consumers an increased incentive to buy fuel-efficient cars, raising demand for fuel efficient vehicles and making it easier for automakers to comply with the standards.[174] Indeed, even if fuel prices do not actually rise, a 2013 study shows that consumers believe future prices will be the same as current prices (stated more formally, average consumer beliefs are typically indistinguishable from a no-change forecast).[175] So the fact that prices are currently rising will motivate consumers to buy more fuel-efficient vehicles. In other words, even if consumers just expect fuel prices to rise (whether or not they actually rise), consumers will have the incentive to buy fuel-efficient cars.

In any event, fuel prices change very quickly and the accuracy of the forecast tends to be very low. As such, the agencies should recognize that the value of fuel efficiency provides an insurance value against future and unpredictable developments in gasoline markets. The agencies should not relegate any consideration of different, realistic gas prices to the sensitivity analysis, but instead should more systematically incorporate various gasoline price scenarios into their main analysis.

III. THE AGENCIES HAVE ARBITRARILY IGNORED CONSUMER VALUATION OF FUEL SAVINGS AND THE WELFARE BENEFITS OF THE BASELINE STANDARDS

The agencies' incomplete and inaccurate estimations of the fuel savings and time savings from increasing vehicle efficiency render its cost-benefit analysis arbitrary. Moreover, much of the proposed rollback's justification undercuts even those partial estimations, alleging that the private benefits of fuel economy standards must be illusory and will be offset by lost welfare from other vehicle attributes. Elsewhere, the agencies' model and the proposed rule's justification depend on inconsistent assumptions that either consumers do not value fuel economy at all, or else that consumers very strongly value fuel economy. The agencies have

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[171] Current gas prices from EIA are available here: https://www.eia.gov/petroleum/gasdiesel/

[172] *Id.*

[173] See https://oilprice.com/Energy/Oil-Prices/100-Oil-Is-A-Distinct-Possibility.html, https://www.aljazeera.com/news/2018/09/oil-prices-hit-year-high-81-looming-iran-sanctions-180925060509728.html and https://www.wsj.com/articles/opecs-wildcards-could-push-oil-to-100-1538737295

[174] EIA (2018A), at 113 (2018) (showing that sales of cars and other high-efficiency automobiles are expected to increase relative to sales of other vehicles starting in 2020 as gas prices motivate consumers to adopt more fuel-efficient vehicles).

[175] Anderson et al. (2013).

failed to consider important economic theories and evidence—both from new literature and from the agencies' own past rulemakings—that explain why fuel economy standards can deliver significant net private welfare gains. One such important concept is that many vehicle attributes, like horsepower and size, are positional goods, and so regulation of fuel economy can help correct the positional externality. The agencies also fail to consider the distributional aspect of consumer valuation of fuel economy and the health effects associated with refueling.

A. The myriad problems with the scrappage, rebound, and sales modules cause the agencies to underestimate the net forgone private savings from fuel economy

In their various tables summarizing the costs and benefits of the proposed rollback, the agencies present the forgone private savings from the proposed rollback as a net calculation. For example, the estimate of "higher fuel costs from lower fuel economy" includes "lost fuel savings from lowered fuel economy of MY's 2017-2029 *and gained fuel savings from more quickly replacing* MY's 1997 to 2029 with newer vehicles."[176] All the myriad problems with the agencies' scrappage, rebound, and sales modules (detailed throughout these comments) have therefore once again infected their calculation of costs and benefits. In this case, by overestimating the effect of the proposed rollback on the replacement of older vehicles with newer vehicles, the agencies have overestimated "gained fuel savings" that will allegedly offset lost fuel savings under the proposed rollback. If the agencies correct the problems with their scrappage, rebound, and sales modules, the estimates of net forgone private savings will increase, showing that the proposed rollback will be more detrimental to the personal welfare of vehicle owners than the agencies currently calculate.

B. The agencies' position on consumer valuation of fuel economy is internally inconsistent and provides false support for the rollback

Much of the Proposed Rule's justification and models depend on the incorrect and unsupported assumption that consumers do not value fuel economy. Nowhere is that wrong assumption more apparent or more problematic than in the agencies' sales module.

When purchasing a vehicle, an individual pays the upfront cost of the vehicle, and the consumer will also need to pay for fuel for the vehicle over time. The degree to which consumers value fuel economy relative to the objective, present discounted value of fuel savings, generally expressed as a ratio or a percentage of full valuation, is a key parameter for assessing how vehicle sales will react to fuel efficiency standards. If consumers have a valuation of less than 100%, that suggests that consumers undervalue fuel efficiency, implying that increases in fuel efficiency will not lead to as large of an increase in automobile demand as a standard economic

[176] *E.g.*, 83 Fed. Reg. at 43,065 (emphasis added).

model would suggest.[177] An undervaluation likely reflects a market failure, such as an informational failure, myopia, supply side failures, positional externalities, or so forth—as discussed below, and as discussed by the agencies at length in the 2012 rulemaking. Fuel economy regulations, therefore, can correct the market failure and so deliver net private welfare gains.[178] If consumers instead have greater than 100% valuation of fuel economy, then emissions standards will increase demand for more fuel-efficient vehicles by *more* than a standard economic model would predict.[179]

Despite the centrality of this parameter to accurate estimation of the demand response to the proposed rollback, the agencies arbitrarily omit the parameter from their sales module, thus implicitly assuming that consumers have a 0% valuation of fuel economy. To derive estimates for how the baseline standards would affect sales (which ultimately leads to the agencies' inflated fatality numbers), the agencies use a model that connects claimed price changes (attributed to the baseline standards) with sales.[180] That sales module ignores consumer valuation of fuel economy and so effectively treats consumers as having zero valuation of fuel economy.[181] Ignoring the amount that consumers value fuel economy in the sales module allows the agency to significantly boost the sales drop that it attributes to the baseline standards.[182] This drop in sales then drives the agencies' inflated estimates about the effect of the baseline standards on fleet size and fatalities.

Similarly, at various points throughout the proposed rule, the agencies assume that consumers' low valuation of fuel economy creates compliance "challenges for achieving increased fuel economy levels and lower CO_2 emission rates" and offer these challenges as a justification for the proposed rollback.[183] Thus, an assumed very low or zero valuation of fuel economy is central to the proposed rollback's justification.

But neither the literature the agencies cite nor any of the literature they ignore supports such an extreme and arbitrary assumption as a very low or zero valuation. The agencies' failure to estimate consumer valuation of fuel economy in their sales module results in their gross

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[177] Steven Berry et al. (1995).

[178] *E.g.*, Alcott & Sunstein (2015) (explaining that CAFE standards can correct internalities).

[179] *See, e.g.* Busse et al. (2013).

[180] *See* 83 Fed. Reg. at 43,074.

[181] *Id.* at 43,075. The agencies claim that their model operates at "too high a level of aggregation to capture" consumer preference for fuel efficiency. *Id.*

[182] The agencies conclude that, because of their assumptions, including their implicit assumption that consumers do not value fuel economy, it is "reasonable to assume" that lowering the standards will "increase total sales of new cars and light trucks during future model years." *Id.*

[183] *E.g.*, *id.* at 42,993; *see also id.* at 43,217 (blaming "consumers not being interested in better fuel economy" for manufacturers' alleged need to "manag[e] their CAFE compliance obligations through use of credits").

overestimation of the alleged safety benefits of this proposed rollback, as explained throughout our comments. In fact, because EPA's 2017 *Final Determination* confirmed that "[e]ven with the lowest fuel prices projected by AEO 2016 . . . the lifetime fuel savings significantly outweigh the increased lifetime costs,"[184] there is good reason to believe that the original standards would raise consumer demand and hasten adoption of new vehicles, while the proposed rollback will have the opposite effect.

Moreover, the 0% valuation conflicts with agencies' own analysis. The agencies conclude—after reviewing only a very narrow set of literature (see next subsection critiquing the agencies' literature review)—that consumers instead value "at least half—and perhaps all—of the savings in future fuel costs."[185] The agencies' rebound module also implicitly assumes that consumers will have an extremely strong reaction to changes in fuel economy, indicating a strong valuation of fuel economy, and the scrappage module incorporates a cost-per-mile factor that assumes consumers value both absolute and relative fuel economy.[186] Elsewhere, the agencies rely on a payback assumption that consumers are willing to pay for fuel economy technology that returns the investment within 30 months.[187]

The agencies' inconsistent positions on consumer valuation of fuel economy are arbitrary and capricious. On the one hand, the agencies argue that consumers value fuel economy so fully that there can be no private welfare benefits to increasing fuel economy by regulation.[188] And on the other hand, the agencies argue the exact opposite, that consumers have so little regard for fuel economy that manufacturers cannot sell efficient vehicles.[189] In fact, neither extreme position is supported either by the literature that the agencies cite nor by the important additional literature that the agencies ignore.

C. The agencies fail to consider important theoretical and empirical literature

The Agencies' Three Preferred Studies: The proposed rollback's discussion of consumer valuation of fuel economy relies almost entirely on three sources: Sallee et al. (2016), Busse et al. (2013), and Allcott & Wozny (2014).[190] Before critiquing the agencies' reason for focusing only on these studies and the agencies' failure to look at other important literature, it is worth

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[184] Final Determination at 7.

[185] 83 Fed. Reg. at 43,073; *see also id.* at 43,075.

[186] See the sections of our comments on new vehicle sales, scrappage, and rebound for more details on all these inconsistent assumptions.

[187] *Id.* at 43,217.

[188] *See, e.g.*, *id.* at 43,072, 43,075.

[189] *Id.* at 42,993.

[190] *Id.* at 43,072-73.

noting that these three sources in no way support either the proposition that consumers do not value fuel economy at all (as the agencies implicitly assume in their sales model), nor the position that consumers already so perfectly value fuel economy that there is no possible benefit to efficiency standards (as the agencies imply in their literature review). The best read of even just these three studies is that consumers do value fuel economy but are not reliably willing to pay exactly $1 today for a net present expected savings in future fuel costs of just over $1, as classic economic theory would predict. Instead, there is a gap, and that gap creates the potential for a well-designed regulation to deliver net private benefits. Allcott & Wozny estimate that consumers are probably incorporating about 55% of future fuel costs into their vehicle purchase decisions;[191] Busse et al. estimate a very wide range (between 54% and 117%);[192] Sallee et al. find that consumers may "incorporate slightly more than 100% of changes in future fuel costs" into their decisions,[193] but also find "modest undervaluation" of "70 to 86%" among large-scale fleet operators.[194] None of these studies estimates a 0% valuation, as the agencies' sales module implicitly does.

The agencies justify their decision to focus almost exclusively on these three studies by highlighting problems with cross-sectional and discrete choice studies, and by citing those problems as a reason to prefer studies based on panel data.[195] While cross-sectional and discrete choice studies may have limitations, the studies the agencies focus on also have limitations. Most notably, as the agencies acknowledge, only one study they rely on, Busse et al., includes any direct examination of new vehicle sales, and even that estimate "is based on more limited information";[196] the other two studies, Sallee et al. and Allcott & Wozny, both focus exclusively on used vehicles.[197] And each of the three studies has various other limitations and idiosyncrasies with its choice of data and methodology. Sallee et al., for example, excludes data on hybrid vehicles.[198] Just as these various limitations would not necessarily be grounds to completely ignore these three studies, neither should all other literature be ignored outright.

Ignoring All Other Empirical Literature: Even as they admit the limitations of the three studies that they rely on, the agencies assume that the limitations of all other studies are fatal flaws and so essentially ignore all other literature, including literature that helps explain the energy

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[191] *Id.* at 43,072. With different model choices, that number either rises to 76%, *id.* (when using oil future market data) or drops to 55%; *id.* at 43,073 (with greater disaggregation of the MPG groups).

[192] *Id.*

[193] *Id.* at 43,072.

[194] *Id.* at 43,703.

[195] *Id.* at 43,071.

[196] *Id.* at 43,073.

[197] *Id.*

[198] PRIA at 936, n. 487.

efficiency paradox. Such an extreme reaction is not warranted. When a study raises useful and relevant points, it should not be ignored simply because the agencies prefer a different methodological structure, or even just because the study has not been published in a peer-reviewed journal. The agencies should assess the study's quality and relevance, and particularly should have a good reason to ignore studies that the agencies previously relied upon.

For example, the agencies identify in footnote 223 that Kilian & Sims (2006) also used a longitudinal approach to examine consumer valuation, similar to the methodology of the agencies' three preferred studies; yet the agencies exclude the results of this study because it is "unpublished" and so its "empirical results are subject to change."[199] It is true that the quality and finality of unpublished studies should be carefully examined before relying on them, and if they are of insufficient quality or relevance, they will not deserve equal consideration with literature published in peer-reviewed journals. Yet neither should unpublished studies, if otherwise relevant and of sufficient quality, be automatically ignored just because they are unpublished.[200] In this case, for example, the Kilian & Sims paper raises a relevant result and theory worthy of further consideration: specifically, that consumers react more strongly to a potential loss of fuel savings than to a potential gain in fuel savings.[201] Given that the agencies have relied on Killian & Sims in the past,[202] and given the relevance of their finding to the proposed decrease in fuel economy standards, the agencies should review the study's quality to determine its relevance, rather than dismiss it out of hand. The agencies should also more thoroughly search the literature for analysis of whether consumers will react differently to a rollback of fuel economy standards than to an increase in standards, and the agencies should generally review the literature that they had previously examined and relied on during the 2012 rulemaking.[203]

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[199] 83 Fed. Reg. at 43,072 n.223.

[200] *See, e.g.*, EPA (2010a), at 7-45 ("Because peer-reviewed academic journals may be more likely to publish work using novel approaches compared to established techniques, some studies of interest may be found in government reports, working papers, dissertations, unpublished research, and other 'gray literature.' Including studies from the gray literature may also help mitigate 'publication bias' that results from researchers being more likely to present and/or editors being more likely to publish studies that demonstrate statistically significant results, or results that are of an expected sign or magnitude. . . . [T]he analyst should develop an explicit set of selection criteria to evaluate each of the potentially relevant studies for quality and applicability to the policy case.").

[201] Kilian & Sims (2006), at 3 ("[T]he responses of automobile prices to positive changes in the real price of gasoline are far greater in magnitude than in the baseline case, whereas decreases in the price of gasoline have little or no effect on prices.").

[202] EPA (2010b), at 39 (explaining that Kilian & Sims suggests that consumers may be willing to pay more to avoid a decrease in fuel economy than to gain an increase in fuel economy). This literature review was commissioned in support of NHTSA and EPA's earlier rulemakings.

[203] *Id.*

The agencies should also review the most up-to-date literature. For example, the agencies should consider David Greene et al.'s recently published meta-analysis of marginal willingness-to-pay estimates for fuel economy. These authors find a mean estimate for willingness to pay of $853 for a $0.01/mile reduction in fuel costs.[204] The agencies have failed to do a thorough search of the literature and to base their decision on all of the reliable information available to them.

Ignoring Other Explanations for the Efficiency Paradox: The agencies claim that previous rulemakings relied heavily on the belief that consumers' undervaluation of fuel economy was due to "myopia,"[205] and falsely assert that the prior rules could only be justified by assuming that consumers value less than one-third of fuel savings.[206] In the past, the agencies did raise the idea of consumer myopia and various "internalities" among the many reasons why consumers may fail to achieve their welfare-maximizing level of fuel economy in the marketplace without the assistance of regulation. But, the agencies also previously explored many other reasons for the energy efficiency paradox which supported the decision to adopt the baseline standards—reasons which the agencies now ignore. For example, in the 2012 rule, the agencies explained that what seems like an undervaluation of fuel economy could result from consumers "lack[ing] the information necessary to estimate the value of future fuel savings, or not hav[ing] a full understanding of this information even when it is presented," or that "[i]n the face of such a complicated choice, consumers may use simplified decision rules," and may focus on "visible attributes that convey status."[207] Yet, with no analysis of the relevant literature, the agencies now assume that consumers must be perfectly informed about fuel economy[208] and so conclude that "it is reasonable to believe that U.S. consumers value future fuel savings accurately."[209]

In fact, important literature explains why, even with the assistance of somewhat improved—though surely not yet optimized—labels that provide consumers with information on fuel savings, consumers may still face challenges to fully incorporating that information into their decisionmaking. James Sallee, for example, has explained that:

> [A]ccurate valuation of lifetime present discounted fuel costs is challenging, both because the calculation is cognitively difficult and because the information required is hard to obtain. Government labels aid in this task, but they do not resolve all uncertainty because the labels are incomplete and inaccurate and because

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[204] Greene et al. (2018) at 270-71 (finding a range from a mean estimate of $693 in market sales and revealed preference studies, to $1225 in stated-preference studies; meanwhile, NHTSA data would suggest that a $0.01/mile reduction should deliver about $1150 in lifetime fuel savings).

[205] 83 Fed. Reg. at 43,216.

[206] *Id.* at 43,073.

[207] 77 Fed. Reg. 62,624, 62,914 (Oct. 15, 2012).

[208] 83 Fed. Reg. at 42,993.

[209] *Id.* at 43,216.

> heterogeneity in usage patterns implies that labels can resolve only a modest portion of the relevant uncertainty.[210]

Because the variation in fuel costs across automobiles—though "substantial"—is also "dwarfed by variation in prices," and given the costs of obtaining and processing more information about fuel economy, consumers tend to be "inattentive" to fuel economy. The financial loss in future fuel savings to any individual from making a "mistake" in their choice of fuel economy may be less than the costs of the effort to obtain and process more information on fuel economy before the decision—yet, "in the aggregate," the result could be billions of dollars in lost fuel savings across the entire U.S. car market.[211] Because "firms will bring to market only those innovations that garner attention," firms may underprovide important but "shrouded" innovations in fuel economy that may rationally escape consumers' attention.[212] Yet because increased attention "involves real costs" for consumers, policy fixes focused on increasing information and attention may not improve welfare; instead, energy efficiency standards become the optimal policy solution.[213] The agencies have failed to consider the ongoing challenges to information processing that consumers face and so fail to consider how regulation can help consumers overcome these challenges and maximize private welfare.

Similarly, the agencies now ignore explanations of supply-side market failures that helped justify past rulemakings. In the 2012 rule's impact analysis, the agencies explained that imperfect competition in the vehicle market could "reduce[ ] producers' profit incentive to supply the level of fuel economy that buyers are willing to pay for."[214] Asymmetric information between manufacturers and consumers could also cause fuel economy to "remain persistently lower than that demanded by potential buyers."[215] Manufacturers may "deliberately limit the range of fuel economy levels they offer" if manufacturers "mistakenly believe" that consumers are unwilling to pay for improved fuel economy.[216]

Other important literature further explores these supply-side market failures. Manufacturers may face a first-mover disadvantage for developing new fuel-efficiency technologies, and regulation can help overcome that perceived disadvantage as well as bring down costs through economies of scale and learning, and thus may "lead to a more optimal provision of fuel economy in the

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[210] Sallee (2014), at 782. Note also that NHTSA has not fulfilled its statutory obligation to develop a consumer education program on fuel economy and greenhouse gas emissions. 49 U.S.C. § 32908(g).

[211] *Id.* at 783.

[212] *Id.* at 784.

[213] *Id.* at 785. Note that Sallee et al. (2016), which the agencies rely on, cite Sallee (2014) as an important "caveat" to some of the conclusions drawn in Sallee et al. (2016). *See* Sallee et al. (2016), at n. 5.

[214] NHTSA 2012 FRIA at 987-88.

[215] *Id.*

[216] *Id.*

marketplace."[217] As manufacturers offer more fuel-efficiency technology and the technology becomes more widespread in the market, consumer attitudes toward that technology will change.[218] Manufacturers also shape consumer preferences through advertising. Yet now, the agencies assume that it is consumer preferences alone that shape and constrain manufacturers' compliance options,[219] without considering manufacturers' role in shaping the options available in the marketplace and consumers' attitudes toward those options. A review of the broader set of literature, on both supply-side and demand-side obstacles to the efficient provision of fuel economy, demonstrates that the justification for the proposed rollback runs counter to the available evidence.

In Tables II-25 to II-28, the agencies' presentation of costs and benefits seem to count the forgone private savings from the increased fuel economy that the original 2012 standards would provide. Implicit in the calculations in those tables is some theory for why consumers will value fuel savings once a regulatory standard helps deliver increased fuel economy, even though consumers are unable to achieve those fuel savings on their own in an unregulated marketplace. Viable theories supported by the literature include some combination of informational failure, attention costs, myopia, positional externalities, or supply-side failures. Much of the agencies' discussion in the *Federal Register* notice and preliminary regulatory impact analysis either ignores or seems skeptical of these theories, and as already noted, much of their modeling relies on inconsistent assumptions that consumers instead do not value fuel economy. As the agencies redo their analysis in response to these and other public comments, they should preserve the calculation of private savings from fuel economy reported in these tables (corrected so that the mistakes with the scrappage, rebound, and sales modules do not cause an undervaluation of net private savings). By more fully valuing the private fuel savings from the 2012 standards, together with other corrections to the analysis, it will be apparent that the proposed rollback is not justified.

D. Surveys on consumer satisfaction

The proposed rollback insists that consumers value fuel savings accurately,[220] that consumers "generally tend not to be interested in better fuel economy above other attributes,"[221] and that consumers are "unlikely" to "suddenly become more interested in fuel economy over other

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[217] NAS (2015), at 319.

[218] *Id.*

[219] *E.g.*, 83 Fed. Reg. at 43,217 (blaming "consumers not being interested in better fuel economy" for manufacturers' alleged need to "manag[e] their CAFE compliance obligations through use of credits").

[220] *Id.* at 43,216.

[221] *Id.* at 43,217 (citing manufacturer comments and an NAS study; but see *infra* on contradictory evidence from the same NAS study).

attributes" in the "foreseeable future."[222] The agencies rely on these statements to claim there are compliance challenges with the 2012 standards, and so justify the proposed rollback. Yet these conclusions are not supported by extensive data from consumer satisfaction surveys.

National Academy: As reported by a 2015 review of fuel economy standard by the National Academy of Sciences, "the public's perception of the CAFE standards and support for raising the standards has been highly positive for the past 25 years."[223] In one survey, for example, 77% of respondents supported higher fuel economy standards even after being told that it would increase the costs of buying or leasing; in another survey, 82% of respondents supported standards of 56 miles per gallon by 2025.[224] The proposed rollback's various pronouncements on consumer valuation are inconsistent with these findings.

ACSI and J.D. Power Surveys: Two long-running surveys of consumer satisfaction with their motor vehicles provide a good deal of publicly available data: the American Customer Satisfaction Index, and J.D. Power's APEAL survey. The data from these two surveys strongly suggests that consumers at least partly value fuel economy, that they value it even when fuel prices are dropping, that they sometimes value it more than other attributes, that they want more of it and are not satisfied by the levels currently provided, and that fuel economy is among the attributes with the most room for improvement and most potential to contribute to greater customer satisfaction with their vehicles.

This section of our comments will look first at recent evidence from these surveys specifically on fuel economy, before taking a more historical and graphical look at data going back to 1994.

Since 1994, the American Customer Satisfaction Index (ACSI) has conducted annual surveys on consumers' satisfaction with "recent purchases and driving experiences" in both mass-market and luxury cars and trucks.[225] Since 2016, ACSI has included details and scores for individual attributes, including gas mileage. In the 2016, 2017, and 2018 surveys, gas mileage has consistently been the lowest-ranked attribute for consumer satisfaction, in both mass market and luxury vehicles.[226] The results of the 2017 survey confirmed that "[r]egardless of category,

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[222] *Id. see also id.* at 42,993 (assuming that only "a relatively small percentage of buyers" value fuel economy, and citing only a single news report).

[223] NAS (2015), at 317.

[224] *Id.* at 318.

[225] For example, in 2018, they conducted 4,649 interviews about "recent purchases and driving experiences. *See* ACSI, *Automobile Report 2018*, https://www.theacsi.org/news-and-resources/customer-satisfaction-reports/reports-2018/acsi-automobile-report-2018/acsi-automobile-report-2018-download [hereafter "2018 ACSI Report"]. As a result, their data may reflect more than just purchases of new vehicles and may include purchases of used vehicles and driving experiences in vehicles that the interviewee did not directly purchase.

[226] ACSI, *Automobile Report 2016,* https://www.theacsi.org/images/stories/images/reports/16aug_auto-report.pdf [hereafter "2016 ACSI Report"]; ACSI, *Automobile Report 2017*,

everybody wants better gas mileage," and that of all the attributes, gas mileage "shows the most room for improvement."[227] The 2018 report made identical comments, adding that "gas mileage continues to be the low point" among all vehicle attributes.[228]

J.D. Power has conducted the U.S. Automotive Performance, Execution and Layout (APEAL) Study for twenty-three years. Its most recent survey, for example, interviewed nearly 68,000 purchasers and lessees of new Model Year 2018 vehicles within ninety-days of ownership.[229] At various times, the APEAL study has included details and comments on fuel economy specifically, and in more recent years, individual attributes including fuel economy have been scored and ranked separately. In 2007, J.D. Power observed that over half of that year's total drop in overall customer satisfaction with new vehicle performance could be attributed to "a significant decrease in owner delight with fuel economy," noting that "manufacturers that deliver more fuel-efficient vehicles . . . stand a better chance of delighting their customers."[230] In 2008, J.D. Power reported that "fuel economy and practicality are increasingly important in vehicle selection process" and attributed yet another overall dip in consumer satisfaction "primarily due to decline in satisfaction in fuel economy."[231] In 2009, an uptick in overall consumer satisfaction was "driven primarily by increased owner satisfaction with fuel economy," which J.D. Power attributed not just to fuel prices, but also to the fact that more manufacturers were designing--and more consumers were buying--fuel-efficient vehicles.[232] In 2010, the vehicles that scored the best included those with "unexpected fuel economy."[233] In 2011, newly launched vehicle models scored higher than redesigned models, partly due to higher scores for fuel economy.[234] In 2012,

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http://marketing.theacsi.org/acton/attachment/5132/f-0058/1/-/-/-/-/ACSI%20Automobile%20Report%202017.pdf [hereafter "2017 ACSI Report"]; 2018 ACSI Report.

[227] 2017 ACSI Report.

[228] 2018 ACSI Report.

[229] Joseph Dobrian, *2018 New Car Appeal Shows Biggest Improvement in History*, J.D. POWER (July 25, 2018), https://www.jdpower.com/cars/ratings/performance-and-design/2018/2018-us-apeal-study-results.

[230] J.D. Power, *Fuel Price Concerns Lead to Decrease in Vehicle Appeal*, June 26, 2008, https://web.archive.org/web/20090221020855/http://www.jdpower.com/corporate/news/releases/pressrelease.aspx?ID=2008078.

[231] Jeff Youngs, J.D. Power, 2008 APEAL Study Results (Dec. 31, 2007), https://www.jdpower.com/Cars/Ratings/Performance-and-Design/2008/2008-apeal-study-results.

[232] Jeff Youngs, J.D. Power, 2009 APEAL Study Results, Dec. 31, 2008, https://www.jdpower.com/Cars/Ratings/Performance-and-Design/2009/2009-apeal-study-results.

[233] Paul A. Eisenstein, *U.S. Automakers Gain APEAL—and Appeal*, NBC NEWS (July 22, 2010), http://www.nbcnews.com/id/38346050/ns/business-the_driver_seat/t/us-automakers-gain-apeal-appeal/ (reporting on APEAL scores).

[234] J.D. Power, *Automakers Face Up to Tough Market Conditions by Offering the Most Appealing Lineup of New Vehicles in History*, July 27, 2011, https://web.archive.org/web/20120304214343/http://www.jdpower.com:80/content/press-release-auto/7uCb2L3/owner-reported-fuel-economy-from-apeal-study-.htm.

owners shifted toward smaller and more fuel-efficient vehicles, and satisfaction with fuel economy showed the greatest overall increase, helping to drive the total APEAL score up. That year, J.D. power reported that "*47 percent of owners say gas mileage was one of the most important factors in choosing their new vehicle, up from 40 percent in 2011*."[235] In 2014, fuel economy was the only attribute with a year-over-year improvement in owner satisfaction, driven not just by fuel prices but by vehicle efficiency itself. Nevertheless, "fuel economy is still a problem area for automakers . . . [and] *continues to be the lowest-scoring category in the study by a wide margin*."[236] In other words, consumers have not been satisfied with the fuel economy provided by manufacturers, and it drags down their overall satisfaction with their new vehicles. In 2016, an improvement in fuel economy had the largest impact on overall increase in satisfaction; increased satisfaction with the related attribute of driving range was the second-most-important attribute in driving overall gains in consumer happiness.[237] And in 2018, satisfaction with fuel economy rose again slightly (though remained relatively quite low compared to all other attributes), with J.D. Power reporting that "*customers are more satisfied with their fuel economy despite increases in fuel prices*."[238] Driving range rounded out the "top 10 vehicle attributes with the greatest positive effect year over year on overall score."[239] Looking back over J.D. Power's survey results from the last decade, consumers have consistently expressed dissatisfaction with current levels of fuel economy and a desire for greater fuel economy than the market was providing, even during periods when gas prices were falling.

These robust surveys undercut many of the agencies' justifications and conclusions. The upshot from the ACSI and J.D. Power survey is that consumers are not satisfied with the currently available levels of fuel economy, they want greater fuel economy improvements even when gasoline prices fall, and they are unable to obtain in the marketplace the amount of fuel economy they would prefer. Additionally, as the graph in the next subsection suggests, fuel economy could have a relationship to overall customer satisfaction with their vehicles that other attributes, like horsepower and size, in fact might lack.

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[235] J.D. Power, *As Vehicle Appeal Improves, Owners Find that Downsizing Doesn't Necessarily Mean Downgrading*, July 25, 2012, http://www.jdpower.com/press-releases/2012-us-automotive-performance-execution-and-layout-apeal-study.

[236] Jeff Youngs, J.D. Power, 2014 APEAL Study Results (July 23, 2014), https://www.jdpower.com/Cars/Ratings/Performance-and-Design/2014/2014-apeal-study-results.

[237] J.D. Power, Safety Features Score Big, Boosting New-Vehicle Appeal, July 27, 2016, http://www.jdpower.com/press-releases/jd-power-2016-us-automotive-performance-execution-and-layout-apeal-study.

[238] Joseph Dobrian, 2018 New Car Appeal Shows Biggest Improvement in History (July 25, 2018), https://www.jdpower.com/cars/ratings/performance-and-design/2018/2018-us-apeal-study-results.

[239] J.D. Power, Infographic: 2018 Performance and Design Key Stats, July 25, 2018, https://www.jdpower.com/cars/ratings/quality/2018/infographic-2018-us-apeal-study-key-stats.

Graphing Attributes Against Fuel Economy: Data from these long-running, robust consumer satisfaction surveys can be plotted against relative changes in attributes like average horsepower, size, acceleration, and fuel economy. The resulting graph, Figure 1 below, is not a full economic analysis, but even a coarse look at the data is revealing.

These are the data sources for the graph that appears below:

- Horsepower: graphed in red below, data on the percent change in average light-duty vehicle horsepower since a baseline of 1994 is drawn from EPA's 2018 report on *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends*.[240]
- Weight: graphed in yellow below, data on the percent change in average light-duty vehicle weight since a baseline of 1994 is also drawn from that 2018 EPA report.
- Acceleration: graphed in orange below, numerical data on acceleration is not provided directly by the 2018 EPA report; however, numerical estimates of relative changes in average vehicle acceleration since 1994 were backed out from EPA's own chart on acceleration.[241]
- Fuel economy: graphed in green below, data on the percent change in average adjusted fuel economy since 1994 is also drawn from EPA's 2018 report.[242]
- Consumer Satisfaction: graphed in various shades of blue below, there are three sets of data on consumer satisfaction.
    - The American Customer Satisfaction Index (ACSI) has conducted annual surveys since 1994 about consumers' satisfaction with "recent purchases and driving experiences" in both mass-market and luxury cars and trucks.[243] Their survey captures opinions about gas mileage, driving performance, dependability, safety, comfort, and other "critical elements of the automobile experience."[244] Scores out of a possible 100 are given for each manufacturer and as an industry-wide average going back to the baseline year of 1994.[245] The industry-wide average is used here.
    - J.D. Power has conducted the U.S. Automotive Performance, Execution and Layout (APEAL) Study for twenty-three years. Its most recent survey interviewed nearly 68,000 purchasers and lessees of new Model Year 2018 vehicles within ninety-days of ownership.[246] The survey covers 90 attributes in 10 categories: fuel economy, exterior,

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[240] EPA (2018a), at tbl. 2.1.

[241] *Id.* at Figure 3.11.

[242] Adjusted fuel economy values "reflect real world performance and are not comparable to automaker standards compliance levels." EPA, *Trends* at 4.

[243] For example, in 2018, ACSI conducted 4,649 interviews about "recent purchases and driving experiences. *See* 2018 ACSI Report. As a result, their data may reflect more than just purchases of new vehicles, and may include purchases of used vehicles and driving experiences in vehicles that the interviewee did not directly purchase.

[244] ACSI, Automobiles, https://www.theacsi.org/industries/manufacturing/automobile.

[245] ACSI, Benchmarks by Company: Automobiles and Light Vehicles, https://www.theacsi.org/index.php?option=com_content&view=article&id=149&catid=&Itemid=214&i=Automobiles+and+Light+Vehicles.

[246] Joseph Dobrian, J.D. Power, *2018 New Car Appeal Shows Biggest Improvement in History*, July 25, 2018, https://www.jdpower.com/cars/ratings/performance-and-design/2018/2018-us-apeal-study-results.

seats, interior, driving dynamics, storage and space, engine and transmission, visibility and safety, HVAC, and audio/communication/entertainment/navigation.[247] Historical APEAL scores are not compiled in a single database online, but many can be pieced together from press releases and old media coverage. We have compiled industry-wide APEAL scores going back to 2001 (except for the year 2002, which was not available online).[248]

- From personal communications with J.D. Power employees, as well as from observations on how more recent press releases discussed historical scores, we learned that the scale for the scoring was changed between 2005 and 2006.[249] Therefore, there are two separate sets of data from the APEAL survey: 2001 to 2005, with year 2001 results as the baseline; and post 2006, with year 2006 results as the baseline.

There may be some slight time lag between the year when a survey was conducted and the model year of the vehicles covered, though note that, for example, the APEAL survey conducted in the summer of 2018 focused on Model Year 2018 vehicles. The ACSI survey results also cover more than just customer experiences with new vehicles, and also includes all recent vehicle purchases. Yet despite such limitations, the raw data is still revealing.

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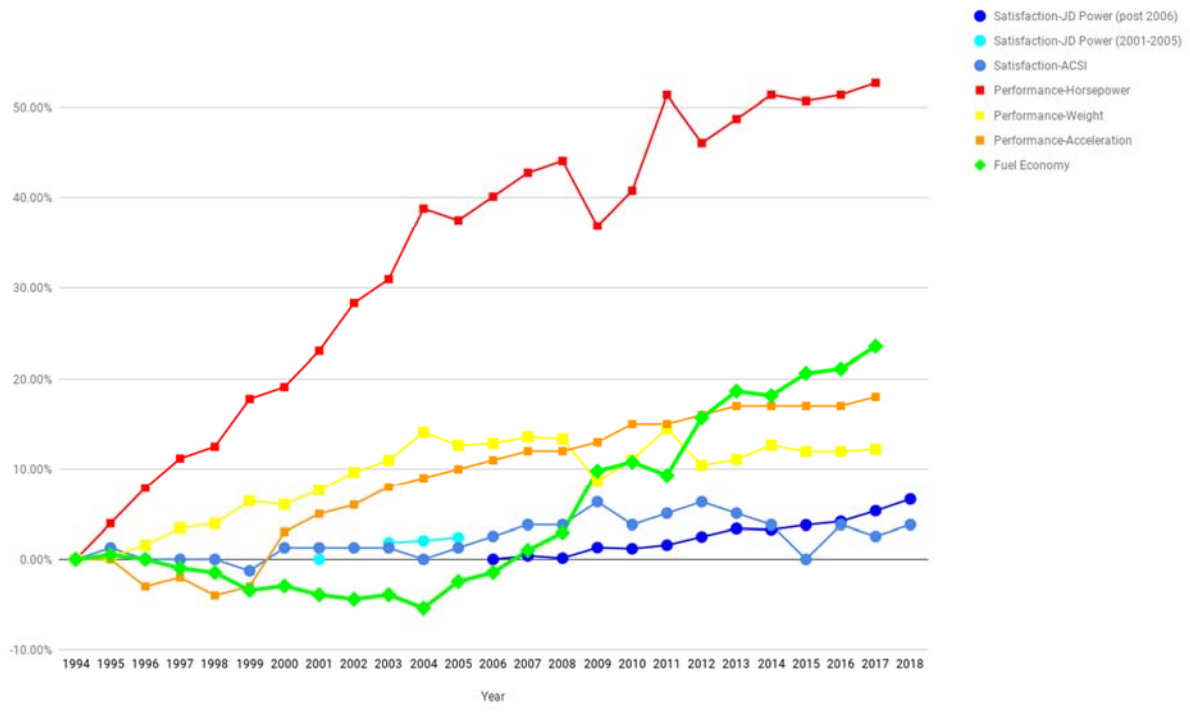
[247] J.D. Power, *U.S. Automotive Performance, Executive and Layout (APEAL) Study*, http://www.jdpower.com/press-releases/jd-power-2017-us-automotive-performance-execution-and-layout-apeal-study.

[248] Data compiled from: 2018 score (https://www.jdpower.com/cars/ratings/performance-and-design/2018/2018-us-apeal-study-results); 2013-2017 scores (http://www.jdpower.com/cars/articles/jd-power-studies/infographic-2017-us-apeal-study-key-stats); 2012 score (http://www.jdpower.com/press-releases/2012-us-automotive-performance-execution-and-layout-apeal-study); 2010-2011 scores (http://www.jdpower.com/cars/articles/jd-power-studies/2011-apeal-study-results); 2009 score (https://www.thetorquereport.com/news/porsche-once-again-leads-in-2009-j-d-power-apeal-study/); 2007-2008 scores (https://web.archive.org/web/20090221020855/http://www.jdpower.com/corporate/news/releases/pressrelease.aspx?ID=2008078); 2006 score (https://acurazine.com/forums/automotive-news-6/j-d-power-apeal-study-news-%2A%2A2014-results-page-1-%2A%2A-394014/; and *American Drivers Rate Midland Motors*, Birmingham Post UK, June 30, 2006, 2006 WLNR 113085817); 2005 score (*Exhaust Notes*, Winnipeg Free Press, Sept. 30, 2005, 2005 WLNR 15414064; and *Lexus Owners Love Their Cars: Power Study*, Globe & Mail, Sept. 29, 2005, 2005 WLNR 15327636); 2004 score (*Nissan Scores Well in Consumer Survey*, Clarion-Ledger (Jackson MS), Oct. 15, 2004., 2004 WLNR 23140691; and *Notebook*, Automotive News (Newsday), Nov. 4, 2004, 2004 WLNR 5166450); 2003 score (http://money.cnn.com/2003/10/07/pf/autos/jdpower_apeal/); 2001 score (*Standard Catalog of Buick 1903-2004* p.329, listing the industry average APEAL score for 2001), *available at* https://books.google.com/books?id=PO65ddhim6kC&pg=PA329&lpg=PA329&dq=%22Automotive+Performance,+Execution,+and+Layout%22+2001+average&source=bl&ots=rPwLoRViPJ&sig=8o2uv-GkvDjIGBlA41hjvP9C0w0&hl=en&sa=X&ved=0ahUKEwjN3MWXr73bAhVpjFQKHcdsC9wQ6AEIVjAH#v=onepage&q=%22Automotive%20Performance%2C%20Execution%2C%20and%20Layout%22%202001%20average&f=false.

[249] E-mail Correspondence between Jason A. Schwartz and J.D. Power staff (June 12, 2018).

Figure 1. Changes in Vehicle Attributes versus Changes in Consumer Satisfaction with Vehicles



Overall, consumer satisfaction with their recent vehicle purchases has been mostly flat since 1994, with some possible slight upticks in recent years. The huge increase in vehicle horsepower from 1994 through 2011—a relative increase of over 50%—does not appear to have had any obvious effect on consumer satisfaction. Vehicle weight and acceleration also rose from the late 1990s through about 2011, but have remained relatively flat since, and there again is no obvious relationship between their early rise and consumer satisfaction.

Meanwhile, horsepower has continued to grow, and to a lesser extent acceleration has continued to increase, even as fuel economy has shot up significantly over the last decade. This period of both significant growth in fuel economy and moderate increases in horsepower and acceleration, does appear to correlate with a slight uptick in consumer satisfaction in recent years.

Though further study would be required, from this graphical presentation of the data there appears no obvious reason to believe that a rise in fuel economy will cause a decrease in vehicle performance or consumer satisfaction—to the contrary, a rise in fuel economy at least appears correlated with similar upticks in horsepower and consumer satisfaction. Furthermore, this graphical presentation of the data shows large increases in vehicle performance attributes in the late 1990s and early 2000s that do not appear to be obviously correlated with any contemporaneous increases in consumer satisfaction. One reason why horsepower could increase by 50% without consumers becoming much happier about their vehicle purchases is because motor vehicles in general, and especially their performance attributes like horsepower,

acceleration, and size, are positional goods. The theory and evidence of vehicles as positional goods is explored further in the next section.

E. Vehicles' positional attributes create externalities and impede consumers from achieving efficient levels of fuel economy absent a cooperative regulatory solution

In the regulatory impact analysis, the agencies assert that because requiring manufacturers to focus on fuel economy will necessarily entail lost consumer welfare as the manufacturers sacrifice other improvements to horsepower, weight, and volume, consumers will be "substantially better off under the agencies' proposed action than if the baseline standards remained in force."[250] In fact, the exact opposite may be true: because horsepower, weight, and volume are all positional attributes, the consumption of increasing levels of those attributes may deliver little if any increased consumer welfare.

The value of a "positional good" depends on how it compares with similar goods possessed by others.[251] The owner of a positional good derives more welfare from that good than expected when considering only its functional qualities. The prominent explanation for this phenomenon is that highly visible consumption becomes a signal for status,[252] and people value status because they anticipate it will translate into more favorable treatment in economic and social interactions.[253] For example, jewelry, silk ties, and expensive champagne all have very little functional value, but their consumption is conspicuous and conveys status to others.

Other goods, like cars, have both functional and positional value. Consumers may partially value vehicle size and horsepower for their functional utility like hauling capacity and speed, but a growing body of research indicates that many consumers do not necessarily want the biggest and fastest vehicle, so long as their vehicle is bigger and faster than their friends' and neighbors' vehicles. According to a recent U.S. survey on the visibility of 31 expenditure categories (from food to mobile phones), new or used motor vehicle purchases were the second most visible

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[250] PRIA at 934, 943, 1097; *see also* 83 Fed. Reg. at 43,255 (predicting welfare losses relating to the performance of more efficient vehicles).

[251] Frank (1985), at 101.

[252] *Id.* at 107 ("When an individual's ability level cannot be observed directly, such observable components of his consumption bundle constitute a signal to others about his total income level, and on average, therefore, about his level of ability. . . . [I]mperfect information about ability might create incentives for people to rearrange consumption patterns to favor observable goods."). Consumption patterns might vary depending on the relevant population in the status competition. People might compete among friends, neighbors, and coworkers; within their socio-economic class; with higher classes; or on a society-wide basis. *See* Carlsson et al. (2007), at 590. If a particular population has more reliable, independent information on abilities or income, consumption patterns for observable goods might shift. Frank (1985), at 108.

[253] Weiss & Fershtman (1998), at 802. Status can be instrumental, in that higher status can carry better consumption opportunities, access to better employment, and even better marriage prospects. Hopkins & Kornienko (2004), 1087. Factors like psychology, biological hardwiring, and envy also should not be ignored.

expenditure; related expenditures on gasoline/diesel, vehicle maintenance, and insurance were all substantially less visible.[254] Surveys also consistently confirm that cars are highly positional goods, that people prefer a relative increase in a car's value to an absolute increase,[255] and that the more visible features of cars are more positional.[256] Financial savings, in contrast, are typically considered non-positional.[257]

The more observable prestige features of vehicles include newness, brand, size, design, and power. While many of these traits have functional value (such as capacity, safety, and performance),[258] they also all have relative value: consumers value power not just for speed but for the status signal and for the ability to out-accelerate others at a traffic light; consumers do not necessarily want a *big* car, but they do want a *bigger* car.[259] As Bob Lutz, the former Vice Chairman of General Motors, has stated, "aspirational aspects overwhelm the functional differences" when customers choose cars.[260] Similarly, as J.D. Power has reported, "[w]e strive to own vehicles of which our neighbors will approve."[261] Meanwhile, given the low visibility of

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[254] Heffetz (2011), at 1106 (vehicle purchase had a visibility index of 0.73, second only to tobacco products (0.76); gasoline/diesel had a visibility index of 0.39, car repairs were at 0.42, and car insurance fell near the bottom at 0.23).

[255] Specifically, a majority of people surveyed would trade a decrease in their car's absolute value for an increase in its relative value compared to other people's cars: in other words, they are happy to have their car lose value so long as everyone else loses more value on average. *See, e.g.,* Carlsson et al. (2007), at 588, 593 (reporting results of a Swedish survey); Alpizar et al. (2005), at 412 (reporting results of Costa Rican survey). Though some such surveys were conducted in other countries, if anything positionality for cars could be stronger in the United States, given the American affinity for cars and the income distribution. *See* Heffner et al. (2005), at 2 ("In the words of automobile psychologist G. Clotaire Rapaille, Americans are in 'a permanent search of an identity' and 'cars are very key . . . [they are] maybe the best way for Americans to express themselves.'"); Hopkins & Kornienko (2004) (noting that positional effects increase as society's income increases, because the portion of income spent on conspicuous consumption increases). On the other hand, cars may be more a necessity and less a luxury for some U.S. consumers compared to some consumers in other countries. *See* Grinblatt et al. (2004).

[256] Carlsson et al. (2007), at 588, 593 (finding support for hypothesis that "visible goods and their characteristics, such as the value of cars, are more positional than less visible goods and their characteristics, such as car safety.").

[257] *See, e.g.*, Moav & Neeman (2009).

[258] Carlsson et al. (2007), at 595, could not provide a clear answer to the question of whether cars are completely positional. On average cars are highly positional, but that reflects a good deal of heterogeneity: cars may be completely positional for some people, but are possibly completely non-positional for others. *Id.* at 596.

[259] Verhoef & van Wee (2000), at 4 ("However, most cars in most Western countries have engines with much more power than needed, given the characteristics of infrastructure, speed limits, and travel distances."). *See also* Hoen & Geurs (2011).

[260] George Will, *Americans and Their Cars*, TOWNHALL DAILY, Apr. 18, 2002, *available at* http://townhall.com/columnists/GeorgeWill/2002/04/18/americans_and_their_cars.

[261] Jeff Youngs, J.D. Power, *2007 APEAL Study Results*, Dec. 32, 2006, https://web.archive.org/web/20160514230140/http://www.jdpower.com/cars/articles/jd-power-studies/2007-apeal-study-results

gasoline expenditures and of financial savings, fuel efficiency itself is currently a relatively non-positional good.[262]

A vehicle's size and weight are also positional for safety reasons, in addition to status motivations. To the extent smaller cars may at times fare worse in crashes with bigger cars, consumers may value bigger cars not because of any intrinsic safety value, but because of the average fleet size.

The trouble with positional goods is they impose externalities. This is obvious in the safety context: if Joan upgrades from her compact car to a large pick-up truck, she may feel somewhat safer, but her purchase marginally increases the perceived risk to all other drivers. It also applies in the status context. Again, if Joan buys a big, fast, flashy vehicle to move up the status hierarchy, John's big, fast, flashy car is no longer as rare. John feels relatively worse off and so will have to invest in an even bigger, faster, flashier car just to restore his previous status position. Joan's purchase made John feel worse off (a positional externality), and then John's subsequent purchase made Joan feel worse off (another positional externality), and at the end they wind up with the same relative status that they started with. As a result, both consumers spend resources without actually improving their relative status.

Because vehicle purchase decisions are made non-cooperatively but in fact alter the spending behavior and perceived safety of others, consumers get stuck on a "positional treadmill" that does not increase welfare.[263] Yet if any individual unilaterally tries to opt out of this "expenditure arms race," it would only move that consumer backwards on the status or safety hierarchy, which for most consumers is unacceptable.[264] And given limited resources and limited market options, the over-consumption of positional goods results in under-consumption of non-positional goods (such as fuel efficiency). If consumers could maintain their relative economic position, they might be more willing to pay for non-positional goods.[265]

Fuel economy regulation, therefore, is a cooperative solution that allows consumers to achieve what they could not in the non-cooperative open market: namely, an increase in fuel economy

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[262] *See* Hoen & Geurs (2011).

[263] Frank (2005), at 137.

[264] Frank (2005), at 105-06.

[265] Frank & Sunstein (2001), at 326 ("If people could maintain their relative economic position, they would be willing to pay more, and possibly a great deal more, to purchase many of the goods that regulation attempts to deliver. . . .[W]hen an individual buys additional safety in isolation, he experiences not only an absolute decline in the amounts of other goods and services he can buy, but also a decline in his relative living standards. In contrast, when a regulation requires all workers to purchase additional safety, each worker gives up the same amount of other goods, so no worker experiences a decline in relative living standards. If relative living standards matter, then an individual will value an across-the-board increase in safety more highly than an increase in safety that he alone purchases.").

without losing position in the status hierarchy.[266] Regulations similarly help consumers select fuel economy without falling behind in the safety/size perceived rankings, since with time the average size of vehicles in the fleet will shift. Regulations will also help correct a supply-side problem, since theory predicts that manufacturers will devote their research and development budget to status goods,[267] thus causing an oversupply of positional attributes at the expense of fuel economy.

Positional goods theory explains that: the agencies are incorrect that if manufacturers could redirect their research and development budgets from fuel economy to performance attributes that consumers would inherently become "substantially better off under"; the agencies are incorrect that consumers are able to demand in the market their desired levels of fuel economy; and the agencies are overlooking an important benefit of the regulation, which is correcting the market failures caused by positional externalities.

The Agencies' Proposed Alternative Approaches to Consumer Valuation Ignore Positionality and Other Explanations for the Energy Efficiency Paradox: The agencies suggest two alternative approaches to consumer valuation for the future. They propose either that in the future the agencies should assume that consumers fully (or near fully) value fuel savings in both the baseline scenario and under efficiency standards, or else assume that consumers partly value fuel savings to the same degree in both the baseline scenario and under efficiency standards.[268] The upshot of both alternatives would be similar: the private fuel saving benefits generated by increased efficiency standards would be devalued, and the assumed valuations under the baseline would partly or fully cancel out the private fuel saving benefits under the standards. Either approach would likely send agencies in search of alleged welfare losses attributed to increased fuel efficiency to explain why, if consumers fully value fuel savings, they do not already demand them in the marketplace.

Both of these proposed alternative approaches would be a mistake. There is no evidence that there are substantial private welfare losses associated with increasing fuel economy.[269] To the contrary, the graph presented above depicts neither a loss of consumer satisfaction associated

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[266] Correcting for negative externalities and collective action problems is a classic case for regulation. "Analytically, positional externalities are no different from ordinary environmental pollutants." *Id.* at 364. Such regulation is not about taking public action just because one consumer's increased consumption makes another consumer unhappy or envious; rather, regulation is justified to address a market failure. *Id.* at 365. Even if not everyone wants to solve this particular collective action problem, "we do not require unanimity as a precondition for unquestionably legitimate collective action in other spheres." *Id.* at 366. *See also* Verhoef & van Wee (2000), at 13-14. ("On the free market, consumers would inefficiently strongly stimulate each other to purchase more luxurious variants. Corrective taxes [or a CAFE standard with tradable permits] may protect consumers against such treadmills.").

[267] Cooper et al. (2001).

[268] 83 Fed. Reg. at 43,074.

[269] *See, e.g.*, Huang et al. (2018), at 194 (finding that "automakers have typically been able to implement fuel-saving technologies without harm to vehicle operational characteristics" like "acceleration, handling, ride comfort, noise, braking feel, and vibration").

with increasing fuel economy, nor a gain in consumer satisfaction associated with increasing performance attributes. Moreover, there are several other explanations supported by theory and literature that explain why consumers would fully value private fuel savings achieved under an efficiency standard and yet are unable to demand that the market increase fuel economy under the baseline in the absence of regulatory interventions. Positional goods theory is one important explanation that the agencies have failed to consider, together with explanations about information processing, myopia and internalities, supply-side market failures, and other evidence considered by the agencies in past rulemakings that the agencies now inexplicably ignore. The agencies should continue to value forgone private savings from fuel economy as they have in Tables II-25 to II-28 (once those calculations are corrected for mistakes from the scrappage, rebound, and sales modules).

F. Problems with the agencies' valuation of the refueling surplus

Multiple problems with the agencies' calculation of refueling surplus (the time savings and other benefits from having to refuel less) result in a significant underestimation of the proposed rollback's forgone benefits and show that the agencies have arbitrarily failed to consider important aspects of the issue and have ignored important evidence.

Rebound: First, because the agencies have miscalculated the rebound effect (as described in Section VI), they are overestimating the number of refueling trips that the purchasers of new, more-efficient vehicles would make, and so are underestimating the forgone benefits from the lost refueling surplus.

Outdated Data: Second, the valuation of lost refueling surplus is based on outdated data. Though the agencies' link to the *Value of Travel Time Savings Memo* appearing in footnote 258 of the proposed rollback is a broken link,[270] it seems very likely that the agencies are using an outdated version of NHTSA's own *Value of Travel Time Savings Memo*. The current version was updated last in 2016.[271] The version of the memorandum included in the regulatory docket is the 2011 version.[272] Meanwhile, the values that the proposed rollback uses for the percentages of personal and business travel in urban areas (94.4% versus 5.6%) and in intercity travel (87% versus 13%) match neither the 2016 nor the 2011 versions (both of which list instead, for example, 78.6%

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[270] 83 Fed. Reg. at 43,085 n.258.

[271] Dept. of Transp., *The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations* (2016), https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20Travel%20Time%20Guidance.pdf.

[272] https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0679.

personal travel in intercity); instead, these numbers seem to come from the 2003 version of the memorandum.[273]

Not only are the percentages of personal versus business travel outdated in a way that leads to underestimating the total hourly valuation for intercity travel, but the base wage rate is outdated as well. The agencies inexplicably start with Bureau of Labor Statistics data for "total hourly employer compensation costs *for 2010*," and present the data in uninflated 2010$.[274] Using the same data source and same methodology but updating to current, year 2017 wages would increase the base wage in the agencies' calculations from $29.68 to $35.52.[275] The urban versus rural percentages of the total miles driven figures should also be updated from the 2011 data used in the proposed rollback,[276] to the current FHWA data available for year 2017.[277]

Using these data updates but otherwise keeping the rest of the methodology the same,[278] the total weighted value of travel time per hour used in this regulatory analysis should be at least $21.41, not $17.73. The agencies may have underestimated the value of travel time by 20% just through use of old data.[279]

Excluding Children: The next step in the methodology is to multiply that per individual per hour value of travel time by the average vehicle occupancy during refueling trips. Here, the proposed rollback uses figures of 1.21 people per trip in passenger cars, and 1.23 people per trip in light trucks.[280] The proposed rule cites to the 2011 Tire Pressure Monitoring System study as the

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[273] *See* NHTSA 2012 FRIA at 874 (table viii-6, showing identical numbers as the current proposed rollback's table ii-39); *id.* at 873 n.448 (citing the 1997 and 2003 guidelines).

[274] 83 Fed. Reg. at 43.085 & n.259. At 83 Fed. Reg. 43,088, the proposed rollback does discuss "updating time values to current dollars," but that line follows a reference to having "updated the final rule to reflect peer reviewer suggestions," and includes a citation to a 2012 regulatory docket. It seems likely that this text was cut and pasted from a previous rulemaking (as was much of the analysis and discussions in this section), making it impossible for the reader to tell from the *Federal Register* notice or from the regulatory impact analysis whether the 2010$ figures that appear so prominently in the tables in this section were in fact inflated to current dollars for purposes of tallying forgone benefits.

[275] *See* BLS, *Employer Costs for Employee Compensation Historical Listing*, tbl 1. (data for 2017), https://www.bls.gov/web/ecec/ececqrtn.pdf.

[276] 83 Fed. Reg. at 43,087 n.261.

[277] *Available at* https://www.fhwa.dot.gov/policyinformation/travel_monitoring/17dectvt/17dectvt.pdf. This update would slightly change the weights to about 70% urban, 30% rural, which would slightly decrease the value of time calculation compared to the weights used in the proposed rollback (67.1% urban and 32.9% rural), but would be more up-to-date.

[278] These comments do not necessarily endorse the rest of the methodology. For example, there are questions about discounting personal travel time saved versus business travel time saved.

[279] If the agencies did inflate from 2010$ to more current dollars, the underestimation would still likely exist, though it may not be quite as large.

[280] 83 Fed. Reg. at 43,087.

source of these figures, but the source is unclear because the only document on the Tire Pressure Monitoring System provided in the regulatory docket is the

User's Coding Manual.[281] The agencies' failure to make available the full data and methodology used to calculate these average occupancy figures frustrates any meaningful public review. Nevertheless, the agencies do disclose that their estimated occupancy figures specifically exclude children under 16 years of age,[282] because "it is assumed that the opportunity cost of children's time is zero."[283]

This is the third major problem with the refueling valuation: the exclusion of children's value of time. The choice not to count children violates both NHTSA's own guidelines and best practices for cost-benefit analysis. In the 2016 *Value of Travel Time Savings* memorandum, NHTSA considers whether the value of travel time is different for parents versus children, but ultimately concludes that "it must be assumed that all travelers' VTTS are independent and additive," and later expands that "Although riders may be a family with a joint VTTS or passengers in a car pool or transit vehicle with independent values, these circumstances can seldom be distinguished. Therefore, all individuals are assumed to have independent values. Except for specific distinctions [such as personal versus business travel], we consider it inappropriate to use different income levels or sources for different categories of traveler."[284]

Turning to other cost-benefit guidelines, OMB's *Circular A-4* instructs agencies to estimate "gains or losses of time in work, leisure and/or commuting/travel settings," but nowhere distinguishes between children's and adult's valuations, except to note that, for health effects, "the monetary values for children should be at least as large as the values for adults . . . unless there is specific and compelling evidence to suggest otherwise."[285] Writing on the concept of "standing in cost-benefit analysis," Dale Whittington and Duncan MacRae conclude that "there is a clear consensus that children should be counted" in cost-benefit analysis.[286] The agencies fail to provide any compelling argument why they should break from this clear consensus and treat all children's time as worthless.

In 1965, when Congress first directed the control of motor vehicle air pollution to protect "the health or welfare of *any person*" after taking into "appropriate consideration . . . economic

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[281] https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0681.

[282] 83 Fed. Reg. at 43,087 n.262.

[283] *Id.* at 43,086.

[284] 2016 VTTS Memo, at 5, 12.

[285] OMB Circular A-4 at 31, 37.

[286] Whittington & MacRae. (1986), at 666.

costs,"[287] Congress clearly had in mind not just the welfare and costs of adults, but of "any person." And when Congress mandated the "maximum feasible average fuel economy" after considering "economic practicability . . . and the need of the United States to conserve energy,"[288] it spoke not just of the needs of adults, but of the entire U.S. population. By excluding all children under the age of sixteen, the agencies arbitrarily undercount the proposed rollback's forgone refueling benefits.

Erasing 40%: A fourth major problem with the agencies' refueling valuation is the decision to erase 40% of the total value due to the assumption (drawn from the Tire Pressure Monitoring System study) that "40% of refueling trips are for reasons other than a low reading on the gas gauge" and that "owners who refuel on a fixed schedule will continue to do so."[289] But if vehicles become more efficient such that the gasoline tank is less empty after driving a given number of miles, either drivers will make fewer refueling trips or, minimally, those who continue to refuel on a fixed schedule will spend less time at the pump on each refueling trip, because their gasoline tanks will not have been as depleted over a given period of time. The agencies' own calculations indicate that time spent filling and paying at the pump makes up nearly two-thirds of the total time spent on average refueling trips for both cars and trucks.[290] Even for drivers who continue to refuel on a fixed schedule, they will save time at the pump, because their tanks will be less empty at the start of refueling. The agencies cannot completely discount those time savings.

Additionally, not every refueling trip that is "for reasons other than a low reading on the gas gauge" is automatically an example of someone who "refuel[s] on a fixed schedule." The *User's Coding Manual* for the Tire Pressure Monitoring System study included multiple possible responses for the primary reason for the stop besides either low gas tank or a routine schedule, including refueling trips motivated because it was "convenient at this time," "to get/do something else (e.g., food, rest stop)," to take advantage of "price," to "top off for specific reason (e.g., before long trip)," or for some "other" reason.[291] The refueling portions of stops based on all these reasons may become shorter or may not occur at all if vehicles become more efficient and need less frequent refueling. The agencies cannot throw out the refueling time savings associated with all these other reasons for typical refueling stops.

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[287] Pub. L. 89-272, 79 Stat. 992 (Oct. 20, 1965) (emphasis added); *compare* 42 U.S.C. § 7521(a) (controlling pollution that "endanger[s] public health or welfare," after giving "appropriate consideration to the cost of compliance").

[288] 49 U.S.C. § 32902(f).

[289] 83 Fed. Reg. at 43,088.

[290] *Id.* at 43,087, tbl. II-41.

[291] NHTSA (2017) at 236.

Moreover, the relevance of the agencies' data is questionable. The *User's Coding Manual* for the Tire Pressure Monitoring System study on which the agencies so heavily rely suggest that data was collecting on "vehicles entering the gas station to refuel during five 15-minute data collection time periods (08:00 – 08:15 a.m., 1000 – 10:15 a.m., 12:00 – 12:15 p.m., 2:00 – 2:15 p.m., and 4:00 – 4:15 p.m.). These time periods were to last the full 15 minutes, unless a weather-related reason or cooperation issues resulted in the need to prematurely suspend data collection at that site."[292] The study seems not to have captured those who refuel outside the hours of 8am-4pm, nor to have captured refueling behavior during inclement weather. There is no reason to believe based on the study that drivers who refuel outside of those specific conditions would continue to operate on a rigidly fixed refueling schedule regardless of how full the tank of their more fuel-efficient vehicles may be.

Altogether, the agencies have thrown out 40% of the refueling time savings benefits without a reasonable justification for ignoring those potential benefits—on top of the underestimations of time savings due to the rebound miscalculation, the use of outdated data, and the complete exclusion of all children under the age of 16.

Fuel Cost and Emission Savings*:* Finally, the agencies also may be excluding the cost savings and emissions savings from not having to combust fuel to drive to refueling stations as often. The agencies acknowledge that while these savings "may seem like a small amount" per individual and per year, they are "much more significant at the macro level."[293] Yet even though the agencies explained how "direct estimation . . . of this benefit" would be possible, instead the agencies insisted that "this benefit is implicitly captured in the separate measure of overall valuation of fuel savings."[294] The agencies do not clearly explain how these additional cost savings and emissions reductions are actually accounted for in their methodology, and given all the myriad problems with the agencies' calculations of vehicle miles travel (as detailed throughout these comments), it is quite possible that these additional refueling benefits are, in fact, not "implicitly accounted for elsewhere" in either the fuel savings or emissions reductions calculations. If not, then that is an additional undercounting of the forgone refueling benefits of the proposed rollback.

The agencies also ignore the health and welfare consequences of the emissions associated with refueling and refueling stations.[295] Residential proximity to gasoline stations, for example, may have "a significant association" with childhood leukemia, due to benzene emissions from

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[292] NHTSA (2017) at 31. *See also id.* at 210 (suggesting that no interviews with refueling drivers were conducted after 6pm).

[293] 83 Fed. Reg. at 43,088.

[294] *Id.* at 43,088 (also insisting that emissions benefits are also "implicitly accounted for elsewhere").

[295] *Compare* 83 Fed. Reg. at 43,344 (where the agencies consider the "exposure and health effects associated with traffic," but not those associated with refueling).

gasoline.[296] Regular exposure to refueling stations, from employment or otherwise, may also have genotoxic and other serious health effects.[297] It is not clear that the agencies' consideration of upstream emissions from the fuel distribution system fully capture the health effects from exposure during refueling and from proximity to or working at refueling stations. If not, then the agencies have ignored yet another important aspect of the regulatory issue before them.

G. Distributional impacts

The agencies assert that the alleged reduction in vehicle purchase price will particularly "make the difference" for "some low-income purchasers."[298] First, the agencies' assumptions about the likely change in purchase price are problematic. Not only have the agencies overestimated the average change in purchase price because of multiple mistakes in their analysis—for example, as discussed in these comments, the agencies' failure to accurately model how manufacturers will efficiently use all available compliance flexibilities, including penalties—but the agencies ignore evidence specifically on the price of lower-cost vehicles.[299] For example, a study by Synapse Energy Economics shows that over the last ten years, the price of lower-cost vehicles has remained constant even as fuel economy has risen with the standards.[300] The study shows that while the range of prices of new vehicles has increased, those increases occurred because the price of high-end vehicles went up as more features were added; the price of more affordable vehicles, on the other hand, has not changed.[301] Similar findings were also reported in EPA's own analysis leading up to the 2017 Final Determination. In that analysis, EPA found that car sales recovered to pre-recession sales levels by 2015 under increasing fuel-efficiency standards and have continued to rise since then.[302] Ultimately, EPA found in the 2017 Final Determination that "prices in recent years, adjusted for quality and inflation, have been flat, not increasing."[303]

Second, the agencies have failed to consider the other side of the coin for impacts to low-income consumers: the loss of fuel savings. Low-income consumers spend a relatively larger fraction of

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[296] Infante (2017); Steinmaus & Smith (2017).

[297] *E.g.*, Rekhadevi (2010).

[298] 83 Fed. Reg. at 43,223.

[299] *See* Section II.

[300] Tyler Comings & Avi Allison, Synapse Energy Economics Inc., *More Mileage for Your Money: Fuel Economy Increases While Vehicle Prices Remain Stable* 5 (2017), https://consumersunion.org/wp-content/uploads/2017/03/Synapse-CU-Affordability-Report-3-15-corrected-1.pdf.

[301] *Id.*

[302] Draft TAR at 6-2 (2016).

[303] EPA, Final Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation—Response to Comments 136 (2017) [hereafter "Final Determination RTC"].

their income on fuel than on the up-front price of their vehicles compared to high-income households. As a result, fuel-efficiency increases are more beneficial to low-income consumers than they are to high-income consumers.[304] In other words, the proposed rollback will not *help* low-income consumers as the agencies claim. Instead, reducing the standards will likely harm these consumers the most. As Greene & Welch note, "[The 2022-2025] fuel economy improvements will benefit all income groups and . . . the impacts will be progressive. The highest income quintile is projected to average a savings of 0.5% of their income annually, increasing uniformly to 2.2% of income saved annually for the lowest income quintile."[305] The evidence on the impact of the existing standards on low-income consumers does not support the proposed rollback.

IV. GENERAL PROBLEMS WITH THE AGENCIES' DATA ANALYSIS

The agencies' proposed conclusions regarding sales, fleet size, and VMT are fatally flawed because the agencies made grave mistakes in their econometric analysis, leading to results that should not be used to inform policymaking. These mistakes include:

- **Failing to account for endogeneity** – endogeneity occurs when findings about an explanatory variable—for example, about the impact of new vehicle price on sales—cannot be given a causal interpretation for one of the following reasons:[306]
    - **Omitted variable bias** – omitted variable bias occurs when the agencies fail to control for important variables that have an influence on a feature (like scrappage) but are correlated with one of the variables used to calculate that feature (like new vehicle prices); when this error is present a regression can show incorrect predictions about the relationship between the variables;[307]
    - **Simultaneity** – simultaneity arises when one or more of the explanatory variables is jointly determined with the dependent variable;[308] of particular concern is reverse causation where the variable of interest (like car sales) affects the explanatory variable (like new car price);
- **Unreliable data** – unreliable data limit the extent to which the agencies can learn about the historical relationships and thus predict future circumstances;
- **Overfitting** – overfitting occurs when an analyst includes individual variables and interactions of variables merely to improve the extent to which the model predicts past behavior, instead of basing the specific formulation of the model on a strong theoretical foundation.

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[304] Draft TAR at 6-2.

[305] Greene & Welch (2017), at 13.

[306] Cameron (2005), at 92.

[307] Wooldridge (2009), at 89-90 (for background on the bias introduced by omitted variables).

[308] *Id.* at 546.

All of these problems permeate the agencies' analysis. To evaluate the effects of a policy change, the agencies must understand the true relationships underlying the various elements they investigate. Once those relationships are uncovered and quantified, inferences can be drawn to inform new policies. Those inferences need to be based on causal relationships and not just correlations. Correlations can only show that two elements tend to move together, but when two elements move together that does not necessarily mean that the change in one variable is the cause of the change in the values of the other variable.

For instance, a researcher could look at income data and asthma data and conclude that there is a relationship between low income and high asthma incidence. However, this is not a causal relationship but rather a correlation. It is not the low income in itself that causes asthma but rather environmental factors that tend to be associated with income. For instance, lower income households tend to live closer to highways and freeways as the car noise and pollution make the housing there more affordable. At the same time, major road proximity has been found to elevate risk of asthma.[309] Consider a policy that subsidizes sports facilities in wooded areas for people with low income. Based on historical data, a researcher could infer that there is a relatively low value in building such facilities, given that the low-income population tends to suffer heavily from asthma and thus will spend little time using the facility. But such a conclusion would overlook the fact that with the low-income population spending considerably more time in areas with clean air, the prevalence of asthma in that group could drop. A new sports facility could break the correlational link between the income and asthma, thus demonstrating that any conclusions that had been based on the historical correlations were wrong.

The need to uncover the causal, structural relationships between elements of interest for policymaking was pointed out for the first time by Robert E. Lucas in his seminal article, describing what has been knowns as the "Lucas critique."[310] In the article, Lucas argued that it is a mistaken approach to try to predict the effects of a change in economic policy solely on the basis of relationships observed in historical data, especially highly aggregated historical data. Lucas argued that "[g]iven that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models." In other words, a policy change might affect or even completely break the correlated relationships. Lucas also adds that reliance on correlations for setting policy is invalid because any attempt to compare different alternatives would be meaningless without any knowledge of the actual causal relationships.[311]

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[309] For discussions about road proximity and asthma incidence, *see* Li, et al. (2011), at 34.

[310] Lucas (1976), at 19–46. The article has been quoted in over 1,000 economic papers (according to the scientific database scienwebofknowledge.com) and multiple textbooks. It has also spurred the shift macroeconomics towards using micro-foundations. *See* Sargent (1987), at 397–98.

[311] Lucas (1976), at 41.

Given that the agencies have set out to predict how the baseline standards and alternatives affect elements such as new car sales, scrappage rates, miles driven, and fatalities in the Proposed Rule, the agencies should examine and uncover the causal relationships between those elements based on good data and economic modeling. But rather than follow the economic literature and principles of good econometric analysis, the agencies have focused only on a series of correlations not causal relationships. Endogeneity problems that manifested themselves as omitted variable bias and simultaneity bias are rampant in the agencies' analysis.

Throughout the agencies' analysis, they ignore signs of these problems. For example, the agencies exclude several critical variables from the scrappage analysis based on incorrect coefficient signs and/or statistical significance, despite the importance of those variables to theory and past analyses[312]; the value of a vehicle as scrap metal or as parts due to statistical insignificance; and the interest rate due to unexpected sign and worsening overall fit of the regressions.[313] Other times, the agencies merely try to explain away the problem without addressing the counterintuitive results, like in the case of the incorrect sign on fuel efficiency for new SUVs and vans in the scrappage model.[314] Instead of ignoring these problems, the agencies should consider the inconsistent results as evidence of serious econometric problems and attempt to address the underlying issues.

