ISSUE BRIEF

Preparing for the Midterm Review of the Fuel Economy and Greenhouse Gas Emissions Rate Standards for Light-Duty Vehicles

A Summary of Priority Research Questions

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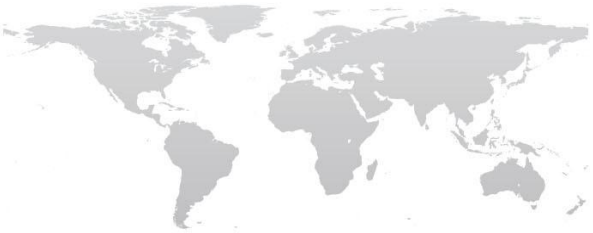
RESOURCES FOR THE FUTURE



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Resources for the Future

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Key Points

At the RFF workshop, participants identified several major research areas to improve understanding of passenger vehicle fuel economy and greenhouse gas emissions rate standards and the agencies' midterm review of them:

- Consumer demand for fuel economy: heterogeneity and policy implications
- Manufacturer responses to tighter standards: recent behavior, innovation, and technology adoption
- Distributional consequences of tighter standards
- Cost-benefit analysis: how to define the no-policy scenario, against which costs and benefits of tighter standards are compared
- Alternative fuel vehicles: crediting and consumer experiences

Introduction

The purpose of this workshop was to identify major research areas that can improve understanding of the effects of the current standards and the agencies' review of them. In designing the workshop, we wanted to include experts from academia, nonprofits, and industry, as well as from the key agencies and other government staff with responsibilities affecting the review. We were pleased that this meeting was well attended by the expert community, with broad representation of the various groups.

We describe here the major research themes that emerged at the workshop, summarizing what we have learned in the recent literature, and then listing open research questions (although some of the research is already underway). There was a lively debate at the workshop on many of the

[1] Krupnick: senior fellow and director of Resources for the Future's (RFF) Center for Energy Economics and Policy. Linn: fellow, RFF. McConnell: senior fellow, RFF. This summary reflects presentations and discussion from a workshop held by Resources for the Future on December 17, 2013. This workshop was made possible by the generous support of the Stephen D. Bechtel Foundation to RFF's Center for Energy Economics and Policy.

issues described here, and this document does not represent a consensus of the participants. Also, we want to note that some of these questions may be too broad for the agencies to include directly in their evaluation, but research on them will nonetheless inform our understanding of the effects of policy on light-duty energy consumption and greenhouse gas (GHG) emissions. We provide links to the presentations at http://www.rff.org/Events/Pages/CAFE-Midterm-Research-Workshop.aspx.

Background

The light-duty vehicle Corporate Average Fuel Economy (CAFE) and GHG emissions rate standards are the centerpiece of US efforts to reduce oil use and GHG emissions from the transportation sector. In 2012, the two lead agencies, the Environmental Protection Agency (EPA) and the Department of Transportation's National Highway Safety Administration (NHTSA) set stricter standards each year through the period to 2025.[2] Both agencies have committed to conduct a midterm evaluation of the later years of the standards. Specifically, the agencies will complete a Technical Assessment Report of the appropriateness of the 2022-2025 standards by November 15, 2017, and they will make final decisions based on the evaluation by April 1, 2018.

The goal of the process is for NHTSA to finalize its 2025 standards and for the EPA to determine whether the 2022-2025 standards remain appropriate under the Clean Air Act. According to the notice in the *Federal Register* the evaluation will be totally fresh, as comprehensive as the original standard-setting process, collaborative, conducted with the California Air Resources Board, and balanced, among other features. It will be based on "all relevant factors and the expected impact of those factors on the manufacturers' ability to comply, without placing decisive weight on any particular factor or projection." The factors listed in the Federal Register cover technology, its costs, as well as fuel costs, employment, issues related to alternate-fueled vehicles, consumer acceptance, penetration rates, and "any other factors that may be deemed relevant to the review."

