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How Fuel Economy Standards Affect Fleet Turnover and Used Vehicle Scrappage: Comment on the Safer Affordable Fuel-Efficient (SAFE) Vehicles Proposed Rule for Model Years 2021-2026 Passenger Cars and Light Trucks

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Short biographical statement:

Kenneth Gillingham is an Associate Professor of Economics at Yale University, with appointments in the School of Forestry & Environmental Studies, Department of Economics, and School of Management. He is also a faculty research fellow at the National Bureau of Economic Research. In 2015-2016 he served as the Senior Economist for Energy & the Environment at the White House Council of Economic Advisers and in 2005 he served as a Fellow for Energy & the Environment at the White House Council of Economic Advisers. He is an energy and environmental economist, with research in transportation, energy efficiency, and the adoption of new technologies.

He has published over 40 publications, including in top journals in economics, science, and business. Many of these publications focus on the economics of fuel economy standards and related issues. He has presented this work at top universities both in the United States and internationally. In 2007, he was a Fulbright Fellow in New Zealand and he has held visiting positions at the University of Chicago, Stanford University, Indiana University, and University of California-Berkeley. He holds a PhD from Stanford University in Management Science & Engineering and Economics, an MS in Statistics and an MS in Management Science & Engineering from Stanford, and an AB in Economics and Environmental Studies from Dartmouth College.

This comment is based on his expertise in the modeling of fuel economy standards and involved a review of the literature and discussions with colleagues also working on this issue, such as Arthur van Benthem of the University of Pennsylvania and Mark Jacobsen at the University of California-San Diego.

This short comment summarizes the basic economics underpinning how fuel economy standards affect fleet turnover and vehicle scrappage.[1] It is a general comment that applies to any fuel economy standard but is of particular relevance to the federal proposal for 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). Specifically, I discuss how the August 2018 Notice of Proposed Rulemaking (NPRM) for the SAFE Rule models the relationships that lead to scrappage. I then compare the approach taken in the NPRM to the approach in the 2016 Midterm Review Draft Technical Assessment Report (TAR).[2]

The key take-away is that the 2018 NPRM appears to be implicitly making modeling choices that are inconsistent with economic theory and that lead to erroneous estimates of fleet size, vehicle miles traveled, and crash fatalities. This commenter strongly encourages the Agencies to correct these errors in the modeling.

Fuel economy standards require automakers to maintain a fleet-wide fuel economy, which in the United States is adjusted by the footprint of the vehicles. To comply with fuel economy standards, automakers have several options, but the Agencies assume that automakers comply entirely by adding new technology and keeping all other attributes the same. For simplicity, this comment will follow suit in making this assumption.

Adding new technologies comes with a cost, so there will be some degree of passthrough of this cost to consumers and the price of new vehicles will increase while fuel economy improves. Thus, the key question is how new vehicle buyers respond to a slightly different set of vehicles on the dealer lots. This new set of vehicles will come with both the slightly higher prices and improved fuel economy. <u>Will new vehicle buyers be more or less likely to make a purchase of a more efficient but more expensive vehicle?</u>

This is a fundamental question about new vehicle buyers. On this question the 2016 TAR assumed that there would be no change on net. The argument is that some buyers might be drawn into the new vehicle market because of the appealing fuel economy improvements, while some buyers would be deterred from the market due to the higher prices. The 2018 NPRM assumed that new vehicle buyers would ignore the fuel economy improvements and thus the NPRM argues it can use the historical relationship between vehicle prices and sales to calculate the reduction in new vehicle sales from the increase in prices.[3] I will address each of the possibilities in turn, starting with the effects we might see if new vehicle sales decrease due to an increase in new vehicle prices.

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[1] For the sake of readability, this comment uses the term "fuel economy standards" to refer to both Corporate Average Fuel Economy (CAFE) and Vehicle Greenhouse Gas Standards.
[2] The 2016 TAR and the final Technical Support Document can both be accessed here: https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas
[3] See comment in the docket from K. Gillingham, J. Stock, and W. Davis for more on the response in vehicle sales to changes in fuel economy.

New Vehicle Sales Decrease

Suppose that there is a decrease in new vehicle sales due to the higher prices of the higher fuel economy vehicles. This is the case assumed in the NPRM. This assumption would imply a series of simultaneous adjustments:

1. When new vehicle sales decrease, some households who would have bought new vehicles will choose to buy used vehicles.
2. This increases the demand for used vehicles. With more households looking for used vehicles, used vehicle prices will increase.
3. When new vehicle prices and used vehicle prices increase, this leads some households to decide to own fewer vehicles, and either use their existing vehicles more or use other modes of transportation.
4. When used vehicle prices increase, some households will decide to hold on to their used vehicle longer rather than scrap it. For example, a household that has a 15-year-old vehicle that needs maintenance will be more likely to have the work done on the vehicle than scrap it if it would cost more to buy a replacement used vehicle.