V. THE AGENCIES' ANALYSIS OF HOW FUEL ECONOMY AND EMISSION STANDARDS CHANGE FLEET COMPOSITION, VEHICLE TRAVEL, AND SAFETY IS FUNDAMENTALLY FLAWED

The agencies assert that higher new vehicle prices[315] under the baseline standards will cause consumers to reduce their purchases of new vehicles, and retain or buy used vehicles.[316] The agencies analyze these changes using newly developed models of the new vehicle and used vehicle fleets and find huge increases in the total fleet size and vehicle miles traveled (VMT). The agencies then find that the baseline standards will cause a number of negative effects including, most importantly, increased fatalities.[317] Specifically, the agencies claim that the change in composition of the vehicle fleet will result in 6,180 to 7,880 additional fatalities for

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[312] PRIA at 1012, 1030, 1032.

[313] *Id.* at 1030.

[314] *Id.* at 1024.

[315] Whenever we refer to an "increase in new vehicle price" or "higher new vehicle price," this refers to a shift from the Proposed Rule to the baseline standards.

[316] The agencies refer to this effect as slower "turnover." 83 Fed. Reg. at 42,993. The two models, when combined, can be used to analyze the change in the distribution of vehicles by model year caused by a change in fuel economy and emission standards. However, because the models are disconnected, it is impossible to determine which new vehicles replace which used vehicles. It is therefore impossible to estimate the actual change in turnover of vehicles due to the baseline standards using the models the agencies have developed.

[317] 83 Fed. Reg. at 42,993.

model years 1977 to 2029, "as operated throughout those vehicles useful lives," or approximately 50 percent of the total fatalities attributed to the baseline standards.[318]

The agencies' assertion that the baseline standards will cause vehicle prices to go up in such a way that consumers alter their purchasing decisions is flawed. We address that issue in Section II. But even if the agencies are correct that the baseline standards will cause new vehicle prices to increase, their analysis of the implications of those price increases—and, in particular, their estimates of additional fatalities associated with those increases—is fundamentally flawed for two critical reasons.

First, the agencies' estimates and modeling of the impact of price increases on total fleet size and vehicle miles traveled (VMT) violate economic theory. Correcting the agencies' errors in this area will significantly reduce (or even reverse) the purported effect of the baseline standards on safety.

Second, even if the agencies are right that increased new vehicle prices lead to an increase in the number and proportion of older vehicles in the market, the safety impact of those vehicles is overstated. The data supporting the agencies' conclusions are improperly inflated in ways that contradict the agencies' prior analyses and the available evidence.

A. The agencies' assumption that fleet size and VMT will increase under the baseline standards is arbitrary and capricious

The result of the agencies' analysis of the baseline greenhouse gas standards and fuel economy standards—and the effect of rolling back those standards—is strongly dependent on new modeling that attempts to estimate how changes in new vehicle prices and fuel economy affect the number of vehicles by model year and body style (car, SUV, pickup) (the "composition" of the fleet). The agencies use separate models to estimate the composition of the vehicle fleet: (1) a "dynamic sales model," which estimates the change in new vehicle sales for different levels of fuel efficiency and greenhouse gas emission standards;[319] and (2) a "dynamic scrappage model," which estimates the change in the composition of the used vehicle fleet for different levels of fuel efficiency and greenhouse gas emission standards.

The dynamic *sales* model is based on the theory that increasing fuel efficiency will increase new vehicle prices and reduce consumer demand for new vehicles.[320] The dynamic *scrappage* model

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[318] *Id.* at 43,152-53 (estimating total fatalities attributed to the baseline CAFE standards, which includes a combination of the effects from the sales model, scrappage model, and dynamic fleet share model); *id.* at 43,157 (estimating the same for a rollback of the GHG emission standards); id. at 43,254 (explaining that the fatality impacts are calculated for "model years through 2029 as operated throughout those vehicles' useful lives").

[319] This is supplemented by a "dynamic fleet share model," which estimates the change in the distribution of new vehicle sales between cars, SUVs, and trucks.

[320] *Id.* at 43,075.

is based on a theory that increases in the cost of buying new vehicles will reduce demand for new vehicles and increase demand for relatively new used vehicles. The increase in demand for used vehicles causes an increase in the price of relatively new used vehicles and, therefore, longer retention of older used vehicles.[321] This effect cascades throughout the used vehicle fleet, eventually resulting in an increase in the price of very old vehicles that might otherwise have been sold for parts and raw materials ("scrapped").[322] The increase in the value of these cars can reduce the rate at which they are scrapped rather than held or resold.[323]

But while those theories may be relatively uncontroversial, the agencies then make a totally unsupported leap to assert that "[b]ecause higher used vehicle prices will lower the number of vehicles whose cost of maintenance is higher than their value, *it is expected that* . . . some vehicles that would have been scrapped without replacement under lower new vehicle prices will now remain on the road because their value will have increased," referred to as "non-replacement scrappage" by the agencies.[324] According to the agencies, that non-replacement scrappage leads to a significant increase in the number of total vehicles on the road, which is attributable to the baseline standards.[325]

The agencies' analysis then assumes that vehicles at each age, including those that, but-for the baseline standards would have been scrapped, are driven the number of miles established in a set of VMT schedules. That is, the agencies assume that existing VMT schedules should be applied to those additional vehicles and thus uses those schedules to calculate the number of fatalities that are attributable to scrappage.[326] Because those schedules assume each vehicle of a certain age and type in the fleet drives a set amount of miles without any adjustment for the increase in total fleet size or vehicle quality (i.e., wear and tear and durability), the finding that the standards cause the fleet size to increase results in a significant increase in total VMT. This increase in VMT in turn drives fatalities.[327]

There are two severe flaws in this analysis, which render the rule arbitrary and capricious and which we discuss in turn below:

- First, the agencies have provided no explanation to support the assumption that higher prices (even if they were real), would lead to non-replacement scrappage and an increase

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[321] The agencies' analysis uses a combination of the increased price of new vehicles and the decrease in cost per mile (CPM) of operating new vehicles as proxies for how the standards will increase the prices of used vehicles. PRIA at 1004.

[322] 83 Fed. Reg. at 43,092.

[323] *See* PRIA at 998.

[324] *Id.* at 1004; 83 Fed. Reg. at 43,095.

[325] PRIA at 1004, 1058.

[326] 83 Fed. Reg. at 43,099.

[327] *Id.* at 43,188; PRIA at 998.

in the total fleet size. Indeed, the academic literature and standard economic theory demonstrate that the assumption is unreasonable.

- Second, even if there were additional vehicles on the road, the agencies have not provided a reasonable explanation to support the assumption that total vehicle miles traveled should increase. Again, the academic literature and standard economic theory demonstrate that the assumption is unreasonable.

Any sales and scrappage modeling should take this established economic research into account. In addition, as we also explain in detail below, the agencies' analysis is riddled with serious econometric errors. Should the agencies still seek to estimate scrappage effects, we summarize our advice on a "path forward" below. Ignoring the fundamental principles that we outline here would be arbitrary and capricious.

1. The agencies' assumption that an increase in vehicle price will substantially increase the size of the used vehicle fleet is fundamentally flawed

The agencies use a reduced form scrappage model to estimate scrappage rates.

The model ignores the simultaneous interactions and the impact that the variables in the model have on each other and fails to take basic economic theory into account.

The model produces a substantial increase in the size of the used vehicle fleet. The increase is so large that it substantially exceeds the decrease in aggregate new vehicle sales that is predicted by the dynamic sales model. The results of these two models lead to a large increase in total aggregate fleet size attributable to the baseline standards. These conclusions are flawed for a number of reasons discussed at length below:

- They are inconsistent with basic economic theory;
- They are inconsistent with the academic literature, including the work of Howard Gruenspecht, the economist whom the agencies rely on for their theory; and,
- They produce results that are inconsistent with even the agencies' explanation of the relationship between fuel economy and scrappage.

a.) *Standard economic theory supports an assumption that fleet size will either stay the same or decrease with an increase in vehicle prices*

i.) Fleet size will either stay the same or decrease with an increase in vehicle prices

Economic theory supports the possibility that new vehicle price increases may change the distribution of new and used vehicles and, ultimately, could slow scrappage of used vehicles that would have been replaced by other vehicles. If the price of new vehicles increases with more stringent standards, some portion of households that would have purchased a new vehicle may instead keep their current vehicle or purchase a used vehicle. This shift out of the aggregate demand curve for used vehicles may ultimately increase the number of *used* vehicles on the road.

But economic theory provides no support for the idea that a shift to used vehicles will cause an increase in the total number of vehicles on the road.[328]

First, price changes cause only relatively modest changes in scrappage rates in the first place because prices are not the most important factor in scrappage decisions. Most scrappage is due to age-related factors that are unrelated to increases in price.[329] As a result, the elasticity of scrappage with respect to used vehicle price is low (between -0.4 to -0.7),[330] meaning that the shift to used vehicles for a given price increase is low.[331] As such, even if there is a shift to used vehicles, the effect of price on scrappage should be small, and certainly not so large that it overwhelms the reduction in new vehicle sales.

Second, when price increases on both used and new vehicles, the value of the services provided by those vehicles does not change. As a result, in equilibrium, when price increases and the value of the services is unchanged, the amount of the good purchased decreases. In other words, a potentially scrapped vehicle is diverted from the scrap heap only if there is used vehicle demand that the owner can meet by choosing to sell rather than scrap. But the additional used vehicle demand is directly related to a reduction in new vehicle demand. There is no reason to believe that it will increase the number of *total* vehicles on the road. Any shift towards used vehicles is connected to the decrease in new vehicles. New and used cars are substitutes,[332] and as such we should expect that the quantity and prices in the new vehicles sales market will affect quantity and prices in the used vehicles sales market and vice versa.[333]

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[328] As explained further below, just as new vehicle *price* affects scrappage rates only by changing used vehicle demand (and therefore price), changes in new vehicle fuel efficiency (holding price constant) also only affect scrappage rates by changing used vehicle demand (and therefore price). Therefore, fuel efficiency increases should affect only fleet composition and not fleet size. New vehicle fuel efficiency (holding price constant) would have the opposite effect on fleet composition that increased new vehicle price has. As a positive attribute, higher new vehicle fuel efficiency will increase demand for new vehicles, thereby reducing demand for (and price of) used vehicles.

[329] Bento et al. (2018), at 178 (stating that "the inelasticity of this parameter suggests that accurately modeling vehicle lifetime is of first order importance, as most scrappage will occur due to age-related, exogenous scrappage rather than policy induced, endogenous scrappage").

[330] Bento et al. (2018), at 159; Jacobsen & van Benthem (2015), at 1325.

[331] Jacobsen & van Benthem (2015), at 1333 (Table 6).

[332] PRIA at 930, 1053.

[333] For example, in his dissertation, Howard Gruenspecht, includes the scrappage rate, new car price, and new car sales in his regression for used car price. Gruenspecht (1982a), at 81, 99-101. In his structural scrappage regression, Gruenspecht includes new cars sales. *Id.* at 106-107. In his corresponding reduced form regression, he includes vehicle miles traveled per capita to address overall demand for driving, in addition to the vehicle stock in the previous period. *Id.* at 86, 109-113. Finally, Gruenspecht demonstrates that the quantity of new vehicle demand is a function of vehicle miles traveled per capita and vehicle stock in the previous period, in addition to new vehicle price. Gruenspecht (1982a), at 87; *see also* Goulder et al. (2012), at 192 (using a model that solves for supply-demand equilibrium in the new and used car markets").

Ignoring these facts, the agencies assert that higher new vehicle prices will reduce scrappage rates more than they reduce new vehicle purchase rates, so that over time, more used vehicles are retained than needed to replace forgone new vehicle purchases.[334] The enormous discrepancy between the change in new vehicle purchases and the increased fleet size is due in part to the agencies' irrational decision not to connect the results of the new vehicle sales model and the scrappage model so that they influence each other.[335] Moreover, many of the variables—including used car prices, used car scrapping rates, and new car sales—are functions of each other and therefore using one to predict the other can be circular (that is, they suffer from the simultaneity bias). For example, changes in the price of new vehicles changes the scrappage rate of used vehicles. But changing the supply of used vehicles (via scrappage) also affects the price of new vehicles.[336] Lowering the number of used vehicles on the market may increase used vehicle prices, which may reduce the price disparity between relatively new used vehicles and brand new vehicles, thereby increasing demand for new vehicles and, therefore, the price of new vehicles.

The agencies argue that it is not necessary to connect the new vehicle purchase decision and used vehicle scrappage because different households are making the decision to buy a new car and scrapping a used car.[337] But while different households might be making those decisions, the decisions are connected through the market, as new vehicle sales, new vehicle price, used vehicle price, and scrappage rates are jointly determined in the marketplace. The agencies should connect the results from the new sales model and the scrappage model.

Third, instead of an increase, it is actually more likely that price increases would cause a small decrease in the total fleet size. Most households that would have purchased a new vehicle but that instead purchase a used vehicle will likely purchase a close substitute (i.e., a low age/mileage used vehicle). This effect moves down through the fleet before it affects scrappage. As explained above, as the new vehicle price increase raises the prices for used vehicles, a portion of buyers that would have bought young used vehicles will buy vehicles that are slightly older; and vehicles owners who would have bought the older used vehicles will buy even older vehicles; and so on down the chain. Some of the last buyers at the bottom of that chain will be supplied by vehicles that, without the standards, would have been scrapped. But a portion of used vehicle purchasers that would have purchased a used vehicle before used vehicle prices went up

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[334] 83 Fed. Reg. at 43,099 ("Our models indicate that the ratio of the magnitude of the scrappage effect to the sales effect is greater than one so that the fleet grows under more stringent scenarios").

[335] *Id.* (explaining that "while both models are informed by new vehicle prices, the model of vehicle sales does not respond to the size and age profile of the on-road fleet, and the model of vehicle scrappage rates does not respond to the quantity of new vehicles sold").

[336] *See* Gruenspecht (1982a), at 82.

[337] 83 Fed. Reg. at 43,099.

will instead choose to forgo a vehicle purchase. This happens as some who may have been planning to replace their old used car may now decide that, facing higher prices, they are better off opting out of the market into alternative forms of transportation. These consumers may instead make the same number of car trips using fewer vehicles. For example, some families may be unable to afford a used car for their teen, or will sell their sedan to buy a used minivan instead of being able to keep both. Others may reduce their need for a vehicle (or second vehicle) and travel by alternative means such as walking, biking, ride sharing service, or public transit.[338] The magnitude of this decline in fleet size is dependent on the price elasticity of used vehicle supply and the elasticity of substitution between used vehicles and alternative forms of transportation. If demand is very elastic, for example because teenage drivers can get rides with friends or mass transportation is readily available in that location, there will be more of a shift than if demand is inelastic. Either way, this force will likely *reduce* the total number of used vehicles on the road.

ii.) The agencies' explanations for their fleet size results are unavailing

The agencies offer a few explanations to address the fact that their description and results are inconsistent with basic economic theory, but those arguments are unavailing.

First, the agencies assert that the number of vehicles not scrapped will be higher than the decrease in new vehicles sales[339] because the used vehicle fleet is so much larger than the new vehicle fleet.[340] But the total number of vehicles (new and used) and total VMT is determined in general equilibrium where supply meets demand. These market clearing conditions are influenced by underlying supply and demand curves, which are related to the elasticity of demand and the elasticity of scrapping, not magnitudes of the relative markets.

Second, the agencies argue that households require more than one used vehicle to replace the full lifetime of a new vehicle and that this increases the fleet size.[341] But as fleet size is measured on a per annual basis, more cars with a shorter-life span does not lead to a larger annual fleet size. Moreover, this reasoning is predicated on VMT schedules remaining constant (which they should not, as discussed below). In addition, households purchase "close substitute[s] for new models"[342] and those substitutes are unlikely to be multiple used vehicles. Instead, previous purchasers of new

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[338] *See, e.g.*, Gruenspecht (1982a), at 120; Letter from Dr. Mark Jacobsen and Dr. Arthur van Benthem at 2, Docket No. EPA-HQ-OAR-2018-0283 and Docket No. NHTSA-2018-0067 (Oct. 8, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-2650 [hereafter "Jacobsen & van Benthem Docket Letter"].

[339] PRIA at 1057.

[340] *Id.* at 1057.

[341] Responses to Interagency Comments on NPRM Round 8 Received 7-11-2018, at 2-3, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (12th Attachment, pdf page 3).

[342] PRIA at 930.

vehicles will purchase a relatively new used vehicle, an effect that moves down the chain, as explained above.

Third, the agencies concede that their results may not be "intuitive for reviewers" because normally increased prices would not lead to a bigger fleet, rather "reduced prices of new vehicles and increased sales," as promised under the Proposed Rule, "should lead to a larger on-road fleet."[343] The agencies nonetheless argue that "the increased sales" that one might expect from reducing prices under the Proposed Rule are "more than offset" by the accelerated scrappage shown in the agencies' modeling. But this reasoning does not help the agencies because it is the *results of the model* that violate economic theory. The agencies cannot support the theoretical validity of their model by pointing to the results of their model. The fact that a model shows a counterintuitive result is a reason to fix the model, not a reason to dismiss intuition and theory.

For all these reasons, EPA was correct to note in comments on the Proposed Rule prior to its publication that "[t]he total number of registered vehicles would not change significantly as a result of consumer decisions to retain used vehicles longer instead of purchasing new vehicles."[344] As EPA recognized, it is inconsistent with basic economic principles to expect that fleet size would decrease with the Proposed Rule, relative to the baseline.[345]

b.) *The agencies' scrappage assumptions are inconsistent with the academic literature*

In an effort to support the assumption that increased prices lead to a larger fleet, the agencies cite heavily to several academic papers. But those papers do not support the conclusions the agencies reach. Namely, while the academic literature supports a connection between new vehicle prices and slower replacement scrappage, the literature does not support the assumption that fleet size would increase due to non-replacement scrappage. Instead, they show that vehicle price increases and fuel efficiency increases are likely to, if anything, decrease fleet size as explained above.

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[343] 83 Fed. Reg. at 43,098 ("While it might be natural to assume that reduced prices of new vehicles and increased sales should lead to a larger on-road fleet, in our modelling, the increased sales are more than offset by the somewhat accelerated scrappage that accompanies the estimated decrease in new vehicle prices.").

[344] EPA review of CAFE model with "GHG" settings, Slide 8 (08-Mar ver.), attached to Email from William Charmley to Chandana Achanta regarding Material for today's Light-duty GHG NPRM discussion, June 18, 2018, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th attachment).

[345] *See id.*; Responses to Interagency Comments on NPRM Round 8 Received 7-11-2018, at 2-3, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (12th Attachment, pdf page 3).

i.) The cited literature does not support the assumption that price increases will lead to a slower non-replacement rate of scrapped vehicles and fleet size increases

The agencies' scrappage assumptions are based primarily on a paper and dissertation by Howard Gruenspecht, which studied the impact of fuel efficiency regulations on pollution reductions.[346] In those papers, Gruenspecht found that pollution reductions may be partially offset if a policy-induced fuel efficiency increase causes some potential new-vehicle purchasers to switch from lower-emitting new vehicles to higher-emitting used vehicles, and from lower-emitting used vehicles to higher-emitting older used vehicles.[347] Under Gruenspecht's theory, this effect culminates in a slower rate of vehicle scrappage.

The agencies repeatedly cite to Gruenspecht to support the assumption that higher vehicle prices will lead to both replacement and non-replacement scrappage, which the agencies largely do not distinguish and call collectively the "Gruenspecht effect."[348] But the agencies misunderstand the papers. Gruenspecht's research was concerned with the effect of increases in new vehicle price on the scrappage of used vehicles *that would have been replaced by new vehicles or newer used vehicles*—what the agencies refer to as slower "replacement scrappage," not with non-replacement scrappage.[349] In fact, as Gruenspecht explained in his dissertation, which formed the basis for the 1982 paper, "*the desired number of vehicles in the stock is insensitive to variation in the price of new cars"* and "the primary effect of a change in new car prices is to alter the composition of the vehicle stock via its effect on scrapping decisions" not to change fleet size.[350] Indeed, because of this, Gruenspecht held the "aggregate vehicles miles travelled (VMT) and the total number of vehicles" constant in his analysis, a fact that the agencies ignore in the Proposed Rule.[351]

The other cited authors that have actually studied the phenomenon addressed in the Gruenspecht paper also all address only replacement scrappage, and do not address at all the idea of non-replacement scrappage. For example, the agencies point to an analysis conducted by the California Air Resources Board as support for "including some estimate of the Gruenspecht effect," but the agencies themselves acknowledge that CARB did not analyze non-replacement

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[346] 83 Fed. Reg. at 43,093.

[347] Gruenspecht (1982a), at 129-135; Gruenspecht (1982b), at 330.

[348] 83 Fed. Reg. at 43,093, 43,094, 43,095, 43,096; PRIA at 932, 999, 1002, 1013, 1014.

[349] 83 Fed. Reg. at 43,095 ("Aggregate measure of the Gruenspecht effect will include changes to scrappage rates both from slower replacement rates, and slower non-replacement scrappage rate"); PRIA at 1004. Other academic papers refer to this effect as "used car leakage." *See* Jacobsen & van Benthem (2015), at 1331.

[350] Gruenspecht (1982a), at 120 (emphasis added).

[351] Gruenspecht (1982b), at 328-29.

scrappage.[352] As such the CARB analysis has no bearing at all on the question of whether the agencies should assume that slower non-replacement scrappage is "expected."[353]

Another paper that the agencies cite in support of their scrappage model is an empirical analysis of the relationship between fuel price increases and scrappage rates among used vehicles conducted by Mark Jacobson and Arthur van Benthem.[354] Unlike the Gruenspecht and CARB analyses, Jacobsen & van Benthem did not hold fleet size constant.[355] But after finding that an increase in the price of used vehicles gives owners an incentive to postpone the decision to scrap,[356] Jacobson & van Benthem found a decline in the fleet size when estimating the Gruenspecht effect, not an increase, as the agencies find.[357] The paper did not set out to estimate the *magnitude* of any effect on the total fleet size and cannot be read as support for any magnitude estimate. But because the paper shows a decline in fleet size, it cannot be used to support any conclusion that fleet size should go up with reduced scrappage. As the authors have explained in a letter to the agencies regarding the Proposed Rule, under standard economic theory, if the baseline standards increase vehicle prices, the total fleet size would likely decrease over time.[358] Similarly, an earlier paper by Goulder, Jacobson & van Benthem suggested that tighter emission standards would lead to an overall decrease in fleet size, even after accounting for an increase in used car sales.[359]

In addition to these papers, the agencies assert that Greenspan & Cohen's paper offered "additional foundations from which to think about vehicle stock and scrappage."[360] But that paper does not address non-replacement scrappage. And by the agencies' own admission, Greenspan & Cohen hypothesized a pathway through which "engineering scrappage seems to *increase,*" rather than decrease, with increasing emissions standards because emissions controls

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[352] 83 Fed. Reg. at 43,094.

[353] PRIA at 1004 ("Because higher used vehicle prices will lower the number of vehicles whose cost of maintenance is higher than their value, it is *expected* that not only will replacements of used vehicles slow, but also, that some vehicles that would have been scrapped without replacement under lower new vehicle prices will now remain on the road because their value will have increased. Aggregate measures of the Gruenspecht effect in this analysis will include changes to scrappage rates both from slower replacement rates, and slower nonreplacement scrappage rates") (emphasis added).

[354] 83 Fed. Reg. at 43, 093, 43,094, 43,097 (citing Jacobsen & van Benthem (2015)).

[355] Jacobsen & van Benthem (2015), at 1329-1330.

[356] *Id.*, at 1313.

[357] Jacobsen & van Benthem (2015) found a decline in the fleet size when estimating the Gruenspecht Effect. If NHTSA has not already done so, NHTSA will see this result after running the Jacobsen & van Benthem (2015) code. *See* Jacobsen and Benthem Data, https://www.aeaweb.org/aer/data/10503/20130935_data.zip.

[358] Jacobsen & van Benthem Docket Letter at 1.

[359] Goulder et al. (2012), at 200 (Table 6.3).

[360] PRIA at 1000-1001.

may make vehicles more complicated to maintain.[361] As such, that paper does not support the agencies' argument in the Proposed Rule that higher emissions standards cause reduced scrappage.

The agencies cite to a number of other academic papers as support for their scrappage model.[362] But the cited literature does not support the agencies' analysis.

For example, the papers by Walker, Parks, & Bento et al. estimated the effect of the elasticity of scrappage with respect to new or used vehicle price.[363] The agencies do not use these elasticity estimates in their modeling and do not analyze whether the implied elasticities of scrappage derived from their scrappage model are consistent with this literature. Were the agencies to use those estimates, it is likely that the scrappage effect would decrease substantially because, as Bento et al. found, these elasticities show that most scrappage is due to age-related factors that are unrelated to increases in price.[364]

Greene & Chen (1981) and Feeney & Cardebring (1988) analyzed the life expectancy of different types of vehicles and did not look at the impact of a fuel efficiency program or vehicle price changes on those rates.

Hamilton & Macauley (1999) also looked at vehicle longevity and found that it was likely related to factors such as the driving environment. The paper did not address the impact of vehicle price or fuel efficiency on scrappage.

Busse et al. (2013), Sallee et al. (2016), and Alcott & Wonzy (2014) all focused on whether and how much consumers value fuel efficiency, using data on used vehicles. The former two papers did not calculate a scrappage rate as a function of vehicle price of fuel efficiency. Of these papers, only Alcott & Wonzy (2014, p. 784) estimated a simple scrappage model (i.e., vehicle survival probability as a function of vehicle age, model year, and fuel economy), though this estimate did not analyze the price effect on scrappage.

Li et al. (2009) focused on the effect of gasoline price on fleet fuel economy, not the effect of vehicle prices on scrappage. While Li et al. (2009) controlled for the effect of fuel efficiency on used vehicle scrappage, the paper did not address the key issue underlying the agencies' theory that an increase in existing vehicle prices will reduce the scrappage rate of those vehicles.

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[361] See 83 Fed. Reg. at 43,093; PRIA at 1000. Greenspan and Cohen's results show that any impact on the durability of vehicles doesn't meet the standard 95% significance level with a t-statistic of -1.3. Greenspan & Cohen (1999), at 374-375.

[362] *See* 83 Fed. Reg. at 43,094 (citing to Walker (1968), Parks (1977), Greene and Chen (1981), Feeney and Cardebring (1988); Greenspan and Cohen (1999); Hamilton and Macauley (1999); and Bento et al. (2018)).

[363] Walker (1968); Parks (1977); Greenspan and Cohen (1999); and Bento et al. (2018).

[364] Bento, et al. (2018), at 178 (stating that "the inelasticity of this parameter suggests that accurately modeling vehicle lifetime is of first order importance, as most scrappage will occur due to age-related, exogenous scrappage rather than policy induced, endogenous scrappage"); Goldberg (1998), at 31 (explaining that "the substitution effects towards used cars were estimated to be small" and that "policies oriented towards shifting the composition of the new car fleet towards more fuel efficient vehicles seem promising").

Thus, none of these papers is relevant to the Gruenspecht effect. In sum, contrary to the agencies' assertions, the economic literature provides no support for the agencies' underlying assumption that higher vehicle prices lead to slower non-replacement scrappage.

ii.) The empirical findings of the rebound literature show that increased fuel efficiency should not increase fleet size either directly or through higher new vehicle prices

The empirical literature on the rebound effect also supports the assumption that an increase in new vehicle price or fuel efficiency will not change the overall fleet size and that, if anything, it should *reduce* total vehicles on the road:

- In a study of the relationship between gasoline prices and travel demand, Paul Schimek hypothesized that an increase in vehicle price decreases vehicle stock.[365] Using U.S. time series data primarily from the Federal Highway Administration, Schimek separately estimated the effect of gas prices on vehicle stock, vehicle fuel efficiency, and vehicle miles traveled.[366] His results confirm the hypothesis that real vehicle price has a *negative*, statistically significant impact on vehicle stock.[367]
- In their 2007 study estimating the rebound effect caused by changes in fuel efficiency, Kenneth Small and Kurt Van Dender derived estimates of the relationship between vehicle price and fleet size. By simultaneously estimating a system of equations for VMT per capita, fleet size, and fuel efficiency for the United States from 1966 to 2001, Small and Van Dender also found that an increase in new vehicle price has a *negative*, statistically significant effect on total vehicle stock.[368] They also found that changes in fuel cost per mile had a statistically insignificant effect on fleet size, with the sign of the effect varying by the method of regression.[369]
- Phillippe Barla and coauthors applied the methodology developed by Small and Van Dender to panel data at the provincial level in Canada from 1990 to 2004.[370] They found that new vehicle price, vehicle km traveled per adult, and fuel cost per km all have a negative but statistically insignificant effect on the per-adult stock of vehicles.[371]
- In a 2010 paper, Kent Hymel, Kenneth Small, and Kurt Van Dender extended the methodology developed by Small and van Dender (2007) by including an additional

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[365] Schimek (1996), at 84.

[366] Schimek (1996), at 85 (applying OLS after rejecting simultaneity).

[367] *Id.*, at 86 (Table 2).

[368] Small and Van Dender (2007), at 39 (Table 3).

[369] *Id.* (showing coefficient of vehicle price, pv, with a negative statistically significant value).

[370] Barla et al. (2009), at 390.

[371] *Id.* at 398.

simultaneous equation for congestion.[372] They found that the price of new vehicles has a statistically insignificant effect on vehicle stock.[373] A 2015 paper by Hymel and Small also found a statistically insignificant impact.[374]

Overall, these results are consistent with the assumptions utilized by Gruenspecht and the findings of Jacobsen and van Benthem: if an increase in vehicle price has any effect on vehicle stock, it is likely negative. The agencies' contrary analysis is fatally flawed.

c.) *Charts showing simplified impact of a change in new vehicle price*

Figure 2 below demonstrates in simplified form, the changes in supply and demand that might lead from a change in the price of new vehicles. For purposes of simplicity, in these charts we abstract from simultaneity in the vehicle market. For example, we do not show the demand and supply for vehicle miles traveled and safety, which are simultaneously determined with the number of new and used vehicles. For comparability, we also assume that consumer valuation of the fuel efficiency increase is less than ΔK, as the agencies assume in the sales module, though the opposite could be true shifting households from used to new vehicles.

<u>In the first chart</u>, when prices go up, sales decrease from N_1 to N_2 and prices of new vehicles increase from P_1 to P_2. In other words, new vehicle demand shifts out and new vehicle supply shifts in.

<u>The second chart</u> shows changes in the used vehicle market. As increases in new vehicle price shift out used vehicle demand, demand for used vehicles (on net) shifts out and causes increasing sales from U_1 to U_2 and price from C_1 to C_2. The change in prices on the used car market feeds back into the demand curve for new cars. The total effect of the interactions between the two markets is the increased share of used vehicles. The change in vehicle stock is $\Delta U - \Delta N$. This would does not lead to an overall increase in fleet size (i.e., $\Delta U - \Delta N \leq 0$).

<u>In the third chart</u>, as the price of used vehicles increases, because of the shift in demand for public transportation, the number of mass transit trips increase from T_1 to T_2. Similarly, some households who forgo buying a new vehicle will instead carpool or find other sharing vehicle sharing arrangements within and between households; this will increase the number of passengers per vehicle.

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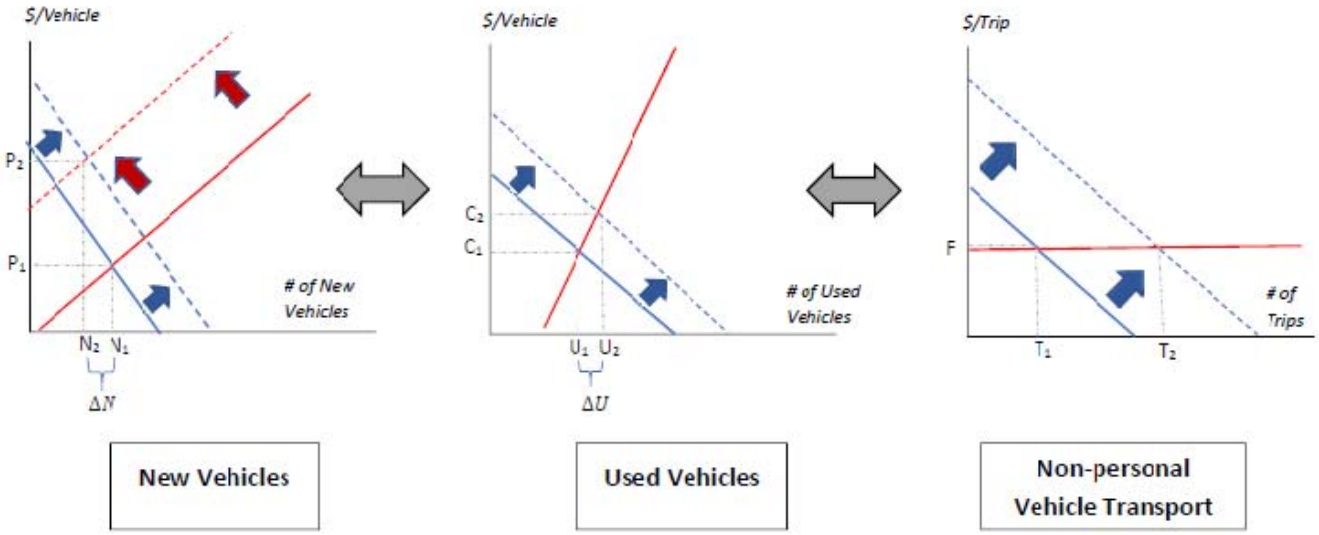
[372] Hymel (2010), at 1221.

[373] *Id.* at 1231 (Table 3 showing a lack of significant of coefficient corresponding to *pv*).

[374] Hymel and Small (2015), at Table B2.

Figure 2. Theory Underlying Gruenspecht Effect (from Proposed Rule to Baseline Standards)



Red and blue curves in the above charts represent the supply and demand curves, respectively, for their corresponding market. In the case of non-personal vehicle transport, we assume that the marginal cost is constant (i.e., the supply curve is horizontal).

d.) *Further econometric and analytical errors*

i.) Omitted variables

In the scrappage model, the agencies have, without explanation, omitted a number of other variables that are critical to understanding the scrappage effect including:[375]

- Turnover rate and/or other connections between new and used vehicle markets and VMT (e.g., new vehicle sales, VMT per capita, and vehicle stock);[376]
- The price of scrapped metal and other variables critical to the scrappage theory laid out in the literature by Walk, Parks, Gruenspecht, and Bento[377]

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[375] PRIA at 1012

[376] In his structural scrappage regression, Gruenspecht (1982a) at 106-107, includes new cars sales. In his corresponding reduced form regression, Gruenspecht, 1982a), at 86, 109-113, includes vehicle miles traveled per capita to address overall demand for driving, in addition to the vehicle stock in the previous period. Bento et al. (2018), at page 171, (Table 3)include turnover rate in their structural scrappage regression.

[377] As noted by Gruenspecht (1982b) at 328, a vehicle is scrapped when the price of a vehicle less its scrappage cost is less than its scrappage value. According to the literature cited by NHTSA, maintenance and repair costs (Walker (1968); Parks (1977) at 1104; Gruenspecht (1982a), at 105-114; Greenspan and Cohen (1999); Bento et al., (2018)) and scrappage value (Parks (1977) at 1104; Gruenspecht (2011), at 105-114; Bento et al., (2018)), are almost always included in scrappage regressions. In the exception to the rule, Jacobsen & van Benthem (2015) include various

- Environmental causes of scrappage, including improvements in crash avoidance technology and national migration to fair weather areas; and[378]
- Percent of imported vehicles.[379]

In addition, using new vehicle price to determine scrappage rates fails to control for several variables that affect used vehicles and are independent of new vehicles. For example, odometer readings affect used vehicle price because more driving implies more wear and tear, and lower remaining vehicle value, holding age constant.[380] Vehicle brand can affect used vehicle price because it is a proxy for vehicle durability, which is correlated with used vehicle price and scrappage.[381] Some vehicle brands are associated with durability and a robust used vehicle price. Brand (along with model year) can control for the "repair incidence distribution."[382]

For the sales model, in addition to fuel efficiency, the agencies fail to control for several other important confounding variables.[383] Some key variables that the agencies should control for are: vehicle attributes; vehicle quality or durability; vehicle search costs; socio-economic and demographic variables; and geographic variables.[384] Vehicle miles traveled per capita, vehicle stock and other connections to the used vehicle market, and aggregate VMT are also omitted.[385]

Failure to address the omission of variables critical to the theory underlying the agencies' modeling conclusions raises serious questions about the agencies' ability to appropriately estimate the effect of new vehicle prices on fleet turnover. Indeed, if variables used in the academic literature unexpectedly have an incorrect sign or are insignificant, the agencies should consider the possibility that the model is missspecified or that factors in the model are endogenous.[386]

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fixed effects to address potential omitted variable bias. Consistent with the theory, new vehicle price and all other variables that affect scrappage via used vehicle price should be divided (i.e., indexed) by the maintenance and repair costs. Gruenspecht (1982b), at 328; Parks (1977), at 1105; Greenspan and Cohen (1999), at 375. This is also true for scrappage value or scrappage price (i.e., the value of scrap metal). Gruenspecht (1982b); Parks (1977) at 1104.

[378] Hamilton and Macauley, (1999).

[379] Bento et al., (2018), at 174.

[380] Greenspan and Cohen, (1999) at 375 to 376.

[381] Chen and Lin (2006) at 749 (Table 2); Parks (1977); Jacobsen and Benthem (2015); Li et al. (2009).

[382] Gruenspecht (1982a), at 97, 109-113.

[383] PRIA at 949

[384] Li et al. (2009); McCarthy (1996) at 454.

[385] Gruenspecht (1982a), at 87 (explaining that the quantity of new vehicle demand is a function of vehicle miles traveled per capita and vehicle stock in the previous period, in additional to new vehicle price).

[386] For example, fleet turnover and its common proxy variable – new vehicle sales - are potentially endogenous. Bento et al. (2018) at 163. Due to the aggregate nature of the data (Li et al., (2009) at 125), many other variables

ii.) The impact of fuel efficiency on scrappage in the agencies' results is evidence of a grave error

According to standard economic theory, when price is held constant, fuel efficiency should increase the value of a vehicle and cause demand for the vehicle to go up, leading to higher scrappage rates. In other words, when fuel efficiency improves, that increases demand for new vehicles, which reduces demand for used vehicles, reduces the price of used vehicles, and ultimately, increases (replacement) scrappage.[387] Fuel efficiency would not cause the fleet size to increase. Like new vehicle price, changes in fuel efficiency should not lead to a change in total fleet size, but only a relative change in the proportion of new and used vehicles, as explained above.

The agencies agree that increasing fuel efficiency without changing vehicle prices should increase scrappage.[388] But when the agencies control for price in the scrappage model, the model provides the opposite result: an increase in fuel efficiency leads to both decreased scrappage and an increased fleet size. This is evidence of a grave error.

The error is evident in a sensitivity that the agencies provide. The agencies include cost per mile (CPM) of new vehicles in the scrappage model in order to take into account the effect that fuel efficiency will have on used vehicle demand and scrappage.[389] In the PRIA, the agencies then present results of a sensitivity analysis where they disable the new vehicle sales model and dynamic fleet share model, and rebound,[390] and assume that the baseline standards will cause a $0 price increase in new vehicles.[391] Notably, this sensitivity case does not disable the entire

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may suffer from endogeneity problems; the most critical of which is maintenance and repair costs. PRIA, 1011-1012.[386] Indeed, NHTSA recognizes the potential endogeneity of maintenance and repair costs. PRIA, 1011-1012.

[387] *See* Jacobsen & van Benthem, (2015), at 1318; Gruenspecht (1982a); Gruenspecht (1982b).

[388] 83 Fed. Reg. at 43,093 ("Where [consumers'] additional value of fuel savings associated with a technology is greater than any loss of value from trade-offs with other attributes, the demand for new vehicles will also shift *upwards*."); PRIA at 1027 ("As expected, the cost of travel for new vehicles is inversely related to the scrappage of cars and pickups—as new vehicles are more efficient there is an increase in the demand for new vehicles, and a decrease in the demand for used vehicles, holding new vehicle price constant").

[389] PRIA at 1027. Note, however, that this is only relevant if consumers value fuel efficiency. If consumers do not value fuel efficiency, the CPM on new vehicles would not affect vehicle purchasing decisions and so would not need to be included in the scrappage model. Put another way, only non-quality improvements are arbitraged into used vehicle price. Hamilton and Macauley (1999), at 257 (another way to address this problem would be to subtract the portion of fuel efficiency increases that consumers value from the new vehicle price increase to create a quality adjusted price variable).

[390] This is because the only elements of the agencies' analysis that change VMT are the number of vehicles by Model Year (as determined by the sales and scrappage models) and the rebound analysis, and the only elements of the agencies' analysis that change fatalities are the VMT by model year.

[391] PRIA at 1531 (describing the "Scrappage and Fleet Share Disabled" as an analysis of the baseline and proposed standards when the new vehicle sales remain at levels specified for MY 2016 and new vehicle prices are kept at MY 2016 levels for the purpose of estimating scrappage).

scrappage module. Rather under this case, the fuel efficiency improvements of the baseline standards (expressed as changes in CPM) continue to affect scrappage decisions, and therefore the distribution of vehicle model years within the used vehicle fleet and the total vehicle fleet size.[392]

As such, any difference in fleet size between the baseline standards and the Proposed Rule in this sensitivity case is fully attributable to the fuel efficiency effect on scrappage.[393] In addition, because the agencies present each sensitivity case with the rebound effect disabled, any change in VMT or fatalities between the baseline standards and the Proposed Rule in this sensitivity case is fully attributable to the fuel efficiency effect.

But while holding new vehicle price constant should mean that scrappage goes up, the agencies' sensitivity analysis shows the opposite. As shown in Table 1, the agencies' analysis shows that holding new vehicle price and rebound constant leads to a theoretically nonsensical decrease in scrappage and, as a result, an *increase* in fleet size (by 59 million vehicles), VMT (by 280 billion miles), and fatalities (by 2640 deaths). In fact, these nonsensical results are the cause of 40% of the fleet size increase and fatalities—as well as the related portion of the CO_2 increases, congestion, and fuel consumption—that the agencies attribute to the baseline standards. This points to deep flaws in the agencies' scrappage model.

Table 1. Cumulative Changes in Fleet Size, Travel (VMT) and Fatalities Through MY 2029 Under Baseline CAFE and CO_2 Standards (Without Rebound)

(adapted from Tables 13-5 and 13-6 of the PRIA[394])

Sensitivity Case	**Fleet Size (millions)**	**VMT (billion miles)**	**Fatalities**
Reference Case	190	690	6340
Scrappage and Fleet Share Disabled	59	280	2640

The error appears to be driven by the fuel efficiency estimates for new SUVs and vans. The agencies' scrappage model is separated into different regressions for three styles of vehicle: cars, Vans/SUVs, and Pickups.[395] In the regression for each style, the agencies include variables for new vehicle price and new vehicle CPM as the explanatory variables for determining scrappage

[392] *Id.* at 1050-1051 (describing the scrappage model as using the same variables but with new vehicle price effectively set to its MY 2016 value, and showing that variables related to CPM have not been set to zero).

[393] This is because the only elements of the agencies' analysis that change fleet size are the new vehicle sales, scrappage, and dynamic fleet share model.

[394] PRIA at 1540, 1542.

[395] *Id.*at 1006.

rates. In addition, the agencies include a number of control variables related to vehicle age, model year, used vehicle CPM, and GDP.[396]

The coefficients of the new vehicle CPM variables for each body style represent the extent to which the model expects new vehicle fuel efficiency (represented as new vehicle CPM) to change scrappage rates for that body style. Negative values for the new vehicle CPM variables represent a prediction that as new vehicle fuel efficiency increases (i.e., the costs of driving a new car decrease), scrappage rates will increase. Positive values for new vehicle CPM represent the prediction that as new vehicle fuel efficiency increases (i.e., the costs of driving a new car decrease), scrappage rates will decrease. Economic theory would, therefore, predict only negative values for the new vehicle CPM variable: to the extent new vehicles of different body styles cause different changes to used vehicle demand for a given fuel efficiency change, the only difference in the model should be the magnitude of the change.

But in running the model, the results show that the relationship between scrappage rates and the fuel efficiency of one of those categories of vehicles (SUVs and vans) is positive and of such a high magnitude that it is throwing off the rest of the agencies' results, as shown in Table 2. Specifically, the magnitude of new SUVs and vans is 6.6 times larger than the magnitude of the new car CPM value, and over 13.9 times larger than the new pickups CPM value. The high relative magnitude of the value for SUVs is causing the scrappage model to generate lower scrappage, a larger fleet, additional VMT, and more fatalities due to improvements in fuel efficiency, holding new vehicle price constant.[397] And this effect increases over time because the agencies' dynamic fleet share model increases the proportion of new vehicles that are SUVs (and pickup trucks) as compared to cars.[398]

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[396] *See Id.* at 1044. The agency also includes lagged versions of these variables (e.g., the new vehicle price in the prior year), interactions between the variable and itself (e.g. age^2 and age^3), and interactions between variables (e.g., the interaction between age and model year). The inclusion of interaction variables make it very difficult to evaluate the results of the regression for an individual variable of interest. However, because new and used vehicle CPM are included without any interactions, the results for these variables can be interpreted as the effect of CPM changes on scrappage rates. This is done simply by adding up (new or used) CPM with the lagged variable for (new or used) CPM. *Id.* at 1027 ("By summing the current and lagged period new vehicle cost per mile coefficients, the overall level effect of the cost of travel can be computed by body style").

[397] Because the agencies do not present the effect of changes in CPM on scrappage for the three body styles combined, it is not possible to determine the exact combined effect.

[398] *Id.* at 953, 1046 ("Rather than apply the shares based on the regulatory class distinction [taken from the EIA's NEMS model], the CAFE model applies the shares to body-style. This is done to account for the large-scale shift in recent years to crossover utility vehicles that have model variants in both the passenger car and light truck regulatory fleets.").

Table 2. Aggregated New Vehicle CPM Coefficient Values[399] from Scrappage Model

(adapted from Tables 8-20 and 8-21 of the PRIA[400])

Sensitivity Case	Cars	Vans/SUVs	Pickups
Reference	-0.02087	0.137725	-0.00994
Scrappage Price Disabled	-0.02087	0.137725	-0.00994

There is no possible reason for CPM to have an impact on Vans/SUVs that is up to 14 times larger than for new cars and trucks. Despite the importance of the issue, the agencies try to explain away the inconsistency in one short sentence in the PRIA: "It may be either that cost per mile is negatively correlated with van/SUV attributes consumers value more than fuel economy and/or that increases in the cost of travel result in a shift away from pickups and towards vans/SUVs which may be slightly more fuel efficient."[401]

But that explanation is insufficient. The agencies provide no specific support for the idea that consumers would value other attributes over fuel efficiency so much more than for new pickups. And if consumers are shifting "from pickups and towards vans/SUVs which may be slightly more fuel efficient," that should have the opposite effect because it would show higher valuation of fuel efficiency.[402] Moreover, the agencies do not explain why this effect would be so much more significant for SUVs than for cars or pickups. If the agencies' theory was true, then the CPM coefficients would have opposite *and offsetting* effects between Vans/SUVs and pickups. Yet the SUV coefficients are *substantially* larger than those for pickups.

The sheer magnitude of interrelated econometric errors in the scrappage model (as explained throughout these comments) makes it difficult to pinpoint the specific problem that led to results such as a CPM variable for Vans/SUVs that is the wrong sign and of such high a magnitude that it overpowers the results of other variables, but it is possible that econometric errors led to this problem.

New vehicle CPM is endogenous with many other variables. Scrappage, new vehicle sales, and fuel efficiency are all determined simultaneously and the agencies' did not take this into account.[403] In addition, the agencies have explicitly excluded several theoretically important

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[399] Aggregated CPM is the sum of New CPM and Lag New CPM, as described by the agency. *Id.* at 1027.

[400] *Id.* at 1044, 1051

[401] *Id.* at 1027.

[402] *Id.*

[403] Small and Van Dender (2007), at 31 (explaining the potential endogeneity of the fuel cost per mile); Li et al. (2009), at 125 (explaining that due to the aggregate nature of the data many other variables may suffer from

explanatory variables (e.g., the cost of maintenance and repair), which are potentially correlated with fuel efficiency.[404]

Notably, the agencies' methodology is inconsistent with almost all of the scrappage studies that the agencies cite as support for their approach.[405] A paper by Shanjun Li et al., provides a useful example of how the agencies could include fuel efficiency in their regression without raising the econometric concerns that may be leading to their nonsensical results. Li et al. include fuel price and vehicle fuel efficiency (gallons per mile) of used vehicles as well as a variable that captures the interaction of fuel efficiency of used vehicles and fuel price in their regression as explanatory variables.[406] Unlike the agencies' model, the regression analysis used in the Li et al. paper found results that are consistent with economic theory: a decrease in overall demand for vehicles and an increase in demand for more fuel-efficient cars.[407]

Another possible error is that the agencies' scrappage regression is overfit. For example, the agencies' regression for Vans/SUVs is different than the regression for cars and trucks. For Vans/SUVs, the agencies include age and age squared, whereas for cars they also included age cubed.[408] The agencies are overfitting their model to predict past behavior by including variables that have no clear relationship with scrappage rates or new car price (such as age cubed), rather than taking the more economically appropriate process of theorizing a model and the variables that should be included in it. Out-of-sample testing would help NHTSA highlight this potential overfit problem. If the agencies cannot address this error, they have two options. They can select an atomistic dataset that has sufficient detail to capture the key features of the scrappage market. Alternatively, they can choose to zero out the incorrect coefficient. As the model currently stands, this incorrect sign leads to fundamentally flawed results.

Moreover, the CPM results in the scrappage model are inconsistent with the agencies' sale model. In the sales module, the agencies have chosen to ignore consumer demand for fuel

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endogeneity problems, such as maintenance and repair costs); *See also* Gruenspecht (1982a), at 82; PRIA at 1015-1016.

[404] *Id.*at 1000 (indirectly making this point with respect to fuel efficiency and maintenance and repair costs when emphasizing that "Greenspan & Cohen also note that engineering scrappage seems to increase where EPA emission standards also increase; as more costs goes towards compliance technologies, it becomes more expensive to maintain and repair more complicated parts, and scrappage increases"). In other words, maintenance and repair costs are correlated with respect to fuel efficiency and scrappage rates.

[405] Walker (1968); Parks (1977); Gruenspecht (1982a); Greenspan and Cohen (1999); Bento et al. (2018). Note that Jacobsen & van Benthem (2015) include a variable related to *used* vehicle fuel efficiency for the same reason the agencies include used vehicle CPM. Jacobson and van Betham (2015), at 1318. However this is different than the inclusion of new vehicle CPM at issue here.

[406] Li et al. (2009), at 127.

[407] Gruenspecht (1982a), at 81.

[408] PRIA at 1025.

economy and significantly boosted the price impact of the baseline standards as a result.[409] But in the scrappage model, the agencies have incongruously allowed consumer valuation of fuel economy to drive a significant portion of the estimated fatalities. This inconsistency is arbitrary and capricious.

2. The agencies' assumption that VMT will go up is flawed

Even if the agencies are correct that the total fleet size would go up with an increase in prices (and they are not), the agencies' conclusion that the increase in the total fleet size would automatically lead to an increase in total VMT is illogical.

The agencies' analysis shows an overall increase of over 2 trillion additional vehicle miles traveled attributable to the baseline standards through 2050.[410] This increase comes from two sources: (1) the rebound effect and (2) an increase in fleet size due to non-replacement scrappage combined with an assumption that each vehicle of the same age and body type drives a fixed average number of miles per year. We address the first effect, rebound, in Section VI. The second effect is the result of a critical error.

Specifically, because the agencies assume that each additional car is driven a number of miles equivalent to the average VMT rate of a car of its age without adjusting per-vehicle VMT based on fleet size increases, the total VMT predicted by the model becomes inflated. And because the agencies' estimates of fatalities attributable to the baseline standards are primarily a function of fleet VMT, the inflated VMT results in substantially inflated fatality estimates and quantified economic costs.[411]

The agencies provide no theoretical explanation for the increase beyond conclusory claims that "if more used vehicles are supplied, there likely is some small resulting increase in VMT" and a "small increase in VMT is consistent with a larger fleet size."[412] But in fact, economic theory, the academic literature, and the agencies prior analyses[413] all show that an increase in the price of new vehicles would not lead to an increase in overall VMT. Instead, aggregate VMT, like vehicle stock, would remain constant or decline. The fact that changes in VMT go in the *opposite direction* (positive rather than negative) from what theory and the literature would support demonstrates that the agencies' modeling approach is critically flawed.

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[409] *See* III.

[410] PRIA at 1412.

[411] *Id.* at 1412.

[412] 83 Fed. Reg. at 43,099; *see also id.* at 43,098 ("The overall size of the on-road fleet determines the total amount of VMT."); PRIA at 1055, 1058 ("[I]t is reasonable to assume that changing the distribution of vehicle age and the fleet size across regulatory alternatives will result in non-constant VMT across those alternatives.").

[413] 77 Fed. Reg. at 62,716 (explaining the agencies' prior approach, which uses static vehicle turnover model and non-rebound VMT schedules that do not vary based on the stringency of the standards); *see also* Draft TAR at 10-6.

a.) *The increase in VMT that the scrappage model produces is inconsistent with economic theory and the academic literature*

Economic theory does not support the agencies' conclusion that an increase in new vehicle price would lead to an increase in aggregate VMT. Vehicles are durable goods that are purchased not for immediate consumption, but for the consumption of a stream of services over time (in this case VMT). Economic theory makes clear that households select their vehicle and VMT to maximize utility subject to their budget constraints.[414] The number of miles a consumer decides to drive is determined by the relative cost of driving (i.e., its price), subject to a budget constraint.[415] For example, because a consumer's budget constraint is affected by the fixed cost of the vehicle, a policy that increases the price of used vehicles reduces the amount consumers choose to use their vehicle.

In other words, vehicle ownership decisions are influenced by the relationship between fixed costs of owning a vehicle and the value (consumer surplus) that consumers derive from that vehicle ownership.[416] In sum, VMT is influenced by vehicle choice and vehicle choice is influenced by VMT.[417] And a "unified model of vehicle choice and usage" is necessary.[418] In a paper on the distributional effects of fuel efficiency standards, Sarah West summarizes this point:

> The joint nature of the demand for vehicles and miles complicates estimation of these demands. The choice of vehicle and VMT are related because characteristics that influence a household to purchase a certain vehicle may also influence that household's choice of miles . . . . Since the demand for VMT depends on the price per mile, and thus fuel efficiency, the household's choice of vehicle affects their demand for miles, and vice versa. To reliability estimate the demand for miles, one must construct a model of the joint choice of vehicles and miles.[419]

The papers that have analyzed the impact of price changes on VMT in this way have found that increased price decreases total VMT, rather than increases VMT as the agencies found. For example, a 2008 paper by Lucas Davis used household (i.e., microeconomic) data to show that demand for durable goods (such as vehicles) is a function of the marginal cost of using the good

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[414] Gillingham (2011), at 3; Davis (2008), at 531-32; Durbin and McFadden (1984) (discussing simultaneous decisionmaking of purchase and usage for durable goods); West (2004), at 737; Goldberg (1998), at 4-5; Small and Van Dender (2007), at 26.

[415] West (2004), at 739-740; Davis (2008), at 532-33.

[416] Gruenspecht (1982a), at 120.

[417] Goldberg (1998), at 4-5, 8; West (2004), at 737; Davis (2008), at 532-33.

[418] Goldberg (1998), at 4-5.

[419] West (2004), at 737.

and of net income (conditional on household characteristics).[420] Davis' results are consistent with a reduction in VMT as new vehicle price increases. The marginal cost of driving component that determines VMT is not a function of purchase price, but is instead a function of the price of driving and the opportunity cost of driving (i.e., the value of time spent driving as measured by wages) (conditional on the good's characteristics). However, the net income component that determines VMT is a function of the good's price. Because an increase in prices reduces relative income, it would also reduce VMT. [421]

Small and van Dander also estimated rebound using a methodology that relies on macroeconomic data. Their analyses also showed that VMT goes *down* when new vehicle price goes up.[422]

Thus, even if, as the agencies hypothesize, some households end up purchasing multiple used vehicles (or retaining a used vehicle and purchasing an additional used vehicle) to achieve the same level of transportation services as they would have had with a new vehicle,[423] there is no reason to think that they will end up consuming substantially more transportation services (through additional VMT).[424]

To be sure, changes in new and used vehicle prices could have some effect on VMT. Households that were planning to purchase a vehicle without the standards will face one of three choices if standards increase the price of new and used vehicles:

- For consumers that purchase older vehicles, they may choose to drive fewer miles per year than they would have without the standards for reasons beyond effects on the direct cost-per-mile of driving (which should be captured in estimates of rebound). Older vehicles may be less enjoyable to drive than newer vehicles and older vehicles may be less reliable, leading consumers to forgo some trips that they would have taken with a newer vehicle.[425]
- For those households that choose to spend more money on a vehicle when vehicle prices rise, remaining household income will decline and so consumption of other goods (including driving) may decline.

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[420] David (2008), at 533.

[421] *See also* West (2004), at 737; Goldberg (1998), at 4-5. To the extent that any shift to used cars increases any consumer's income, that effect would be small because the shift is not big, as explained above.

[422] Small and Van Dender (2007), at 38-39.

[423] PRIA at 1058 ("used vehicles only have a portion of their original life left, so that it will take more than one used vehicle to replace the full lifetime of a new vehicle, at least in the long-run").

[424] Fleet size increases could have some small increase in VMT because vehicles that are more available will be driven more.

[425] 83 Fed. Reg. at 43,104 (discussing the findings of West et al. (2015), who found that "[b]ecause these replacements offered lower-quality transportation service, their buyers did not drive them more than the vehicles they replaced").

- As discussed above, some households may choose to forgo purchasing a vehicle at all, which could lead the overall fleet size to decrease. These households would obtain transportation services through alternative means (public transportation, bicycle, ride sharing). This would cause an overall, though likely small, decrease in fleet VMT.

Because of these possibilities, to the extent the standards cause a shift from new vehicles to used vehicles, and towards older rather than newer used vehicles, the amount of total driving done by used vehicles, and in particular older used vehicles, relative to new vehicles, may increase. But without significant changes to the demand for VMT, any non-rebound related increases will be a transfer of VMT from new vehicles (that are not sold) to newer used vehicles. None of the scenarios described suggest that economic theory would expect an increase in aggregate VMT.

Gruenspecht recognized the theory behind this principle in his 1982 dissertation[426] and acknowledged that total VMT should not change as a result of the shift from new cars to used cars.[427] As a result, when running the EPA Mobile Source Emissions Model to assess the impact of fuel efficiency regulations on pollution reduction, he imposed an equality constraint on total U.S. VMT. In explaining his decision to control against a decrease he explained:

> "If the relationship between annual per vehicle VMT and vehicle age is held constant despite the shift in the composition of the vehicle stock, aggregate VMT would decrease due to the greater use of low annual VMT (i.e., older) vehicles when standards applied to new cars are made more efficient. To offset this effect, which would be unlikely to accompany real world shifts in composition, annual per VMT is adjusted upwards proportionately by an amount sufficient to restore the baseline level of aggregate VMT."[428]

Gruenspecht's underlying theoretical insight that VMT should not change demonstrates that the agencies' approach is incorrect.

In comments to NHTSA prior to the publication of the Proposed Rule, EPA also took the position that economic theory provides no support for the agencies' conclusion that increases in fuel efficiency and greenhouse-gas emission standards will result in an increase in aggregate VMT, other than through the rebound effect. EPA staff highlighted for NHTSA that with or without the standards, demand for VMT is unchanged, other than through potential changes in the marginal cost of driving, which should already be addressed by the rebound effect.[429] EPA

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[426] The dissertation is dated 1982. The agencies mistakenly cite it as his 1981 dissertation.

[427] Gruenspecht (1982a), at 126.

[428] *Id*.

[429] EPA Further Review of CAFE Model & Inputs, June 18, 2018 at 5, attached to Email from William Charmley (June 18, 2018) ("A change in the overall fleet size due to the Augural standards might not in and of itself be problematic, as long as the VMT schedules are adjusted to account for overall travel activity that is distributed over

staff correctly explained: "With no rebound, we would not expect to see any change in total VMT, since by definition rebound is measured as the change in VMT for a given change in fuel cost per mile."[430] NHTSA never provided an adequate explanation for dismissing EPA's comments and publishing the Proposed Rule.

In sum, the agencies' decision to employ a methodological approach that results in a significant increase in VMT, even though such an increase is inconsistent with economic theory, the academic literature, and agency staff analysis, is arbitrary and capricious. The agencies' reliance on the fatalities and costs that arise from the increase in VMT to justify the rollback is also arbitrary and capricious.

b.) *Any VMT changes caused by the baseline standards should already be captured by the rebound estimates*

Moreover, to the extent that VMT changes at all when price or fuel efficiency changes, that VMT change should already be accounted for in the agencies' rebound estimates. (We separately critique the agencies' rebound estimates in Section IV.)

As we explained above, VMT does not go up with changes in scrappage. But VMT can go up with rebound. As explained more at length in Section IV, rebound is comprised of three separate effects. Two of those effects cause increased driving because of consumers' increased income: (1) a reduction in the relative cost of driving compared to other forms of transportation—the "substitution effect;" (2) an increase in consumers' overall income (since they have to spend less on gasoline) that results in consuming more of many things (including driving)—the "income effect." The third effect depresses driving: (3) a reduction in consumers overall income (since consumers have to spend more for a more expensive but fuel efficient car) that results in consuming less of many things (including driving)— "the capital cost income effect."

Several of the rebound papers that the agencies assess in their rebound estimate calculate the rebound effect of increased fuel efficiency by looking both at the effect that fuel efficiency has on lowering the cost of driving, as well as on total driving and fleet size (partially through changes in vehicle prices).[431] For example, Small and van Dender (2007) define the rebound effect as $\frac{\varepsilon_{M,PM}+\varepsilon_{M,V}\varepsilon_{V,PM}}{1-\varepsilon_{M,V}\varepsilon_{V,M}}$ where $\varepsilon_{M,PM}$ is the elasticity of VMT to the fuel cost per mile, $\varepsilon_{M,V}$ is the elasticity of VMT to fleet size, $\varepsilon_{V,PM}$ is the elasticity of fleet size to the fuel cost per mile, and $\varepsilon_{V,M}$ is the elasticity of fleet size to VMT. In this way, these papers effectively already

a larger number of vehicles."), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th attachment).

[430] *Id.* at 9.

[431] Scimek (1996), at 84; Small and Van Dender (2007), at 31; Barla et al. (2009), at 389-391; Hymel et al. (2010), at 1223-1224; Hymel and Small (2015), at 31.

account for any possible fleet size changes.[432] These papers demonstrate that, to the extent fleet size is changing at all, that change is best captured through the rebound effect, and not through the scrappage estimates in the Proposed Rule.

c.) *Vehicles scrapped under the proposed policy and not the baseline policy are marginal by definition, and the average VMT does not apply*

Even if the agencies are correct about the impact of non-replacement scrappage (and they are not, as discussed above), the agencies' use of average VMT schedules in the calculations also led to a significant inflation in the agencies' estimates of aggregate VMT increases. Some of the most critical variables for analyzing VMT schedules are: fleet size and composition, accident and repair rates of vehicles of a particular age and class (i.e., controls for quality), vehicle brand (i.e., a control for durability), number of households owning vehicles, and average number of vehicles per household. In the VMT calculations, the agencies applied VMT schedules that were calculated using the number of miles traveled by the average vehicle for a given age and style (car, SUV, pickup truck, van, medium-duty pickup/van) to vehicles that would have been scrapped if not for the baseline standards.[433]

But the agencies ignored confounding variables that could make those vehicles only "marginal" vehicles, with characteristics that would have made them candidates for earlier scrappage relative to the average vehicles of that particular body style and vintage without the baseline standards. These characteristics might include more wear and tear (i.e., higher odometer readings and more accidents) and lower durability (i.e., of a brand with higher scrappage rates). Conditional on age, vehicles with higher odometer readings are both more likely to be scrapped and more likely to be driven fewer miles annually.[434] There is reason to believe that these marginal vehicles are also driven less than average vehicles of the same style and vintage. Data from Sweden indicate that some portion of scrapped vehicles are not driven prior to scrappage even though they are registered and could be driven.[435] As such, it is inappropriate to assume that the vehicles that would be scrapped under the Proposed Rule but would not have been scrapped

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[432] *See also* Joshua Linn, Resources for the Future, *Missing Fuel Cost Savings: Some Clues Emerge* (Oct. 9, 2018), http://www.rff.org/blog/2018/missing-fuel-cost-savings-some-clues-emerge (analyzing the agencies' VMT conclusions with respect to both scrappage and rebound and concluding that they are double counted).

[433] 83 Fed. Reg. at 43,090 ("the CAFE model tabulates 'mileage accumulation' schedules, which relate average annual miles driven to vehicle age, based on vehicles' body style").

[434] The current VMT schedules indicate that households drive vehicles less as the vehicles depreciate. While the agencies' VMT schedules vary VMT by vehicle age, odometer readings are a better indicator of depreciation than age. Busse, et al. (2013), at 233; Salee, et al. (2016), at 63-65. Because "conditional on age, vehicles with higher odometer readings have less remaining life," and have lower economic value (higher depreciation). Salle et al. (2016), at 66 (Figure 1); *see also* Jacobsen & van Benthem (2015), at 1330. At the same time, high mileage vehicles are likely driven less because less reliable vehicles (i.e., vehicles that are more likely to break down) impose a higher marginal costs of driving.

[435] Feeney and Cardebring (1988), at 455.

under the baseline standards would be driven the same as an average vehicle of their age and style.

Given the divergent characteristics of the non-scrapped vehicles and average vehicles, it is also likely that buyers of these almost scrapped vehicles are different than the vehicle owner of the average vehicle of that particular age and style. For example, the drivers may be younger, have lower incomes, live in places where driving every day is not necessary, etc. The owners of marginal vehicles likely make different driving decisions than would the average owners of the average vehicles of the corresponding age and style. Those owners may drive their vehicles less for any number of reasons.

By assuming all vehicles in the fleet are driven the amount that an average vehicle of that age and style are driven even after a vast increase in the fleet size, the agencies have failed to control for omitted variables and inflated the estimates of aggregate VMT increases.

An additional concern with the aggregate VMT analysis is the datasets the agencies use to construct the VMT schedules. For vehicles older than fifteen years, that dataset includes data from the 2008 recession.[436] But as the agencies themselves acknowledge, that year is unrepresentative and so should not be used. Given that a significant number of affected vehicles in the model are fifteen years or older,[437] a significant portion of VMT may come from vehicles whose schedules were calculated using this skewed data. This likely has serious consequences for the aggregate VMT estimates.

d.) *The agencies' analysis is inconsistent with their rebound welfare analysis*

The agencies' VMT analysis is also inconsistent with the agencies' rebound analysis, which finds that all fatalities stemming from those additional vehicle miles are offset by the private welfare benefits of increased driving.[438] It is arbitrary and capricious to include these offsetting benefits for rebound but ignore them for scrappage. Specifically, according to the agencies, drivers would gain expected utility from driving that must exceed their private cost from increased fatality risk (i.e., in this case from having a vehicle in the baseline policy that they do not have under the preferred policy). If an owner does not want to drive his or her used car more (i.e., does not want to take the relative risk to enjoy driving a used car more), that owner can sell the used car to someone else who would want to drive it (otherwise, it would be scrapped). In that case, the *marginal private benefits of driving* are equal to *the marginal costs of driving*. Therefore, the *private benefit of driving* must be greater than the *private fatality cost*, since we know that the private costs of driving include more than just fatality risk (i.e., time and gas

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[436] PRIA at 973.

[437] 83 Fed. Reg. at 43,097.

[438] *Id.* at 43,105 (showing that the costs of rebound are offset by the welfare benefits).

prices). Given that the agencies have included this welfare benefit in the rebound analysis, they should include it in the scrappage context.

3. Path forward

a.) *The agencies must conduct more study and have their models peer reviewed*

As explained above, the agencies' brand new scrappage model goes against basic economic theory.[439] In light of this, as well as the model's novel application, the agencies must have the model peer-reviewed.[440] The agencies should also conduct more inter-model comparisons. As discussed earlier, Bento et al. (2018) estimated that scrappage elasticity is -0.4 and Jacobsen and van Benthem (2015) estimated that it is -0.7.[441] The agencies' results are not consistent with these elasticity estimates. The agencies must provide an explanation for the divergence.

Out-of-sample testing is also necessary for the agencies' scrappage and sales models—as is true of any model. The nonsense results found by NHTSA indicate that NHTSA's scrappage model performs poorly out-of-sample.[442] The need for these kinds of checks is also consistent with the agencies' past consideration of the challenges of modeling scrappage. In its 2016 Proposed Determination, EPA rejected the use of a scrappage model based on the fact that the analysis requires additional scrutiny.[443] Specifically, EPA called for out-of-sample testing and inter-model comparison.[444] Such analyses would be consistent with similar out-of-sample analyses conducted in the scrappage literature.[445] The agencies have not identified anything in the literature or their approach that explains the change in EPA's conclusion on this point now.

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[439] PRIA at 1049 ("In summary, this analysis includes the effect of differentiated fuel economy regulations that only affect new and not used vehicles—and to our knowledge is the first dynamic vehicle scrappage model implemented in a larger framework.").

[440] See 77 Fed. Reg. 62,624 (summarizing the many studies that supported the Clean Car Standards and describing the peer-review that the agencies used to analyze that information).

[441] Jacobsen & van Benthem (2015), at 1333 (Table 6); *see also* Walker (1968), at 505; Gruenspecht (1982b), at 330; Bento et al. (2018), at 159. Though less relevant due to age, older papers estimate that the elasticity of scrappage with respect to new vehicle price is between -0.7 to -1.0. Walker (1968), at 505; Gruenspecht (1982b), at 330.

[442] Jacobsen & van Benthem Docket Letter. Their concern is unsurprising, as the agencies likely overfitted the data as the agencies selected models to maximize their explanation of in sample variation; this is true even as the agencies apply Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) in addition to root mean squared error (RMSE). See PRIA at 1015.

[443] EPA, Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation at A-43 (2016), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3DO.pdf [hereinafter "Proposed Determination].

[444] *Id*.

[445] Parks (1977), at 1111-1114; Greenstone and Cohen (1999), at 367-380.

b.) *In order to study the impact of new vehicle sales on scrappage and VMT, the agencies should link new vehicle sales and changes in used vehicle retention*

A fundamental flaw of the agencies' analysis is that the agencies have developed separate and unconnected models to estimate the size and composition of the fleet, and the number of miles traveled by various vehicles within that fleet. Consumer decisions regarding when to buy or not buy a new vehicle; decisions about buying, holding, selling, or scrapping a used vehicle; and decisions about how many miles to drive each vehicle that is owned; are all related to each other. The agencies' failure to connect these models is a large part of what is leading to unjustified results. The agencies should abandon their clearly incorrect approach and retain the approach the agencies have used for past fuel efficiency and GHG emission standards.

However, if the agencies insist on evaluating the dynamic changes in fleet composition that would be caused by the baseline standards, they must modify their approach in order to take into account these interconnections. There are a number of options for doing this, including:

- Developing an interconnected vehicle choice model;
- Using more sophisticated econometric techniques to connect the existing separate models;
- Controlling for all omitted variables;
- Applying fleet size and VMT constraints on the existing scrappage model while correcting for some of the econometric errors in the agencies' current approach.

