The Distributional Burden of Fuel Taxes and Transportation User Fees

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February 2022
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ABSTRACT

User fees have long been considered as a potential way to finance transportation infrastructure projects. By taxing infrastructure users, they align the financing with the receipt of benefits. One important objection to user fees is that they may be regressive. If the use of highways and other transportation modes is not very income elastic, then user fees will loom larger relative to household income for low- income than to high-income households,

This paper presents new evidence on the distributional burden of user fees for transportation infrastructure, including gasoline and diesel taxes. It considers these fees as a share of household income as well as total household spending. It begins by considering gasoline taxes, which are regressive when measured as a share of current income, but relatively evenly distributed, or progressive, when measured relative to household spending. It also considers the distributional effects of two alternative ways to finance highways: a household-level vehicle miles tax (VMT), and a commercial VMT. The burdens of the household VMT are broadly similar to those of a gasoline excise tax, but it places greater burdens on the drivers of hybrid and electric vehicles, who are disproportionately high income. High income households also bear a heavier share of the commercial VMT than their lower-income counterparts, because they devote a larger share of their budget to expensive tradeable good such as vehicles and audio-visual equipment.

The paper also considers the distributional burden of increased user fees on pub-lic transit and on some other transportation such as infrastructure use. Charges for subways and commuter rail are progressive. Bus expenditures, in contrast, are highly regressive, and loom much larger for low- than high-consumption households.

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Acknowlegements: Glaeser and Poterba are co-PIs on a U.S. Department of Transportation (DOT) research grant to the NBER; Gorback is a post-doctoral researcher supported by this project. Any viewpoints expressed in this paper are the authors', and should not be interpreted as representing the DOT, NBER, or any other organization.

1 Introduction

The Infrastructure Investment and Jobs Act of 2021 (IIJA), the largest public commitment to infrastructure investment in decades, includes a variety of pilot programs meant to explore novel ways of funding transportation infrastructure, many of them taking the form of user fees. These fees, levied on consumers of transportation services, align infrastructure finance with infrastructure use. The gasoline tax is the most widely discussed user fee, but there are many others in place and many more that have been proposed.

The primary objection to user fees is that they are regressive. Chernick and Reschovsky (1997) and others point out that gasoline expenditures represent a larger share of income for low-income than high-income households. This may reflect a greater ratio of transportation outlays relative to income for lower income households, or differences in the nature of transportation service consumption across the income spectrum. For example, as electric vehicles have entered the market, high income households have been early adopters. This raises concerns that the poor, who often have less fuel efficient and older vehicles, end up paying for more gasoline than their higher-income counterparts. Even if low-income and high-income drivers drive the same miles, it may take more gasoline, and more taxes, for the low-income driver. Poterba (1990) suggested that because consumption as a share of income is higher for low-income households, regressivity should be analyzed by measuring gasoline, or other transportation expenditures, as a budget share rather than as an income share. Viewed this way gasoline taxes are less reg ressive than when income is the metric for household well-being. There remain concerns that low consumption households have less flexibility in their budgets, and smaller shares of discretionary spending, to respond to an increase in transportation charges.

Motivated by the increased attention to transportation infrastructure financing, as well as changes in the nature of transportation service provision and innovations in alternatives to gasoline-powered vehicles, this paper presents new evidence on the distributional properties of transportation user fees. It considers gasoline taxes as well as other user fees, for airports, commuter rail, and urban buses. It also presents evidence on the distributional impacts of a key alternative to the current set of user fees: a Vehicle Miles Tax (VMT) either levied at

the household level, or at the commercial level.

We calculate user fee expenditure shares for travel by various modes, and examine how these vary by income. We find that user fees for public transportation are less regressive for rail or subway, we can measure time and trips spent on all three. Both trip counts and wait time are much higher for low income bus riders. In contrast, commuter rail usage increases with income, and subway trips are relatively flat across income in areas with developed systems. Overall, the expenditure share of public transportation declines with income, but ticks up at the highest income levels. These findings are consistent with subway and commuter rail having higher fares than buses; as higher income individuals switch modes, they spend more on public transportation.

We continue by analyzing the distributional features of the current federal gasoline excise tax. It has been fixed in nominal terms since 1993, so its burden as a share of expenditure has declined. Relative to analyses using data from before 2010, the rise of hybrid/electric vehicles, especially among higher income groups, has shifted the user fee burden of the gas tax relatively more towards low income households. The expenditure share on gasoline for those making below $100k nears 10%, and is relatively constant for households in different income groups below this level, but it declines above $100K and falls to 5% for the highest income group. The current gasoline tax is, therefore, regressive.

We then examine two alternatives to the current set of user charges. First, we consider a household-level VMT. Not only is this a more direct form of charging a fee for road usage, but it brings hybrid/electric drivers back into the tax base.The VMT addresses an important concern regarding the erosion of the gasoline tax base that may take place as electric vehicles (EVs) gain in popularity. We show that matching the mean current federal gas cost per mile, or adopting a VMT that is revenue neutral, results in a distributional pattern very similar to that of the current gasoline tax. EV ownership is not currently widespread enough to alter the analysis. A VMT would, however, place new burdens on hybrid/electric vehicle owners, particularly if the revenue collected was sufficient to fully fund the user-fee portion of the Federal Highway Trust. Drivers who own hybrid and electric vehicles tend to be in the upper strata of the income distribution. A Carmax survey (Carmax, 2017) found that 17 percent of hybrid/EV owners have household income of more than $200,000, and that 30 percent

have incomes above $150,000. Davis and Sallee (2020) report that in 2017, the probability of owning an electric or hybrid vehicle rises from negligible at the lowest income levels to over 4 percent at the hie the higher-income population.

