



From gallons to miles: A disaggregate analysis of automobile travel and externality taxes[☆]



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ABSTRACT

Policymakers have prioritized increasing highway revenues as rising fuel economy and a fixed federal gasoline tax have led to highway funding deficits. We use a novel disaggregate sample of motorists to estimate the effect of the price of a vehicle mile traveled on VMT, and we provide the first national assessment of VMT and gasoline taxes that are designed to raise a given amount of revenue. We find that a VMT tax dominates a gasoline tax on efficiency, distributional, and political grounds when policymakers enact independent fuel economy policies and when the VMT tax is differentiated with externalities imposed per mile.

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1. Introduction

Personal vehicle transportation is central to the nation's economic prosperity and to households' way of life (Winston and Shirley (1998)). Unfortunately, driving also generates substantial congestion, pollution, and traffic accident externalities that cost American society hundreds of billions of dollars per year (Parry et al. (2007)). Based on the voluminous literature on consumers' demand for gasoline,¹ economists have paid the most attention to analyzing policies to reduce pollution and have long argued that gasoline taxes are more cost effective than Corporate Average Fuel Economy (CAFE) standards because they encourage motorists to both reduce their driving, measured by vehicle-miles-traveled (VMT), and to improve their vehicles' fuel economy.² In contrast, CAFE does not affect motorists' VMT in their existing (pre-CAFE) vehicles and it likely increases motorists' VMT in their new, post-CAFE vehicles because it improves fuel economy and reduces operating costs.

Unfortunately, policymakers have preferred to increase CAFE standards over time and to maintain the federal gasoline tax at its 1993 level of 18.4 cents per gallon. This inefficient approach has been

compounded by policymakers' reliance on gasoline tax revenues to maintain and expand the highway system. Increasing CAFE standards, while improving the fuel economy of the nation's automobile fleet, has led to declines in gas tax revenues per mile and, along with the fixed gasoline tax, has led to shortfalls in the Highway Trust Fund, which pays for roadway maintenance and improvements. In fact, the U.S. Treasury has transferred more than \$140 billion in general funds since 2008 to keep the Highway Trust Fund solvent (U.S. Congressional Budget Office (2016)). In the midst of this impasse, Congress reiterated its staunch opposition to raising the gasoline tax when they passed a new five year, \$305 billion national transportation bill in 2015. The U.S. Congressional Budget Office projects that by 2026 the cumulative shortfall in the highway account will be \$75 billion unless additional revenues are raised.³

Facing a limited set of options, some policymakers have become attracted to the idea of financing highway expenditures by charging motorists and truckers for their use of the road system in accordance with the amount that they drive, as measured by vehicle-miles-traveled. A VMT tax has the potential to generate a more stable stream of revenues than a gasoline tax because motorists cannot reduce their tax burden by driving more fuel efficient vehicles. The National Surface Transportation Infrastructure Financing Commission recommended that policymakers replace the gasoline tax with a VMT tax to stabilize transportation funding. Interest in implementing a VMT tax is growing at the state level on both coasts. Oregon has recruited more than 1500 volunteers and launched an exploratory study, "OreGO," of the effects

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¹ Havranek et al.'s (2012) meta-analysis drew on more than 200 estimates of the price elasticity of gasoline demand.

² Dahl (1979) conducted an early study of the gasoline tax; more recent work includes Bento et al. (2009) and Li et al. (2014).

³ <https://www.cbo.gov/sites/default/files/51300-2016-03-HighwayTrustFund.pdf>

of replacing its gasoline tax with a VMT tax. California is conducting a pilot VMT study and Hawaii and the state of Washington are expected to conduct one. On the east coast, Connecticut, Delaware, New Hampshire, and Pennsylvania have, as part of the I-95 Corridor Coalition, applied for federal support to test how a VMT tax could work across multiple states.⁴

The scholarly economics literature has paid little attention to the economic effects of a VMT tax because the oil burning externality is a direct function of fuel consumed and because, until recently, policymakers have not even mentioned it among possible policy options.⁵ But given that (1) policymakers have become increasingly concerned with raising highway revenues as well as reducing fuel consumption, (2) travelers' attach utility to VMT, and (3) some automobile externalities (e.g., congestion and vehicle collisions) accrue more naturally per mile driven rather than per gallon of fuel consumed, it is important to know whether social welfare is increased more by a VMT tax than by gasoline taxes that are equivalent in terms of generating revenue or reducing fuel consumption. And to evaluate the long-run viability of both taxes, it is important to understand how they interact with separate but related government policies, including CAFE standards and highway funding that is tied to tax receipts. As we discuss in detail below, because each tax affects different drivers differently and because both taxes affect multiple automobile externalities, it is difficult to unambiguously resolve these issues on purely theoretical grounds.

In this paper, we develop a model of motorists' short-run demand for automobile travel measured in vehicle miles that explicitly accounts for heterogeneity across drivers and their vehicles, and we estimate drivers' responses to changes in the marginal cost of driving a mile in their current vehicles. The model allows us to compare the effects of gasoline and VMT taxes on fuel consumption, vehicle miles traveled, consumer surplus, government revenues, the social costs of automobile externalities, and social welfare. In theory, a gasoline tax should have the greatest impact on motorists who are committed to driving the most fuel inefficient vehicles, and a VMT tax should have the greatest impact on motorists who are committed to driving the most miles.