In any of these cases, the agencies should control for omitted variables[446] and abide by the fundamental principles that we have laid out in these comments.

i.) Retaining the peer-reviewed approach from the Clean Car Standards

Without a robust methodology to account for the interconnections between the different fleet composition models, the only economically valid path forward would be to adopt the approach that the agencies used in their regulation promulgating the Clean Car Standards: assume a

[446] If it is not possible to control for the omitted variables, the agencies should consider included fixed effects for the following variables: brand fixed effects, vehicle type (segment or class) fixed effects; time scale fixed effects; geographic fixed effects; age and model year fixed effects, including dummies for the interactions between them. *See* Li et al. (2009) (dummies can control for omitted vehicle attributes and explaining that geographic fixed effects can capture unobserved demographics and other unobserved geographic variables that affect vehicle demand); Hamilton and Macauley, (1999), at 254; Li et al., (2009); PRIA, 948, 1012 (finding strong evidence of time trend in their new vehicles sales analysis and noting that scrap metal quantity decreases over time indicating the potential need for time-period fixed effect); Parks (1977), at 1104, at 1110; Gruenspecht, (1982a), at 97; Hamilton and Macauley, (1999); Jacobsen and Benthem (2015), at 1321. The agencies currently use polynomial variables for age and model year, however fixed effects are flexible and commonly applied in the literature. To "avoid imposing restrictions on the pattern of scrapping responses to new car price development across age groups," Gruenspecht (1982a) at 115) interacts new vehicle price with age dummies. Given the high statistical significance of these parameters, the agencies should consider this alternative instead of time trends.

constant, not dynamic, fleet.[447] Use of the new scrappage model in its current form without fleet size constraints is not a valid option.

In order to address any effects caused by the aging of the vehicle fleet,[448] the agencies could develop a simpler logistic scrappage model like those that solely capture the effect of vehicle age on scrappage, but those would not generally show an increase in overall VMT or fleet size.[449]

ii.) Vehicle choice model

An approach that models consumer decisionmaking using a vehicle choice model could, in theory, be a coherent and integrated approach to estimating the effect of the baseline standards on fleet composition. This is the approach taken by Jacobsen and van Benthem in a paper that the agencies repeatedly cite.[450] However, before making this change, the agencies would have to address the significant shortcomings of vehicle choice models that they identify in the Proposed Rule and ensure that those problems are addressed.[451]

iii.) Simultaneous equations

The agencies could investigate the use of simultaneous equations to estimate new vehicle sales, scrappage, and vehicle-miles traveled simultaneously.

Specifying structural models of the various components, rather than the reduced form, disconnected models, used in the Proposed Rule would aid in both ensuring consistency with the literature, as well as in identifying sources of endogeneity and candidate instrumental variables.

The agencies could build on the estimation strategies begun in Small and Van Dender (2007).[452] However, the agencies would need to separate total fleet size into new and used components.[453]

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[447] 77 Fed. Reg. at 62,716 (explaining the agencies' prior approach, which uses static vehicle turnover model and non-rebound VMT schedules that do not vary based on the stringency of the standards); *see also* Draft TAR at 10-6.

[448] Bento et al. (2018), at 178.

[449] Walker (1968), at 503; Green and Chen (1981), at 383; Feeney and Cardebring (1988), at 460; Hamilton and Macauley (1999), at 253; Bento et al. (2018), at 161.

[450] Jacobson and van Benthem (2015), at 1328-1329 (the authors refer to their model as a simulation model that captures leakage from scrappage and vehicle choice); Proposed Determination at A-43 ("We note that it relies on an estimated model of consumer vehicle choices that, as with most other models, has not been tested for out-of-sample validity or comparability with other models.").

[451] 83 Fed. Reg. at 43,076-43,078. EPA has previously argued that vehicle choice models are insufficient for policy making. Proposed Determination at A-44, A-47, A-48. EPA concluded that vehicle choice models are poor predictors of future shares, *id.* at A-45, often are out-performed by constant share models and have not been tested for their forecast ability. *Id.* at A-44).

[452] *See generally* Small and Van Dender (2007), at 30-33 (discussing methods).

[453] Id.

In addition, in order to properly control for variables at the vehicle and household level, the agencies should estimate VMT schedules of marginally scrapped vehicles.

iv.) Fleetsize and VMT constraints

If the agency does not adopt one of the above approaches, the only economically valid approach would be to apply "constraints" on aggregate fleet size and VMT in the VOLPE simulation so that aggregate fleet size and VMT does not change across the proposed and baseline rules. This approach would not be a panacea and would not address all of the flaws outlined above. But it would at least constrain the errors driving the increases in fleet size and VMT.

In interagency comments to NHTSA, EPA staff proposed a similar solution. EPA recommended that the agencies impose constraints on fleet size and VMT so that the agencies can isolate the Gruenspecht effect (or shift to used vehicles).[454] The methodology proposed by EPA staff would also allow fleet size to grow over time (in line with historical observation) and to just capture the scrappage factor: the aging of the fleet.[455]

In response to EPA's suggestions, NHTSA asserted that it could not use the adjustment factors proposed by EPA because they would be internally inconsistent.[456] But the agencies' scrappage results are inconsistent with basic economic logic and the academic literature and that is why these constraints are necessary. In fact, Gruenspecht himself recognized the need to impose fleet size and VMT constraints after modeling the connections between new car market, the used car market, and households' VMT decisions (as acknowledged by the agencies).[457] Gruenspecht explained that the disadvantage of the reduced form model he used (i.e., where scrappage is modeled as a function of new vehicle price and not the theoretically correct used vehicle price) is

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[454] Summary points from EPA review of CAFE model (NPRM version)–Effect of EPA code revisions. Meeting with Office of Management and Budget/OIRA 6/18/2018, slides 2-3, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th Attachment, pdf pages 4-5); EPA Further Review of CAFE Model & Inputs at 6-7 (June 18, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th Attachment, pdf pages 15-16).

[455] *See* Bento et al., (2018) at 178. Specifically, EPA found that the scrappage rate curves so that overall fleet size is unaffected by the policy (though it grows over time) and that VMT increases only with the rebound effect (and not scrappage). Summary points from EPA review of CAFE model (NPRM version)–Effect of EPA code revisions, Meeting with Office of Management and Budget/OIRA 6/18/2018, slides 2-3, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th Attachment, pdf pages 4-5); EPA Further Review of CAFE Model & Inputs at 6-7 (June 18, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th Attachment, pdf pages 15-16).

[456] NHTSA, Responses to Interagency Comments on NPRM Round 8 Received 7-11-2018, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (12th Attachment, pdf page 4).

[457] Gruenspecht (1982a), at 120, 126; Gruenspecht (1982b), at 329.

that it may produce inaccurate results and that constraints were thus necessary.[458] Specifically, he states:

> The primary argument in favor of the structural approach is based on the observation that new car markets are cleared primarily through quantity variation, while used car markets are cleared mostly though price adjustments. Therefore, used car prices and new car prices need not move in tandem. According to the framework developed in Section 4 and 5, there is no direct link between rational scrapping decisions and new car prices. Therefore a direct regression of scrapping rates on new car prices may fail to yield coefficients that approximate those obtained by solving a structural scrapping model that explicitly models the link between new car prices and used car prices.[459]

In other words, there is no direct link between new vehicle prices and used car scrappage. Instead, any link between scrapping decisions and new car prices is only indirect through the price of used cars. Because of this indirect connection, it is possible that a model will produce strange and theoretically inconsistent results without constraints, as the agencies' model indeed produced in the Proposed Rule.

An additional argument that NHTSA cited is that fleet size and VMT constraints may reverse the aging trend of the fleet observed over the last few decades.[460] But as the methodology could allow average historical fleet size growth as a modeling input, this concern is invalid. In fact, EPA provided an alternative approach to NHSTA during the period before the agencies published the Proposed Rule and modified the code to allow "the user to select a fleet growth rate."[461] The agencies provide no evidence that the problem could not be overcome in that way now.

Even if fleet size and VMT constraints are imposed on the model, other changes are still necessary to ensure that the agencies' approach will yield valid results. In particular, the agencies will need to carefully consider the connections between the simultaneously determined variables among the various disparate new vehicle sales, scrappage, and VMT models. In doing so, the agencies should carefully consider how the variables are connected based on theory. For

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[458] Gruenspecht (1982a), at 93.

[459] Gruenspecht (1982a), at 93.

[460] NHTSA, Response to Interagency Comments on NPRM Round 8 Received 7-11-2018, at 3-4, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (12th Attachment, pdf pages 3-4).

[461] Summary points from EPA review of CAFE model (NPRM version)–Effect of EPA code revisions, Meeting with Office of Management and Budget/OIRA 6/18/2018, slides 2-3, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th Attachment, pdf pages 4-5); EPA Further Review of CAFE Model & Inputs at 6-7 (June 18, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th Attachment, pdf pages 15-16).

example, Gruenspecht (1981): included the scrappage rate, new vehicle price, and new vehicle sales in his regression for used vehicle price;[462] in his structural scrappage regression, Gruenspecht (1982) included new vehicle sales;[463] in his corresponding reduced form regression, Gruenspecht (1982) included vehicle miles traveled per capita in order to address overall demand for driving, in addition to the vehicle stock in the previous period.[464] Gruenspecht (1982) also demonstrated that the quantity of new vehicle demand is a function of vehicle miles traveled per capita and vehicle stock in the previous period, in addition to new vehicle price.[465] The agencies should include the variables that Gruenspecht and others have traditionally included in their scrappage analysis, including price of vehicles indexed by maintenance and repair costs, the price of scrap metal, and interest rates.[466]

One shortcoming of this methodology is that it cannot capture the possibility of fleet size and VMT declining as new and used vehicle prices increase. Specifically, holding VMT and fleet size constant ignores the possibility that people will switch from used vehicles to shared forms of transit (e.g., mass transportation, existing household vehicles) as these prices increase. These features could cause a decline in fleet size and VMT should the new vehicle price change be large and should be assessed.[467] The agencies should model that as well

B. Safety consequences of changes in fleet composition

Even if the agencies are right that higher new vehicle prices will lead to an increase in the fleet size and total VMT (and they are not), their safety estimates are inflated.

1. Demand for vehicle safety should lower the impact of scrappage estimates

To make their fleet composition calculations, the agencies calculated the change in "distribution of both ages and model years present in the on-road fleet."[468] Then the agencies combined that information with data showing the fatality rates of vehicles by model year.[469]

But in calculating the impact that the price increases have on fatalities through slower turnover, the agencies have failed to consider the impact that a consumer preference for safety would have

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[462] Gruenspecht (1982a), at 81, 99-101.

[463] *Id.* at 106-107.

[464] *Id.* at 86, 109-113.

[465] *Id.* at 87.

[466] *Id. at 70.* Gruenspecht (1982a), at 103, 109-113, 117 (including interest rates).

[467] Jacobsen & van Benthem Docket Letter at 2. (referring to a switch from the baseline policy to the Proposed Rule and stating that the extent to which the fleet will decrease "depends on the magnitude of the price changes and the aggregate elasticity to the outside good").

[468] 83 Fed. Reg. at 43,135.

[469] *Id.* at 43,135-37.

on that slower turnover.[470] For some time, the literature has demonstrated that consumers prefer safer vehicles. Since the 1980s, a top vehicle safety rating for a particular vehicle model has significantly increased demand for that vehicle model.[471] The agencies themselves acknowledge that safety is a vehicle attribute that consumers value.[472] Given this preference, consumers may continue to choose relatively safer new and used cars and manufacturers may continue to supply relatively safer vehicles, and so the impact that any decreased turnover would have on safety would be muted.

It would be unreasonable for the agencies to ignore the fact that safety affects consumer decisionmaking. Academic economists have developed tools that can facilitate analysis of these types of interconnected relationships. For example, fuel efficiency programs may lead to more congestion through rebound, but the additional congestion itself deters travel and depresses the impact of the additional congestion. For that reason, Hymel et al. used simultaneous equations that capture the inter-connected relationship between fuel efficiency and congestion to estimate the impact of fuel-efficiency programs on congestion.[473] Likewise, Small and Van Dender recognized the endogenous characteristic of fuel efficiency: fuel efficiency causes more driving and more driving causes a demand for fuel efficiency to increase. Because of this interaction, Small and Van Dender calculated the impact of fuel efficiency programs on VMT through simultaneous equations.[474] As these papers show, all the vehicle aspects (VMT, fuel efficiency, vehicle age) are interrelated and ignoring the feedback effects (those interconnectedness), as the agencies are currently doing, produces flawed or even meaningless results. The agencies should estimate the simultaneous interaction between fuel-efficiency standards and safety. Without fixing these flaws, the agencies' results are arbitrary and capricious.

2. The failure to control for confounding factors has led to inflated estimates

The agencies also fail to control for confounding factors. There are three major causes of crashes: "the driver, the vehicle, and the environment in which crashes occur."[475] Within these categories, many different features besides design can lead to changes in the real-world

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[470] *See* PRIA at 952-953 (listing the inputs in the sales model, which does not include any variable or proxy variable for vehicle safety).

[471] McCarthy (1990), at 534-41 (explaining that studies in the 1980s showed that vehicle safety was one of the most important attributes for consumers); *see also* Kaul et al. (2010) (describing US consumer preferences for safety features).

[472] PRIA at 933 ("this analysis recognizes that manufacturers' changes in the fuel economy and emissions levels of new vehicles in response to raising or lowering federal standards may also entail changes in other attributes that . . . potential buyers also value . . . include[ing] . . . occupant safety").

[473] Hymel et al. (2010), at 1220-21.

[474] Small & Van Dender (2007), at 30-31; *see also* Hymel & Small (2015), at 95 (using simultaneous equations to calculate impact of fuel efficiency on VMT).

[475] Farmer and Lund (2006), at 342.

performance of the on-road vehicle fleet. For example, improved safety laws and programs (including speed limits and licensing laws), urbanization (i.e., congestion), driver behavior like seat belt use, improved road design, improved traffic law enforcement, less alcohol-impaired driving, economic downturns, and improvements in ambulance response times can all lead to fewer fatalities.[476]

As such, these factors are typically studied in the literature through the age of the vehicle (as a proxy for driver), the model year (to account for vehicle design), and the calendar year (to account for environmental factors).[477]

In the Proposed Rule, the agencies attempt to quantify the influence of vehicle age and vintage (i.e., model year) on fatalities by analyzing aggregate fatality data from years 1996 to 2015.[478] Specifically, the agencies look at "real world performance in the on-road vehicle fleet."[479] The agencies explain that they used age as a proxy variable for driver behavior[480] and vehicle model year as a proxy for safety technology trends. The agencies use the results of those quantifications to predict how changes in turnover will affect road fatalities.

But those quantifications are inflated for two reasons.

First, the agencies fail to control for the third factor that is relevant to crashes: environmental changes.[481] Specifically, as the driving environment has generally improved over time,[482] the coefficients corresponding to model year overestimate improvements in the safety features between the model years. Not controlling for all the non-vehicle variables that increase safety

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[476] See Famer & Lund (2006), at 339-341; Farmer & Lund (2015), at 685-686 (citing the 2008 recession, improvements in road design, and improved driver behavior as potential factors that improved on-road performance); *see also* Anderson & Searson (2015) at 202 (explaining that a vehicle's age and crash risk are likely correlated with the characteristics of the average driver associated with vehicles of a particular age as well as with the distance and type of driving associated with vehicle age and explaining that "[r]isks created by conditions separate from the vehicle (road-safety related changes to infrastructure, speed limits, other legislation, enforcement and behavior)" likely also have an impact on the crash statistics).

[477] Farmer and Lund (2006), at 341-342; Anderson and Searson (2015), at 202.

[478] 83 Fed. Reg. at 43,136. Specifically, the agency regresses U.S. fatalities per billion miles on a polynomial of vehicle age (a proxy for driver behavior) and model year fixed effects: $F_{it} = \beta_0 + \sum_{j=1}^{4} B_j * Age_{it}{}^{j} + \sum_{i=1976}^{2014} \gamma_i * MY_i + \varepsilon_{it}$ where F_{ijt} are fatalities of model year i in calendar year t, Age_{it} is vehicle age of model year i in calendar year t, MY_i is model year i, and ε_{it} is the error term. In this regression, γ_i are the values of interest (i.e., improvements in safety).

[479] 83 Fed. Reg. at 43,140.

[480] Farmer and Lund (2006), at 341-342; PRIA at 1406-1407.

[481] *See Id.* at 1382; 83 Fed. Reg. at 43,136 (explaining that the model lacked the "internal structure" to account for vehicle speed, seat belt use, drug use, or age of drivers); PRIA at 1392 (stating that "fatality rates associated with different model year vehicles are influenced by the vehicle itself and by driver behavior" ignoring environmental factors altogether).

[482] Farmer and Lund, (2015) at 686 (Figure 2).

over time is unacceptable and biases the results towards very high fatalities under baseline standards.

Second, the vehicle age variables are only a rough proxy for driver behavior because they can only capture driver behavior that does not change over time. For example, if the social acceptance of drunk driving decreases and consequently drunk driving decreases, the age variable would not capture that change. As such, the agencies could not adequately control for driver behavior trends. And a decrease in fatalities could look like it was caused by vehicle improvements over time rather than societal changes.

In statistical terms, because of these problems, the safety estimates suffer from omitted variable bias. The agencies recognize the issues with respect to seat belt use trends but ignore (or fail to recognize) the overall extent of this problem in their analysis.[483]

Omitted variable bias is a serious statistical problem in the vehicle safety context. Omitted variable bias occurs when an omitted variable (e.g., environmental and behavior trends) is correlated with the included regressor (e.g., the age of the vehicle and model year), and when these omitted variables are determinants of the dependent variables (e.g., fatalities).[484] Environmental and behavioral trends clearly affect fatalities and are correlated perfectly with age and model year. Since the bias gets worse as the regressors become more correlated (e.g., age of the vehicle and model year) with the omitted variables (e.g., environmental and behavior trends),[485] the perfect correlation of the calendar year variable with model year plus age creates a severe bias.

As a result of the omission of these variables in the safety analysis, the agencies do not capture causal relationships between vehicle vintage (i.e., model year) and vehicle age and fatalities, but only correlations, leading to misleading and sometimes even meaningless estimates.

Figure 3 shows that results of the agencies' age estimates contradict the literature and intuition. That Figure confirms that the agencies' analysis captures meaningless correlations and not causation. Figure 3 plots the agencies' estimate of the relationship between car age and fatalities and shows a huge drop in fatalities as vehicles age.[486] But as the literature demonstrates, fatalities clearly increase with vehicle age.[487] Indeed, NHTSA recognized this in 2013, in a report cited

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[483] PRIA at 1395-1399.

[484] Stock and Watson (2007), at 187.

[485] *Id.* at 190.

[486] The estimated relationship is given by polynomial: $28.59 - 3.63\text{x} + 0.76x^2 - .04x^3 + 0.0005x^4$. *See* 83 Fed. Reg. at 43,138.

[487] Farmer and Lund (2006), at 339 (Figure 3); Farmer and Lund (2015), at 686 (Figure 1).

and described in the Proposed Rule.[488] And the agencies also recognized this in the Proposed Rule.[489]

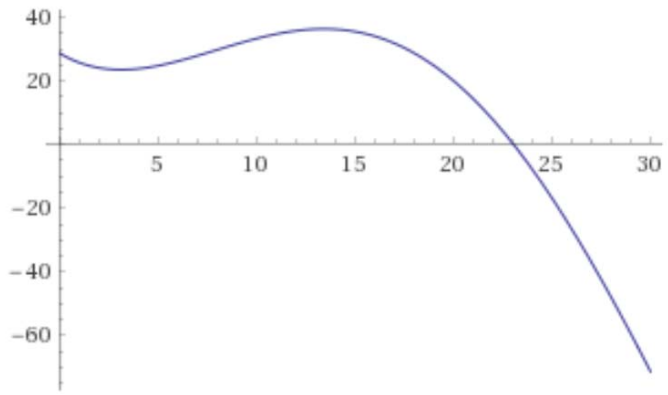

Figure 3. Agencies estimate of relationship between car age (x-axis) and fatalities per billion miles (y-axis)

As Figure 3 helps show, estimating correlations instead of causal relationships poses huge problems for the type of predictive analysis that the agencies have set out to do. As economic textbooks have long acknowledged: "Knowing that two factors are correlated provides no predictive power; prediction requires understanding the causal links between the factors."[490]

The agencies do not adequately address these biases, despite several strategies that are available in the literature. For example, analyses, including by NHTSA itself, have been able to calculate the impact of vehicle design changes on safety, while controlling for many of the related and confounding behavioral or environmental factors.[491] In its prior rules, NHTSA itself has controlled for vehicle age, body type, air bag deployment, roadway function class, day/night, occupant age, gender, number of vehicles in crash, restraint use, principal impact point, speeding involved, speed limit, ejection status, rollover, interstate road, occurring at an intersection, motorcycle involved in the crash, roadway departure, number of occupants; even more

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[488] 83 Fed. Reg. at 43,135 (describing National Center for Statistics and Analysis, *How Vehicle Age and Model Year Relate to Driver Injury Severity in Fatal Crashes* 6 (Aug. 2013), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811825).

[489] *Id*.

[490] Grueber (2010), at 66.

[491] *See* Farmer & Lund (2015), at 685-686 (describing studies); Blows et al. (2003), at 354 (controlling for driver demographics (e.g., age, sex, race, education level), behavioral characteristics (e.g., alcohol and marijuana consumption, driving speed, seatbelt usage), and vehicle characteristics (engine size, inspection certificate); Ryb et al. (2013), at 257 (controlling for driver age, sex, weight, seatbelt use); Farmer and Lund (2006), at 339-341.

behavioral variables are controlled for in the literature.[492] Indeed, in the PRIA, the agencies showed how fatalities by vehicle age are correlated with seat belt usage, alcohol consumption, and speeding.[493] The agencies concluded: "[t]herefore, it is important to control for behavioral aspects associated with vehicle age so only vehicle design differences are reflected in the estimate of safety impacts."[494] Inexplicably, the agencies then claimed to have addressed this issue by controlling solely for vehicle age.[495] However, given the omission of important confounding factors in the analysis, controlling solely for age is insufficient.

Rather than control for these factors when analyzing the actual safety impact of changes in fleet turnover, the agencies argue that they are unable to include additional control variables because "[v]ehicle interactions are simply not modeled at this level."[496] But NHTSA has managed to control for these factors before.[497] And as the model's results are counterintuitive and in conflict with economic research, the agencies should fix the model rather than ignoring the problem. The agencies further argue that they cannot control for these variables, because they cannot project (i.e., forecast) the variables into the future.[498] But as long as the agency controls for the confounding variables, it does not matter how those variables change in the future.

Given the flaws of the current methodology and the importance of the safety findings to the agencies' ultimate results, the agencies should control for all of the variables that they have controlled for in the past and which are controlled for in the literature. This should also include all relevant variables from the mass-footprint regressions discussed below to avoid double counting the impacts of vehicle mass on fatalities.

Additionally, as the usage of aggregated data does not allow for full identification of the effects,[499] the agencies should disaggregate their data (i.e., use more atomistic or regional data) allowing them to break the strict equality between calendar year, model year, and age of vehicle (discussed above); this would allow the agencies to control more generally for trends in environment and behavioral safety over time.[500] For example, the agencies can create model year

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[492] Glassbrenner (2012), at 26-39, 4349; NHTSA (2013b), at 2-3; NHTSA (2018), at 528.

[493] PRIA at 1393-94.

[494] *Id.* at 1394.

[495] *Id.* at 1394-95.

[496] *Id.* at 1381.

[497] NHTSA (2013b), at 2-3.

[498] PRIA at 1381-82.

[499] *See* NHTSA (2013b), at 6

[500] Ideally, we would like to control for other safety trends over time independent of vehicle design. Ideally, the agency could instead estimate $F_{it} = \beta_0 + \sum_{j=1}^{4} B_j * Age_{it}{}^{j} + \sum_{i=1976}^{2014} MY_i + \sum_{k=1}^{K} \mu_k * Time_t{}^{k} + \alpha X_{it} + \varepsilon_{it}$ where X_{it} would control for more detailed behavioral and environmental variables (discussed in the previous suggestion)

groups for which safety features do *not* change (i.e., between model redesigns) to break the link between calendar year, model year, and vehicle age[501]; this requires data at the vehicle model and body style level in addition to calendar year and model year.[502] The agencies should also consider running an age-period-cohort (APC) model as a sensitivity analysis, where model year is the cohort.[503] The agencies should also conduct a sensitivity analysis that replaces the age variable with a calendar year variable and use that specification if it improves model fit.

The agencies performed some plausibility checks on their results, but they are unconvincing. For example, the agencies compared their results with those of Glassbrenner, one of the authors who has conducted studies on the impact of vehicle design improvements and who has controlled for some of the confounding factors discussed above.[504] The agencies also compared their results with data from Kahane, who controlled for seatbelt usage.[505] The agencies claimed that it is "encouraging" that their approach and the Kahane and Glassbrenner approaches showed a "similar directional trend" in their results.[506] But the fact that the directional trend is similar does not address whether or not the agencies' approach ignores too many confounding variables to be at all reliable. Indeed, the agencies could be *vastly* inflating the change in fatalities and the directional trends could still go in the same direction. In fact, the agencies acknowledge that their analysis shows some significant divergence with the data provided by Kahane and attribute this difference to the fact that Kahane directly controls for seatbelt usage whereas their analysis does not.[507] Comparing the results with the Kahane and Glassbrenner results is thus not sufficient. The agencies should control for the confounding variables themselves, as described here, and provide the estimates to the public for comment. Any other strategy would lead to unreliable and inflated results.

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and the polynomial of time (i.e., calendar year or the year that the accident occurred in) would control for more generally for trends in environment and behavioral trends. However, panel data only allows an analyst to control for two of these three variables, as the calendar year equals vehicle age plus model year. Anderson and Searson (2015), at 203. A consequence of this technical problem in safety regressions is that analysts can only control for two out of the three variables using a standard regression analysis, such that the coefficients of the remaining variables (i.e., the age variable and the model year fixed effects) suffer from omitted variable bias. This situation is known as the classical age-period-cohort (APC) problem that arises in human health studies. *Id.*

[501] Farmer and Lund (2006), at 336.

[502] *Id.* at 335.

[503] *See* Anderson & Searson (2015), at 203-205 (discussing age-cohort models).

[504] PRIA at 1395-1396.

[505] *Id*. at 1396-1397.

[506] *Id*.

[507] PRIA at 1397.

Given the counterintuitive results shown above for vehicle age, the agencies should also expand the set of model fit tests. Specifically, they should compare the model results to Farmer and Lund (2015) and NHTSA (2013); the latter of which is an update of Glassbrenner by NHTSA.

3. The agencies have not provided an adequate explanation for why past safety trends are likely to continue until the mid-2020s

The agencies' estimates of safety trends lacks an adequate explanation. To evaluate the impact of turnover on safety, it is critical to understand the improvements in safety that would be obtained through more turnover as distinct from those that would be obtained regardless of fleet turnover. Specifically, the agencies must come up with an estimate or prediction about the safety improvements that would be missed with lower turnover. In the Proposed Rule, the agencies analyze the past safety trends and assume that the past trend in safety improvements will continue until the mid-2020s.[508]

But data on existing and past safety trends reflects improvements that are different in kind from the safety improvements that are expected between now and the mid-2020s, and so data on past trends is not a good basis for concluding that safety will continue to increase along the same trajectory through the mid-2020s.

The safety trend data reflects a number of improvements that were made to vehicles, which generally improve passenger safety if and when there is a crash. For example, the improvements that have been adopted over the past decade or so include, electronic stability controls,[509] side airbags,[510] and bumper alignment.[511] But to improve safety in the future, manufacturers will have to adopt more engineering changes that help vehicles *avoid* crashes, rather than focusing on mitigating them. Some potential technologies include forward collision warning; crash imminent braking; dynamic brake support; pedestrian automatic emergency breaking (PAEB); rear automatic breaking; semi-automatic headlamp beam switching; rear turn signal lamp color; lane departure warning; and blind spot detection.[512] Crash avoidance technology may not be adopted as easily or readily as crash mitigation technologies have been. In fact, the agencies acknowledge that the effectiveness of crash avoidance technologies and the pace of their adoption "are highly uncertain."[513] These future safety technologies differ from past safety technologies in a fundamental way. Should those new safety technologies be adopted, the predicted fatalities for

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[508] 83 Fed. Reg. at 43,139.

[509] Wenzel (2013), at 71-81.

[510] *Id.* at Figure 3.

[511] *Id.* at Figure 4.

[512] *See* 83 Fed. Reg. at 43,139-40.

[513] *Id.* at 43,139.

all the older vehicle vintages will have to be lowered as well because effective crash avoidance technologies will lower all vehicles' fatality costs.

NHTSA should explain how its assumption that the trends will continue through the mid-2020s is valid.

VI. THE AGENCIES' CHOICE OF REBOUND EFFECT IS ARBITRARY AND CAPRICIOUS

Improved vehicle efficiency makes driving cheaper, and so encourages more driving. This is termed the "rebound effect."[514] Rebound is expressed in terms of the percentage of any fuel economy savings that will be lost once consumers act on those preferences for increased driving. That additional driving results in a number of costs (increased air pollution, fuel consumption, traffic congestion, and vehicle crashes), and benefits (additional consumer utility of driving, reduced time to refuel vehicles) and the agencies have previously considered these costs and benefits when setting their standards.[515] The agencies relied on a 10% rebound estimate in the Clean Car Standards. But now the agencies have arbitrarily doubled that estimate.[516]

To arrive that the new estimate, the agencies make significant changes to their assumptions about the magnitude of the rebound effect. These changes result in a significant increase in the costs and fatalities that the agencies attribute to the baseline standards.[517] These fatalities and costs serve as a justification for rolling back those standards.[518] These methodological changes account for 3,170, or 25 percent of the additional fatalities that the agencies ascribe to the baseline standards,[519] and 6.5-6.8 percent of the quantified net benefits that the agencies claim would be gained from rolling back the baseline standards.[520] But the agencies' methodological changes are inconsistent with the best available evidence regarding rebound. And the agencies have failed to provide a reasoned basis for their new rebound conclusions.

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[514] 77 Fed. Reg. at 62,924. More specifically, this is considered the "direct" rebound effect. While the academic literature also discusses an indirect rebound effect, *see* Gillingham et al. (2016), at 72, that effect has not been incorporated into the agencies' analysis and is not the subject of our comments on rebound.

[515] Draft TAR at 10-9 to 10-10-21; 77 Fed. Reg. at 62,716.

[516] *Compare* 77 Fed. Reg. at 62,716, 62,924 (10%) *with* 83 Fed. Reg. at 43,104 (20%).

[517] PRIA at 1546, 1548 (showing higher net benefits of roll back under agencies new rebound assumptions than under previous rebound assumptions).

[518] 83 Fed. Reg. at 43,211 (explaining that NHTSA considers increased emissions that result from additional driving due to the rebound effect); *id.* at 43,212 (explaining that NHTSA considers increased fatalities that result from additional driving due to the rebound effect); *id.* at 43,230 (explaining that EPA considers the level of GHG emission reductions, which is determined, in part, by increased driving due to rebound); *id.* at 43,231 (explaining that EPA considers additional fatalities that result from increased driving due to rebound).

[519] *Id.* at 43,153; see also PRIA at 1540.

[520] *Id.* at 1546, 1548.

A. Defining rebound

There are three different components of rebound with fuel efficiency regulations. First, fuel efficiency lowers the per mile cost of driving. As the activity costs less, consumers will do more of it compared to other things. This is called the "substitution effect." Second, as driving costs less, consumers can afford more of everything, including driving. This is called the "income effect." Third, the decrease in the cost of driving is enabled by fuel efficiency technology that could increase the cost of the vehicle.[521] So consumers who spend more money upfront on a fuel efficient vehicle will have less income to spend on other products, including driving. This "capital cost income effect" has a negative rebound effect by offsetting the income effect from fuel savings. These components of rebound should be analyzed using the following formula:

ΔVMT equals $\frac{\partial q^H}{\partial p}\Delta p + \frac{\partial q}{\partial I}(q\Delta p - C)$

Where:

- $\frac{\partial q^H}{\partial p}$ is the change in (Hicksian) demand for VMT from a price change,
- $\frac{\partial q_0}{\partial I}$ is the change in (Marshallian) demand for VMT from an income change,
- q is the demand for VMT,
- p is the cost per mile of driving, and
- C is the additional cost associated with acquiring the improved energy efficient vehicle.[522]

This definition includes the three independent effects on VMT from the purchasing of a vehicle:

- $\frac{\partial q^H}{\partial p}\Delta p$ measures the substitution (effect) towards more driving with a decrease in the cost of driving (from a more efficient vehicle);
- $\frac{\partial q}{\partial I}q\Delta p$ measures the increased demand for driving due to more money being in a household's pocket from a lower cost of driving;
- and $\frac{\partial q}{\partial I}C$ measures the decreased demand for driving due to less money being in a household's pocket from the capital cost of acquiring the vehicle.

B. The agencies arbitrarily changed their rebound estimates to 20% from the previous estimates of 10%

The agencies have proposed to use a rebound estimate of 20% after previously setting it at 10%.[523] But the agencies have failed to show that there are good reasons for their decision to

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[521] For more detail on this aspect of the formula, see Section II.

[522] Gillingham (2014b), at 11375-11378.

[523] 83 Fed. Reg. at 43,104.

reverse course in this way.[524] The agencies cite NHTSA's 2005-2011 CAFE standards to assert that they are merely returning to past practice in using a 20% rebound estimate.[525] But in doing so, they ignore 10 years of their own analyses, the advances in the academic literature, and expert conclusions regarding the appropriate rebound estimate. Since that 2005 rulemaking, the agencies have updated their analysis and they have not relied on that 20% rate. In 2010, the agencies used a 10% rebound estimate as part of the agencies' joint CAFE and GHG emission standards for MY2012-2016.[526] In 2012, in adopting the Clean Car Standards, the agencies again arrived at the conclusion that an estimate of 10% would best reflect the rebound expected for the baseline standards.[527] In 2016, in the Draft TAR, the agencies collectively updated their evaluation of the literature and proposed to reaffirm their conclusion that 10% was the appropriate rebound estimate.[528] In 2017, EPA finalized its portion of that proposal and found that the 10% rebound estimate was appropriate.[529] In fact, as far back as 2009, NHTSA determined that the literature did not support a 20% rebound estimate.[530]

All of the arguments that the agencies provide for reserving course on these prior analyses are unavailing. As such, the agencies have failed to satisfy their duty to provide a "reasoned explanation . . . for disregarding facts and circumstances that underlay or were engendered by the prior policy."[531]

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[524] Fox Television Stations, 556 U.S. at 515.

[525] 83 Fed. Reg. at 43,104 (explaining that the use of 20% "represents a return to the value employed in the analyses for MYs 2005-2011 CAFE standards").

[526] Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 25,324, 25,516-516 (May 7, 2010) (explaining use of 10% estimate).

[527] 77 Fed. Reg. at 62,924.

[528] Draft TAR at 10-9 to 10-21.

[529] *See* Final Determination (concluding that the baseline standards were appropriate in light of the Draft TAR, Proposed Determination, Proposed Determination TSD, and public comments); EPA, Proposed Determination on the Appropriateness of the Model year 2025-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards under the Midterm Evaluation: Technical Support Document at 3-8 to 3-21 (2016), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100Q3L4.PDF?Dockey=P100Q3L4.PDF [hereafter "Proposed Determination TSD"] (reconsidering rebound literature on rebound considered as part of Draft TAR and literature since Draft TAR to conclude 10% rebound estimate is appropriate).

[530] At that time, NHTSA used a 15% rebound rate when establishing the MY 2011-2015 CAFE standards, without EPA's involvement. NHTSA, Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks: Final Regulatory Impact Analysis at VIII-5 to VIII-8 (2009), https://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/CAFE_Final_Rule_MY2011_FRIA.pdf (explaining why NHTSA selected a 15% rebound estimate); *id.* at I-47 to I-49 (explaining why the agency rejected a 20% rebound estimate advocated by some commenters).

[531] *Fox Television Stations*, 556 U.S. at 516.

1. The agencies point to no new evidence supporting a 20% rebound and, in fact, ignore new evidence on rebound that does not support the new 20% assumption

In order to support a 20% rebound estimate, the agencies primarily point to an average that they calculate from various rebound estimates in the academic literature and criticize their prior conclusions as inconsistent with those averages.[532]

As a preliminary matter, the data that the agencies discuss in the proposed rule has generally already been discussed and considered by the agencies in previous rulemakings in which they arrived at the 10% rebound estimate. And the agencies have not identified a meaningful change in the facts, which would justify the new estimate. Specifically, the table on pre-2008 studies that the agencies cite contains the same data that the agencies used to arrive at a different conclusion in 2012.[533] As is made clear in Table 3 below, derived from the various cited rules, virtually all of the post-2008 studies that the agencies now list and discuss were already considered when the agencies promulgated the Clean Car Standards and when they reaffirmed those standards as part of the Draft TAR and EPA's Final Determination. The agencies have not explained how they arrived at different factual conclusions using the same evidence.

[532] 83 Fed. Reg. at 43,100-101, 43,104, 43,105.

[533] NHTSA 2012 FRIA at 849 (TABLE VIII–1, presenting summary statistics on rebound estimates for pre-2008 studies).

Table 3. Post-2008 Rebound Studies Discussed or Considered as Part of Rulemaking and Analyses

	SAFE Proposed Rule[534]	Clean Car Standards[535]	TAR[536]	EPA Final Determination[537]
Small and Van Dender (2007)	X	X	X	X
Barla et al. (2009)	X		*	*
Bento (2009)	X		X	X
Waddud (2009)	X		X	X
Hymel et al. (2010)	X[538]	X	X	X
Gillingham (2011)		X	X	
West and Pickrell (2011)	X		X	
Anjovic and Haas	X			
Green (2012)	X (not discussed)	X	X	X
Su (2012)	X		X	X
Linn (2013)	X		X	X
Frondel and Vance (2013)	X		X	X
Liu (2014)	X		X	X
Gillingham (2014)	X		X	X
Wang and Chen (2014)				X
Weber and Farsi (2014)	X			
Hymel & Small (2015)	X		X	X
West et al. (2015)	X		X	X
DeBorger (2016)	X		X	X
Gillingham et al. (2016)			X	X
Stapleton et al. (2016, 2017)	X (only in PRIA[539])			

Italicized studies are studies that have been considered in previous agency analyses but that are not discussed in the Proposed Rule.
Bold studies are studies considered in the Proposed Rule that have not been considered previously.
* included in discussion of Gillingham (2016)

[534] PRIA at 983-992.

[535] EPA & NHTSA, Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards at 4-23 to 4-24 (2012) [hereafter "Clean Car Standards TSD"].

[536] Draft TAR at 10-9 to 10-19

[537] Proposed Determination TSD at 3-8 to 3-21.

[538] The agencies discuss Hymel et al. (2010) but do not include it in the list of studies they considered. *See* 83 Fed. Reg. at 43,103; PRIA at 983.

[539] *Id.* at 992.

As Table 3 shows, the Proposed Rule identifies three studies that the agencies did not previously consider: Anjovic and Haas (2012), Weber and Farsi (2014); and Stapleton et al. (2016; 2017).[540] But the agencies do not even purport to rely on these new studies as particularly relevant when selecting their rebound estimate.[541] And in any event, the new studies do not provide strong new support for the agencies' 20% rebound estimate. All three of the papers studied rebound outside the United States, which, as we explain in detail below, should receive relatively less weight. Moreover, Weber and Farsi (2014) used cross-sectional data (an analysis of rebound in only one year), which, as we also explain below, should also receive relatively less weight. Therefore, the only new evidence that the agencies considered does not support the change in position.

While the studies the agencies discuss in the proposed rule have previously been considered, the Proposed Rule inexplicably fails to discuss a number of studies that were previously considered. As demonstrated by the bolded studies in Table 3, the agencies fail to discuss, mention, or even list a number of studies that they previously considering in arriving at their 10% rebound estimate, including Gillingham (2011), Wang and Chen (2014), and Gillingham (2016). These latter two studies provided substantial support for the agencies' 2012 and 2016 decisions to use a 10% rebound estimate.[542] The agencies also fail to analyze Greene (2012), even though it is listed in a table in the PRIA.[543] That paper also provided strong support for the agencies' previous 10% rebound findings.[544] Ignoring these studies now is arbitrary and capricious.

As Table 3 helps illustrate, contrary to the agencies' claim,[545] they have not conducted a complete survey of the economic literature on the rebound effect with respect to vehicles. Many of the missing studies are high-quality studies that should inform the agencies' decisionmaking. Besides the studies that the agencies previously considered, the agencies also omit many of the recent papers on this topic, including a 2015 study by Ken Gillingham, A Jenn, and I.M

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[540] *See* 83 Fed. Reg. at 43,101.

[541] *See* PRIA at 992-994 (discussing the key studies the agencies use to select a rebound estimate without discussing any of these studies).

[542] Draft TAR at 10-19 to 10-20 (listing Gillingham (2016) in the "Basis for Rebound Effect Used in the Draft TAR" section); Proposed Determination TSD at 3-16, 3-19 (discussing Wang and Chen (2014) as the only new study since the Draft TAR, and relying on the fact that the study found *no* rebound effect for households other than low-income households as part of the "Basis for Rebound Effect Used in this Proposed Determination" discussion).

[543] PRIA at 983 (listing Green (2012) in Table 8-8 without any further discussion).

[544] Proposed Determination TSD at 3-12 to 3-13, 3-20 (stating that Greene (2012) "appears to support the theory that the magnitude of the rebound effect "is by now on the order of 10 percent" and discussing the study in the "Basis for Rebound Effect Used in this Proposed Determination" section); Draft TAR at 10-14, 10-20 (same).

[545] PRIA at 982 ("Table 8-8 summarizes estimates of the rebound effect reported in research that has become available since the agencies' original survey, which extended through 2008").

Azevedo,[546] and a 2018 paper by T.P. Wenzel and K.S. Fujita.[547] These estimates generally contain rebound estimates that are lower than 20% and the agencies should not ignore them.

In addition, a large number—32—of the studies identified in a recent meta-analysis of the rebound literature are missing from the agencies' analysis, including 14 US-based estimates.[548] Of these omitted estimates, Wang and Chen (2014) and Dillon et al. (2015) are particularly useful rebound studies because they provided estimates of U.S. rebound, estimated fuel efficiency rebound (which, as is described below is distinct from other less useful estimates of rebound that appear in the literature), and used methods that account for endogeneity.[549] These additional studies do not support the agencies' decision to reject the 10% estimate and adopt the 20% instead and the agencies should not ignore them either.

2. The Proposed Rule's criticisms of the 10% rebound estimate are not compelling

In defending their reinterpretation of the evidence, the agencies primarily argue that the basis for the 10% rebound estimate was limited to a 2007 study by Small and Van Dender, whose assumptions have not borne out.[550] Specifically, the agencies argue that the 10% estimate was justified only if income increases are as assumed in that paper, and according to the agencies, follow-up analyses by Hymel et al. (2010) and Hymel and Small (2015), found a weaker relationship between rebound and income and produced higher rebound estimates as a result.[551] But this argument is wrong for several reasons.

First, the agencies are incorrect that the single Small and Van Dender (2007) study formed the only basis for their prior conclusion that rebound falls as incomes rise and that a 10% estimate was appropriate. In their 2012 Clean Car Standards, the agencies also cited to a wider range of academic literature, including Greene (2007), and Hymel et al. (2010), to support the specific claim that rebound will decline over time due to increases in income.[552] The agencies reaffirmed this claim in 2016 and cited several high quality and more recent academic studies, including Wadud et al. (2009), Green (2012), Gillingham (2014), and Hymel and Small (2015).[553] In the

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[546] Gillingham et al. (2015).

[547] Wenzel & Fujita (2018).

[548] *Compare* Dimitropoulos et al. (2018), at 173 (identifying 45 studies, including 21 studies of the U.S.) *with* PRIA at 983 (identifying 16 studies, including 10 studies of the U.S. included in Dimitropoulos et al. (2018) and 3 studies of the U.S. that are not included in Dimitropoulos et al. (2018)).

[549] Dillon et al. (2015); Wang & Chen (2014). Note, however, that both studies omit capital costs and are cross-sectional estimates; the latter study provides only short-run estimates. *See* Dimitropoulos et al. (2018), Appendix D.

[550] 83 Fed. Reg. at 43,104-105; PRIA at 989.

[551] 77 Fed. Reg. at 62,924 (discussing academic literature supporting a rebound rate that declines over time)

[552] 77 Fed. Reg. at 62,924 (citing Greene (2007), and Hymel et al. (2010)).

[553] Proposed Determination TSD at 3-20 ("Wadud et al. (2009) and Gillingham (2014) find that household and individual-vehicle rebound increases, respectively, with increases in household income"); Draft TAR at 10-20

2016 analyses, the agencies also cited a 2016 peer-reviewed assessment of the rebound literature by Ken Gillingham and coauthors.[554] The Gillingham paper developed selection criteria for identifying the most reliable studies, and selected only two studies of US rebound effect as meeting the criteria.[555] Both of these studies arrived at rebound estimates below 10%.[556] All of these papers supported the previous conclusion that rebound falls with income. Ignoring all of this support for the 2012 and 2016 determinations is arbitrary and capricious.

Second, the agencies now point to a handful of studies that they had already considered, including Hymel et al. (2010), Hymel and Small (2015), and claim those studies undermine the agencies' previous conclusions about the relationship between income and rebound and the 10% estimate.[557] The agencies fail to acknowledge that they previously used these very studies to *support* the income effect, as described above. Moreover, while some of the rebound estimates presented in those studies are higher than those found in Small and Van Dender (2007), those higher estimates do not undermine the 10% estimate for several reasons.[558] For example, the 18% estimate in Hymel and Small (2015) that the agencies now rely on was produced using a deliberately simplified model, which the agencies previously concluded is more relevant for estimating rebound from changes in fuel prices than rebound from changes in fuel efficiency.[559] In any event, using more sophisticated modeling, the Hymel and Small (2015) paper found a 4.0%-4.2% rebound estimate, which the authors found to be more representative than the 18% rebound estimate cited by the agencies.[560] As such, that paper recognizes that the 18% estimate may not be accurate. In addition, Hymel and Small (2015) studied a time period that included the

("Greene [2012] reports evidence that the magnitude of the rebound effect is likely to be declining over time as household incomes rise which would be consistent with Gillingham's (2014) results showing that individual-vehicle rebound increases with household income").

[554] Draft TAR at 10-20; Proposed Determination TSD at 3-20.

[555] Gillingham (2016), at 75 (Table 1). Of the 8 studies cited, the only two estimates for the U.S. are below 10% (focusing on the data for the more recent time period from Hughes et al. (2008). The four state estimates average to 13%. *Id.*

[556] Gillingham (2016) at 75. Gillingham also lists estimates from U.S. states, which average to 13%. *Id.*

[557] *See* 83 Fed. Reg. at 43,105.

[558] Draft TAR at 10-17 ("these influences are small enough in magnitude that they do not fully offset the downward trend in VMT response elasticities due to higher incomes and other factors. Hence, even assuming that the variables retain their 2003–2009 values into the indefinite future, they would not prevent a further diminishing of the magnitude of the rebound effect if incomes continue to grow at anything like historic rates").

[559] Draft TAR at 10-17 (explaining that the Hymel and Small conclusions are "important to understand the rebound effect based upon fuel prices, they may not be as relevant to the rebound effect due to fuel efficiency").

[560] Hymel and Small (2015), at 98 ("The results for our preferred specification, labeled Model 3, are summarized in Table 3"); *id.* at 103 (Table 8, presenting US 2000-2009 average fuel efficiency elasticity under more sophisticated Models 3 and 5 of -0.042 and -0.040). The confusion over their preferred estimate likely arises because they refer to model 1 as their "base specification" and "base model" as it similar to the model estimated in Small and Van Dender (2007).

2008 recession, which the authors characterizes as a period of "turmoil in energy markets;" the authors noted that the financial crisis biased their estimates upwards.[561] The agencies have elsewhere criticized data based on this time period as non-representative.[562] And the papers still found a significant income effect and found that the rebound effect declines with income increases, which confirms rather than undermines the findings of Small and Van Dender (2007).[563] As Professor Kenneth Small, one of the authors of Small and Van Dender (2007), Hymel et al. (2010), and Hymel and Small (2015), has explained in a letter to the agencies,[564] the agencies mischaracterize the conclusions of these papers; due to expected future changes in income and other factors, Small states that the best estimate of the type of rebound at issue in the Proposed Rule is *substantially* lower than even the agencies' previous 10% estimate: 0.2% in 2025.[565]

The agencies also point to the recent study from DeBorger et al. (2016), as evidence that the income effect in Small and Van Dender was overstated.[566] But that study, according to its authors, lacked sufficient data to robustly test for the existence of the income effect, and called for additional testing of their results with respect to the income effect.[567] Even then, like Small and Van Dender (2007), the study found a negative income effect (though it is statistically insignificant). [568] Moreover, the study was based in Holland which differs considerably from the

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[561] PRIA at 993-994 (citing Hymel and Small (2015), at 94 (discussing weakness of studies of driving during the "most significant recession since the 1930s, accompanied by turmoil in housing markets including foreclosures requiring many people to move"); Hymel and Small (2015), at 93 ("We also estimated Model 2 omitting years 2008 and 2009, in order to evaluate the effect of the financial crisis on the rebound effect. This change decreases the rebound effect through changes in pm, pm2, and pm ∗ inc. The short run rebound effect falls by about 1 percentage point and the long run rebound effect falls by about 8 percentage points, relative to the version of Model 2 that includes years 2008 and 2009. One would expect that drivers would be more sensitive to driving costs following the financial crisis, and our estimation bears that out… The estimates from a version of Model 1 without years 2008 and 2009 also yielded smaller rebound effect estimates compared to the 1966–2009 version.").

[562] 83 Fed. Reg. at 43,089; PRIA at 966.

[563] Hymel and Small (2015), at 102-103 ("Furthermore, we confirm earlier findings that the rebound effect became substantially smaller in magnitude over the course of that time period, probably due to a combination of higher real incomes, lower real fuel costs, and higher urbanization").

[564] Letter from Dr. Kenneth Small, Docket No. EPA-HQ-OAR-2018-0283 and Docket No. NHTSA-2018-0067 (Sept. 14, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-2698; *see also* Hymel et al. (2010) (estimating rebound of 13% in 2004); Hymel and Small (2015) (estimating rebound of 18% during 200-2009 period).

[565] Letter from Dr. Kenneth Small at 2, Docket No. EPA-HQ-OAR-2018-0283 and Docket No. NHTSA-2018-0067 (Sept. 14, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-2698.

[566] PRIA at 983.

[567] DeBorger et al. (2016), at 13 (emphasizing that their result "has to be corroborated by other studies").

[568] The study found a statistically insignificant relationship between income and rebound, the direction of that impact was still negative. *Id* ("Although we use panel data, the number of MOT-tests observed in a 10-year period is too small to carry out a panel data analysis of the impact of changes in income on the coefficients for fuel price and

U.S., and should be given considerably less weight on this issue than Small and Van Dender (2007), Hymel et al. (2010), and Hymel and Small (2015). As such, that study does not support the agencies' proposed conclusions.[569]

Third, the agencies' argument that the slowdown in income from the levels expected in 2012 undermines the prior 10% estimate is incorrect. The relevant time-period for estimating income growth and rebound is the period during which consumers will be using vehicles subject to the baseline standards: 2020 to 2050, not the earlier time periods discussed in Small and Van Dender (2007) and Hymel and Small (2015). At this time, the agencies expect GPD per capita to be substantially higher during the 2020 to 2050 period than the 2000s.[570] Pointing to the fact that income grew at a slower rate than expected in the 2007 paper does not undermine the agencies' conclusions in issuing the Clean Car Standards that over the 2020-2050 period, income will be sufficiently high to support a 10% rebound estimate.[571]

Fourth, the agencies provide an unsupported assertion that rebound may *increase* as income increases because increases in income will allow consumers to own multiple cars, which will then be driven more. The agencies argue that higher income families have multiple vehicles and cite to "some studies," which they do not identify, that find that households with multiple vehicles have higher rebound.[572] In fact, a systematic analysis of studies suggests that the rebound effect is *smaller* for households with multiple vehicles.[573] The Proposed Rule's analysis on this point conveniently ignores the Wang and Chen (2014) study, which found that the rebound effect is only significant for households making $25,000 or less—an important insight that should be taken into account in rebound assessments.[574]

As these papers all show, the relationship between rising incomes and lower rebound is strongly supported. The literature indicates that the rebound effect should decline with rising income for

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fuel efficiency in our demand equation. However, what we can do is carry out a cross-sectional analysis and analyze whether the sensitivity of kilometre demand for changes in the fuel price and in fuel efficiency depend on a household's place in the income distribution…The point estimates also seem to suggest that the sensitivity of demand to changes in fuel efficiency declines with income. However, the interaction term of the fuel efficiency variable with income is not significant at the usual significance levels, and we are unable to reject the hypothesis that the size of the rebound effect is independent of a household's position in the income distribution").

[569] PRIA at 989 n. 528.

[570] *Id.* at 993.

[571] *Id.* at 982 ("income growth that had been anticipated to erode the value of the rebound effect had not materialized").

[572] *Id.* at 989.

[573] Dimitropoulos (2018), at 170-171.

[574] Proposed Determination TSD at 3-16 (Wang and Chen (2014) "find that the rebound effect is only significant for the lowest income households (up to $25,000)").

two reasons.[575] First, as incomes rise, the rebound income effect diminishes because household demand for vehicle travel is closer to saturation levels. In particular, high-income families will feel less of a budget constraint (i.e., they are consuming all goods, including driving, nearer to or at their optimal level).[576] Second, as incomes rise, the opportunity cost of spending time in a vehicle increases. As time costs increase relative to energy costs, the relative importance of energy costs should decline, and drivers should limit the extent to which fuel efficiency will increase driving.[577] This effect is magnified by the fact that as income and driving increase over time, congestion will also increase. This will require drivers to spend more time in their vehicles and limit the extent to which drivers respond to lower prices with more driving.[578]

A few additional details support a lower rebound estimate as income increases. For example, there is evidence in the literature regarding rebound and energy efficiency outside of the passenger vehicle sector, which shows that rebound declines with income.[579] This includes studies of rebound related to residential energy use from greater adoption of efficient appliances such as refrigerators, air conditioners, and solar lanterns. Studies that compare rebound across countries also provide empirical support for the agencies' prior conclusions that the rebound effect declines as income rises.[580] In addition, because congestion can have a moderating effect on rebound, the agencies should model the impact that expected increases in congestion will have on rebound during 2020-2050.[581] Finally, high-quality academic literature that the agencies have failed to consider provides independent support for the prior 10% rebound estimate. In particular, in a 2009 literature review of the direct rebound effect in multiple sectors, Steve Sorrell and coauthors conclude that long-run rebound is between 10% to 30%, with the best estimate closer to 10%.[582]

For all of these reasons, EPA was correct to note during the interagency review process that NHTSA's own analysis and the literature indicate that the rebound effect is expected to decline

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[575] Sorrell et al. (2009), at 1357, 1360 n. 8; Dimitropoulos et al. (2018), at 171.

[576] *Id.* at 1357.

[577] *Id.* at 1366 n. 8.

[578] *See* Hymel et al. (2010) at 1221.

[579] Azevedo (2014), at 411-12 (identifying studies that show that the rebound effect of home energy use varies by income).

[580] *See* Dimitropoulos et al. (2018), at 172.

[581] The agencies should also take into account the relationship between income, congestion, and VMT when developing VMT schedules. *See* Section V.A.2.

[582] Sorrell et al. (2009) at 1360; *id.* at 1361 ("Moreover, most studies assume that the response to a change in fuel prices is equal in size to the response to a change in fuel efficiency, but opposite in sign . . . Few studies test this assumption explicitly and those that do are either unable to reject the hypothesis that the two elasticities are equal in magnitude, or find that the fuel-efficiency is less than the fuel cost per kilometer elasticity . . . The implication is that the direct rebound effect may lie towards the lower end of the above range (i.e., around 10%).")

over time as income rises.[583] As this section demonstrates, the literature does not support the agencies' proposal to abandon the 10% rebound estimate that they previously adopted.

C. The agencies' approach led them to estimate an inflated rebound effect

The agencies have adopted a methodology that uses the average of the estimates of rebound that they have collected.[584] However, using averages is a disfavored approach for a number of reasons. The averaging approach does not address the disparity in precision and quality of the estimates that are part of the average. It does not account for the pertinence of specific estimates to the particular policy context. And it does not address the fact that multiple studies have overlapping samples, overlapping authors, or overlapping methods. Using an averaging method here was inappropriate because the estimates of rebound presented in the academic literature are not equally valid estimates of rebound and are not equally relevant to the question the agencies investigate here. As such, as described further below, a simple average does not lead to a reliable estimate.

The agencies should more proactively evaluate rebound estimates based on selection criteria. In the alternative, the agencies should conduct a sophisticated meta-analysis of the existing rebound literature to arrive at the best estimate, consistent with EPA's guidelines for reaching conclusions using multiple studies. In either case, a rebound estimate of 20% would not be supported.

1. The simple average that the agencies use to calculate the rebound effect in the Proposed Rule is unreliable and produces improperly inflated estimates

Instead of considering all available studies equally, the agencies should consider only those estimates of rebound that are predictive of the kind of rebound at issue here or should give non-preferred studies only partial weight. Many of the studies that the agencies include in their average do not meet the below requirements for full weight or inclusion. That error renders the agencies' conclusions arbitrary and capricious.

In summary, the best estimates include:

- Measures of the driving changes due to changes in fuel efficiency, rather than measures of how driving changes as fuel price changes or that measure how fuel consumption changes as fuel price changes.
- U.S.-based national studies rather than studies of rebound in other countries or within single U.S. states.
- Measures that best reflect the time period of the analysis (i.e., 2020-2050), including studies that use more recent data (i.e., measures conducted after the 2008 recession).

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[583] EPA, *Comments on NPRM and Preliminary RIA sent to OMB,* at 1659 (July 26, 2018) (explaining that literature and NHTSA's previous findings reported "persuasive evidence that the magnitude of the rebound effect is likely to be declining over time").

[584] 83 Fed. Reg. at 43,100 (finding that the average values of pre-2008 studies to be 22-23%); *id.* at 43,105 (discussing 10%-40% average rebound of post-2008 studies); PRIA at 993.

- Studies with high quality identification strategies, including those that account for the endogeneity of fuel efficiency.
- Measures that include data from multiple years (i.e., panel methods) or that apply an experimental/quasi-experimental approach and that are internally valid.
- Short-run and medium run estimates of rebound because long-run estimates suffer from identification problems.[585]

The most important categories of rebound estimates are discussed in turn. The agencies should follow these guidelines.

a.) *The agencies should consider estimates of fuel efficiency rebound rather than other proxy estimates of rebound*

There are four types of econometric estimates of the rebound effect in the academic literature, some of which are better than others for estimating the rebound rate of fuel efficiency or emissions standards.[586]

The agencies should give the most weight to estimates of the elasticity of distance traveled with respect to fuel efficiency, as this is the directly relevant estimate. For this reason, in a recent meta-analysis of rebound estimates in the literature, Dimitropoulos and coauthors explained that "the elasticity of travel demand with respect to fuel efficiency should be preferred to other measures whenever this is possible."[587]

- **Fuel efficiency rebound**. The most relevant rebound estimate for the purposes of the Proposed Rule is the extent to which driving changes due to changes in fuel efficiency—called the "elasticity of distance travelled with respect to fuel efficiency" or "fuel efficiency rebound." The agencies have previously acknowledged that estimates of fuel efficiency rebound are the most directly relevant measures for the purpose of estimating the effect of the baseline standards.[588]
- **CPM rebound**. When fuel efficiency rebound cannot be measured, the next closest proxy estimate would be to measure the extent to which driving changes as the cost per mile (CPM) of driving decreases—called the "elasticity of distance traveled with respect to the cost of driving" or "CPM rebound." The cost of driving includes fuel costs per mile (fuel price divided by fuel efficiency), but could also include other costs such as depreciation. However, its estimation raises several concerns, in particular because measures of CPM rebound diverge from measures of fuel efficiency rebound for a number of behavioral economic

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[585] Gillingham et al. (2016), at 74-75.

[586] Sorrel et al., (2009), at 1358-1360; Dimitropoulos et al., (2018) at 164.

[587] Dimitropoulos et al. (2018), at 196.

[588] NHTSA 2012 FRIA at 847 ("ideally, the rebound effects measured directly by estimating the change in vehicle use, during some time period that results from a change in vehicle fuel efficient").

reasons. Changes in CPM, and particularly changes in gasoline prices, are highly salient and so have more influence on consumer behavior than fuel efficiency changes.[589] In addition, many of the recent studies that measure the change in cost of driving have been measures of consumer response to fuel price *increases*, but consumers tend to be more responsive to price increases than decreases[590] and because fuel efficiency acts like a price *decrease*, studies that measure rebound based on price increases may overestimate fuel efficiency rebound. The Dimitropoulos meta-analysis found that the elasticity of driving with respect to fuel efficiency is significantly lower than the elasticity of driving with respect to fuel costs and fuel price.[591] In addition, changes in fuel price can change the cost of driving for both new and used vehicles. Studies of CPM rebound often use data on the change in driving behavior of both new and used vehicles. Yet, the change in driving by newer vehicles is less responsive than the change in driving by older vehicles for a given fuel efficiency increase.[592] Therefore, by including used vehicles, studies of CPM rebound will be an overestimate of fuel efficiency rebound. Finally, in a large portion of the studies of CPM rebound, the methods used to measure rebound have been flawed and have biased estimates upward.[593] When costs of driving increase (such as due to a gasoline price hike), consumers are more likely to buy a more fuel efficient vehicle. However, the type of consumer that is likely to buy a fuel efficient vehicle when prices increase is also likely to be the type to benefit most from a fuel efficient vehicle (i.e., they have a long commute).[594] A large portion of studies of CPM rebound do not account for this relationship (such as by controlling for the endogeneity of fuel-efficiency), and so effectively assume that these interactions do not occur. This causes an overestimate of CPM rebound and therefore, when used as a proxy for fuel efficiency rebound, causes the rebound rate to be inflated.

- **Fuel price rebound.** A subset of the cost of driving, fuel price, introduces a third estimate of rebound: the extent to which driving changes due to changes in fuel price— the "elasticity of distance travelled with respect to fuel price" or "fuel price rebound."[595] Fuel price is a component of the cost of driving and so fuel price rebound is a poor proxy for fuel efficiency rebound for the same reasons that CPM rebound is a poor proxy. But fuel price rebound is

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[589] Gillingham et al. (2016), at 74; Azevedo (2014), at 409. Some economists argue that the elasticity of distance traveled with respect to fuel efficiency should be higher than elasticity of distance traveled with respect to cost of driving due to its permanence relative to the fleeting nature of price changes. Tierney & Hibbard (2018), at 14. However, empirical evidence does not support this finding, as discussed later.

[590] Tierney & Hibbard (2018), at 15.

[591] Dimitropoulos et al. (2018), at 169-170.

[592] Gillingham et al. (2015), at S49.

[593] Small and Van Dender (2007), at 27.

[594] *Id.*

[595] Dimitropoulos et al. (2018), at 164.

also an overestimate for an additional reason: fuel price rebound considers only reductions in the fuel-related costs of driving, whereas fuel efficiency involves reduction in the cost of driving but also includes the increased cost of purchasing a more fuel efficient vehicle.[596] Studies of fuel price rebound do not take into account the capital cost income effect, which has a moderating effect on rebound. So, when used as a proxy for fuel efficiency rebound, fuel price driving will cause estimates to be inflated.[597]

- **Fuel consumption rebound.** The least useful measure of the rebound effect caused by fuel efficiency changes comes from estimates of the extent to which fuel *consumption* changes as fuel price changes—the "elasticity of fuel consumption with respect to fuel price" or "fuel consumption rebound." This type of estimate does not directly measure changes in driving. And academic studies have shown that changes in fuel consumption will always produce higher rebound estimates than changes in fuel efficiency will in a real world setting (i.e., when fuel efficiency is endogenous), and so this rebound estimate serves as an upper bound when used as a proxy for the rebound effect.[598] This has led some academics to ignore this latter group of estimates when trying to estimate the relationship between fuel efficiency and driving.[599]

Given that fuel efficiency rebound is the effect that the agencies are trying to measure, and given the lack of evidence that the other measures are equivalent, the agencies should focus primarily, if not exclusively, on studies that measure fuel efficiency rebound.

b.) *The agencies should take care in selecting studies to avoid features that would improperly inflate the estimates*

In addition, there are several features that could make fuel-efficiency rebound studies unreliable. The agencies need to consider these issues as well in selecting which studies to include:

Estimates of rebound that incorporate capital costs. The agencies should prefer elasticity estimates that account for the capital cost of the new vehicles. Because high capital costs reduce rebound by reducing consumers' income available to purchase other goods, such as driving (the "capital cost income effect"), analyses that omit capital costs will yield inflated estimates of

[596] Gillingham et al. (2016), at 69. Cost of driving rebound may also suffer from this problem to the extent that the cost of driving parameter fails to include an estimate of vehicle capital costs.

[597] Dimitropoulos et al. (2018), Appendix D; Gillingham et al. (2016), at 68-69. Note however that a handful of studies of the elasticity of driving with respect to fuel price control for the capital cost and so would not suffer from this error. However, this still constitutes a minority of studies. Of the 1,142 rebound estimates in the Dimitropoulos et al. (2018) dataset, 236 estimates account for capital costs.

[598] Sorrel et al., (2009), at 1359 n. 6; Sorrel and Dimitropoulos (2008), at 16-18.

[599] Dimitropoulos et al. (2018), at 165.

rebound.[600] Only 14% of the studies on which the agencies relied account for capital costs,[601] we should expect this to bias a simple average upwards.

Estimates of rebound in the United States. U.S.-based estimates are far more relevant than foreign estimates for measuring the effects of a policy that would change the cost of driving for U.S. drivers. It is not merely that U.S. drivers and foreign drivers are culturally different. Rather, the U.S. differs substantially from other regions in terms of the price of gasoline, the density of the population, and income levels; each of which has been shown in various studies to affect the rebound effect.[602] The U.S. has characteristics that are generally associated with lower rebound in the academic literature: higher incomes, lower population densities, and lower fuel prices.[603] Many countries that are the subject of rebound studies—generally European countries—have higher income, population density, and fuel prices. Therefore, taking an average of both U.S. and foreign estimates will inflate the estimate of rebound that will occur in the U.S. In addition, studies at the national-scale are more relevant than studies of various states and subregions, as the latter only capture subsets of the relevant population. Because state studies are more likely to use reliable data sources such as odometer readings, state level studies should not be ignored. However, in developing a methodology to weight studies, the agencies should take into account the divergent characteristics of the state studied. Only 56% of estimates in the agencies' analysis are for the United States,[604] so we should expect the use of these estimates to bias a simple average upwards.

Estimates of rebound that will occur in 2020-2050. As discussed above, rebound is relevant in the context of the Proposed Rule only to the extent that improved fuel efficiency increases driving during the 2020-2050 period. The agencies should therefore use studies that can project the rebound effect of the 2020-2050 timeframe rather than assume that estimates of historic rebound can be directly applied to the baseline standards. More recent studies that look at more recent data will be more applicable than older studies. In other words, more recent studies are better predictors of future rebound because "behavioral responses are contingent upon technical, institutional, policy and demographic factors that vary widely between groups and over time."[605]

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[600] Dimitropoulos et al. (2018) at 171.

[601] *See id.*, Appendix D (listing studies). Dimitropoulos excluded three estimates that contain this feature: Waddud (2009), West and Pickrell (2011), and West et al. (2015).

[602] Dimitropoulos et al. (2018) at 172; EPA (2018), at 31; Gillingham et al. (2016), at 75.

[603] Dimitropoulos et al. (2018), at 171.

[604] *See id.*, Appendix D (listing studies). Specifically, the following recent studies use data from outside of the United States: De Borger (2016) (Denmark); Barla (2009) (Canada); Frondel and Vance (2012); Anajovic and Haas (2012); Weber and Farsi (2014); and Stapleton (2016, 2017). This other estimates using date from outside of the United States were not included in Dimitropoulos et al. (2018): Waddud (2009), West and Pickrell (2011), and West et al. (2015).

[605] Sorrel et al. (2009), at 1359.

In the Clean Car Standards, the agencies noted that "[w]hile some older studies provide valuable information on the potential magnitude of the rebound effect, those that include more recent information may provide more reliable estimates of how this rule will affect future driving behavior."[606] Now the agencies rely on many older studies, including a number of studies prior to 2008 when income was depressed, in calculating average rebound effects.[607] This reliance on older studies using data on older vehicles biases the estimate upwards.[608]

Studies using strong statistical methods and data. The agencies should only rely on, or should more heavily weight, studies with a strong statistical and methodological basis and reliable data.[609] Most importantly, reliable studies account for the fact that fuel efficiency is correlated with other attributes (that is, fuel efficiency is endogenous).[610] There is evidence that more fuel-efficient vehicles have a lower rebound effect.[611] Energy efficiency may be correlated with other vehicle attributes,[612] household attributes, and time; some of which are unobservable.[613] As such, the agencies should place greater weight on studies that address this endogeneity, usually using instrumental variables or simultaneous equations.[614] Failure to account for endogeneity means that the study is unable to disentangle to what extent VMT is rising because of fuel efficiency and to what extent it has risen due to changes in other factors (including reverse causality). In other words, studies that do not address issues with endogeneity may overstate the extent to

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[606] NHTSA 2012 RIA at 848.

[607] PRIA at 981 (Table 8-7).

[608] Dimitropoulos et al. (2018), at 171.

[609] Gillingham et al. (2016), at 74.

[610] *Id.*; Small and Van Dender (2007), at 30; Sorrell et al. (2009), at 1363.

[611] Gillingham et al. (2015), at 549.

[612] Sorrell et al. (2009), at 1357; Gillingham et al. (2016), at 69.

[613] Sorrell et al. (2009), at 1358.

[614] The net effect of these trends is unclear. Dimitropoulos et al., (2018), at 171. GDP increases over time and will decrease the rebound effect. Congestion and density tend to increase over time and increasing congestion will decrease rebound, Hymel et al. (2010), while increased density has been shown to increase the rebound effect. As such, the agencies should also include a density adjustment to their VMT schedules to control for density. Similarly, the future direction of gasoline prices is relatively uncertain. The U.S. Energy Information Agency generally assumes a long-run upward trend in gasoline prices, which implies a higher rebound effect. But as with density, this suggests a need to adjust VMT schedules.

which fuel efficiency is the cause of extra VMT.[615] Only 28% of estimates in the agencies' analysis account for endogeneity,[616] and we should expect this to bias a simple average upwards.

Additionally, some estimation strategies are preferred to others. For example, cross-sectional studies should be given less weight (or dropped altogether) as they: disagree over appropriate specification;[617] suffer from omitted variable bias making them unreliable;[618] and are only as representative as the year the data was taken.[619] Time-series data may not be as reliable due to the fact that a limited number of data points are available.[620] Academic economists also disagree about how to properly construct models using this data.[621] These econometric issues led one careful survey of the literature to conclude that "estimates from many econometric studies appear vulnerable to bias, likely leading to an inflated estimate. The most likely effect of the latter is to lead the direct rebound effect to be overestimated."[622] Panel methods and experimental designs should be treated as preferred methodologies.[623]

Studies that use odometer data at the vehicle or household level are the most reliable. This is particularly the case because some micro-economic data are known to be problematic. For example, many cross-sectional microeconomic studies use data from the 2009 NHTSA household survey. Those estimates "should be interpreted with caution" since they present rebound estimates that range from 0% to 87% using identical datasets.[624] The 2009 NHTSA dataset is also problematic because it includes data from 2009, a highly non-representative year,

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[615] Small and Van Dender (2007), at 40; Dimitropoulos et al. (2018), at 172 & n. 23. Note that there is some evidence pointing to downward bias as well. *See* Small and Van Dender (2007), at 30. A meta-analysis by Dimitropoulos finds some downward bias. Dimitropoulos et al., (2018), at 172 & n. 23. However multi-collinearity raises questions about how to accurately interpret this result. The direction of the bias is not completely unclear.