Second, we consider a commercial VMT. Four states, Kentucky, New York, Oregon and-New Mexico, have already adopted such a policy. We assume that shipping costs are passed on to end-use consumers of tradeable goods, so adding a VMT on top of the current diesel tax impacts consumption and expenditure shares, depending on the bundle of goods households purchase. We find that higher income households face greater burdens from the commercial VMT than their lower income counterparts, because tradeable goods represent a larger share of their budget.

A number of recent studies have considered various aspects of the VMT, notably Davis and Sallee (2020), Langer, Maheshri and WIiston (2017), and van Dender (2019) The study that is most closely related to our household VMT study is Weatherford (2012), who finds that moving from a fuel tax to a mileage-based user fee have only very little distributional impact. We build on this study but use more recent data which includes the rise of hybrid/electric personal vehicles, especially among higher income groups. We find somewhat greater progressivity of the VMT relative to the gas tax, which is due to the growth in high-income, hybrid/electric owners who, at present bear little of the fuel tax burden.

There is relatively little prior work focused on a VMT levied on businesses, although the idea is not new. Small, Winston and Evans (1989) propose replacing current commercial user fees with taxes based on pavement wear, to match the marginal cost of damage imposed by trucks. They find substantial welfare gains are possible, but their policy is more expansive than the one we consider, and also involves optimizing highway expenditure.

The paper is divided into six sections. Following this introduction, Section 2 provides background on user fees, where they are levied, and past work assessing their distribution. Section 3 introduces the data that form the basis for our analysis, and Section 4 presents our core findings on the distributional impacts of current transportation user fees. Section 5 focuses on the two alternative user fee policies that we consider, and Section 6 concludes.

2 Background on User Fees in Transportation

User fees are the component of travel costs used to fund transportation infrastructure, such as roads, bridges, public transportation networks, and airports. For roads and bridges, these include the gasoline and diesel taxes, tolls, public parking, and may one day include vehicle miles taxes. For public transportation, we pay user fees in the form of bus, subway, and rail fares. When purchasing a plane ticket, the consumer will pay a variety of user fees to local and federal governments, including FAA taxes, an EPA fuel tax, the Local Aiport Projects facility charge, as well as DHA fees. Transportation user fees are levied at a variety of levels, and used to fund and maintain infrastructure. Importantly, these user fees do not contribute a large part of revenues for any level of government, and many local and state governments rely heavily on intergovernmental transfer to fund infrastructure.

As shown in Figure 1, local governments rely heavily on fees levied at airports and to use public transportation. These shares have been growing since the 1990's, especially after accounting for intergovernmental transfers to municipalities to use in maintaining their public transit sector and airports. Panels (c) and (d) in Figure 1 show that state budget rely more on car-related user fees, such as highways and tolls, and especially on fuel taxes, which make up about 3% of state revenues in 2017. Importantly, states have become less reliant on car-related fees over time, with fuel taxes falling to 3% in 2017 from nearly 10% in 1970. Finally, federal revenues rely very little on any form of transportation user fee, with the exception of fuel taxes, which comprise between 1 and 2% of the revenues. Reliance on the gas and diesel taxes has been declining over time as these tax rates have not been lifted in decades, even as fuel efficiency has increased. The current federal gas tax has not been updated since 1993, and is not indexed to inflation.

As with revenues, expenditures also vary by government level. All levels of government have historically allocated meaningful expenditure shares to highway infrastructure, though this has declined across the board in the last two decades. In contrast, the federal government spends little on public transportation directly, while state and local governments allocate large shares to public transportation. Similarly, the federal and state governments have reduced air travel expenditures, as local governments have increased.

Regardless of the level of government, expenditures often outstrip revenues from user fees for large infrastructure projects and systems. For example, using data from the National Transit Database, we can calculate the total operating costs and revenues by agency, as in Figure 2. All of the top 50 largest transit authorities run budget deficits, with the largest having operating costs many billions more than their fare revenues. For example, the Metropolitan Transit Authority in New York City has operating expenses approaching $9 billion per year, but only brings in $4.5 billion in fares. Panel (b) shows that the cost for an average trips varies between $5 and $10 for most of these agencies, but the average fare charged barely reaches $2.

Given the general lack of revenue to cover operating expenses, policymakers have been keen to come up with new revenue sources. The Infrastructure Investment and Jobs Act (2021), proposes new programs and pilots around VMTs; however, an eventual policy adoption must weight the benefits of revenue generation against the costs of imposing travel burdens on constituents, especially those with lower incomes. As such, we explore whether different types of user fees exhibit regressivity. The information we provide on current transportation mode utilization by income group can inform the burden of user charges on these transport modes, as well as the relative distributional burdens of different financing models.

3 Data

In order to perform our analyses, we draw on a variety of datasets. We use the National Household Travel Survey (NHTS) to study transportation utilization by mode and income group. The NHTS is conducted every 8 years to study household travel patterns, and is a key input into national, state, and regional infrastructure planning. The survey recruits households and asks them about their trips in a 24 hour period, including mode, purpose, trip length, time of day, among other characteristics. These surveys are then linked to a suite of demographic and socio-economic, vehicle, and location characteristics. We use data from three 2017 NHTS products: the household survey, the trip level survey, and the vehicle survey. The data covers 264k individuals in 139k households, across 924k trips, and 256k unique vehicles.

