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Gasoline price uncertainty and the design of fuel economy standards[☆]

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ABSTRACT

What are the implications of gasoline price volatility for the design of fuel economy policies? I show that this problem has a strong parallel to Weitzman's (1974) classic model of using price or quantity controls to regulate an externality. Changes in fuel prices act as shocks to the marginal cost of complying with the standard. Assuming constant marginal damages from fuel consumption, an application of Weitzman (1974) implies that a fixed fuel economy standard reduces expected welfare relative to a "price" policy such as a feebate or, equivalently, a fuel economy standard that is indexed to the price of gasoline. When the regulator is constrained to use a fixed standard, I show that the usual approach to setting the standard—equate expected marginal compliance cost to marginal damage—is likely to be sub-optimal because the standard may not bind if the realized gasoline price is sufficiently high. Instead, the optimal fixed standard will be relatively relaxed and may be non-binding even at the expected gasoline price. Finally, I show that although an attribute-based standard allows vehicle choices to flexibly respond to gasoline price shocks, the resulting distortions imply that the optimal fuel economy standard is not attribute-based.

1. Introduction

In October 2012, the U.S. Environmental Protection Agency (EPA) and the National Highway Transportation and Safety Administration (NHTSA) jointly issued new fuel economy standards for U.S. light-duty vehicles. These standards are scheduled to become increasingly stringent over time, reaching a fleet-wide average fuel economy of 55 miles per gallon in 2025. When the standards were issued, the EPA and NHTSA scheduled a "mid-term review" in 2017–2018 to determine whether the standards for 2022–2025 should be revised. Thus, the standards set in 2012 were locked in place through 2021—nine years after the standards were set—and any revisions made in 2017–2018 will be locked in for seven years. The EPA concluded the mid-term review in January 2017, affirming the original 2022–2025 standards. Two months later, however, the new administration opened a review of that decision. This new review is scheduled to conclude in April 2018.

Throughout the debate over the 2022–2025 standards, there has been discussion among industry participants and regulators of whether the standards should be loosened given the substantial decrease in gasoline prices since the standards were set. In October 2012, the prevailing U.S. average gasoline price was \$3.45/gallon, but by January 2016 the price had fallen to \$1.51/gallon.[1] Because consumers' willingness to pay for fuel-efficient vehicles depends on fuel prices (Allcott and Wozny, 2014; Busse et al., 2013; Sallee et al., 2016), this decrease in the price of gasoline has increased the cost of complying with the new fuel economy standards and therefore raised concerns as to whether the regulatory path set in 2012 should be sustained. For instance, in April 2015, a spokesperson for the Alliance of Automobile Manufacturers said that "Given the extremely long 15-year lead time for the standards, the government set a mid-term review in 2017 as a reality check for regulatory assumptions. One of the assumptions was that the price of gas would be much higher than today, and that affects what consumers buy. Sales of our most fuel-efficient vehicles go up and down with the price of gasoline. A mid-term reality check is a good idea, especially since our compliance is based on what consumers buy, not what we offer for sale." (Detroit News, 2015).

Spurred by this policy question, this paper examines the welfare economics of fuel economy standards under uncertain future gasoline prices and therefore uncertain future compliance costs. I begin by framing the problem in the context of Weitzman's (1974) "Prices vs Quantities", which facilitates a welfare comparison of a standard that varies with the gasoline price versus a standard that is fixed in place. I

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[1] These prices are pre-tax and real \$2016. See Section 2.2 for a discussion of the gasoline price data used in this paper.

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present a model in which the private benefits of fuel economy that accrue to vehicle producers and consumers are moderated by the price of gasoline so that, absent regulation, private agents will choose fuel efficient vehicles when gasoline prices are high and inefficient vehicles when gasoline prices are low. Fuel economy policy is motivated in the model by climate change externalities that are associated with vehicles' fuel consumption per mile. In this framework, a fuel economy standard that varies with the price of gasoline—allowing greater fuel use per mile when the gasoline price falls but tightening when the gasoline price rises—can be equivalent to a revenue-neutral "feebate" that taxes inefficient vehicles and subsidizes efficient vehicles (since under a feebate agents' fuel economy choices would also rise and fall with the gasoline price). Thus, in the language of Weitzman (1974), a gasoline price-indexed fuel economy standard acts as a "price" policy. In contrast, a traditional fixed standard acts as a "quantity" policy.

To distill intuition, I simplify the model so that, in the absence of uncertainty over future gasoline prices, a feebate policy can achieve the first-best welfare outcome by acting effectively as a tax on gasoline. Likewise, a fuel economy standard can achieve the first-best by acting as a standard on the quantity of gasoline consumed. The key assumption underpinning the paper is that the marginal external damage associated with vehicles' fuel use per mile is locally constant and unaffected by gasoline price shocks. Treating marginal damage as constant in U.S. vehicle emissions is a natural consequence of the fact that CO_2—the primary driver of the externality—is a global stock pollutant (Newell and Pizer, 2003).[2]

The paper's first result has been intuited by others (Anderson and Sallee, 2016) and is a direct application of Weitzman (1974): indexing the fuel economy standard to the price of gasoline—or, equivalently, using a revenue-neutral feebate—can achieve the first-best with uncertain fuel prices because it can equate the marginal cost of abatement with its marginal benefit at any fuel price. This result can also be seen as an application of models of general indexed regulation (Ellermann and Wing, 2003; Newell and Pizer, 2008), where the index variable (the gasoline price) is perfectly correlated with marginal compliance cost. In contrast, a fixed fuel economy standard will result in an excessive marginal abatement cost (and too much abatement) when fuel prices are lower than what was expected when the policy was set, and too small a marginal abatement cost (and too little abatement) when realized fuel prices are high. In either case, there is a welfare loss relative to the first-best.

