Policy Brief:
The Rebound Effect and the Rollback of Fuel Economy Standards

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Abstract

The August 2018 proposed rollback of 2020-2026 fuel economy standards by the Trump Administration is the subject of great controversy in the policy community. The rollback was justified based on an analysis indicating that the previous fuel economy standards would associated with over 12,000 additional fatalities over the lifetime of the vehicles affected. The largest contributor to these fatalities is the rebound effect, which was changed from 10% in the previous rule to 20%. This article summarizes what we know about the rebound effect specific to fuel economy standards. A careful review indicates that the recent literature supports a central estimate closer to 10%, undermining a key argument used to support the rollback of the standards. Yet there are wide uncertainty bounds around this central estimate and several poorly-understood factors further increase our uncertainty in this key parameter, emphasizing the need for sensitivity analysis and further work in this policy-relevant area.

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In August 2018, the Trump Administration proposed a rollback of fuel economy standards. The rule finalized in 2012 and affirmed in a Technical Assessment Report in 2016 was set to substantially tighten standards through 2025, while the 2018 proposed rule freezes the standards at 2020 levels through 2026 (EPA/DOT 2018). The legal and political arguments for rolling back the standards were based on an analysis indicating that such an action would reduce crash fatalities by 12,700 lives over the lifetime of vehicles through model year 2029. This argument was in part underpinned by a doubling of the "rebound effect" of fuel economy standards from 10% in previous Administration analysis to 20% in the 2018 proposed rule.[1] In the analysis by the U.S. Environmental Protection Agency and Department of Transportation (henceforth, the "agencies"), the rebound effect is defined as the percentage increase driving in driving that occurs when vehicles become more efficient and thus have a lower cost per mile of driving, but it is defined more broadly as an estimate of the market and behavioral responses to an energy efficiency policy that may reduce the energy savings from the policy (Gillingham et al. 2016).

Without the additional driving from the doubling of the rebound effect, the estimate of 12,700 lives lost is reduced by roughly one third. Interestingly, the increased rebound effect has a very small effect on the cost-benefit analysis, as in both the 2016 and 2018 analyses the agencies assume that the welfare losses due to increased fatalities are exactly offset by consumer surplus benefits of additional driving, and all other welfare changes are also close to offsetting. Thus, the choice of the rebound is not pivotal to the net benefits in either analysis; it is instead of primary importance for the legal and political argument in the 2018 proposed rule.

This article reviews the recent literature on the rebound effect, focusing narrowly on the doubling of the central estimate to 20%. The review reveals that the recent literature on the fuel price/fuel economy elasticity of driving tends to point to an estimate around -0.1, which corresponds to a 10% rebound. Further, it highlights key factors that should be considered in the choice of a rebound effect in this context—some of which are specific to fuel economy standards and most of which are areas where future research is warranted. Finally, the article concludes with a brief discussion of how the choice of the rebound effect can be improved going forward.

[1] For example, in this context, a 10% rebound implies that there is a "rebound" in fuel use from increased driving that leads to 10% of the fuel savings from the improved fuel economy still being consumed, so that only 90% of the reduction in fuel savings would occur.

Recent Literature Relevant to the Rebound Effect of Fuel Economy Standards

Economists have long used estimates of fuel price elasticities to quantify the direct behavioral response by drivers to the lower cost per mile of driving due to fuel economy standards (this is often known as the "direct rebound effect") (Gillingham et al. 2016). In the past decade, there has been a substantial growth in studies estimating the fuel price elasticity of driving. Some of these studies examine the relationship between the fuel price and driving decisions, while others examine the relationship between the cost per mile of driving (the fuel price divided by the fuel economy). There are only a few studies that directly examine the relationship between the fuel economy of the vehicle and driving, largely due to the difficulty in finding plausibly exogenous sources of variation in fuel economy. In order to use fuel price elasticities as estimates of the rebound effect, one must make the implicit assumption that consumers respond to reduced fuel prices in the same way that they respond to improved fuel economy, for both changes reduce the cost per mile of driving.

The most recent literature tends to be based on either survey data, largely from the National Household Transportation Survey, or odometer reading data from state vehicle inspection programs. In the 2018 proposed rule, the agencies argue that odometer reading data is the most reliable data when they are discussing the relationship between vehicle miles traveled and vehicle age, but do not make this distinction in the discussion of the rebound effect. Odometer readings allow for improved identification strategies, are often be considered more reliable because they are measured rather than self-reported, and may be more representative by covering nearly the entire light duty fleet in a region.