The person level data aggregates the raw survey data to the individuals and provides many of the demographic and socio-economic characteristics in the survey. It also provides household weights used to aggregate to population level statistics. We use this data to estimate the number of households using each mode of transportation, in each income bin. The 2017 NHTS contains 11 income bins, with the highest bin top-coded at $200,000.

The trip level data contains trip characteristics, such as mode, purpose, and length. We use this data to study trip shares by mode and income, as well as travel wait times for public transportation. Specifically, we study the following modes: private vehicle, bus, subway, commuter rail, airplane, and tolls[1]. Finally, the vehicle survey gives us data on vehicles, such as their age, fuel type, and annual miles traveled.

While the NHTS is suitable for utilization and wait times, but does not have data on travel costs. For that, we turn to the Consumer Expenditure Survey (CEX). The CEX is a nationwide survey conducted quarterly by the Bureau of Labor Statistics. It provides estimates of annual expenditures on a variety of consumer goods and services by income bin. We use data on "gasoline, other fuels, and motor oils" as well as "public and other transportation" for 2019.

We use SafeGraph data from 2019 to track travel to different transportation modes. SafeGraph tracks cellular devices, and records visits to points-of-interest (POIs), as well as the visitors' home and work census block groups.[2] While we do not have data on purpose of a trip, SafeGraph assigns a NAICS industry code to each POI. We examine trips to three categories of POI's, as defined by the following NAICS codes, provided by SafeGraph: Scheduled Passenger Air Transport (NAICS 48111), Line-hail Railroads (NAICS 482111), and Bus and Other Motor Vehicle Transit Systems (NAICS 485111). Finally, we aggregate the number of trips to each NAICS category to derive the number of air, rail, and bus trips originating in each block group. This allows us to overlay travel data with demographic characteristics from the American Community Survey at fine geographies.

For commercial policy evaluation, we incorporate data from the Commodity Flow Survey

[1]The 2017 NHTS does not contain a question about tolls, in this case we instead use data from the 2009 NHTS.

[2]Only origin-destination pairs with at least 4 visitors are recorded in SafeGraph, so we are under-reporting trips along infrequent routes.

(CFS) and the Freight Analysis Framework (FAF), which builds on the nonpublic CFS . The CFS tracks commodities flowing across states and industries in the U.S. We use 2017 data to identify how far, and how many goods travel. In particular, we calculate the total tons, ton-miles, miles, and values for 21 3-digit NAICS, 19 4-digit NAICS, 1 5-digit and 1-6 digit NAICS, all mutually exclusive. The FAF data allows us to break down how much freight traveled between states by commodity, as well as by transport mode.

4 Distributional Impact of Charges for Public Transportation

To measure the distributional burden of user fees for public transportation, we compute the share of total expenditure as well as income going to public transportation (using the median income for each bin). Analysis by expenditure share, rather than income alone is motivated by Poterba (1990), who observed that consumption as a share of expenditure is a more useful indicator than consumption as a share of income, especially for those at the highest and lowest income levels. At low income levels, income is often lower than expenditures due to net transfers, for example from tax credits or in-kind aid. At high incomes, expenditure falls below income because of substantial saving. Particularly at lower income levels, the consumption metric may be helpful. When we do not have expenditure share, we analyze utilization rates, or time spent on travel. Time spent on travel is an important component of the cost of transportation.

4.1 Public Transporation

Figure 3 breaks down the number of trips taken each day by mode and income group, using data from the NHTS. For each income group, we plot the share of trips taken by either bus, subway, commuter rail, or which paid a toll. Panel (a) shows that bus utilization is decreasing in income, with individuals in the lowest income bin (<$10,000) using the bus approximately 0.3 times each day (roughly once every three days). In contrast, only individuals in the highest income bin use the 0.03 times a day. Panel (b) shows the same

breakdown for subway use. Subway use is very popular again for the lowest income bin, with 0.05 trips taken per day on average. In contrast to bus usage, subway use increases with income after its decline from the first to second income bin. This reflects the reliance of low-income inner city neighborhoods on public transit, as well as the relatively high incomes in urban cores across the country, such as Manhattan, where proximity to a subway is highly valued. Commuter rail use, in panel (c) displays the most progressive use of any form of public transit. The wealthiest survey respondents reported using commuter rail 0.022 times each day, while utilization falls steeply for incomes below $100,000. Commuter rail tends to be co-located with wealthy suburbs surrounding dense cities, and fare costs are higher than public bus or subways. Finally, panel (d) shows toll use by income bin.[3] Toll use is relatively high for the lowest income respondents, with about 0.25 daily trips including some form of toll. After the lowest bin, paying tolls becomes again more progressive, with the richest respondents paying tolls on 0.3 trips per day.

While the NHTS do not collect data on public transit fare structure, toll amounts, or gasoline purchased, it does collect data on another travel cost: wait time. Figure 4 shows how many minutes of wait time the average trip on public transit includes. Across all three available public transit options, bus, subway, and commuter rail, richer respondents reported less wait time than poor respondents. Panel (a) shows that trips in the lowest income bin included 11 minutes of wait time, while trips taken by individuals in the highest bin had approximately half as much wait time, at 6.5 minutes.

