PRIA Appendix 2: Alternative Analysis

The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule III for Model Years 2022 to 2031 Passenger Cars and Light Trucks

December 2025

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

A2. Results Using Revealed Preference

When multiple vehicles are available at the same purchase price, choosing one that does not minimize fuel expenses reveals a preference for the features it offers *other than* higher fuel economy. The greater the difference in fuel expenses between the model a buyer chooses and the competing model with minimum fuel expenses, the higher is that buyer's apparent valuation of—or revealed preference for—the other attributes the chosen model offers. This principle of "revealed preference," originally developed by noted economist Paul Samuelson, applies broadly to consumers' choices, not just to buyers' preferences among vehicle models, and continues to be a leading approach in economic analysis of consumer behavior.[1] An accompanying principle is that in the absence of externalities, any change in the prices of competing products that causes a consumer to switch from the one initially chosen to another product that was also initially available involves a welfare loss.[2] Office of Management and Budget (OMB) Circular A-4, which outlines best practices for agencies conducting regulatory impact analysis, recognizes revealed preference as a core empirical basis for valuing benefits and costs by noting that evidence from actual choices in markets should generally be preferred over stated preferences or intentions whenever feasible.

In the context of the proposed rule, the analysis presented in this appendix interprets car buyers' reluctance to purchase higher MPG models (in the absence of requirements that manufacturers offer them throughout their product lines) as revealing buyers' preference for—and higher valuation of—improvements in features other than fuel economy. This analysis attempts to estimate the benefits consumers gain from being able to purchase models offering lower fuel economy than previously adopted Corporate Average Fuel Economy (CAFE) standards would have required, in combination with improved other features, and compares those benefits with the social costs generated by a fleet with higher fuel economy.

A2.1. Key Facts Pointing Toward High Costs of Compliance with the 2024 Rule

This appendix offers alternative cost-benefit analyses built more on market observations than on engineering projections. Overall, these analyses further support the reasonableness of the proposed rule and the unreasonableness of the existing rule. The economic principles are the same as in this Preliminary Regulatory Impact Analysis (PRIA)'s Figure 7-1: regulation creates costs reflected in that figure's supply curves and affects consumer values reflected in that figure's demand curves. The key differences between this appendix and Chapter 7 of the PRIA are the data sources and the treatment of revealed preference. This appendix imposes the revealed preference restriction that the private benefits of consumer choice are not negative; Chapter 7 does not.

A2.1.1. Market Size and Importance

A key economic fact about the U.S. market for light-duty vehicles is its sheer size. Thirteen million new gasoline- and diesel-powered passenger cars, sport utility vehicles, and light trucks are sold annually, with consumers spending more than $600 billion on them. The consumer value created significantly exceeds expenditures, reflecting substantial consumer surplus. That is, cars and light trucks offer more than transportation—they deliver freedom, mobility, and reliability. Beyond fuel efficiency, vehicle buyers also value affordability, safety, reliability, driving performance, and much more.

[1] Samuelson (1948), "Consumption theory in terms of revealed preference." *Economica*. See also recent developments by Blundell, Richard; Browning, Martin; Cherchye, Laurens; Crawford, Ian; De Rock, Bram; and Vermeulen, Frederic. 2015. "Sharp for SARP: Nonparametric Bounds on Counterfactual Demands." American Economic Journal: Microeconomics 7(1): 43–60.

[2] The welfare loss could be essentially zero if the consumer is indifferent between the two choices. This possibility highlights the importance of quantitative estimates of the difficulty of substitution (DoS) between vehicles.

A2.1.2. The Indirect and Incidental Relationship Between "Fuel-Economy Standards" and Market Wide Fuel Consumption

A key economic fact about the 2024 CAFE rule is that it rewarded the sales of fuel-efficient vehicles while penalizing the sales of less efficient ones, rather than penalizing vehicle owners in proportion to the fossil fuels that they burn. That is, the link between the rule's economic incentives and total fuel consumption by regulated vehicle markets is indirect and incidental.

Under the 2024 rule, the market-wide sales-weighted harmonic mean of fuel-economy ratings must not fall short of CAFE target fuel economy. The fuel-economy ratings, expressed in miles per gallon (MPG), are assigned by the rule according to laboratory test cycle measurements for various vehicle designs. The average for a particular manufacturer in a particular segment (by footprint, car versus truck) may fall short of the target, but the manufacturer must ultimately compensate by exceeding the target in other segments or in other years.[3]

The fuel-economy rating applicable to a particular vehicle's sale is not connected to the fossil fuels used by that vehicle after it leaves the showroom. Two vehicles with the same fuel-economy rating can result in vastly different fossil fuel usage. One may be driven intensely for decades, while the other is put on display in a museum never to be driven again. One may primarily carry light payloads on highway trips, while the other primarily carries heavy payloads between intra-city destinations.

A2.2. Summary of Costs and Benefits

This appendix estimates that the total benefits of the National Highway Transportation Safety Administration (NHTSA)'s proposed action far exceed the total costs. The annualized value of monetized benefits to the United States is estimated at $18 billion to $20 billion, as shown in Table A2-1. The annualized costs associated with additional fossil fuel use are estimated to be less than $1 billion, relative to the baseline of retaining the 2024 rule setting CAFE standards for light-duty vehicles. This puts the net benefits of the proposed action in the hundreds of billions in net present value (NPV).

Table A2-1: Summary of Benefits and Costs in Billions of 2024 Dollars, Annualized Over Years 2027-2050

Benefit Category	Range	Cost Category	Range
Private (light-duty vehicle users)			
Vehicle composition	17 - 18	External safety	-0.5 - -0.6
Vehicle quantity	0.1 - 0.1	Congestion	0.0 - 0.0
Fuel tax revenue	1 - 2	Health	0.2 - 0.2
Total Benefits	18 - 20	Total Costs	-0.3 - -0.4

A2.2.1. Resource and Opportunity Costs: Vehicle Markets

Of all the benefit and cost categories, by far the largest one reflects the opportunity and resource costs of changing the vehicle composition away from what consumers want. Most of the benefits come from having a composition of light-duty vehicles closer to what consumers want.