[616] *See* Dimitropoulos et al. (2018), Appendix D (listing studies with this feature). Specifically, the following studies have this feature: West and Pickrell (2011), Su (2012), Linn (2013), Liu et. al (2014), Gillingham (2014), and West et. al. (2015). Dimitroupoulos excluded three estimates with this feature: Waddud (2009), West and Pickrell (2011), and West et al. (2015).

[617] Sorrell et al. (2009), at 1360.

[618] Gillingham et al. (2016), at 73-74.

[619] 83 Fed. Reg. at 43,089; PRIA at 966.

[620] Sorrel et al. (2009), at 1360.

[621] *Id.* (identifying disagreement regarding appropriate specification with respect serial correlation and lagged dependent variables).

[622] *Id.* at 1364. *But see* Dimitropoulos et al. (2018), at 169 (finding some evidence of negative bias).

[623] Gillingham et al., (2016), at 74 (recommending quasi-experimental approaches); *but see* Sorrel et al. (2009), at 1364 ("The methodological quality of many quasi-experimental studies is poor, while the estimates from many econometric studies appear vulnerable to bias. The most likely effect of the latter is to lead the direct rebound effect to be overestimated"). Advances in experimental design may explain some of the difference between Gillingham et al.'s 2016 conclusions and Sorrel et al.'s earlier conclusions.

[624] Sorrel et al. (2009), at 1360.

relies on self-reported odometer readings and has a poor sample size.[625] Alternatively, studies that rely on more aggregated data on travel demand can have significant measurement errors.[626] As shown in Table 4, 44% of the studies in the agencies' analysis are cross-sectional, of which 86% are based on the problematic NHTSA household surveys.

Medium-run elasticity estimates are more reliable. Academic studies of rebound often include different estimates for different timeframes, including rebound over the short-run, over the medium-run, and over the long-run. Generally, these estimates find that the rebound effect increases over time (i.e., driving is less elastic in the short-run than in the long-run) because households have more opportunities to take action that results in more driving over time (e.g., taking a new job further from home).[627] Currently, NHTSA relies exclusively on long-run estimates.

The agencies need to take a dynamic approach to rebound instead of disregarding short and medium-run estimates as in the current approach. Not only is the current approach incorrect but it is also inconsistent with the agencies' approach elsewhere. For instance, the agencies' scrappage model employs lagged variables that capture the shifts in behavior from short- to long-run.[628] At the very least, the agencies should incorporate the movement from short-run rebound effects to long-run rebound effects on VMT rather than apply a single rebound estimate to all vehicles in all years.

In addition, long-run rebound estimates do not have a strong statistical and methodological basis.[629] In an analysis of the rebound effect and related academic literature, which the agencies have inexplicably failed to consider, Ken Gillingham and coauthors note that

> Long-run elasticies are harder to estimate credibly and thus harder to come by. All [reliable studies also] provide either short-run or medium-run estimates. . . . . [W]e believe that short-run and medium-run estimates are more reliable.[630]

The agencies should consider reducing their reliance on long-run estimates by substituting them with the medium-run estimates available in the literature, by including both long-run and medium-run estimates, or by carefully selecting only those long-run estimates that were developed using methodologies that address the concerns identified above.

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[625] 83 Fed. Reg. at 43,089; PRIA at 966.

[626] Dimitropoulos et al. (2018), at 165 & n. 6.

[627] Gillingham et al. (2016), at 74.

[628] PRIA at 1044 (showing lagged variables in the scrappage model).

[629] Gillingham et al. (2016), at 74.

[630] Gillingham et al. (2016), at 74.

The agencies have ignored many relevant and recent studies of rebound in the academic literature and relied on several studies that contain problematic and non-representative data and findings, as summarized in Table 4. And the studies that they include in their calculations of average rebound estimates largely fail to meet the criteria of reliable and predictive estimates for the type of rebound at issue in the Proposed Rule. Moreover, these lower quality estimates tend to be biased in one direction: upwards.[631] As a result, the agencies' conclusions regarding the appropriate rebound estimate of 20% are, inappropriately biased upwards.

[631] Upward biases result from including studies that: estimate elasticities of VMT demand and fuel consumption with respect to driving cost and fuel price, forget capital costs, use data from non-US countries, and estimate the long-run effect. Other quality issues have an unclear effect. No approach that the agencies use clearly biases estimates downwards.

Table 4. Disfavored Features in the Post-2008 Rebound Studies Considered by Agencies[632]

Authors (Date)	Non-preferred rebound estimate [a]	Omitted Capital Costs[b]	Non-US Data	Non-representative period[c]	Ignores endogeneity[d]	Not panel data	2009 NHTSA Survey
Barla et al. (2009)	✓		✓		*		
Bento (2009)	✓				✓	✓	
Wadud (2009)	✓	✓		✓	✓	✓	
West and Pickrell (2011)	*	✓			✓	✓	✓
Anjovic and Haas (2012)	✓	✓	✓	✓	✓	✓	
Su (2012)	✓	✓			✓	✓	✓
Greene (2012)	*	✓		✓	✓	✓	
Linn (2013)	*	✓			*	✓	✓
Frondel and Vance (2013)	*	✓	✓		*		
Liu (2014)	*	✓				✓	✓
Gillingham (2014)	X	✓	State-level		*		
Weber and Farsi (2014)		✓	✓		*	✓	
Hymel & Small (2015)	✓						
West et al. (2015)		✓				✓	✓
DeBorger (2016)	*	✓	✓		*		
Stapleton et al. (2016, 2017)	*	✓	✓	✓	✓	✓	

[*] *At least one estimate in the study avoids the problem. If a range is presented, some estimates that make up the range may suffer from the problem.*

[a] *Wadud (2009) is the sole fuel consumption rebound estimate. (cont. on next page)*

[b] *West et al. (2015) accounts for the price of the vehicle. But the authors also look at groups that do and do not receive a vehicle subsidy. This is problematic because the subsidy group buys a cheaper vehicle and receives a subsidy. Therefore, the results of this study should be interpreted as supporting a negative rebound effect if capital costs are accounted for.*

[c] *We define a study as using data from a non-representative time period if it includes data from before the 1990s. Note that even if studies use data from a non-representative period, this issue can be explicitly addressed through updating explanatory variables (e.g., GDP per capita) ex-post in some cases.*

[d] *While West and Pickrell (2011) attempt to address simultaneity, the study did so inadequately according to the authors*

[632] The information in this table is derived from Dimitropoulos et al. (2018), Appendix D, with the exception of Wadud (2009), West and Pickrell (2011), and West, et al (2015).

2. The Agencies should follow EPA guidelines regarding how to draw valid conclusions from an academic literature that involves multiple estimates

EPA has developed guidelines on meta-analysis that provide best practices for how the agency should rigorously evaluate circumstances such as this where the academic literature is varied and contains a number of potentially relevant estimates.[633] EPA's guidelines are consistent with the best practices established in the academic literature.[634] By using a simple average of many studies of varying quality, the agencies have failed to follow EPA's own guidelines and so their conclusions regarding the appropriate rebound rate are not reliable.

In its guidelines, EPA identifies a number of types of meta-analysis methods.[635] EPA explicitly describes four types of meta-analysis in a 2016 update on its guidelines:

(1) **Closely Matched Studies:** "Develop independent estimates for relevant cases, using only studies that are closely matched on . . . individual characteristics."[636]
(2) **Weighted Average:** "Develop a baseline distribution of estimates . . . and a set of adjustment factors for . . . individual characteristics as warranted."[637]
(3) **Meta-regression:** "Develop a meta-regression model to estimate [rebound] as a function of . . . individual characteristics."[638]
(4) **Structural Model:** "Develop and estimate a structural preference function."[639]

By generally averaging studies without any specific weighting, the agencies have adopted none of these meta-analysis techniques.

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[633] EPA, *Report of the EPA Working Group on VSL Meta-Analyses*, Report EE-0494. (2006), http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0494-01.pdf/$file/EE-0494-01.pdf [hereafter "EPA Meta-Analysis Guidelines"]; *see also* EPA, *Valuing Mortality Risk Reductions for Environmental Policy: A White Paper* at 46-53 (2010), https://www.epa.gov/sites/production/files/2017-08/documents/ee-0563-1.pdf [hereafter "Meta-Analysis Guidelines 2010 Update"]; EPA, Valuing Mortality Risk Reductions for Policy: a Meta-Analytic Approach (2016), https://yosemite.epa.gov/sab/sabproduct.nsf/36a1ca3f683ae57a85256ce9006a32d0/0CA9E925C9A702F285257F380050C842/$File/VSL+white+paper_final_020516.pdf. [hereafter "Meta-Analysis Guidelines 2016 Update"].

[634] Several guidelines are available for meta-regression in the academic literature: Nelson, & Kennedy (2009); Rhodes (2012).

[635] EPA Meta-Analysis Guidelines at 19-24.

[636] *Id.* at 8.

[637] *Id.*

[638] *Id.*

[639] *Id.*

EPA's initial guidelines and subsequent application of those guidelines include direction for how the agencies should consider multiple studies to arrive at an individual value for use in a regulatory setting.[640] The agencies have failed to meet a number of these directives including:

- The need to establish *a priori* decision rules for which studies and individual values will be included or excluded or more heavily weighted;[641]
- The need to use a valid method for synthesizing the results of multiple studies in order to address econometric complications, including duplicate estimates, dependent errors (overlapping data and study authors), and heteroskedasticity (variance in precision of study);[642]
- The need to identify the population to be studied up-front (e.g., rebound *caused by fuel efficiency* among *U.S. households*);[643]
- The need to characterize and measure the uncertainty of combined estimates, such as through standard errors or confidence intervals;[644]
- The preference for analyses that incorporate several study characteristics together (e.g., meta-regression) over separate analyses of individual predictors of outcomes for different subsets of studies.[645]

The agencies' approach in the Proposed Rule—averaging estimates from a seemingly arbitrary subset of estimates in the literature—does not meet these criteria. The agencies have not identified any particular criteria for including or rejecting studies. Nor have they identified how exactly they synthesized the results from multiple studies. They have used studies that cover a wide range of populations (e.g., U.S. based studies and non-U.S. based studies, studies that measure elasticity of driving with respect to cost of driving and studies that measure elasticity of driving with respect to fuel efficiency, etc). Beyond reporting incredibly large ranges within the literature, the agencies do not discuss uncertainty in their preferred 20% rebound estimate. And by averaging all studies, the agencies incorporate different study characteristics but do so in a way that treats all characteristics equally.

The agencies should move away from the proposed approach and use one of the meta-analysis methodologies discussed in EPA's meta-analysis guidelines instead. Each option is discussed in turn.

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[640] The purpose of the meta-analysis guidance was for the construction of the Value of a Statistical Life (VSL). *Id.* However, the procedures and principles are broadly applicable.

[641] *Id.* at 9.

[642] *Id.* at 10.

[643] *Id.* at 19-20.

[644] *Id.* at 20.

[645] *Id.* at 22.

Meta-Regression. Meta-regression is a particularly valuable form of meta-analysis,[646] which uses econometric techniques to combine different studies and arrive at joint conclusions. Meta-regression allows analysts to adjust for factual and methodological causes of variation between different studies.[647] Specifically, it can control for many of the features of rebound studies that make them less relevant to the particular policy context of the Proposed Rule. Done correctly, meta-regression can address a variety of confounding issues including duplicate estimates, omitted variables, measurement error, dependent errors, and heteroskedasticity. EPA's guidelines provide detailed recommendations for the construction of a proper meta-regression.[648]

Only one academic study, by Alexandros Dimitropoulos and coauthors, has conducted a meta-regression of the rebound effect.[649] The study produces a variety of rebound estimates, including two estimates using two different preferred regression methods—fixed-effects regression and weighted-least squares regression.[650] While approximately one third of the data is not from the U.S., the study's meta-regression methodology at least partially addresses the issue of divergent geographic studies. This allows the authors to derive a long-run rebound effect of approximately 15% for a country approximately like the U.S.[651]

The study's methodology is sound. But the agencies should not rely on the study's rebound estimates for three reasons. First, the standard errors of the top-line regressions are so large that they limit the ability to make statistically significant claims about the magnitude of rebound for the purpose of setting policy.[652] Second, the two different preferred regression methods in the paper produce substantially different results about the overall magnitude of the rebound effect. Third, the results of the weighted-least squares regression demonstrate that very imprecise studies (i.e., studies with a very wide range of estimates) are driving up the rebound effect in the fixed effects regression.[653] These features of the study suggest that the specific estimates of the study are not reliable indicators of rebound.

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[646] Howard and Sterner (2017), at 205.

[647] *Id.* at 205-06.

[648] EPA Meta-Analysis Guidelines at 10-25 with specific focus on meta-regression at 23-25; Meta-Analysis Guidelines 2010 Update at 46-53; Meta-Analysis Guidelines 2016 Update at 20-25.

[649] Dimitropoulos et al. (2018), at 163, 166; *id.* at 170 (Table IV).

[650] The paper also reports results in its abstract. Dimitropoulos et al. (2018), at 163. However, these estimates are not the results of their sophisticated meta-regression.

[651] *Id.* at 172 (Table V).

[652] *Id.*

[653] Dimitropoulos et al. (2018) makes their data and code available in Appendix D. Applying the average sample size as weights within groups in the fixed effects regression also produces a negative estimate of -0.55 instead of -0.4 or 0.15. Additionally, variables for sample size and standard errors are statistically significant if included individually or jointly in the fixed effects regression, which indicates an upward bias. Furthermore, the increased capital cost of new vehicles is not accounted for and should further push down these rebound effect estimates.

While the study is not useful for making specific claims about rebound, it is nonetheless useful as evidence of the directional impact of particular estimate attributes. This meta-regression finds that rebound is lower for elasticities of fuel-efficiency than elasticities of fuel price and CPM; rebound is lower as income increases, rebound is lower over time and is generally lower in the U.S., and rebound is higher for single vehicle owners than multi-vehicle families.[654] These directional estimates can be taken into account through other meta-analysis methodologies, discussed above.

Closely Matched Studies. An alternative methodology to meta-regression would be for the agencies to use only studies that most closely match the context of the policy.[655] This can be accomplished by applying selection criteria to the available studies. In addition, because studies often contain multiple estimates or ranges of estimates based on different factors, the agencies should select the estimate within each study that most accurately reflects the rebound at issue in this Proposed Rule. For example, if a study provides rebound estimates for different countries, the estimate for U.S. households should be used rather than a range of estimates based on estimates from different geographies. Similarly, estimates with greater statistical precision (e.g., estimates with a larger number of observations) should be selected. And as the agencies explained when selecting the 10% rebound estimate for the Clean Car Standards, a rebound of 10% is better justified than 20% when the agencies clearly define selection criteria for the best estimates of the rebound effect.[656]

An approach that considers only rebound estimates that are highly relevant to the agencies' proposal would also be consistent with the recommendations that EPA provided to NHTSA as part of the interagency review of the Proposed Rule. As part of that interagency process, EPA recommended that NHTSA not use an average, but instead critically examine which studies are most likely to reflect rebound from fuel economy standards.[657] And EPA explained that of the 18 studies (12 U.S. and 6 international) in the last decade, EPA identified two that most clearly meet its criteria: Hymel and Small (2015), which estimates a rebound effect of 4% to 18%, and Greene (2012), which estimates a rebound effect of 10%. As EPA explained, "recent U.S. aggregate, time series studies find a rebound effect lower than 20%."[658] The agencies should follow this more careful and accurate approach in analyzing the rebound effect in this Proposed Rule. In

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[654] *Id.* at 170 (Table IV).

[655] Meta-Analysis Guidelines 2016 Update at 8.

[656] 77 Fed. Reg. at 62,924 (identifying criteria that led the agencies to put less emphasis on certain studies including those that measure the elasticity of demand for gasoline and studies of rebound outside the US).

[657] EPA, Review of CAFE model with "GHG" settings (08-Mar ver.), at 31-33, attached to Email from William Charmley to Chandana Achanta regarding Material for today's Light-duty GHG NPRM discussion, June 18, 2018, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (5th attachment, pdf pages 120-122).

[658] *Id.*

addition, many of the peer reviewed papers that are discussed above but that are largely ignored by the agencies attempt to do just this.[659] Using criteria to select for only high quality and relevant studies, these literature syntheses arrive at a common value of 10% for the long-run rebound effect. These consensus values are far below the 20% selected by the agencies in the Proposed Rule.

Two other approaches to meta-analysis discussed in EPA's guidelines would not be optimal to estimate rebound:

Weighted Average. While not preferred, the agencies could develop an approach that weights studies by their quality and relevance to the policy context of the Proposed Rule (rebound caused by fuel efficiency increases in the U.S. during the 2020-2050 period). Lower-quality and less precise studies would be given less weight in line with our recommendations in these comments and so would have less influence over the weighted-average rebound value. However, it is not clear what weights would be appropriate for studies of different populations or of different types of effects. For this reason, using closely matched studies or a more sophisticated meta-regression would likely be preferable approaches to this type of meta-analysis.

Structural Model. Instead of relying on existing estimates of rebound in the academic literature, the agencies could build a structural model to estimate rebound, similar to how the agencies constructed models to estimate new vehicle sales and scrappage. For this approach to be valid, the agencies would have to be careful to avoid the structural and econometric criticisms raised throughout these comments. For example, the agencies would have to appropriately address the fact that VMT, including due to rebound, is simultaneously determined with fleet size. This type of approach would be a significant undertaking and should be subject to peer review and other validation.

[659] Sorrell et al. (2009), at 1360-1361; Gillingham et al (2016), at 73-78.

D. The agencies' rebound analysis is inconsistent with other parts of the Proposed Rule

In addition to the discussion above, the agencies' use of a 20% rebound effect is arbitrary and capricious because the assumptions underlying that value are inconsistent with the agencies' analysis regarding other issues in the Proposed Rule.

The Proposed Rule assumes both higher new vehicle costs associated with compliance with baseline standards and a higher rebound effect than were previously used when promulgating and evaluating the Clean Car Standards. However, higher new vehicle purchase prices for the same level of fuel efficiency should result in a reduction in the rebound effect. Specifically, higher vehicle purchase prices will increase the "capital cost income effect," (the *C* in the third component of the rebound effect defined in the introduction of this section (i.e., $\frac{\partial q}{\partial I} C$)).This will reduce (or even reverse) the level of rebound caused by the baseline standards attributable to the income and substitution effects. The agencies have wholly failed to acknowledge any relationship between increasing their assumptions about new vehicle prices under the baseline standards and, simultaneously, increasing estimates of rebound from the same level of fuel efficiency.

In addition, the agencies fail to acknowledge the inconsistency between their assumptions about rebound and their assumptions about, and costs attributable to, congestion. The agencies' analysis concludes that the baseline standards will result in higher levels of congestion than would occur under the Proposed Rule.[660] However, rising congestion over time should decrease the rebound effect.[661] The agencies have ignored the relationship between congestion and rebound. The agencies' assumptions that congestion (and its underlying costs) will increase under the baseline standards compared to the Propose Rule, without also changing the magnitude of the rebound effect under the baseline standards relative to the Proposed Rule is internally inconsistent.

Finally, the Proposed Rule is inconsistent in its modeling of short-run and long-run effects. Specifically, ignoring short and medium-run estimates of rebound is inconsistent with the agencies' approach to other dynamic effects that change over time. For example, the agencies' new vehicle sales model and scrappage model employ lagged variables in order to capture the shifts in behavior from short- to long-run.[662]

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[660] PRIA at 977-978

[661] Hymel et al. (2010), at 1235.

[662] PRIA at 949 (showing lagged variables in the sales model); *id.* at 1044 (showing lagged variables in the scrappage model).

VII. THE AGENCIES SHOULD NOT RELY ON THE SAFETY CONSEQUENCES OF MASS

The agencies claim that the impact of the baseline standards on vehicle mass justifies the Proposed Rule. According to the agencies, the baseline standards will cause manufacturers to reduce the weight of new cars and light trucks.[663] In the agencies' analysis, that weight reduction has the potential to increase the risk of injury for the occupants of those lighter vehicles.[664] According to the agencies, under the baseline standards, the mass issue will lead to approximately 160-468[665]of additional fatalities when compared to the Proposed Rule.[666] And the agencies assert that the emissions reductions and lost fuel-savings that the Proposed Rule will cause are justified because of the safety concerns associated with this mass issue, along with the rebound and fleet composition concerns (addressed in Sections V and VI).[667]

The agencies' reliance on the mass-related fatalities is flawed because as the agencies' own analysis shows, there is no relationship between vehicle mass and safety. As the agencies explain, the effect of mass reductions in light duty vehicles is not statistically significant at the 95th percent confidence level.[668] In other words, the effect of mass reduction on safety cannot be reliably distinguished from zero. Only once the agency calculates the impact at the 85th percent confidence level do the results for two out of the five categories of vehicles show any statistical significance.[669] But anything lower than the 90th percent confidence interval is likely not reliable.[670]

Notably, the impact of mass is even less significant now than it was when the Clean Car Standards were issued. In 2012 and 2016, the agencies found minimal evidence of any relationship between mass and safety, and that evidence was statistically significant only at the

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[663] 83 Fed. Reg. at 42,991.

[664] *Id.* at 43,067 (line 6).

[665] *Id.* at 43,149-158; PRIA at 1411-1418. The agencies do not provide any information about the timeframe for this loss.

[666] 83 Fed. Reg. at 43,152 (estimating total fatalities attributed to mass from a rollback of the fuel efficiency standards); *id.* at 43,157 (estimating total fatalities attributed to mass from a rollback of the GHG emission standards).

[667] *Id.* at 42,995.

[668] *Id.* at 43,111.

[669] *Id.* at 43,111.

[670] *See* Wooldridge (2009), at 137 (explaining that reliance on variables that are statistically significant below 90% requires further study). Ninety-five percent is the default confidence interval in commonly used statistical programs like STATA, SAS, and MATLAB. *See* https://www.stata.com/manuals13/rregress.pdf; http://support.sas.com/documentation/cdl/en/procstat/67528/HTML/default/viewer.htm#procstat_univariate_examples09.htm; https://www.mathworks.com/help/stats/prob.normaldistribution.paramci.html; http://repec.org/bocode/o/outreg2.html.

90th confidence interval, which is weak evidence.[671] Now the agencies are not even able to say that much. The fact that the mass effects are not statistically significant even at the 90th confidence interval now is consistent with the most recent literature on this topic. In a recent paper, Wenzel reviewed NHTSA's data and concluded that the "effect of mass reduction while maintaining footprint on societal U.S. fatality risk is small, and not statistically significant at the 95% or 90% confidence level for all vehicle types."[672] According to the study, "[r]educing vehicle mass does not consistently increase risk across all footprint deciles for any combination of vehicle type and crash type."[673] In fact, after running a decline analysis, Wenzel finds that reducing mass increases safety more than decreases safety for the vast majority of crash and vehicle combinations:

> Reducing vehicle mass does not consistently increase risk across all footprint deciles for any combination of vehicle type and crash type. Risk increases with decreasing mass in a majority of footprint deciles for only 6 of the 27 crash and vehicle combinations, but few of these increases are statistically significant. On the other hand, risk decreases with decreasing mass in a majority of footprint deciles for 16 of the 27 crash and vehicle combinations; in some cases these risk reductions are large and statistically significant. If reducing vehicle mass while maintaining footprint inherently leads to an increase in risk, the coefficients on mass reduction should be more consistently positive, and with a larger R2, across the 27 vehicle/crash combinations, than shown in the analysis.[674]

Wenzel found that the impact of mass was insignificant even as the weight of trucks has trended upwards over time.[675]

Indeed, the research and analysis actually supports a conclusion that reducing mass improves safety if anything.[676] For example, Bento et al. looked at impacts of CAFE standards on weight distribution and mean weight and found that pre-footprint standards actually decreased fatalities on net by reducing weight of vehicles (even as it spread out the distribution). Specifically, he found that pre-footprint regulations saved 393 lives nationally.[677] Given that the agencies' results showing fatalities associated with changes in vehicle mass due to the baseline standards are not statistically significant, Bento's results are not outside the range of possibility even under NHTSA's own analysis.

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[671] Draft TAR at 8-21, 8-22, 8-27 and 8-31; 77 Fed. Reg. at 62,747-48.

[672] Wenzel (2018), at x.

[673] *Id.* at v.

[674] Id.

[675] *See* 83 Fed. Reg. at 43,111-12 (describing trend upward trend in vehicle mass).

[676] See, e.g., Wenzel (2018), at 110.

[677] Bento et al, (2017), at 24-25.

Moreover, footprint-based standards were introduced in 2012 to mitigate the potential negative effects of decreasing the mass of vehicles (i.e., by creating crumple space). And when footprint is held fixed, "no judicious combination of mass reductions in the various classes of vehicles results in a statistically significant fatality increase and many potential combinations are safety-neutral as point estimates."[678] Similarly, a 2015 study by the National Academy of Sciences found that "a reduction in the weight of vehicles is not generally associated with greater societal safety risks" as long as the size mix of vehicles remains roughly the same.[679] Similarly, in a 2013 study, Jacobsen found no evidence that footprint standards affect fatalities.[680]

There may be several reasons other than the fact that standards are footprint-based, to explain the evidence showing that mass reductions do not affect safety.

First, other independent factors likely reduce the impact of mass on safety. For example, as the agencies concede, the "designs and materials of more recent model year vehicles may have weakened the historical statistical relationships between mass, size, and safety."[681] Additionally, fuel efficiency and safety ratings may be positively related via production decisions.[682]

Second, recent work by Tolouei also supports the findings that narrowing the weight distribution of vehicles will save lives.[683]

Third, as the National Academy of Sciences has explained, manufacturers will reduce mass "across all vehicle sizes, with proportionately more mass removed from heavier vehicles."[684] This decreases any negative effect that mass reductions would have on safety.[685]

Due to this factor, in the 2016 Draft TAR, EPA analyzed the impact of mass by adding weight reduction constraints.[686] Ignoring all of this research, the agencies' current analysis applies mass

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[678] Wenzel (2018), at x.

[679] NAS (2015), at 363-364 (finding 10.2); *see also* Anderson, et al. (2011), at 6-7 (concluding that "the impact of fuel economy standards on road safety is less clear. . . based on the available literature, it is difficult to draw definitive conclusions about the direction, let alone the magnitude, of the link between external accident costs and fuel economy regulations").

[680] Jacobsen (2013), at 2.

[681] PRIA at 1333.

[682] Chen & Run (2010), at 114.

[683] Tolouei (2015), at 267.

[684] NAS (2015), at 240.

[685] *Id.*; Wenzel (2018), at 110.

[686] Draft TAR at 8-58, 8-59.

reductions without regard to the size of the vehicle.[687] If nothing else, the agencies should use the same constraints that EPA used in the Draft TAR when analyzing the Proposed Rule.

As a last point, NHTSA had LBNL analyze its mass results and LBNL found that mass reductions may increase the number of accidents but that each crash results in fewer fatalities.[688] That unexpected result demonstrates that the agencies' conclusions are incorrect.

As the evidence shows, there is no negative safety impact due to mass changes. EPA is on record reaching a similar conclusion. In 2017, EPA explained in the Final Determination that the fleet can absorb modest levels of mass reduction without any net increase in fatalities.[689] The agencies have failed to explain their changed conclusion now and have presented no new evidence that would justify the change. The agencies' reliance on those fatalities despite their statistical insignificance is arbitrary and capricious.

VIII. THE AGENCIES' EMPLOYMENT ANALYSIS IS INCOMPLETE

The agencies' employment analysis does not provide any justification for the Proposed Rule either. The agencies introduce the Proposed Rule by explaining that the proposal follows the President's promise to change the standards if they threaten automotive sector jobs.[690] But the actual analysis conducted by the agencies shows that this concern does not support the Proposed Repeal at all. To the contrary, according to the agencies' own numbers, the Proposed Repeal would *reduce* auto-sector jobs due to the decision to eliminate the mandate to use fuel-efficient technologies, with 50 to 60 thousand jobs lost between 2020 and 2030.[691]

The agencies' jobs analysis is incomplete. In particular, the agencies' analysis focuses on the automotive sector only and does not investigate the job losses in the long-term or with reference to other job sectors.[692] As even the agencies acknowledge, total economy-wide employment effects might be very different from those found within the regulated sector.[693] A proper methodology should thus look at the economy-wide effects, including all relevant general equilibrium channels.[694]

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[687] *See* 83 Fed. Reg. at 43,113 (explaining how the agencies calculated fatalities as a function of mass without any discussion of footprint); *id.* at 43,110 (discussing correlation between mass and footprint but then arguing that correlation has decreased over time).

[688] PRIA at 1336-1337.

[689] Final Determination at 26-27.

[690] 83 Fed. Reg. at 42,987.

[691] *Id.* at 43,436-37 (Table VIII-39).

[692] *Id.* at 43,078-79, 43,436.

[693] *Id.* at 43,078-79.

[694] In their annual reports on the costs and benefits of federal regulations, OMB has repeatedly advised agencies not to fall into the "pitfall" of ignoring long-run and economy-wide effects. *See*

Additionally, employment effects should be part of traditional cost-benefit analysis and should be conducted in a way that makes it easy for both decisionmakers and the public to assess how the employment effects compare to other effects of the proposed regulatory change. Therefore, instead of simply reporting the number of jobs affected, the agencies should focus on the associated welfare effects and use a recognized cost-benefit methodology to quantify the respective employment welfare impacts.[695]

IX. THE AGENCIES' EMISSIONS' ANALYSIS IS INACCURATE AND INCOMPLETE

The agencies have inaccurately and incompletely quantified the increases in both greenhouse gas emissions and emissions of criteria and toxic pollutants that will result from the Proposed Rule. As detailed more thoroughly in our separate comments that were submitted jointly with other organizations on the social cost of greenhouse gases,[696] at least the following serious problems cause significant underestimates of the Proposed Rule's health and welfare effects:

- The myriad modeling problems, especially with the rebound, scrappage, and sales modules, cause the agencies to underestimate the increase in fuel consumption—and so underestimate the increase in upstream and downstream emissions associated with fuel consumption—that will result from the proposed rollback.
- The agencies have assumed that 50% of the increase in fuel consumption from the Proposed Rule will be met by increased imports of refined gasoline, and that 45% will be met by increased domestic refining of imported crude oil. Yet the agencies arbitrarily ignore all upstream emissions associated with fuel production that occur abroad, even though all foreign emissions of greenhouse gases, and some foreign emissions of other pollutants, will have direct effects on the United States. Additionally, those assumptions on imports are completely inconsistent with other parts of the agencies' model.
- The agencies overestimate upstream emissions from electric vehicles by arbitrarily applying a national average to upstream electricity emissions, instead of accounting for cleaner regional mixes.
- The agencies' treatment of emissions associated with refueling trips is unclear, and so those emissions may be undercounted.
- The inconsistency between the total emissions tallies in the preliminary regulatory impact analysis and the draft environmental impact statement is unexplained.

Additionally, the agencies fixate on alleged on-road fatality effects while arbitrarily ignoring the mortalities, morbidities, and other welfare effects associated with emissions. The agencies

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https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/2015_cb/2015-cost- benefit-report.pdf at 42. *See also* SAB Advice on the Use of Economy-Wide Models in Evaluating the Social Costs, Benefits, and Economic Impacts of Air Regulations, Environmental Protection Agency Science Advisory Board Economy-Wide Modeling Panel, EPA-SAP-17-012 (2017).

[695] *See* Bartik (2012); Bartik (2015).

[696] *See* https://policyintegrity.org/what-we-do/update/3190.

misleadingly tout figures on how many lives the Proposed Rule will allegededly save from traffic accidents, without assessing any of the real-world impacts from the increase in greenhouse gas emissions, criteria pollutant emissions, and toxic pollutant emissions, which will include: climate-related deaths and illnesses from excessive heat, excessive cold, extreme weather events, diarrhea, vector-borne diseases, food- and water-borne diseases, cardiovascular and respiratory effects, food scarcity, water scarcity, and conflict;[697] as well as mortalities and morbidities from increases in particulate matter and other pollutants, including premature adult and infant mortality, acute bronchitis, respiratory emergency room visits, non-fatal heart attacks, asthma exacerbations, strokes, reproductive and developmental effects, cancer and genotoxicity effects, and work-loss days.[698] In the entire Proposed Rule, ocean acidification—a major environmental impact from increased carbon dioxide emissions—is never mentioned, and a host of other climate- and pollution-related effects are arbitrarily omitted or given short shrift.

As our separate comments on the social cost of greenhouse gases explain, the agencies must more accurately and fully monetize climate damages by applying the Interagency Working Group's estimates of the social cost of greenhouse gases. The agencies' so-called "interim" estimates have manipulated and decimated the valuation of the full costs of climate damages in ways at odds with the best available science, the best practices for economic analysis, and the legal standards for rational decisionmaking. The "interim" values ignore the real costs of climate change by arbitrarily attempting to limit the valuation to purportedly domestic-only effects; by arbitrarily discounting future climate effects at a 7% discount rate that is inappropriate for long-term climate effects; and by arbitrarily failing to address uncertainty over catastrophic damages, tipping points, option value, and risk aversion.

X. MISSING DOCKET INFORMATION

Finally, we submitted comments flagging important information that was missing from the docket and so impeding public review.[699] That information has still not been provided. The missing information frustrates the opportunity for meaningful public comment.

Respectfully,

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[697] Carleton et al. (2018); Howard (2014); SAFE Rule Draft EIS at S-21.

[698] SAFE Rule Draft EIS at S-9, 2-27, 4-24 (listing the human health and welfare impacts from the increased particulate matter emissions under the proposed rollbacks).

[699] https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0899.

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ATTACHMENT B

Policy Integrity et al., Comments on Quantifying and Monetizing Greenhouse Gas Emissions in the Safer Affordable Fuel-Efficient Vehicles Proposed Rule and Preliminary Regulatory Impact Analysis, EPA-HQ-OAR-2018-0283 and NHTSA-2018-006 (October 26, 2018)

October 26, 2018

Dockets: EPA-HQ-OAR-2018-0283 & NHTSA-2018-0067

Subject: Comments on Quantifying and Monetizing Greenhouse Gas Emissions in the Safer Affordable Fuel-Efficient Vehicles Proposed Rule and Preliminary Regulatory Impact Analysis

Submitted by: Environmental Defense Fund, Institute for Policy Integrity at New York University School of Law, Natural Resources Defense Council, Sierra Club, and Union of Concerned Scientists[1]

The following comments focus on EPA and NHTSA's (the agencies') inaccurate quantification of greenhouse gas emissions and their failure to accurately and fully monetize the climate damages from those emissions using the social cost of greenhouse gases in the proposed SAFE rule and preliminary regulatory impact analysis (PRIA). The agency's so-called "interim" metrics have manipulated and decimated the estimates of the full costs of climate damages in ways at odds with the best available science, the best practices for economic analysis, and the legal standards for rational decisionmaking. The "interim" values ignore the real costs of climate change by arbitrarily attempting to limit the valuation to purportedly domestic-only effects; by arbitrarily discounting future climate effects at a 7% discount rate that is inappropriate for long-term climate effects; and by arbitrarily failing to address uncertainty over catastrophic damages, tipping points, option value, and risk aversion.

As per the agencies' instructions for submitting comments, these comments are submitted to the EPA's docket, but should be considered in NHTSA's docket as well. We have separately submitted similar comments on NHTSA's Draft Environmental Impact Statement (DEIS)

I. The Agencies Inaccurately and Incompletely Quantifies Emissions

It is impossible to provide decision-makers and the public with the necessary context to understand the difference in climate, public health, and welfare impacts between the proposed rollback and the 2012 baseline standards if emissions have not been fully and accurately quantified. They have not.

Note that while these comments focus on greenhouse gas emissions, many of the critiques apply equally to the estimates and presentation of criteria and toxic pollutants as well.

Problems with the Rebound, Scrappage, and Sales Modules—Plus Other Problematic Modeling Choices—Infect the Agencies' Estimates of Emissions

The estimates of both upstream and downstream emissions derive from the Volpe model's predictions about miles driven and fuel consumed. Various separate comments submitted by our groups on the PRIA and proposed rule detail the numerous serious problems with the economic theory, methodology, and data that the agencies used to build the Volpe model's rebound, scrappage, and sales modules. To give just one example, in the vehicle sales module, the analysis assumes that consumers care about vehicle cost but place zero value on fuel savings. This unrealistic assumption lets the agencies miscalculate sales of new vehicles versus retention of older, dirtier vehicles under the standards. As a

[1] Our organizations may separately and independently submit other comments on other issues raised by the proposed rollback and the preliminary regulatory impact analysis.

result, the agencies grossly underestimate the net emission reductions achieved by the 2012 baseline standards. Such serious problems indicate that the agencies are likely severely underestimating the increase in emissions resulting from the proposed action as compared to the no-action alternative. The agencies must reexamine their estimates of all emissions—greenhouse gases, criteria pollutants, and toxic pollutants—to correct any and all problems with the Volpe model that have resulted in undercounting the increase in pollution under the proposed rollback.

The Agencies Ignore Entire Categories of Significant Upstream Emissions

Section 10.2.3 of the PRIA clarifies that it is only quantifying "the resulting increases in domestic emissions" from upstream fuel production and distribution.[2] In particular, the PRIA's methodology for quantifying upstream effects counts emissions only if the fuel extraction, refining, distribution, and storage activities happened within U.S. borders. The PRIA assumes that 50% of the increased fuel consumption that results from lowering CAFE standards will be satisfied by imported finished gasoline products:[3] it therefore ignores all emissions from extracting, refining, and transporting the crude oil to supply that 50% of finished gasoline products. The other 50% of increased fuel consumption is estimated to come from increased domestic refining, but the PRIA further assumes that 90% of the crude oil feeding into that increased domestic refining will come from imported crude petroleum:[4] the PRIA therefore further ignores all emissions from extracting that imported crude, and likely some portion of emissions from transporting that crude before it was imported. Altogether, the PRIA ignores 95% of upstream emissions from fuel extraction,[5] 50% of upstream emissions from refining, at least 50% of upstream emissions from distribution of crude, and some unclear portion of upstream emissions from distribution of finished gasoline.[6]

These same assumptions—50% imported finished gasoline, 90% imported crude—also appear in the proposed rule,[7] as well as in the spreadsheet on parameters for the reference case in the agencies' sensitivity analysis files. The reference case parameters file also confirms that these "fuel import assumptions" are held constant from 2015 through 2050.

There are several significant problems with ignoring upstream emissions just because they originate outside U.S. borders.

First, as further detailed *infra* in the section on the global social cost of greenhouse gases, the Clean Air Act requires a more global perspective on greenhouse gas emissions and climate change.

Second, emissions that originate abroad can still have direct impacts on the United States. This is especially true of greenhouse gases, which are global pollutants that readily mix in the atmosphere and affect global climate. All greenhouse gases, regardless of their point of origin anywhere on the planet, will cause the same climate damages for the United States. Though criteria and toxic pollutants are usually thought of as local pollution, even some criteria and toxic pollutants emitted abroad can directly impact the United States. For example, in 2017, Canada supplied 43% of all crude imported into the

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[2] EPA & NHTSA. Preliminary Regulatory Impact Analysis. The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021 – 2026 Passenger Cars and Light Trucks (Jul. 2018, updated Aug. 23, 2018, Oct. 16, 2018) [Hereinafter PRIA] at 1291.

[3] PRIA at 1299 ("Using NEMS, it was estimated that 50% of increased gasoline consumption would be supplied by increased domestic refining.").

[4] PRIA at 1291 ("90% of this additional [domestic] refining would use imported crude petroleum.").

[5] 50% * 90% = 45%. 45% +50% = 95%.

[6] It is not immediately clear which distribution, transportation, and storage activities were counted. For example, crude may be extracted in Country A, transported to Country B for refining, transported again to Country C for storage, until finally imported to the United States. It is not clear which portion of emissions during the transportation between Countries A, B, and C—if any—is counted.

[7] 83 Fed. Reg. at 43,335.

United States, 45% of imported finished motor gasoline, and 30% of imported gasoline blending components; Mexico further supplied another 8% of crude imported into the United States.[8] EPA has in the past recognized that U.S. emissions of criteria and toxic pollution can affect health and welfare in our neighboring countries;[9] similarly, depending on the location of Canada and Mexico's fuel production and distribution facilities and on prevailing winds, their emissions can affect health and welfare in the United States. None of these upstream emissions—and especially the global greenhouse gas pollutants—should be completely ignored.

Third, as detailed further *infra* on the global social cost of greenhouse gases, through international spill-over effects, foreign reciprocity, the extraterritorial interest of the U.S. government and its citizens, and altruism, worldwide climate effects also affect U.S. welfare and matter to U.S. decisionmakers and the public.

Fourth, the assumptions are also questionable, especially over the long term. Much of the proposed rollback explicitly relies on the assumption that the United States will very soon become a net exporter of petroleum products. Indeed, the PRIA uses that assumption as a justification for not counting other potential social costs of the proposed rollback, such as military and security costs.[10] It is unclear why the agencies think that, solely for the purposes of quantifying upstream emissions, the United States will continue to import 50% of its gasoline and 90% of its crude *through the year 2050* to satisfy increased fuel consumption. By failing to adjust these assumptions over time, the agencies are not only undercounting all upstream emissions, but in particular they are undercounting *future* upstream emissions. Because the climate systems will continue to become even more stressed over time, future emissions are increasingly damaging,[11] and it is precisely these emissions that the agencies are ignoring.

Other Quantification Issues

<u>Overestimating EV Emissions:</u> The proposed rollback may be overestimating upstream emissions from electric vehicle use, and so underestimating the net greenhouse gas increases of the proposed action to roll back CAFE standards. After acknowledging that upstream emissions would vary "across the country," the agencies instead assume "that the future EV fleet would charge from a grid whose mix is uniform across the country."[12] This assumption ignores the fact that EV usage may be clustered in states

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[8] In 2017, US imported from all countries: 2.9 billion barrels of crude, 11 million barrels of finished motor gasoline, 220 million barrels of motor gasoline blending components. Of that, Canada supplied 1.25 billion barrels of crude (43%), 5 million barrels of finished motor gasoline (45%), and 66 million barrels of motor gasoline blending components (30%). Mexico supplied 222 million barrels of crude (8%), 1.5 million barrels of blending components (<1%). EIA, Petroleum & Other Liquids, https://www.eia.gov/dnav/pet/pet_move_impcus_d_nus_Z00_mbbl_a.htm

[9] In the analysis of the Cross-State Air Pollution Rule, EPA noted— though could not quantify—the "substantial health and environmental benefits that are likely to occur for Canadians" as U.S. states reduce their emissions of particulate matter and ozone—pollutants that can drift long distances across geographic borders. Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone, 75 Fed. Reg. 45,210, 45,351 (proposed Aug. 2, 2010). Similarly, in the Mercury and Air Toxics Standards, EPA concluded that a reduction of mercury emissions from U.S. power plants would generate health benefits for foreign consumers of fish, both from U.S. exports and from fish sourced in foreign countries. EPA did not quantify these foreign health benefits, however, due to complexities in the scientific modeling. U.S. ENVTL. PROT. AGENCY, REGULATORY IMPACT ANALYSIS FOR THE FINAL MERCURY AND AIR TOXICS STANDARDS 65 (2011) ("Reductions in domestic fish tissue concentrations can also impact the health of foreign consumers . . . [and] reductions in U.S. power plant emissions will result in a lowering of the global burden of elemental mercury.").

[10] PRIA at 1068.

[11] For example, the social cost of greenhouse gases increases over time because an additional ton of emissions will inflict greater damages in the future when total atmospheric concentrations of greenhouse gases are already much higher. As emissions accumulate in the atmosphere, each additional ton becomes that much more damaging. *See e.g.*, IWG, Technical Update of the Social Cost of Carbon (2016, hereinafter 2016 TSD), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf.

[12] DEIS at 2-23; *see also* PRIA at 1304.

with cleaner electricity fuel mixes. Notably, about half of EV sales in 2016 and 2017 occurred in California,[13] and California has a significantly cleaner current and planned electricity system than the national average.[14]

Unclear Treatment of Refueling Emissions: The proposed rule notes that greenhouse gas savings under the standards from not have to drive as often to refuel are "implicitly accounted for elsewhere" in the model,[15] though the rule does not clearly explain where or how those emissions are quantified. The proposed rule admits that, while the related fuel savings from not having to drive as often to refuel (which it also assumes are "implicitly captured" elsewhere) may seem to be a small benefit per individual consumer, the effect "is much more significant at the macro level."[16] It is not clear if or how the agencies actually quantify the similarly "significant" greenhouse gas emissions from refueling trips.

Unexplained Inconsistency between the DEIS and PRIA: The cumulative tallies of direct and indirect carbon dioxide emissions that appear in the DEIS (a difference of 4500 $MMTCO_2$ from passenger cars between the no-action alternative and alternative 1; and a difference of 2900 $MMTCO_2$ from light trucks between the no-action alternative and alternative 1)[17] are markedly different than the quantifications that appear in the PRIA and proposed rule (a difference of 329 $MMTCO_2$ from passenger cars between the no-action alternative and alternative 1; and a difference of 480 $MMTCO_2$ from light trucks between the no-action alternative and alternative 1).[18] Not just the magnitude of the numbers but also the relative share of responsibility between cars and trucks seems to be different between the DEIS estimates and the PRIA estimates. Given that the DEIS and PRIA both rely on the same models,[19] it is possible that the different cumulative estimates are explained by different timescales[20] and by the DEIS's reliance on GCAM to estimate emissions from cars and trucks over the years 2061-2100 by applying a projected rate of change.[21] Yet neither the DEIS nor the PRIA fully explains the different estimates in the two interrelated documents.

II. The Agencies' Description of Their Methodology for Monetizing Climate Damages Is Incomplete or Inapplicable

The PRIA's description of the methodology for estimating the social cost of greenhouse gases is incomplete or inapplicable in several ways. For example, when discussing a sensitivity analysis using a 2.5% discount rate, the PRIA starts reporting different estimates of monetized climate damages "under the rate-based and mass-based scenarios, respectively."[22] There are no rate-based versus mass-based alternatives under the proposed CAFE standards. Evidently, this language and the monetized estimate of climate damages ($3.8 to $3.9 billion) were copied and pasted directly from a different rulemaking (namely, from the stay, repeal, or replacement of the Clean Power Plan). It is unclear how much of the PRIA's description of its methodology or its monetized values using the social cost of greenhouse gases are also copied from a different rulemaking and so inapplicable to this rulemaking.

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[13] EVAdoption, 2017 EV Sales and Market Share by US State, http://evadoption.com/ev-market-share/ev-market-share-state/; *see also* Dept. of Energy, Registered Electric Vehicles by State, https://www.afdc.energy.gov/data/10961.

[14] EIA, Energy-Related Carbon Dioxide Emissions by State, 2000-2015, https://www.eia.gov/environment/emissions/state/analysis/.

[15] 83 Fed. Reg. at 43,088.

[16] *Id.*

[17] DEIS Appendix at page D-13.

[18] PRIA at 92, table 1-77.

[19] DEIS at 2-17 (discussing reliance on Volpe, GREET, MOVES, NEMS, and so forth).

[20] *Compare* PRIA at 123 (calculating emissions over the lifetime of the vehicles) *with* DEIS at D-13 (calculating emissions over the years 2021-2100).

[21] DEIS at 5-21.

[22] PRIA at 1102.

In addition, the PRIA promises several critical documents to enable the public to understand the derivation of the social cost of greenhouse gas estimates—documents which are, in fact, not currently in the rulemaking dockets. Specifically, the PRIA promises, on page 1101, that "the full set of SC-CO2 results through 2050 is available in the docket." Page 1100 further promises that "to better understand how the results" for estimates of the social cost of carbon "vary across scenarios, results of each model run are available in the docket." Additionally, on page 1534, footnote 910 says that "a detailed description of the methods used to construct these alternative values" for the social cost of methane and nitrous oxide "is available in the docket for this rule." None of that promised information is available in either docket for this rulemaking, at least according to our best searches of the docket. The promised but missing information is essential to allow the public to fully understand, among other things, how the discount rates and socioeconomic scenarios affect the estimates. The frequency distribution chart on page 1101, for example, provides insufficiently fine-grained information on how negative estimates of the social cost of carbon may be skewing the overall result. As the PRIA itself states, the full "results of each model run" are needed to "better understand how the results vary across scenarios." The frequency distribution chart also gives no information on the runs conducted at a 2.5% discount rate, and dockets contain none of the promised information on the methodology for calculating the social cost of methane and nitrous oxide.

These errors and omissions in the agencies' description of their methodology frustrate any meaningful opportunity to comment on the use of the social cost of greenhouse gases. Nevertheless, even with the incomplete and partially inapplicable description provided, it is clear that the agencies are not using the best available estimates based on the most recent science and economic literature. The values of the social cost of greenhouse gases currently used in the PRIA fall well short of that standard. In particular, the agencies' approaches to the issues of global versus domestic climate damages, discount rates, and treatment of uncertainty are inconsistent with best practices and the most recent science and economic literature, and result in severely undercounting the social cost of greenhouse gases. The agencies instead should use the 2016 estimates from the Interagency Working Group (IWG) for the social cost of carbon, methane, and nitrous oxide. The next several sections explain why.

III. Executive Order 13,783 Does Not Bar Agencies from Following the IWG's Best Practices

The PRIA concludes that a new "interim" social cost of carbon estimate became necessary following Executive Order 13,783.[23] President Trump's Executive Order 13,783, issued March 28, 2017, officially disbanded the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) and withdrew the technical support documents that underpinned their range of estimates.[24] Nevertheless, Executive Order 13,783 assumes that federal agencies will continue to "monetiz[e] the value of changes in greenhouse gas emissions" and instructs agencies to ensure such estimates are "consistent with the guidance contained in OMB Circular A-4."[25] Consequently, while NHTSA, EPA, and other federal agencies no longer have technical guidance directing them to exclusively rely on the IWG's estimates to monetize climate effects, by no means does the new Executive Order imply that agencies should not monetize important effects in their regulatory analyses or environmental impact statements. In fact, Circular A-4 instructs agencies to monetize costs and benefits whenever feasible.[26]

The Executive Order does not prohibit agencies from relying on the same choice of models as the IWG, the same inputs and assumptions as the IWG, the same statistical methodologies as the IWG, or the same ultimate values as derived by the IWG. To the contrary, because the Executive Order requires

[23] PRIA at 1062.
[24] Exec. Order. No. 13,783 § 5(b), 82 Fed. Reg. 16,093 (Mar. 28, 2017).
[25] *Id.* § 5(c).
[26] OMB, Circular A-4 at 27 (2003) ("You should monetize quantitative estimates whenever possible.").

consistency with Circular A-4, as agencies follow the Circular's standards for using the best available data and methodologies, they will necessarily choose similar data, methodologies, and estimates as the IWG, since the IWG's work continues to represent the best available estimates.[27] The new Executive Order does not preclude agencies from using the same range of estimates as developed by the IWG, so long as the agency explains that the data and methodology that produced those estimates are consistent with Circular A-4 and, more broadly, with standards for rational decisionmaking.

As explained throughout these comments, the IWG's estimates of the social cost of greenhouse gases are, in fact, already consistent with the Circular A-4 and represent the best existing estimates of the lower bound of the range for the social cost of greenhouse gases. Therefore, the IWG estimates or those of a similar or higher value[28] should be used in regulatory analyses and environmental impact statements.

IV. The Agencies Must Rely on a Global Estimate of the Social Cost of Greenhouse Gases

The proposed rule claims that "both domestic and global perspectives were considered" on "the cost of CO2 emissions and resulting climate damages," and refers the reader to "Chapter 9 of the Regulatory Impact Analysis."[29] That statement is false. While Chapter 9 does not mention the social cost of carbon, Chapter 8 and its Appendix make clear that the PRIA focuses exclusively on a domestic-only value of the social cost of carbon, claiming that such a perspective is required by Executive Order 13,783 and Circular A-4.[30] To the contrary, not only is it inconsistent with Circular A-4 and best economic practices to fail to estimate the global damages of U.S. greenhouse gas emissions in regulatory analyses, but existing methods for estimating a "domestic-only" value—including the agencies' approach—are unreliable, incomplete, and inconsistent with Circular A-4. The agencies' domestic-only estimate fails to use models built for the purpose of calculating regional damages, ignores recent literature on significant U.S. climate damages, and fails to reflect international spillovers to the United States, U.S. benefits from foreign reciprocal actions, and the extraterritorial interests of U.S. citizens including financial interests and altruism.

The agencies never explain why the proposed rule claims that the "global perspective" was considered when in fact the PRIA never uses a global estimate. Notably, an e-mail included in EPA's rulemaking docket entitled "SCC Language for Light Duty" refers to "on-going discussions regarding the global estimate," and EPA transmitted to the Office of Management and Budget a spreadsheet listing global estimates.[31] Nevertheless, neither the proposed rollback nor the PRIA explains why the agencies failed to use the global numbers.

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[27] Richard L. Revesz et al., *Best Cost Estimate of Greenhouse Gases*, 357 SCIENCE 6352 (2017) (explaining that, even after Trump's Executive Order, the social cost of greenhouse gas estimate of around $50 per ton of carbon dioxide is still the best estimate).

[28] *See*, *e.g.*, Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014) (explaining that current estimates omit key damage categories and, therefore, are very likely underestimates). *See also* Tamma Carleton et al., *Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits* (Becker Friedmand Inst. Working Paper No. 2018-51) (finding substantial willingness to pay to avoid just climate-related mortalities).

[29] 83 Fed. Reg. at 43,106.

[30] PRIA 1062-63; 1063 ("adopting a domestic perspective in our central analysis"); 1084 (showing "economic damages from future changes in the global climate [that] will be borne throughout the U.S. economy"); 1098 (describing the "methodology used to develop interim domestic SC-CO2 estimates"); 1101 (describing sensitivity analysis but not mentioning a global SCC sensitivity analysis); 1531 (same).

[31] https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453 (see the PDFs entitled "Social cost of carbon email exchange between EPA and OMB, July 16, 2018" and "Social cost of carbon spreadsheet provided by EPA to OMB, July 16, 2018").

A Global Estimate of Climate Damages Is Required by Statute[32]

Section 202 of the Clean Air Act charges EPA with protecting public health and welfare,[33] where "welfare" is defined to include "effects on . . . weather . . . and climate."[34] When interpreting that language, the Supreme Court found "there is nothing counterintuitive to the notion that EPA can curtail the emission of substances that are putting the *global* climate out of kilter."[35] When industry challenged another EPA climate program by arguing that the Clean Air Act "was concerned about local, not global effects," the U.S. Court of Appeals for the D.C. Circuit had "little trouble disposing of Industry Petitioners' argument that the [Clean Air Act's prevention of significant deterioration] program is specifically focused solely on localized air pollution," finding instead that the statute was "meant to address a much broader range of harms," including "precisely the types of harms caused by greenhouse gases."[36]

To assess the necessary protections of public welfare under Section 202 of the Clean Air Act, EPA must value not only domestic welfare changes from climate effects occurring within U.S. borders, but also other significant U.S. welfare interests affected by climate—including U.S. interests in foreign businesses and property, in global tourism, in global commons like the oceans, and in global existence values and altruism; U.S. benefits from reciprocal foreign actions on climate; and U.S. effects that spill over from foreign climate damages through our interconnected economy, national security, and public health—as well as other significant global effects. As explained below, continued use of the global estimate of climate damages—as opposed to a domestic-only value—is the only defensible way to accurately capture the full costs of climate pollution to public welfare.

Similarly, the statutory instruction for NHTSA to consider "need of the United States to conserve energy" should be read to include at least all those same significant U.S. welfare interested impacted by climate effects occurring outside U.S. borders listed above, including from spillovers, reciprocity, and extraterritorial interests.[37]

Circular A-4 Requires "Different Emphases . . . Depending on the Nature" of the Regulatory Issue

Since 2010, and including some recent agency actions under the Trump administration,[38] federal agencies routinely based their regulatory decision and NEPA reviews on global estimates of the social cost of greenhouse gases. Though agencies often also disclosed a "highly speculative" range that tried to

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[32] This subsection draws from Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columbia J. Envtl. L. 203 (2017). See *id.* for additional discussion of how Section 115 of the Clean Air Act, which explicitly requires the United States to take a global perspective on the effects of its greenhouse gas emissions, interacts with Section 202.

[33] 42 U.S.C. § 7521.

[34] 42 U.S.C. § 7602(h); *Massachusetts v. EPA*, 127 S.Ct. 1438, 1447 (2007).

[35] *Mass. v. EPA,* 127 S.Ct. at 1461 (emphasis added).

[36] *Coalition for Responsible Regulation v. EPA*, 684 F.3d 102, 138 (D.C. Cir. 2012), aff'd in part *Util. Air Regulatory Grp. v. EPA*, 134 S.Ct. 2427 (2014).

[37] *See* Howard & Schwartz, *supra* at 252-53 *(*explaining how EPCA may require a global perspective on climate effects, and how the Ninth Circuit listed global SCC estimates as reasonable values for NHTSA to have chosen).

[38] E.g., Dep't of Energy, Energy Conservation Program: Energy Conservation Standards for Walk-In Cooler and Freezer Refrigeration Systems, 82 Fed. Reg. 31,808, 31,812 (July 10, 2017) ("DOE maintains that consideration of global benefits is appropriate because of the global nature of the climate change problem."); U.S. Dep't of Interior, Bureau of Ocean Energy Mgmt., Draft Envtl. Impact Statement: Liberty Development Project at 3-129, 4-246 (Aug. 2017) (BOEM, Liberty Development Project), *available at* https://cdxnodengn.epa.gov/cdx-enepa-II/public/action/eis/details?eisId= 236901 (calling the global social cost of carbon estimates developed in 2016 by the Interagency Working Group "a useful measure" and applying them to analyze the consequences of offshore oil and gas drilling). Note that the final EIS (August 2018) for the Liberty Development Project does change from the global estimate to the indefensible domestic-only estimate.

capture exclusively U.S. climate costs, emphasis on a global value has been recognized as more accurate given the science and economics of climate change, as more consistent with best economic practices, and as crucial to advancing U.S. strategic goals.[39]

Opponents of climate regulation have long challenged the global number in court and other forums, and often attempted to use Circular A-4 as support.[40] Specifically, opponents have seized on Circular A-4's instructions to "focus" on effects to "citizens and residents of the United States," while any significant effects occurring "beyond the borders of the United States . . . should be reported separately."[41] Importantly, despite this language and such challenges, the U.S. Court of Appeals for the Seventh Circuit had no trouble concluding that a global focus for the social cost of greenhouse gases was reasonable:

> AHRI and Zero Zone [the industry petitioners] next contend that DOE [the Department of Energy] arbitrarily considered the global benefits to the environment but only considered the national costs. They emphasize that the [statute] only concerns "national energy and water conservation." In the New Standards Rule, DOE did not let this submission go unanswered. It explained that climate change "involves a global externality," meaning that carbon released in the United States affects the climate of the entire world. According to DOE, national energy conservation has global effects, and, therefore, those global effects are an appropriate consideration when looking at a national policy. Further, AHRI and Zero Zone point to no global costs that should have been considered alongside these benefits. Therefore, DOE acted reasonably when it compared global benefits to national costs.[42]

Circular A-4's reference to effects "beyond the borders" confirms that it is appropriate for agencies to consider the global effects of U.S. greenhouse gas emissions. While Circular A-4 may suggest that most typical decisions should focus on U.S. effects, the Circular cautions agencies that special cases call for different emphases:

> [Y]ou cannot conduct a good regulatory analysis according to a formula. Conducting high-quality analysis requires competent professional judgment. ***Different regulations may call for different emphases*** in the analysis, ***depending on the nature and complexity*** of the regulatory issues and the sensitivity of the benefit and cost estimates to the key assumptions.[43]

In fact, Circular A-4 elsewhere assumes that agencies' analyses will not always be conducted from purely the perspective of the United States, as one of its instructions only applies "as long as the analysis is conducted from the United States perspective,"[44] suggesting that in some circumstances it is appropriate for the analysis to be global. For example, in the past NHTSA also sometimes adopted a global perspective on the analysis of potential monopsony benefits to U.S. consumers resulting from the reduced price of foreign oil imports following energy efficiency increases.[45]

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[39] *See generally* Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columbia J. Envtl. L. 203 (2017).

[40] Ted Gayer & W. Kip Viscusi, *Determining the Proper Scope of Climate Change Policy Benefits in U.S. Regulatory Analyses: Domestic versus Global Approaches*, 10 Rev. Envtl. Econ. & Pol'y 245 (2016) (citing Circular A-4 to argue against a global perspective on the social cost of carbon); *see also, e.g.*, Petitioners Brief on Procedural and Record-Based Issues at 70, in *West Virginia v. EPA*, case 15-1363, D.C. Cir. (filed February 19, 2016) (challenging EPA's use of the global social cost of carbon).

[41] Circular A-4 at 15. Note that A-4 slightly conflates "accrue to citizens" with "borders of the United States": U.S. citizens have financial and other interests tied to effects beyond the borders of the United States, as discussed further below.

[42] Zero Zone v. Dept. of Energy, 832 F.3d 654, 679 (7th Cir., 2016).

[43] Circular A-4 at 3.

[44] *Id.* at 38 (counting international transfers as costs and benefits "as long as the analysis is conducted from the United States perspective").

[45] *See* Howard & Schwartz, *supra* note 39, at 268-69.

Perhaps more than any other issue, the nature of the issue of climate change requires precisely such a "different emphasis" from the default domestic-only assumption. To avoid a global "tragedy of the commons" that could irreparably damage all countries, including the United States, every nation should ideally set policy according to the global social cost of greenhouse gases.[46] Climate and clean air are global common resources, meaning they are freely available to all countries, but any one country's use—i.e., pollution—imposes harms on the polluting country as well as the rest of the world. Because greenhouse pollution does not stay within geographic borders but rather mixes in the atmosphere and affects climate worldwide, each ton emitted by the United States not only creates domestic harms, but also imposes large externalities on the rest of the world. Conversely, each ton of greenhouse gases abated in another country benefits the United States along with the rest of the world.

If all countries set their greenhouse emission levels based on only domestic costs and benefits, ignoring the large global externalities, the aggregate result would be substantially sub-optimal climate protections and significantly increased risks of severe harms to all nations, including the United States. Thus, basic economic principles demonstrate that the United States stands to benefit greatly if all countries apply global social cost of greenhouse gas values in their regulatory decisions and project reviews. Indeed, the United States stands to gain hundreds of billions or even trillions of dollars in direct benefits from efficient foreign action on climate change.[47] Moreover, if all countries reverted to a domestic-only SCC, U.S. industry would be placed at a competitive disadvantage internationally, since a GDP-based SCC would be higher in the U.S. than in other countries; only a global SCC puts U.S. industry on a level playing field with the rest of the world.[48]

In order to ensure that other nations continue to use global social cost of greenhouse gas values, it is important that the United States itself continue to do so.[49] The United States is engaged in a repeated strategic dynamic with several significant players—including the United Kingdom, Germany, Sweden, and others—that have already adopted a global framework for valuing the social cost of greenhouse gases.[50] For example, until recently Canada and Mexico had explicitly borrowed the U.S. estimates of a global social cost of carbon to set their own fuel efficiency standards.[51] For the United States to now depart from this collaborative dynamic by reverting to a domestic-only estimate would undermine the country's long-term interests and could jeopardize emissions reductions underway in other countries, which are already benefiting the United States. Indeed, there is some circumstantial evidence that tit-for-tat defections may be underway. Until September 2017, Mexico explicitly borrowed the IWG's estimates of the social cost of carbon for use in its own regulatory impact analyses;[52] by October 2017,

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[46] *See* Garrett Hardin, *The Tragedy of the Commons*, 162 Science 1243 (1968) ("[E]ach pursuing [only its] own best interest . . . in a commons brings ruin to all.").

[47] Policy Integrity, *Foreign Action, Domestic Windfall: The U.S. Economy Stands to Gain Trillions from Foreign Climate Action* (2015), http://policyintegrity.org/files/publications/ForeignActionDomesticWindfall.pdf

[48] Other flawed methods for calculating domestic-only SCCs, like proportion of worldwide shoreline, would also result in a higher domestic SCC for the U.S. than for most other countries.

[49] *See* Robert Axelrod, *The Evolution of Cooperation* 10-11 (1984) (on repeated prisoner's dilemma games).

[50] *See* Howard & Schwartz, *supra* note 39, at Appendix B.

[51] *See* Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations, SOR/2013-24, 147 Can. Gazette pt. II, 450, 544 (Can.), *available at* http://canadagazette.gc.ca/rp-pr/p2/2013/2013-03-13/html/sor-dors24-eng.html ("The values used by Environment Canada are based on the extensive work of the U.S. Interagency Working Group on the Social Cost of Carbon."); Jason Furman & Brian Deese, *The Economic Benefits of a 50 Percent Target for Clean Energy Generation by 2025*, White House Blog, June 29, 2016 (summarizing the North American Leader's Summit announcement that U.S., Canada, and Mexico would "align" their SCC estimates).

[52] www.cofemersimir.gob.mx/expediente/20708/mir/43430/anexo/3805458 ("Para monetizar esta reducción de emisiones, se utilizó como base el concepto de costo social del carbón (CSC), publicado para su uso en los análisis de impacto normativo realizado por las agencias del gobierno de los Estados Unidos[10]. [Fn10: Véase el documento "Social Cost of Carbon for

the U.S. Bureau of Land Management and EPA had begun using an interim domestic-only estimate of the social cost of carbon;[53] in a July 2018 regulatory impact analysis for a rule reducing methane emissions from the oil and gas sector, Mexico seems to abandon the IWG numbers in favor of its own valuation based solely on the cost of Mexican climate-related weather disasters.[54] If other countries follow the lead of the United States and base their climate policies without weighing the full global externalities of their emissions, the United States will suffer.

For these and other reasons, reliance on a domestic-only valuation is inappropriate. In the past, some agencies have, in addition to the global estimate, also disclosed a "highly speculative" estimate of the domestic-only effects of climate change. In particular, the Department of Energy always includes a chapter on a domestic-only value of carbon emissions in the economic analyses supporting its energy efficiency standards; EPA has also often disclosed similar estimates.[55] Such an approach is consistent with Circular A-4's suggestion that agencies should usually disclose domestic effects separately from global effects. However, as we have discussed, reliance on a domestic-only methodology would be inconsistent with both the inherent nature of climate change and the standards of Circular A-4. Consequently, under Circular A-4, the agencies should have estimated, and used in their primary analysis, the global social cost of greenhouse gases.

Benefits and Costs that "Accrue to U.S. Citizens" Are Much Broader Than Effects "within U.S. Borders"

To follow Circular A-4's instruction to analyze all significant effects that "accrue[s] to U.S. citizens," agencies must look beyond "U.S. borders" to a much broader range of climate effects. Circular A-4 instructs to estimate *all* important "opportunity costs," meaning "what individuals are willing to forgo to enjoy a particular benefit."[56] U.S. individuals are willing to forgo money to enjoy benefits or avoid costs from climate effects that occur beyond U.S. borders, and all such significant effects must be captured.[57]

International Spillovers: First, agencies may not ignore significant, indirect costs to trade, human health, and security likely to "spill over" to the United States as other regions experience climate change damages.[58] Due to its unique place among countries—both as the largest economy with trade- and investment-dependent links throughout the world, and as a military superpower—the United States is particularly vulnerable to effects that will spill over from other regions of the world. Spillover scenarios could entail a variety of serious costs to the United States as unchecked climate change devastates other countries. Correspondingly, mitigation or adaptation efforts that avoid climate damages to foreign countries will radiate benefits back to the United States as well.[59] While the current IAMs provide

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Regulatory Impact Analysis". Interagency Working Group on Social Cost of Carbon (IWGSCC), United States Government. 2011.]").

[53] https://www.regulations.gov/document?D=BLM-2017-0002-0002; https://www.epa.gov/sites/production/files/2017-11/documents/oilgas_memo_proposed-stay_2017-10.pdf

[54] http://www.cofemersimir.gob.mx/mirs/45614.

[55] Howard & Schwartz, *supra* note 39, at 220-21.

[56] Circular A-4 at 18.

[57] This section draws heavily from Howard & Schwartz (2017), *supra* note 39, and includes passages taken directly from that article (which was written by co-authors of these comments).

[58] Indeed, the integrated assessment models used to develop the global SCC estimates largely ignore inter-regional costs entirely. *See* Howard 2014, *supra* note **Error! Bookmark not defined.**. Though some positive spillover effects are also possible, such as technology spillovers that reduce the cost of mitigation or adaptation, *see* S. Rao et al., *Importance of Technological Change and Spillovers in Long-Term Climate Policy*, 27 ENERGY J. 123-39 (2006), overall spillovers likely mean that the U.S. share of the global SCC is underestimated, *see* Jody Freeman & Andrew Guzman, *Climate Change and U.S. Interests*, 109 COLUMBIA L. REV. 1531 (2009).

[59] *See* Freeman & Guzman, *supra* note 58, at 1563-93.

reliable but conservative estimates of global damages, they currently cannot calculate reliable region-specific estimates, in part because they do not model such spillovers.

As climate change disrupts the economies of other countries, decreased availability of imported inputs, intermediary goods, and consumption goods may cause supply shocks to the U.S. economy. Shocks to the supply of energy, technological, and agricultural goods could be especially damaging. For example, when Thailand—the world's second-largest producer of hard-drives—experienced flooding in 2011, U.S. consumers faced higher prices for many electronic goods, from computers to cameras.[60] A recent economic study explored how heat stress-induced reductions in productivity worldwide will ripple through the interconnected global supply network.[61] Similarly, the U.S. economy could experience demand shocks as climate-affected countries decrease their demand for U.S. goods. Financial markets may also suffer as foreign countries become less able to loan money to the United States and as the value of U.S. firms declines with shrinking foreign profits. As seen historically, economic disruptions in one country can cause financial crises that reverberate globally at a breakneck pace.[62]

The human dimension of climate spillovers includes migration and health effects. Water and food scarcity, flooding or extreme weather events, violent conflicts, economic collapses, and a number of other climate damages could precipitate mass migration to the United States from regions worldwide, especially, perhaps, from Latin America. For example, a 10% decline in crop yields could trigger the emigration of 2% of the entire Mexican population to other regions, mostly to the United States.[63] Such an influx could strain the U.S. economy and will likely lead to increased U.S. expenditures on migration prevention. Infectious disease could also spill across the U.S. borders, exacerbated by ecological collapses, the breakdown of public infrastructure in poorer nations, declining resources available for prevention, shifting habitats for disease vectors, and mass migration.

Finally, climate change is predicted to exacerbate existing security threats—and possibly catalyze new security threats—to the United States.[64] Besides threats to U.S. military installations and operations at home and abroad from flooding, storms, extreme heat, and wildfires,[65] Secretary of Defense Mattis has explained that "Climate change is impacting stability in areas of the world where our troops are operating today."[66] The National Defense Authorization Act for Fiscal Year 2018 found that "climate change is a direct threat to the national security of the United States" and that "[a]s global temperature rise, droughts and famines can lead to more failed states, which are breeding grounds of extremist and terrorist organizations."[67] The Department of Defense's 2014 Defense Review declared that climate effects "are threat multipliers that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions—conditions that can enable terrorist activity and other forms of violence," and as a result "climate change may increase the frequency, scale, and complexity of future missions, including defense support to civil authorities, while at the same time

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[60] *See* Charles Arthur, *Thailand's Devastating Floods Are Hitting PC Hard Drive Supplies*, THE GUARDIAN, Oct. 25, 2011.

[61] Leonie Wenz & Anders Levermann, *Enhanced Economic Connectivity to Foster Heat Stress-Related Losses*, SCIENCE ADVANCES (June 10, 2016).

[62] *See* Steven L. Schwarcz, *Systemic Risk*, 97 GEO. L.J. 193, 249 (2008) (observing that financial collapse in one country is inevitably felt beyond that country's borders).