This wait time comes at a cost. Assuming an individual works 50 weeks per year and 35 hours per week, we can calculate the average wage for each income bin. We can then find the annual cost of the time spent waiting for the bus by multiplying this hourly wage by the share of an hour waited, over 252 work days (261 business days less federal holidays). Finally, we can aggregate the forgone wages spent waiting by the number of people in each income bin who took each transportation mode. Panel (a) shows that aggregate foregone wages increase steeply between the lowest income bin up to $75,000, after which they become somewhat noisy due to the small share of individuals who take trips on buses.

Panel (b) show the same measures, wait time and foregone wages, measured for subway

[3]The toll data comes from the 2009 NHTS survey, and has different income bins.

rides. Again, the poorer individuals wait the longest for subways, as richer individuals can pay to locate closer to a subway, or to stations with more lines or more frequent service. The average subway trips for a rider in the poorest income bin includes 9-10 minutes of waiting, while the average subway trip for an individual in the top income bins only include 5.5 minutes of waiting. While the poorest pay more in minutes, the rich pay more in foregone wages, as shown by the nearly monotone increase in the aggregate cost of time across bins. The richest households are foregoing a minimum of $800 million per year, which is a lower bound as annual income is assumed to be $200,000, but is in fact censored and higher in reality.

Panel (c) shows the wait and foregone earnings for commuter rail. Commuter rail is the least utilized nationally, and also the most progressively used. Wait times are less monotone than those associated with bus or subway trips, likely as these trains come less frequently and service wider areas. Riders in the lowest two income bins wait 15-18 minutes on average, while those in the highest bins wait 11-15 minutes. Similar to the subway results, the opportunity cost paid in aggregate is much larger at higher incomes, approaching $1.25 billion per year, reflecting that the composition of commuter rail riders is skewed towards the rich and they have longer wait times than with the subway.

While the NHTS can reveal ridership patterns by income, it cannot tell us how much people spend on travel. To examine expenditure shares, we use data from the CEX. Figure 5 shows that expenditure on public transportation is generally decreasing by income, but U-shaped for expenditure shares. This is in line with the NHTS results, which find high utilization of public bus transportation for low incomes, with higher utilization of subways and commuter rails at higher incomes. At the lowest incomes, people spend 1.3% of their annual expenditures on public transportation, but 4.6% of their income. This reflects the fact that many low-income individuals receive higher amount of aid, such that they may end up spending more than they earn. At the highest end of income, individuals spend 2% of their expenditures on public transportation, which is higher than the 1.5% of their income. This shows how high-income individuals tend to spend less than they earn, such that the same amount of spending is a lower share of expenditure than it is income.

4.2 Private Vehicles

Driving a car is not necessarily progressive, but the amount of travel is, as shown in Figure 6. Panel (a) shows that individuals with the lowest incomes take 3.5 trips per day by car. Daily car trips increases quickly up to incomes of $50,000, where is roughly plateaus at 4.5-4.8 trips per day by car. In contrast, annual miles driven increases monotonically with income, with those in the top two income bins driving around 8,000 miles a year, and those in the lowest driving roughly 5,000 miles.

At first glance, this may look like the richest individuals will then pay the most in gasoline taxes, as they consume the most miles. However, richer households buy much more fuel efficient vehicles than their poorer counterparts. Figure 8 shows that approximately 5% of households in 2017 had hybrid vehicles, while only about 0.5% of lower income groups did. Additionally, those in the lowest income groups have much older, and often less fuel efficient, vehicles. The lowest income households have vehicles 5-6 years older than the higher income households.

Again turning to the CEX for data on fuel relative to total expenditures and income, 7 shows that using the expenditure share, rather than income share, makes the fuel expenditure profile by income much flatter. Those in the lowest income group spend roughly 4% of their outlays on fuel per year, while those in the highest income group spend 2% of their annual outlays on fuel. If we were to compare these two groups using income share, gas taxes would look much more regressive, as the lowest income groups spend 13% of their income on fuel, and the highest income spent 1.7% of their income of fuel.

5 Distributional Impact of Alternative User Fee Structures

This section applies the same approach to computing the distributional impact of user fee structures to two alternatives to the status quo, personal and commercial VMT adoption.

5.1 Replacing the Federal Gasoline Tax with VMT

First, we consider replacing the federal gasoline tax with a VMT. We envision limiting this to personal vehicles, as much of the commercial vehicle fleet relies on diesel. The federal gasoline tax was created in 1932, and last updated in 1993, when it was set at 18.4 cents per gallon. To keep up with inflation, the equivalent tax rate in 2021 would be set at about 34 cents per gallon. Further diminishing the purchasing power of the gas tax, infrastructure costs have been increasing, in particular for new lane-miles (Brooks and Liscow, 2019; Mehrotra, Turner and Uribe, 2021). Finally, vehicles have become more fuel efficient, and the tax collected per vehicle mile traveled has fallen. The static tax rate, rising infrastructure costs, and increased fuel efficiency have all contributed to a growing gap between tax revenues allocated to the Federal Highway Trust, $43.4 billion in 2021, and its expected outlays, expected to average $60.4 billion over FY2021-FY2025 (Kirk and Mallett, 2020).