Table 1 below summarizes the literature relevant for a central estimate of the rebound effect of fuel economy standards in the United States. I restrict my review to publicly available literature from the past decade based in the United States. This review differs from the discussion in the proposed rulemaking in several ways. First, it excludes estimates from outside of the United States, and in particular Europe, as consumer behavior has been shown to be different in Europe due to different urban form and public transportation access (Gillingham and Munk-Nielsen 2018). Second, it excludes estimates from unpublished work that is inaccessible (West and Pickrell 2011) or work that estimates something other than the rebound effect (e.g., Wadud et al. 2009). Third, it excludes estimates that the authors argue are inappropriate for using as an estimate of the rebound effect. For example, Gillingham (2014) examines the response to the 2008 gasoline price shock, an unusual period when gasoline prices were particularly salient to consumers. The rulemaking states that it is reporting all long-run elasticity estimates, when in fact most estimates can best be interpreted as short-run or medium-run responses (e.g., a response within two years). Table 1 follows the agencies in how these are presented.[2]

Summarizing Table of the Best Evidence Available for a Central Estimate of the Rebound Effect for Fuel Economy Standards in the United States
(Studies in **Boldface** are *not* included in the 2018 Proposed Rule)

Study	*Data*	*Rebound Estimate*
Bento et al. (2009)	2001 survey	34%
Hymel et al. (2010)	**State-level 1966-2004**	**9%**
Gillingham (2011)	**Odometer; CA 2001-2009**	**1%**
Greene (2012)	**Aggregate 1966-2007**	**0%**
Su (2012)	2009 survey	11-19%
Liu et al. (2014)	2009 survey; MD/DC/VA	40%
Gillingham et al. (2015)	**Odometer; PA 2000-2010**	**10%**
Hymel & Small (2015)	State-level 1966-2004	4-18%
Leung (2015)	**2009 survey**	**10%**
Linn (2016)	2009 survey	20-40%
Langer et al. (2017)	**Odometer; OH 2009-2013**	**11%**
West et al. (2017)	Odometer; TX 2010-2011	0%
Knittel & Sandler (2018)	**Odometer; CA 1998-2010**	**14.7%**
Wenzel & Fujita (2018)	**Odometer; TX 2005-2010**	**7.5-15.9%**

Notes: All of the estimates reported are VMT elasticities with respect to the gasoline price or cost per mile of driving with the exception of Gillingham (2011), Greene (2012), and West et al. (2018), which are elasticities with respect to fuel economy. This table converts these elasticity estimates to percentage rebound effects. The 2018 proposed rule references the following papers that are excluded from this table: Wadud et al. (2009), which estimates an elasticity of gasoline consumption, Gillingham (2014), which is a study focused on a single gasoline price shock, and West and Pickrell (2011), which is not a publicly available study. The 2018 proposed rule incorrectly references Linn (2016) as Linn (2013). Bento et al. (2009) give the average VMT elasticity with respect to the price of gasoline as -0.34 on p.685 (implying a 34% rebound); the 2018 proposed rule reports a range of 21-38%, but it is unclear where this range comes from. The 9% estimate from Hymel et al. (2009) was taken from the authors' preferred estimate in the conclusion (p.1235) with the calculation of variables at 2004 values, but a variety of other estimates were reported. The 4-18% estimates from Hymel and Small (2015) is from the authors' preferred estimates in Table 8; the 2018 proposed rule chooses only the high estimate. The 7.5%-15.9% range for Wenzel & Fujita (2018) is based a conversation with the authors, who suggest considering both the estimate based on fuel prices and the estimate based on the cost per mile to be consistent with the rest of the literature, which use both. Knittel and Sandler (2018) has been available as a working paper since 2013 and Wenzel and Fujita (2018) was reviewed by analysts at the Agencies and was published in 3/2018, prior to the release of the proposed rule.

[2] The only two studies that claim to provide a long-run rebound effect are Hymel et al. (2010) and Hymel & Small (2015). For both of these, Table 1 presents the long-run estimates. The short-run estimates in both of these studies are near-zero. One important note is that the estimates based on survey data from a single year are primarily using variation in gasoline prices over time within the year, so it would be incorrect to call these long-run estimates.

A few clear findings are apparent from Table 1. First, there is a relatively wide range of estimates. In general, studies using survey data tend to have much higher rebound effect estimates than those using odometer reading data, which should be given more weight in the choice of the central case rebound effect. Second, while one should be cautious in taking a simple average over studies (due to differences in regions, time periods, and methodologies), in doing so, we see that the average over all studies is 14.1%, and the average over all studies using the more reliable odometer readings is 8.1%. Third, all of the studies in boldface are *not* included in the 2018 proposed rule, and in general these studies not only tend to be studies using odometer readings, but also tend to show smaller rebound effects than those that are included in the 2018 proposed rule. Indeed, excluding all of these studies, weighting studies from surveys equally with studies from odometer readings, and including international studies is how the agencies are able to argue for a 20% rebound.