Resource costs include, but are not limited to, the "Vehicle technology costs" referenced in the 2024 rule. Resource costs also include capital equipment, additional maintenance, human time, and effort required to manage a fleet of vehicles whose composition would, under the 2024 rule, become increasingly divorced from what consumers want to drive.

[3] Under both no action and the proposed rule, a manufacturer can transfer compliance between fleets, though subject to statutory limits. The 2024 rule permits compliance trading between manufacturers through its CAFE Credit Program. That is, a manufacturer that failed to meet the standard could attain compliance by purchasing "credits" from another manufacturer based on the amount by which the latter exceeded the standard. Inter-manufacturer compliance trading would not be permitted under the proposed rule. The change is reflected in the analysis that follows.

In establishing standards, the agency must consider that new vehicles' potential buyers and users value a wide range of attributes. The attributes include, but are not limited to, occupant protection and other safety features, vehicle size and carrying capacity (for both passengers and luggage or cargo), ride comfort, and performance attributes, such as acceleration, power braking, and maneuverability. The 2024 rule would eliminate the opportunity to purchase inexpensive low-MPG vehicles that offer more of these other features, which is a significant cost to consumers looking for features that the high-MPG vehicles do not offer.

Table A2-1 includes opportunity costs.[4] This analysis quantifies resource and opportunity costs with a market-based approach, originating with the 2020 Council of Economic Advisers (CEA) report on the SAFE Vehicles rule.[5] The report quantifies the ease, or difficulty, of inducing consumers to give up low-MPG vehicles (*L*) and accept high-MPG vehicles (*H*) instead. The DoS parameter is an economic measure of consumer preferences and the situations in which they use vehicles, as opposed to a legal term. CEA uses earlier regulatory changes by the U.S. Environmental Protection Agency (EPA) and NHTSA to measure the DoS parameter, which is a key element of market responses to legal changes made by NHTSA in 2024 and of this analysis.[6]

EPA's tailpipe and NHTSA's CAFE rules apply to a broad fleet of light-duty vehicles that include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) as well as gasoline- and diesel-powered passenger cars and light trucks. However, Congress placed specific limitations on how NHTSA considers the fuel economy of alternative-fueled vehicles, which includes not only BEVs and fuel cell electric vehicles (FCEVs), but also the electrical operation of PHEVs. Congress also restricted NHTSA from considering the availability of credits when setting standards. The fuel economies of BEVs and FCEV technologies are excluded entirely from NHTSA's standard-setting analysis.

The analysis in this appendix excludes any possibility that some of the gasoline- or diesel-powered vehicles sold under the proposed rule would have been electric vehicle (EV) sales under the 2024 rule, or vice versa.[7] This scenario is approximated by the market behavior CEA observed because not many EVs were sold at that time, though the approximation is imperfect because those EV sales were not zero.[8] This approximation errs in the direction of understating consumer benefits because the estimates are not applied to consumers who would have purchased EVs under the 2024 rule when the internal combustion vehicles they preferred became prohibitively expensive.

Any RIA prepared in 2025 and using the 2024 rule as its no-action baseline is subject to substantial uncertainty because that rule imposed fuel-economy standards well beyond what has yet been experienced in the United States. That is, any such RIA is unavoidably an extrapolation exercise. The extrapolation required by this analysis is apparent in the PRIA Appendix 2 Alternative Analysis worksheet.[9] This calculation of cost also allows for future technological progress in vehicle manufacturing that steadily increases the fuel efficiency of each subsequent model year (MY) at the annual rate observed in EPA's automotive trends data for MYs 1978-2011. Estimating this rate of progress introduces another source of uncertainty.

Using the revealed preference method, the estimates of combined savings in resource and opportunity costs ("benefits") relating to the composition of vehicle fleets range from $17 billion to $18 billion annually.[10] Reducing quality-adjusted vehicle prices also increases consumer surplus by leading to an increase in vehicle

[4] Foregone consumer surplus is an instance of opportunity cost. This important cost category is emphasized in regulatory impact analysis (RIA) guidance from the Office of Management and Budget.
[5] See https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf. Resource and opportunity costs are not reported separately in this appendix because they are a combined category in the CEA model of the regulatory costs of fuel-economy standards.
[6] CEA focuses on the price at which automakers historically bought credits to comply with EPA/NHTSA rules (EPA's tailpipe emission standards are based on the same fleet-average laboratory test cycle results as NHTSA's CAFE standards). If enough consumers view low-MPG and high-MPG vehicles as functionally interchangeable, then manufacturers would have found it relatively easy to comply with more stringent EPA/NHTSA standards by marketing the high-MPG vehicles, without dropping their purchase price or elevating prices of low-MPG vehicles, rather than seeking compliance credits from other manufacturers. In this case, tightening the standard would have resulted in only a slight increase in the credit prices. Instead, compliance credit prices increased markedly as the standard tightened, which is evidence that consumers were unsatisfied with the federally prescribed vehicle composition until they faced a significant price premium for the low-MPG vehicles.
[7] For PHEVs, the analysis uses fuel-economy values that assume "charge sustaining" (gasoline-only) operation only.
[8] See https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf.
[9] The PRIA_Appendix2_AlternativeAnalysis.xlsx can be found in the rulemaking docket (NHTSA-2025-0491) by filtering for Supporting & Related Material.
[10] The economic principles are the same as in this PRIA's Figure 7-1: regulation creates costs reflected in that figure's supply curves and affects consumer values reflected in that figure's demand curves. The key differences between this appendix and Chapter 7 of the PRIA are the data sources and the treatment of revealed preference. This appendix imposes the revealed preference restriction that the private benefits of consumer choice are not negative; Chapter 7 does not.

purchases. This addition to consumer surplus is another example of reduced opportunity costs, because its loss would have been a consequence of the previous rule. Its amount can be approximated as one half the decline in quality-adjusted price multiplied by the increase in quantity. The annualized estimate of this addition to consumer surplus is positive but less than $1 billion.