The midterm evaluation represents a unique research opportunity because of the mandated review, and because data, evidence, and modeling will be important inputs for the agencies' decision process. Although the academic literature on vehicle markets has grown in recent years, major questions remain about consumer and manufacturer responses to the regulations and about how the costs and benefits of the rule should be estimated—points that the agencies

[2] .The Environmental Protection Agency (EPA) standards project an emissions rate reduction from the light-duty fleet from 250 grams of carbon dioxide per mile (g CO_2/mile, 35 mpg) in 2016 to 163 g CO2/mile (up to 55 mpg) in 2025, and are considered final unless they are changed. (The estimate of 55 mpg assumes that fuel economy increases account for all of the emissions rate reductions.) NHTSA published complementary fuel economy targets of about 35.5 mpg in 2016 and 49.1 mpg in 2025, though the NHTSA standards are only finalized through 2021.

readily acknowledge. Because the review will not be completed for several years there is sufficient time to undertake significant new research to address these questions.

1. Understanding the Energy Paradox

Many participants argued that the existence and extent of the energy efficiency gap—where manufacturers do not adopt technologies that a strict engineering-type cost analysis suggests they should—is one of the key questions for evaluating the vehicle standards. The Regulatory Impact Analyses (RIA) by the agencies for the 2017-2025 standards[3] concluded that the benefits of these standards would be close to three times higher than the costs, with the fuel savings over the life of the vehicle accounting for the majority of the benefits. But, if the fuel savings are this large relative to costs, why isn't more of this technology being delivered by manufacturers and demanded by consumers, even in the private market? Understanding this apparent energy paradox is critical for evaluating the standards by helping to identify the appropriate baseline for assessment of the effects of the overall regulations, and by contributing to a determination of which policies to combine with standards (e.g. labeling) to make them most cost effective.

The agencies' analyses conclude that there is a large energy efficiency gap because manufacturers apparently fail to adopt technologies for which the fuel savings far outweigh the costs of the technologies. In addition, the agencies' reviews of the literature on consumer behavior found that the evidence on whether consumers value fuel economy to be inconsistent; some studies find evidence of consumer myopia (one explanation for the energy paradox)and some do not (Greene 2010 and Helfand and Wolverton 2009). This appears to be an area in which more research is needed.

EMPIRICAL EVIDENCE FROM RECENT WORK ON THE ENERGY PARADOX

Some of the recent empirical work on this issue was presented at the workshop. Allcott and Wozny (forthcoming) and Busse et al. (2013) find that the average implied discount rate that consumers apply to fuel economy savings is close to, or perhaps slightly larger than, borrowing rates, suggesting that there is no paradox from myopia , or perhaps a "small" one. Allcott (2013) concludes that, on average, consumers only slightly underestimate fuel cost differences between vehicles. These studies find much less consumer underestimation than the agencies' analysis would suggest. These recent studies, however, tend to use fuel price variation to estimate consumer tradeoffs between vehicle costs and fuel savings. One important question is then

[3] Final Rulemaking for 2017-2025 Light Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Regulatory Impact Analysis, EPA, Washington, D.C., pg. 729. August 2012. http://www.epa.gov/otaq/climate/documents/420r12016.pdf

whether this is an accurate way to identify vehicle cost/fuel economy trade-offs for evaluation of fuel economy standards.

Other recent studies have suggested other explanations for why consumers may not fully value fuel economy. Greene (2011) uses a simulation model to show that consumers would greatly undervalue fuel economy savings under assumed loss aversion and plausible assumptions on uncertainty. In another simulation model, Bento et al. (2012) show that heterogeneity among consumers can result in an undervaluation of fuel economy. The assumptions underlying these models have not yet been tested empirically.

QUESTIONS FOR FUTURE RESEARCH

1. Some of the recent empirical literature has used fuel price variation to estimate consumer's implicit discount rates for fuel savings, but do consumers respond similarly to fuel economy and fuel prices when purchasing a vehicle?

2. Are there costs to consumers that have been left out of the engineering analysis that may account for the apparent energy paradox, such as changes in other vehicle attributes from fuel economy-improving technologies?

3. What are additional ways to empirically identify consumer tradeoffs between vehicle costs, fuel savings over time?

2. Consumer Heterogeneity

The recent energy paradox literature cited above demonstrates that a key issue in resolving the debate over the paradox is the heterogeneity across consumers, including implicit discount rates and attitudes about fuel savings; for example, Allcott (2013) found that a substantial share of surveyed individuals systematically mis-estimate the fuel costs of particular vehicles. Workshop participants put forward a number of reasons about why some people may not value fuel economy, or appear not to, including the cost of borrowing, tradeoffs between fuel economy and other vehicle characteristics like safety, lack of information, salience, rational inattention and loss aversion.