These findings cast doubt on the argument for a central case estimate of 20% for the rebound effect of fuel economy standards.

Further Considerations Not Addressed in The Above Rebound Estimates

The above estimates form the core of the evidence base available to provide guidance on the rebound effect of fuel economy standards. However, the actual effect may be influenced by several other factors that are not necessarily included in the estimates. The ideal estimate of the rebound effect quantifies the consumer response in the amount driven to all of the changes that occur due to fuel economy standards: higher fuel economy vehicles, higher priced vehicles, vehicles with different attributes (some of which are valued by consumers). Further, for policy analysis, we are interested in both the short-run rebound effect and the long-run rebound effect, which accounts for all longer-term margins of adjustment by consumers to the different vehicles (e.g., if it is less expensive to commute, some households may choose to live further away in the long-run). Thus, there are important caveats to using the rebound estimates given above.

First, consumers may respond differently to changes in fuel economy than changes in fuel prices. For instance, there are several papers in the literature suggesting that the response to fuel economy may be less than the response to fuel prices, implying that the evidence above *overestimates* the rebound effect (West et al. 2017, De Borger et al. 2016, Greene 2012, Gillingham 2011). One rationale for this is that gasoline prices are more visible and thus more salient to consumers. In contrast, there is one paper providing evidence suggesting that the response to fuel economy may be greater than the response to fuel prices, suggesting an *underestimate* of the rebound effect (Linn 2016). A rationale for this finding is that changes in fuel economy are more permanent than fuel price changes. It is possible the sign depends on the exact circumstances.

Second, there is likely to be a larger response to fuel economy standards in the long-run. As by-and-large the estimates above are short-run or medium-run, they are appropriate for policy analysis for the first few years of the policy likely *underestimate* the rebound effect in the long-run. Unfortunately, it is extremely difficult to directly identify long-run effects. The limited evidence available suggests that long-run rebound effects are only modestly larger than short-run effects (e.g., Hymel and Small 2015).

Third, as households get wealthier and roads more congested, the time value of driving becomes more important than the cost of fuel (Hymel and Small 2015, Hymel et al. 2010, Small and Van Dender 2007). These factors both suggest that the above studies may provide useful guidance for today but are *overestimating* the rebound effect in the future.

Fourth, fuel economy will change along with a bundle of attributes, and some of these changes may mean that driving is less appealing. West et al. (2017) show that drivers induced into higher fuel economy vehicles that are lower performing do not drive any more than they had previously. This would imply that the above studies (besides West et al.) *overestimate* the rebound effect.

Fifth, if fuel economy standards are met by adding costly technology to vehicles, then vehicle prices might increase, reducing the budget available for driving. This would imply that the above studies *overestimate* the rebound. Similarly, there may be an indirect rebound effect whereby money saved at the pump due to higher fuel economy vehicles may be diverted to other uses that use fuel and create emissions, while money spent on more expensive vehicles may divert money away from other uses. The net effect could be positive or negative (Borenstein 2015, Gillingham et al. 2016) and Fullerton and Ta (2018) argue that in general equilibrium the effect can easily be negative. Importantly, this indirect effect could influence emissions, but would not influence driving, and thus would not lead to additional crash fatalities.

Finally, there may be a macroeconomic rebound effect if fuel economy standards reduce the global demand for oil, lowering the global oil price and leading to more consumption globally in equilibrium (and possibly influencing the direction of innovation). On net, this effect may reduce or increase global emissions, but it is usually expected to increase global emissions, implying that the above studies are an *underestimate* of the rebound (the effect on driving in the United States would be expected to be small, relative to the effect globally).

The magnitudes of these seven additional considerations are quite uncertain and should increase the uncertainty bounds around any central case estimate of the rebound effect. However, what is critical for interpretation is that these factors do not point in a single direction—a roughly equal number suggest an upward bias of the studies above as suggest a downward bias. Given the current state of evidence, it would be difficult to argue for a higher or lower central case rebound effect based on these factors. Notably, the 2018 proposed rule is not relying on any of these factors to justify the decision to use a 20% rebound.

Concluding Remarks

The assumed 20% rebound effect plays a major role in the justification of the proposed rollback of fuel economy standards, yet this choice does not appear justified as a central case estimate based on the latest literature. This review points to an estimate on the order of 10%, but it also reveals the wide range of values in the literature, underscoring important uncertainty in the value chosen. Furthermore, the review highlights multiple further factors influencing the rebound that are relatively poorly understood and often work in diverging directions. This leaves us with the surprising conclusion that, despite a large literature on the rebound effect, there is still substantial uncertainty in the rebound effect for fuel economy standards and many remaining areas for future research. Policymakers must choose a central case estimate based on the best evidence available, but the large uncertainty around any central case underscores the need for careful sensitivity analysis.

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