I focus the remainder of the paper on the question of how best to set a fuel economy standard when it cannot be indexed to the gasoline price and cannot be changed for many years once it is set. Following a first order condition (FOC) from Weitzman (1974), the usual rule for setting such a fixed standard is to equate the expected marginal cost of compliance, evaluated at the standard, to the marginal external harm. I show, however, that this policy rule ignores the non-trivial probability that if the realized gasoline price is sufficiently high, the standard will not bind. That is, firms and consumers may, if the gasoline price is high enough, voluntarily select a level of fuel economy that exceeds the standard. I derive a new first order condition that accounts for this possibility and show that the optimal fixed standard equates expected marginal compliance cost, *conditional on the standard binding*, to marginal external harm. This optimal standard is more lax than that implied by the usual Weitzman (1974) rule, and I show that given historic gasoline price uncertainty and estimates of marginal damage from the literature, the difference between the optimal standard and the usual Weitzman (1974) standard can be economically large. In fact, the optimal standard may be so lax that it is non-binding even at the expected future gasoline price. I also derive an expression for the expected welfare loss (relative to the first-best) under a fixed and possibly non-binding standard, and I show that a standard set using the usual Weitzman (1974) FOC may yield lower welfare than that obtained by not setting any standard at all.

Brozovic et al. (2004) also studies optimal pollution control standards that may not bind, using a model with two discrete firm types. The results presented here expand on this prior work by presenting intuitive formulas for the optimal standard and expected welfare loss under a continuous distribution of abatement cost uncertainty, and by calibrating the model to demonstrate that its implications are economically significant for fuel economy regulation. Another related paper is Costello and Karp (2004), which examines the merits of setting a potentially non-binding pollution standard to learn about a firm's marginal abatement cost.[3]

Finally, I study whether basing the fuel economy standard on vehicle attributes such as footprint or weight can mitigate the welfare losses associated with a fixed standard. The U.S. fuel economy standards set in 2012 are in fact footprint-based: vehicles with a large wheelbase are assigned a less stringent standard, as shown in Fig. 1. Ito and Sallee (forthcoming) shows, using a model similar to that presented here but assuming complete information, that attribute-based regulation (ABR) reduces welfare by distorting choices of the attribute: consumers purchase vehicles that are larger than optimal.[4] When the gasoline price is uncertain, however, ABR may confer benefits by building flexibility into the regulation, as suggested in (Anderson and Sallee, 2016). For instance, if the gasoline price is lower than expected, agents can shift to vehicles with larger footprints and lower fuel economy, mitigating the increase in the marginal abatement cost. As noted by Lutsey (2015), this flexibility benefit of ABR was highlighted in General Motors (2009) on the proposed regulation. In addition, the response of vehicle choices to fuel prices was modeled by NHTSA in its Regulatory Impact Analysis (NHTSA, 2012), and Leard et al. (2016) finds evidence that the recent fuel price decrease has indeed modestly affected fleet-average footprint and fuel economy. I show here, however, that even if fuel prices are uncertain, attribute-basing reduces expected welfare relative to an optimally-set non-attribute-based standard, since the distortions caused to the attribute and to fuel economy outweigh the flexibility benefit.

The paper proceeds as follows. Section 2 describes U.S. fuel economy standards and characterizes U.S. gasoline price volatility, and Section 3 introduces the paper's model of the vehicle market. Section 4 then applies Weitzman (1974) to the comparison of fixed versus gasoline price-indexed fuel economy standards. Sections 5 and 6 then present the main results of the paper: Section 5 discusses the optimal level for a fixed fuel economy standard, and Section 6 assesses whether an attribute-based standard can be welfare-improving. Section 7 discusses the potential importance of several non-modeled factors, such as covariance between the gasoline price and marginal damage, banking and borrowing of fuel economy credits, under-valuation of fuel economy by consumers, and firms' investment dynamics. Section 8 concludes.

2. Policy background and gasoline price data

2.1. 2012 EPA and NHTSA fuel economy standards

This section discusses the U.S. fuel economy standards set by the EPA and NHTSA in 2012, focusing on three of their characteristics that are important for this paper: attribute-basing, credit trading, and banking and borrowing. For additional information, see Environmental Protection Agency (2012) or the complete rule in the Federal Register (2012). Fig. 1 shows the planned path of the footprint-based fuel

[2] Even if marginal damage were not locally constant, setting a tax or feebate schedule would achieve the first-best and welfare dominate a fixed standard in the presence of fuel price uncertainty, per arguments given in Kaplow and Shavell (2002).

[3] Costello and Karp's (2004) model is structured so that, in the absence of an incentive to learn, the optimal standard always binds.

[4] Whitefoot and Skerlos (2012) and Gillingham (2013) also illustrate the incentive to increase vehicle size under ABR, using models that allow for automakers' market power.

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