Our disaggregated empirical approach is able to overcome limitations that characterize the previous literature on gasoline demand, which has generally used aggregated automobile transportation and gasoline sales data.⁶ Aggregate gasoline demand studies specify fuel consumption or expenditures as the dependent variable and measure the price of travel as dollars per gallon of gasoline at a broad geographical level. But data that aggregates motorists' behavior makes it impossible to determine their individual VMT, vehicle fuel efficiency, or the price that they normally pay for gasoline. Ignoring those differences and making assumptions about average fuel economy, gasoline prices, and VMT to construct an aggregate price per mile of travel will generally lead to biased estimates of the price elasticity of the demand for automobile travel and hence the economic effects of a VMT tax.⁷

We initially assess the economic effects of gasoline and VMT taxes that each: (1) reduce total fuel consumption by 1%, or (2) raise an

additional \$55 billion per year for highway spending, which roughly aligns with the annual sums called for by the 2015 federal transportation bill. Surprisingly, we find that the taxes have very similar effects on social welfare. But when we account for the recent increase in CAFE standards that calls for significant improvements in vehicle fuel economy, and when we exploit the flexibility of a VMT tax by setting different rates for urban and rural driving, we find that a VMT tax designed to increase highway spending \$55 billion per year increases annual welfare by \$10.5 billion or nearly 20% more than a gasoline tax does because: (1) the differentiated VMT tax is better than the gasoline tax at targeting its tax to and affecting the behavior of those drivers who create the greatest externalities, and (2) the greater fuel economy that results from a higher CAFE standard effectively reduces a gasoline tax and its benefits, but has less effect on a VMT tax and its benefits.

Our empirical findings therefore indicate that implementing a VMT tax is a more efficient policy than raising the gasoline tax to improve the financial and economic condition of the highway system. Importantly, we also identify considerations that suggest that a VMT tax is likely to be more politically attractive to policymakers than is raising the gasoline tax.

2. The short-run demand for automobile travel

Households' demand for a given vehicle type and their utilization of that vehicle have been modeled as joint decisions to facilitate analyses of policies that in the long run may cause households to change the vehicles they own (e.g., [Manning and Winston \(1985\)](#)). We conduct a short-run analysis that treats an individual motorist's vehicle as fixed; the average length of time that motorists tend to keep their vehicles suggests that the short run in this case is at least five years. We discuss later how our findings would be affected if we conducted a long-run analysis.

2.1. Demand specification

Conditional on owning a particular vehicle, individual i 's use of a vehicle c for a given time period t is measured by the vehicle-miles-traveled (VMT) accumulated over that time period, which depends on the individual's and vehicle's characteristics, and on contemporaneous economic conditions. We assume that individual i 's utilization equation in period t has a generalized Cobb-Douglas functional form given by:

$$VMT_{c(i)t} = f_{c(i)} \lambda_i p_{c(i)t}^{\beta_i} \quad (1)$$

The function $f_{c(i)}$, which we specify as $f_{c(i)} = \exp(\lambda_i + \theta Z_{c(i)})$, contains an individual fixed effect, λ_i , that captures individuals' unobserved characteristics that affect their utilization of a vehicle and a vector of vehicle characteristics, $Z_{c(i)}$, excluding fuel economy, which forms part of the price of driving a mile. To capture heterogeneity among drivers, the price elasticity, β_i , is specified as $\beta_i = \psi X_i$, where X_i includes driver and vehicle characteristics. The vectors θ and ψ are estimable parameters.

The price of driving a mile, $p_{c(i)t}$, is equal to the price of gasoline in month t for driver i divided by vehicle $c(i)$'s fuel economy; thus, this price is likely to vary significantly across drivers because different vehicles have different fuel economies and because the price of gasoline varies both geographically and over time. The utilization equation is more general than a standard Cobb-Douglas demand function for VMT because the price elasticity is allowed to vary by driver and vehicle characteristics and over time.

To estimate the parameters in Eq. (1), we take natural logs and combine terms to obtain the log-linear estimating equation

$$\log VMT_{it} = \lambda_i + \theta Z_{c(i)} + \tilde{\lambda}_t + \beta_i \log(p_{c(i)t}) + \varepsilon_{it} \quad (2)$$

⁴ [Moran and Ball \(2016\)](#) provide a detailed discussion of the Oregon study and suggest that other states should follow it. The Illinois Senate has proposed legislation to roll back the state's motor fuel tax and replace it with a VMT tax within the state's boundaries. However, Illinois has not conducted an experiment, and it is not expected that its VMT legislation will be approved.

⁵ An exception is [Parry \(2005\)](#), who calibrated a theoretical model that suggested that VMT taxes could out-perform gasoline taxes at reducing automobile externalities. The disaggregated empirical approach that we take here enables us to assess the taxes' distributional effects by carefully identifying who is affected by each tax, and to formulate a differentiated VMT tax, which increases efficiency.

⁶ [McMullen et al. \(2010\)](#) estimated the behavior of a cross-section of drivers in Oregon to compare the distributional effects of a VMT tax and a gasoline tax, but a cross-sectional model cannot control for the potential bias that is caused by unobserved household and city characteristics that are likely to be correlated with the price of gasoline, vehicle fuel economy, and vehicle miles driven.

⁷ [Levin et al. \(2014\)](#) find that aggregating gasoline prices tends to reduce the estimated elasticity of gasoline demand.

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