A2.2.2. Fuel Expenditure and "Drive Value" in a Revealed Preference Model

To avoid double counting, Table A2-1 does not include an additional cost or benefit for fuel expenditures. A consumer fully cognizant of the fuel consumption of a lower MPG vehicle may nonetheless prefer that vehicle because it offers other features whose value more than offsets the additional fuel expenses. According to the principle of revealed preference, a rule that increased prices for low-MPG vehicles enough to persuade the consumer to switch to a high-MPG vehicle is a consumer harm, not a "benefit" equal to the consumer's reduced spending on fuel, because the savings on fuel is more than offset by the loss of utility provided by the low-MPG vehicle's other features.[11] With the difference between these two categories already captured by consumer surplus, including an estimate of one without an estimate of the other in the cost-benefit analysis would substantially distort the results.[12]

Another approach would be to assume that consumers are unaware of the higher fuel expenses associated with purchasing low-MPG vehicles, but empirical evidence supports the claim that consumers value a significant portion of the lifetime fuel expenses at the time of purchase.[13] A potential solution that encourages rational decision-making is to improve consumer information rather than regulating the choice set of vehicles available in the market.[14] There is immense heterogeneity among consumers, whose diverse circumstances—such as varying commuting distances, household budgets, climate conditions, and even preferences for vehicle features like towing capacity or off-road capability—profoundly shape their choices. The lack of granular knowledge of the individual contexts and preferences makes it difficult to model consumer choice from a bottom-up approach.

A2.3. Economic Models of Regulatory Impact

Fundamentally, the economic models used in this appendix to analyze this action are supply and demand models. The supply of vehicles reflects processes of innovation, manufacturing, and retailing, subject to regulatory constraints. Demand for vehicles derives from demand for transportation, safety, freedom, mobility, reliability, and other characteristics valued by household and commercial owners of vehicles. The vehicle market piece of the analysis is sufficient by itself to estimate a significant portion of the resource and opportunity costs of fuel-economy standards.

A2.3.1. Vehicle Supply and Demand: The Composition of Sales

Fuel-economy regulations are imposed on new vehicles. Resource and opportunity costs are calculated once for each cohort of new vehicles. The calculation begins by letting L and H denote the market-level quantities of new low-MPG and high-MPG vehicles, respectively. Model year subscripts are omitted, with the understanding that quantities, prices, and standards vary by model year and fleet.

Though the cost formulas are derived in this two-type setting, the two-type cost formulas also describe models with an arbitrarily large number of vehicle types.[15] For cost-benefit estimation purposes, this analysis

---

[11] PRIA Chapter 2.1.2 explains how the empirical evidence supports the claim that consumers value a significant portion of the lifetime fuel expenses at the time of purchase.
[12] The net of these two is essentially an increase in the quality-adjusted price, as shown by the microeconomics result known as "Shephard's Lemma."
[13] See the literature cited in Chapter 2.1.2 of this PRIA.
[14] OMB Circular A-4 encourages "informational measures rather than regulation." It concludes that "a particularly demanding burden of proof is required to demonstrate the need for . . . mandatory uniform quality standards for goods or services if the potential problem can be adequately dealt with through voluntary standards or by disclosing information of the hazard to buyers or users." To be clear, Circular A-4 does not assert that information alone is necessarily adequate to address market failures associated with externalities, which is why this proposed action includes separate environmental items in its regulatory impact calculus.
[15] The many-vehicle case would be analyzed with vectors, which is demonstrated in this footnote and elsewhere confine the analysis to the two-type case. The vector analysis lets q denote a (potentially long) vector of market quantities of vehicle models, which differ in many characteristics, including emissions. The CAFE standards affect these quantities, including setting some of them to zero as vehicles leave the market and moving others off of zero

therefore summarizes the fuel-economy ratings for low- and high-MPG vehicles as two constants *l* and *h*. Therefore, with a market-level fuel-economy target of $MPG \in (l,h)$, the market-level regulatory constraint is:

Equation A2-1: The Fleet Fuel Consumption Constraint

$$\frac{L}{l}+\frac{H}{h}\leq\frac{L+H}{MPG}$$

The left-hand side of the regulatory constraint Equation A2-1 is the actual fuel consumption if each vehicle sold were driven a mile under the laboratory test conditions. The right-hand side is the aggregate gallons of fuel consumed if every vehicle sold were driven a mile and each vehicle had fuel economy equal to the standard *MPG*. *MPG* is a policy parameter while *L* and *H* are market outcomes. Stricter standards correspond to values of *MPG* further from zero. The regulatory constraint Equation A2-1 has an equivalent representation as a constraint on the quantity share of high-MPG vehicles, *H*/(*L*+*H*):

Equation A2-2: Fuel Standards Constrain Fleet Composition

$$\frac{H}{L+H}\geq\frac{h}{h-l}\left(1-\frac{l}{MPG}\right)$$

Henceforth, the regulatory constraint in Equation A2-2 is assumed to hold with equality. It is an arithmetic demonstration of the earlier conclusion that fuel-economy regulation directly encourages sales of high-MPG vehicles and discourages sales of low-MPG vehicles. How the vehicles are driven after they leave the showroom is notably absent from the regulatory constraint.