So in this case, we assumed we would see fewer new vehicles on the road, and this means that we would see more old vehicles, but fewer total vehicles in the fleet, than in a setting without fuel economy standards. The reason we would see a decline in the overall number of registered vehicles on net is that the prices of both new and used vehicles increase, so vehicles in general are somewhat less attractive relative to other modes of transportation, thus leading to less demand for vehicles.[4]

The implications of this are as follows:

- <u>Composition Effect</u>. The overall vehicle fleet would be older and more old vehicles on the road could lead to greater crash fatalities due to less safety equipment and in some cases greater emissions.
- <u>Scale Effect</u>. The overall vehicle fleet would be smaller, which would tend to lead to fewer miles driven and thus lower crash fatalities and emissions.

Thus, from an economic theory standpoint, <u>the net result is ambiguous in terms of whether crash fatalities from this effect will increase or decrease</u>.

The 2018 NPRM does not model the full set of simultaneous changes that would occur. Rather, it attempts to estimate a direct relationship between new vehicle prices, used vehicle prices, and scrappage. There is no model examining the effect of increased new and used vehicle prices on the total fleet size. In other words, <u>the scale effect is ignored</u> in the

[4] Economists would call the option to not hold a vehicle the "outside option." Note this does not necessarily mean that households do not have a vehicle at all. The outside option can be the option not to have a 3rd vehicle for example. By raising new and used vehicle prices, fuel economy standards would make holding vehicles less appealing and thus the outside option relatively more appealing.

NPRM modeling and the composition effect is modeled in an ad hoc way without including all four adjustments described above. Instead of modeling all adjustments, the NPRM infers total fleet size through a set of calculations and somehow finds that the total fleet size increases. This would be saying that the price of vehicles goes up and people choose to buy more of them. The bottom line is that straightforward economic logic tells us that these calculations must be incorrect.

But it's also important to realize that these calculations only make sense at all if new vehicle sales decrease, which is possible, but not necessarily going to be the case.

New Vehicle Sales Stay Constant

Suppose new vehicle sales stay constant, as was assumed in the 2016 TAR. This is the case where just as many households are induced to be new vehicle buyers by the more appealing higher fuel economy vehicles as are deterred from buying a new vehicle due to the higher prices.

In this case, the demand for used vehicles does not change. Thus, the market price of used vehicles does not change. If there is no change in the price of used vehicles, the household decision of whether to scrap old vehicles is unaffected. So there would be just as many vehicles on the road with or without fuel economy standards.

In this case, economic logic suggests that households would shift some of their driving from older vehicles to the more appealing higher fuel economy new vehicles then they would have without more stringent standards. If older vehicles are driven less and newer vehicles are driven more, this would likely *reduce* crash fatalities and emissions. The 2016 TAR did not model this effect, but it is a likely outcome if new vehicle sales stayed constant.

New Vehicle Sales Increase

It is also possible that new vehicle sales increase. This could occur if automakers are not optimally providing the fuel economy that consumers desire. For example, suppose the future fuel savings from the improved fuel economy under more stringent standards outweigh the increase in the purchase price of a new vehicle. If consumers fully or mostly value the future fuel savings (as the NPRM is arguing they do), then it is possible that the new set of vehicles on the dealer lot will be sufficiently more appealing to consumers that new vehicle sales would increase with more stringent fuel economy standards.

While this case could only occur if automakers are not optimally providing fuel economy, note that this is implicit in the assumption in the NPRM modeling that automakers only assume that consumers value a payback period of 2.5 years. So it is actually consistent in one respect with the modeling logic in the NPRM.

If new vehicle sales increase with the change in the set of vehicles offered to consumers (despite the increase in price), then there would be no additional scrappage, and in fact, there would likely even be less scrappage. The following changes would occur simultaneously in the market:

1. When new vehicle sales increase, some households who buy the new vehicles would be pulled from those buying used vehicles.
2. This decreases the demand for used vehicles. With fewer households looking for used vehicles, used vehicle prices will decrease.
3. When new vehicles are more appealing despite the higher prices and used vehicle prices decrease, this leads some households to decide to own more vehicles.
4. When used vehicle prices decrease, some households will decide to scrap their vehicle and get another used vehicle rather than repair it. This will lead to fewer used vehicles on the road.