[63] Shuaizhang Feng, Alan B. Krueger & Michael Oppenheimer, *Linkages Among Climate Change, Crop Yields and Mexico-U.S. Cross-Border Migration*, 107 PROC. NAT'L ACAD. SCI. 14,257 (2010).

[64] *See* CNA Military Advisory Board, *National Security and the Accelerating Risks of Climate Change* (2014).

[65] U.S. Gov't Accountability Office, GAO-14-446 *Climate Change Adaptation: DOD Can Improve Infrastructure Planning and Processes to Better Account for Potential Impacts* (2014); Union of Concerned Scientists, *The U.S. Military on the Front Lines of Rising Seas* (2016).

[66] Andrew Revkin, *Trump's Defense Secretary Cites Climate Change as National Security Challenge*, ProPublica, Mar. 14, 2017.

[67] H.R. 2810-75, § 335(a)(9), (b)(1).

undermining the capacity of our domestic installations to support training activities."[68] As an example of the climate-security-migration nexus, prolonged drought in Syria likely exacerbated the social and political tensions that erupted into an ongoing civil war,[69] which has triggered an international migration and humanitarian crisis.[70]

Because of these interconnections, attempts to artificially segregate a U.S.-only portion of climate damages will inevitably result in misleading underestimates. Some experts on the social cost of carbon have concluded that, given that integrated assessment models currently do not capture many of these key inter-regional costs, use of the global SCC may be further justified as a proxy to capturing all spillover effects.[71] Though surely not all climate damages will spill back to affect the United States, many will, and together with other justifications, the likelihood of significant spillovers makes a global valuation the better, more transparent accounting of the full range of costs and benefits that matter to U.S. policymakers and the public.

Reciprocal Foreign Actions: Second, an indirect consequence of the United States using a global social cost of greenhouse gas to justify actions that protect against climate damages is that foreign countries take reciprocal actions that benefit the United States. Circular A-4 requires that the "same standards of information and analysis quality that apply to direct benefits and costs should be applied to ancillary benefits and countervailing risks."[72] Consequently, any attempt to estimate a domestic-only value of the social cost of greenhouse gas must include indirect effects from reciprocal foreign actions.

As detailed more in Howard & Schwartz (2017), because the world's climate is a single interconnected system, the United States benefits greatly when foreign countries consider the global externalities of their greenhouse gas pollution and cut emissions accordingly. Game theory predicts that one viable strategy for the United States to encourage other countries to think globally in setting their climate policies is for the United States to do the same, in a tit-for-tat, lead-by-example, or coalition-building dynamic. In fact, most other countries with climate policies already use a global social cost of carbon or set their carbon taxes or allowances at prices above their domestic-only costs, consistent with the global perspective used to date by U.S. agencies to value the cost of greenhouse gases. Both Republican and Democratic administrations have recognized that the analytical and regulatory choices of U.S. agencies can affect the actions of foreign countries, which in turn affect U.S. citizens.[73]

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[68] U.S. Dep't of Defense, *Quadrennial Defense Review 2014* vi, 8 (2014).; see also U.S. Dep't of Defense, *Report to Congress: National Security Implications of Climate-Related Risks and a Changing Climate* (2015), *available at* http://archive.defense.gov/pubs/150724-congressional-report-on-national-implications-of-climate-change.pdf?source=govdelivery ("Global climate change will have wide-ranging implications for U.S. national security interests over the foreseeable future because it will aggravate existing problems—such as poverty, social tensions, environmental degradation, ineffectual leadership, and weak political institutions—that threaten domestic stability in a number of countries.")

[69] *See* Center for American Progress et al., *The Arab Spring and Climate Change: A Climate and Security Correlations Series* (2013); Colin P. Kelley et al., *Climate Change in the Fertile Crescent and Implications of the Recent Syrian Drought*, 112 PROC. NAT'L ACAD. SCI. 3241 (2014); Peter H. Gleick, *Water, Drought, Climate Change, and Conflict in Syria*, 6 WEATHER, CLIMATE & SOCIETY, 331 (2014).

[70] *See, e.g.*, *Ending Syria War Key to Migrant Crisis, Says U.S. General*, BBC.COM (Sept. 14, 2015).

[71] *See* Robert E. Kopp & Bryan K. Mignone, Circumspection, Reciprocity, and Optimal Carbon Prices, 120 CLIMATE CHANGE 831, 833 (2013).

[72] Circular A-4 at 26.

[73] Howard & Schwartz, *supra* note 39, at 232-37 (citing acknowledgement of this phenomenon by both the Bush administration and the Obama administration).

According to one study, over the next fifteen years, direct U.S. benefits from global climate policies already in effect could reach over $2 trillion.[74] Any attempt to estimate a domestic-only value of the social cost of greenhouse gases must include such indirect effects from reciprocal foreign actions.[75]

Accounting for U.S. benefits from global reciprocal action still understates the potential loss from failing to account for reciprocity. As noted above, other countries may select a domestic SCC in response to the U.S. selecting a domestic number. Since a GDP-based SCC would be higher for the U.S. than other nations, U.S. industry would be placed at a competitive disadvantage internationally if all countries reverted to their own domestic-only SCCs. Thus, not only should the United States account for reciprocity, but it should do so in a general equilibrium context.

Extraterritorial Interests: Circular A-4 requires agencies to count all significant costs and benefits, and specifically explains the importance of including "non-use" values like "bequest and existence values": "ignoring these values in your regulatory analysis may significantly understate the benefits and/or costs of regulatory action."[76] Similarly, while Circular A-4 distinguishes altruism from non-use values, the guidance instructs agencies that "if there is evidence of selective altruism, it needs to be considered specifically in both benefits and costs."[77] Many costs and benefits accrue to U.S. citizens from use values, non-use values, and altruism attached to climate effects occurring outside the U.S. borders.

U.S. citizens have economic and other interests abroad that are not fully reflected in the U.S. share of global GDP. As explained above, GDP does not reflect significant U.S. ownership interests in foreign businesses, properties, and other assets, as well as consumption abroad including tourism, or even the 8 million Americans living abroad.

The United States also has a willingness to pay—as well as a legal obligation—to protect the global commons of the oceans and Antarctica from climate damages. For example, the Madrid Protocol on Environmental Protection to the Antarctic Treaty commits the United States and other parties to the "comprehensive protection of the Antarctic environment," including "regular and effective monitoring" of "effects of activities carried on both within and outside the Antarctic Treaty area on the Antarctic environment."[78] The share of climate damages for which the United States is responsible is not limited to our geographic borders.

Similarly, U.S. citizens value natural resources and plant and animal lives abroad, even if they never use those resources or see those plants or animals. For example, the "existence value" of restoring the Prince William Sound after the 1989 Exxon Valdez oil tanker disaster—that is, the benefits derived by Americans who would never visit Alaska but nevertheless felt strongly about preserving the existence of this pristine environment—was estimated in the billions of dollars.[79] Though the methodologies for calculating existence value remain controversial,[80] U.S. citizens certainly have a non-zero willingness to pay to protect rainforests, charismatic megafauna like pandas, and other life and environments existing in foreign countries. U.S. citizens also have an altruistic willingness to pay to protect foreign citizens'

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[74] Policy Integrity, *Foreign Action, Domestic Windfall: The U.S. Economy Stands to Gain Trillions from Foreign Climate Action* 11 (2015), http://policyintegrity.org/files/publications/ForeignActionDomesticWindfall.pdf

[75] Kotchen shows that the optimally strategic social cost of greenhouse gas value will be strictly higher than the domestic value for all countries. Matthew J. Kotchen, *Which Social Cost of Carbon? A Theoretical Perspective* (NBER Working Paper, 2016).

[76] Circular A-4 at 22.

[77] *Id.*

[78] Madrid Protocol on Environmental Protection to the Antarctic Treaty (1991), http://www.ats.aq/documents/recatt/Att006_e.pdf

[79] RICHARD REVESZ & MICHAEL LIVERMORE, RETAKING RATIONALITY 121 (2008).

[80] *Id.* at 129.

health and welfare.[81] This altruism is "selective altruism," consistent with Circular A-4, because the United States is directly responsible for most of the historic emissions contributing to climate change.[82]

The Agencies Implicitly Count Global Cost Savings While Ignoring Global Climate Effects: The inextricable interconnectedness of global economic interests is apparent from the fact that the agencies never attempt to separate out cost savings to foreign interests. Yet because all industry compliance costs ultimately fall on the owners, employees, or customers of regulated and affected firms, a significant portion of the proposed action's alleged cost savings would ultimately accrue to foreign owners and foreign customers of manufacturers. The agencies never distinguish between those cost savings that would accrue to foreign entities as opposed to U.S. citizens or U.S. entities, and so their calculations of cost savings implicitly include all global effects.

For example, the agencies' calculations of compliance costs for the CAFE standards make the simplifying assumption that manufacturers will be able to pass through all technology costs to U.S. consumers. In reality, the agencies acknowledge that manufacturers will not always be able to pass costs directly to the buyer of the specific car associated with those costs. Instead, either the manufacturer's profits will decline to the detriment of its investors, or else the manufacturer will recover those extra costs by charging higher prices for its other models.[83] In particular, the agencies assume that the buyers of electric vehicles are not willing to pay the full additional technology costs, and the difference must be borne by investors or other customers. There is no reason to think that when a manufacturer tries to recover lost profits by increasing the price of other models, it will only affect prices of vehicles sold to U.S. citizens as opposed to also affecting the prices of vehicles either sold abroad in foreign markets or sold domestically to foreign-owned businesses that operate fleets in the United States. Putting aside any problems with the agencies' assumptions about EV buyers' willingness to pay, it is clear that when the agencies report that the proposed rollback will save U.S. purchasers of new cars $255.6 billion,[84] some significant but undefined portion of that amount will actually accrue to: foreign shareholders of manufacturers, foreign customers of vehicles sold abroad, and foreign entities purchasing vehicles in the United States, including investors of businesses that operate fleets in the United States. Nevertheless, the agencies fully count all these global cost savings and lumps them together with domestic cost savings.

The agencies do not, for instance, distinguish between savings that might accrue to the investors of Japan-headquartered Toyota Motors as compared to savings that might accrue to the investors of U.S.-headquartered General Motors. And of course, both manufacturers are publicly traded companies with significant non-U.S. investors. Economy-wide, between 20-30% of U.S. stocks and 35% of U.S. corporate debt are held by foreigners.[85] Similarly, both manufacturers have customers not just in the United States, but across the world. Finally, foreign entities may purchase cars and light trucks within the U.S. marketplace. For instance, Agrium's retail agricultural supply business operates one of the largest

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[81] *See* Arden Rowell, *Foreign Impacts and Climate Change*, 39 Harvard Environmental Law Rev. 371 (2015); David A. Dana, *Valuing Foreign Lives and Civilizations in Cost-Benefit Analysis: The Case of the United States and Climate Change Policy* (Northwestern Faculty Working Paper 196, 2009), http://scholarlycommons.law.northwestern.edu/cgi/viewcontent.cgi?article=1195&context=facultyworkingpapers (discussing U.S. charitable giving abroad and foreign aid, and how those metrics likely severely underestimate true U.S. willingness to pay to protect foreign welfare).

[82] Datablog, *A History of CO_2 Emissions*, THE GUARDIAN (Sept. 2, 2009) (from 1900-2004, the United States emitted 314,772.1 million metric tons of carbon dioxide; Russia and China follow, with only around 89,000 million metric tons each).

[83] 83 Fed. Reg. at 43,085.

[84] 83 Fed. Reg. 43,062. Using this figure in no way endorses the agencies' calculations of cost savings as accurate.

[85] Heather Long, *Foreign Investors Can't Get Enough of the U.S.*, CNN, Oct. 1, 2015, http://money.cnn.com/2015/10/01/investing/foreign-investors-buy-us-stocks-bonds/index.html.

corporate fleets of pickup trucks and cargo vans operating in the United States;[86] Agrium is a privately-owned company based in Canada.[87] In sum, a significant portion of the regulatory effects passing through regulated companies would ultimately be experienced by foreign owners or foreign customers. Yet despite counting compliance costs in full regardless of whether they are accrued inside or outside of the United States, the agencies ignore legitimate effects of climate change occurring outside U.S. borders. This inconsistent treatment of costs and benefits is patently arbitrary and capricious.

The agencies also take a global perspective on the monopsony effect even while insisting it must take a domestic perspective on climate change. The agencies argue that even though relaxing the CAFE standards will increase U.S. fuel demand, the resulting increase in the global fuel price will not result in a monopsony cost effect for U.S. consumers. The agencies' reason is that the United States is increasingly self-sufficient with respect to its supply of gasoline and will become a net exporter within the decade.[88] As a result, the agencies conclude that any increase in global fuel price resulting from the proposed action will result in a transfer from U.S. consumers to domestic producers, and not to foreign producers, resulting in $0 in monopsony costs from the domestic perspective.

This assumption on monopsony is wrong for several reasons, and is inconsistent with the approach the agencies take on climate damages. Even assuming that the United States will soon become a net exporter of petroleum, there are still foreign suppliers in the meantime, and there would continue to be foreign suppliers even after the United States achieves net-export status. Petroleum prices are set in a global market. The assumption that all U.S. consumers purchase their fuel from domestic producers also runs counter to the agencies' wildly different assumptions regarding upstream emissions, where the analysis imagined that 95% of increased fuel consumption through the year 2050 would come either from imported gasoline or imported crude.[89] If the assumptions from the upstream analysis were applied to the monopsony analysis, the price increase resulting from the CAFE rollbacks would result in a hefty transfer from U.S. consumers to foreign producers. Regardless, there are significant foreign shareholders of even "domestic" producers. The Government Pension Fund of Norway, for instance, owned over seven million shares in ConocoPhillips as of 2017,[90] and in general there is significant foreign direct investment in U.S. fossil fuel extraction.[91] Even within a transfer from a U.S. consumer to a nominally domestic producer, some of the distributional benefits accrue outside the United States.

Yet the agencies ignore all this and instead assume $0 in monopsony costs. Essentially, the agencies are taking a global perspective on the monopsony effect, counting any financial transfers from a U.S. consumer to a foreign entity as a wash. Despite this global approach to monopsony costs, the agencies

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[86] FleetTrax, The Largest Fleets in America, https://fleettrax.net/largest-fleets-america/ ("Agrium also owns and operates a staggering 7,627 pickup trucks and cargo vans—a record number for this list."; reporting on "the largest private fleets operating in the United States"); *see also* Transport Topics, 2017 Essential Financial and Operating Information for the 100 Largest Private Carriers in North America https://www.ttnews.com/top100/private/2017?order=field_pickups_cargo_vans&sort=desc. Presumably Agrium purchases at least some of its new light trucks from manufacturers in the U.S. market subject to CAFE standards.

[87] Yahoo Finance, Agrium, https://finance.yahoo.com/company/agrium?h=eyJlIjoiYWdyaXVtIiwibiI6IkFncml1bSJ9&.tsrc=fin-srch. Agrium's parent company is the Canadian-based Nutrien.

[88] PRIA at 114; 83 Fed. Reg. 43,067.

[89] *See supra* on upstream emissions; *see also* PRIA at 1073, which assumes for the purposes of calculating energy shock costs that 75% of increased consumption will come from increased imports—again, that number is very different from 0%.

[90] See Morningstar, ConocoPhillips Major Shareholders (last visited Dec. 12, 2017), http://investors.morningstar.com/ownership/shareholders-major.html?t=COP&region=usa&culture=en-US&ownerCountry=USA.

[91] Dept. of Treasury, *U.S. Portfolio Holdings of Foreign Securities*, exhibit 19 (2017) https://www.treasury.gov/press-center/press-releases/Documents/shl2016_final_20170421.pdf (market value of foreign holdings of U.S. securities, by industry).

inconsistently insist on taking a domestic-only perspective on climate damages. Again, this inconsistent treatment of effects is patently arbitrary and capricious.

Standards of Rational Decisionmaking Require Consideration of Important, Globally Interconnected Climate Costs

The Administrative Procedure Act, as interpreted by the Supreme Court in *State Farm*, requires agencies to consider all "important aspect[s] of the problem" and articulate a rational connection between the facts and the choice made.[92]

Two courts of appeals have already applied arbitrary and capricious review to support the use of a global social cost of carbon in setting regulatory standards. In *Center for Biological Diversity v. NHTSA*, the U.S. Court of Appeals for the Ninth Circuit not only held that it was arbitrary not to monetize the greenhouse gas benefits of vehicle efficiency standards, but also approvingly cited a partial consensus among experts around an estimate of "$50 per ton of carbon (or $13.60 per ton CO2),"[93] which, in the year 2006 when the rule was issued, would have been consistent with estimates of a global social cost of carbon.[94] More recently, in *Zero Zone v. Department of Energy*, the Court of Appeals for the Seventh Circuit found, in response to petitioners' challenge that the agency's consideration of the global social cost of carbon was arbitrary, that the agency had acted reasonably in considering the global climate effects.[95]

For more details on the justification for a global value of the social cost of greenhouse gases, including the applicable standards of rational decisionmaking, please see Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columbia J. Envtl. L. 203 (2017). Another strong defense of the global valuation as consistent with best economic practices appears in a letter published in a recent issue of *The Review of Environmental Economics and Policy*, co-authored by Nobel laureate Kenneth Arrow.[96]

No Current Methodology for Estimating a "Domestic-Only" Value Is Consistent with Circular A-4

OMB, the National Academies of Sciences, and the economic literature all agree that existing methodologies for calculating a "domestic-only" value of the social cost of greenhouse gases are deeply flawed and result in severe and misleading underestimates.

In developing the social cost of carbon, the IWG did offer some such domestic estimates. Using the results of one economic model (FUND) as well as the U.S. share of global gross domestic product ("GDP"), the group generated an "approximate, provisional, and ***highly speculative***" range of 7–23% of the global social cost of carbon as an estimate of the purely direct climate effects to the United States.[97] Yet, as the IWG itself acknowledged, this range is almost certainly an underestimate because it ignores

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[92] 5 U.S.C. § 706; *see* Motor Vehicle Manufacturers Assoc. v. State Farm Mutual Auto. Ins. Co., 463 U.S. 29, 41-42 (1983) (applying the standards of review to deregulatory action and concluding that when "rescinding a rule" an agency "is obligated to supply a reasoned analysis for the change beyond that which may be required when an agency does not act in the first instance").

[93] 538 F.3d at 1199, 1201.

[94] *See* Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011-2015, 73 Fed. Reg. 24,352, 24,414 (May 2, 2008) (the National Highway Traffic Safety Administration estimated that $14 per ton of carbon dioxide approximated global benefits).

[95] 832 F.3d at 679.

[96] Richard Revesz, Kenneth Arrow et al., *The Social Cost of Carbon: A Global Imperative*, 11 REEP 172 (2017).

[97] INTERAGENCY WORKING GROUP ON SOCIAL COST OF CARBON, TECHNICAL SUPPORT DOCUMENT: SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 at 11 (2010).

significant, indirect costs to trade, human health, and security that are likely to "spill over" into the United States as other regions experience climate change damages, among other effects.[98]

Neither the existing IAMs nor a share of global GDP are appropriate bases for calculating a domestic-only estimate. The IAMs were never designed to calculate a domestic SCC, since a global SCC is the economic efficient value. FUND, like other IAMS, includes some simplifying assumptions: of relevance, FUND and the other IAMs are not able to capture the adverse effects that the impacts of climate change in other countries will have on the United States through trade linkages, national security, migration, and other forces.[99] This is why the IWG characterized the domestic-only estimate from FUND as a "highly speculative" underestimate. Similarly, a domestic-only estimate based on some rigid conception of geographic borders or U.S. share of world GDP will fail to capture all the climate-related costs and benefits that matter to U.S. citizens.[100] U.S. citizens have economic and other interests abroad that are not fully reflected in the U.S. share of global GDP. GDP is a "monetary value of final goods and services—that is, those that are bought by the final user—produced in a country in a given period of time."[101] GDP therefore does not reflect significant U.S. ownership interests in foreign businesses, properties, and other assets, as well as consumption abroad including tourism,[102] or even the 8 million Americans living abroad.[103] At the same time, GDP is also over-inclusive, counting productive operations in the United States that are owned by foreigners. Gross National Income ("GNI"), by contrast, defines its scope not by location but by ownership interests.[104] However, not only has GNI fallen out of favor as a metric used in international economic policy,[105] but using a domestic-only SCC based on GNI would make the SCC metrics incommensurable with other costs in regulatory impact analyses, since most regulatory costs are calculated by U.S. agencies regardless of whether they fall to U.S.-owned entities or to foreign-owned entities operating in the United States.[106] Furthermore, both GDP and GNI are dependent on what happens in other countries, due to trade and the international flow of capital. The artificial constraints of both metrics counsel against a rigid split based on either U.S. GDP or U.S. GNI.[107]

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[98] *Id.* (explaining that the IAMs, like FUND, do "not account for how damages in other regions could affect the United States (e.g., global migration, economic and political destabilization").

[99] *See, e.g.*, Dept. of Defense, *National Security Implications of Climate-Related Risks and a Changing Climate* (2015), *available at* http://archive.defense.gov/pubs/150724-congressional-report-on-national-implications-of-climate-change.pdf?source=govdelivery.

[100] A domestic-only SCC would fail to "provide to the public and to OMB a careful and transparent analysis of the anticipated consequences of economically significant regulatory actions." Office of Information and Regulatory Affairs, *Regulatory Impact Analysis: A Primer* 2 (2011).

[101] Tim Callen, *Gross Domestic Product: An Economy's All*, IMF, http://www.imf.org/external/pubs/ft/fandd/basics/gdp.htm (last updated Mar. 28, 2012).

[102] "U.S. residents spend millions each year on foreign travel, including travel to places that are at substantial risk from climate change, such as European cities like Venice and tropical destinations like the Caribbean islands." David A. Dana, *Valuing Foreign Lives and Civilizations in Cost-Benefit Analysis: The Case of the United States and Climate Change Policy* (Northwestern Faculty Working Paper 196, 2009), http://scholarlycommons.law.northwestern.edu/cgi/viewcontent.cgi?article=1195&context=facultyworkingpapers.

[103] Assoc. of Americans Resident Oversees, https://www.aaro.org/about-aaro/6m-americans-abroad. Admittedly 8 million is only 0.1% of the total population living outside the United States.

[104] *GNI, Atlas Method (Current US$)*, THE WORLD BANK, http://data.worldbank.org/indicator/NY.GNP.ATLS.CD.

[105] *Id*.

[106] U.S. Office of Management and Budget & Secretariat General of the European Commission, *Review of Application of EU and US Regulatory Impact Assessment Guidelines on the Analysis of Impacts on International Trade and Development* 13 (2008).

[107] Advanced Notice of Proposed Rulemaking on Regulating Greenhouse Gas Emissions Under the Clean Air Act, 73 Fed. Reg. 44,354, 44,415 (July 30, 2008) ("Furthermore, international effects of climate change may also affect domestic benefits directly and indirectly to the extent U.S. citizens value international impacts (e.g., for tourism reasons, concerns for the existence of ecosystems, and/or concern for others); U.S. international interests are affected (e.g., risks to U.S. national security, or the U.S. economy from potential disruptions in other nations).").

As a result, in 2015, OMB concluded, along with several other agencies, that "good methodologies for estimating domestic damages do not currently exist."[108] Similarly, the NAS recently concluded that current IAMs cannot accurately estimate the domestic social cost of greenhouse gases, and that estimates based on U.S. share of global GDP would be likewise insufficient.[109] The agencies even quote the NAS report's warnings that current IAMs do not model international spillovers or reciprocity[110]—and yet, the agencies take no action as a result of that caution against domestic-only estimates. William Nordhaus, the developer of the DICE model who recently won the Nobel Prize in Economics for his work on modeling climate effects,[111] recently cautioned that "regional damage estimates are both incomplete and poorly understood," and "there is little agreement on the distribution of the SCC by region."[112] In short, any domestic-only estimate will be inaccurate, misleading, and out of step with the best available economic literature, in violation of Circular A-4's standards for information quality.

The Agencies Rely on Sources that Cannot Accurately Calculate a Domestic-Only Estimate and that Explicitly Caution Against Using Domestic-Only Estimates

The agencies report that their domestic-only estimates are "calculated directly" from the models FUND and PAGE; for the model DICE, the agencies simply assume that U.S. damages are 10% of global damages.[113] The agencies thus use these models in ways they were never designed for—indeed, in ways their designers specifically cautioned against. The agencies furthermore fail to assess the most up-to-date literature on U.S. damages and fails to take steps to reflect spillover effects, reciprocal benefits, or U.S. interests beyond our borders. The agencies' methodology is deeply flawed.

The integrated assessment models used by the agencies to calculate the social cost of greenhouse gases were designed to create global estimates and are best suited for those purposes. The models are limited in how accurately and fully they can estimate domestic values of the social cost of greenhouse gases. For example, the models make simplifying assumptions about the extent of heterogeneity in crucial parameters like relative prices and discount rates.[114] The models also simplify or ignore completely global spillovers from trade, migration, and other sources.[115] These types of spillovers will not, in many cases, affect the global estimate of climate change damages, but they will change (perhaps dramatically so) the domestic estimates, as detailed below. For example, trade effects will net to zero globally. A decrease in exports by one country must correspond to a decrease in imports for another country.[116]

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[108] In November 2013, OMB requested public comments on the social cost of carbon. In 2015, OMB along with the rest of the Interagency Working Group issued a formal response to those comments. Interagency Working Group on the Social Cost of Carbon, *Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12,866* at 36 (July 2015) [hereinafter, OMB 2015 Response to Comments].

[109] National Academies of Sciences, Engineering, and Medicine, *Valuing climate damages: Updating estimation of the social cost of carbon dioxide* at 53 (2017) [hereinafter NAS Second Report].

[110] PRIA at 1065 ("The Academies' report also discussed the challenges in developing domestic SC-CO2 estimates, noting that current IAMs do not model all relevant regional interactions – i.e., how climate change impacts in other regions of the world could affect the United States, through pathways such as global migration, economic destabilization, and political destabilization. The Academies concluded that it 'is important to consider what constitutes a domestic impact in the case of a global pollutant that could have international implications that impact the United States. More thoroughly estimating a domestic SC-CO2 would therefore need to consider the potential implications of climate impacts on, and actions by, other countries, which also have impacts on the United States.'").

[111] https://www.nobelprize.org/prizes/economic-sciences/2018/nordhaus/facts/

[112] William Nordhaus, *Revisiting the Social Cost of Carbon*, 114 PNAS 1518, 1522 (2017).

[113] PRIA at 1098.

[114] Christian Gollier & James K. Hammitt, *The Long-Run Discount Rate Controversy*, 6 ANNU. REV. RESOUR. ECON. 273–295 (2014) at 287-289.

[115] *See generally* Howard & Schwartz (2017), *supra* note 39.

[116] *See, e.g.* PAUL R. KRUGMAN, MAURICE OBSTFELD & MARC J. MELITZ, INTERNATIONAL ECONOMICS: THEORY AND POLICY (10 ed. 2015). Such changes could have an effect on overall levels of trade, in turn effecting global damage estimates.

Global estimates will also generally be more accurate than domestic estimates because aggregation of multiple values reduces the error of the overall estimate.[117]

Examining the individual models used by the agencies to calculate the domestic social cost of greenhouse gases highlights the current limitations facing calculation of a domestic value of the social cost of greenhouse gases. The agency uses three models: FUND 3.8, PAGE09, and DICE 2010.[118] The FUND model generally estimates domestic damages from climate change by scaling estimates according to gross domestic product or population. For instance, forestry damages are "mapped to the FUND regions assuming that the impact is uniform [relative] to GDP."[119] Similarly, domestic energy consumption changes are a function of gross domestic product, and the authors note that "heating demand is linear in the number of people" in a FUND region.[120] Scaling damages by gross domestic product and population will fail to capture important differences between countries like pre-existing climate, interconnectedness of trade relationships, climate change preparedness, and preferences.

These issues are readily apparent in the case of agricultural damage estimates in FUND. Agriculture is one of the most important sectors driving the relatively low damages in the FUND model. Yet, recent evidence on this sector that incorporates cutting-edge estimates of crop yield changes finds that the FUND model substantially understates the agricultural damages from climate change.[121] Particularly for domestic damages, new research shows that FUND dramatically understates the effect of warming on agricultural outcomes globally and for individual countries like the United States.[122] These higher damage estimates come from updates to the relationship between warming and crop yield but also from a more thorough modeling of international trade in agricultural products.

The PAGE09 model scales global damages estimates according to regional coastline length, with the IWG noting that, "The [domestic] scaling factor in PAGE09 is based on the length of a region's coastline relative to the EU…Because of the long coastline in the EU, other regions are, on average, less vulnerable than the EU for the same sea level and temperature increase."[123] The model also uses GDP scaling, stating that "other regions lose more or less [output] depending upon their GDP per capita and weights factors."[124] Coast-line length provides a reasonable scaling factor for damages from flooding, coastal storms, and other sea-level rise issues, but it likely understates damages to the United States, where increases in mortality, agricultural losses, and other effects will likely also occur in inland, warm areas of the country.[125] Scaling by gross domestic product has the same limitations noted above in the context of the FUND model.

Finally, the author of DICE 2010 has explicitly warned against using a domestic-only value. In a recent article, William Nordhaus states that, "The regional estimates [of the social cost of greenhouse gases] are poorly understood, often varying by a factor of 2 across the three models. Moreover, regional damage estimates are highly correlated with output shares." He later reiterates that "the regional

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[117] *See, e.g.* SIDNEY I RESNICK, A PROBABILITY PATH (2013) at 203.

[118] PRIA at 1098.

[119] DAVID ANTHOFF & RICHARD S. J. TOL, THE CLIMATE FRAMEWORK FOR UNCERTAINTY, NEGOTIATION, AND DISTRIBUTION (FUND), TECHNICAL DESCRIPTION, VERSION 3.8 (2014) at 8.

[120] *Id.* at 10.

[121] Frances C Francis C Moore, Uris Lantz C Baldos & Thomas Hertel, *Economic impacts of climate change on agriculture: a comparison of process-based and statistical yield models*, 12 ENVIRON. RES. LETT. 65008 (2017).

[122] F. C. Moore et al., *New Science of Climate Change Impacts on Agriculture Implies Higher Social Cost of Carbon*, 1–43 (2017).

[123] IWG, 2013 Technical Update to the Social Cost of Carbon, at 10.

[124] Chris Hope, *Critical issues for the calculation of the social cost of CO2: why the estimates from PAGE09 are higher than those from PAGE2002*, 117 CLIM. CHANGE 531–543 (2013) at 539.

[125] Solomon Hsiang et al., *Economic Damage from Climate Change in the United States*, 1369 SCIENCE. 1362–1369 (2017).

damage estimates are both incomplete and poorly understood."[126] These statements reinforce the conclusion of OMB that "good methodologies for estimating domestic damages do not currently exist."[127]

In conclusion, the agencies' estimation of the domestic-only social cost of greenhouse gases ignores "important aspect[s] of the problem" and fails to articulate a rational connection between the data and the choice made, and is therefore arbitrary and capricious in violation of the Administrative Procedure Act.[128]

V. The Agencies Must Rely on a 3% or Lower Discount Rate for Intergenerational Effects—or a Declining Discount Rate

Because of the long lifespan of greenhouse gases and the long-term or irreversible consequences of climate change, the effects of today's emissions changes will stretch out over the next several centuries. The time horizon for an agency's analysis of climate effects, as well as the discount rate applied to future costs and benefits, determines how an agency treats future generations. Previously, federal agencies had focused on a central estimate of the social cost of greenhouse gases calculated at a 3% discount rate. The agencies now propose to give equal consideration to estimates calculated at a 7% discount rate, alleging that this is required by Circular A-4.[129] The agencies are wrong. Not only does use of a 7% discount rate violate statutorily required consideration of impacts on future generations, but a 7% rate for intergenerational climate effects is inconsistent with best economic practices, including under Circular A-4. In 2015, OMB explained that "Circular A-4 is a living document. . . . [T]he use of ***7 percent is <u>not</u> considered appropriate*** for intergenerational discounting. There is wide support for this view in the academic literature, and it is recognized in Circular A-4 itself. "[130] While Circular A-4 tells agencies generally to use a 7% discount rate in addition to lower rates for typical rules,[131] the guidance does not intend for default assumptions to produce analyses inconsistent with best economic practices. Circular A-4 clearly supports using lower rates to the exclusion of a 7% rate for the costs and benefits occurring over the extremely long, 300-year time horizon of climate effects.

Statutory Authority Requires Protecting the Needs of Future Generations; a 7% Discount Rate Ignores Those Future Needs

Section 202 of the Clean Air Act requires EPA to regulate a source category that "causes, or contributes to, air pollution which may reasonably be anticipate[d] to endanger public health or welfare."[132] The Clean Air Act explicitly defines "welfare" to include "effects on . . . climate."[133] The terms "endanger" and "reasonably anticipate" are not defined, but their plain dictionary definitions include a temporal element, and legislative history confirms that this language was chosen deliberately to ensure that harms need not be imminent before EPA must act.

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[126] William D Nordhaus, *Revisiting the social cost of carbon*, 114 PROC. NATL. ACAD. SCI. U. S. A. 1518–1523 (2017) at 1522.

[127] OMB 2015 Response to Comments, *supra* 108.

[128] 5 U.S.C. § 706; *see* Motor Vehicle Manufacturers Assoc. v. State Farm Mutual Auto. Ins. Co., 463 U.S. 29, 41-42 (1983) (applying the standards of review to deregulatory action and concluding that when "rescinding a rule" an agency "is obligated to supply a reasoned analysis for the change beyond that which may be required when an agency does not act in the first instance").

[129] PRIA 1078.

[130] OMB 2015 Response to Comments, *supra* note 108, at 36.

[131] Circular A-4 at 36 ("For regulatory analysis, you should provide estimates of net benefits using both 3 percent and 7 percent….If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent.").

[132] 42 U.S.C. § 7411(b)(1)(A).

[133] 42 U.S.C. § 7602(h).

In the 1970 Clean Air Act amendments, EPA's authority to regulate air pollution dangers was substantially strengthened, and Congress was motivated partly by the desire to protect future generations. For example, Senator Baker said about Section 202's standards for motor vehicle emissions: "I personally have great faith that the automobile industry…can meet these requirements, and that in any event we must meet them, if we are to protect the *health and welfare of this and future generations*."[134] More generally, Senator Muskie—a subcommittee chair who was instrumental in passing the Clean Air Act—explained the amendments were designed to "*deal with the long-term aspects* as well as the short term,"[135] and minority leader Senator Scott spoke specifically about the legislation's importance for protecting future generations from climate change: "Unless this outpouring of contaminants is controlled, scientists tell us we may very well experience *irreversible atmospheric and climatic changes* capable of producing a snowballing adverse effect to the health and safety of our citizens….*To guarantee that future generations of Americans can live without fear* of the destruction of the very air they breathe, I urge immediate passage."[136] When he signed the Clean Air Act Amendments of 1970 into law, President Nixon pronounced that "1970 will be known as the year of the beginning, in which we really began to move on the problems of *clean air* and clean water and open spaces *for the future generations of America*."[137]

The U.S. Court of Appeals for the District of Columbia Circuit confirmed the future-looking nature of EPA's authority when it ruled, in *Ethyl Corp v. EPA*, that the word "endanger" in the Clean Air Act made that statute "precautionary," and EPA need not wait for certain evidence of imminent harm before acting to prevent dangerous pollution.[138] Years later, that same Court of Appeals also upheld EPA's 2009 endangerment finding on greenhouse gas emissions from motor vehicles under Section 202. The endangerment finding spoke of the need to protect future generations in its very first sentence,[139] and the D.C. Circuit upheld[140] the finding as based on "evidence of current and future effects." Industry petitioners questioned the judgment on the grounds that there was "too much uncertainty" in the evidence. The Court recalled that the Act was meant to be "precautionary in nature" and warned that "[a]waiting certainty will often allow for only reactive, not preventive, regulation." The Court concluded that the language "may reasonably be anticipated to endanger" required "a precautionary, forward-looking scientific judgment."[141]

In summary, the use of the phrase "may reasonably be anticipated to endanger public health or welfare" requires EPA to consider the effects of climate change to future generations. Applying a 7% discount rate to the social cost of greenhouse gases means that, after a generation or two, future climate damages are insignificant. The use of such a rate thus effectively ignores the needs of future

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[134] Clean Air Act Amendments of 1970 Legislative History vol. 1, 268, Senate Debate on S. 4358, Sept. 21, 1970.

[135] *Id.* at 144.

[136] *Id.* at 349 (statement of Senator Scott).

[137] *Id.* at 106; President's Remarks upon Signing the Clean Air Amendments of 1970 Into Law, Dec. 31, 1970 https://babel.hathitrust.org/cgi/pt?id=mdp.39015077941642;view=1up;seq=245 (continuing, "We can look back and say, in the Roosevelt room on the last day of 1970, we signed a historic piece of legislation that put us far down the road toward a goal that Theodore Roosevelt, 70 years ago, spoke eloquently about, a goal of clean air, clean water, and open spaces for the future generations of America.").

[138] 541 F.2d 1, 13 (D.C. Cir. 1975).

[139] Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 18886-01 (2009).

[140] Coal. for Responsible Regulation, Inc. v. E.P.A., 684 F.3d 102, 121–22 (D.C. Cir. 2012), aff'd in part, rev'd in part sub nom. Util. Air Regulatory Grp. v. E.P.A., 134 S. Ct. 2427, (2014), and amended sub nom. Coal. for Responsible Regulation, Inc. v. Envtl. Prot. Agency, 606 F. App'x 6 (D.C. Cir. 2015).

[141] *Id.*

generations. Doing so would arbitrarily fail to consider an important statutory factor that Congress wrote into the Clean Air Act requirements.

NHTSA's statutory obligations are similarly future-looking. While the "need" to conserve energy is never strictly defined by the statutory text alone,[142] the language was originally added by the National Energy Conservation Policy Act of 1978, as a criterion for determining "economically justified."[143] The codified congressional findings for that Act reveal a concern for future needs, with a focus on the energy needs of future generations: "unless effective measures are promptly taken . . . to reduce the rate of growth of demand for energy, the United States will become . . . unable to provide the energy to meet future needs."[144] Upon signing the National Energy Conservation Policy Act into law in November 1978, President Carter concluded that "Today we can rightfully claim that we have a conscious national policy for dealing with the energy problems of the present and also to help us deal with them in the future."[145] Again, using a discount rate that effectively ignores the needs of future generations would arbitrarily fail to consider an important statutory factor.

A 7% Discount Rate Is Not "Sound and Defensible" or "Appropriate" for Climate Effects

Circular A-4 clearly requires agency analysts to do more than rigidly apply default assumptions: "You cannot conduct a good regulatory analysis according to a formula. Conducting high-quality analysis requires competent professional judgment."[146] As such, analysis must be "based on the best reasonably obtainable scientific, technical, and economic information available,"[147] and agencies must "***[u]se sound and defensible values*** or procedures to monetize benefits and costs, and ensure that key analytical assumptions are defensible."[148] Rather than assume a 7% discount rate should be applied automatically to every analysis, Circular A-4 requires agencies to justify the choice of discount rates for each analysis: "[S]tate in your report what assumptions were used, *such as . . . the discount rates* applied to future benefits and costs," and explain "clearly how you arrived at your estimates."[149] Based on Circular A-4's criteria, there are numerous reasons why applying a 7% discount rate to climate effects that occur over a 300-year time horizon would be unjustifiable.

First, basing the discount rate on the **consumption rate of interest** is the correct framework for analysis of climate effects; a discount rate based on the private return to capital is inappropriate. Circular A-4 does suggest that 7% should be a "default position" that reflects regulations that primarily displace capital investments; however, the Circular explains that "[w]hen regulation primarily and directly affects private consumption . . . *a lower discount rate is appropriate*."[150] The 7% discount rate is based on a private sector rate of return on capital, but private market participants typically have short time horizons. By contrast, climate change concerns the public well-being broadly. Rather than evaluating an optimal outcome from the narrow perspective of investors alone, economic theory requires analysts to make the optimal choices based on societal preferences and social discount rates. Moreover, because

[142] See 42 U.S.C. § 6291

[143] Language added by Pub. L. 95-619 (1978), subsection 325(d) of the National Energy Conservation Policy Act, amending 42 USC 6295(l) to include the "need of the nation to conserve energy." The "economically justified" phrase dates back to original EPCA, Pub. L. 94-163 (1975).

[144] Pub. L. 95-619 § 102; subsequently amended to read "effective measures must continue to be taken" so the United States is "more able to provide energy to meet future needs." 42 U.S.C. § 8201.

[145] GAO Legislative History PL 95-619 pt 7, Remarks on Signing HR 4018, 5263, 5037, 5146, and 5289 (Nov. 9, 1978).

[146] Circular A-4 at 3.

[147] *Id.* at 17.

[148] *Id.* at 27.

[149] *Id.* at 3.

[150] *Id.* at 33.

climate change is expected to largely affect large-scale consumption, as opposed to capital investment,[151] a 7% rate is inappropriate.

The agencies themselves also indicated that, because the main effect of CAFE and greenhouse gas standards is to change the price of cars—a consumer good—a 3% discount rate is most appropriate. The agencies indicate that the 7% discount rate is only used in the regulatory impact analysis because there is some uncertainty over whether the compliance costs can completely be passed through to buyers instead of affecting manufacturers' investments.[152] Yet, much of the PRIA's conclusions hinges on the assumption that all costs will be passed through from manufacturers to consumers.[153] The agencies never explain why some uncertainty about the completeness of cost pass-through is so much more important than the considerable uncertainty about long-term discount rates such that they are willing to entertain an inappropriately high discount rate like 7% but fail to consider a declining discount rate framework.

In 2013, OMB called for public comments on the social cost of greenhouse gases. In its 2015 Response to Comment document,[154] OMB (together with the other agencies from the IWG) explained that

> the consumption rate of interest is the correct concept to use . . . as the impacts of climate change are measured in consumption-equivalent units in the three IAMs used to estimate the SCC. This is consistent with OMB guidance in Circular A-4, which states that when a regulation is expected to primarily affect private consumption—for instance, via higher prices for goods and services—it is appropriate to use the consumption rate of interest to reflect how private individuals trade-off current and future consumption.[155]

The Council of Economic Advisers similarly interprets Circular A-4 as requiring agencies to choose the appropriate discount rate based on the nature of the regulation: "[I]n Circular A-4 by the Office of Management and Budget (OMB) the appropriate discount rate to use in evaluating the net costs or benefits of a regulation depends on whether the regulation primarily and directly affects private consumption or private capital."[156] The NAS also explained that a consumption rate of interest is the

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[151] "There are two rationales for discounting future benefits—one based on consumption and the other on investment. The consumption rate of discount reflects the rate at which society is willing to trade consumption in the future for consumption today. Basically, we discount the consumption of future generations because we assume future generations will be wealthier than we are and that the utility people receive from consumption declines as their level of consumption increases. . . . The investment approach says that, as long as the rate of return to investment is positive, we need to invest less than a dollar today to obtain a dollar of benefits in the future. Under the investment approach, the discount rate is the rate of return on investment. If there were no distortions or inefficiencies in markets, the consumption rate of discount would equal the rate of return on investment. There are, however, many reasons why the two may differ. As a result, using a consumption rather than investment approach will often lead to very different discount rates." Maureen Cropper, *How Should Benefits and Costs Be Discounted in an Intergenerational Context?*, 183 RESOURCES 30, 33.

[152] PRIA at 1078.

[153] See supra on global costs.

[154] Note that this document was not withdrawn by Executive Order 13,783.

[155] OMB 2015 Response to Comments, *supra* note 108, at 22.

[156] Council of Econ. Advisers, *Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate* at 1 (CEA Issue Brief, 2017), *available at* https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf. In theory, the two rates would be the same, but "given distortions in the economy from taxation, imperfect capital markets, externalities, and other sources, the SRTP and the marginal product of capital need not coincide, and analysts face a choice between the appropriate opportunity cost of a project and the appropriate discount rate for its benefits." *Id.* at 9. The correct discount rate for climate change is the social return to capital (i.e., returns minus the costs of externalities), not the private return to capital (which measures solely the returns).

appropriate basis for a discount rate for climate effects.[157] There is also strong consensus through the economic literature that a capital discount rate like 7% is inappropriate for climate change.[158] Finally, each of the three integrated assessment models upon which the agencies bases their analysis—DICE, FUND, and PAGE—uses consumption discount rates; a capital discount rate is thus inconsistent with the underlying models. (See the technical appendix on discounting attached to these comments for more details.) For these reason, 7% is an inappropriate choice of discount rate for the impacts of climate change.

Second, **uncertainty over the long time horizon** of climate effects should drive analysts to select a lower discount rate. As an example of when a 7% discount rate is appropriate, Circular A-4 identifies an EPA rule with a 30-year timeframe of costs and benefits.[159] By contrast, greenhouse gas emissions generate effects stretching out across 300 years. As Circular A-4 notes, while "[p]rivate market rates provide a reliable reference for determining how society values time within a generation, but for extremely long time periods no comparable private rates exist."[160]

Circular A-4 discusses how uncertainty over long time horizons drives the discount rate lower: "the longer the horizon for the analysis," the greater the "uncertainty about the appropriate value of the discount rate," which supports a lower rate.[161] Circular A-4 cites the work of renowned economist Martin Weitzman and concludes that the "certainty-equivalent discount factor corresponds to ***the minimum discount rate having any substantial positive probability***."[162] The NAS makes the same point about discount rates and uncertainty.[163] In fact, as discussed more below and in the technical appendix on discounting, uncertainty over the discount rate is best addressed by adopting a declining discount rate framework.

Third, a 7% discount rate **ignores catastrophic risks and the welfare of future generations**. As demonstrated in the graph of the frequency distribution of social cost of carbon estimates, the 7% rate truncates the long right-hand tail of social costs relative to the 3% rate's distribution. The long right-hand tail represents the possibility of catastrophic damages. As Pindyck explains "the possibility of a catastrophic outcome is an essential driver of the [social cost of greenhouse gases]."[164] The 7% discount rate effectively assumes that present-day Americans are barely willing to pay anything at all to prevent

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[157] NAS Second Report, *supra* note 109, at 28; *see also* Kenneth Arrow et al., Is There a Role for Benefit-Cost Analysis in Environmental, Health, and Safety Regulation?, 272 Science 221 (1996) (explaining that a consumption-based discount rate is appropriate for climate change).

[158] In addition to the CEA and NAS reports, see, for example, this article by the former chair of the NAS panel on the social cost of greenhouse gases: Richard Newell (2017, October 10). Unpacking the Administration's Revised Social Cost of Carbon. Available at http://www.rff.org/blog/2017/unpacking-administration-s-revised-social-cost-carbon. *See also* Comments from Robert Pindyck, to BLM, on the Social Cost of Methane in the Proposed Suspension of the Waste Prevention Rule (submitted Nov. 5, 2017, https://www.regulations.gov/document?D=BLM-2017-0002-16107).

[159] Circular A-4 at 34. *See also* OMB 2015 Response to Comments, *supra* note 108, at 21 ("While most regulatory impact analysis is conducted over a time frame in the range of 20 to 50 years").

[160] Circular A-4 at 36.

[161] *Id*.

[162] *Id.*; *see also* CEA, *supra* note 156, at 9: "Weitzman (1998, 2001) showed theoretically and Newell and Pizer (2003) and Groom et al. (2007) confirm empirically that discount rate uncertainty can have a large effect on net present values. A main result from these studies is that if there is a persistent element to the uncertainty in the discount rate (e.g., the rate follows a random walk), then it will result in an effective (or certainty-equivalent) discount rate that declines over time. Consequently, lower discount rates tend to dominate over the very long term, regardless of whether the estimated investment effects are predominantly measured in private capital or consumption terms (see Weitzman 1998, 2001; Newell and Pizer 2003; Groom et al. 2005, 2007; Gollier 2008; Summers and Zeckhauser 2008; and Gollier and Weitzman 2010)."

[163] NAS Second Report, *supra* note 109, at 27.

[164] Pindyck, Robert. 2013. "Climate change policy: What do the models tell us?" Journal of Economic Literature, 51(3), 860-872.

medium- to long-term catastrophes. This assumption violates the agencies' statutory duty to protect the future needs of Americans. At the same time, the 7% distribution also misleadingly exaggerates the possibility of negative estimates of the social cost of greenhouse gases.[165] A negative social cost of greenhouse gases implies a discount rate so high that society is willing to sacrifice serious impacts to future generations for the sake of small, short-term benefits (such as slightly and temporarily improved fertilization for agriculture). Again, this assumption contravenes the agencies' statutory responsibilities to protect the welfare of future Americans.

Fourth, a 7% discount rate would be inappropriate for climate change because it is based on **outdated data and diverges from the current economic consensus**. Circular A-4 requires that assumptions—including discount rate choices—are "based on the best reasonably obtainable scientific, technical, and economic information available."[166] Yet Circular A-4's own default assumption of a 7% discount rate was published 14 years ago and was based on data from decades ago.[167] Circular A-4's guidance on discount rates is in need of an update, as the Council of Economic Advisers detailed earlier this year after reviewing the best available economic data and theory:

> The discount rate guidance for Federal policies and projects was last revised in 2003. Since then a general reduction in interest rates along with a reduction in the forecast of long-run interest rates, warrants serious consideration for a reduction in the discount rates used for benefit-cost analysis.[168]

In addition to recommending a value below 7% as the discount factor based on private capital returns, the Council of Economic Advisers further explains that, because long-term interest rates have fallen, a discount rate based on the consumption rate of interest "should be at most 2 percent."[169] The latest OMB updates to Circular A-94, the document on which Circular A-4 based its discount rates,[170] also show that more up-to-date long-run discount rates are historically low. In the February 2018 update to Circular A-94's discount rates, the OMB found that the real, 30-year discount rate is 0.6 percent,[171] the lowest rate since the OMB began tracking the number.[172] Notably, the OMB also shows that the current real interest rate is negative for maturities less than 10 years.[173]

These low interest rates further confirm that applying a 7% rate to a context like climate change would be wildly out of step with the latest data and theory. Similarly, recent expert elicitations—a technique supported by Circular A-4 for filling in gaps in knowledge[174]—indicate that a growing consensus among experts in climate economics for a discount rate between 2% and 3%; 5% represents the upper range of

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[165] In the Monte Carlo simulation data, the 7% discount rate doubles the frequency of negative estimates compared to the 3% discount rate simulations, from a frequency of 4% to 8%.

[166] CEQ regulations implementing NEPA similarly require that information in NEPA documents be "of high quality" and states that "[a]ccurate scientific analysis . . . [is] essential to implementing NEPA." 40 C.F.R. § 1500.1(b).

[167] The 7% rate was based on a 1992 report; the 3% rate was based on data from the thirty years preceding the publication of Circular A-4 in 2003. Circular A-4 at 33.

[168] CEA, *supra* note 156, at 1; *id.* at 3 ("In general the evidence supports lowering these discount rates, with a plausible best guess based on the available information being that the lower discount rate should be at most 2 percent while the upper discount rate should also likely be reduced."); *id.* at 6 ("The Congressional Budget Office, the Blue Chip consensus forecasts, and the Administration forecasts all place the ten year treasury yield at less than 4 percent in the future, while at the same time forecasting CPI inflation of 2.3 or 2.4 percent per year. The implied real ten year Treasury yield is thus below 2 percent in all these forecasts.").

[169] *Id.* at 1.

[170] Circular A-4 at 33.

[171] OMB Circular A-94 Appendix C (2018).

[172] https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/a94/dischist-2017.pdf

[173] Circular A-94 Appendix C, *supra* note 171.

[174] Circular A-4 at 41.

values recommended by experts, and few to no experts support discount rates greater than 5% being applied to the costs and benefits of climate change.[175] Based on current economic data and theory, the most appropriate discount rate for climate change is 3% or lower.

Fifth, Circular A-4 requires more of analysts than giving all possible assumptions and scenarios equal attention in a sensitivity analysis; if alternate assumptions would fundamentally change the decision, Circular A-4 requires analysts to select the **most appropriate assumptions from the sensitivity analysis**.

Circular A-4 indicates that significant intergenerational effects will warrant a special sensitivity analysis focused on discount rates even lower than 3%:

> Special ethical considerations arise when comparing benefits and costs across generations. . . It may not be appropriate for society to demonstrate a similar preference when deciding between the well-being of current and future generations. . . If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent.[176]

Elsewhere in Circular A-4, OMB clarifies that sensitivity analysis should not result in a rigid application of all available assumptions regardless of plausibility. Circular A-4 instructs agencies to depart from default assumptions when special issues "call for different emphases" depending on "the sensitivity of the benefit and cost estimates to the key assumptions."[177] More specifically:

> If benefit or cost estimates depend heavily on certain assumptions, you should make those assumptions explicit and carry out *sensitivity analyses using plausible alternative assumptions*. If the value of net benefits changes from positive to negative (or vice versa) or if the relative ranking of regulatory options changes with alternative plausible assumptions, you should conduct further analysis to determine ***which of the alternative assumptions is more appropriate***.[178]

In other words, if using a 7% discount rate would fundamentally change the agency's decision compared to using a 3% or lower discount rate, the agency must evaluate which assumption is most appropriate. Since OMB, the Council of Economic Advisers, the National Academies of Sciences, and the economic literature all conclude that a 7% rate is inappropriate for climate change, agencies should select a 3% or lower rate. The agencies' selection of a 7% discount rate cannot be justified as "based on the best reasonably obtainable scientific, technical, and economic information available" and so is inconsistent with best practices for cost-benefit analysis under Circular A-4.

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[175] Howard and Sylvan (2015) at 33-34; M.A. Drupp, et al., *Discounting Disentangled: An Expert Survey on the Determinants of the Long-Term Social Discount Rate* (London School of Economics and Political Science Working Paper, May 2015) (finding consensus on social discount rates between 1-3%). Pindyck, in a survey of 534 experts on climate change, finds a mean discount rate of 2.9% in the climate change context and this rate drops to 2.6% when he drops individuals that lack confidence in their knowledge. Pindyck, R. S. (2016). *The social cost of carbon revisited* (No. w22807). National Bureau of Economic Research. Unlike Howard and Sylvan (2016), Pindyck (2016) combines economists and natural scientists in his survey, though the mean constant discount rate drops to 2.7% when including only economists. Again, this further supports the finding that the appropriate discount rate is between 2% and 3%.

[176] Circular A-4 at 35-36.

[177] *Id.* at 3.

[178] *Id.* at 42.

Application of a Declining Discount Rate Is Actionable Under the Current Economic Literature

Circular A-4 contemplates the use of declining discount rates in its reference to the work of Weitzman.[179] As the Council of Economic Advisers explained earlier this year, Weitzman and others developed the foundation for a declining discount rate approach, wherein rates start relatively higher for near-term costs and benefits but steadily decline over time according to a predetermined schedule until, in the very long-term, very low rates dominate due to uncertainty.[180] The National Academies of Sciences' report also strongly endorses a declining discount rate approach.[181] Notably, Marten et al., which developed the methodology for the social cost of methane, also note the "agreement that the use of a constant discount rate over long time horizons with uncertain changes in the consumption per capita growth is not theoretically consistent."[182]

One possible schedule of declining discount rates was proposed by Weitzman.[183] It is derived from a broad survey of top economists and other climate experts and explicitly incorporates arguments around interest rate uncertainty. Work by Arrow *et al*, Cropper *et al*, and Gollier and Weitzman, among others, similarly argue for a declining interest rate schedule and lay out the fundamental logic.[184] Another schedule of declining discount rates has been adopted by the United Kingdom.[185]

The technical appendix on discounting attached to these comments more thoroughly reviews the various schedules of declining discount rates available for agencies to select and explains why agencies not only can but should adopt a declining discount framework to address uncertainty. The agencies are wrong in stating that "additional research and analysis is still needed to develop a methodology for implementing a declining discount rate."[186]

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[179] Circular A-4, at page 36, cites to Weitzman's chapter in Portney & Weyant, eds. (1999); that chapter, at page 29, recommends a declining discount rate approach: "a sliding-scale social discounting strategy" with the rate at 3-4% through year 25; then around 2% until year 75; then around 1% until year 300; and then 0% after year 300.

[180] CEA, *supra* note 156, at 9 ("[A]nother way to incorporate uncertainty when discounting the benefits and costs of policies and projects that accrue in the far future—applying discount rates that decline over time. This approach uses a higher discount rate initially, but then applies a graduated schedule of lower discount rates further out in time. The first argument is based on the application of the Ramsey framework in a stochastic setting (Gollier 2013), and the second is based on Weitzman's 'expected net present value' approach (Weitzman 1998, Gollier and Weitzman 2010). In light of these arguments, the governments of the United Kingdom and France apply declining discount rates to their official public project evaluations.").

[181] NAS Second Report, *supra* note 109.

[182] Marten, A.L., Kopits, E.A., Griffiths, C.W., Newbold, S.C., and A. Wolverton. 2015. Incremental CH4 and N2O Mitigation Benefits Consistent with the U.S. Government's SC-CO2 Estimates. Climate Policy. 15(2): 272-298.

[183] Martin L. Weitzman, *Gamma Discounting*, 91 AM. ECON. REV. 260, 270 (2001). Weitzman's schedule is as follows:

1-5 years	6-25 years	26-75 years	76-300 years	300+ years
4%	3%	2%	1%	0%

[184] Kenneth J. Arrow et al., *Determining Benefits and Costs for Future Generations*, 341 SCIENCE 349 (2013); Kenneth J. Arrow et al., *Should Governments Use a Declining Discount Rate in Project Analysis?*, REV ENVIRON ECON POLICY 8 (2014); Maureen L. Cropper et al., *Declining Discount Rates*, AMERICAN ECONOMIC REVIEW: PAPERS AND PROCEEDINGS (2014); Christian Gollier & Martin L. Weitzman, *How Should the Distant Future Be Discounted When Discount Rates Are Uncertain?* 107 ECONOMICS LETTERS 3 (2010).

[185] Joseph Lowe, H.M. Treasury, U.K., Intergenerational Wealth Transfers and Social Discounting: Supplementary Green Book Guidance 5 (2008), *available at* http://www.hm-treasury.gov.uk/d/4(5).pdf. The U.K. declining discount rate schedule that subtracts out a time preference value is as follows:

0-30 years	31-75 years	76-125 years	126-200 years	201-300 years	301+ years
3.00%	2.57%	2.14%	1.71%	1.29%	0.86%

[186] PRIA 1102.

Problems with the Agencies' Use of a 2.5% Discount Rate in a Sensitivity Analysis

The PRIA suggests that a 2.5% discount rate should be used as a sensitivity analysis.[187] Unfortunately, as already discussed above, the description of the 2.5% discount rate sensitivity run is incomplete and inapplicable to this proceeding. The description references different estimates of forgone climate benefits "under the rate-based and mass-based scenarios, respectively."[188] There are no rate-based versus mass-based scenarios for the CAFE standards. This language, and likely the associated numbers, was evidentially taken from a different regulatory analysis. It is impossible for the reader to know what portion of the PRIA's description of the 2.5% sensitivity run, if any, is actually applicable to this rulemaking. The impossibility for the reader to understand is compounded by the agencies' failure to include in the regulatory docket the complete "full set of SC-CO_2 results" as promised.[189]

A 300-Year Time Horizon Is Required

Related to the choice of discount rate, a 300-year time horizon for analysis of climate effects is required by best economic practices. In 2017, the National Academies of Sciences issued a report stressing the importance of a longer time horizon for calculating the social cost of greenhouse gases. The report states that, "[i]n the context of the socioeconomic, damage, and discounting assumptions, the time horizon needs to be long enough to capture the vast majority of the present value of damages."[190] The report goes on to note that the length of the time horizon is dependent "on the rate at which undiscounted damages grow over time and on the rate at which they are discounted. Longer time horizons allow for representation and evaluation of longer-run geophysical system dynamics, such as sea level change and the carbon cycle."[191] In other words, after selecting the appropriate discount rate based on theory and data (in this case, 3% or below), analysts should determine the time horizon necessary to capture all costs and benefits that will have important net present values at the discount rate. Therefore, a 3% or lower discount rate for climate change implies the need for a 300-year horizon to capture all significant values. NAS reviewed the best available, peer-reviewed scientific literature and concluded that the effects of greenhouse gas emissions over a 300-year period are sufficiently well established and reliable as to merit consideration in estimates of the social cost of greenhouse gases.[192]

VI. The Agencies Arbitrarily Fail to Follow Prescribed Practices for Dealing with Uncertainty

The agencies note that several important factors are incompletely or inadequately represented in the integrated assessment models, including uncertainty over catastrophic damages and extrapolation of damages to high temperatures.[193] That mere mention of significant uncertainty that could lead to much higher social cost of greenhouse gas estimates hardly satisfies *Circular A-4*'s requirements for quantitative treatment of uncertainty. The IWG highlighted a 95th percentile estimate to address uncertainty over catastrophic damages, tipping points, option value, and risk aversion. The agencies should have done the same, but failed to do so. The agencies admit that the distributions "have long right tails"[194] and depicts a range of estimates from the 5th to 95th percentiles,[195] but by giving a 5th percentile estimate equal standing with the 95th percentile estimate, the agencies obscure the

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[187] PRIA 1102.
[188] PRIA 1102.
[189] PRIA 1101 (promising materials available in the docket); see supra on their unavailability.
[190] NAS Second Report, *supra* note 109, at 78.
[191] *Id.*
[192] Nat'l Acad. Of Sci., *Assessment of Approaches to Updating the Social Cost of Carbon* 49 (2016), at 32.
[193] PRIA 1064.
[194] PRIA at 1101.
[195] *Id*.

significance of low-probability, high-catastrophe outcomes.[196] By failing to give serious treatment to such sensitivity analyses, the agencies overlook how different (and more plausible) assumptions would change its cost-benefit calculation.

(Uncertainty in general, as well as uncertainty over the discount rate in particular, are discussed in greater detail in the technical appendices attached to these comments.)

Circular A-4's Prescriptions for Uncertainty

Circular A-4 requires thorough treatment of uncertainty around both values and outcomes,[197] and for especially large or complex matters it recommends a formal probabilistic analysis.[198] Generally, Circular A-4 encourages agencies to disclose the full probability distribution of potential consequences, including both upper and lower bound estimates in addition to central estimates.[199]

However, this guidance comes with some caveats. First, this approach to central estimates and the probability distribution "is appropriate as long as society is 'risk neutral' with respect to the regulatory alternatives."[200] But if society is risk averse—as is the case with climate change[201]—different considerations need to be taken into account. Second, in 2011, the Office of Information and Regulatory Affairs interpreted Circular A-4's goal as "not to characterize the full range of *possible* outcomes . . . but rather the range of *plausible* outcomes."[202] Agency analysts must exercise judgment. Finally, as with all elements of agencies' economic analyses, Circular A-4 stresses that "Your analysis should be credible, objective, realistic, and scientifically balanced."[203]

Consequently, while it may be appropriate to disclose the full probability distribution of an uncertainty analysis, it is not appropriate under Circular A-4 to give a low-percentile estimate of the social cost of greenhouse gases equal weight in decision-making with the central and upper-percentile estimates. Giving equal attention to a low-percentile estimate is not "credible, objective, realistic, and scientifically balanced," does not reflect "plausible" scenarios, and would undermine consideration of risk aversion. Instead, a proper and plausible treatment of uncertainty in the context of climate change will support higher estimates of the social cost of greenhouse gases.

A 95th Percentile Value as a Treatment of Uncertainty over Damages

The IWG accounted for uncertainty in numerous rigorous ways. The group modeled the uncertainty over the value of the equilibrium climate sensitivity parameter using the Roe and Baker distribution calibrated to the IPCC reports. Additionally, using well-established analytic tools to capture and reflect

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[196] The presentation of results further obscures the importance of these low-probability events by exploiting a well-documented mental heuristic called "probability neglect" that causes people to irrationally reduce small probability risks entirely down to zero. A reader of the analysis might be misled to believe that these low-probability events are not important, when in fact, they would lead to substantial economic losses. *See* Cass R. Sunstein, *Probability Neglect: Emotions, Worst Cases, and Law*, 112 Yale L. J. 61, 63, 72 (2002); Valerie F. Reyna & Charles J. Brainerd, *Numeracy, ratio bias, and denominator neglect in judgments of risk and probability*, 18 LEARN. INDIVID. DIFFER. 89 (2008).

[197] Circular A-4, at 42, requires probability distributions for "values as well for each of the outcomes"; the social cost of greenhouse gases is a value with a probability distribution.

[198] *Id.* at 41.

[199] Circular A-4 at 18, 40; *id.* at 45 ("When you provide only upper and lower bounds (in addition to best estimates), you should, if possible, *use the 95 and 5 percent* confidence bounds.").

[200] *Id.* at 42.

[201] *See* INTERAGENCY WORKING GROUP ON SOCIAL COST OF CARBON, TECHNICAL SUPPORT DOCUMENT: SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 at 11 (2010).

[202] Office of Information and Regulatory Affairs, *Regulatory Impact Analysis: A Primer* 2 (2011). This is best understood as drawing the line at insignificant or scientifically unsupported outcomes. By contrast, the low-probability but catastrophic potential outcomes of climate change are highly significant and the scientific literature demands giving them due attention.

[203] Circular A-4 at 39.

uncertainty, including a Monte Carlo simulation to randomly select the equilibrium climate sensitivity parameter and other uncertainty parameters selected by the model developers, the IWG quantitatively modeled the uncertainty underlying how greenhouse gas emissions affect temperature.

To further deal with uncertainty, the IWG recommended to agencies a range of four estimates: three central or mean-average estimates at a 2.5%, 3%, and 5% discount rate respectively, and a 95th percentile value at the 3% discount rate. While the IWG's technical support documents disclosed fuller probabilities distributions, these four estimates were chosen by agencies to be the focus for decisionmaking. In particular, application of the 95th percentile value was not part of an effort to show the probability distribution around the 3% discount rate; rather, the 95th percentile value serves as a methodological shortcut to approximate the uncertainties around low-probability but high-damage, catastrophic, or irreversible outcomes that are currently omitted or undercounted in the economic models.

The shape of the distribution of climate risks and damages includes a long tail of lower-probability, high-damage, irreversible outcomes due to "tipping points" in planetary systems, inter-sectoral interactions, and other deep uncertainties. Climate damages are not normally distributed around a central estimate, but rather feature a significant right skew toward catastrophic outcomes. In fact, a 2015 survey of economic experts concludes that catastrophic outcomes are increasingly likely to occur.[204] Because the three integrated assessment models that the IWG's methodology relied on are unable to systematically account for these potential catastrophic outcomes, a 95th percentile value was selected instead to account for such uncertainty. There are no similarly systematic biases pointing in the other direction which might warrant giving weight to a low-percentile estimate.

Additionally, the 95th percentile value addresses the strong possibility of widespread risk aversion with respect to climate change. The integrated assessment models do not reflect that individuals likely have a higher willingness to pay to reduce low-probability, high-impact damages than they do to reduce the likelihood of higher-probability but lower impact damages with the same expected cost. Beyond individual members of society, governments also have reasons to exercise some degree of risk aversion to irreversible outcomes like climate change.

In short, the 95th percentile estimate attempts to capture risk aversion and uncertainties around lower-probability, high-damage, irreversible outcomes that are currently omitted or undercounted by the models. There is no need to balance out this estimate with a low-percentile value, because the reverse assumptions are not reasonable:

- There is no reason to believe the public or the government will be systematically risk seeking with respect to climate change.[205]
- The consequences of overestimating the risk of climate damages (i.e., spending more than we need to on mitigation and adaptation) are not nearly as irreversible as the consequences of underestimating the risk of climate damage (i.e., failing to prevent catastrophic outcomes).

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[204] Policy Integrity, *Expert Consensus on the Economics of Climate Change* 2 (2015), *available at* http://policyintegrity.org/files/publications/ExpertConsensusReport.pdf [hereinafter *Expert Consensus*] ("Experts believe that there is greater than a 20% likelihood that this same climate scenario would lead to a 'catastrophic' economic impact (defined as a global GDP loss of 25% or more)."). *See also* Robert Pindyck, *The Social Cost of Carbon Revisited* (National Bureau of Economic Research, No. w22807, 2016).

[205] As a 2009 survey revealed, the vast majority of economic experts support the idea that "uncertainty associated with the environmental and economic effects of greenhouse gas emissions increases the value of emission controls, assuming some level of risk-aversion." *See Expert Consensus, supra* note 204, at 3 (citing 2009 survey).

- Though some uncertainties might point in the direction of lower social cost of greenhouse gas values, such as those related to the development of breakthrough adaptation technologies, the models already account for such uncertainties around adaptation; on balance, most uncertainties strongly point toward higher, not lower, social cost of greenhouse gas estimates.[206]
- There is no empirical basis for any "long tail" of potential benefits that would counteract the potential for extreme harm associated with climate change.

Moreover, even the best existing estimates of the social cost of greenhouse gases are likely underestimated because the models currently omit many significant categories of damages—such as depressed economic growth, pests, pathogens, erosion, air pollution, fire, dwindling energy supply, health costs, political conflict, and ocean acidification—and because of other methodological choices.[207] There is little to no support among economic experts to give weight to any estimate lower than the 5% discount rate estimate.[208] Rather, even a discount rate at 3% or below likely continues to underestimate the true social cost of greenhouse gases.

The National Academies of Sciences did recommend that the IWG document its full treatment of uncertainty in an appendix and disclose low-probability as well as high-probability estimates of the social cost of greenhouse gases.[209] However, that does not mean it would be appropriate for individual agencies to rely on low-percentile estimates to justify decisions. While disclosing low-percentile estimates as a sensitivity analysis may promote transparency, relying on such an estimate for decisionmaking—in the face of contrary guidance from the best available science and economics on uncertainty and risk—would not be a "credible, objective, realistic, and scientifically balanced" approach to uncertainty.

By giving only a scant graphical presentation of the 95th percentile value, and by misleadingly placing that value on equal footing with a 5th percentile estimate, the agencies have failed to address uncertainties over catastrophic outcomes, tipping points, risk aversion, and option value, and so has violated the prescriptions of Circular A-4. The IWG emphasized the 95th percentile (not the 5th percentile) to address this systematic downward bias in the social cost of greenhouse gases. By giving equal weight to the 5th and 95th percentiles, the agencies are ignoring this systematic bias and failing to

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[206] *See* Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014). R. Tol, *The Social Cost of Carbon*, 3 Annual Rev. Res. Econ. 419 (2011) ("[U]ndesirable surprises seem more likely than desirable surprises. Although it is relatively easy to imagine a disaster scenario for climate change—for example, involving massive sea level rise or monsoon failure that could even lead to mass migration and violent conflict—it is not at all easy to imagine that climate change will be a huge boost to human welfare.").

[207] *See* Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, *supra* note 28; Howard 2014, *supra* note **Error! Bookmark not defined.**; Frances C. Moore & Delavane B. Diaz, *Temperature Impacts on Economic Growth Warrant Stringent Mitigation Policy*, 5 NATURE CLIMATE CHANGE 127 (2015) (demonstrating SCC may be biased downward by more than a factor of six by failing to include the climate's effect on economic growth).

[208] The existing estimates based on the 5% discount rate already provides a lower-bound; indeed, if anything the 5% discount rate is already far too conservative as a lower-bound. A recent survey of 365 experts on the economics of climate change found that 90% of experts believe a 3% discount rate or lower is appropriate for climate change; a 5% discount rate falls on the extremely high end of what experts would recommend. *Expert Consensus, supra* note 204, at 21; *see also* Drupp, M.A., et al. *Discounting Disentangled: An Expert Survey on the Determinants of the Long-Term Social Discount Rate* (London School of Economics and Political Science Working Paper, May 2015) (finding consensus on social discount rates between 1-3%). Only 8% of the experts surveyed believe that the central estimate of the social cost of carbon is below $40, and 69% of experts believed the value should be at or above the central estimate of $40. *Expert Consensus, supra* note 204, at 18.