US residents are increasingly adopting hybrid and electric vehicles, whittling away at the gas tax revenues. As of 2020, sales of hybrids, plug-in hybrids, and all-electric vehicles grew to 5.4% of all light vehicle sales, from 2.3% in 2011, the year in which all-electric vehicles first came to market, and 0% in 1999, the year the Toyota Prius came ot market. Importantly, all-electric vehicle sales alone have grown from 0.1% of all sales in 2011, to 1.7% in 2020, none of which pay any federal gas tax (Davis and Boundy, 2019). As this market continues to grow, policymakers have increasingly considered switching to the vehicle miles tax (VMT), which would tax drivers based on their road usage rather than gas consumption, ensuring that electric car drivers would contribute to paying for the infrastructure maintenance costs that they impose on the system.

Proposals for the VMT vary, so we consider three options: (1) anchoring the tax per mile to the mean effective tax per mile under the current federal gasoline tax rate, (2) setting the tax per mile such that the same amount of revenue is collected under the proposed VMT and the current federal gasoline tax, and (3) choosing the tax per mile to fully fund the Federal Highway Trust. We detail each proposal below, but first outline some characteristics of the current tax regime, including miles traveled, mean revenues paid per person, and aggregate revenues.

5.1.1 Miles and Federal Revenues under Current Gas Tax

As of 2017, the most recent year for while we have data from the National Household Travel Survey, the average household drives about 12,000 miles per year, or about 33 miles per day. This mean masks substantial heterogeneity in travel, with the 25^{th} percentile driving 15 miles per day, and the 75^{th} percentile driving nearly triple that at 42 miles per day. Additionally, panel (a) in Figure 9 shows that richer households tend to drive more per annum than their low-income counterparts, suggesting the gasoline tax would be progressive. However, for taxes paid per mile, we need to know not only how many miles driven, but how many miles per gallon each vehicle uses, and on average, lower-income households drive older and less fuel efficient vehicles. Panel (b) shows that when we take into account vehicle fuel efficiency, the tax burden per mile is higher at low incomes, falling over most of the income distribution, before rising again for the very highest incomes.

5.1.2 Modeling the Effects of a VMT

To analyze the impact of various alternatives to the current user fee structure, and the impact on miles driven and revenues, we develop a simple theoretical framework. Let each household i have a quasi-linear separable utility with power function for transport such that,

$$U_i(T_i) = Y_i - pT_i + AT_i^{\sigma} \tag{1}$$

Households earn income Y_i, and T_i represents travel in miles, which is paid at a price per mile, p. This yields a first order condition of the constant elasticity functional form after taking logs,

$$\frac{\partial U_i}{\partial T_i} : ln(T_i) = \frac{1}{1-\sigma} ln(A\sigma) - \frac{1}{1-\sigma} ln(p) \tag{2}$$

Equation 2 identifies the price elasticity of demand for travel, $\varepsilon_g = -\dfrac{1}{1-\sigma}$, which we set to $\varepsilon_g = -0.31$, a middle ground in the elasticities estimated by Levin, Lewis and Wolak (2017).

Finally, the change in utility, in dollars, from a change in the price of gasoline is as follows,

$$\Delta U_i(T_i, T_i^j) = \Big(\frac{1}{\sigma} - 1\Big)(pT_i(p) - (p - \tau + t_j)T_i^{(j)}(p - \tau + t_j)) \tag{3}$$

where j indexes our three proposals. Each of our three VMT options will use a different $t_j \in \{t_1, t_2, t_3\}$, and since the VMT would replace the existing fuel tax in our proposal, the price paid after policy adoption is the original gas price per mile paid at the pump, p, less the original gas tax per mile, τ, plus the VMT tax per mile, t_j.

In reality, initial p and τ are going to vary by the observed gasoline prices in one's area, as well as by a household's fuel utilization, such that each household has their own gas price per mile, p_i, and their own tax per mile, τ_i, motivated by panel (b) of Figure 9. Moving from a tax on gasoline consumption, to a tax on miles consumption, removes the heterogeneity in how much people are taxed per mile, so t_j is fixed across households.

For hybrid and electric vehicles, we have to modify their price per mile, as they do not pay the federal fuel tax as gasoline vehicles do. To do this, we set the cost per mile, p^e, for electric vehicles at 4 cents, which assumes the vehicle travels 3 miles per kWh, at the average rate for electricity of 11.7 cents per kWh (Advanced Vehicles Testing Activity, 2011). For hybrid vehicles, we assume a an average price of \$2.41/gallon, taken from the NHTS sample, and an efficiency of 45 mpg, yielding a hybrid cost per mile of $p^h = \$0.055$, or 5 and a half cents per mile. These prices do not vary across households due to data limitations.

We can calculate miles driven under t_j as the initial miles driven, T_i, less (plus) the change in miles as prices rise (fall), relative to the initial price per mile,

$$T_i^{(j)} = T_i + T_i\Big(\frac{t_j - \tau_i}{p_i}\Big)\varepsilon_g \tag{4}$$

and tax revenues are $t_j \times T_i^{(j)}$.

We consider the distributional impact of three VMT options, corresponding to different revenue raised. The options differ only in their proposed t_j.

(1) Match VMT at Current Effective Tax/Mile: Our first VMT proposal would set $t_1 = \frac{1}{n}\sum_i \tau_i = \$0.0089$, or $\frac{9}{10}^{ths}$ of a cent per mile. This policy would induce no behavior

changes on average; however, depending on the difference between t_1 and τ_i, will still induce a change in miles driven for individuals.