The policy parameters corresponding to the quantitative results for the revealed preference approach are shown in Table A2-2. Each table entry is the weighted-average harmonic mean of the fleet-specific achieved fuel economy, using sales weights.[16] Market averages are essential for connection to the opportunity cost modeling, which is at the market level. Below, this analysis discusses how limits on inter-fleet and inter-manufacturer credit trading affect the interpretation of the results.

Table A2-2: Market Average MPG Achieved by Model Year and Alternative as Used in the Economic Modeling

Model year	No Action	Alt 1	Alt 2	Alt 3
2027	43.5	42.2	42.2	42.4
2028	45.8	40.3	40.4	40.6
2029	47.5	40.8	40.8	41.3
2030	48.5	41.1	41.1	41.6
2031	48.8	41.3	41.3	41.8

Note that the weights on passenger cars and light trucks change substantially in model year 2028 due to the reclassification of vehicles. The change in weights by itself increases the harmonic-mean CAFE required fuel economy because the MPG requirement for passenger cars exceeds the requirement for light trucks. That is, the achieved MPG in MY 2028 and beyond would be even lower than indicated in the Alt 1, Alt 2, and Alt 3 columns for a hypothetical rule that had the same fleet standards as this proposed rule but did not reclassify

as vehicles enter. Let *p*, *c*, and *g* denote the corresponding vectors of retail prices, marginal production costs, and fuel consumption per mile (i.e., the reciprocal of the fuel-economy ratings), respectively. With one-for-one pass-through of costs to retail prices, $p = \mu + c + (g–G)\lambda$, where *G* and λ are scalars denoting the (reciprocal of the) fuel-economy standard and the equilibrium price of a compliance credit measured in gallons per mile per vehicle, and μ is a vector of vehicle-specific markups that, by the pass-through assumption, are independent of the CAFE standard. If the CAFE standard is binding and dot indicates vector dot product, then $g \cdot q = Gq$, which means that specific vehicles can deviate from the standard but the market sales-weighted average emissions does not. It follows that the standard has a retail price effect that varies across vehicles. The sales-weighted retail price impact is simply the scalar $-\lambda$. In words, the average price effect of a stricter standard (lower *G*) is exactly the compliance credit price λ, regardless of whether there are just two vehicle types or many.

[16] For example, the preferred alterative column (Alt 2) of Table A2-2 corresponds to the TOTAL row of the preamble's Table I-2.

vehicles. The purpose of this appendix is to project the net benefits of the proposed rule, accounting for both the reclassification and the change in fleet requirements.

A2.3.2. Resource and Opportunity Costs of Increasing MPG

F(*L*,*H*) denotes a constant returns quantity index for the industry, of the same type as the Bureau of Economic Analysis uses in its industry and national accounting. Specifically, *F* reflects consumer preferences. In this way, purchases of low-MPG vehicles *L* and high-MPG vehicles *H* reflect derived demands by consumers seeking transportation, freedom, mobility, reliability, and other characteristics.[17]

The elasticity of substitution quantifies how easy it is to induce the industry's consumers to switch between *L* and *H*. If the market views *L* and *H* as poor substitutes, then the elasticity of substitution in *F* is low, regardless of whether regulators think that high-MPG vehicles are just as good or better for owners than low-MPG vehicles are. In that case, high-MPG vehicles will need to sell for a steep discount, and low-MPG vehicles for a substantial premium, in order for consumers to make purchases that align with the standards at a market level. The close substitution case is represented with a high elasticity of substitution, in which case consumers readily switch from low-MPG vehicles to high-MPG vehicles with little price change.

Though this analysis does not treat the elasticity of substitution as a constant, the elasticity can be understood as a parameter that allows consideration of scenarios corresponding to various assumptions about the ease of consumer substitution. Using market signals to assess which scenario is more realistic is known as revealed preference. As emphasized in OMB guidance for RIAs, revealed preference is an important component of reliable cost-benefit analysis.

The "supply" of *F* reflects the marginal costs of producing the two vehicle types. Regulatory distortions increase this marginal cost, which is passed through one-for-one to the purchasers of vehicles.[18] Because *F* is a quantity index representing consumer preferences, regulatory-induced shifts reflect both added manufacturing costs and added opportunity costs of a fleet composition *H*/*L* that differs from what consumers desire. These costs increase, and are convex (i.e., increase at an increasing rate), as *H*/*L* increases above the desired level. The rate of increase is greater (less) when *H* and *L* are poor (close) substitutes, which is why CEA consulted actual results of fuel-economy standards to gauge the ease of substitution. The level curves of *F* and the role of its substitution rates are illustrated in Figure 3 of the CEA report.

From the equality version of the regulatory constraint in Equation A2-2, the ratio *H*/*L* is increasing in fleet MPG:

Equation A2-3: Fleet Composition Constraint

$$\frac{H}{L} = \frac{h}{l}\frac{MPG-l}{h-MPG}$$

The average cost per quality-adjusted vehicle is the cost of producing one unit of *F*(*L*,*H*). There is exactly one ratio *H*/*L* and one fleet *MPG* that minimizes this average cost. The average cost of producing a unit of *F*(*L*,*H*) represents a quality-adjusted price increase in the sense that *F*(*L*,*H*) is more expensive to produce when consumers are not free to choose the mix of vehicles that they want.

The analysis lets MPG_0 denote the average-cost-minimizing fleet *MPG*. On a per-vehicle basis, the resource and opportunity costs associated with fleet compositions that differ from what consumers want is the difference between the average cost under regulation and the average cost that would be achieved at MPG_0.[19] *F* itself is a quality-adjusted quantity in that, when $MPG > MPG_0$, replacing *H* sales with *L* sales reduces *F* even though it has no effect on the raw number of vehicles.