[209] Nat'l Acad. Of Sci., *Assessment of Approaches to Updating the Social Cost of Carbon* 49 (2016) ("[T]he IWG could identify a high percentile (e.g., 90th, 95th) and corresponding low percentile (e.g., 10th, 5th) of the SCC frequency distributions on each graph.").

consider the accepted logic that climate change is likely to bring with it more bad surprises than good surprises.

Tellingly, the agencies' sensitivity analysis files include a spreadsheet that details the reference scenario. That spreadsheet's "emissions cost" tab shows the social cost of carbon numbers that the agencies used in their analysis from the 2012 rulemaking, with columns for the low estimates (calculated at a 5% discount rate), average estimate (3% discount rate), high estimate (2.5% discount rate) and "very high" (the 95th percentile of the 3% distribution). Those same column headings were copied to list the social cost of carbon estimates used in this proposed action. Under the "very high" column, which had previously served as a placeholder for the 95th percentile estimate treatment of uncertainty, the agencies' files now simply list the value as $0.

Uncertainty over Climate Damages Points Toward a Higher Social Cost of Greenhouse Gases

The agencies attempt to call into question the validity of the social cost of greenhouse gas estimates by highlighting the "uncertainty" around climate change. The proposed rule says that greenhouse gases only "theoretically" contribute to climate change,[210] when in fact the causal relationship is very well established.[211] The proposed rule belittles the climate damages that will be directly experienced in the United States—"albeit uncertain"[212]—despite the assessment of the U.S. Global Change Research Program that the United States is already experiencing significant climate impacts.[213] The implication is that climate impacts are somehow more uncertain and so should be treated with more skepticism than other costs and benefits, despite the fact that the U.S. Court of Appeals for the Ninth Circuit has already cautioned NHTSA about that sort of logic.[214]

The PRIA also insists that "uncertainties do not all work in the same direction in terms of their influence on the SC-CO2 estimates."[215] While that may be technically true, overall uncertainty about the full effects of climate change actually *raises* the social cost of greenhouse gases and warrants *more* stringent climate policy.[216] The integrated assessment models (IAMs) currently used to calculate the social cost of greenhouse gases show that the net effect of uncertainty about economic damage resulting from climate change, costs of mitigation, future economic development, and many other parameters raises the social cost of greenhouse gases compared to the case where models simply use our current best guesses of these parameters.[217] Even so, IAMs still underestimate the impact of uncertainty by not

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[210] 83 Fed. Reg. 43,067.

[211] *See e.g.,* 74 Fed. Reg. 66,496 (Dec. 15, 2009) ("Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act").

[212] 83 Fed. Reg. at 43,067.

[213] https://science2017.globalchange.gov/chapter/executive-summary/ ("Global sea level rise has already affected the United States; the incidence of daily tidal flooding is accelerating in more than 25 Atlantic and Gulf Coast cities. . . . Annual trends toward earlier spring melt and reduced snowpack are already affecting water resources in the western United States and these trends are expected to continue.")

[214] *Center for Biological Diversity v. NHTSA*, 538 F.2d 1172, 1199 (9th Cir. 2008) (holding that NHTSA could not fail to quantify and monetize the most important regulatory effect—climate change—when it had quantified other uncertain effects like congestion).

[215] PRIA at 1064.

[216] Peterson (2006) states "Most modeling results show (as can be expected) that there is optimally more emission abatement if uncertainties in parameters or the possibility of catastrophic events are considered." Peterson, S. (2006). Uncertainty and economic analysis of climate change: A survey of approaches and findings. *Environmental Modeling & Assessment*, *11*(1), 1-17.

[217] Tol, R. S. (1999). Safe policies in an uncertain climate: an application of FUND. *Global Environmental Change*, *9*(3), 221-232; Peterson, S. (2006). Uncertainty and economic analysis of climate change: A survey of approaches and findings. *Environmental Modeling & Assessment*, *11*(1), 1-17; IWG, Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis (2016).

accounting for a host of fundamental features of the climate problem: the irreversibility of climate change, society's aversion to risk and other social preferences, option value, and many catastrophic impacts.[218] Rather than being a reason not to take action, uncertainty increases the social cost of greenhouse gases and should lead to more stringent policy to address climate change.

A technical appendix attached to these comments more fully details how uncertainty on the whole points toward an even higher social cost of greenhouse gases. The appendix covers such topics as insufficient modeling of catastrophic outcomes (including unlucky states of the world, deep uncertainty over the probability distributions for specific climate parameters, and tipping points), failure to include a risk premium, exclusion of the real option value of preventing irreversible greenhouse gas emissions, and how the social cost of greenhouse gases would increase with improved modeling of uncertainty.

VII. The Agencies Have Cherry-Picked Methodological Revisions to Advance a Predetermined Goal, without Engaging in a Holistic Update

The agencies explain that their estimates of the social cost of carbon are simply "interim values" until an improved estimate can be developed.[219] The revisions to the Interagency Working Group's 2016 estimates that the agencies made to produce these interim values are all methodologically unsound: ignoring the global values in favor of an inaccurate and incomplete domestic-only estimate; applying the inappropriate 7% discount rate alongside the 3% discount rate in the central analysis; and failing to disclose a 95th percentile estimate. What links these select revisions together is a common, predetermined goal: artificially lowering the social cost of carbon to support deregulation.

This is an arbitrary approach to updating the social cost of carbon. The agencies do not engage with any of the most recent literature on damages (see the technical appendix attached to these comments on damage literature), does not update the underlying models (the agencies continue to use DICE-2010, even though DICE-2016R has been published[220]), does not move toward a declining discount rate, and does not implement any of the recommendations for improving the social cost of greenhouse gas methodology as articulated by the National Academies of Sciences. The agencies note, but then do nothing about, the National Academies of Sciences' warning that domestic-only numbers fail to account for spillovers and reciprocity.[221] Agencies should pursue a holistic update of the social cost of greenhouse gas methodology, but the "interim value" revisions all appear cherry-picked to lower the valuation. As such, the interim values are biased and should not be used in analysis.

To ensure that the agencies are using the best available data and methodologies to monetize the full social cost of greenhouse gases, a thorough review of the relevant economics and scientific literature is critical. Specifically, the agencies should consider the data, assumptions, and methods applied in the latest peer-reviewed publications with special attention applied to consensus-type documents, such as the Intergovernmental Panel on Climate Change. The agencies should adopt such consensus findings as their central assumptions; alternative views with significant support should be considered through sensitivity analysis. An agency should undergo such a thorough review at frequent intervals—such as every three years (as undertaken by the IWG) or every five years (as recommended by the NAS panel).

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[218] Pindyck, R. S. (2007). Uncertainty in environmental economics. *Review of environmental economics and policy*, *1*(1), 45-65; Golub, A., Narita, D., & Schmidt, M. G. (2014). Uncertainty in integrated assessment models of climate change: Alternative analytical approaches. *Environmental Modeling & Assessment*, *19*(2), 99-109; Lemoine, D., & Rudik, I. (2017). Managing Climate Change Under Uncertainty: Recursive Integrated Assessment at an Inflection Point. *Annual Review of Resource Economics* 9:18.1-18.26.

[219] PRIA 1062.

[220] William D Nordhaus, *Revisiting the social cost of carbon*, 114 PROC. NATL. ACAD. SCI. U. S. A. 1518–1523 (2017).

[221] PRIA 1065.

The now-disbanded Interagency Working Group undertook such a process of regular and systematic revisions. In 2010—and again in the 2013 and 2016 updates—the IWG's analytic process was science-based, open, and transparent. The IWG hosted a thorough public comment period in 2013.[222] The 2010 Technical Support Document (TSD) set out in detail the IWG's decision-making process with respect to how it assessed and employed the models.[223] The Government Accountability Office (GAO) found that "the working group's processes and methods reflected the following three principles: Used consensus-based decision making, Relied on existing academic literature and models, and Took steps to disclose limitations and incorporate new information."[224]

To ensure social cost of greenhouse gases reflect the best available science, agencies should not cherry pick modeling-assumptions. Instead, any update of the social cost of greenhouse gases requires a thorough review of peer-reviewed research to develop consensus-based modeling assumptions. In particular, the review process allows for the development of pre-specified frameworks and criteria upon which assumptions can be assessed. In fact, the NAS recently conducted such a review—and developed these frameworks and criteria—to enable a thorough near-term update of social cost of greenhouse gas estimates by agencies. The National Academies of Sciences' reports are attached to these comments, so that the agencies might review their recommendations for a holistic update to the methodology.

VIII. The Agencies Fails to Appropriately Consider Unquantified Benefits

The PRIA repeatedly talks about its proposed action's "total net benefits,"[225] without acknowledging that the proposal may entail significant unquantified forgone benefits. In fact, over the course of 1621 pages, the PRIA has only a single section, passingly a mere paragraph, that includes the word "unquantified" in the heading.[226] Though the DEIS does contain some scattered additional discussion of some qualitative effects, by incorporating the PRIA into the DEIS and referring readers to the PRIA's monetization of costs and benefits to understand "the full context of the potential impacts of GHG emissions and climate change," the DEIS implies that the PRIA's presentation of the social cost of greenhouse gases fully captures all relevant climate impacts from the rule. It does not, since the PRIA gives no serious weight to the unquantified forgone benefits to climate, as well as other unquantified forgone benefits, such as the unquantified public health consequences of various criteria and toxic pollution. Even putting aside the agencies' severely manipulated underestimates of the monetized forgone climate benefits, the PRIA fails to explain why the proposed action's estimated cost savings justify the sum of both the monetized and unmonetized forgone benefits.

Experts widely acknowledge that even the best existing estimates of the social cost of greenhouse gases are almost certainly underestimates of true global damages—perhaps severe underestimates.[227] Using different discount rates; selecting different models; applying different treatments to uncertainty, climate sensitivity, and the potential for catastrophic damages; and making other reasonable

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[222] Notice of Availability and Request for Comments: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order No. 12866, 78 Fed. Reg. 70,586 (Nov. 26, 2013); IWG, *Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866* (July 2015), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-response-to-comments-final-july-2015.pdf.

[223] *See generally* 2010 TSD, *supra* note **Error! Bookmark not defined.**.

[224] GAO, REGULATORY IMPACT ANALYSIS: Development of Social Cost of Carbon Estimates, GAO-14-663 (2014).

[225] PRIA at 14, 107 ("the preferred alternative . . . maximizes net benefits"), 537 ("Net Benefits—Total benefits minus total costs"), 1080.

[226] PRIA 1327 ("Other Unquantified Health and Environmental Effects").

[227] *See* Richard L. Revesz, Peter H. Howard, Kenneth Arrow, Lawrence H. Goulder, Robert E. Kopp, Michael A. Livermore, Michael Oppenheimer & Thomas Sterner, *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014).

assumptions could yield very different, and much larger estimates.[228] For example, a 2014 report found current social cost of carbon estimates omit or poorly quantify damages to the following sectors:

> agriculture, forestry, and fisheries (including pests, pathogens, and weeds, erosion, fires, and ocean acidification); ecosystem services (including biodiversity and habitat loss); health impacts (including Lyme disease and respiratory illness from increased ozone pollution, pollen, and wildfire smoke); inter-regional damages (including migration of human and economic capital); inter-sector damages (including the combined surge effects of stronger storms and rising sea levels); exacerbation of existing non-climate stresses (including the combined effect of the over pumping of groundwater and climate-driven reductions in regional water supplies); socially contingent damages (including increases in violence and other social conflict); decreasing growth rates (including decreases in labor productivity and increases in capital depreciation); weather variability (including increased drought and inland flooding); and catastrophic impacts (including unknown unknowns on the scale of the rapid melting of Arctic permafrost or ice sheets).[229]

Circular A-4 requires that "When there are important non-monetary values at stake, you should also identify them in your analysis."[230] Specifically, agencies must "Include a summary table that lists all the unquantified benefits and costs, and use your professional judgment to highlight (e.g., with categories or rank ordering) those that you believe are most important."[231] The Circular cautions that "the most efficient alternative will not necessarily be the one with the largest quantified and monetized net-benefit estimate."[232] The agencies must therefore fully disclose the limitations of their social cost of greenhouse gas estimates and include detailed charts of all important, unquantified climate effects. The PRIA's cursory reference to "the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts"[233] is insufficient. The PRIA must then explain why, after giving appropriate weight to all the unquantified climate effects and all the unquantified forgone benefits from other emissions, the proposed action's cost savings justify its forgone benefits.

IX. The Agencies Appropriately Give Equal Weight to the Three Most Peer-Reviewed Models, but Should Use the Updated Models

The agencies explain that they have relied on "the same ensemble of three integrated assessment models (IAMs) that were used to develop the IWG global SC-CO2 estimates."[234] Indeed, because the Interagency Working Group used the best available data and methodology, it is appropriate for agencies to continue to rely on its methodology and its 2016 estimates. In fact, the agencies should have relied more consistently on the Interagency Working Group's inputs and assumptions, and so focused on a global valuation calculation at a 3% or lower discount rate.

The agencies also explain the virtues of equally weighting the results of the three most peer-reviewed integrated assessment models in order to balance out the limitations and omissions of any one model.[235] In any future applications of the social cost of greenhouse gases, the agencies should continue

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[228] *Id.*; *see also* Joint Comments from Institute for Policy Integrity et al., to Office of Information and Regulatory Affairs, on the Technical Update of the Social Cost of Carbon, OMB-2013-0007-0085, Feb. 26, 2014.

[229] Peter Howard, *Omitted Damages: What's Missing from the Social Cost of Carbon* 5 (Cost of Carbon Project Report, 2014), http://costofcarbon.org/.

[230] Circular A-4 at 3.

[231] *Id.* at 27.

[232] *Id.* at 2.

[233] PRIA 1064.

[234] PRIA 1100.

[235] PRIA at 1101.

to rely on the Interagency Working Group's methodology and use multiple peer-reviewed models. That said, the agencies have failed to use the most up-to-date versions of those models, and should use the updated models in future calculations.

Agencies Should Continue to Rely on the Interagency Working Group's Methodology and Estimates

In 2016, IWG published updated central estimates for the social cost of greenhouse gases: $50 per ton of carbon dioxide, $1440 per ton of methane, and $18,000 per ton of nitrous oxide (in 2017 dollars for year 2020 emissions).[236] Notwithstanding the recent Executive Order disbanding the IWG, the estimates updated by that group in 2016 are still the best estimates of the lower bound of the social cost of greenhouse gases, reflecting current best practices and best scientific and economic literature. Agencies should continue to use estimates of a similar or higher value[237] in their regulatory analyses and environmental impact statements. In particular, when estimating the social cost of greenhouse gases, agencies should use multiple peer-reviewed models, a global estimate of climate damages, and a 3% or lower discount rate for the central estimate.

Any departure from IWG's most recent estimates would require agencies to engage with the complex integrated assessment models and ensure consistency with the most current scientific and economic literature, which overwhelmingly supports a global estimate based on a 3% or lower discount rate. Indeed, since the IWG's estimates omit important damage categories and so are best treated as a lower bound, if anything the social cost of greenhouse gas values used by agencies should be even higher.

Agencies Must Not Rely on a Single Model, but Must Use Multiple, Peer-Reviewed Models

Circular A-4 requires agencies to use "the best reasonably obtainable scientific, technical, and economic information available. To achieve this, you should rely on peer-reviewed literature, where available."[238]

Since the IWG first issued the federal social cost of carbon protocol in 2010, this methodology has relied on the three most cited, most peer-reviewed integrated assessment models (IAMs). These three IAMs—called DICE (the Dynamic Integrated Model of Climate and the Economy[239]), FUND (the Climate Framework for Uncertainty, Negotiation, and Distribution[240]), and PAGE (Policy Analysis of the Greenhouse Effect[241])—draw on the best available scientific and economic data to link physical impacts to the economic damages of each marginal ton of greenhouse gas emissions. As noted previously, each model translates emissions into changes in atmospheric greenhouse gas concentrations, atmospheric concentrations into temperature changes, and temperature changes into economic damages, which can then be adjusted according to a discount rate. These three models have been combined with inputs derived from peer-reviewed literature on climate sensitivity, socio-economic and emissions trajectories, and discount rates. The results of the three models have been given equal weight in federal agencies' estimates and have been run through statistical techniques like Monte Carlo analysis to account for uncertainty.

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[236] U.S. Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), "Technical support document: Technical update of the social cost of carbon for regulatory impact analysis under executive order 12866 & Addendum: Application of the methodology to estimate the social cost of methane and the social cost of nitrous oxide" (2016; https://obamawhitehouse.archives.gov/omb/oira/social-cost-of-carbon).

[237] *See supra* note 28.

[238] OMB, Circular A-4, at 17.

[239] William D. Nordhaus, *Estimates of the social cost of carbon: concepts and results from the DICE-2013R model and alternative approaches*, 1 JOURNAL OF THE ASSOCIATION OF ENVIRONMENTAL AND RESOURCE ECONOMISTS 1 (2014).

[240] David Anthoff & Richard S.J. Tol, THE CLIMATE FRAMEWORK FOR UNCERTAINTY, NEGOTIATION AND DISTRIBUTION (FUND), TECHNICAL DESCRIPTION, VERSION 3.6 (2012), *available at* http://www.fund-model.org/versions.

[241] Chris Hope, *The Marginal Impact of CO_2 from PAGE2002: An Integrated Assessment Model Incorporating the IPCC's Five Reasons for Concern*, 6 INTEGRATED ASSESSMENT J. 19 (2006).

In a 2017 report, the National Academies of Sciences (NAS) recommended future improvements to this methodology. Specifically, over the next five years the NAS recommends unbundling the four essential steps in the IAMs into four separate "modules": a socio-economic and emissions scenario module, a climate change module, an economic damage module, and a discount rate module.[242] Unbundling these four steps into separate modules could allow for easier, more transparent updates to each individual component in order to better reflect the best available science and capture the full range of uncertainty in the literature. These four modules could be built from scratch or drawn from the existing IAMs. Either way, the integrated modular framework envisioned by NAS for the future will require significant time and resource commitments from federal agencies.

In the meantime, the NAS has supported the continued near-term use of the existing social cost of greenhouse gas estimates based on the DICE, FUND, and PAGE models, as used by federal agencies to date.[243] In short, DICE, FUND, and PAGE continue to represent the state-of-the-art models. The Government Accountability Office found in 2014 that the estimates derived from these models and used by federal agencies are consensus-based, rely on peer-reviewed academic literature, disclose relevant limitations, and are designed to incorporate new information via public comments and updated research.[244] In fact, the social cost of greenhouse gas estimates used in federal regulatory proposals and EISs have been subject to over 80 distinct public comment periods.[245] The economics literature confirms that estimates based on these three IAMs remain the best available estimates.[246] In 2016, the U.S. Court of Appeals for the Seventh Circuit held the estimates used to date by agencies are reasonable.[247] Just last month, the District of Montana rejected an agency's Environmental Assessment for failure to incorporate the federal social cost of carbon estimates into its cost-benefit analysis of a proposed mine expansion.[248]

Regardless of Executive Order 13,783's withdrawal of the guidance requiring federal agencies to rely on IWG's technical support documents to estimate the social cost of greenhouse gases, IWG's choice of DICE, FUND, and PAGE, its use of inputs and assumptions, and its statistical analysis still represent the state-of-the-art approach based on the best available, peer-reviewed literature. This approach satisfies Circular A-4's requirements for information quality and transparency. Therefore, in complying with the Executive Order's instructions to ensure that social cost of greenhouse gas estimates are consistent with Circular A-4, agencies will necessarily have to rely on models like DICE, FUND, and PAGE, to use the same or similar inputs and assumptions as the IWG, and to apply statistical analyses like Monte Carlo.

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[242] Nat'l Acad. Sci., Eng. & Medicine, *Valuing Climate Damages: Updating Estimates of the Social Cost of Carbon Dioxide* 3 (2017) [hereinafter "NAS, Second Report"] (recommending an "integrated modular approach").

[243] Specifically, NAS concluded that a near-term update was not necessary or appropriate and the current estimates should continue to be used while future improvements are developed over time. Nat'l Acad. Sci., Eng. & Medicine, *Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update* 1 (2016) [hereinafter "NAS, First Report"].

[244] Gov't Accountability Office, *Regulatory Impact Analysis: Development of Social Cost of Carbon Estimates* (2014).

[245] Howard & Schwartz, *supra* note 39, at Appendix A.

[246] *E.g.*, Richard G. Newell et al., *Carbon Market Lessons and Global Policy Outlook*, 343 SCIENCE 1316 (2014); Bonnie L. Keeler et al., *The Social Costs of Nitrogen*, 2 SCIENCE ADVANCES e1600219 (2016); Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014) (co-authored with Nobel Laureate Kenneth Arrow, among others).

[247] *Zero Zone*, 832 F.3d at 678-79 (7th Cir. 2016) (finding that the agency "acted reasonably" in using global estimates of the social cost of carbon, and that the estimates chosen were not arbitrary or capricious).

[248] *Montana Environmental Information Center*, 2017 WL 3480262, at *12-15, 19.

The unavoidable fact is that DICE, FUND, and PAGE are still the dominant, most peer-reviewed models,[249] and most estimates in the literature continue to rely on those models.[250] Each of these models has been developed over decades of research, and has been subject to rigorous peer review, documented in the published literature. While other models exist, they lack DICE's, FUND's, and PAGE's long history of peer review or exhibit other limitations. For example, the World Bank has created ENVISAGE, which models a more detailed breakdown of market sectors,[251] but unfortunately does not account for non-market impacts and so would omit a large portion of significant climate effects. Models like ENVISAGE are therefore not currently appropriate choices under the criteria of Circular A-4.[252]

An approach based on multiple, peer-reviewed models (like DICE, FUND, and PAGE) is more rigorous and more consistent with Circular A-4 than reliance on a single model or estimate. DICE, FUND, and PAGE each include many of the most significant climate effects, use appropriate discount rates and other assumptions, address uncertainty, are based on peer-reviewed data, and are transparent.[253] However, each IAM also has its own limitations and is sensitive to its own assumptions. No model fully captures all the significant climate effects.[254] By giving weight to multiple models—as the IWG did—agencies can balance out some of these limitations and produce more robust estimates.[255]

Finally, while agencies should be careful not to cherry-pick a single estimate from the literature, it is noteworthy that various estimates in the literature are consistent with the numbers derived from a weighted average of DICE, FUND, and PAGE—namely, with a central estimate of about $40 per ton of carbon dioxide, and a high-percentile estimate of about $120, for year 2015 emissions (in 2016 dollars, at a 3% discount rate). The latest central estimate from DICE's developers is $87 (at a 3% discount rate);[256] from FUND's developers, $12;[257] and from PAGE's developers, $123, with a high-percentile estimate of $332.[258]

In fact, much of the literature suggests that a central estimate of $40 per ton is a very conservative underestimate. A 2013 meta-analysis of the broader literature found a mean estimate of $59 per ton of

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[249] *See* Interagency Working Group on the Social Cost of Carbon, *Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12,866* at 7 (July 2015) ("DICE, FUND, and PAGE are the most widely used and widely cited models in the economic literature that link physical impacts to economic damages for the purposes of estimating the SCC."), *citing* Nat'l Acad. Sci., Eng. & Medicine, *Hidden Cost of Energy: Unpriced Consequences of Energy Production and Use* (2010) ("the most widely used impact assessment models").

[250] R.S. Tol, *The Social Cost of Carbon*, 3 Annual Rev. Res. Econ. 419 (2011); T. Havranek et al., *Selective Reporting and the Social Cost of Carbon*, 51 Energy Econ. 394 (2015).

[251] World Bank, *The Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model* (2008), *available at* http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1193838209522/Envisage7b.pdf.

[252] Similarly, Intertemporal Computable Equilibrium System (ICES) does not account for non-market impacts. *See* https://www.cmcc.it/models/ices-intertemporal-computable-equilibrium-system. Other models include CRED, which is worthy of further study for future use. Frank Ackerman, Elizabeth A. Stanton & Ramón Bueno, *CRED: A New Model of Climate and Development*, 85 ECOLOGICAL ECONOMICS 166 (2013). Accounting for omitted impacts more generally, E.A. Stanton, F. Ackerman, R. Bueno, *Reason, Empathy, and Fair Play: The Climate Policy Gap*, (Stockholm Environment Inst. Working Paper 2012-02), find a doubling of the SCC using the CRED model.

[253] While sensitivity analysis can address parametric uncertainty within a model, using multiple models helps address structural uncertainty.

[254] *See* Howard 2014, *supra* note **Error! Bookmark not defined.**.

[255] Moore, F., Baldos, U., & Hertel, T. (2017). Economic impacts of climate change on agriculture: a comparison of process-based and statistical yield models. *Environmental Research Letters*.

[256] William Nordhaus, *Revisiting the Social Cost of Carbon*, Proc. Nat'l Acad. Sci. (2017) (estimate a range of $21 to $141).

[257] D. Anthoff & R. Tol, *The Uncertainty about the Social Cost of Carbon: A Decomposition Analysis Using FUND*, 177 Climatic Change 515 (2013).

[258] C. Hope, *The social cost of CO2 from the PAGE09 model*, 39 Economics (2011); C. Hope, *Critical issues for the calculation of the social cost of CO2*, 117 *Climatic Change*, 531 (2013).

carbon dioxide,[259] and a soon-to-be-published update by the same author finds a mean estimate of $108 (at a 1% discount rate).[260] A 2015 meta-analysis—which sought out estimates besides just those based on DICE, FUND, and PAGE—found a mean estimate of $83 per ton of carbon dioxide.[261] Various studies relying on expert elicitation[262] from a large body of climate economists and scientists have found mean estimates of $50 per ton of carbon dioxide,[263] $96-$144 per ton of carbon dioxide,[264] and $80-$100 per ton of carbon dioxide.[265] There is a growing consensus in the literature that even the best existing estimates of the social cost of greenhouse gases may severely underestimate the true marginal cost of climate damages.[266] Overall, a central estimate of $40 per ton of carbon dioxide at a 3% discount rate, with a high-percentile estimate of about $120 for year 2015 emissions, is consistent with the best available literature; if anything, the best available literature supports considerably higher estimates.[267]

Similarly, a comparison of international estimates of the social cost of greenhouse gases suggests that a central estimate of $40 per ton of carbon dioxide is a very conservative value. Sweden places the long-term valuation of carbon dioxide at $168 per ton; Germany calculates a "climate cost" of $167 per ton of carbon dioxide in the year 2030; the United Kingdom's "shadow price of carbon" has a central value of $115 by 2030; Norway's social cost of carbon is valued at $104 per ton for year 2030 emissions; and various corporations have adopted internal shadow prices as high as $80 per ton of carbon dioxide.[268]

Indeed, a number of our organizations have previously commented on ways in which the IWG's approach could be improved to more accurately reflect the true social cost of greenhouse gases. As discussed in our Technical Appendix on Uncertainty, the IWG's SCC estimates represents a lower bound by, for example, failing to include a risk premium and only partially modeling tipping points. We strongly encourage further efforts to address these omissions, as well as omitted climate damages more generally. Nevertheless, the IWG's approach represents the best and most rigorous effort that the U.S. government has engaged in thus far to realistically estimate the social cost of greenhouse gases. We therefore strongly urge the agencies to adopt the IWG's approach for estimating the social cost of

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[259] R. Tol, *Targets for Global Climate Policy: An Overview*, 37 J. Econ. Dynamics & Control 911 (2013).

[260] R. Tol, *Economic Impacts of Climate Change* (Univ. Sussex Working Paper No. 75-2015, 2015).

[261] S. Nocera et al., *The Economic Impact of Greenhouse Gas Abatement through a Meta-Analysis: Valuation, Consequences and Implications in terms of Transport Policy*. 37 Transport Policy 31 (2015).

[262] Circular A-4, at 41, supports use of expert elicitation as a valuable tool to fill gaps in knowledge.

[263] Scott Holladay & Jason Schwartz, *Economists and Climate Change* 43 (Inst. Policy Integrity Brief, 2009 (directly surveying experts about the SCC).

[264] Peter Howard & Derek Sylvan, *The Economic Climate: Establishing Expert Consensus on the Economics of Climate Change* (Inst. Policy Integrity Working Paper 2015/1) (using survey results to calibrate the DICE-2013R damage function).

[265] R. Pindyck, *The Social Cost of Carbon Revisited* (Nat'l Bureau of Econ. Res. No. w22807, 2016) ($80-$100 is the trimmed range of estimates at a 4% discount rate; without trimming of outlier responses, the estimate is $200).

[266] *E.g.,* Howard & Sylvan, *supra* note 264; Pindyck, *supra* note 265. The underestimation results from a variety of factors, including omitted and outdated climate impacts (including ignoring impacts to economic growth and tipping points), simplified utility functions (including ignoring relative prices), and applying constant instead of a declining discount rate. *See* Howard, *supra* note 254; Revesz et al., *supra* note 2466; J.C. Van Den Bergh & W.J. Botzen, A Lower Bound to the Social Cost of CO2 Emissions, 4 Nature Climate Change 253 (2014) (proposing $125 per metric ton of carbon dioxide in 1995 dollars, or about $200 in today's dollars, as the lower bound estimate). *See also* F.C. Moore & D.B. Diaz, *Temperature Impacts on Economic Growth Warrant Stringent Mitigation Policy*, 5 Nature Climate Change 127 (2015) (concluding the SCC may be six times higher after accounting for potential growth impacts of climate change). Accounting for both potential impacts of climate change on economic growth and other omitted impacts, S. Dietz and N. Stern find a two- to seven-fold increase in the SCC. *Endogenous growth, convexity of damage and climate risk: how Nordhaus' framework supports deep cuts in carbon emissions*. 125 *The Economic Journal* 574 (2015).

[267] Note that the various estimates cited in the paragraph have not all been converted to standard 2017$, and may not all reflect the same year emissions. Nevertheless, the magnitude of this range suggests that $40 per ton of year 2015 emissions is a conservative estimate.

[268] *See* Howard & Schwartz, *supra* note 39, at Appendix B. All these estimates are in 2016$.

carbon, with the understanding that such estimates should be seen as a conservative lower-bound estimate of the true impacts of this pollutant.

The Agencies Should Use the Most Updated Models

The agencies explain that they use DICE 2010, FUND 3.8, and PAGE 2009.[269] However, not only is DICE 2010 not considered to be a major update of the DICE model,[270] but two major updates have occurred more recently: DICE-2013R[271] and DICE-2016R.[272] In using the outdated DICE 2010, the agencies have failed to use the "best available science and economics" as required by Executive Order 13,783, and failed to follow the recommendations of the National Academies of Sciences on updating the integrated assessment models.[273] Updating from DICE 2010 to the most recent model would increase the social cost of greenhouse gases and enable a Monte Carlo simulation (as in FUND and PAGE) to better specify uncertainty.[274]

X. The Agencies Must Use the Social Cost of Methane and Social Cost of Nitrous Oxide

It is only in a sensitivity analysis that the agencies give any non-zero value to the climate damages associated with methane and nitrous oxide emissions.[275] In the PRIA's main analysis, all methane and nitrous oxide emissions, and consequently the vast majority of upstream greenhouse gas emissions, are not monetized at all. That is a blatantly arbitrary omission, because, as the U.S. Court of Appeals for the Ninth Circuit has ruled, the social cost of greenhouse gases is certainly not zero.[276] The approach also misunderstands the role of sensitivity analysis, which is to test "how the results of your analysis vary with plausible changes in assumptions."[277] The non-zero value of methane and nitrous oxide emissions is a fact, not an assumption, and it was not plausible in the first place to assume the social cost of methane and nitrous oxide to be zero in the main analysis.

The sensitivity analysis first proposes to value the social cost of methane and nitrous oxide by converting emissions into carbon dioxide-equivalent units using the relative global warming potentials. There are several problems with such an approach. First, conversion using relative global warming potential is less accurate than direct modeling. Scientists have long argued that the full social costs of specific, non-carbon dioxide gases like methane and nitrous oxide should be assessed through separate models and methodologies, which would more accurately account for varying atmospheric life spans, among other

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[269] PRIA 1098.

[270] *See* Nordhaus, W., & Sztorc, P. (2013). DICE 2013R: Introduction and user's manual.

[271] Nordhaus, W. (2014). Estimates of the social cost of carbon: concepts and results from the DICE-2013R model and alternative approaches. *Journal of the Association of Environmental and Resource Economists*, *1*(1/2), 273-312.

[272] Nordhaus, W. D. (2017). Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences*, 201609244.

[273] *See* National Academies of Sciences, Engineering, and Medicine. (2017). *Valuing climate damages: Updating estimation of the social cost of carbon dioxide*. National Academies Press. Note that the Interagency Working Group was incorrect in 2016 in failing to update the DICE model from DICE-2010 to DICE-2013R, which was available at the time. *Cf.* IWG, 2013 Technical Update (updating the models). *See also* Marten, A.L., Kopits, E.A., Griffiths, C.W., Newbold, S.C., and A. Wolverton. 2015. Incremental CH4 and N2O Mitigation Benefits Consistent with the U.S. Government's SC-CO2 Estimates. Climate Policy. 15(2): 272-298 (anticipating that the models will be continually updated).

[274] The update would also increase the agencies' calculation of the domestic-only share from 10% to 15%, *see* Nordhaus, W. D. (2017). Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences*, 201609244. But, as explained *supra* in these comments, a domestic-only value is the wrong framework and is inaccurate.

[275] PRIA 1062 fn 604.

[276] 538 F.3d at 1200.

[277] Circular A-4 at 41.

differences.[278] The Interagency Working Group did precisely that in 2016,[279] endorsing estimates developed in the peer-reviewed work by Marten *et al*.[280] The IWG's estimates of the social cost of methane and social cost of nitrous oxide are based on the same transparent, consensus-driven, publically reviewed, conservative approach as the social cost of carbon's thoroughly vetted methodology. Under Executive Order 13,783's call to base estimates on the best available science and economics, the agencies should use the more accurate direct estimates of the social cost of methane and nitrous oxide.

Second, even if the agencies were to stick with the less accurate approach of converting using relative global warming potentials, the agencies have chosen at best an outdated and at worst an incorrect estimate of GWP. The PRIA claims that its sensitivity analysis uses the GWP values of 25 for methane and 298 for nitrous oxide, citing the Intergovernmental Panel on Climate Change's 2007 work.[281] However, there is some confusion even about this: in the sensitivity analysis files, the "emission damage costs $/metric-ton" for methane is set at "$25," not at 25 times the value of the social cost of carbon. It is therefore unclear which value the sensitivity analysis actually used. Regardless, a GWP of 25 for methane is out of date. EPA currently lists methane's global warming potential as 28-36 over 100 years, and 84-87 over 20 years.[282] Meanwhile, the IPCC updated its estimates in 2013, and now recommends using a GWP for methane of 85 to 87 times greater than carbon dioxide after 20 years and 30 to 36 times greater than carbon dioxide after 100 years (after making the recommended adjustment for fossil methane).[283] The agencies' use of 25 for methane's GWP is below even the low end of the new ranges, and is severely below the range that captures methane's relative impacts over a shorter 20-year period. While the best option remains directly calculating the social cost of methane and nitrous oxide, minimally the agencies should update their GWP values and should conduct sensitivity analysis over the entire global warming potential range, instead of merely utilizing the low estimate from an outdated 100-year timescale range.

Sincerely,

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Tomás Carbonell, Senior Attorney and Director of Regulatory Policy, Environmental Defense Fund
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Iliana Paul, Policy Analyst, Institute for Policy Integrity, NYU School of Law*
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[278] *See* Disa Thureson & Chris Hope, *Is Weitzman Right? The Social Cost of Greenhouse Gases in an IAM World* 21 (Örebro University-Swedish Business School Working Paper 3/2012).

[279] 2016 Addendum, *supra* note 236.

[280] Alex L. Marten et al., *Incremental CH4 and N2O Mitigation Benefits Consistent With the US Government's SC-CO2 Estimates,* Climate Policy (2014).

[281] PRIA 1534, fn 910.

[282] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

[283] IPCC Working Group I, Fifth Assessment Report, Climate Change 2013: The Physical Science Basis, Chapter 8: Anthropogenic and Natural Radiative Forcing (2014) at 633, 711-712, 714 (Table 8.7), available at https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf (see the adjustment identified in note B for fossil methane).

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* No part of this document purports to present New York University School of Law's views, if any.

Attached:

- Technical Appendix on Uncertainty
- Technical Appendix on Discounting
- Technical Appendix on Damage Literature
- Interagency Working Group on the Social Cost of Greenhouse Gases: 2010 TSD, 2015 Response to Comments, 2016 TSD, 2016 Addendum.
- National Academies of Sciences, *Valuing Climate Damages: Updating Estimates of the Social Cost of Carbon Dioxide* (2017)
- Robert S. Pindyck, Comments on Proposed Rule and Regulatory Impact Analysis on the Delay and Suspension of Certain Requirements for Waste Prevention and Resource Conservation (2017)
- Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columbia J. Envtl. L. 203 (2017)
- Richard L. Revesz et al., *Best Cost Estimate of Greenhouse Gases*, 357 Science 6352 (2017)
- Peter Howard & Thomas Sterner, *Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates*. *Environmental and Resource Economics*, 1-29 (2016).
- Peter Howard & Derek Sylvan, *The Economic Climate: Establishing Expert Consensus on the Economics of Climate Change* (Inst. Policy Integrity Working Paper 2015/1)

Due to copyright limitations, other literature cited in these comments is not attached to our submission. We note, however, that NHTSA already captured many of these citations, drawn from our comments on the NEPA scoping process, and listed them in an appendix to the DEIS. We presume that the agencies will similarly enter into the record all the relevant literature from these comments. We have provided full citations and URLs wherever possible, and the agencies have access to journal articles and so forth.

TECHNICAL APPENDIX: UNCERTAINTY

Contrary to the arguments made by many opposed to strong federal climate action, uncertainty about the full effects of climate change *raises* the social cost of greenhouse gases and warrants *more* stringent climate policy.[284] Integrated assessment models (IAMs) currently used to calculate the SCC show that the net effect of uncertainty about economic damage resulting from climate change, costs of mitigation, future economic development, and many other parameters raises the SCC compared to the case where models simply use our current best guesses of these parameters.[285] Even so, IAMs still underestimate the impact of uncertainty on the SCC by not accounting for a host of fundamental features of the climate problem: the irreversibility of climate change, society's aversion to risk and other social preferences, option value, and many catastrophic impacts.[286] Rather than being a reason not to take action, uncertainty increases the SCC and should lead to more stringent policy to address climate change.[287]

Types of Uncertainty in the IAMs

IAMs incorporate two types of uncertainty: parametric uncertainty and stochastic uncertainty. Parametric uncertainty covers uncertainty in model design and inputs, including the selected parameters, correct functional forms, appropriate probability distribution functions, and model structure. With learning, these uncertainties should decline over time as more information becomes available.[288] Stochastic uncertainty is persistent randomness in the economic-climate system, including various environmental phenomena such as volcanic eruptions and sun spots.[289] Uncertainties are present in each component of the IAMs: socio-economic scenarios, the simple climate model, the damage and abatement cost functions, and the social welfare function (including the discount rate).[290]

When modeling climate change uncertainty, scientists and economists have long emphasized the importance of accounting for the potential of catastrophic climate change.[291] Catastrophic outcomes combine several overlapping concepts including unlucky states of the world (i.e., bad draws), deep

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[284] Sonja Peterson, *Uncertainty and economic analysis of climate change: A survey of approaches and findings*, 11 Environmental Modeling & Assessment 1-17 (2006) ("Most modeling results show (as can be expected) that there is optimally more emission abatement if uncertainties in parameters or the possibility of catastrophic events are considered.").

[285] *Id.;* Richard SJ Tol, Safe policies in an uncertain climate: an application of FUND, 9 *Global Environmental Change* 221-232 (1999).

[286] Robert S Pindyck, *Uncertainty in environmental economics*, 1 Review of environmental economics and policy 45-65 (2007); Golub et al, *surpa* note 218; Lemoine & Rudik, *supra* note 218.

[287] *See* cites *supra* note 286.

[288] Learning comes in multiple forms: passive learning of anticipated information that arrives exogenous to the emission policy (such as academic research), active learning of information that directly stems from the choice of the GHG emission level (via the policy process), and learning of unanticipated information. Antje Kann & John P. Weyant, *Approaches for performing uncertainty analysis in large-scale energy/economic policy models*, 5 Environmental Modeling & Assessment 29-46 (2000); Derek Lemoine & Ivan Rudik, *Managing Climate Change Under Uncertainty: Recursive Integrated Assessment at an Inflection Point*, 9 *Annual Review of Resource Economics* 18.1-18.26 (2017).

[289] A potential third type of uncertainty arises due to ethical or value judgements: normative uncertainty. Peterson (2006) *supra* note 284; Geoffrey Heal & Antony Millner, *Reflections: Uncertainty and decision making in climate change economics*, 8 Review of Environmental Economics and Policy 120-137 (2014). For example, there is some normative debate over the appropriate consumption discount rate to apply in climate economics, though widespread consensus exists that using the social opportunity cost of capital is inappropriate (see earlier discussion). Preference uncertainty should be modeled as a declining discount rate over time (see earlier discussion), not using uncertain parameters. Kann & Weyant, *supra* note 288 and Golub et al. *supra* note 218.

[290] Peterson (2006), *supra* note 284; Pindyck (2007), *supra* note 218; Heal & Millner 2014, *supra* note 289.

[291] William Nordhaus, A Question of Balance: Weighing the Options on Global Warming Policies (2008); Robert E. Kopp, Rachael L. Shwom, Gernot Wagner, and Jiacan Yuan, Tipping elements and climate–economic shocks: Pathways toward integrated assessment, 4 *Earth's Future* 346-372 (2016).

uncertainty, and climate tipping points and elements.[292] Traditionally, IAM developers address uncertainty by specifying probability distributions over various climate and economic parameters. This type of uncertainty implies the possibility of an especially bad draw if multiple uncertain parameters turn out to be lower than we expect, causing actual climate damages to greatly exceed expected damages.

Our understanding of the climate and economic systems is also affected by so-called "deep uncertainty," which can be thought of as uncertainty over the true probability distributions for specific climate and economic parameters.[293] The mean and variance of many uncertain climate phenomena are unknown due to lack of data, resulting in "fat-tailed distributions"—i.e., the tail of the distributions decline to zero slower than the normal distribution. Fat-tailed distributions result when the best guess of the distribution is derived under learning.[294] Given the general opinion that bad surprises are likely to outweigh good surprises in the case of climate change,[295] modelers capture deep uncertainty by selecting probability distributions with a fat upper tail which reflects the greater likelihood of extreme events.[296] The possibility of fat tails increases the likelihood of a "very" bad draw with high economic costs, and can result in a very high (and potentially infinite) expected cost of climate change (a phenomenon known as the dismal theory).[297]

Climate tipping elements are environmental thresholds where a small change in climate forcing can lead to large, non-linear shifts in the future state of the climate (over short and long periods of time) through positive feedback (i.e., snowball) effects.[298] Tipping points refer to economically relevant thresholds after which change occurs rapidly (i.e., Gladwellian tipping points), such that opportunities for adaptation and intervention are limited.[299] Tipping point examples include the reorganization of the Atlantic meridional overturning circulation (AMOC) and a shift to a more persistent El Niño regime in the Pacific Ocean.[300] Social tipping points—including climate-induced migration and conflict—also exist. These various tipping points interact, such that triggering one tipping point may affect the probabilities of triggering other tipping points.[301] There is some overlap between tipping point events and fat tails in

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[292] Kopp et al. (2016), *supra* note 291.

[293] *Id.*

[294] William Nordhaus, *An Analysis of the Dismal Theorem* (Cowles Foundation Discussion Paper No. 1686, 2009); Martin L. Weitzman, *Fat-tailed uncertainty in the economics of catastrophic climate change*, 5 Review of Environmental Economics and Policy 275-292 (2011). Robert S Pindyck, *Fat tails, thin tails, and climate change policy*, 5 Review of Environmental Economics and Policy 258-274 (2011).

[295] Michael D Mastrandrea, Calculating the benefits of climate policy: examining the assumptions of integrated assessment models (Pew Center on Global Climate Change Working Paper, 2009); Richard SJ Tol, On the uncertainty about the total economic impact of climate change, 53 Environmental and Resource Economics 97-116 (2012).

[296] Weitzman (2011), *supra* note 294, makes clear that "deep structural uncertainty about the unknown unknowns of what might go very wrong is coupled with essentially unlimited downside liability on possible planetary damages. This is a recipe for producing what are called 'fat tails' in the extreme of critical probability distributions."

[297] Martin L Weitzman, *On modeling and interpreting the economics of catastrophic climate change*, 91 The Review of Economics and Statistics 1-19 (2009); Nordhaus (2009), *supra* note 294; Weitzman (2011), *supra* note 294.

[298] Tipping elements are characterized by: (1) deep uncertainty, (2) absence from climate models, (3) larger resulting changes relative to the initial change crossing the relevant threshold, and (4) irreversibility. Kopp et al. (2016), *supra* note 291.

[299] *Id.*

[300] *Id.*; Elmar Kriegler, Jim W. Hall, Hermann Held, Richard Dawson, and Hans Joachim Schellnhuber, Imprecise probability assessment of tipping points in the climate system, 106 *Proceedings of the national Academy of Sciences* 5041-5046 (2009); Delavane Diaz & Klaus Keller, A potential disintegration of the West Antarctic Ice Sheet: Implications for economic analyses of climate policy, 106 *The American Economic Review* 607-611 (2016). See Table 1 of Kopp et al. (2016) *supra* note 291, for a full list of known tipping elements and points.

[301] Kriegler et al. (2009), *supra* note 300; Cai, Yongyang, Timothy M. Lenton, and Thomas S. Lontzek, *Risk of multiple interacting tipping points should encourage rapid CO2 emission reduction*, 6 Nature Climate Change 520-525 (2016); Kopp et al. (2016) *supra* note 291.

that the probability distributions for how likely, how quick, and how damaging tipping points will be are unknown.[302] Accounting fully for these most pressing, and potentially most dramatic, uncertainties in the climate-economic system matter because humans are risk averse and tipping points—like many other aspects of climate change—are, by definition, irreversible

How IAMs and the IWG Account for Uncertainty

Currently, IAMs (including all of those used by the IWG) capture uncertainty in two ways: deterministically and through uncertainty propagation. For the deterministic method, the modeler assumes away uncertainty (and thus the possibility of bad draws and fat tails) by setting parameters equal to their most likely (median) value. Using these values, the modeler calculates the median SCC value. Typically, the modeler conducts sensitivity analysis over key parameters—one at a time or jointly—to determine the robustness of the modeling results. This is the approach employed by Nordhaus in the preferred specification of the DICE model[303] used by the IWG.

Uncertainty propagation is most commonly carried out using Monte Carlo simulation. In these simulations, the modeler randomly draws parameter values from each of the model's probability distributions, calculates the SCC for the draw, and then repeats this exercise thousands of times to calculate a mean social cost of carbon.[304] Tol, Anthoff, and Hope employ this technique in FUND and PAGE—as did the IWG (2010, 2013, and 2016)[305]—by specifying probability distributions for the climate and economic parameters in the models. These models are especially helpful for assessing the net effect of different parametric and stochastic uncertainties. For instance, both the costs of mitigation and the damage from climate change are uncertain. Higher costs would warrant less stringent climate policies, while higher damages lead to more stringent policy, so theoretically, the effect of these two factors on climate policy could be ambiguous. Uncertainty propagation in an IAM calibrated to empirically motivated distributions, however, shows that climate damage uncertainty outweighs the effect of cost uncertainty, leading to a stricter policy when uncertainty is taken into account than when it is ignored.[306] This can be seen in the resulting right-skewed distribution of the SCC (see Figure 1 in IWG (2016)) where the mean (Monte Carlo) SCC value clearly exceeds the median (deterministic) SCC value.

The IWG was rigorous in addressing uncertainty. First, it conducted Monte Carlo simulations over the above IAMs specifying different possible outcomes for climate sensitivity (represented by a right skewed, fat tailed distribution to capture the potential of higher than expected warming). It also used scenario analysis: five different emissions growth scenarios and three discount rates. Second, the IWG (2016)[307] reported the various moments and percentiles—including the 95th percentile—of the resulting

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[302] Peter Howard, *Omitted Damages: What's Missing from the Social Cost of Carbon* 5 (Cost of Carbon Project Report, 2014), http://costofcarbon.org/; Kopp et al. (2016) *supra* note 291.

[303] *See* Nordhaus & Sztorc 2013, *supra* note 270.

[304] In alternative calculation method, the modeler "performs optimization of polices for a large number of possible parameter combinations individually and estimates their probability weighted sum." Golub et al. *supra* note 218. In more recent DICE-2016, Nordhaus conducts a three parameter analysis using this method to determine a SCC confidence interval. Given that PAGE and FUND model hundred(s) of uncertainty parameters, this methodology appears limited in the number of uncertain variables that can be easily specified.

[305] Interagency Working Group on Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2010). Interagency Working Group on Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2013). Interagency Working Group on Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2016).

[306] Tol (1999), *supra* note 285, in characterizing the FUND model, states, "Uncertainties about climate change impacts are more serious than uncertainties about emission reduction costs, so that welfare-maximizing policies are stricter under uncertainty than under certainty."

[307] IWG (2016) *supra* note 305.

SCC estimates. Third, the IWG put in place an updating process, e.g., the 2013 and 2016 revisions, which updates the models as new information becomes available.[308] As such, the IWG used the various tools that economists have developed over time to address the uncertainty inherent in estimating the economic cost of pollution: reporting various measures of uncertainty, using Monte Carlo simulations, and updating estimates as evolving research advances our knowledge of climate change. Even so, the IWG underestimate the SCC by failing to capture key features of the climate problem.

Current IAMs Underestimate the SCC by Failing to Sufficiently Model Uncertainty

Given the current treatment of uncertainty by the IWG (2016) and the three IAMs that they employ, the IWG (2016) estimates represent an underestimate of the SCC. DICE clearly underestimates the true value of the SCC by effectively eliminating the possibility of bad draws and fat tails through a deterministic model that relies on the median SCC value. Even with their calculation of the mean SCC, the FUND and PAGE also underestimate the metric's true value by ignoring key features of the climate-economic problem. Properly addressing the limitations of these models' treatment of uncertainty would further increase the SCC.

First, current IAMs insufficiently model catastrophic impacts. DICE fails to model both the possibility of bad draws and fat tails by applying the deterministic approach. Alternatively, FUND and PAGE ignore deep uncertainty by relying predominately on the thin-tailed triangular and gamma distributions.[309] The IWG (2010) only partially addresses this oversight by replacing the ECS parameter in DICE, FUND, and PAGE with a fat-tailed, right-skewed distribution calibrated to the IPCC's assumptions (2007), even though many other economic and climate phenomenon in IAMs are likely characterized by fat tails, including climate damages from high temperature levels, positive climate feedback effects, and tipping points.[310] Recent work in stochastic dynamic programming tends to better integrate fat tails – particularly with respect to tipping points (see below) – and address additional aversion to this type of uncertainty (also known as ambiguity aversion); doing so can further increase the SCC under uncertainty.[311]

In contrast to their approach to fat tails, the IAMs used by the IWG (2010; 2013; 2016) sometimes address climate tipping points, though they do not apply state-of-the-art methods for doing so. In early versions of DICE (DICE-2010 and earlier), Nordhaus implicitly attributes larger portions of the SCC to tipping points by including certainty equivalent damages of catastrophic events - representing two-thirds to three-quarter of damages in DICE – calibrated to an earlier Nordhaus (1994) survey of experts.[312] In PAGE09, Hope also explicitly models climate tipping points as a singular, discrete event (of a 5% to 25% loss in GDP) that has a probability (which grows as temperature increases) of occurring in

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[308] IWG (2010) *supra* note 305.

[309] Howard (2014), *supra* note 302. While both FUND and PAGE employ thin tailed distributions, the resulting distribution of the SCC is not always thin-tailed. In PAGE09, the ECS parameter is endogenous, such that the distribution of the ECS has a long tail following the IPCC (2007). *See* Z Chen, M Marquis, KB Averyt, M Tignor, & HL Miller, Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change (2007). Similarly, while Anthoff and Tol do not explicitly utilize fat-tail distributions, the distribution of net present welfare from a Monte Carlos simulation is fat tailed. DAVID ANTHOFF & RICHARD S. J. TOL, THE CLIMATE FRAMEWORK FOR UNCERTAINTY, NEGOTIATION, AND DISTRIBUTION (FUND), TECHNICAL DESCRIPTION, VERSION 3.8 (2014). Explicitly modeling parameter distributions as fat tailed may further increase the SCC.

[310] Weitzman (2011), *supra* note 294; Kopp et al. (2016) *supra* note 291.

[311] Derek Lemoine & Christian P. Traeger, *Ambiguous tipping points*, 132 Journal of Economic Behavior & Organization 5-18 (2016); Lemoine & Rudik (2017), *supra* note 218. IAM modelers currently assume that society is equally averse to known unknown and known unknowns. Lemoine & Traeger, *id*.

[312] William Nordhaus & Joseph Boyer, Warning the World: Economic Models of Global Warming (2000); Nordhaus (2008) *supra* note 264; Howard (2014), *supra* note 302; Kopp et al. (2016) *supra* note 291.

each time period.[313] Though not in the preferred versions of the IAMs employed by the IWG, some research also integrates specific tipping points into these IAMs finding even higher SCC estimates.[314] Despite the obvious methodological basis for addressing tipping points, the latest versions of DICE[315] and FUND exclude tipping points in their preferred specifications. Research shows that if these models were to correctly account for the full range of climate impacts—including tipping points—the resulting SCC estimates would increase.[316]

The IWG approach also fails to include a risk premium—that is, the amount of money society would require in order to accept the uncertainty (i.e., variance) over the magnitude of warming and the resulting damages from climate change relative to mean damages (IWG, 2010; IWG, 2015)). The mean of a distribution, which is a measure of a distribution's central tendency, represents only one descriptor or "moment" of a distribution's shape. Each IAM parameter and the resulting SCC distributions have differing levels of variance (i.e., spread around the mean), skewness (i.e., a measure of asymmetry), and kurtosis (which, like skewness, is another descriptor of a distribution's tail) as well as means.[317] It is generally understood that people are risk averse in that they prefer input parameter distributions and (the resulting) SCC distributions with lower variances, holding the mean constant.[318] While the IWG assumes a risk-neutral central planner by using a constant discount rate (setting the risk premium to zero), this assumption does not correspond with empirical evidence,[319] current IAM assumptions,[320] the

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[313] Hope (2006) also calibrated a discontinuous damage function in PAGE-99 used by IWG (2010); see Chris Hope, *The Marginal Impact of CO_2 from PAGE2002: An Integrated Assessment Model Incorporating the IPCC's Five Reasons for Concern*, 6 INTEGRATED ASSESSMENT J. 19 (2006). Howard (2014), *supra* note 302.

[314] Kopp et al. (2016) *supra* note 291.

[315] For DICE-2013 and DICE-2016, Nordhaus calibrates the DICE damage function using a meta-analysis based on estimates that mostly exclude tipping point damages. Peter H Howard & Thomas Sterner, *Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates*, 68 Environmental and Resource Economics 1-29 (2016).

[316] Using FUND, Link and Tol (2011) find that a collapse of the AMOC would decrease GDP (and thus increase the SCC) by a small amount. Earlier modeling of this collapse in DICE find a more significance increase. P. Michael Link & Richard SJ Tol, Estimation of the economic impact of temperature changes induced by a shutdown of the thermohaline circulation: an application of FUND, 104 *Climatic Change* 287-304 (2011); Klaus Keller, Kelvin Tan, François MM Morel, & David F. Bradford*, Preserving the Ocean Circulation: Implications for Climate Policy*, 47 Climatic Change 17-43 (2000); Michael D Mastrandrea & Stephen H. Schneider*, Integrated assessment of abrupt climatic changes*, 1 Climate Policy 433-449 (2001); Klaus Keller, Benjamin M. Bolker, & David F. Bradford, *Uncertain climate thresholds and optimal economic growth*, 48 Journal of Environmental Economics and management 723-741 (2004). With respect to thawing of the permafrost, Hope and Schaefer (2016) and Gonzalez-Eguino and Neumann (2016) find increases in damages (and thus an increase in the SCC) when integrating this tipping element into the PAGE09 and DICE-2013R, respectively. Chris Hope & Kevin Schaefer. *Economic impacts of carbon dioxide and methane released from thawing permafrost*, 6 Nature Climate Change 56-59 (2016); Mikel González-Eguino & Marc B. Neumann, *Significant implications of permafrost thawing for climate change control*, 136 Climatic Change 381-388 (2016). Looking at the collapse of the West Antarctic Ice sheet, Nicholls et al. (2008) find a potential for significant increases in costs (and thus the SCC) in FUND. Robert J Nicholls, Richard SJ Tol, & Athanasios T. Vafeidis, Global estimates of the impact of a collapse of the West Antarctic ice sheet: an application of FUND, 91 *Climatic Change* 171-191 (2008). Ceronsky et al. (2011) model three tipping points (collapse of the Atlantic Ocean Meridional Overturning Circulation, large scale dissociation of oceanic methane hydrates; and a high equilibrium climate sensitivity parameter), and finds a large increase in the SCC in some cases. Megan Ceronsky, David Anthoff, Cameron Hepburn, and Richard SJ Tol, *Checking the price tag on catastrophe: The social cost of carbon under non-linear climate response* (ESRI working paper No. 392, 2011).

[317] Alexander Golub & Michael Brody, *Uncertainty, climate change, and irreversible environmental effects: application of real options to environmental benefit-cost analysis*, 7 Journal of Environmental Studies and Sciences 7 519-526 (2017); see Figure 1 in IWG (2016) supra note 305.

[318] In other words, society prefers a narrow distribution of climate damages around mean level of damages X to a wider distribution of damages also centered on the same mean of X because they avoid the potential for very high damages even at the cost of eliminating the chance of very low damages.

[319] IWG, 2010 *supra* note 305, at fn 22; Cai et al., 2016, *supra* note 301, at 521.

[320] The developers of each of the three IAMs used by the IWG (2010; 2013; 2016) assume a risk aversion society. Nordhaus and Sztorc 2013 *supra* note 270; Anthoff & Tol (2013) *supra* note 257; DAVID ANTHOFF & RICHARD S. J. TOL, THE CLIMATE FRAMEWORK FOR UNCERTAINTY, NEGOTIATION, AND DISTRIBUTION (FUND), TECHNICAL DESCRIPTION, VERSION 3.5 (2010); Chris Hope, *Critical issues for the*

NAS (2017) recommendations, nor with the IWG's own discussion (2010) of the possible values of the elasticity of the marginal utility of consumption. Evidence from behavioral experiments indicate that people and society are also averse to other attributes of parameter distributions – specifically to the thickness of the tails of distributions – leading to an additional ambiguity premium (Heal and Millner, 2014).[321] Designing IAMs to properly account for the risk and ambiguity premiums from uncertain climate damages would increase the resulting SCC values they generate.

Even under the IWG's current assumption of risk neutrality, the mean SCC from uncertainty propagation excludes the (real) option value of preventing marginal CO_2 emissions.[322] Option value reflects the value of future flexibility due to uncertainty and irreversibility; in this case, the irreversibility of CO2 emissions due to their long life in the atmosphere.[323] If society exercises the option of emitting an additional unit of CO2 emissions today, "we will lose future flexibility that the [mitigation] option gave" leading to possible "regret and…a desire to 'undo'" the additional emission because it "constrains future behavior."[324] Given that the SCC is calculated on the Business as Usual (BAU) emission pathway, option value will undoubtedly be positive for an incremental emission because society will regret this emission in most possible futures.

Though sometimes the social cost of carbon and a carbon tax are thought of as interchangeable ways to value climate damages, agencies should be careful to distinguish two categories of the literature. The first is the economic literature that calculates the optimal carbon tax in a scenario where the world has shifted to an optimal emissions pathway. The second is literature that assesses the social cost of carbon on the business-as-usual (BAU) emissions pathway; the world is currently on the BAU pathway, since optimal climate policies have not been implemented. There are currently no numerical estimates of the risk premium and option value associated with an incremental emission on the BAU emissions path. Although there are stochastic dynamic optimization models that implicitly account for these two values, they analyze *optimal,* sequential decision making under climate uncertainty.[325] By nature of being optimization models (instead of policy models), these complex models focus on calculating the optimal tax and not the social cost of carbon, which differ in that the former is the present value of marginal

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calculation of the social cost of CO2: why the estimates from PAGE09 are higher than those from PAGE2002, 117 CLIM. CHANGE 531–543 (2013) at 539.

[321] According to Heal and Millner (2014) *supra* note 289, there is an ongoing debate of whether ambiguity aversion is rational or a behavioral mistake. Given the strong possibility that this debate is unlikely to be resolved, the authors recommend exploring both assumptions.

[322] Kenneth J Arrow & Anthony C. Fisher*, Environmental preservation, uncertainty, and irreversibility*, 88 The Quarterly Journal of Economics 312-319 (1974); Avinash K Dixit and Robert S Pindyck, Investment under uncertainty (1994); Christian P Traeger, On option values in environmental and resource economics, 37 Resource and Energy Economics 242-252 (2014).

In the discrete emission case, there are two overlapping types of option value: real option value and quasi-option value. Real option value is the full value of future flexibility of maintaining the option to mitigate, and mathematically equals the maximal value that can be derived from the option to [emit] now or later (incorporating learning) less the maximal value that can be derived from the possibility to [emit] now or never. Traeger (2014) *supra* note 322, equation 5. Quasi-option value is the value of future learning conditional on delaying the emission decision, which mathematically equals the value of mitigation to the decision maker who anticipates learning less the value of mitigation to the decision maker who anticipates only the ability to delay his/her decision, and not learning. *Id.* The two values are related, such that real option value can be decomposed into:

$$\mathrm{DPOV} = \mathbf{Max}\{QOV + SOV - \mathbf{Max}\{NPV, 0\}, 0\} = \mathbf{Max}\{QOV + SOV - \mathrm{SCC}, 0\}$$

where DPOV is the real option value, QOV is quasi-option value, SOV is simple option value (the value of the option to emit in the future condition on mitigating now), and NPV is the expected net present value of emitting the additional unit or the mean SCC in our case. *Id.*

[323] Even if society drastically reduced CO2 emissions, CO2 concentrations would continue to rise in the near future and many impacts would occur regardless due to lags in the climate system. Robert S Pindyck, *Uncertainty in environmental economics*, 1 Review of environmental economics and policy 45-65 (2007).

[324] Pindyck (2007) *supra* note 218.

[325] Kann & Weyant *supra* note 288; Pindyck (2007) *supra* note 218; Golub et al. (2014) *supra* note *218*.

damages on the optimal emissions path rather than on the BAU emissions path.[326] While society faces the irreversibility of emissions on the BAU emissions path when abatement is essentially near zero (i.e., far below the optimal level even in the deterministic problem),[327] the stochastic dynamic optimization model must also account for a potential counteracting abatement cost irreversibility – the sunk costs of investing in abatement technology if we learn that climate change is less severe than expected – by the nature of being on the optimal emissions path that balances the cost of emissions and abatement. In the optimal case, uncertainty and irreversibility of abatement *can theoretically* lead to a lower optimal emissions tax, unlike the social cost of carbon. The difference in the implication for the optimal tax and the SCC means that the stochastic dynamic modeling results are less applicable to the SCC.

What can we learn from new literature on stochastic dynamic programming models?

Bearing in mind the limitations of stochastic dynamic modeling, some new research provides valuable insights that are relevant to calculation of the social cost of greenhouse gases. The new and growing stochastic dynamic optimization literature implies that the IWG's SCC estimates are downward biased. The literature is made up of three models – real option, finite horizon, and infinite horizon models – of which the infinite time horizon (i.e., stochastic dynamic programming (SDP)) models are the most comprehensive for analyzing the impact of uncertainty on optimal sequential abatement policies.[328] Recent computational advancements in SDP are helping overcome the need for strong simplifying assumptions in this literature for purpose of tractability. Traditionally, these simplifications led to unrealistically fast rates of learning – leading to incorrect outcomes – and difficulty in comparing results across papers (due to differing uncertain parameters, models of learning, and model types). Even so, newer methods still only allow for a handful of uncertain parameters compared to the hundreds of uncertain parameters in FUND and PAGE. Despite these limitations, the literature supports the above finding that the SCC, if anything, increases under uncertainty.[329]

First, uncertainty increases the optimal emissions tax under realistic parameter values and modeling scenarios. While the impact of uncertainty on the optimal emissions tax (relative to the deterministic problem) depends on the uncertain parameters considered, the type of learning, and the model type (real option, finite horizon, and infinite horizon), the optimal tax clearly increases when tipping points or black swan events are included in stochastic optimization problems.[330] For SDP models, uncertainty

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[326] Nordhaus (2014) makes this difference clear when he clarifies that "With an optimized climate policy…the SCC will equal the carbon price…In the more realistic case where climate policy is not optimized, it is conventional to measure the SCC as the marginal damage of emissions along the actual path. There is some inconsistency in the literature on the definition of the path along which the SCC should be calculated. This paper will generally define the SCC as the marginal damages along the baseline path of emissions and output and not along the optimized emissions path." William D. Nordhaus, *Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches*, 1 J. ASSOC. ENVIRON. RESOUR. ECON. 1 (2014).

[327] On the BAU path, emissions far exceed their optimal level even without considering uncertainty. As a consequence, society is likely to regret an additional emission of CO2 in most future states of the world. Alternatively, society is unlikely to regret current abatement levels unless the extremely unlikely scenarios that there is little to no warming and/or damages from climate change.

[328] Kann & Weyant *supra* note 288; Pindyck (2007) *supra* note 218; Golub et al. (2014) *supra* note 218.

[329] Kann & Weyant *supra* note 288; Pindyck (2007) *supra* note 218; Golub et al. (2014) *supra* note 218; Lemoine & Rudik 2017 supra note 218. Comparing the optimal tax to the mean SCC is made further difficult by the frequent use of DICE as the base from which most stochastic dynamic optimization models are built. As a consequence, deterministic model runs are frequently the base of comparison for these models (Lemoine & Rudik, *id*).

[330] The real options literature tends to find an increase in the optimal emissions path under uncertainty relative to the deterministic case (Pindyck 2007 *supra* note 218), though the opposite is true when modelers account for the possibility of large damages (i.e., tipping point or black swan events) even with a risk-neutral society (Pindyck 2007 *supra* note 296; Golub et al 2014 *supra* note *259*). Solving finite horizon models employing non-recursive methods, modelers find that the results differ depending on the model of learning – the research demonstrates stricter emission paths under uncertainty without learning

tends to strengthen the optimal emissions path relative to the determinist case even without tipping points,[331] and these results are strengthened under realistic preference assumptions.[332] Given that there is no counter-balancing tipping abatement cost,[333] the complete modeling of climate uncertainty – which fully accounts for tipping points and fat tails – increases the optimal tax. Uncertainty leads to a stricter optimal emissions policy even if with irreversible mitigation costs, highlighting that the SCC would also increase when factoring in risk aversion and irreversibility given that abatement costs are very low on the BAU emissions path.

Second, given the importance of catastrophic impacts under uncertainty (as shown in the previous paragraph), the full and accurate modeling of tipping points and unknown knowns is critical when modeling climate change. The most sophisticated climate-economic models of tipping points – which include the possibility of multiple correlated tipping points in stochastic dynamic IAMs – find an increase in the optimal tax by 100%[334] to 800%[335] relative to the deterministic case without them. More realistic modeling of tipping points will also increase the SCC.

Finally, improved modeling of preferences will amplify the impact of uncertainty on the SCC. Adopting Epstein-Zin preferences that disentangle risk aversion and time preferences can significantly increase the SCC under uncertainty.[336] Recent research has shown that accurate estimation of decisions under uncertainty crucially depends on distinguishing between risk and time preferences.[337] By conflating risk and time preferences, current models substantially understate the degree of risk aversion exhibited by most individuals, artificially lowering the SCC. Similarly, adopting ambiguity aversion increase the SCC, but to a much lesser extent than risk aversion.[338] Finally, allowing for the price of non-market goods to increase with their relative scarcity can amplify the positive effect that even small tipping points have on the SCC if the tipping point impacts non-market services.[339] Including more realistic preference assumptions in IAMs would further increase the SCC under uncertainty.

(with emission reductions up to 30% in some cases) and the impact under passive learning has a relatively small impact due the presence of sunken mitigation investment costs - except when tipping thresholds are included (Golub et al 2014 *supra* note *218*).

[331] Using SDP, modelers find that uncertainty over the equilibrium climate sensitivity parameter generally increases the optimal tax by a small amount, though the magnitude of this impact is unclear (Golub et al. (2014) *supra* note *218*; Lemoine & Rudik 2017 supra note 218). Similarly, non-catastrophic damages can have opposing effects dependent on the parameters changed, though emissions appear to decline overall when you consider their uncertainty jointly.

[332] Pindyck (2007) *supra* note 218; Golub et al. (2014) *supra* note *218*; Lemoine & Rudik 2017 supra note 218.

[333] Pindyck (2007) *supra* note 218.

[334] Derek Lemoine & Christian P. Traeger, *Economics of tipping the climate dominoes*. 6 NAT. CLIM. CHANG. 514-519 (2016).

[335] Cai et al. 2016 *supra* note 301.

[336] Cai et al. 2016 *supra* note 301; Lemoine & Rudik 2017 supra note 218. The standard utility function adopted in IAMs with constant relative risk version implies that the elasticity of substitution equals the inversion of relative risk aversion. As a consequence, the society's preferences for the intra-generational distribution of consumption, the intergenerational distribution of consumption, and risk aversion hold a fixed relationship. For purposes of stochastic dynamic programming, this is problematic because this assumption conflates intertemporal consumption smoothing and risk aversion. WJ Wouter Botzen & Jeroen CJM van den Bergh, *Specifications of social welfare in economic studies of climate policy: overview of criteria and related policy insights*, 58 Environmental and Resource Economics 1-33 (2014). By adopting the Epstein-Zinn utility function which separates these two parameters, modelers can calibrate them according to empirical evidence. For example, Cai et al. (2016) *supra* note 301 replace the DICE risk aversion of 1.45 and elasticity parameter of 1/1.45 with values of 3.066 and 1.5, respectively.

[337] James Andreoni & Charles Sprenger, *Risk Preferences Are Not Time Preferences*, 102 AM. ECON. REV. 3357–3376 (2012).

[338] Lemoine & Traeger (2016) *supra* note 311.

[339] Typically, IAMs assume constant relative prices of consumption goods. Reyer Gerlagh & B. C. C. Van der Zwaan, *Long-term substitutability between environmental and man-made goods*, 44 Journal of Environmental Economics and Management 329-345 (2002); Thomas Sterner & U. Martin Persson, *An even sterner review: Introducing relative prices into the discounting debate*, 2 Review of Environmental Economics and Policy 61-76 (2008). By replacing the standard isoelastic utility function in

Introducing stochastic dynamic modeling (which captures option value and risk premiums), updating the representation of tipping points, and including more realistic preference structures in traditional IAMs will – as in the optimal tax – further increase the SCC under uncertainty

Conclusion: Uncertainty Raises the Social Cost of Greenhouse Gases

Overall, the message is clear: climate uncertainty is *never* a rationale for ignoring the SCC or shortening the time horizon of IAMs. Instead, our best estimates suggest that increased variability implies a higher SCC and a need for more stringent emission regulations.[340] Current omission of key features of the climate problem under uncertainty (the risk and climate premiums, option value, and fat tailed probability distributions) and incomplete modeling of tipping points imply that the SCC will further increase with the improved modeling of uncertainty in IAMs.

IAMs with a nested CES utility function following Sterner and Persson (2008), Cai et al. (2015) find that even a relatively small tipping point (i.e., a 5% loss) can substantially increase the SCC in the stochastic dynamic setting. Yongyang Cai, Kenneth L. Judd, Timothy M. Lenton, Thomas S. Lontzek, & Daiju Narita, *Environmental tipping points significantly affect the cost− benefit assessment of climate policies*, 112 PROC. NATL. ACAD. SCI. 4606-4611 (2015).