(2) Match Current Federal Gas Tax Revenues: Our second VMT proposal would set t_2 s.t revenues equal those under the current federal gas tax,

$$Revenue^2 = \sum_i t_2 T_i^{(2)} = \sum_i 0.184 \times gal_i \tag{5}$$

where gal_i is the number of gallons of gasoline used by household i. We minimize the difference between these two revenues to estimate a $t_2 = \$0.0088$, effectively the same as under proposal 1.

(3) Fund the Federal Highway Trust: Finally, for proposal 3, we set t_3 to fully fund the Federal Highway Trust (FHT). Of the \$40.5 billion raised to fund the FHT 2017, federal fuel taxes comprised \$25.7 billion, or 64% of the revenues. Over the 2021-2025 fiscal years, projections estimate FHT outlays of \$60.43 billion on average, with revenues coming up short at only \$42.9 billion. If we assume all revenues sources maintain a constant share, VMT would need to raise $0.64 \times 60.43 = \$38.35$ billion towards fully funding the FHT.

$$\$38.35 \text{ billion} = \sum_i t_3 T_i^{(3)} \tag{6}$$

We minimize the difference between this budget target and VMT tax revenues, yielding a VMT of $t^3 = \$0.021$, or about 2 cents per mile. This is roughly 2.3 times higher than the VMT's in the other two proposals, or the average price paid per mile under the current federal fuel tax.

5.1.3 VMT Counterfactual Results

Table 2 shows how the VMT proposals differ in their miles and taxes paid relative to the baseline of our current gasoline tax regime. In addition, we also provide summary statistics for the percent change in price per mile, $\%\Delta ppm_i = 100 * (t^j - \tau_i)/(p_i)$, as well as the amount of welfare lost by switching from the baseline to the proposal. Positive values for welfare change indicate that welfare was higher under the gasoline tax regime than under the new VMT.

Under the current tax regime, households drive on average about 12k miles per year, and pay $105.25 in fuel taxes. Moving to proposal 1, we see little change in average driving behavior, and taxes paid rise on average by less than a dollar. Similarly, welfare only declines by about one dollar. The results are generally the same moving on to proposal 2, with average taxes paid by the household roughly constant at $105, and welfare falling by less than 63 cents.

Moving to proposal 3, in which we have significantly raised the taxes per mile from a baseline average of $0.009 to $0.021, we see miles fall by 4% on average, as drivers drive less in light of the higher tax. Even with this fall in miles driven, taxes paid rises from $105.25/year to $244.93/year, or 133%. As such, welfare declines significantly, with residents losing an average of $74.54 per month.

We can also disaggregate the welfare results by income and type of vehicle owned to explore the distributional features of these different VMT options and to compare them with the current gasoline tax regime. The top row of 10 shows the mean welfare loss per gasoline-household, as well as the aggregate welfare losses for all households, for each VMT option. In the first two cases, the average gasoline household is better off; however, in order to fully fund the FHT, gasoline-households will lose between $68 and $78 in welfare a year. Results are marginally different by income bin, suggesting the burden will fall relatively harder on the lower income groups as a share of expenditures.

A key argument for a VMT is that drivers who do not consume gasoline are not paying to use publicly provided roads as are the gasoline-households. The bottom row of 10 displays the welfare impacts for households with electric or hybrid vehicles. As expected, panel (a) shows higher welfare losses for the hybrid/electric households as they had not been paying any federal fuel costs prior to the VMT adoption. Under the first two VMT options, hybrid/electric households end up losing between $50 and $70 per year, and under the FHT proposal, they lose $110 and $155 more in welfare per year. Welfare losses on average decline with income, likely more regressive once calculated as a share of income.

None of these welfare calculations include the potential benefits of reducing other taxes that are currently levied to fund the FHT, or the lower driving externalities, such as reduced congestion and emissions. Were we to incorporate improvements to infrastructure paid for

by the new revenue, on top of benefits of less traffic and lower emissions, we would expect to find smaller welfare losses. Because vehicle mile taxes would not be levied at the gas pump, they would likely be paid once per year or in installments, both of which we know will impact price salience, and perhaps change the value of ε_g we have assumed in this analysis.

5.2 Expanding the Commercial VMT

We also consider the implications of an expanded vehicle miles tax, but for commercial vehicles. Heavy trucks are currently taxed at \$0.24 per gallon of diesel, but this taxation is unlinked to the value, weight, or distance of the shipped goods. This results in trucks often maxing out load capacities, which results in significant road damage. In most states, the majority of trucking tax paid were fuel taxes, and one-off fees such as registration fees and tire taxes. Small, Winston and Evans (1989) note that in a handful of states, taxes have varied by miles traveled or by vehicle weight. New Mexico, New York and Oregon have moved towards a VMT for commercial trucks that varies with the trucks' maximum load capacity (\$0.01-0.29 per mile, depends on weight). On the other hand, Kentucky has adopted a flat fare structure set in the middle of the other states' ranges at \$0.03/mile, regardless of weight.

Our analysis of the commercial VMT differs from that of the all-drivers VMT in two ways. First, we do not replace the diesel tax with a VMT, but instead add a VMT in addition to the diesel tax, as the commercial vehicle fleet is not greening at the same rate as the personal fleet. Second, in addition to analyzing how VMTs would change commercial vehicles mileage (to be added in next draft), we analyze how adopting a commercial VMT changes the end-user price of traded goods. This unifies our analysis of the commercial and personal VMT policies by centering both of them on the household, rather than the vehicle. In the commercial context, we first estimate the share of shipping costs and fuel taxes currently in household's expenditure. Next, we explore how an additional commercial VMT would impact household's expenditure and consumption bundles. We do this in a simple framework analagous to a compensating/equivalent variation study.