[17] The economics of derived demand was developed by Alfred Marshall in *Principles of Economics*, MacMillan and Co., 1895, and Sir John Hicks' *The Theory of Wages*, MacMillan and Co., 1932. Its real-world applications have proliferated since then, as with Gary S. Becker's, "A theory of the allocation of time", *Economic Journal*, 1965, and CEA's *Economic Report of the President*, 2019.
[18] Earlier NHTSA analyses of effects of vehicle regulation on retail prices also assume one-for-one pass-through.
[19] The impact of one regulation relative to a baseline of another regulation is the difference between the corresponding two average costs.

Instead of referring to quality-adjusted prices and quantities, equivalent results could be obtained by referencing "raw" quantities *L* + *H* and examining how regulation shifts the supply and demand for raw quantities, as Figure 7-1 of this PRIA does.[20] This appendix offers the quality-adjusted exposition because of its close correspondence to CEA's report and to the national income accounting convention of decomposing industry revenue into quality-adjusted price and quality-adjusted quantity indexes.

A2.3.2.1. Opportunity Costs at a Point in Time

This appendix seeks a point estimate for per-vehicle resource and opportunity costs. Specifically, it uses market information to assess how quickly the effect of *MPG* on average cost increases with *MPG*.

The costs of increasing MPG (equivalently, the sales share of high-MPG vehicles) beyond MPG_0 can be quantified algebraically as the quadratic formula in Equation A2-4:[21]

Equation A2-4: Quadratic Impact Formula

$$\text{impact of MPG on per-vehicle cost} \equiv \Delta(\text{MPG}) = \frac{k_0}{2\sigma_0}(\text{MPG-MPG}_0)^2$$

where k_0 is a constant that depends only on the unregulated outcome and σ_0 is the elasticity of substitution between vehicle types in the quantity index *F* at the unregulated fuel-economy standard.[22]

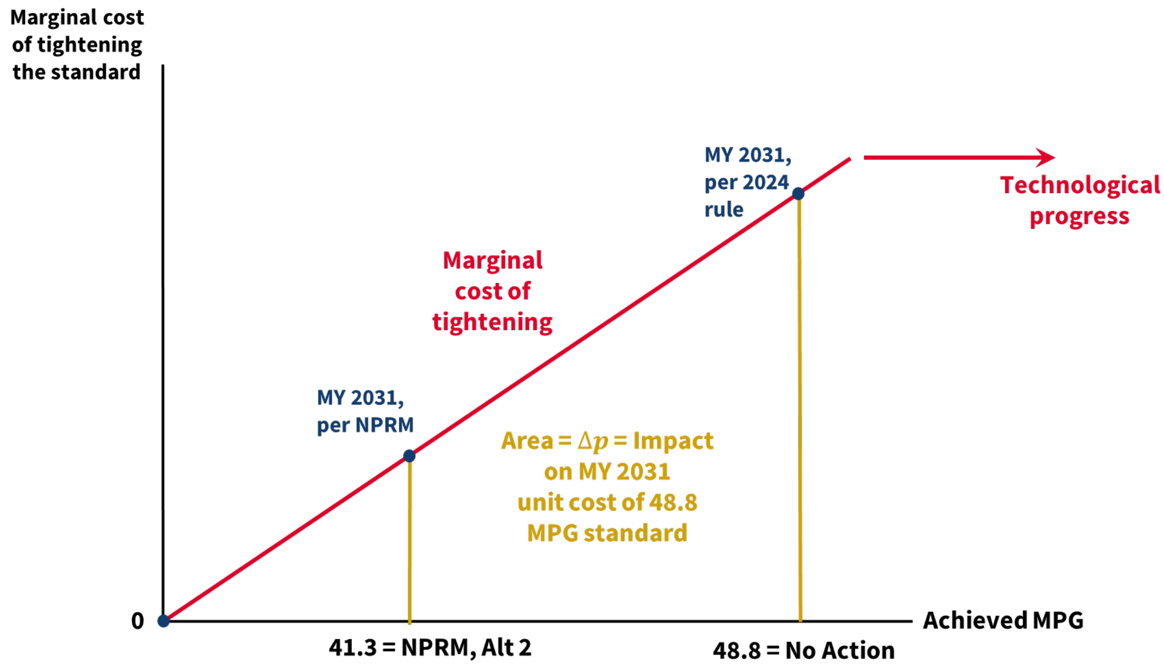
Because the formula is inversely proportional to the elasticity of substitution at the unregulated vehicle composition, it formalizes what was previously concluded about the ease of substitution between vehicles. If the market views *H* and *L* as poor substitutes, then σ_0 is low, and the standard *MPG* has a large effect on per-vehicle cost, especially to the extent it departs from what consumers want (represented as MPG_0). A fundamental omission from NHTSA's 2024 rule was any attempt to assess the degree of substitutability.

Equation A2-4 readily allows for technological progress in vehicle manufacturing by letting MPG_0 increase with time at the same rate under the proposed rule and with no action. This progress may represent changes in consumer preferences such as the increased adoption of (non-plug-in) hybrid vehicles. It may represent engineering advances, changes in consumer attitudes or circumstances, or trends in the structure of energy prices. All of the cost-benefit scenarios from the revealed preference approach assume technological progress in this way, with details explained further in Chapter A2.3.2.2 of this appendix.

The *MPG* derivative of Equation A2-4 is illustrated by Figure A2-1 red line, adapted from CEA (2020). The cost impact shown in Equation A2-4 therefore corresponds to areas in the figure. The red arrow indicates the assumed technological progress that shifts the red line horizontally over time. Two standards are shown as points on the red line.