QUESTIONS FOR FUTURE RESEARCH

1. What are the key sources of heterogeneity in consumer discount rates and fuel economy valuation?

2. What are the reasons for under and over-valuation of fuel economy and can these be sorted out quantitatively?

3. What are the policy implications of such heterogeneity? What does it suggest about the structure of the standards? What are the implications for the appropriateness and the shape of the footprint standards? Would better labeling help?

4. How have recent standards affected used vehicle markets and poorer households?

3. Vehicle Choice and Use

There was a lot of discussion at the workshop about how standards could affect vehicle use and vehicle choice. Standards result in better fuel economy and lower driving costs, leading to more driving, or the so-called "rebound effect". One presenter at the workshop also pointed out that higher fuel economy could have the opposite effect on fuel use if households with more than one vehicle shift driving toward the newer vehicle with better fuel economy. There are also likely to be effects of the standards on purchase decisions, including the types of cars people buy, and how long they hold onto their older vehicles. These effects are likely to differ by income groups.

WHAT HAVE WE LEARNED?

There is a good deal of empirical work on the magnitude of the rebound effect. Several studies conducted or published since the rulemaking (Gillingham forthcoming; Knittel and Sandler 2013; Linn 2013) suggest an average rebound effect of somewhere between 0.1 and 0.25, meaning that a 1 percent reduction in fuel costs raises driving by 0.1 to 0.25 percent. This range is slightly higher than the value used by the agencies in setting the standards. There was interest by some workshop participants in refining this range and in understanding the heterogeneity of consumer responses to the cost of driving.

Although there is a sizable literature on vehicle choice, there has been very little work directly on the effects of standards on consumers' decisions about whether and when to buy or lease a new vehicle, and the effect on the overall age and size mix of the fleet of vehicles. In fact, the agencies' analyses assume that the standards do not affect vehicle size mix and attributes aside from fuel economy.

QUESTIONS FOR FUTURE RESEARCH

1. What is the magnitude of the rebound effect, and how does it differ by household income or other characteristics? Do people respond differently to changes in fuel prices and change in fuel economy?

2. How do consumers make decisions about when and whether to buy a new car and how is that decision affected by vehicle price or fuel economy? How do people decide whether to buy or lease a vehicle?

3. Can more leasing result in faster turnover and faster learning about new technologies?

4. How are the standards likely to affect the attributes, size and age mix of the fleet?

5. 5. How do consumers value vehicle attributes other than fuel economy?

6. 6. Are there vehicle choice models of sufficient quality and robustness to contribute to regulatory analysis?

4. Understanding Manufacturer Behavior

Regulatory analysis tends to focus on technologies to improve fuel economy and the costs of those technologies. In the models currently used by the agencies, manufacturers choose which technologies to add based on their cost-effectiveness (i.e., cost of the technology net of some share of future fuel savings), with the technology costs marked-up to reflect other fixed costs. The technology costs are assumed to decrease over time for new technologies because of an assumed rate of learning. However, there has been little empirical work on learning rates for new technologies in vehicle markets.

Several research papers by authors at the workshop developed models to explore whether the standards may create incentives for manufacturers to adjust vehicle mix and/or vehicle footprint sizes. Whitefoot and Skerlos (2011) and Jacobsen (2013), using simulation models, show that based on costs and demand elasticity estimates, manufacturers would tend to want to increase vehicle footprint (compared to current levels) to take advantage of the looser standards for bigger vehicles.

WHAT HAVE WE LEARNED?

There is anecdotal evidence that manufactures have increased footprints (made vehicles larger), although a rigorous analysis has not been done. There is also anecdotal and statistical evidence that manufacturers have increased the rate at which they add technology due to the standards (Klier and Linn 2013). Certain technologies have proven to be more effective/less costly than anticipated. It is unclear whether this is due to learning over time, or whether the tighter current and expected standards caused these outcomes.