5.2.1 Framework for Analyzing Consumption Responses to Commercial VMT

We first calculate the share of consumer expenditures attributable to shipping costs and federal diesel taxes. Consumers live in destinations, and they consume goods after its final shipping stage. Let a consumer i, living in location s, consume a variety of tradable goods, c. They spend e_{ics} on each type of good. These tradable goods can be produced locally, or traded across space, and the share produced non-locally varies by location, $NonLocal_{sc} \in [0, 1]$. Not all goods are shipped via trucks, for example the US transports much of its fuel by pipeline rather than truck. As such, each good also has a share shipped by truck that varies over space, $Truck_{cs} \in [0, 1]$. It costs money to ship tradable goods, and these shipping rates per mile vary by region of the country according to local costs, with a price per mile of PPM_s. For example, truck drivers may prefer certain routes to others and charge more for less desireable routes (Yang, 2021). Because we do not observe the shipping cost in the price tag of the end-user goods we consume, we calculate shipping costs ($PPM_s \times Miles_{cs}$) relative to shipped goods' value, $Value_{cs}$. We can perform similar analysis using the diesel price per mile, $\frac{\tau_d}{MPG}$, instead of price per mile.

For each expenditure category, c, consumers pay a share γ_{cs} in shipping costs. This share only applies to $NonLocal_{cs}$ expenditures shipped by $Truck_{cs}$. We scale by total expenditure to recover:

$$ShippingShare_{is} = \frac{\sum_c \gamma_{cs} exp_{ics} NonLocal_{cs} Truck_{cs}}{TotalExp_{is}} \tag{7}$$

Where

$$\gamma^1_{cs} = \frac{PPM_s Miles_{cs}}{Value_{cs}} \tag{8}$$

$$\gamma^2_{cs} = \frac{\tau}{MPG} \frac{Miles_{cs}}{Value_{cs}} \tag{9}$$

5.2.2 Implications of Commercial VMT Adoption

We use expenditure data from the Survey of Consumer Expenditures (2019) and identify 9 major tradable goods categories: food at home, housing (furniture and appliances), pharmaceutical & medical supplies, apparel, new & used vehicle purchases, gasoline, and entertain-

ment goods (such as pet supplies, or audio visual equipment).[4] To construct $NonLocal_{sc}$ shares for each location and good category, we use data from the Commodity Flow Survey (2017). $NonLocal_{sc}$ is set to the share of good c consumed in state s coming from outside of state s, the most granular geography available. This proxies for whether a good was shipped or produced locally, as in oranges from a California farmer's market (local) vs. oranges shipped in from Florida (nonlocal). To calculate the share of each category shipped using trucks, we collect data from the Freight Analysis Framework (FAF, 2017) data. This allows us to calculate the share of category c arriving in state s by truck vs. other modes. For both the non-local and trucking shares, we consider share of category *value*, not category *volume*.

Once we have the shares for each expenditure category, we also need data on prices and quantities of each category. PPM_s comes from DAT Freight & Analytics (prices collected in February 2022). These prices vary across 5 US regions, as well as by truck type $\in \{Van, Refridgerated, Flatbed\}$.[5]. The other relevant shipping cost is the federal diesel tax, set at \$0.244/gallon. At an average of 6.4 miles per gallon (Leslie and Murray, 2019), this translates to an average fuel cost of about \$0.04 per mile. Finally, we use data on miles shipped, $Miles_{cs}$, and value of traded category, $Value_{cs}$, from the Commodity Flow Survey (2017). We summarize the variables used in calculating $ShippingShare_{is}$ in Table 3.

Figure 11 shows the distribution of γ^1_{cs} and of γ^2_{cs} by income. The average households spends about 0.06% fo their expenditure on shipping costs. This translates to about \$48/quarter. If we consider the federal diesel fuel tax component of expenditure, the average household spends 0.001% of their total expenditure on commercial diesel taxes, or about \$5 per quarter across all tradable goods. There is not much evidence of patterns by income bin, so we can't draw conclusions on the current regressivity of diesel tax passthrough on households.

Setting the VMT on commercial vehicles could be informed by the costs imposed by truckers on pavement and bridge maintenance. Beider and Austin (2019) report estimates social costs imposed by heavy trucks per mile. Costs increase with vehicle weight, holding

[4]We examine the average annual expenditures by major line items in the Consumer Expenditure Survey as in https://www.bls.gov/cex/tables/calendar-year/mean/cu-all-multi-year-2013-2020.pdf

[5]Refrigerated prices applied to food commodities; flatbed prices applied to vehicle purchases; all other tradable goods assigned van prices. The prices are contract rates seen by producers looking to purchase shipping services, inclusive of taxes, driver wages, tolls, gas, etc

axles fixed: for example, for 5-axle trucks, the damage costs per mile are estimated to increase from \$0.05/mile for 70-80k lb truck, to \$0.85/mile for 110-120k lb truck. Costs also decrease with vehicle axle count: a truck weighing 100-110k with 5 axles imposes \$0.83/mile of damage, while an additional axle drops this damage to \$0.50/mile. Unfortunately, these damage costs are significantly higher than any VMT adopted, be it flat or varying by weight. As such, we anchor our analysis to a middle-of-the-road flat VMT, as in Kentucky, and set our VMT to \$0.03 per mile. Combined with the existing to the diesel fuel tax cost per mile, this nearly doubles the taxation costs per mile. We choose to supplement rather than supplant as the electrification of the commercial vehicle fleet lags that of the personal vehicle fleet, with the overwhelming majority of commercial drivers still pay diesel taxes.