[20] Appendix III of Mulligan, Casey B. (2025), "Equilibrium responses to price controls: a supply-chain approach," *Public Choice* 203: 23-52, proves the equivalence between the "Barzel approach" (corresponding to this PRIA's Figure 7-1 featuring raw quantities) and the "supply-chain approach" (corresponding to the exposition in this appendix featuring quality-adjusted quantities).
[21] This is a second-order Taylor approximation to the impact on average cost per quality-adjusted vehicle in the neighborhood of no standard (MPG_0). CEA (https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf) found that a quantity index *F* with a constant elasticity of substitution (CES) would be closely approximated by the quadratic Equation A2-4, except when the standard is especially tight, in which case linear marginal cost underestimates compliance costs.
[22] The quadratic Equation A2-4 is a second-order approximation to the regulatory impact if the quantity index function *F*(*L*,*H*) exhibits constant returns. The index function could have CES, but it need not. Without CES, the elasticity of substitution varies with MPG.

Figure A2-1: Opportunity and Resource Costs for Two Standards, Per Light-Duty Vehicle



The 2020 study by CEA measured the ease of market substitution between high- and low-MPG vehicles, thereby providing the slope of the red line. In terms of Equation A2-4, that slope is the ratio k_0/σ_0. That is why this appendix refers to the slope as the DoS parameter. If consumers would readily switch from low-MPG vehicles to high-MPG vehicles, then the compliance credit prices would barely increase with higher standards, because manufacturers would be increasing the high-MPG intensity of their sales with little consumer resistance. CEA found the opposite: tighter standards were associated with substantially greater regulatory credit prices.[23]

CEA used the latest public inter-manufacturer data and other marginal cost data that was available at the time of conducting their study, which referred to market conditions prior to 2017. Perhaps the CEA timeframe is advantageous because it preceded a period in which standards would fluctuate substantially between administrations, thereby creating capital gains and losses in compliance credit markets.

What follows draws more precisely from the CEA opportunity cost model, including allowing for standards to vary by model year. It also allows for technological progress in vehicle manufacturing and other modeling approaches.

A2.3.3.2. Opportunity and Resource Costs by Model Year

For each model year (MYs 2027-2050) and vehicle class scenario, the corresponding per-vehicle combined opportunity and resource cost of the proposed rule is calculated from that year's no-action standard and projected MPG. The method used is Figure A2-1 adjusted over time for technological change.

To estimate a rate of technological progress in light-duty vehicles, this analysis used EPA's automotive trends data for MYs 1978-2011, before greenhouse gas standards were imposed. When real-world MPG was regressed on year and horsepower, the coefficient on year was 0.553. When weight was added to the

[23] CEA (https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf) also considered the possibility that inter-manufacturer credit markets are not competitive in the sense that manufacturers might withhold some of their trading in order to favorably affect the credit market price, driving a wedge between their marginal cost of compliance and the credit price. CEA notes that some automakers sell credits, while others purchase credits (https://www.fueleconomy.gov/feg/pdfs/420r16010.pdf). If large enough, the former have an incentive to drive up the price while the latter have an incentive to push it down. The credit price may be a conservative estimate of the marginal cost of compliance if larger manufacturers tend to be net buyers.

regression, the year coefficient was 0.133. Except for sensitivity analysis, the annual rate of progress is taken to be the average of these two, 0.343.

With technological progress modeled in this way, eventually even the toughest standards have no cost. Arithmetically, MPG_0 eventually catches up with the MPG-equivalent of target set for the out years by the 2024 rule.

The average cost impact of the no-action target $MPG_{no\text{-}action}$ relative to the $MPG_{proposed}$ that would prevail under the proposed rule is $\Delta(MPG_{no\text{-}action}) - \Delta(MPG_{proposed})$.

Take, for example, MY 2031. From Table A2-2, the no-action *MPG* is 48.8. The Alternative 2 MPG is 41.3. The reduction in the quality-adjusted price per vehicle is the base of Figure A2-1's impact trapezoid (7.5 MPG) times the average of its two marginal cost heights. The heights are found from CEA's Figure 4, adjusted from 2018 dollars to 2024 dollars. Due to the assumed technological progress, 48.8 and 41.3 MPG in MY 2031 are equivalent to 46.7 and 39.2 MPG in the CEA chart, respectively. There the marginal cost heights are $261 per MPG per vehicle and $179 per MPG per vehicle, respectively, which yields an average of $220 per MPG per vehicle. The price impact is therefore $1,651 per vehicle (up to rounding, 1651 = 220 × 7.5), or 3 percent of the average price of a new vehicle.

Applied to 13 million vehicles produced in MY 2031, the cost savings for that year would be about $21 billion. The annualized entry in Table A2-1 is somewhat less because MY 2031 represents the model year with the largest per-vehicle cost savings, and savings are lower in other model years. See the cost calculations in the PRIA Appendix 2 Alternative Analysis worksheet for further details.[24]