QUESTIONS FOR FUTURE RESEARCH

1. Are there reasons other than consumer myopia about fuel economy that could lead manufacturers to add fuel economy technology to vehicles at a slower rate that might be expected? How are decisions over fuel economy and other characteristics made by manufacturers across their vehicle fleets?

2. What are plausible rates of learning for new technologies? How do learning rates differ across technology types?

3. What are the fixed costs associated with adopting technology? How do design cycles affect the rate of technology adoption? Will stranded costs become more important if successively tighter standards increase the rate of technological change?

4. How have actual technology costs compared with ex ante estimates?

5. How do the standards affect manufacturer decisions over the size mix of the fleet they produce?

6. Is it possible to identify how much the standards have caused manufacturers to adjust footprints in the last few years and how has that affected CO2 emissions?

7. How do the standards affect the rate of innovation and technology adoption?

5. Assessing Costs and Benefits

The EPA and NHTSA assume that vehicle prices and characteristics would not change in the absence of tightened standards. These assumptions contradict developments in the passenger vehicles market over the past several decades, but estimating the no-policy counterfactual (or the so-called baseline to which the world with standards must be compared) is extremely challenging. Nonetheless, doing so is critical to a reasonably accurate assessment of benefits and costs of the standards. In fact, an improved framework for considering costs and benefits will be important. Two additional issues related to the overall midterm evaluation that came up at the workshop are: 1) should the evaluation explicitly account for distributional consequences (as discussed above), and 2) the agencies should further consider uncertainty in modeling assumptions.

WHAT HAVE WE LEARNED?

There is some evidence (Klier and Linn 2013) that recently tightened US and European standards reduced horsepower and torque compared to a no-policy counterfactual in which these characteristics would improve; failing to account for improvements in vehicle characteristics in the counterfactual would cause an underestimate of the costs of tighter standards. Jacobsen (2013) also suggests that standards can be regressive by raising the prices of used vehicles.

QUESTIONS FOR FUTURE RESEARCH

1. How should the baseline be defined and estimated? How much difference does this make to estimation of the costs and benefits?

2. If there is an energy paradox or efficiency gap, how do the reasons for this effect alter a benefit-cost analysis of the standards?

3. What are the welfare consequences if tighter standards affect vehicle characteristics other than fuel economy?

4. What are the consequences of consumer heterogeneity for welfare analysis?

5. How wide should the scope of the cost-benefit analysis be and how much does increasing the scope matter? For instance, should the effect of the new standards on world oil prices be counted? Should general equilibrium effects of the standards on the economy be counted?

6. How should energy security benefits be considered?

7. How do EPA and NHTSA estimates of costs and benefits compare with estimates derived from other models such as the National Energy Modeling System?

6. Crediting for Natural Gas and Plug-in Vehicles

The EPA and NHTSA predicted fairly modest rates of adoption for plug-in vehicles by 2025. The development of the plug-in vehicle market is explicitly listed, however, as one of the criteria for the review. There are numerous provisions in the standards that allow for additional crediting for vehicles that meet certain criteria, including plug-ins. The agencies argue that special considerations of these technologies justify the over-crediting. Certain "off cycle" technologies are also eligible for crediting.

WHAT HAVE WE LEARNED?

Several new plug-in models have entered the US market in the past several years, and many more are expected to come. There has been some analysis of the early experiences—consumer satisfaction, performance of the technology, etc.—and some new estimates of the GHG benefits of electric vehicles. Furthermore, cheap natural gas has made it more likely that either natural gas or fuels derived from it will penetrate the light-duty fleet.

QUESTIONS FOR FUTURE RESEARCH

1. What have consumer experiences been with plug-in vehicles? Is there evidence of demand spillovers or other market failures for the adoption of these vehicles?

2. How do crediting provisions affect the penetration rate of various types of vehicles into the fleet?

3. What affects do alternative ways of crediting such vehicles have on the overall costs and benefits of the standards?

7. The Need for Better Data

Many participants argued that high-quality data are essential for addressing these questions. While a number of data sources exist at little or no cost, there was some discussion about providing ready-to-use versions of the data in a centralized location. There was also some discussion about data sources that have not been used widely for economics research, such as data on consumer behavior from marketing or industry consultants.

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