[340] Golub et al. (2014) *supra* note 218 states "The most important general policy implication from the literature is that despite a wide variety of analytical approaches addressing different types of climate change uncertainty, none of those studies supports the argument that no action against climate change should be taken until uncertainty is resolved. On the contrary, uncertainty despite its resolution in the future is often found to favor a stricter policy." *See also* Comments from Robert Pindyck, to BLM, on the Social Cost of Methane in the Proposed Suspension of the Waste Prevention Rule (submitted Nov. 5, 2017) ("Specifically, my expert opinion about the uncertainty associated with Integrated Assessment Models (IAMs) was used to justify setting the SC-CH4 to zero until this uncertainty is resolved. That conclusion does not logically follow and I have rejected it in the past, and I reiterate my rejection of that view again here. While at this time we do not know the Social Cost of Carbon (SCC) or the Social Cost of Methane with precision, we do know that the correct values are well above zero…Because of my concerns about the IAMs used by the now-disbanded Interagency Working Group to compute the SCC and SC-CH4, I have undertaken two lines of research that do not rely on IAMs…[They lead] me to believe that the SCC is larger than the value estimated by the U.S. Government."

TECHNICAL APPENDIX: DISCOUNTING

1. The Underlying IAMs All Use a Consumption Discount Rate

Employing a consumption discount rate would also ensure that the U.S. government is consistent with the assumptions employed by the underlying IAM models: DICE, FUND, and PAGE. Each of these IAMs employs consumption discount rates calibrated using the standard Ramsey formula.[341] In DICE-2010, the elasticity of the pure rate of time preference is 1.5 and an elasticity of the marginal utility of consumption (η) of 2.0. Together with its assumed per capita consumption growth path, the average discount rate over the next three hundred years is 2.4%.[342] However, more recent versions of DICE (DICE-2013R and DICE-2016) update η to 1.45; this implies an increase of the average discount rate over the timespan of the models to between 3.1% and 3.2% depending on the consumption growth path.[343] In FUND 3.8 and (the mode values in) PAGE09, both model parameters are equal to 1.0. Based on the assumed growth rate of the U.S. economy (without climate damages), the average U.S. discount rate in FUND 3.8 is 2.0% over the timespan of the model (without considering climate damages). Unlike FUND 3.8, PAGE09 specifies triangular distributions for both parameters with a pure rate of time preference of between 0.1 and 2 with a mean of 1.03 and an elasticity of the marginal utility of consumption of between 0.5 and 2 with a mean 1.17. Using the PAGE09's mode values (without accounting for climate damages), the average discount rate over the timespan of the models is approximately 3.3% with a range of 1.2% to 6.5%. Rounding up the annual growth rate over the last 50 years to approximately 2%,[344] the range of best estimates of the SDR implied in the short-run by these three models is approximately 3% (PAGE09's mode estimate and FUND 3.8) to 4.4% (DICE-2016), though the PAGE09 model alone implies a range of 1.1% to 6.0% with a central estimate of 3%. The range of potential consumption discount rates in these IAMs is relatively consistent with IWG[345] in the short-run, though the discount rates of the IAMs employed by the IWG decline over time (due to declining growth rates over time) implying a potential upward bias to the IWG consumption discount rates.

2. A Declining Discount Rate is Justified to Address Discount Rate Uncertainty

A strong consensus has developed in economics that the appropriate way to discount intergenerational benefits is through a declining discount rate.[346] Not only are declining discount rate theoretically

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[341] Richard Newell (2017, October 10). Unpacking the Administration's Revised Social Cost of Carbon. Available at http://www.rff.org/blog/2017/unpacking-administration-s-revised-social-cost-carbon.

[342] Due to a slowing of global growth, DICE-2010 implies a declining discount rate schedule of 5.1% in 2015, 3.9% from 2015 to 2050; 2.9% from 2055 to 2100; 2.2% from 2105 to 2200, and 1.9% from 2205 to 2300. This would be a steeper decline if Nordhaus accounted for the positive and normative uncertainty underlying the SDR.

[343] Due to a slowing of global growth, DICE-2016 implies a declining discount rate schedule of 5.1% in 2015, 4.7% from 2015 to 2050; 4.1% from 2055 to 2100; 3.1% from 2105 to 2200, and 2.5% from 2205 to 2300.

[344] According to the World Bank, the average global and United States per capita growth rates were 1.7% and 1.9%, respectively.

[345] Interagency Working Group on Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2010). Interagency Working Group on Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2013). Interagency Working Group on Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2016).

[346] Kenneth J. Arrow et al., *Determining Benefits and Costs for Future Generations*, 341 Science 349 (2013); Kenneth J. Arrow et al., *Should Governments Use a Declining Discount Rate in Project Analysis?*, Rev Environ Econ Policy 8 (2014); Maureen L. Cropper et al., *Declining Discount Rates*, American Economic Review: Papers and Proceedings (2014); Christian Gollier & Martin L. Weitzman, *How Should the Distant Future Be Discounted When Discount Rates Are Uncertain?* 107 Economics Letters 3 (2010). Arrow et al. (2014) at 160-161 states that "We have argued that theory provides compelling arguments for using a declining certainty-equivalent discount rate," and concludes the paper by stating "Establishing a procedure for estimating a [declining discount rate]

correct, they are actionable (i.e., doable given our current knowledge) and consistent with OMB's *Circular A-4*. Perhaps the best reason to adopt a declining discount rate is the simple fact that there is considerable uncertainty around which discount rate to use. The uncertainty in the rate points directly to the need to use a declining rate, as the impact of the uncertainty grows exponentially over time such that the correct discount rate is not an arithmetic average of possible discount rates.[347] Uncertainty about future discount rates could stem from a number of sources particularly salient in the context of climate change, including uncertainty about future economic growth, consumption, the consumption rate of interest, and preferences. Additionally, economic theory shows that if there is debate or disagreement over which discount rate to use, this should lead to the use of a declining discount rate.[348] Though, the range of potential discount rates is limited by theory to potential consumption discount rates (see earlier discussion), which is certainly less than 7%.

There is a consensus that declining discount rates are appropriate for intergenerational discounting

Since the IWG undertook its initial analysis and before the most recent estimates of the SCC, a large and growing majority of leading climate economists' consensus[349] has come out in favor of using a declining discount rate for climate damages to reflect long-term uncertainty in interest rates. This consensus view is held whether economists favor descriptive (i.e., market) or prescriptive (i.e., normative) approaches to discounting.[350] Several key papers[351] outline this consensus and present the arguments that strongly support the use of declining discount rates for long-term benefit-cost analysis in both the normative and positive contexts. Finally, in a recent survey of experts on the economics of climate change, Howard and Sylvan (2015)[352], found that experts support using a declining discount rate relative to a constant discount rate at a ratio of approximately 2 to 1.

Economists have recently highlighted two main motivations for using a declining discount rate, which we elaborate on in what follows. First, if the discount rate for a project is fixed but uncertain, then the certainty-equivalent discount rate will decline over time, meaning that benefits should be discounted using a declining rate.[353] Second, uncertainty about the growth rate of consumption or output also implies that a declining discount rate should be used, so long as shocks to consumption are positively correlated over time.[354] In addition to these two arguments, other motivations for declining discount

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for project analysis would be an improvement over the OMB's current practice of recommending fixed discount rates that are rarely updated."

[347] Larry Karp, Global warming and hyperbolic discounting, 89 Journal of Public Economics 261-282 (2005) (The mathematical "intuition for this result is that as [time] increases, smaller values of r in the support of the distribution are relatively more important in determining the expectation of e−rt" where r is the constant discount rate.") Or as Cameron Hepburn, *Hyperbolic Discounting And Resource Collapse*, 103 *Royal Economic Society Annual Conference 2004* (2004) puts it, ("The intuition behind this idea is that scenarios with a higher discount rate are given less weight as time passes, precisely because their discount factor is falling more rapidly" over time.)

[348] Martin L Weitzman, Gamma discounting, 91 AM. ECON. REV. 260-271 (2001). Geoffrey M. Heal, & Antony Millner, Agreeing to disagree on climate policy, 111 PROC. NATL. ACAD. SCI. 3695-3698 (2014).

[349] *See generally* Arrow et al. (2013), *supra* note 317.

[350] Mark C. Freeman, Ben Groom, Ekaterini Panopoulou, & Theologos Pantelidis, Declining discount rates and the Fisher Effect: Inflated past, discounted future?, 73 J. ENVIRON. ECON. MANAGE. 32-49 (2015).

[351] *See generally* Arrow et al., 2013; Arrow et al., 2014;; Cropper et al., 2014, *supra* note 317. *See also* Christian Gollier, & James K. Hammitt, The long-run discount rate controversy, 6 ANNU. REV. RESOUR. ECON. 273-295 (2014).

[352] Peter Howard & Derek Sylvan, *The Economic Climate: Establishing Expert Consensus on the Economics of Climate Change,* INST. POLICY INTEGRITY WORKING PAPER (2015).

[353] This argument was first developed in Weitzman (1998) and Weitzman (2001). Martin L Weitzman, Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate, 36 J. ENVIRON. ECON. MANAGE. 201–208 (1998). Martin L Weitzman, Gamma discounting, 91 AM. ECON. REV. 260-271 (2001). *See* Weitzman (2001) *supra* note 319.

[354] *See* Christian Gollier, Should we discount the far-distant future at its lowest possible rate?, 3 *Economics: The Open-Access, Open-Assessment E-Journal* 1-14 (2009).

rates have long been recognized. For instance, if the growth rate of consumption declines over time, the Ramsey rule[355] for discounting will lead to a declining discount rate.[356]

In the descriptive setting adopted by the IWG (2010),[357] economists have demonstrated that calculating the expected net present value of a project is equivalent to discounting at a declining certainty equivalent discount rate when (1) discount rates are uncertain, and (2) discount rates are positively correlated.[358] Real consumption interest rates are uncertain given that there are no multi-generation assets to reflect long-term discount rates and the real returns to all assets—including government bonds—are risky due to inflation and default risk.[359] Furthermore, recent empirical work analyzing U.S. government bonds demonstrates that they are positively correlated over time; this empirical work has estimated several declining discount rate schedules that the IWG can use.[360]

Currently when evaluating projects, the U.S. government applies the descriptive approach using constant rates of 3% and 7% based on the private rates of return on consumer savings and capital investments. As discussed previously, applying a capital discount rate to climate change costs and benefits is inappropriate. Instead, analysis should focus on the uncertainty underlying the future consumption discount rate.[361] Past U.S. government analyses[362] modeled three consumption discount rates reflecting this uncertainty. If the U.S. government correctly returns its focus on multiple consumption discount rates, then the expected net present value argument given above implies that a declining discount rate is the appropriate way to perform discounting. As an alternative, given that the Ramsey discount rate approach is the appropriate methodology in intergenerational settings, the U.S. government could use a fixed, low discount rate as an approximation of the Ramsey equation following the recommendation of Marten et al. (2015);[363] see our discussion on Martin et al. (2015). This is roughly IWG (2010)[364]'s goal for using the constant 2.5% discount rate.

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[355] The Ramsey discount rate equation for the social discount rate is $r = \delta + \eta * g$ where r is the social discount rate, δ is the pure rate of time preference, η is the aversion to inter-generational inequality, and *g* is the growth rate of per capita consumption. For the original development, *see*, Frank Plumpton Ramsey, *A mathematical theory of saving*, 38 The Economic Journal 543-559 (1928).

[356] Higher growth rates lead to higher discounting of the future in the Ramsey model because growth will make future generations wealthier. If marginal utility of consumption declines in consumption, then, one should more heavily discount consumption gains by wealthier generations. Thus, if growth rates decline over time, then the rate at which the future is discounted should also decline. *See*, *e.g.,* Arrow et al. (2014) supra note 317 at 148. It is standard in IAMs to assume that the growth rate of consumption will fall over time. *See*, *e.g.,* William D. Nordhaus, Revisiting the social cost of carbon, 114 PROC. NATL. ACAD. SCI. 1518-1523 (2017) at 1519 ("Growth in global per capita output over the 1980–2015 period was 2.2% per year. Growth in global per capita output from 2015 to 2050 is projected at 2.1% per year, whereas that to 2100 is projected at 1.9% per year.") Similarly, Chris Hope, The social cost of CO2 from the PAGE09 model, Economics The Open-Access, Open-Assessment E-Journal Discussion Paper No. 2011-39 (2011) at 22 assumes that growth will decline. For instance, in the U.S., growth is 1.9% per year in 2008 and declines to 1.7% per year by 2040. Using data provided by Dr. David Anthoff (one of the founders of FUND), FUND assumes that the global growth rate was 1.8% per year from 1980–2015 period, 1.4% per year from 2015 to 2050 and 2015 to 2100, and then dropping to 1.0% from 2100 to 2200 and then 0.7% from 2200 to 2300. *See* David Anthoff, & Richard SJ Tol, The Climate Framework for Uncertainty, Negotiation and Distribution (FUND): Technical description, Version 3.8." Discussion paper. URL http://www.fund-model.org.

[357] [357] *See* IWG (2010), *supra* note 316.

[358] *See* Arrow et al. (2014) *supra* note 317 at 157.

[359] *See generally* Gollier and Hammitt 2014, *supra* note 322.

[360] *See generally* Arrow et al., 2013; Arrow et al., 2014;; Cropper et al., 2014, *supra* note 317. *See also* Freeman et al. (2015), *supra* note 321. Finally, see Elyès Jouini, & Clotilde Napp, How to aggregate experts' discount rates: An equilibrium approach, 36 ECON. MODELLING 235-243 (2014).

[361] *See generally* Newell (2017) *supra* note 312.

[362] *See* IWG (2010; 2013; 2016) *supra* note 316.

[363] *See* Alex L.Marten, Elizabeth A. Kopits, Charles W. Griffiths, Stephen C. Newbold, & Ann Wolverton, Incremental CH4 and N2O mitigation benefits consistent with the US Government's SC-CO2 estimates, 15 CLIMATE POL'Y 272-298 (2015).

[364] *See* IWG (2010) *supra* note 316.

If the normative approach to discounting is used in the future (i.e., the current approach of IAMs), economists have demonstrated that an extended Ramsey rule[365] implies a declining discount rate when (1) the growth rate of per capita consumption is stochastic,[366] and (2) consumption shocks are positively correlated over time (or their mean or variances are uncertain).[367] While a constant adjustment downwards (known as the precautionary effect[368]) can be theoretically correct when growth rates are independent and identically distributed,[369] empirical evidence supports the two above assumptions for the United States, thus implying a declining discount rate (Cropper et al., 2014; Arrow et al., 2014; IPCC, 2014).[370] We should further expect this positive correlation to strengthen over time due to the negative impact of climate change on consumption, as climate change causes an uncertain permanent reduction in consumption (Gollier, 2009).[371]

Several papers have estimated declining discount rate schedules for specific values of the pure rate of time preference and elasticity of marginal utility of consumption[372], though recent work demonstrates that the precautionary effect increases and discount rates decrease further when catastrophic economic risks (such as the Great Depression and the 2008 housing crisis) are modeled.[373] It should be noted that

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[365] If the future growth of consumption is uncertainty with mean μ and variance σ^2, an extended Ramsey equation $r = \delta + \eta * \mu - 0.5\eta^2\sigma^2$ applies where r is the social discount rate, δ is the pure rate of time preference, η is the aversion to inter-generational inequality, and g is the growth rate of per capita consumption. Gollier (2012, Chapter 3) shows that we can rewrite the extended discount rate as $r = \delta + \eta * g - 0.5\eta(\eta + 1)\sigma^2$ where g is the growth rate of expected consumption and $\eta + 1$ is prudence. Christian Gollier, Pricing the Planet's Future: The Economics of Discounting in an Uncertain World, Princeton University Press (2012) at Chapter 3.

[366] The IWG assumption of five possible socio-economic scenarios implies an uncertain growth path.

[367] *See generally* Arrow et al., 2013; Arrow et al., 2014; Gollier & Hammitt, 2014; Cropper et al., 2014, *supra* note 317. The intuition of this result requires us to recognize that the social planner is prudent in these models (i.e., saves more when faces riskier income). When there is a positive correlation between growth rates in per capita consumption, the representative agent faces more cumulative risk over time with respect to the "duration of the time spent in the bad state." Christian Gollier, Discounting with fat-tailed economic growth, 37*Journal of Risk and Uncertainty* 171-186 (2008). In other words, "the existence of a positive correlation in the changes in consumption tends to magnify the long-term risk compared to short-term risks. This induces the prudent representative agent to purchase more zero-coupon bonds with a long maturity, thereby reducing the equilibrium long-term rate." Christian Gollier, The consumption-based determinants of the term structure of discount rates, 1 *Mathematics and Financial Economics* 81-101 (2007). Mathematically, the intuition is that under prudence, the third term in the extended Ramsey equation (*see* footnote 323) is negative, and a "positive [first-degree stochastic] correlation in changes in consumption raises the riskiness of consumption at date T, without changing its expected value. Under prudence, this reduces the interest rate associated to maturity T" (Gollier et al., 2007) by "increasing the strength of the precautionary effect" in the extended Ramsey equation (Arrow et al., 2014; Cropper et al., 2014 *supra* note 317).

[368] The precautionary effect measures aversion to future "wiggles" in consumption (i.e., preference for consumption smoothing); see Christian P Traeger, *On option values in environmental and resource economics*, 37 *Resource and Energy Economics* 242-252 (2014).

[369] *See* Cropper et al 2014 *supra* note 317.

[370] Cropper et al., 2014; Arrow et al., 2014; IPCC, 2014) Essentially, the precautionary effect increases over time when shocks to the growth rate are positively correlated, implying that future societies require higher returns to face the additional uncertainty. See Cropper et al., 2014 and Arrow et al., 2014 *supra* note 317. *See also* Intergovernmental Panel on Climate Change, *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*, Cambridge University Press, 2014 [hereinafter, IPCC 2014].

[371] *See* Christian Gollier, Should we discount the far-distant future at its lowest possible rate?, 3 *Economics: The Open-Access, Open-Assessment E-Journal* 1-14 (2009). Due to the deep uncertainty characterizing future climate damages, some analysts argue that the stochastic processes underlying the long-run consumption growth path cannot be econometrically estimated; see Gollier (2012) *supra* note 336 and Martin L Weitzman, A Review of The Stern Review of the Economics of Climate Change, 45 J. ECON. LIT. 703 (2007). In other words, economic damages, and thus future economic growth, are ambiguous. Agents must then form subjectivity probabilities, which may be better interpreted as a belief (*see* Cropper et al., 2014 *Supra* note 317). Again, theory shows that ambiguity leads to a declining discount rate schedule by Jensen's inequality (*see* Cropper et al 2014 *supra* note 317).

[372] For example, Arrow et al. (2014) *supra* note 317

[373] *See* Gollier and Hammitt 2014 *supra* note 322 and Arrow et al. (2014) *supra* note 317.

this decline in discount rates due to uncertainty in the global growth path is in addition to that resulting from a declining central growth path over time.[374]

Additionally, a related literature has developed over the last decade demonstrating that normative uncertainty (i.e., heterogeneity) over the pure rate of time preference (δ)—a measure of impatience—also leads to a declining social discount rate.[375] Despite individuals differing in their pure rate of time preference,[376] an equilibrium (consumption) discount exists in the economy. In the context of IAMs, modelers aggregate social preferences (often measured using surveyed experts) by calibrating the preferences of a representative agent to this equilibrium.[377] The literature generally finds a declining social discount rate due to a declining collective pure rate of time preference.[378] The heterogeneity of preferences and the uncertainty surrounding economic growth hold simultaneously,[379] leading to potentially two sources of declining discount rates in the normative context.

Declining Rates are Actionable and Time-Consistent

There are multiple declining discount rate schedules from which the U.S. government can choose, of which several are provided in Arrow et al. (2014) and Cropper et al. (2014).[380] One possible declining interest rate schedule for consideration by the IWG is the one proposed by Weitzman (2001).[381] It is derived from a broad survey of top economists in context of climate change, and explicitly incorporates arguments around interest rate uncertainty.[382] Other declining discount rate schedule include Newell and Pizer (2003); Groom et al. (2007); Freeman et al. (2015).[383] Many leading economists support the

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[374] A common assumption in IAMs is that global growth will slow over time leading to a declining discount rate schedule over time; *see* footnote 7. Uncertainty over future consumption growth and heterogeneous preferences (discussed below) would lead to a more rapid decline in the social discount rate. See also Marten et al 2015 *supra* note 345 and William D. Nordhaus, *Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches*, 1 J. ASSOC. ENVIRON. RESOUR. ECON. 1 (2014).

[375] See Arrow et al 2014 and Cropper et al 2014 *supra 317*. See also Mark C. Freeman, & Ben Groom, How certain are we about the certainty-equivalent long term social discount rate?, 79 J. ENVIRON. ECON. MANAGE. 152-168 (2016).

[376] *See* Christian Gollier, & Richard Zeckhauser, Aggregation of heterogeneous time preferences, 113 J. POL. 878-896 (2005).

[377] See Antony Millner & Geoffrey Heal, *Collective intertemporal choice: time consistency vs. time invariance,* Grantham Research Institute on Climate Change and the Environment No. 220 (2015). See also Freeman and Groom 2016 *supra* 346.

[378] See Jouini and Napp, 2014 *supra* note 331, Freeman and Groom 2016 *supra* 346, and Gollier & Zeckhauser, 2005 *supra* note 347. *See also* Elyès Jouini, Jean-Michel Marin, & Clotilde Napp, Discounting and divergence of opinion, 145 J. ECON. THEORY 830-859 (2010). The intuition for declining discount rates due to heterogeneous pure rates of time preference is laid out in Gollier and Zeckhauser (2005). In equilibrium, the least patient individuals trade future consumption to the most patient individuals for current consumption, subject to the relative value of their tolerance for consumption fluctuations. Thus, while public policies in the near term mostly impact the most impatient individuals (i.e., the individuals with the most consumption in the near term), long-run public policies in the distant future are mostly going to impact the most patient individuals (i.e., the individuals with the most consumption in the long-run).

[379] *See* Jouini and Napp 2014 *supra* note 331 and Jouini et al 2010 *supra* note 349.

[380] *See* Arrow et al 2014 and Cropper et al 2014 *supra* note 317.

[381] Weitzman (2001)'s schedule is as follows: 4% for 1-5 years; 3% for 6-25 years; 2% for 26-75 years; 1% for 76-300 years; and 0% for 300+ years; see Weitzman (2001) *supra* note 319.

[382] Freeman and Groom (2015) demonstrate that this schedule only holds if the heterogeneous responses to the survey were due to differing ethical interpretations of the corresponding discount rate question; *see* Mark C Freeman., & Ben Groom, Positively gamma discounting: combining the opinions of experts on the social discount rate, 125 ECON. J. 1015-1024 (2015). A recent survey by Drupp et al. (2015) – which includes Freeman and Groom as co-authors – supports the Weitzman (2001) assumption; see Moritz A Drupp, Mark Freeman, Ben Groom, & Frikk Nesje, Discounting disentangled, Memorandum, Department of Economics, University of Oslo, No. 20/2015 (2015).

[383] See Richard G. Newell, and William A. Pizer, Discounting the distant future: how much do uncertain rates increase valuations?, 46 J. ENVIRON. ECON. MANAGE. 52-71 (2003). See also Ben Groom, Phoebe Koundouri, Ekaterini Panopoulou, &Theologos Pantelidis, Discounting the distant future: how much does model selection affect the certainty equivalent rate?, 22 J. APPL. ECONOMETRICS 641-656 (2007). Finally, see Freeman et al., 2015 *supra* note 353.

United States government adopting a declining discount rate schedule.[384] Moreover, the United States would not be alone in using a declining discount rate. It is standard practice for the United Kingdom and French governments, among others.[385] The U.K. schedule explicitly subtracts out an estimated time preference.[386] France's schedule is roughly similar to the United Kingdom's. Importantly, all of these discount rate schedules yield lower present values than the constant 2.5% discount rate employed by IWG (2010),[387] suggesting that even the lowest discount rate evaluated by the IWG is too high.[388] The consensus of leading economists is that a declining discount rate schedule should be used, harmonious with the approach of other countries like the United Kingdom. Adopting such a schedule would likely increase the SCC substantially from the administration's 3% estimate, potentially up to two to three fold (Arrow et al., 2013; Arrow et al., 2014; Freeman et al., 2015).[389]

A declining discount rate motived by discount rate or growth rate uncertainty avoids the time inconsistency problem that can arise if a declining pure rate of time preference (δ) is used. Circular A-4 cautions that "[u]sing the same discount rate across generations has the advantage of preventing time-inconsistency problems."[390] A time inconsistent decision is one where a decision maker changes his or her plan over time, solely because time has passed. For instance, consider a decision maker choosing whether to make an investment that involves an up-front payment followed by future benefits. A time consistent decision maker would invest in the project if it had a positive net-present value, and that decision would be the same whether it was made 10 years before investment or 1 year before investment. A time inconsistent decision maker might change his or her mind as the date of the investment arrived, despite no new information becoming available. Consider a decision maker who has a declining pure rate of time preference (δ) trying to decide whether to invest in a project that has large up-front costs followed by future benefits. 10 years prior to the date of investment, the decision maker will believe that this project is a relatively unattractive investment because both the benefits and costs would be discounted at a low rate. Closer to the date of investment, however, the costs would be relatively highly discounted, possibly leading to a reversal of the individual's decision. Again, the discount rate schedule is time consistent as long as δ is constant.

The arguments provided here for using a declining consumption discount rate are not subject to this time inconsistency critique. First, time inconsistency occurs if the decision maker has a declining pure rate of time preference, not due to a decreasing discount rate term structure.[391] Second, uncertainty about growth or the discount rate avoids time inconsistency because uncertainty is only resolved in the future, after investment decisions have already been made. As the NAS (2017) notes, "One objection frequently made to the use of a declining discount rate is that it may lead to problems of time inconsistency….This apparent inconsistency is not in fact inconsistent….At present, no one knows what

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[384] *See* Arrow et al 2014 and Cropper et al 2014 *supra* note 317.

[385] *See* Gollier and Hammitt 2014 *supra* note 322 and Cropper et al 2014 *supra* note 317.

[386] The U.K. declining discount rate schedule that subtracts out a time preference value is as follows (Lowe, 2008): 3.00% for 0-30 years; 2.57% for 31-75 years; 2.14% for 76-125 years; 1.71% for 126- 200 years; 1.29% for 201- 300 years; and 0.86% for 301+ years.

[387] *See* IWG (2010) *supra* note 316.

[388] Using the IWG's 2010 SCC model, Johnson and Hope (2012) find that the U.K. and Weitzman schedules yield SCCs of $55 and $175 per ton of CO_2, respectively, compared to $35 at a 2.5% discount rate. Because the 2.5% discount rate was included by the IWG (2010) to proxy for a declining discount rate, this result indicates that constant discount rate equivalents may be insufficient to address declining discount rates. *See* IWG (2010) *supra* note 316.

[389] *See* Arrow et al 2013 and Arrow et al 2014 *supra* note 317. See also Freeman et al., 2015 *supra* note 353.

[390] *Circular A-4* at 35.

[391] Gollier (2012) *supra* note 336 ("It is often suggested in the literature that economic agents are time inconsistent if the term structure of the discount rate is decreasing. This is not the case. What is crucial for time consistency is the constancy of the rate of impatience, which is a cornerstone of the classic analysis presented in this book. We have seen that this assumption is compatible with a declining monetary discount rate.").

the distribution of future growth rates…will be; it may be different or the same as the distribution in 2015. Even if it turns out to be the same as the distribution in 2015, that realization is new information that was not available in 2015."[392]

We should note that time-inconsistency is not a reason to ignore heterogeneity (i.e., normative uncertainty) over the pure rate of time preference (δ). If the efficient declining discount rate schedule is time-inconsistent, the appropriate solution is to select the best time-consistent policy. Millner and Heal (2014)[393] do just this by demonstrating that a voting procedure – whereby the median voter determines the collective preference – is: (1) time consistent, (2) welfare enhancing relative to the non-commitment, time-inconsistent approach, and (3) preferred by a majority of agents relative to all other time-consistent plans. Due to the right skewed distribution of the pure rate of time preference and the social discount rate as shown in all previous surveys,[394] the median is less than the mean social discount rate (and pure rate of time preference); the mean social discount rate is what holds in the very short-run under various aggregation methods, such as Weitzman (2001) and Freeman and Groom (2015).[395] Combining an uncertain growth rate and heterogeneous preference together implies a declining discount rate starting at a lower value in the short-run. In addition to the reasons discussed earlier in the comments, this is another reason to exclude a discount rate as high as 7%.

There is an economic consensus on the appropriateness of employing a consumption discount rate (and the inappropriateness of a capital discount rate) in the context of climate change

There is a strong consensus among economists that it is theoretically correct to use consumption discount rates in the intergenerational setting of climate change, such as in the calculation of the SCC. Similarly, there is a strong consensus that a capital discount rate is inappropriate according to "good economics" (Newell, 2017).[396] This consensus holds across panels of experts on the social cost of carbon[397]; surveys of experts on climate change and discount rates;[398] the three most commonly cited IAMs employed in calculating the federal SCC; and the government's own analysis.[399] For more analysis of this issue, see the discussion in the main body our Comments on the inappropriateness using a discount rate premised on the return to capital in intergenerational settings.

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[392] National Academies of Sciences, Engineering, and Medicine, *Valuing climate damages: Updating estimation of the social cost of carbon dioxide* at 53 (2017) at 182.

[393] Antony Millner, & Geoffrey Heal, Collective intertemporal choice: time consistency vs. time invariance, Grantham Research Institute on Climate Change and the Environment No. 220 (2015).

[394] See Weitzman (2001) *supra* note 319, Howard and Sylvan 2015 *supra* note 323, and Drupp et al 2015 *supra* note 353.

[395] See Weitzman (2001) *supra* note 319 and Freeman et al., 2015 *supra* note 353.

[396] The former co-chair of the National Academy of Sciences' Committee on Assessing Approaches to Updating the Social Cost of Carbon – Richard Newell (2017) *supra* note 312 – states that "[t]hough the addition of an estimate calculated using a 7 percent discount rate is consistent with past regulatory guidance under OMB Circular A-4, there are good reasons to think that such a high discount rate is inappropriate for use in estimating the SCC…It is clearly inappropriate, therefore, to use such modeling results with OMB's 7 percent discount rate, which is intended to represent the historical before-tax return on private capital…This is a case where unconsidered adherence to the letter of OMB's simplified discounting approach yields results that are inconsistent with and ungrounded from good economics."

[397] See generally NAS 2017 *supra* note 363.

[398] See Weitzman (2001) *supra* note 319, Howard and Sylvan 2015 *supra* note 323, Drupp et al 2015 *supra* note 353, and Robert Pindyck, The social cost of carbon revisited, National Bureau of Economic Research No. w22807(2016).

[399] *See* IWG 2010 *supra* note 316 and Council of Econ. Advisers, *Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate* at 1 (CEA Issue Brief, 2017).

TECHNICAL APPENDIX: DAMAGE LITERATURE

The Fourth National Climate Assessment was recently published by the U.S. Global Change Research Program.[400] In addition to reviewing that report and the literature on U.S. damages cited therein, the agencies must review the following literature, which contains some of the most up-to-date estimates of U.S. damages from climate change.

Overall Damage Estimates and Review Articles

Solomon Hsiang et al., *Economic Damage from Climate Change in the United States*, 356 SCIENCE. 1362–1369 (2017).

Delavane Diaz & Frances Moore, *Quantifying the economic risks of climate change*, 7 NAT. CLIM. CHANG. 774–782 (2017).

Roberto Roson & Martina Sartori, *Estimation of Climate Change Damage Functions for 140 Regions in the GTAP 9 Database*, 1 J. GLOB. ECON. ANAL. 78–115 (2016).

Derek Lemoine & Sarah Kapnick, *A top-down approach to projecting market impacts of climate change*, NAT. CLIM. CHANG. 7 (2015).

Marshall Burke, Solomon M. Hsiang & Edward Miguel, *Global non-linear effect of temperature on economic production*, 527 NATURE 235–239 (2015).

Agriculture Damages

Wolfram Schlenker, *Crop Responses to Climate and Weather: Cross-Section and Panel Models*, *in* CLIMATE CHANGE AND FOOD SECURITY 99–108 (David Lobell & Marshall Burke eds., 2010).

David B. Lobell, Wolfram Schlenker & Justin Costa-Roberts, *Climate Trends and Global Crop Production Since 1980*, 333 SCIENCE (80). (2011).

Olivier Deschênes & Michael Greenstone, *The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather: Reply*, 102 AM. ECON. REV. 3761–3773 (2012).

Marshall Burke & Kyle Emerick, *Adaptation to Climate Change: Evidence from US Agriculture*, 8 AM. ECON. J. ECON. POLICY 106–140 (2016).

Christopher Severen, Christopher Costello & Olivier Deschênes, *A Forward Looking Ricardian Approach: Do Land Markets Capitalize Climate Change Forecasts?*, 22413 NBER WORK. PAP. 46 (2016).

Wolfram Schlenker, Michael J. Roberts & David B. Lobell, *US maize adaptability*, 3 NAT. CLIM. CHANG. 690–691 (2013).

Wolfram Schlenker & Michael J Roberts, *Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change.*, 106 PROC. NATL. ACAD. SCI. 15594–8 (2009).

Frances C Francis C Moore, Uris Lantz C Baldos & Thomas Hertel, *Economic impacts of climate change on agriculture: a comparison of process-based and statistical yield models*, 12 ENVIRON. RES. LETT. 1–9 (2017).

F. C. Moore et al., *New Science of Climate Change Impacts on Agriculture Implies Higher Social Cost of Carbon*, WORK. PAP. 1–43 (2017).

Forestry Damages

Christopher Guo & Christopher Costello, *The value of adaption: Climate change and timberland management*, 65 J. ENVIRON. ECON. MANAGE. 452–468 (2013).

Effects on Health and Mortality

Alan Barreca et al., *Adapting to climate change: The remarkable decline in the U.S. temperature-mortality relationship over the 20th century*, 124 NBER WORK. PAP. 46 (2016).

Garth Heutel, Nolan H Miller & David Molitor, *Adaptation and the mortality effects of temperature across U.S. climate regions*, No. 23271 NBER WORK. PAP. 58 (2017).

[400] https://science2017.globalchange.gov/

Jan C. Semenza et al., *Climate change and microbiological water quality at California beaches*, 9 ECOHEALTH 293–297 (2012).
Tamma Carleton et al., *Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits* (Becker Friedmand Inst. Working Paper No. 2018-51).

Effects on Labor Productivity and Learning

Joshua Graff Zivin & Matthew MJ Neidell, *Temperature and the allocation of time: Implications for climate change*, 32 J. LABOR ECON. 1–26 (2010).
M. Donadelli et al., *Temperature Shocks and Welfare Costs*, J. ECON. DYN. CONTROL (2017).
Adam Isen & W Reed Walker, *Heat and Long-Run Human Capital Formation*, 26 (2017).
Geoffrey Heal, Jisung Park & Nan Zhong, *Labor Productivity and Temperature*, 1–33 (2017).
Joshua Graff Zivin, Solomon Hsiang & Matthew Neidell, *Temperature and human capital in the short- and long-run*, J. ASSOC. ENVIRON. RESOUR. ECON. 694177 (Forthcoming)

Sea Level Rise

Mathew E. Hauer, Jason M. Evans & Deepak R. Mishra, *Millions projected to be at risk from sea-level rise in the continental United States*, advance on NAT. CLIM. CHANG. (2016).

ATTACHMENT C

Supplemental Comments by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12362 (Dec. 21, 2018)

Institute *for*
Policy Integrity
NEW YORK UNIVERSITY SCHOOL OF LAW

December 21, 2018

VIA ELECTRONIC SUBMISSION

Attn: James Tamm, Office of Rulemaking, Fuel Economy Division, National Highway Traffic Safety Administration (NHTSA)

Re: The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA–2018–0067; FRL–9981–74–OAR; RIN 2127–AL76; RIN 2060–AU09

The Institute for Policy Integrity ("Policy Integrity") at New York University School of Law[1] previously submitted comments to the National Highway Traffic Safety Administration ("NHTSA") and the Environmental Protection Agency ("EPA") (collectively "the agencies") on the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 42,986 (Aug. 24, 2018) ("Proposed Rule").[2]

These supplemental comments respond to certain comments and methodological issues in a report by NERA Economic Consulting and Trinity Consultants ("NERA/Trinity"), submitted as an attachment to the comments of the Alliance of Automobile Manufacturers ("Alliance") at the conclusion of the public comment period.[3]

The Alliance describes the NERA/Trinity analysis as "an independent directional verification of net benefits described in the Proposed Rule" and urges the agencies to "review the NERA econometric study's methodologies for adoption or to review their own models."[4] However, NERA/Trinity rely on proprietary models and data that have not been fully described or disclosed in the limited report attached to the Alliance's comments. The public, therefore, does not have the necessary information to meaningfully evaluate the details of the NERA/Trinity methodology, including the modeling, assumptions, and underlying data. The agencies may not rely on the NERA/Trinity analysis or any other new analysis as an analytical basis for a final rule without first making that information available and providing an opportunity for public comment.

[1] This document does not purport to present New York University School of Law's views, if any.

[2] Comment by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12213 and EPA-HQ-OAR-2018-0283-5083 (Oct. 26, 2018) ("Policy Integrity Comments").

[3] *See* Comments of the Alliance of Automobile Manufacturers, NHTSA-2018-0067-12073 and EPA-HQ-OAR-2018-0283-6186 (Oct. 26, 2018) ("Alliance Comments"), attaching NERA Economic Consulting & Trinity Consultants, Evaluation of Alternative Passenger Car and Light Truck Corporate Average Fuel Economy (CAFE) Standards for Model Years 2021-2026 (Oct. 26, 2018) ("NERA/Trinity Analysis").

[4] Alliance Comments at 10.

Even with the limited information available, critical flaws in the NERA/Trinity analysis make it clear that the agencies cannot reasonably rely on that analysis or similar methodologies to justify the Proposed Rule. One such flaw is the way that NERA/Trinity have calculated the economic benefits of fuel savings attributable to the existing greenhouse gas standards and augural fuel economy standards (together "baseline standards"), which would be forgone by the Proposed Rule. NERA/Trinity's analysis includes only the value of fuel savings that it estimates consumers are willing to pay for when purchasing a vehicle.[5] This approach deviates significantly from the way that the agencies calculated the benefits of fuel savings in the Proposed Rule, which includes the total economic value of saved fuel (the quantity of fuel saved times the expected price of fuel).[6] As explained in Section A below, this approach to valuing the benefits of fuel savings contradicts economic theory and is irrational. Moreover, as explained in Section B below, this approach deviates from the long-standing practice, across agencies and administrations of both parties, for calculating the economic benefits of regulations that result in energy savings. Yet, neither the NERA/Trinity analysis, nor the Alliance comments to which it is attached explain or justify this approach.

As a result of their flawed methodology for accounting for fuel savings, the NERA/Trinity analysis significantly undervalues the benefits of the existing fuel economy and greenhouse gas emission standards, and understates the costs (in the form of forgone benefits) of rolling back those standards. The agencies should not adopt a methodology for valuing the economic benefits of fuel savings consistent with the approach taken by NERA/Trinity.

The NERA/Trinity analysis contains a number of additional flaws. NERA/Trinity employ a flawed scrappage model that appears to result in an increase in overall fleet size and vehicle miles traveled.[7] NERA/Trinity use unsupportable assumptions about the magnitude of the rebound effect.[8] And NERA/Trinity rely on the same VOLPE model that overstates the costs of the standards, including by holding all non-fuel economy attributes constant.[9] These flaws are more fully discussed in Policy Integrity's comments on the Proposed Rule and comments on the agencies' 2012 proposal to establish the baseline standards.

In addition, in order to predict the magnitude and composition of new vehicle sales, NERA/Trinity use an untested "nested logit" consumer choice model. But that model suffers from several flaws, many of which have caused the agencies to reject use of such models in the

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[5] NERA/Trinity Analysis at 54.

[6] *See* Proposed Rule, 83 Fed. Reg. at 43,255.

[7] *See* Policy Integrity Comments at 59-91.

[8] *See id.* at 99-125.

[9] *See* Comments of Institute for Policy Integrity on 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 76 Fed. Reg. 74,854 (proposed Dec. 1, 2011) Docket Nos. EPA-HQ-OAR-2010-0799; NHTSA-2010-0131 at 15-19 (Feb. 13, 2012), https://policyintegrity.org/documents/Final_Comments_on_MY_2017-2025_GHG__CAFE.pdf; *see also* Antonio M. Bento et al., *Flawed Analyses of U.S. Auto Fuel Economy Standards* 362 SCIENCE 2, 4 (2018) ("[B]oth the 2016 TAR and 2018 NPRM have likely overestimated compliance costs. Neither analysis considers the full extent of options that manufacturers have available to respond to these policies, including changes in vehicle prices, performance, and *other attributes*") (emphasis added).

past.[10] The economics literature has found that consumer choice models, and particularly nested logit models, are ill-suited to predict consumer purchasing behavior because they fail to account for manufacturer decisions.[11] Moreover, the NERA/Trinity analysis calculates its willingness-to-pay measure, which it then incorrectly uses as proxy for the benefits of fuel saving, using the output of the nested-logit model while holding other performance attributes constant.[12] However, the same flaws that lead the nested logit model to be a poor predictor of vehicle purchasing decisions, as well as other econometric problems, make the NERA/Trinity willingness-to-pay measure a flawed predictor of actual consumers' willingness to pay for fuel economy.

A. The NERA/Trinity Approach to Valuing the Benefits of Fuel Savings Is Irrational

One of the primary benefits of energy efficiency standards is that they allow consumers to receive a given level of services at lower operating costs. In the case of automobile fuel economy, consumers receive a given level of transportation services while spending less on fuel. Under the baseline standards, consumers save money at the pump because each mile they choose to drive requires the purchase of less fuel and so costs them less. The economic benefits of these fuel savings can be calculated as the quantity of fuel saved multiplied by the economic value of the fuel.[13] However, when presenting the fuel saving benefits of the baseline standards, the NERA/Trinity analysis considers only the value of fuel economy improvements that it asserts consumers consider when making vehicle purchase decisions[14] That is, NERA/Trinity use a purported measure of consumers' willingness to pay for fuel economy improvements rather than the full economic value of fuel saved to calculate the social benefits of the baseline standards. But, leaving out a component of the economic value of fuel savings—the value that consumers do not consider when making a vehicle purchase decision—ignores the presence of market failures and so is not a rational measure of the social benefits of fuel savings.

As the economics literature has explored in detail, consumers often make up-front vehicle purchasing decisions that fail to fully account for future fuel savings.[15] Consumers value fuel economy but their perceived willingness to pay for fuel economy improvements often does not equal the net present expected savings in future fuel costs. That is, consumers may not be willing

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[10] *See* Proposed Rule, 83 Fed. Reg. at 43,076-078; EPA, Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation at A-44 to A-48 (2016), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3DO.pdf).

[11] Gloria Helfand & Ann Wolverton, *Evaluating the Consumer Response to Fuel Economy: A Review of Literature*, 5 INT'L REV. OF ENVTL. AND RESOURCE ECON. 103, 112 (2011), https://www.nowpublishers.com/article/Details/IRERE-0040 ("Langer and Miller (2011) find that discrete choice models that do not consider the supply side result in inconsistent predictions of consumer demand response and that this problem is particularly acute for nested logit approaches.").

[12] NERA/Trinity Analysis at B-4 to B-5.

[13] For analyses of the total benefits fuel saving of a given regulatory action, the annual economic value of fuel savings should be converted to net present value.

[14] NERA/Trinity Analysis at 54.

[15] *See* David Greene et al., *Consumer Willingness to Pay for Vehicle Attributes: What Do We Know?*, 118 TRANSP. RES. 258 (2018), https://doi.org/10.1016/j.tra.2018.09.013 (meta-analysis of the academic literature regarding consumers' willingness to pay for fuel economy and other attributes).

to purchase a vehicle today that is $1 more expensive for a net present expected savings in future fuel costs of over $1. Instead consumers often are willing to purchase a vehicle that will receive $1 in net present expected fuel savings only when the up-front vehicle cost increase is less than $1. This is termed the "energy paradox" or "energy efficiency gap."[16] The economics literature has identified a number of market failures that contribute to the energy efficiency gap, including consumer myopia, consumer loss aversion, information asymmetries, supply-side market failures, and the positional nature of competing vehicle attributes.[17] Some of these market failures, like informational asymmetries and loss aversion, mean that consumers' willingness to pay for future fuel savings does not reflect what they would be willing to pay absent those market failures.[18] Other market failures, such as manufacturer market power or misjudging of consumer preferences, may lead to the undersupply of fuel efficient vehicle options, leaving consumers unable to actualize their willingness to pay for fuel economy improvements in the market.[19]

The presence of market failures means that modeled willingness-to-pay for fuel economy when purchasing a vehicle may not reflect the value consumers actually experience from fuel savings once they have purchased the vehicle. This gap between NERA/Trinity's measure of consumers' willingness to pay for fuel economy improvements and the fuel savings that consumers will actually receive creates the potential for a well-designed regulation to deliver net private benefits by correcting or compensating for market failures. Yet, those net private benefits provided to consumers are the very benefits that NERA/Trinity have, without explanation, excluded from their evaluation of the benefits of the standards.[20]

Due to market failures, *ex ante* measures of consumers' willingness to pay for fuel economy improvements are not the same as the *ex post* economic value of fuel savings actually realized. Those fuel savings result in consumer welfare improvements, even if consumers would not have paid for the fuel saving technology up-front, because consumers have more money to spend on other things.

The rational measure of the *societal* benefits of fuel savings is the full economic value of fuel saved. This is because, regardless of the value consumers appear to place on fuel savings when making vehicle purchase decisions, when they operate more efficient vehicles, they consume fewer real economic resources (e.g., barrels of oil, extraction cost, refining, transportation, etc.) than they would have had they operated less efficient vehicles. These real resource savings are

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[16] Helfand & Wolverton, *supra* note 11 at 105; International Energy Agency, Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency 19-20 (2007), https://www.iea.org/publications/freepublications/publication/mind_the_gap.pdf.

[17] *See* Helfand & Wolverton, *supra* note 11 at 124-40 (reviewing the literature regarding justifications for the energy paradox). *See also* Policy Integrity Comments at 38-40 (explaining reasons for the fuel efficiency gap) *id.* at 47-51 (explaining one reason for the fuel efficiency gap, positional valuation, in detail); DAVID L. GREENE, CONSUMERS' WILLINGNESS TO PAY FOR FUEL ECONOMY AND IMPLICATIONS FOR SALES OF NEW VEHICLES AND SCRAPPAGE OF USED VEHICLES (2018), https://www.edf.org/sites/default/files/CARB_Report_Greene_UTenn_Consumer_Behavior_Modeling.pdf (explaining behavior economic explanations for the fuel efficiency paradox, including loss aversion).

[18] *See* Helfand & Wolverton, *supra* note 11 at 130-134.

[19] *Id.* at 112, 137-140.

[20] NERA/Trinity Analysis at 54, *id.* at H-2.

represented by the price of the fuel (i.e., gasoline or diesel) saved. As Office of Management and Budget Circular A-4—a guide for agencies on regulatory cost-benefit analysis issued under President George W. Bush and reaffirmed by the Trump Administration[21]—explains, the best measure of the economic value of the resources saved due to a regulation is the market price of those resources.[22] For commodities like gasoline and diesel that are subject to significant taxation, Circular A-4 explains that market prices should be adjusted to remove the value of those taxes, which represent a transfer rather than a real resource cost.[23] The economic value to society of the saved resources in a given year is then calculated as the quantity of fuel saved times the tax-adjusted price of the fuel. It is this value, rather than an estimation of consumers' willingness to pay for fuel efficiency technology, that should establish the forgone societal economic benefits of the fuel savings that will result from the Proposed Rule.

B. The NERA/Trinity Approach to Valuing the Benefits of Fuel Savings Is Inconsistent with the Longstanding Practice of Many Agencies Under Administrations of Both Political Parties

In line with executive guidance and economic theory, for the last forty years, the agencies have consistently recognized that it is appropriate to consider the full economic value of energy savings caused by regulation in the assessment of the benefits of that regulation. This approach to valuing the fuel saving benefits of energy efficiency regulation has been consistent under administrations of both political parties. The agencies' historic approach has also been consistent with the approach taken by other federal agencies that promulgate rules with substantial energy saving benefits. The following sections provide a series of examples demonstrating that both NHTSA and EPA have consistently used the full economic value of saved fuel when considering the costs and benefits of regulations that result in fuel savings. This is followed by examples

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[21] Office of Mgmt. & Budget, Circular A-4 at 19 (2003) ("Circular A-4"); *See* Office of Mgmt. & Budget, Guidance Implementing Executive Order 13771 (April 5, 2017) https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/M-17-21-OMB.pdf.

[22] Circular A-4 at 19 ("Market prices provide rich data for estimating benefits and costs based on willingness-to-pay if the goods and services affected by the regulation are traded in well-functioning competitive markets"); *id.* at 21 ("Economists ordinarily consider market prices as the most accurate measure of the marginal value of goods and services to society.")

[23] *Id*. at 21 ("The observed market price of gasoline may not reflect marginal social value due to the inclusion of taxes"); *see also* NHTSA, Final Regulatory Impact Analysis: Corporate Average Fuel Economy for MY 2017-MY 2025 Passenger Cars and Light Trucks 863-64 (2012), https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/fria_2017-2025.pdf ("NHTSA MY 2017-2025 FRIA") ("federal, state, and local taxes are excluded from the social value of fuel savings because these do not reflect costs of resources used in fuel production, and thus do not reflect resource savings that would result from reducing fuel consumption. Instead, fuel taxes simply represent resources that are transferred from purchasers of fuel to road and highway users, since fuel taxes primarily fund construction and maintenance of those facilities."). As OMB and NHTSA have explained, when taking a societal perspective, it is also appropriate to incorporate negative externalities into prices. Circular A-4 at 21; NHTSA MY 2017-2025 FRIA at 864. However, the agencies and NERA/Trinity have appropriately considered these externalities in a separate part of the cost benefit analysis. *See* Proposed Rule, 83 Fed. Reg. at 43,255 (listing pollution, energy security and pollution externalities as separate line-items in the cost benefit analysis); NERA/Trinity Analysis at S-10 to S-11.

from other agencies, demonstrating that the agencies' historic approach has been broadly consistent across the federal government.[24]

1. NHTSA Has Consistently Evaluated the Benefits of Fuel Economy Regulations Using the Full Economic Value of Fuel Savings

In its very first fuel economy regulation in 1977, NHTSA under President Jimmy Carter evaluated "the economic impact of [fuel economy] standards" for model year (MY) 1981-1984 passenger vehicles.[25] In conducting this evaluation, NHTSA compared the upfront increase in vehicle costs to consumer lifetime gasoline costs, and determined that "total consumer costs (that is, retail prices, maintenance costs, and gasoline costs" are anticipated to decrease by about $50 per car or $20 billion nationally."[26] In making this calculation, NHTSA explicitly rejected an approach that would have considered the benefits of fuel savings as consumers' willingness to pay for those savings, stating "since lifetime [fuel savings] benefits do actually accrue to the initial and subsequent owners, they are included in the analysis, regardless of their perception by individuals."[27] As a result, NTHSA included the full economic value of those savings, calculated as the expected quantity of fuel saved times the expected price of fuel.[28]

Later, under President Ronald Reagan, in a regulation that reduced the MY 1985 fuel economy standard for light duty trucks and established standards for MY 1986 trucks, NHTSA considered the expected economic impacts of its regulation using a similar approach.[29] NHTSA projected that vehicle price increases of $35 "would be offset by operating cost savings of $176 for the average 1986 light truck, due to reduced lifetime gasoline consumption."[30] Again, the Reagan Administration considered the full economic value of fuel savings rather than consumers' willingness to pay for fuel economy in the economic analysis that was used to inform its decision regarding the economic practicability of a given level of standards.[31]

Under the George H.W. Bush Administration, NHTSA issued two final rules to improve fuel economy for MY 1992 and MY 1993-1994 light trucks, respectively.[32] While the Final

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[24] Though this section discusses examples across agencies and parties it is not an exhaustive list of all regulations that improve energy efficiency.

[25] Passenger Automobile Average Fuel Economy Standards, 42 Fed. Reg. 33,534, 33,550 (June 30, 1977).

[26] *Id.* at 33,550-551.

[27] NHTSA, Final Impact Assessment of the Automotive Fuel Economy Standards for Model Year 1981-84 Passenger Cars at I-24 (June 30, 1977) ("An important issue which is often raised is that the new car buyer would be impacted more by costs than benefits as that person more readily perceives initial costs than benefits accruing over the life . . . of the vehicle. In our view all costs (and benefits of owning and operating a vehicle) incurred over the economic vehicle life . . . must be accounted for in the analysis, and not only those faced by any one owner such as the new car buyer.")

[28] *Id*.

[29] Light Truck Average Fuel Economy Standards Model Years 1985–86, 49 Fed. Reg. 41,250, 41,252 (Oct. 22, 1984).

[30] *Id.*

[31] NHTSA, Final Regulatory Impact Analysis for Model Years 1985-86 Light Truck Fuel Economy Standards at IV-22 (Sept. 1984) ("operating cost savings are defined as the present value of dollar savings in gasoline that the vehicle owner would realize over the life of the 1986 vehicles").

[32] Light Truck Average Fuel Economy Standards; Model Year 1992, 55 Fed. Reg. 12,487 (April 4, 1990); Light Truck Average Fuel Economy Standards; Model Years 1993-1994, 56 Fed. Reg. 13,779 (April 4, 1991).

Regulatory Impact Analysis documents are not publicly available for either of these rules, the agency's longstanding practice for valuing fuel savings suggests that the agency took the same approach in those rules. The agency should consult those Regulatory Impact Analyses.[33] In addition, in 1992, the agency proposed a rule to establish fuel economy standards for MY 1995-1997 light trucks.[34] That Preliminary Regulatory Impact Analysis is also not publicly available.[35] But when NHTSA later finalized that rule under the Clinton Administration, the Final Regulatory Impact Analysis makes clear that NHTSA considered the full economic value of fuel savings for that rule, not consumers' willingness to pay for those savings when purchasing a vehicle.[36]

In 1994, under the Clinton Administration, NHTSA issued a regulation establishing fuel economy standards for MY 1996-1997 light trucks.[37] In the economic analysis supporting that rulemaking, NHTSA evaluated the operating costs of trucks under different levels of fuel economy standards. NHTSA explained that "operating cost expenditures are defined as the present discounted value of dollar expenditures for gasoline that the vehicle owner would have to make over the life of a vehicle."[38] That is, for each fuel economy level, NHTSA evaluated the benefit of saving fuel using the full economic value of fuel savings, not the consumers' willingness to pay for that level of fuel economy .

Under the George W. Bush Administration, NHTSA again used the full economic value of saved fuel when evaluating the costs and benefits of fuel economy standards for MY 2008-2010 light trucks.[39] In fact, NHTSA again considered and rejected arguments to limit the benefits of fuel savings to the value that individual consumers ascribe to the savings when purchasing a vehicle.[40] NHTSA explained that it was appropriate to use the full economic value of fuel savings both because it was considering the "broader societal effect" of the standards and when taking the consumer perspective:

> The agency believes that CAFE standards should reflect the true economic value of resources that are saved when less fuel is produced and consumed . . . . Consumer's

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[33] *See* NHTSA, Final Regulatory Impact Analysis: Average Fuel Economy Standard for Model Year 1992 Light Trucks (March 1990); Final Regulatory Impact Analysis: Average Fuel Economy Standard for Model Year 1993-1994 Light Trucks (Feb. 1991).

[34] Light Truck Average Fuel Economy Standards Model Years 1995-97, 57 Fed. Reg, 61,379 (proposed Dec. 24 1992).

[35] *See* Preliminary Regulatory Impact Analysis: Average Fuel Economy Standards for Model Years 1995-1997 Light Trucks (Dec. 1992).

[36] NHTSA, Final Regulatory Impact Analysis: Average Fuel Economy Standards for Model Year 1995 Light Trucks at VI-10, VI-14 (March 1993).

[37] Light Truck Average Fuel Economy Standards; Model Years 1996-1997, 59 Fed. Reg. 16,312 (April 6, 1994).

[38] NHTSA, Final Regulatory Evaluation: Average Fuel Economy Standards for Model Years 1996-1997 Light Trucks at VI-11 (Dec. 1993).

[39] *See* Average Fuel Economy Standards for Light Trucks Model Years 2008–2011; Final Rule, 71 Fed. Reg. 17566, 17631 (April 6, 2006) ("MY 2008-2011 Light Truck Standards"); *see also* Corporate Average Fuel Economy and CAFE Reform for MY 2008-2011 Light Trucks: Regulatory Impact Analysis at VIII-21 (March 2006), https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/2006_friapublic.pdf ("MY 2008-2011 Light Truck FRIA") (explaining the methodology for calculating the benefits of fuel savings).

[40] MY 2008-2011 Light Truck Standards, 71 Fed. Reg. at 17631; MY 2008-2011 Light Truck FRIA at VII-20.

> perceptions of these values may differ from their actual impacts, but they will nonetheless experience the full value of actual fuel savings just as they will pay the full increased cost when the vehicle is purchased."[41]

Contrary to the NERA/Trinity analysis,[42] in that rule NHTSA drew a distinction between its modeling of consumer behavior in the purchase of new vehicles (in which it applied estimates of consumer willingness-to-pay), and its societal benefits calculation (in which it used the full economic value of saved fuel).[43]

NHTSA adopted the same approach for the same reasons under the Obama Administration when it issued regulations establishing the baseline standards jointly with EPA. Together, the agencies calculated the benefits of the standards using the full economic value of fuel savings.[44] The agencies explained that fuel prices (multiplied by quantity of fuel saved) "determine[s] the value of fuel savings both to new vehicle buyers and to society."[45] From a consumer perspective, NHTSA stated that "the retail price of fuel is the proper measure for valuing fuel savings."[46] From the societal perspective, NHTSA specifically explained that the proper scope of analysis when calculating the fuel savings benefits in the context of a cost-benefit analysis is "the economic value of fuel savings to *the U.S. economy*,"[47] not consumers' willingness to pay for fuel economy:

> "When estimating the aggregate value to the U.S. economy of fuel savings resulting from alternative increases in CAFE standards—or the ''social'' value of fuel savings—the agency includes fuel savings over the *entire* expected lifetimes of vehicles that would be subject to higher standards, rather than over the shorter periods we assume manufacturers employ to represent the preferences of vehicle buyers, or that buyers are assumed to employ when assessing changes in the net price of purchasing and owning new vehicles. Valuing fuel savings over vehicles' entire lifetimes recognizes the savings in fuel costs that subsequent owners of vehicles will experience from higher fuel economy, even if their initial purchasers do not expect to recover the remaining value of fuel savings when they re-sell those

[41] MY 2008-2011 Light Truck Standards, 71 Fed. Reg. at 17631; *see also* MY 2008-2011 Light Truck FRIA at VII-20 to VII-21.

[42] NERA/Trinity Analysis at 54, B-4 (applying consumer willingness-to-pay to both the sales model and the analysis of societal benefits).

[43] MY 2008-2011 Light Truck FRIA at VII-21 ("The agency does restrict its analysis of sales impacts to a 4.5 year period under the assumption that initial buyer's purchase behavior will be influenced only by their perception of benefits they will receive while owning the vehicle, as opposed to benefits flowing to subsequent owners. However, the agency believes that the lifetime value of impacts from CAFE improvements should be fully reflected in its analysis of societal impacts that will determine CAFE standards.")

[44] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624, 62,715 (Oct. 15, 2012) ("Baseline Standards Rule").

[45] EPA & NHTSA, Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards at 4-7 (2012).

[46] NHTSA MY 2017-2025 FRIA at 863.

[47] *Id.* (emphasis in original).

vehicles, or for other reasons do not value fuel savings beyond the assumed five-year time horizon."[48]

2. EPA Has Consistently Evaluated the Benefits of Fuel Saving Caused by Vehicle Emission Regulations Using the Full Economic Value of Those Savings

In 1980, the Carter Administration EPA proposed a regulation to establish evaporative emission regulations for gasoline-fueled heavy-duty vehicles.[49] EPA projected that this regulation would cause heavy-duty gasoline-fueled vehicles to install closed-loop fuel metering systems that would have the ancillary benefit of improving vehicle fuel economy.[50] When calculating the costs and benefits of the standards, including the fuel economy improvements, EPA used the full economic value of saved gasoline and not a measure of consumers' willingness to pay for fuel economy.[51]

In 1987, the Reagan Administration EPA issued a proposed regulation to comprehensively control evaporative emissions from motor vehicles.[52] As part of that regulation, EPA considered fuel volatility regulations that, if adopted, would have improved the fuel economy of engines.[53] EPA evaluated the economic benefit of this change based on the expected volume of fuel saved multiplied by the expected price of fuel.[54] That is, EPA considered the full economic value of fuel savings and not consumers' willingness to pay for fuel economy.

In 1990, EPA under President George H.W. Bush proposed regulations to establish cold temperature carbon monoxide exhaust emission standards for light-duty vehicles.[55] EPA determined that compliance with the proposed standards would involve technology changes resulting in improved fuel economy.[56] When calculating the net cost of vehicles that comply with the standards, EPA used the full economic value of the expected fuel savings over the life of each vehicle, and not a measure of the benefits of fuel savings limited to consumer willingness-to-pay.[57]

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[48] Baseline Standards Rule, 77 Fed. Reg. at 62,992.

[49] Evaporative Emission Regulation and Test Procedure for Gasoline-Fueled Heavy-Duty Vehicles, 45 Fed. Reg. 28,922 (April 30, 1980).

[50] *Id.* at 28,924.

[51] *Id.*

[52] Regulation of Fuels and Fuel Additives: Volatility Regulations for Gasoline and Alcohol Blends Sold in 1989 and Later Calendar Years, 52 Fed. Reg. 31,274 (Aug. 19, 1987).

[53] EPA, Draft Regulatory Analysis: Control of Gasoline Volatility and Evaporative Hydrocarbon Emissions from New Motor Vehicles at 5-24 (July 1987), https://bit.ly/2Br7pkx.

[54] *Id.* at 5-60 to 5-61.

[55] Interim Regulations for Cold Temperature Carbon Monoxide Emissions From Light-Duty Vehicles and Light-Duty Trucks, 55 Fed. Reg. 38,250 (Sept. 17, 1990).

[56] *Id.* at 38,264.

[57] *Id.*

Similarly, in 2000, EPA under Bill Clinton promulgated regulations establishing "Tier 2" motor vehicle emission standards for both exhaust and evaporative emissions.[58] EPA analysis predicted that requirements of this rulemaking regarding On-board Refueling Vapor Recovery would lead to the adoption of technology that improves fuel economy.[59] When calculating the net cost of the standards, EPA used "the net present value of fuel savings over the life of the vehicle."[60] This reflects the full economic value of fuel saved rather than consumers' willingness to pay for the fuel economy improvements that would lead to such savings.

In a 2004 regulation establishing evaporative emissions from motorcycles, EPA under George W. Bush considered a technology that would reduce fuel leaks and, therefore, save fuel.[61] When evaluating the benefits of these fuel savings, EPA used the full economic value of the savings rather than a measure of consumers' willingness to pay for fuel savings.[62]

As explained above, under the Obama Administration, EPA considered the full economic value of fuel savings when calculating the benefits of its MY 2017 and later greenhouse gas emission standards issued jointly with NHTSA fuel economy standards.[63] EPA specifically rejected using a measure of consumers' willingness to pay for fuel economy, explaining that "regardless how consumers make their decisions on how much fuel economy to purchase, EPA expects that, in the aggregate, they will gain these fuel savings, which will provide actual money in consumers' pockets."[64]

3. The Department of Energy Has Used the Full Economic Value of Energy Savings When Calculating the Benefits of Appliance Efficiency Standards

The Department of Energy (DOE) has consistently used a similar approach for almost 40 years when promulgating regulations that set minimum energy efficiency standards for appliances and commercial and industrial equipment. Pursuant to the Energy Policy and Conservation Act (EPCA), as amended, DOE sets minimum standards for the energy efficiency of consumer appliances and commercial and industrial equipment.[65] Under EPCA, DOE is directed to establish standards that are "designed to achieve the maximum improvement in energy efficiency . . . which [DOE] determines is technologically feasible and economically justified."[66] In evaluating whether standards are economically justified, DOE is directed to weigh the benefits of

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[58] Control of Air Pollution From New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements; Final Rule, 65 Fed. Reg. 6698 (Feb. 10, 2000).

[59] Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements at V-27 (1999), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100F1UV.PDF?Dockey=P100F1UV.PDF.

[60] *Id.* at V-31 n. 9.

[61] Control of Emissions From Highway Motorcycles; Final Rule, 69 Fed. Reg. 2398, 2429 (Jan. 15, 2004).

[62] *Id. See also*, Final Regulatory Support Document: Control of Emissions from Highway Motorcycles at 5-5 (2003), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100231W.PDF?Dockey=P100231W.PDF.

[63] Baseline Standards Rule, 77 Fed. Reg. at 62,715.

[64] 77 Fed. Reg. at 62,924.

[65] 42 U.S.C. § 6295.

[66] 42 U.S.C. § 6295(o)(2)(A) (emphasis added).

more efficient appliances, including energy savings, against the costs of the standards, including higher up-front purchase prices.[67]

The Carter Administration DOE issued the first proposed energy conservation standard for a variety of consumer appliances including refrigerators, freezers, clothes dryers, water heaters, room air conditioners, home heating equipment, kitchen ranges, central air conditioners, and furnaces.[68] This proposed rule established the key analytical considerations that DOE has used to establish energy conservation standards ever since. A critical component of this analysis involves calculating the benefits of the fuel—in the case of appliances, electricity, oil, or natural gas—that is saved due to the standards. DOE presented these benefits as part of two different calculations: (1) the benefits to consumers as represented by the difference in life-cycle cost (LCC)—that is, the sum of the purchase price and the operating expense, including maintenance expenditures, discounted over the lifetime of the appliance—between appliances subject to a standard and the baseline; and (2) the benefits to society, including, primarily, the net present value (NPV) of energy savings over the lifetime of the appliance.[69] These calculations were made using the full economic value of energy savings (and of up-front appliance costs), not a discounted measure based on consumers' willingness to pay for the standards.[70]

Under every administration since, DOE has finalized regulations regarding energy conservation standards that rely on a similar analytical framework to evaluate the economic justification for the standards. That is, DOE considers the full economic value of energy saved to both the consumer and the nation, rather than a measure of consumers' willingness to pay for the more efficient appliance or equipment. To list just a few examples:

- In 1982, the Reagan DOE issued a rule declining to set energy conservation standards for clothes dryers and kitchen ranges on the grounds that they would "not result in a significant conservation of energy and would not be economically justified."[71] In reaching the conclusion regarding economic justification, DOE conducted LCC and NPV analyses using the discounted value of energy saved multiplied by the expected price of electricity, oil, or natural gas (as appropriate for the specific appliance).[72]
- In 1991, the George H.W. Bush DOE issued a regulation establishing energy conservation standards for clothes washers, clothes dryers and dishwashers.[73] DOE

[67] *See id.* § 6295(o)(2)(B)(i) (enumerating factors for DOE to consider).

[68] Energy Conservation Program for Consumer Products; Proposed Rule, 45 Fed. Reg. 43,976 (June 30, 1980).

[69] *Id.* at 44,005-007.

[70] *Id.* at 44,005 n. 1.

[71] Energy Conservation Program for Consumer Products; Final Rule for Clothes Dryers and Kitchens Ranges and Ovens, 47 Fed. Reg. 57,198, 57,198 (Dec. 22, 1982).

[72] *Id.* at 57,202, 57,211, 57,212.

[73] Energy Conservation Program for Consumer Products: Final Rule Regarding Energy Conservation Standards for Three Types of Consumer Products, 56 Fed. Reg. 22,250 (May 14, 1991).

calculated the costs and benefits of those standards to include the net present value of energy savings to consumers and society.[74]

- In 1997, DOE under President Clinton issued the first of seven energy conservation standards. These standards for refrigerators and freezers were set at the level with the lowest life-cycle cost, due to the net present value of energy savings based on the quantity of energy saved and estimated electricity prices.[75]

- In 2002, DOE under President George W. Bush issued new more stringent energy conservation standards for central air conditioners and heat pumps.[76] DOE analyzed the economic effect of these standards based on the standard levels' life-cycle cost and the net present value, both of which included the benefits of energy savings calculated using the full economic value of those savings.[77] The Bush Administration promulgated four additional energy conservation standards, calculating the costs and benefits using the same approach.[78]

- The DOE under President Obama promulgated 40 energy conservation standards for consumer, commercial, and industrial appliances. These regulations all included similar analyses that calculated the benefits of energy savings based on the quantity of energy saved and the price of energy—that is, the full economic value of those savings.[79] The Trump Administration DOE has continued to use an identical methodology when

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[74] *Id.* at 22,254.

[75] Energy Conservation Program for Consumer Products: Energy Conservation Standards for Refrigerators, Refrigerator-Freezers and Freezers, 62 Fed. Reg. 23,102, 23,109, 23,112 (April 28, 1997).

[76] Energy Conservation Program for Consumer Products; Central Air Conditioners and Heat Pumps Energy Conservation Standards, 67 Fed. Reg. 36,368 (May 23, 2002).

[77] *Id.* at 36,400, 36,401-402.

[78] 72 Fed. Reg. 58,190; 72 Fed. Reg. 65,136; 73 Fed. Reg. 58,772; 74 Fed. Reg. 1,092.

[79] *See, e.g.*, Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps, 74 Fed. Reg. 34,080, 34,098 (July 14, 2009) ("DOE calculated the sum of the purchase price and the operating expense—discounted over the lifetime of the equipment—to estimate the range in LCC benefits that consumers would expect to achieve due to standards. . . . Another tool calculates national energy savings and national NPV that would result from the adoption of energy conservation standards."); Energy Conservation Program: Energy Conservation Standards for Ceiling Fans, 82 Fed. Reg. 6,826, 6,828 (Jan. 19, 2017) ("The cumulative net present value (NPV) of total consumer costs and savings of the standards for ceiling fans ranges from $4.488 billion (at a 7-percent discount rate) to $12.123 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product costs for ceiling fans purchased in 2020-2049."); *See also* DOE, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Ceiling Fans at 8-14 (2016), https://www.regulations.gov/document?D=EERE-2012-BT-STD-0045-0149 (detailing the calculation of LCC operating cost to be the net present value of seasonal energy consumption times seasonal electricity prices over the lifetime of the ceiling fan); *id.* at 10-8 (explaining that for the calculation of NPV, "DOE calculated annual [total operating cost] for ceiling fans by summing over the operating costs of all product

classes and sectors in the affected stock.").

considering the economic justification for consumer appliance and commercial and industrial equipment standards.[80]

4. Examples from Other Agencies

A number of other rulemakings have evaluated the economic benefits of energy savings using the full economic value of energy saved rather than a measure of consumers' willingness to pay for those savings.