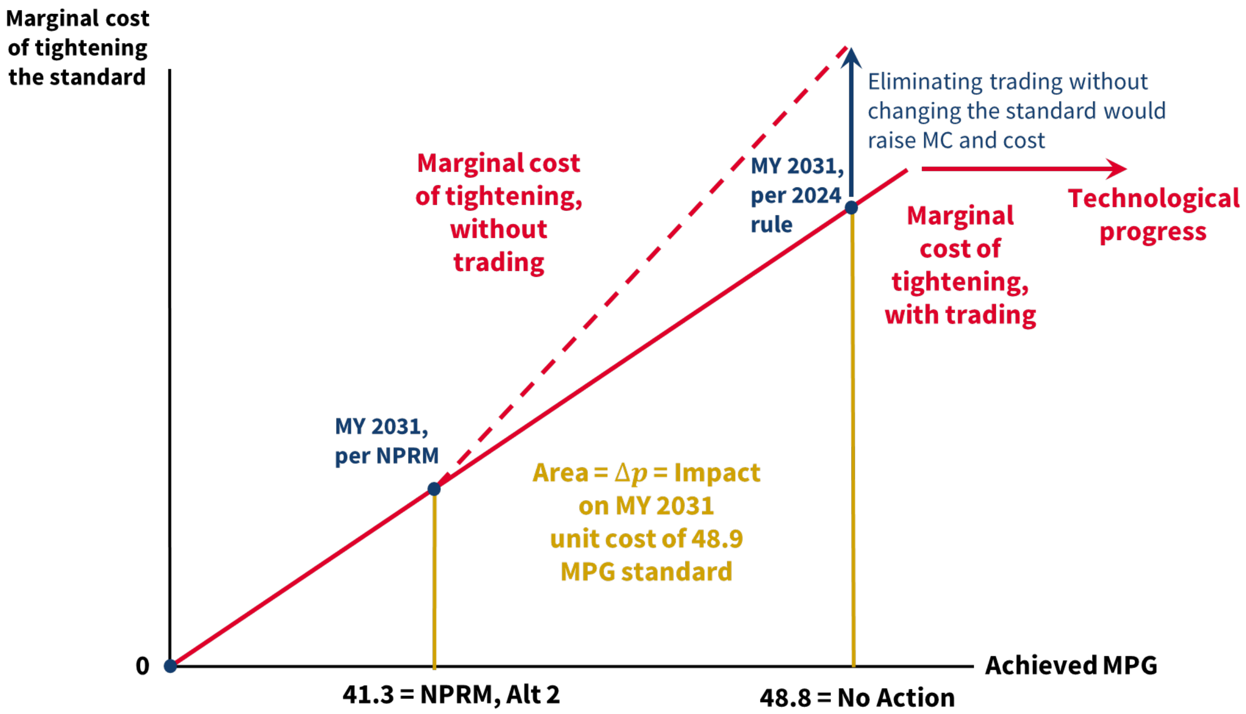
A2.3.2.3. Proposed Elimination of the Inter-Manufacturer Credit Trading Program

The preamble discusses NHTSA's proposal to eliminate the inter-manufacturer credit trading program (which is authorized, but not required, by 49 U.S.C. 32903(f)) beginning with MY 2028. If the standards were to remain as stringent as under the 2024 final rule, such trade would help reduce aggregate compliance costs as manufacturers less able to comply purchase credits from other manufacturers that can over-comply. Such a trading pattern has been observed historically, with Stellantis (formerly Fiat Chrysler Automobiles) emerging as a major buyer as fleet fuel-economy requirements increased. Moving forward, however, it is unclear how the statutory change to the CAFE civil penalty rate to $0 might impact how credits would change manufacturers' compliance costs.

This pattern is illustrated in Figure A2-2. At the more stringent standard of 48.8 MPG, eliminating credit trading would increase the marginal cost of complying with the standard, as indicated by the vertical arrow.

[24] The PRIA_Appendix2_AlternativeAnalysis.xlsx can be found in the rulemaking docket (NHTSA-2025-0491) by filtering for Supporting & Related Material.

Figure A2-2: Opportunity and Resource Costs for Two Standards, With and Without Credit Trading



With Stellantis and other would-be credit buyers unable to trade, the value of reducing the standard would be particularly high, illustrated in Figure A2-2 by the steeper, dashed red line. The dashed line intersects the solid line where the standard is set so that each manufacturer complies on its own. If the intersection is at or above the proposed rule's standard, then the additional cost impact of the proposed rule's proposal to eliminate credit trading is the combination of moving up the vertical arrow and down the dashed line, which is equivalent to moving down the solid line featured in Figure A2-1.

A2.3.3. Vehicle Quantities and Opportunity Costs of Reduced Vehicle Sales

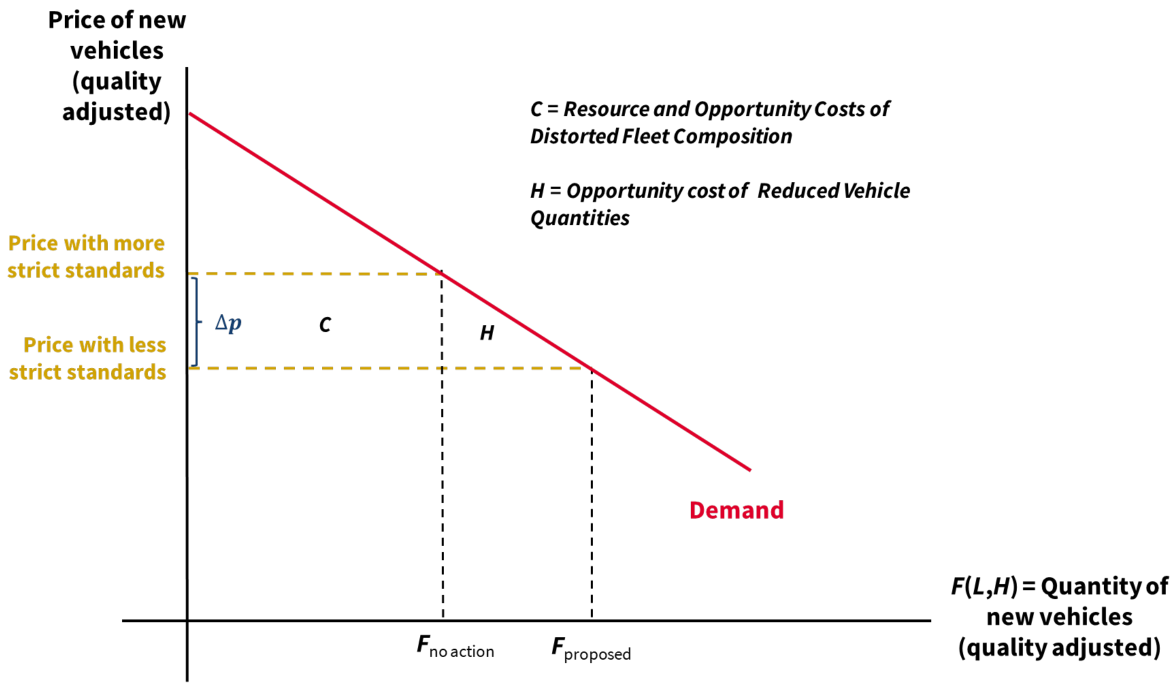
A2.3.3.1. The Price Elasticity of Vehicle Demand