So in this case, we will see more new vehicles on the road and fewer used vehicles on the road, but the overall fleet size will slightly increase. The logic for why the overall fleet size increases is that the increased quality of new vehicles outweighed the increased price of new vehicles, so new vehicle sales increased, and used vehicle prices decrease, so used vehicle sales increase. Thus, the overall number of registered vehicles increases.

The implications of this are as follows:

- Composition Effect. The overall vehicle fleet would be younger, which would likely lead to fewer crash fatalities and potentially fewer emissions.
- Scale Effect. The overall vehicle fleet would be larger, which would tend to lead to more miles driven and thus greater crash fatalities and emissions.

Thus, from an economic theory standpoint, the net result is again ambiguous in terms of whether crash fatalities from this effect will increase or decrease. Note the effect of a shift of driving to the higher fuel economy vehicles would likely occur in this circumstance as well, which would tend to reduce fatalities and emissions, although on net the results are ambiguous.

Vehicle Miles Traveled by Additional Vehicles on the Road

The improperly modeled fleet size in the 2018 NPRM plays a direct role in the calculation of the number of fatalities that a higher fuel economy fleet will cause. Specifically, the augural standards affirmed in the 2016 TAR are modeled in the 2018 NPRM to substantially increase the vehicle fleet, and thus substantially increase vehicle miles traveled (VMT). In the NPRM, fatalities are modeled based on the age of the vehicle and the number of miles driven.

This is another area where the NPRM modeling appears to be problematic. Suppose that the fleet size does become larger, as in the NPRM modeling. This implies that some households keep an extra vehicle, and perhaps some households that never had a vehicle acquire one. Consider the case where some households keep an extra vehicle. Perhaps they had two vehicles before and now they have three. Now we need to determine how that household's total driving will change.

With a third vehicle, one might expect the household's total driving to increase somewhat, because there may be some new opportunities to use the services the additional vehicle might provide (e.g., suppose one of the vehicles is a truck that can occasionally be used for hauling). However, simply adding a third vehicle is not likely to substantially change a household's overall travel demand, as there are only so many miles a household would like to drive. This is seen in classic household travel demand models going back to Manski and Sherman (1980) and in many other more recent papers. Thus, an appropriate modeling of the VMT by the *marginal* vehicle added to a household's fleet is going to provide an estimate of additional driving that is much lower than the VMT by the *average* vehicle of the same age class.[5]

In the NPRM, the VMT for the average vehicle of the same age class is used, presumably for lack of better data. However, economic theory is clear that this is going to be an overestimate of the amount of additional driving.[6]

This means that if the fleet size increases, the amount of increased driving is going to be smaller than is modeled in the NPRM, implying fewer crash fatalities than is modeled in the NPRM. This works the other way as well: if the fleet size decreases, the amount of decreased driving is also going to be smaller than would be implied by the calculations in the NPRM. If the fleet size stays constant, the entire fleet turnover model is shut down and this consideration becomes irrelevant.

Concluding Remarks

The key take-away from this memo is that the 2018 NPRM made a set of very strong and unlikely assumptions that all increase the number of fatalities from an increase in fuel economy standards. Most importantly, the NPRM ignores the scale effect in the modeling and ends up with an economically implausible result. The NPRM also makes strong

[5] A more subtle point is that the people who acquire an additional vehicle are likely to be different than those who drive vehicles of the same age class on average. Thus, using the average vehicle's fatality rate for these additional vehicles is likely to be incorrect as well. I am not aware of any empirical evidence on this, but it could further bias the fatality count, and my hypothesis is that it would bias it upwards.
[6] One could get a handle on how much of an overestimate by using data that has driving by households over time, examining how the amount of driving changes when there are transitions to larger or smaller household vehicle portfolios.

assumptions in modeling how fuel economy standards affect new vehicle sales. Further, the NPRM improperly models the amount of driving for vehicles added to the fleet by assuming that they are driven just as much as the average vehicle of that age class.

Should these strong assumptions be returned to the assumptions in the 2016 TAR, the fatalities due to the modeling of fleet turnover and scrappage would not exist in the analysis. This would make a dramatic difference in the final net benefits estimates of the policy and would alone substantially decrease the fatalities ascribed to fuel economy standards—perhaps by on the order of 50% based on the reported values in the NPRM.

References

Manski, C. and L. Sherman (1980) An Empirical Analysis of Household Choice Among Motor Vehicles, *Transportation Research A*, 14(5-6): 349-366.