- EPA issued regulations establishing new source performance standards to limit methane leaks from the oil and gas sector.[81] When calculating the benefits of these standards, EPA has included the full revenue from recovered natural gas.[82] This was the case even though EPA acknowledged that industry could have chosen to recapture the gas on its own but for various reasons has not—in other words, the economic value of natural gas savings exceeded the industry's willingness to pay for natural gas recovery. The Trump Administration EPA has taken a similar approach to valuing reduced natural gas leaks in its proposal to amend the standards, claiming that "from a social perspective . . . the increased financial returns from natural gas recovery accrues to entities somewhere along the natural gas supply chain and should be accounted for in the national impacts analysis."[83]
- The Bureau of Land Management took an approach that was similar to EPA when setting standards to limit methane leaks from the oil and gas sector on federal land.[84] The Bureau included as benefits the full economic value of any natural gas that would be recovered and sold due to the regulation.[85]
- In regulations establishing energy efficiency standards for new construction of certain government-assisted housing, the U.S. Department of Housing and Urban Development and U.S. Department of Agriculture calculated the benefits of more stringent standards

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[80] *See e.g.*, Energy Conservation Program: Energy Conservation Standards for Walk-In Cooler and Freezer Refrigeration Systems, 82 Fed. Reg. 31,808, 31,843, 31,811 (July 10, 2017).

[81] Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources, 81 Fed. Reg. 35,824 (June 3, 2016).

[82] EPA, Regulatory Impact Analysis of the Final Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources at 3-14 to 3-15 (2016), https://www3.epa.gov/ttnecas1/docs/ria/oilgas_ria_nsps_final_2016-05.pdf.

[83] EPA, Regulatory Impact Analysis for the Proposed Reconsideration of the Oil and Natural Gas Sector Emission Standards for New, Reconstructed, and Modified Sources at 2-13 (2018), https://www.epa.gov/sites/production/files/2018-09/documents/oil_and_natural_gas_nsps_reconsideration_proposal_ria.pdf.

[84] Waste Prevention, Production Subject to Royalties, and Resource Conservation, 81 Fed. Reg. 83,069 (Nov. 18, 2016).

[85] Bureau of Land Management, Regulatory Impact Analysis for: Revisions to 43 CFR 3100 (Onshore Oil and Gas Leasing) and 43 CFR 3600 (Onshore Oil and Gas Operations at 107 (Nov. 10, 2016), https://www.regulations.gov/document?D=BLM-2016-0001-9127.

using the full economic value of energy saved.[86] The agencies justified these standards based on the energy efficiency gap.[87]

We have not found any examples where an agency has calculated the benefits of fuel or energy savings using the consumers' willingness to pay for those savings upfront.

C. Conclusion

The agencies' approach in the Proposed Rule is to consider the full economic value of avoided fuel consumption enabled by more stringent fuel economy standards when calculating the social benefits of the regulation, and the forgone benefits of the proposed rollback.[88] This approach is consistent with economic theory and scholarship, executive branch guidance, and decades of regulatory practice by numerous agencies across administrations of both parties. The agencies should retain this approach rather than adopting the flawed approach to valuing the benefits of fuel saving included in the NERA/Trinity Analysis.

Respectfully,

Bethany Davis Noll
Peter Howard
Richard Revesz
Jason Schwartz
Avi Zevin

[86] Final Affordability Determination—Energy Efficiency Standards, 80 Fed. Reg. 25,901, 25,921 (May 6, 2015).

[87] *Id.* at 25,910.

[88] *See* Proposed Rule, 83 Fed. Reg. at 43,255.

ATTACHMENT D

Reply Comments of the Institute for Policy Integrity to EPA and NHTSA on The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA-2018-0067 and EPA-HQ-OAR-2018-0283 (May 31, 2019)

Institute *for*
Policy Integrity
NEW YORK UNIVERSITY SCHOOL OF LAW

May 31, 2019

VIA ELECTRONIC SUBMISSION

Attn: James Tamm, Office of Rulemaking, Fuel Economy Division, National Highway Traffic Safety Administration; Christopher Lieske, Office of Transportation and Air Quality, Assessment and Standards Division, U.S. Environmental Protection Agency

Re: The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, NHTSA–2018–0067; EPA–HQ–OAR–2018–0283; FRL–9981–74–OAR; RIN-2127–AL76; RIN 2060–AU09

The Institute for Policy Integrity ("Policy Integrity") at New York University School of Law[1] submits the attached supplemental comments to the National Highway Traffic Safety Administration ("NHTSA") and the Environmental Protection Agency ("EPA") (collectively, "the agencies") on the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 42,986 (Aug. 24, 2018) ("Proposed Rule"). Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy.

In October 2018, Policy Integrity previously submitted comments ("October comments") raising concerns with economic analysis that the agencies used to support the Proposed Rule, including the proposed rollback of fuel economy and greenhouse gas emissions standards for model years 2021 through 2025 ("baseline standards").[2] In December 2018, Policy Integrity submitted supplemental comments ("December comments") highlighting concerns with the economic analysis in a report by NERA Economic Consulting ("NERA") and Trinity Consultants ("NERA/Trinity Report"), submitted as an attachment to the comments of the Alliance of Automobile Manufacturers ("Alliance").[3] The Alliance recently submitted further comments, including an attachment from NERA ("NERA Response"), which purports to rebut critiques of the NERA/Trinity Report submitted by Policy Integrity, the California Air Resources Board, and

[1] This document does not purport to present New York University School of Law's views, if any.

[2] Comment by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12213 and EPA-HQ-OAR-2018-0283-5083 (Oct. 26, 2018).

[3] *See* Supplemental Comments by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12362 (Dec. 21, 2018); Comments of the Alliance of Automobile Manufacturers, NHTSA-2018-0067-12073 and EPA-HQ-OAR-2018-0283-6186 (Oct. 26, 2018), attaching NERA Economic Consulting & Trinity Consultants, Evaluation of Alternative Passenger Car and Light Truck Corporate Average Fuel Economy (CAFE) Standards for Model Years 2021-2026 (Oct. 26, 2018).

a number of non-governmental organizations.[4] However, NERA's responses misstate Policy Integrity's October and December comments, fail to respond to those comments, or are incorrect. We have provided more detail on each of the topics discussed in the NERA Response in an attached Appendix and we ask that the entire Appendix be included in the record.

Respectfully,

Bethany Davis Noll
Peter Howard
Jason Schwartz
Avi Zevin

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New York University School of Law

[4] Comments of the Alliance of Automobile Manufacturers, NHTSA-2018-0067-12392 (April 10, 2018), attaching NERA Economic Consulting, Response to Comments on NERA/Trinity Report (April 10, 2019).

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[1] References to academic articles and working papers cited herein are provided in a reference list at the end of these comments and, when publicly available, have been submitted into the docket. All other references are already available in the docket.

The Institute for Policy Integrity ("Policy Integrity") at New York University School of Law[2] submits these supplemental comments to the National Highway Traffic Safety Administration ("NHTSA") and the Environmental Protection Agency ("EPA") (collectively, "the agencies") on the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 42,986 (Aug. 24, 2018) ("Proposed Rule"). Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy.

In October 2018, Policy Integrity submitted comments ("October comments") raising concerns with the economic analysis that the agencies used to support the Proposed Rule, including the proposed rollback of fuel economy and greenhouse gas emissions standards for model years 2021 through 2025 ("baseline standards").[3] In December 2018, Policy Integrity submitted supplemental comments ("December comments") highlighting concerns with the economic analysis in a report by NERA Economic Consulting ("NERA") and Trinity Consultants ("NERA/Trinity Report"), submitted as an attachment to the comments of the Alliance of Automobile Manufacturers ("Alliance").[4] The Alliance recently submitted further comments, including an attachment from NERA ("NERA Response"), which purports to rebut critiques of the NERA/Trinity Report submitted by Policy Integrity, the California Air Resources Board ("CARB"), and a number of non-governmental organizations ("NGOs").[5] However, NERA's responses misstate Policy Integrity's October and December comments, fail to respond to those comments, or are incorrect. As a result, we submit these further supplemental comments to respond to the arguments made in the NERA Response.

I. Procedural Issues

As Policy Integrity noted in its December comments, the Alliance and NERA/Trinity failed to provide critical details regarding their modeling and methodologies, including data, assumptions, equations, and results.[6] The Alliance and NERA purport to have now included this with their responsive comment, filed at the end of April 2019.[7] Given the late date, if the agencies intend to rely on NERA's modeling, methodologies, or assumptions, the agencies must reopen a comment period so that interested parties can review and evaluate NERA's approach more fully and

[2] This document does not purport to present New York University School of Law's views, if any.

[3] Comment by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12213 and EPA-HQ-OAR-2018-0283-5083 (Oct. 26, 2018) ("Policy Integrity October Comments").

[4] *See* Supplemental Comments by the Institute for Policy Integrity at New York University School of Law, NHTSA-2018-0067-12362 (Dec. 21, 2018) ("Policy Integrity December Comments"); Comments of the Alliance of Automobile Manufacturers, NHTSA-2018-0067-12073 and EPA-HQ-OAR-2018-0283-6186 (Oct. 26, 2018) ("Alliance Comments"), attaching NERA Economic Consulting & Trinity Consultants, Evaluation of Alternative Passenger Car and Light Truck Corporate Average Fuel Economy (CAFE) Standards for Model Years 2021-2026 (Oct. 26, 2018) ("NERA/Trinity Report").

[5] Comments of the Alliance of Automobile Manufacturers, NHTSA-2018-0067-12392 (April 10, 2018) ("Alliance Supplemental Comments"), attaching NERA Economic Consulting, Response to Comments on NERA/Trinity Report (April 10, 2019) ("NERA Response").

[6] Policy Integrity December Comments at 1.

[7] *See* NERA Response at 3; Alliance Supplemental Comments, attaching NERA Economic Consulting, Memo to Alliance of Automobile Manufacturers re: CAFÉ Standards Analysis: Data Back Up (April 10, 2019).

comment on it. The agencies would also need to provide an updated environmental impact statement.

Moreover, while the Alliance and NERA claim to have posted "backup files for the modeling and the data we use," Policy Integrity's initial, high-level review of the submitted documents reveals that critical information is still missing. NERA claims that it has included "Stata do" files that would allow third parties to reproduce NERA's results, but we do not see these in the docket. In addition, NERA still has not provided the results of its New Vehicle Market Model and scrappage model. NERA has now provided numbers on total fleet size but has not provided the sales or scrappage effects embedded in those results, and it is not possible for reviewers to calculate those effects given the information provided. Nor does NERA provide statistical validation of those models or the other models used in the analysis. All of this information is essential to understanding NERA's models and methodology. The agencies, therefore, cannot rely on NERA's analysis when finalizing fuel economy or greenhouse gas emission standards; doing so would fail to provide the public with an adequate opportunity to fully understand and comment on the agencies' course of action.

II. New Vehicle Market Model

NERA's response attempts to rebut Policy Integrity, CARB, and NGO criticisms of the nested logit consumer choice model that NERA developed to estimate new vehicle sales and consumer willingness to pay for fuel economy.[8] In its December comments, Policy Integrity highlighted the fact that NERA used an untested consumer choice model that suffers from several flaws, many of which have caused the agencies to reject the use of such models in the past.[9] Policy Integrity also cited economic literature calling into question whether consumer choice models such as the model NERA used in its economic analysis are useful in the policymaking context, citing, in particular, the models' failure to account for manufacturer decisionmaking.[10] NERA fails to provide an adequate response to these points.

A. NERA's New Vehicle Market Model Uses an Untested and Unreliable Methodology

In its response, NERA states that the agencies support the use of vehicle choice models.[11] However, as evidence NERA points only to statements made by NHTSA in 2012, which indicate the agency was interested in developing usable consumer choice models as part of the mid-term evaluation ("MTE"). Yet, NERA's response inexplicably ignores statements by EPA in 2016 *as part of the MTE* that consumer choice models are not yet sufficiently reliable for policymaking and are poor predictors of future vehicle sales by vehicle model and type.[12] EPA's concerns,

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[8] NERA Response at 5.

[9] Policy Integrity December Comments at 2-3.

[10] *Id.* at 3.

[11] NERA Response at 5.

[12] EPA, Proposed Determination on the Appropriateness of the Model year 2025-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards under the Midterm Evaluation at A-44, A-47, A-48 (2016), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100Q3DO.PDF?Dockey=P100Q3DO.PDF (concluding that vehicle choice

which Policy Integrity highlighted in its October comments,[13] are consistent with a later report commissioned by EPA,[14] with the economics literature evaluating vehicle choice models,[15] and with the economics literature on the valuation of vehicle attributes using vehicle choice models.[16] Nor does NERA respond to the concerns raised by both agencies as part of the MTE in the Proposed Rule and identified in the NGO's comments that vehicle choice models fail to account for consumer substitution of vehicles and so "even the more accurate consumer choice model may produce unrealistic projections of future sales volumes at the model, segment, or manufacturer level."[17]

Economist David Greene reviewed the academic literature that estimates consumer valuation using consumer choice models. In his review, Greene found that "estimating consumer willingness to pay for vehicle attributes is a very difficult problem" because researchers face a variety of identification challenges, including multicollinearity of vehicle attributes, measurement error of attributes, omitted variables, and endogeneity.[18] Additionally, few vehicle choice models capture consumer heterogeneity (i.e., variation of preferences among consumers).[19] Recent work by Benjamin Leard demonstrates that assuming all consumers are the same biases model predictions in a way that overestimates the extent to which price changes influence new vehicle sales.[20] In fact, Leard analyzed the Proposed Rule's rollback of the baseline standards using a model that captures consumer heterogeneity and found that the baseline standards would lead to *higher* vehicle sales relative to the proposed rollback.[21]

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models are insufficient for policy making); *id.* at A-45 (concluding that vehicle choice models are poor predictors of future shares); *id.* at A-44 (finding that vehicle choice models often are out-performed by constant share models and have not been tested for their forecast ability).

[13] *See* Policy Integrity October Comments at 88.

[14] EPA (2018).

[15] Haaf, et al. (2014).

[16] Greene et al. (2018).

[17] Comments of Consumer, Environmental, and Public Health Groups on Proposed Rule at A3, NHTSA-2018-0067-12371 (Dec. 20, 2018), https://www.regulations.gov/document?D=NHTSA-2018-0067-12371 ("NGO Supplemental Comments") ("The Agencies further note that, '[i]f a consumer choice model were to drive projected sales of a given vehicle model below some threshold, as consumers have done in the real market,' the model would need to 'generate a new vehicle model to take its place," as this is how manufacturers adapt to demand changes. 83 Fed. Reg. at 43,077.").

[18] Greene et al. (2018) at 261, 267, 273. Multicollinearity involves the interrelationship of multiple independent variables such that it is difficult to disentangle which variable is the ultimate cause of a dependent variable. Endogeneity occurs when findings about an explanatory variable—for example, about the impact of new vehicle price on sales—cannot be given a causal interpretation because important variables have not been controlled for or because the explanatory variable is jointly determined with the dependent variable. *See* Cameron & Trivedi (2005) at 92.

[19] Greene et al. (2018) at 269, 273.

[20] Leard (2019) at 29.

[21] *Id.* Greene et al. (2018) provides supporting evidence that including consumer characteristics, via the inclusion of household and vehicle attribute interactions, can greatly affect results. Green et al. (2018) at 268-269. Similarly, Haaf et al. (2014) finds that including consumer attributes can improve predictive ability. Haaf et al. (2014).

Evidence indicates that consumers do not make "complex, multidimensional choices," like infrequent vehicle choice decisions, in ways that are represented by consumer choice models. Specifically, consumers appear "not [to] optimize continuous trade-offs among all attributes," and instead initially use simple rules of thumb to decrease their choice set before optimizing across a smaller subset of choices.[22] These challenges "virtually guarantee" model misspecification, particularly in revealed preference models such as the model used by NERA.[23]

Moreover, the subset of vehicle choice models that rely on logit specifications, as with NERA's model, perform poorly in out-of-sample tests (that is, tests of data that were not used to develop the model).[24] Nested logit models, the particular model-type used by NERA, are the least commonly applied logit model, do not perform better than non-nested logit models, and produce less accurate predictions of the mix of vehicles sold in the short-run than merely assuming a continuation of existing sales trends.[25] Because of these challenges, existing vehicle choice models are virtually useless for the agencies' current purposes.[26]

NERA's two-stage nested-logit model is not even consistent with best practices in the vehicle choice model literature.[27] For example, in the first stage, the model inappropriately holds key parameters constant,[28] and in the second stage, the model is not designed to address endogeneity concerns raised in the economic literature.[29] In other words, the models may not be able to identify the correct *causal* relationship between fuel economy changes and vehicle sales. These flaws will further worsen the model's out-of-sample predictive ability (that is, the ability to predict the effects of the baseline standards or the proposed rollback on future vehicle sales).

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[22] Greene et al. (2018) at 273-274; Haaf et al. (2014) at 7.

[23] Haaf et al. (2014) at 1. Model misspecification occurs when, the model is not constructed in a way that accurately represents the data-generating process the model is intending to capture.

[24] Haaf et al. (2014).

[25] Greene et al. (2018) at 262; Haaf et al. (2014) at 1.

[26] EPA (2018) at 7-1 ("Some consistency can be found in the fact that most estimates are positive (consumers would prefer lower fuel costs). This 'consensus' however, encompasses such a wide range of values that it is of little use for informing policy decisions. Unfortunately, the results for other attributes are often just as divergent."); *see also* Greene et al. (2018) at 264, 273-74.

[27] *Compare* NERA/Trinity Report at B-4 (assuming consumer homogeneity in first-stage model) *with* Haaf et al. (2014) at 7 (finding homogeneity assumptions lead to poor out-of-sample prediction and estimation bias); *Compare* NERA/Trinity Report at B-4 to B-5 (estimating willingness to pay in second stage model by regressing calibrated parameters on only fuel efficiency, performance, and vehicle size and certain fixed effects) *with* Leard et al. (2017) at 4 (incorporating additional variables such as safety, reliability, comfort, perceived quality, fuel types, incentives, non-fuel operational costs, pollution, prestige, range, and aesthetics); Klier and Linn (2012) at 188, 199 (same); Haaf et al. (2014) at 7 (same).

[28] *See* Haaf et al. (2014) at 2.

[29] NERA's use of fixed effects is not sufficient to address endogeneity; instrumental variables are necessary. Klier and Linn (2012) at 201 (using instrumental variables to address endogeneity because ear, season, and model fixed effects fail to address brand-specific time trends that are likely present). This is despite the fact that instrumental variables are used in the literature that NERA cites as the basis of its nested-logit model. *See* Grigolon & Verboven (2014) at 925; Klier and Linn (2012) at 199, Berry (1994) at 249.

In its response, NERA argues that its model's willingness-to-pay estimates are consistent with the estimates from the economic literature discussed in Greene et al. (2018). This is ironic because Greene et al. (2018) specifically argues that the level of variability in the literature means that the agencies should not use the literature's willingness-to-pay estimates in policymaking because the uncertainty about the actual value is too great. Moreover, NERA compares its results—that consumers are willing to pay $694 for fuel economy that improves the cost-per-mile of driving by $0.01—to the wrong estimates from Greene et al. (2018). The comparable estimates from Table 8 of Greene et al. (2018) (those estimates that, like NERA, fail to use instrumental variables[30]) show that the literature finds a mean estimate of consumer willingness-to-pay for fuel economy of $1,368.

Given the variability of results from consumer choice models, the agencies cannot rely on any particular model, such as NERA's New Vehicle Market Model, to accurately predict sales effects of fuel economy standards or accurately estimate consumer willingness-to-pay for vehicle attributes. This is compounded by the particular flaws in NERA's nested-logit model.

B. NERA Has Failed to Clearly Establish Whether Its New Vehicle Market Model Accounts for Manufacturer Decisionmaking

In its response, NERA asserts that its New Vehicle Market Model does not include one of the flaws with consumer choice models that Policy Integrity identified in its December comments: the failure of such models to take into account manufacturer decisionmaking.[31] But NERA's response appears inconsistent with the description of its modeling approach included in the NERA/Trinity Report, and NERA has failed to provide sufficient information for the public to evaluate what NERA has actually modeled.

Vehicle prices and sales are not only a function of consumer choices, but also of strategic manufacturer behavior to maximize profits. In order to address this problem, NERA would have to implement a new modeling module that takes into account the relationship between manufacturer behavior and vehicle prices. The description of the New Vehicle Market Model in the NERA/Trinity Report includes no information about any module that models strategic behavior of manufacturers, such as strategic pricing of vehicles. Instead, the NERA/Trinity Report suggests that NERA used NHTSA's Volpe model to identify the technologies that can be deployed in vehicle fleets.[32] As the NERA/Trinity Report explains, Volpe works by selecting a technology mix that is cost-minimizing, not one that is profit maximizing for manufacturers.[33] The vehicle technology costs associated with that technology mix appear to then be passed

[30] NERA did not address endogeneity according to the criteria established in Greene et al. (2018).—that is, the use of instrumental variables. Greene et al. (2018) at 267. Comparing Table 6 and Table 8 makes clear that Greene et al. (2018) find use of fixed effects is not sufficient to address endogeneity.

[31] NERA Response at 6-7.

[32] *See* NERA Response at 4 (showing Volpe model information feeding into New Vehicle Market Model).

[33] NERA/Trinity Report at A-7.

through directly into vehicle prices (with a 1.5x "mark-up").[34] NERA explains that it is those vehicle prices that inform consumer purchasing decisions in the New Vehicle Market Model.[35]

In its response, NERA now claims that it simply failed to fully describe its modeling in the NERA/Trinity Report, and that "[t]he New Vehicle Market Model incorporates strategic adjustments in prices and sales by automobile manufacturers that account for changes in costs for their different vehicles as well as interactions in demand among the different vehicles in the manufacturer's fleet."[36] NERA then claims it is now "provid[ing] information on the specifics of our assumptions regarding manufacturer decisions" in which it explains the use of assumed Bertrand competition (that is, firms competition by setting prices, not quantities).[37] But these new statements are virtually impossible to reconcile with the information that was provided in the NERA/Trinity Report. Either the NERA/Trinity Report failed to mention an entire model that NERA used to incorporate manufacturer responses (and misleadingly suggested that costs were merely passed through to consumers), or the NERA Response fails to accurately characterize the approach NERA has taken and NERA did not actually model strategic manufacturer behavior.

There are a number of reasons why the former appears unlikely:

- The NERA/Trinity Report includes flow-charts to illustrate the workings and interactions among models, which include no mention of a manufacturer model.[38]
- The entire Appendix of the NERA/Trinity Report on the New Vehicle Market Model includes no discussion of manufacturer pricing choices or sales mix.[39]
- Words that would imply the use of a manufacturer responsive model—"Bertrand," "competition," "margin," "equilibrium," "profit maximization" "strategic pricing"—are not used in the NERA/Trinity Report at all.
- As explained above, the NERA/Trinity Report contains language suggesting NERA determined vehicle pricing by merely multiplying the vehicle costs from the Volpe model by a 1.5x markup, and not a pricing model that captures strategic manufacturer behavior.
- While neither NERA's "Stata do" files or any other modeling code are included in the docket, files that have been included further suggest that NERA has not incorporated a manufacturer pricing module. Attachment_05_NERA-Report_data_Summary.xlsx is a file that includes information on modeling outputs. Yet while this file includes "cost"

[34] NERA/Trinity Report at H-1 ("For estimating costs of these technologies to consumers, the CAFE model assumes a retail price equivalent (i.e., a 'mark-up') of 1.5 for fuel economy technologies").

[35] NERA/Trinity Report at B-4 ("As described above, the nested logit choice framework provides a method to estimate consumer demand for differentiated products, *using as data the prices and parameters that measure the relative attractiveness of each product*").

[36] NERA Response at 6.

[37] NERA Response at 6-7. Pindyck & Rubinfeld (2009) at 456-459, 696.

[38] NERA/Trinity Report at 4, B-2.

[39] NERA/Trinity Report at B-1 to B-9.

information, it includes none of the pricing information that would be expected as an output of a manufacturer pricing module.

Because NERA has failed to provide the details of its model and, as described above, relevant files are missing from the record, the public has no way of resolving this discrepancy or fully evaluating NERA's approach to modeling new vehicle sales.

III. Scrappage

NERA argues that "increased demand for used vehicles" will raise used vehicle prices and reduce the turnover of used vehicles.[40] According to NERA, this decreased turnover leads somehow to "increases in the number of existing vehicles."[41] That logical leap is similar to the leap made in the Proposed Rule. But the leap is not supported or explained. Nor is it logical. As the literature shows, vehicle price increases and fuel efficiency increases are likely to, if anything, decrease fleet size.[42] Though NERA claims that its model is "based on well-established economic theory and empirical evidence,"[43] in reality, the literature does not support the finding of a fleet size increase. Many top academics submitted evidence in the record, which also supports Policy Integrity's point.[44]

Moreover, the change in sales of new vehicles and the shift in used vehicle demand are connected, as it is the same consumers who are buying either new or used vehicles. Yet, NERA does not model them as connected. As Policy Integrity explained in its October comments, failure to connect the two effects is a fundamental flaw.[45]

NERA also fails to address Policy Integrity's point that regardless of what happens to fleet size, vehicle miles travelled should not increase (other than due to rebound effect, which is addressed separately below).[46]

IV. Rebound

NERA attempts to support the agencies' use of a 20 percent rebound estimate in the Proposed Rule by responding to critiques that Policy Integrity, CARB, and NGOs submitted in their October comments.[47] Among other critiques, Policy Integrity criticized the agencies' use of studies that evaluated consumer response to changes in the cost of driving that were not

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[40] NERA Response at 10.

[41] NERA Response at 10.

[42] *See* Policy Integrity October Comments at 67-69 (summarizing the literature).

[43] NERA Response at 7.

[44] *See* David Bunch, An Evaluation of NHTSA's Economics-based Modeling and Implications for Benefit-Cost Analysis in the NHTSA/EPA August 24, 2018 Notice of Proposed Rulemaking (NPRM), available at https://ww2.arb.ca.gov/expert-reports-specific-subjects-vehicle-technology-vmt-scrappage-consumer-behavior-traffic-safety; Letter from Dr. Mark Jacobsen and Dr. Arthur van Benthem at 2, Docket No. EPA-HQ-OAR-2018-0283 and Docket No. NHTSA-2018-0067 (Oct. 8, 2018).

[45] *See* Policy Integrity October Comments at 63-64.

[46] *See* Policy Integrity October Comments at 79-85.

[47] NERA Response at 15-20.

representative of the kinds of responses that would be expected from the proposed change in U.S. fuel economy standards, including studies that evaluate rebound outside the United States, studies that evaluate rebound over unrepresentative time periods, and studies that evaluate rebound as a result of gas price changes rather than fuel economy changes, among other criteria.[48] In its response, NERA claims that the economic literature supports a 20 percent rebound estimate even under the criteria that Policy Integrity identified for evaluating representative academic studies of rebound.[49] But the analysis of the rebound effect included in NERA's response is, at best, misleading in several regards.

First, NERA attempts to control for studies with unrepresentative criteria by controlling for each of the shortcomings that Policy Integrity identified in the rebound literature one by one, not in combination. As Policy Integrity explained in its October comments, the agencies should not take a simple average of all rebound studies, but rather, consistent with EPA guidelines regarding how to draw valid conclusions from an academic literature that involves multiple estimates, the agencies should evaluate rebound using a meta-analysis of studies.[50] Barring that, the agencies should evaluate only studies that meet pre-determined selection criteria developed in the literature.[51] NERA's alternative approach in its response is to take a simple average of studies that meet one selection criteria. But this approach does not meet EPA's guidelines. Using only studies in Table 3 of NERA's response that meet *all* quality and relevance selection criteria yields only one paper: Hymel and Small (2015).[52] That study estimates rebound to be between 4 percent and 15 percent.[53] And in a letter submitted to the docket, one author of that paper, Kenneth Small, makes clear that due to expected future changes in income and other factors, the best estimate of the type of rebound is at or below the low end of this range.[54] When including all studies that meet all but one criteria, three additional studies meet the selection criteria: Small and Van Dender (2007), Gillingham (2011), and West et al. (2017).[55] Taking an average of those studies yields rebound estimates with a mean between 5 percent and 9 percent and a median of 5 percent to 11 percent. These ranges support the continued use of 10 percent, and not NERA's use of a 20 percent rebound estimate. Moreover, a 10 percent estimate is consistent with the findings of high-quality economic literature reviews, which evaluate studies based on quality and relevance selection criteria,[56] as well as with assumptions used by other government agencies such as U.S. Department of Energy's Energy Information Agency.[57]

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[48] Policy Integrity October Comments at 110-119.

[49] NERA Response at 15-20.

[50] Policy Integrity October Comments at 120-123.

[51] Policy Integrity October Comments at 123-124

[52] Hymel & Small (2015).

[53] NERA Response 19.

[54] Letter from Dr. Kenneth Small, Docket No. EPA-HQ-OAR-2018-0283 and Docket No. NHTSA-2018-0067 (Sept. 14, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-2698

[55] Small & Van Dender (2007); Gillingham (2011); West et al. (2017).

[56] Policy Integrity October Comments at 124.

[57] *See* Gillingham (2013) at 26 n.11 (calculating that EIA's NEMS model uses a rebound estimate of 10 percent).

Second, the NERA analysis fails to respond to Policy Integrity's arguments that only some studies estimate the rebound effect of fuel economy improvements, rather than other types of changes that reduce the cost of driving.[58] For example, changes in fuel economy are likely to cause a different level of rebound depending on how much fuel economy improvement changes vehicle purchase prices (that is, how much standards require consumers to make additional capital expenditure). Fuel economy improvements generally require upfront capital expenditure that can cause an "income effect" where consumers substitute away from driving because they have less income due to upfront capital expenditure. NERA, however, merely averages studies that estimate rebound under different capital cost changes. Doing so makes it impossible to determine the appropriate value of the rebound effect for a fuel economy improvement that involves the particular capital cost increase used in NERA's analysis. NERA assumes that a very high capital cost increase will be required to meet the standards. As a result, the rebound effect should be relatively small. For example, a recent working paper demonstrates that energy efficiency mandates can have a *negative* total rebound effect in the United States if standards result in significant upfront product price increases.[59] If NERA is right that the baseline standards will result in a substantial price increase in vehicles, the negative income effect of that price increase would likely overwhelm the substitution effect and lead to a small or even negative rebound effect.

Third, NERA fails to respond to a number of other critiques regarding the use of a 20 percent rebound estimate in Policy Integrity's October comments, including that the agencies point to no new evidence supporting a 20 percent rebound and, in fact, ignore new evidence on rebound that does not support the new 20 percent assumption;[60] and that the agencies' criticism of prior reasoning for selecting a 10 percent rebound estimate does not withstand scrutiny.[61]

V. Baseline Fuel Economy

NERA argues that a cost-benefit calculation of the agencies' proposal should reflect fuel economy improvements that manufacturers would make even without the standards.[62] As support, NERA provides two citations—"Knittel (2012)" and "Wozny (2013)"—to argue that the empirical literature shows that "higher gasoline prices lead to more fuel-efficient vehicles."[63] But NERA has not included the full citation to either study in its references list. We have not identified the particular papers that NERA is intending to reference. The papers by Knittel and Wozny from around that time period—Busse, Knittel, & Zettelmeyer (2013) and Allcott & Wozny (2014)—are about consumer valuation of fuel economy, not the impact of prices on manufacturer behavior.[64] So, it is unclear what support NERA has for this point.

[58] Policy Integrity October Comments at 113-114.

[59] Fullerton & Ta (2019).

[60] Policy Integrity October Comments at 102-105.

[61] Policy Integrity October Comments at 105-109.

[62] NERA Response at 22-23.

[63] NERA Response at 23.

[64] Busse et al. 220 (2013); Allcott & Wozny (2014) at 784.

As explained in Policy Integrity's October comments, the historical evidence shows that manufacturers have not improved fuel economy when not required to do so, even though consumers value fuel economy.[65] Moreover, NERA uses a consumer choice model to estimate consumer valuation and, because those models are unreliable, has likely not correctly estimated consumer valuation. NERA's response also fails to address NGO arguments that if manufacturers do, in fact, implement all fuel economy improvements desired by consumers, the agencies would have a statutory obligation to incorporate, at minimum, that level of fuel economy into the standards rather than flat-lining the standards as proposed.[66]

In addition, if consumers value fuel economy, as NERA assumes, then the agencies should take that into account when calculating the price impact of the baseline standards. Policy Integrity explained this point in its October comments,[67] and NERA's response fails to address the point.

VI. Fuel Savings Benefits

To calculate the fuel saving benefits of the baseline standards, the NERA/Trinity Report considered only the value of fuel economy improvements that it asserts consumers consider when making vehicle purchase decisions.[68] That is, NERA used a purported measure of consumers' willingness to pay for fuel economy improvements to estimate the benefits of fuel savings. This willingness-to-pay measure is likely incorrect because it is derived from NERA's flawed vehicle choice model. But, as Policy Integrity explained in the December comments, even if NERA's estimate of consumer willingness to pay were accurate, limiting the benefits of fuel economy to that level is incorrect and a departure from the approach that the agencies have consistently taken for calculating the benefits of fuel savings. In its response, NERA presents several justifications for its novel approach to calculating fuel saving benefits. None of those justifications withstand scrutiny.

A. Consumer Willingness to Pay for Fuel Economy Is Not the Correct Measure of Fuel Saving Benefits Given Market Failures

NERA argues that it is standard practice to use consumer willingness to pay to measure the consumer benefits of a particular regulatory action.[69] However, NERA fails to acknowledge that for 40 years—under administrations of both parties— NHTSA, EPA, the Department of Energy, and other agencies have not adopted NERA's approach to valuing energy savings. As Policy Integrity's December comments explain in detail, when calculating the benefits of regulations that save energy, the agencies have consistently used the net present value of energy saved rather than measures that purport to capture consumer preferences for energy saving equipement.[70]

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[65] *See* Policy Integrity October Comments at 40-46; *see also* ICCT Comments, Docket #EPA-HQ-OAR-2018-0283-5456, NHTSA-2018-0067-11741, Attachment 3, p. II-1.

[66] *See* NGO Supplemental Comments at A4-A5.

[67] Policy Integrity October Comments at 34-35.

[68] NERA/Trinity Report at 54.

[69] NERA Response at 27.

[70] Policy Integrity December Comments at 5-14.

In fact the Office of Management and Budget's best practices for agency economic analyses, *Circular A-4*, and EPA's *Guidelines for Preparing Economic Analyses* direct agencies not to use a simplistic measure of consumer willingness-to-pay if there are market failures.[71] Instead, Circular A-4 states that for regulations such as fuel economy, where "cost savings . . . accrue to parties affected by a rule who also bear its costs" agencies should "monetize[] whenever possible" those "direct costs that are averted as a result of a regulatory action."[72]

NERA tacitly acknowleges that the approach that agencies have taken for 40 years is appropriate if there are market failures.[73] NERA nonetheless claims that Policy Integrity has failed to provide evidence of failures in the market for fuel economy.[74] But this is wrong.

First, the agencies themselves relied on the presence of market failures to justify the baseline standards.[75] It is the agencies' burden, not that of commenters, to justify a change in approach.[76]

Second, NERA's claim that Policy Integrity failed to provide empirical evidence of market failures is wrong. In its December comments, Policy Integrity cited several papers that clearly discuss empirical evidence documenting market failures, including papers from David Greene, and Gloria Helfand & Ann Wolverton, as well as Policy Integrity's October comments.[77] For example, David Greene discusses the work of Garth Heutel, who finds evidence of consumer loss aversion in the energy efficiency context.[78] Greene also notes that this evidence is consistent with consumer surveys and with research by the National Research Council showing that manufacturers believe that consumers only account for one to four years of fuel savings when purchasing a vehicle .[79] Similarly, Helfand & Wolverton discuss the empirical evidence for loss aversion.[80] Both papers also discuss the empirical evidence for consumers' use of heuristics

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[71] Office of Mgmt. & Budget, Circular A-4 at 19, 21 (2003) (cautioning that willingness to pay is a good measure of benefits only "if" the underlying market is "well-functioning" and requiring agencies to take "market imperfections" into account when valuing regulatory effects) ("Circular A-4"); EPA, Guidelines for Preparing Economic Analyses 7-21 (2010) (market prices are appropriate only "for goods bought and sold in undistorted markets"); *see also id.* at 7-15 (directing use of healthcare costs not otherwise accounted for in individual consumers' willingness-to-pay to avoid morbidity because "these costs represent diversions from other uses in the economy, [and so] represent real costs to society [that] should be accounted for").

[72] Circular A-4 at 37-38.

[73] NERA Response at 27 ("clear 'market failures' are needed to justify using an alternative approach").

[74] NERA Response at 27-28.

[75] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624, 63,118 (Oct. 15, 2012) ("Baseline Standards Rule") ("NHTSA believes the existing literature offers some support for the view that various failures in the market for fuel economy prevent an economically desirable outcome, which implies that there are likely to be substantial private gains from the final rule.")

[76] FCC v. Fox Television Stations, Inc., 556 U.S. 502 (2009).

[77] Policy Integrity December Comments at 4 (citing Greene (2018); Helfand & Wolverton (2011) 112; Policy Integrity October Comments at 38-40).

[78] Greene (2018) at 10 (citing Heutel (2017)).

[79] Greene (2018) at 13.

[80] Helfand & Wolverton (2011) at 133.

when choosing vehicles rather than rationally calculating expected fuel savings due to the difficulty that they have in performing such calculations (termed "bounded rationality").[81] Helfand and Wolverton also cite evidence of consumer myopia when buying vehicles, indicating that consumers may value future fuel savings but fail to fully account for them when purchasing a vehicle.[82] Finally, in addition to discussing and providing evidence of many of the market failures discussed above, Policy Integrity's October comments present a detailed discussion, including citation of empirical evidence, of the positional nature of vehicle attributes and how that causes externalities that can be addressed by fuel economy standards.[83]

Other studies also found empirical evidence for multiple market failures including split incentives, inattention, salience, heuristic decision making, bounded rationality, myopia, learning by using, loss aversion, and capital market failures.[84] A recent study by Kenneth Gillingham, Sebastian Houde, and Arthur van Bentham has found significant empirical evidence of consumer myopia.[85] That study, which takes advantage of a sophisticated natural experiment, also finds empirical evidence that U.S. consumers substantially undervalue fuel economy and that a number of the studies that the agencies point to in order to claim consumers fully value fuel savings suffer from upward estimation bias.[86] Additional studies have found evidence of producer-side market failures, including imperfect competition and knowledge spillovers.[87]

In order to justify an approach that devalues fuel saving benefits, NERA attempts to identify other explanations for the gap between consumers' *ex ante* willingness to pay for fuel economy and the net present value of fuel savings (the "energy efficiency gap") other than market failures. NERA claims "the observed difference" between full valuation and willingness to pay "could be rational in the presence of high sunk costs and uncertainty over fuel savings."[88] But (despite falesely accuring Policy Integrity of ignoring empirical evidene) NERA has provided no empirical evidence of these alternative explanations. The primary study NERA cites for this claim is a 25-year-old paper by Kevin Hassett and Gilbert Metcalf. [89] Yet this paper provides no empirical statistical evidence for the theory that consumer uncertainty leads to the energy efficiency gap. Recent syntheses of the economic literature suggests that consumer uncertainty is

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[81] Greene (2018) at 17-18 (discussing Turrentine & Kurani (2007); Sallee (2014)); Helfand & Wolverton (2011) at 131-32 (discussing Turrentine & Kurani (2007); Larrick & Soll (2008); Allcott (2010)).

[82] Helfand and Wolverton (2011) at 126 (citing Kubik (2006)).

[83] Policy Integrity October Comments at 47-51 (citing Heffetz (2011); Carlsson et al. (2007); Alpizar et al. (2005)).

[84] Gerarden et al. (2017) at 1503.

[85] Gillingham et al. (2019).

[86] Gillingham et al. (2019) at 16-17. As indicated in Gillingham et al. (2019), this finding is consistent with Leard et al. (2017).

[87] Houde & Spurlock (2016) at 9-15; Gerarden et al. (2017) at 1489-1490.

[88] NERA Response at 28.

[89] NERA Response at 28 (citing Hassett & Metcalf (1993)). NERA also cites to a paper by Gayer and Viscusi, yet that paper merely cites the Hassett & Metcalf (1993) paper despite twenty years passing for new studies. Gayer and Viscusi also appear to argue that consumer information issues are likely addressed by existing informational provisions. But more recent empirical evidence undermines that conclusion. *See* S. Houde (2018).

an insufficient explanation for the energy efficiency gap at best.[90] In order for consumer uncertainty to explain the energy efficiency gap, it requires three additional assumptions: the purchase of the vehicle must be irreversible, the timing of replacement must be flexible, and investment decisions must be discreet rather than continuous."[91] A recent study concluded that a number of these assumptions are unlikely to hold. Perhaps most importantly, an extensive used-vehicle market means that vehicle purchases are not irreversible. Furthermore, the empirical evidence for the uncertainty hypothesis is "mixed" and empirical studies have not measured the relative importance of this explanation and other explanations such as market failures.[92]

Given the presence of market failures, purported measures of consumers' *ex ante* willingness to pay for fuel economy improvements is not the appropriate approach for measuring the fuel saving benefits of the baseline standards. An approach that fails to fully value the savings that actually accrue to consumers and society is also inconsistent with 40 years of agency practice and with best-practice guidelines for agency cost-benefit analysis.

B. NERA's 60-Month Payback Estimate

NERA asserts that the NGOs misunderstood how NERA estimated the value that consumers place on fuel economy improvements when they claimed that "[t]he NERA/Trinity Approach argues that Americans value only 60 months of the fuel savings."[93] NERA now claims that it has included *all* value that consumers place on fuel economy improvements in its calculation of fuel saving benefits. However, NERA's description of its methodology in its initial report suggests this is, at best, misleading.

The NERA/Trinity Report explains "we measure **the value consumers are observed to place on the prospective fuel savings afforded by improved fuel economy** using the estimates of fuel economy changes from the CAFE model and NERA's estimate of consumers' willingness-to-pay for such changes from the New Vehicle Market Model."[94] When describing the payback period it used to determine which fuel economy technologies manufacturers would include without the standards, th report states that "a value of 60-months was used . . . for consistency with the resulsts of the New Vehicle Market Model (which **provides an estimate of the value new vehicle purchasers place on fuel economy improvements**)."[95]

That is, NERA's response fails to actually rebut the NGO's original criticism. NERA appears to have used the same approach to calcuating the amount of fuel economy consumers would demand without fuel economy standards as it used to calculate the economic value that NERA assumes consumers place on fuel economy improvements.

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[90] Gerarden et al. (2017) at 1513 ("The option value of waiting due to uncertainty regarding future energy prices or technological change may explain part of the apparently suboptimal investment in energy-efficient technologies, but probably not a large part, in most cases").

[91] Id.

[92] *Id.* at 1514.

[93] NERA Response at 28.

[94] NERA/Trinity Report at H-2.

[95] NERA/Trinity Report at A-5.

NERA's current claim that the NGOs are confused and that it has not done what it has described in the NERA/Trinity Report serves only to further support Policy Integrity's concerns that NERA has not provided enough explanation and information for the agencies to rely on the conclusions of the NERA/Trinity Report.

C. The Consistency of NERA's Willingness-to-Pay Estimate With Implicit Consumer Discount Rates Does Not Support Undervaluing Fuel Savings

In its response, NERA cites to research showing that its estimates of consumers' *ex ante* willingness to pay for fuel economy are consistent with implicit consumer discount rates found by a number of studies.[96] However, even if true, the consistency of NERA's estimates with implicit discount rates found in the economic literature does not support NERA's claim that consumers' *ex ante* purchasing decisions reflect the appropriate approach to calcuating fuel savings benefits. Rather, empirical studies that find high implicit consumer discount rates merely reflect the fact that, as a result of market failures, consumers do not make vehicle purchasing decisions that are consistent with maximizing the expected net present value of fuel savings. One of the studies that NERA cites in its response explains that high observed implicit consumer discount rates for fuel economy improvements (around 13 percent) are inconsistent with the discount rates standard economic theory predicts consumers would use (around 6 to 7 percent).[97] Put another way, high implicit consumer discount rates reflect the existence of the enegy efficiency gap. And empirical evidence of the energy efficiency gap does not justify devaluing the consumer and social benefits of fuel savings, it supports using the full valuation of those savings. As a result, NERA's identification of these studies provides no support for the approach to valuing fuel saving benefits included in the NERA/Trinity Report.

In fact, an approach that relies on high private discount rates is inconsistent with best practices for agency cost-benefit analysis. The purpose of regulation is to maximize *societal* net benefits not to maximize benefits of any particular private interests. When consumers operate more efficient vehicles, they consume fewer real economic resources (e.g., barrels of oil which must be extracted, refined, transported, etc.) than they would have had they operated less efficient vehicles. These are real resource savings for society, the value of which is represented by the price of the fuel (i.e., gasoline or diesel) saved and not consumers' *ex ante* subjective valuation of those savings. As a result, it is appropriate to calculate the present value of those future savings using the rate that *society* (not private individuals) discounts future costs and benefits (that is, using a social discount rate).[98] Such an approach is consistent with EPA's *Guidelines for Economic Analysis*, which directs EPA to use a social, rather than private, discount rate to

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[96] NERA Response at 28-30.

[97] *See* Allcott & Wozny (2014) at 780 (discussing difference between observed implicit discount rates and "consumers real intertemporal cost of funds"); *id.* at 784 (discussing calculation of real intertemporal cost of funds as the discount rate derived from the opportunity cost of capital if fuel economy improvements are paid for in cash or the interest rate of a loan if fuel economy improvements are financed).

[98] Circular A-4 directs agencies to use discount rates of 3 percent and 7 percent except in specific circumstances such as intergenerational discounting. Circular A-4 at 33. Neither is close to the implied discount rates of 13 percent that NERA uses.

calculate costs and benefits of regulations.[99] It is also consistent with NHTSA's past explanations for why it has consistently calculated fuels savings benefits as the full economic value of those savings.[100]

D. NERA's Undervaluation of Fuel Savings Is Consequential

NERA attempts to minimize the significance of its approach to calculating the benefits of fuel savings by asserting that rolling back the baseline standards would remain net beneficial even if its analysis used the full economic value of fuel saving benefits.[101] But NERA's failure to properly value fuel savings is not harmless error. It is not sufficient that a particular standard level has benefits that exceed costs; when comparing potential standards, the size of the net benefits is relevant. And NERA's response shows that the approach to valuing fuel savings significantly influences which level of standards has the greatest net benefits.[102] As such, the calculation of fuel saving benefits will significantly influence the net benefits of more stringent standards, in the context of statutory mandates that are aimed at maximizing fuel economy and minimizing dangerous air pollution. But because the agencies have historically used the costs and benefits of fuel economy and greenhouse gas emission standards to inform the appropriate level of those standards,[103] reliance on a fundementally flawed economic analysis would render the agency's decisionmaking arbitrary.[104]

Moreover, NERA's calculations show that for Scenario 1 (the Proposed Rule's "preferred alternative") at a 3% discount rate, there is a $42.5 billion difference between the willingness-to-pay approach and full valuation of fuel savings. The total net benefits that NERA/Trinity calculated for Scenario 1 at a 3% discount rate is $98.2 billion. As a result, using the full valuation of fuel savings would, alone, reduce the net benefits of Scenario 1 by almost half.

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[99] EPA, GUIDELINES FOR PREPARING ECONOMIC ANALYSES 6-1 (2010).

[100] Baseline Standards Rule, 77 Fed. Reg. at 62,992 ("When estimating the aggregate value to the U.S. economy of fuel savings resulting from alternative increases in CAFE standards—or the 'social' value of fuel savings—the agency includes fuel savings over the *entire* expected lifetimes of vehicles that would be subject to higher standards").

[101] NERA Response at 30-32.

[102] *See* NERA Response at 32 (finding that NERA Scenario 1 maximizes net benefits under NERA's flawed approach to valuing fuel saving benefits, whereas Scenario 5 maximizes net benefits under the agencies' historical approach to valuing fuel saving benefits).

[103] *See e.g.*, Baseline Standards Rule, 77 Fed. Reg. at 62,777 ("given the technical feasibility of the standard, the cost per vehicle in light of the savings in fuel costs over the lifetime of the vehicle, the very significant reductions in emissions and in oil usage, and the *significantly greater quantified benefits compared to quantified costs*, EPA is confident that the standards are an appropriate and reasonable balance of the factors to consider under section 202(a)") (emphasis added); *id.* at 63,020 ("[r]egardless of what type of analysis is or is not used, considerations relating to costs and benefits remain an important part of CAFE standard setting"); *Ctr. for Biological Diversity*, 538 F.3d 1172, 1186 (9th Cir. 2008) (explaining that NHTSA used a marginal cost-benefit analysis to determine maximum feasible standards for model years 2008-2011).

[104] *Ctr. for Biological Diversity*, 538 F.3d at 1198 ("Even if NHTSA may use a cost-benefit analysis to determine the "maximum feasible" fuel economy standard, it cannot put a thumb on the scale by undervaluing the benefits and overvaluing the costs of more stringent standards").

Correcting any one of NERA's and the agencies' many other errors—e.g., relying on accurate technology compliance cost estimates rather than the agencies' overestimates; using a 10% or lower rebound estimate instead of the agencies' unsupported estimate; using the global social cost of carbon at an appropriate discount rate instead of the agencies' so-called "interim" calculation—would likely show that Scenario 1 produces net costs rather than net benefits. Correcting all of these errors would certainly show this.

E. NERA's Citation of Opportunity Costs Does Not Justify Rolling Back the Baseline Standards

NERA attempts to justify the overall conclusions of its economic analysis by pointing to an alleged undercounting of a separate category of consumer costs.[105] Specifically, NERA claims that both its and the agencies' economic analyses failed to account for consumer welfare losses that result because the baseline standards force consumers to forgo vehicle attributes such as horsepower and weight (what NERA calls "performance attributes") that they also value. NERA calls this category of unaccounted-for costs the "opportunity costs" of the standards.[106]

As a preliminary matter, NERA admits that the results they present "cannot be used directly to estimate the offsetting consumer losses from reduced passenger car and light truck performance."[107] By NERA's own admission, its analysis does not and cannot quanitfy these alleged losses. Thus, NERA's analysis cannot be adopted by the agencies in an attempt to justify rolling back the baseline standards.

Moreover, NERA's identification of "opportunity costs" as an additional (unquantified) cost that would support its economic conclusions regarding the baseline standards is fundementally flawed for a number of reasons.

1. The academic literature does not support NERA's assumption about substantial efficiency-performance tradeoffs

In the absence of market failures, a rational consumer would continue to demand fuel economy improvements until the net present value of fuel savings[108] just meets the upfront cost of adding fuel efficiency technology.[109] The fact that in some limited cases technology can be used to

[105] NERA Response at 32-35.

[106] NERA Response at 33-34.

[107] NERA Response at 35.

[108] Rational consumers would also consider the fact that such technology also saves time at the pump and the value of additional miles traveled. However, the presence of these additional consumer benefits does not change the analysis and so, for simplicity, we refer only to the fuel savings.

[109] Helfand & Dorsey-Palmateer (2015) at 438 ("If vehicle buyers minimize costs of ownership, as in standard economic models, then all else equal, they should be willing to purchase additional fuel-saving technology as long as the additional cost of this technology to them is less than the expected discounted fuel savings"); Helfand & Wolverton (2011) at 129-130 ("the relative preference for performance over fuel economy still does not explain the seeming paradox that fuel savings appears to exceed the cost of adding additional fuel economy to the vehicle. One would expect from economic theory that consumers would continue to demand fuel economy improvements until the benefits of a marginal improvement just meets the cost. Only if there are limits on the total amount of

increase fuel economy *or* increase other vehicle attributes that consumers like does not alter this analysis,[110] because there are many technologies that can improve fuel economy, many technologies that can improve performance, and both fuel economy and performance can be improved at the same time.[111] If there are no market failures (including the availability of an efficient credit market for financing), manufacturers would be expected to add both technology that increases performance up to the level that consumers value that performance *and* technology that increases fuel savings up to the level that the net present value of the fuel savings are equal to the cost of the technology. This is true even if, as would be expected, adding both technologies further increases the upfront purchase price of a vehicle, so long as the additional fuel efficiency technology would still save consumers money *on net*.

The only case in which consumers may not receive performance attributes that they might value, would be where there is a technical or engineering constraint that prevented manufacturers from adding technology that increases performance *and* adding technology that improves fuel efficiency.[112] Yet, empirical evidence shows that automakers have been able to add fuel savings without creating a technical constraint on the amount of other attributes that can be added to vehicles.[113]

In its response, NERA reproduces a chart that purports to show that, historically, performance leveled off as fuel economy standards increased in an attempt to suggest that there has been such a tradeoff.[114] However, NERA's chart is misleading because it uses outdated data from when fuel economy standards were constant to incorrectly argue that manufacturers held fuel economy constant in order to advance performance attributes. As a recent figure from the 2018 EPA Automotive Trends Report (reproduced below) demonstrates,[115] since 2008, fuel economy began to rise (as a result of standards adopted by the agencies), yet performance attributes continued on the same upward path that they had prior to adoption of the standards. This evidence undermines

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efficiency that can go in a vehicle does economic theory predict that the marginal benefit of fuel economy should not equal its marginal cost").

[110] *See* EPA, NHTA & CARB, 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 at 4-26 (2016), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF ("Draft TAR") ("manufacturers may choose to apply technology to improve vehicle performance in lieu of efficiency").

[111] Helfand & Dorsey-Palmateer (2015) at 442 ("Power is also considered a substitute for fuel economy (e.g. Lier & Linn, 2012), though it is possible to increase both power and fuel economy, at a cost").

[112] Helfand & Wolverton (2011) at 129-130 ("Only if there are limits on the total amount of efficiency that can go in a vehicle does economic theory predict that the marginal benefit of fuel economy should not equal its marginal cost").

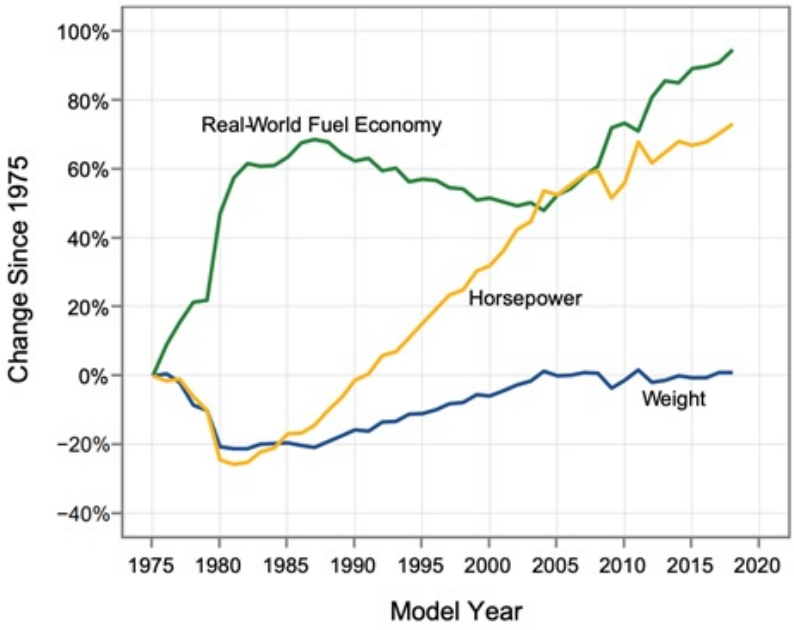
[113] Huang at al. (2018) at 194 (finding that "automakers have typically been able to implement fuel-saving technologies without harm to vehicle operational characteristics" like "acceleration, handling, ride comfort, noise, braking feel, and vibration").

[114] NERA Response at 34.

[115] EPA, 2018 AUTOMOTIVE TRENDS REPORT 30 (2018), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100W5C2.PDF?Dockey=P100W5C2.PDF; *See also* Policy Integrity October Comments at 46, fig. 1 (showing data from 1994-2017, and including acceleration as well as horsepower and weight).

NERA's assertion, based on the outdated data, "that if CAFE standards are tightened, manufacturers would reduce the pace of improvement in these other desirable [performance] features."[116] As the Environmental Defense Fund explained in its October comments to the agencies, EPA concluded as part of the MTE that this change reflects the fact that "the historic tradeoff between performance and fuel economy is far less likely to hold for advanced technology engines."[117]

Figure 3.15. Relative Change in Fuel Economy, Weight, and Horsepower, since Model Year 1975



Moreover, as the agencies discuss in the Draft Technical Assessment Report completed as part of the MTE, even if there is some performance-efficiency tradeoff, studies suggest that there may also be a countervailing effect whereby the increased innovation spurred by the standards ultimately allows both more performance and more efficiency at lower cost.[118] More recent literature notes that learning by doing and knowledge spillovers should further reduce compliance costs, making these tradeoffs less necessary and potentially non-existent.[119]

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[116] NERA Response at 34.

[117] Comments of Environmental Defense Fund Appendix A at 90, NHTSA-2018-0067-12108 (Oct. 26, 2018), https://www.regulations.gov/document?D=NHTSA-2018-0067-12108; *see also* EPA, Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation: Technical Support Document at 4-6 to 4-7 (Nov. 2016), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3L4.pdf; EPA, Final Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation: Response to Comments at 127 (Jan. 2017), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100QQ9Y.pdf.

[118] Draft TAR at 4-32 to 4-34.

[119] Bento et al. (2018) at 1119.

But NERA fails to account for this countervailing effect of the standards on performance.

2. Forgone performance attributes need not result in lost consumer welfare

Even if the baseline standards cause a reduction in vehicle performance attributes compared to what would occur without the standards, NERA has not shown that this will result in a welfare loss. The performance attributes that NERA identifies—such as horsepower and weight—are what the economics literature calls "positional goods."[120] As Policy Integrity explained in detail in its October comments, a fleetwide reduction of positional attributes need not cause *any* aggregate loss of consumer welfare.[121]

Positional goods are goods for which the value to one individual depends on how it compares with similar goods possessed by others.[122] In other words, the good is valued according to how much of the good others have, rather than according to innate characteristics of the good itself. A growing body of research indicates that many consumers do not necessarily want the biggest and fastest vehicle, so long as their vehicle is bigger and faster than their friends' and neighbors' vehicles.[123] Yet the purchase by one consumer of a faster vehicle inflicts a negative externality of diminished status on all other consumers who value having relatively faster vehicles; when those consumers compensate by upgrading to even faster vehicles as well, the first consumer suffers negative externalities in turn.

Because vehicle purchase decisions are made non-cooperatively but in fact alter the spending behavior and perceived safety of others, consumers get stuck on a "positional treadmill" that does not increase welfare.[124] Yet if any individual unilaterally tries to opt out of this "expenditure arms race," it would only move that consumer backwards on the status or safety hierarchy, which for most consumers is unacceptable.[125] If consumers could maintain their relative position with respect to performance attributes, they might not suffer any welfare loss.[126]

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[120] Frank (1985) at 101.

[121] Policy Integrity October Comments at 47-51.

[122] Frank (1985) at 101.

[123] Specifically, a majority of people surveyed would trade a decrease in their car's absolute value for an increase in its relative value compared to other people's cars: in other words, they are happy to have their car lose value so long as everyone else loses more value on average. *See, e.g.*, Carlsson et al. (2007) at 588, 593 (reporting results of a Swedish survey); Alpizar et al. (2005) at 412 (reporting results of Costa Rican survey). Though some such surveys were conducted in other countries, if anything positionality for cars could be stronger in the United States, given the American affinity for cars and the income distribution. *See* Heffner et al. (2005) at 2 ("In the words of automobile psychologist G. Clotaire Rapaille, Americans are in 'a permanent search of an identity' and 'cars are very key . . . [they are] maybe the best way for Americans to express themselves.'"); Hopkins & Kornienko (2004) (noting that positional effects increase as society's income increases, because the portion of income spent on conspicuous consumption increases); Carlsson et al. (2007) at 588, 593 (finding support for hypothesis that "visible goods and their characteristics, such as the value of cars, are more positional than less visible goods and their characteristics, such as car safety").

[124] Frank (2005) at 137.

[125] Frank (2005) at 105-06.

[126] Frank & Sunstein (2001) at 326 ("when a regulation requires all workers to purchase additional safety, each worker gives up the same amount of other goods, so no worker experiences a decline in relative living standards.

Reducing the amount of performance attributes that consumers want in ways that do not change the relative position of consumers will, therefore, not necessarily lead to aggregate welfare losses.

3. An analysis of lost performance would have to account for the benefits of reducing externalities of lost performance

If the agencies decide that the baseline standards result in consumers purchasing vehicles with fewer performance attributes, as NERA claims, the agencies would have to take into account the avoided negative externalities that such performance attributes would have imposed on society. Yet NERA fails to include the negative externalities associated with those vehicle attributes.

Economics has long recognized the various implicit subsidies and externalities imposed on society by vehicles. These include: road and parking construction and maintenance costs, the space used for parking, accidents, road congestion, and pollution.[127] Drivers with higher horsepower vehicles are much more likely to speed—by 10 miles per hour or more—increasing the risk of accidents, damages, and fatalities.[128] Vehicles with attributes that allow faster acceleration also cause a greater number of and more consequential accidents.[129] Similarly, increased weight of a consumer's vehicle imposes a negative externality on the safety of others in an accident.[130] Heavier vehicles also increase the cost of road maintenance and repair.[131] According to academic literature, the cost of these externalities is sizable.[132]

Looking only at the performance attribute benefits of the rollback without also accounting for the costs, as NERA has done, inappropriately puts a thumb on the scale of rolling back the baseline standards.[133]

If relative living standards matter, then an individual will value an across-the-board increase in safety more highly than an increase in safety that he alone purchases").

[127] Tietenberg & Lewis (2018) at 375-376.

[128] Insurance Institute for Highway Safety & Highway Loss Data Institute, *Flexing Muscle: Sports Car Ratings Show Range of Performance*, 52 STATUS REPORT, no. 5, 2016, at 1, https://www.iihs.org/iihs/sr/statusreport/article/51/5/2; Robertson (2018) at 200; McCartt & Hu (2017); Hu & Cicchino (2018); NHTSA, *How Vehicle Age and Model Year Relate to Driver Injury Severity in Fatal Crashes, Traffic Safety Facts: Research Note* (2013), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811825 (showing increased speed increases fatalities).

[129] Kim et al. (2006) at 981.

[130] Anderson & Auffhammer (2013); Policy Integrity, Comments on the Request for Comment on Reconsideration of the Final Determination of the Mid-Term Evaluation of Greenhouse Gas Emissions Standards for Model Year 2022-2025 Light-Duty Vehicles at 12-13 (2017), https://policyintegrity.org/documents/CAFE_standards_jobs_and_preferences_-_Institute_for_Policy_Integrity_(003).pdf.

[131] Ahmed et al. (2015) at 1080.

[132] Gerarden et al. (2017) at 1498; Lemp & Kockelman (2008) at 493-494. The magnitude of these externalities have been studied extensively in the fuel tax literature. *See e.g.* Parry & Small (2005).

[133] *Ctr. for Biological Diversity*, 538 F.3d at 1198.

4. The studies NERA cites do not support the lost opportunity cost values used in its cursory analysis

NERA relies on three studies to support its conclusions regarding the opportunity cost of the baseline standards: Klier and Linn (2013), Klier and Linn (2016), and Leard et al. (2017).[134] But these studies do not provide sufficient support for NERA's claims. Klier and Linn (2013) appears to be a working paper version of Klier and Linn (2016). Linn is a co-author on Leard et al. (2017). Therefore, despite claiming that there are "numerous studies" that support its argument,[135] the total of NERA's evidence includes two unique papers—one of which is currently unpublished—from one group of researchers. Regardless of the academic quality of these particular studies, the point is that the literature NERA attempts to rely on is in its infancy; considerably more research and verification is required before this literature could potentially be used to inform policy. Even the authors of Klier and Linn (2016) refer to their estimates as "rough" and "back-of-the-envelope estimates" that may "overestimate costs."[136]

This conclusion is consistent with a review of the economic literature that EPA commissioned as part of the MTE, which was completed in 2018.[137] That study concluded that consumer valuation of performance attributes is too uncertain to rely on, finding the literature "encompasses such a wide range of values that it is of little use for informing policy decisions . . . The lack of consensus we have found in the literature points to major challenges for researchers attempting to model consumer preferences for vehicles and their attributes." [138] In a follow-up paper, the author of EPA's commissioned study, David Greene, found "striking[ly]" high variation in willingness-to-pay estimates across the literature.[139] As such, Greene et al. (2018) concluded that focusing on any specific willingness-to-pay estimate is methodologically suspect.[140] Yet NERA relies on the same literature that was reviewed by Greene and fails to explain why reliance on these particular estimates is reasonable given the conclusion of that previous literature review.

There are also a number of specific reasons why these papers cannot serve as the basis for reliable calculations of consumers' alleged lost welfare from purportedly forgone performance attributes, consistent with criticisms of NERA's approach to calculating other costs and benefits. First, all three papers assume homogenous consumers.[141] Yet, as Leard himself notes in a recent working paper, incorporating consumer differences in vehicle choice models that derive willingness-to-pay estimates can affect the model's predictions by orders of magnitude.[142]

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[134] NERA Response at 33 n.25.

[135] NERA Response at 33.

[136] Klier & Linn (2016) at 52-53.

[137] EPA (2018).

[138] EPA (2018) at 7-1, 7-3.

[139] Greene et al. (2018) at 264, 273; *id.* at 274 (even after trimming outlines, "one standard deviation exceeds the mean of the [willingness to pay] estimates for most of the attributes...[and] the interquartile range also exceeds the median").

[140] Greene et al. (2018) at 274.

[141] Leard et al. (2017) at 29; *id* at 197 (applying estimates of willingness to pay for vehicle attributes from a model that imposes consumer homogeneity); Klier & Linn (2012) at 29-31; Klier & Linn (2016) at 53.

[142] Leard (2019) at 35, 40.

In addition, Klier and Linn (2016) assumes that standards do not affect vehicle price or market share.[143] This is directly contrary to the modeling assumptions used in Volpe and, as a result, by NERA. Klier and Linn (2016) uses estimates of consumers' willingness to pay for attributes that were developed using a consumer choice model in a prior study;[144] yet, that prior study suffers from a number of shortcomings of consumer choice models discussed above. Moreover, that study relies on several assumptions that may not hold in the real world and so may not be appropriate for policymaking.[145] Klier and Linn (2016) also assumes consumers fully value fuel savings, which is inconsistent with NERA's approach.[146]

Leard et al. (2017) has several features that make its use in this policymaking context inappropriate. The authors employ a survey with a low response rate of 9%. While they address the non-randomness of the individuals that received the survey, they do not appear to address the non-randomness of those that respond (i.e., response bias). Therefore, the results for the subsample that responded may not predict the behavior of all consumers that are affected by the standards. More importantly, they obtain estimates of consumer willingness to pay that the authors characterize as "puzzles."[147] First, the willingness-to-pay estimates suggest that producers are forgoing adoption of fuel savings technologies that could be used to improve performance at a profit. Second, the results that the study finds for consumers' willingness to pay for performance are not high enough to support reducing fuel economy in favor of performance, yet their current and past modeling results suggest manufacturers are reducing fuel economy in favor of performance.[148] The authors suggest these puzzles may be the result of modeling errors (e.g., hidden costs or a failure to model heterogeneous preferences). While this is acceptable in a working paper, reliance on such a study is not appropriate for policymaking.

The papers NERA cites also reinforce the points made above regarding the fact that standards speed up technological innovation.[149] Contrary to NERA's assumptions, this will reduce any tradeoff that may exist between fuel economy attributes and performance attributes over time.[150] In fact, another study previously cited by the agencies suggests that the type of approach adopted in Klier and Linn (2016) may underestimate technological progress and, therefore, may overestimate performance tradeoffs.[151]

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[143] Klier & Linn (2016) at 52.

[144] *See* Klier & Linn (2016) at 52 (citing Klier & Linn (2012)).

[145] Klier & Linn (2012) assumes that: (1) major engine attributes are captured as omissions will lead to biased estimates, (2) engine characteristics are uncorrelated with unobserved vehicle characteristics (i.e., firms are not matching engine platform to vehicle attributes unobserved by the authors), (3) vehicle attributes unobserved by the authors are not adjusted in response to CAFE standards, (4) no vehicles enter the market, and (5) producers do not have other dynamic considerations when making their product decisions. Klier & Linn (2012) at 201, 211.

[146] Klier & Linn (2016) at 53.

[147] Leard et al. (2017) at 29.

[148] Leard et al. (2017) at 29.

[149] Klier & Linn (2016) at 43.

[150] Klier & Linn (2016) at 48-50.

[151] MacKenzie & Heywood (2015) at 919-920; Draft TAR at 4-30.

5. Including lost opportunity cost without recalculating compliance costs would be arbitrary

NERA uses NHTSA's Volpe model to estimate the expected technology that manufactures will deploy to meet the baseline standards, and the costs of that technology.[152] NHTSA's Volpe model assumes that manufacturers will produce vehicles that have roughly the same performance attributes as they would have had without the standards.[153] But holding performance attributes constant when calculating compliance costs cannot be reconciled with NERA's attempt to calculate consumer welfare from forgone performance attributes. NERA has calculated costs using an assumption that *no attributes will be forgone*. But NERA then attempts to monetize performance attributes that will be forgone. These assumptions are plainly inconsistent.

Put another way, NERA claims that rolling back the baseline standards will reduce vehicle prices because vehicles will not include the cost of technology to improve efficiency. At the same time, NERA suggests it would be appropriate to count as benefits of the rollback the additional performance attributes consumers will allegedly purchase when they are not required to purchase efficiency. But, of course, obtaining that additional performance requires technology, which will raise the price of the vehicle. In other words, NERA has failed to account for the cost of performance-enhancing technology while claiming that consumers benefit from additional performance when the baseline standards are rolled back. This is inconsistent.

If NERA is right that consumers will lose welfare due to opportunity costs, the modeling of compliance costs would also have to allow manufacturers the flexibility to produce vehicles with a different mix of attributes and costs that (according to the modeling) better meets consumers demand. Doing so would substantially *reduce* the compliance costs of the rule because the cost modeling would allow manufacturers to produce lower-cost, but lower-performing, vehicles that comply with the standards.[154]

F. Policy Integrity's Critiques of Consumer Benefits Are Not Limited to NERA's Calculation of the Benefits of Fuel Savings

In its response, NERA asserts that Policy Integrity did not question NERA's approach for calcuating consumer benefits of the baseline standards other than fuel savings, including time consumers save by having to refuel less often.[155]

In fact, in its initial comments to the agencies, Policy Integrity raised a number of detailed concerns regarding the methodology for calculating refueling benefits.[156] And NERA's

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[152] NERA/Trinity Report at 5.

[153] Proposed Rule, 83 Fed. Reg. at 43,027.

[154] Helfand & Dorsey-Palmateer at 450; s*ee* Bento et al. (2018) at 4 ("[B]oth the 2016 TAR and 2018 NPRM have likely overestimated compliance costs. Neither analysis considers the full extent of options that manufacturers have available to respond to these policies, including changes in vehicle prices, performance, and *other attributes*") (emphasis added).

[155] NERA Response at 24.

[156] Policy Integrity October Comments at 51-56.

methodology for calucating the benefits of reduced refueling time "follow[s] the formulation used in the NHTSA/EPA PRIA for estimating the value to consumers from reduced refueling time with one minor difference."[157] As a result, the critiques in Policy Integrity's initial comments also call into question NERA's approach. Specifically, the methodology used by the agencies and NERA underestimates the refueling benefits of the baseline standards (and therefore the forgone benefits of the proposal) by overestimating rebound; uses outdated data; fails to recognize any value of time saved for children under 16; erases 40 percent of time saved based on the incorrect assumption that consumers on a fixed schedule will see no savings; and ignores the fuel saving and emission reduction benefits of avoided refueling trips. Neither the original NERA/Trinity Report nor NERA's response rebuts any of these critiques.

VII. Conclusion

The agencies should not rely on NERA's analysis in any final rule that establishes greenhouse gas emissions or fuel economy standards.

[157] NERA/Trinity Report at H-3.

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The following documents are cited in the May 2019 comments submitted by the Institute for Policy Integrity. Where there are no copyright restrictions, the documents are attached so as to make them part of the record. For the documents where there are copyright concerns, we ask that the agencies include them in the record. Many of those documents were cited by the agencies and are thus already part of the record. Where available, we have included links for ease of reference.

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