When regulations add to vehicle costs, consumers will purchase fewer vehicles, at least as measured by the quantity index. To quantify this effect, a market demand curve is added to the analysis. Specifically, let $D(F)$ denote the inverse market demand for F. This establishes the equilibrium value of the quantity index F and the price P of a unit of F. Namely, price is related to the quantity index by the demand equation $P = D(F)$, which also equals the marginal cost of supplying F.[25]

Figure A2-3 illustrates that the resource and opportunity cost savings from the proposed rule for vehicle buyers are equal to the combined area C and H. The rectangular area C by itself represents the resource and opportunity costs of distorted vehicle composition. The height of the rectangle is the quality-adjusted price impact calculated with the methods previously cited. In principle, the price impact is applied to the no-action quantity. However, lacking data on the price and quantity without action, (a) the price impact is expressed as a ratio to the average vehicle price measured in 2025, which is somewhere in between the no-action price and the price that would prevail under the 2024 rule; (b) the proportionate impact is multiplied by the corresponding demand factor $F_{no\text{-}action}/F_{proposed}$; and (c) this estimate is then multiplied by 2024 revenue for the vehicle class.[26]

[25] Adding constant seller markups between marginal cost and *F* would further add to the opportunity costs calculated here.
[26] As long as the demand for vehicles is price inelastic, this calculus slightly underestimates the dollar amount represented by the area *C* in Figure A2-3.

Figure A2-3: Resource and Opportunity Costs Distorted Composition and Reduced Sales



Regulations that reduce the quantity index have an additional opportunity cost measured as the Harberger triangle *H* in the market diagram having *F* on the horizontal axis and *P* on the vertical axis. The market-level price elasticity of vehicle demand is -0.4 for light-duty vehicles.[27] When demand has price elasticity equal to the constant $-\eta$, the opportunity cost area *H* is no greater than vehicle class revenue times $\frac{\left(\frac{P_{no\ action}}{P_{proposed}}\right)^{1+\eta}-1}{1+\eta}$.

A2.3.3.2. Vehicle Cost Categories by Model Year

Dollar values for the areas *C* and *H* are calculated for each scenario and model year (MYs 2027-2050). Model years are combined using either a 3- or 7-percent annual discount rate. The scenario summary is either an annualized value for the years 2027-2050 or an NPV from the perspective of the year 2025. These results are shown in the upper rows of Table A2-3. As expected, the proposed rule is estimated to have annualized benefits in the tens of billions of dollars for buyers of new light-duty vehicles.

If this rule primarily affects the number of new vehicles purchased, thereby indirectly changing fuel consumption and fuel tax revenue, then that additional fuel tax revenue would not count as a net benefit. Fuel taxes are part of the payments made by consumers in excess of the resources needed to own and operate their vehicles. Potentially, the benefit of those revenues to Federal, state, and local treasuries is offset by increased congestion and road repair costs from additional vehicles on the road. That is, vehicle owners' fuel tax payments would reflect a consumer benefit (part of the value of driving) offset by increased social costs (added congestion and road repair).

However, as indicated in the first two rows of Table A2-3, the proposed rule would do much more to change the composition of vehicles than to change their number. Composition changes by themselves do much less to affect road congestion or contribute to road repairs. An indifferent consumer switching to driving a less fuel-efficient vehicle generates a net social benefit associated with the additional tax payments.[28] Therefore,

[27] See also Chapter 4.2 of the PRIA.
[28] This is an example of the Corlett-Hague rule for optimal policy to encourage behavior that is taxed (Corlett, W.J. and D.C. Hague (1953), "Complementarity and the Excess Burden of Taxation," Review of Economic Studies, 21(1): 21-30). See also OMB Circular A-4's conclusion that policies changing tax revenue can nonetheless have net costs or benefits.

Table A2-3 shows zeros for congestion but shows fuel tax revenue as an external benefit of consumer decisions to purchase vehicles that use more gasoline or diesel.[29]

Table A2-3's safety costs not internalized by drivers and the health costs associated with pollutants resulting from gasoline and diesel use are the same as shown in preamble Table IV-27, except converted from NPV to annualized.

Table A2-3: Benefits and Costs of the Proposed CAFE Standards in Billions of 2024 Dollars, Annualized Over Years 2027-2050

	Scenarios					
Scenario name:	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Discount %/yr:	3%	3%	3%	7%	7%	7%
Benefits						
Private: consumer surplus and resource cost savings						
Vehicle composition	18.0	17.9	17.0	17.9	17.9	16.9
Vehicle quantity	0.1	0.1	0.1	0.1	0.1	0.1
Fuel tax revenue	1.6	1.6	1.3	1.6	1.6	1.3
Benefits Total	19.6	19.6	18.3	19.6	19.6	18.3
Costs						
Safety costs not internalized by drivers	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5
Congestion	0	0	0	0	0	0
Health	0.2	0.2	0.2	0.2	0.2	0.2
Costs Total	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3
NET BENEFITS						
Annualized 2027-2050	**20**	**20**	**19**	**20**	**20**	**19**
NPV to 2025	**330**	**330**	**308**	**214**	**213**	**199**

[29] The PRIA includes congestion outcomes related to reduced driving due to the "rebound effect."