In order to analyze the impact of adopting a commercial VMT, we first calculate the change in goods consumption, by category, holding initial expenditure fixed. This allows us to understand how consumption bundles must adjust downwards in light of new taxes. Next, we calculate the change in expenditures needed to purchase the original consumption bundles, demonstrating how much expenditures must grow to keep people at their original bundles. These constructs are similar to the concept of compensating variation; however, we have abstracted away from utility functions and income.

Households spend a portion, $1 - \alpha_{cs}^t$, of their total expenditures on consumption goods, $good_{ics}^t$, and the taxes levied on said goods, tax_{ics}^t:

$$e_{ics}^t = (1 - \alpha_{cs}^t)e_{ics}^t + \alpha_{cs}^t e_{ics}^t \tag{10}$$

$$e_{ics}^t = good_{ics}^t + tax_{ics}^t \tag{11}$$

After a tax policy change, we calculate consumption and expenditure responses, holding the other fixed in time 0:

$$\Delta good_{ics} = (\alpha_{cs}^0 - \alpha_{cs}^1)e_{ics}^0 \tag{12}$$

$$\Delta e_{ics} = \Big(\frac{1 - \alpha_{cs}^0}{1 - \alpha_{cs}^1} - 1\Big)e_{ics}^0 \tag{13}$$

For this exercise, we set $\alpha^0_{cs} = \gamma^2_{cs}$, and $\alpha^1_{cs} = \left(\frac{\tau}{MPG} + \tau_{VMTc}\right)\frac{Miles_{cs}}{Value_{cs}}$, where τ_{VMTc} is the new commercial VMT. Figure 12 displays the results of adopting the proposed commercial VMT. Panel (a) shows that, on average, tradable good consumption declines by 0.002%, with the most decline as percent of original tradable good expenditure among the highest income groups. This makes sense as higher income groups spend relatively more of their incomes on expensive durable tradables, such as audio visual equipment and vehicles. One caveat seems to be that the lowest income group suffers one of the largest drops in income. Similarly, panel (b) shows that the average expenditure needed to purchase one's original tradable good bundle increase by 0.002%. This is increasing in income, again with the exception at the lowest income bin.

6 Conclusion

As electric vehicles become more common, policymakers must grapple with new ways to raise revenue to finance highway infrastructure. In this paper, we have examined the impact of replacing the gasoline tax with a VMT levied on all drivers, or one levied only on commercial vehicles, as a way to bolster declining revenues from gasoline and diesel taxes. We find that adoption of these policies will likely result in a less regressive user fee burden for households, as higher income households are less likely to pay current gasoline taxes because they are early adopters of hybrid and electric vehicles. These households also spend relatively more on tradeable goods, the prices of which are more sensitive to transport costs that would increase in response to a commercial VMT. Adopting either type of VMT would thereforelikely be less regressive than the current gasoline tax.

As various policies encourage alternatives to driving, such as public transit, the role of user fees and other means of financing this infrastructure will attract greater attention. The potential for user fees to finance such infrastructure use is an open issue. We also find that user charges for various forms of public transportation vary in their distributional burdens. Many public transit authorities already offer discounts based on life stage, such as student or senior discounts, in line with reduced fare requirements for authorities that receive federal

funding (CFR Title 49, Section 609). Some also offer low-income fare adjustments. These provisions have important effects in improving the progressivity of user fees for financing these transportation modes. The IIJA includes more than $100 billion for public transporation, with equity and modernization highlighted as key policy goals. User fees financing could provide a way of expanding the revenue base for new public transit projects. We hope to consider in future work how various public transportation policies that create differentials in user fees across households with different average incomes affect the progressivity or regressivity of these fees.

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Tables

Table 1: 2017 NHTS Income Bins and Population

Income Range	Individuals (millions)	Percent
<$10,000	19	6
$10,000-$14,999	14	5
$15,000-$24,999	24	8
$25,000-$34,999	27	9
$35,000-$49,999	33	11
$50,000-$74,999	49	16
$75,000-$99,999	39	13
$100,000-$124,999	32	11
$125,000-$149,999	19	6
$150,000-$199,999	18	6
>$200,000	20	7
Total	302	97.4

Notes: Individuals calculated as the sum of person-level weights from the individual survey. They do not sum to 100% of the population as 2.6% of the survey respondents did not provide an income. Only individuals above the age of 5 are included in the survey.

Table 2: Impact of VMT Proposals on Price per Mile Change, Miles, Taxes Paid, Welfare

	Mean	**Std. Dev.**	**p25**	**p75**
Baseline: Current Gasoline Tax				
Miles	11,894	11,588	5,486	15,287
Taxes Paid	105.25	108.79	46.32	134.02
Proposal 1: Match Current Effective Tax/Mile				
$\%\Delta ppm_i$	0.90	3.48	-0.99	1.71
Miles	11,863	11,561	5,481	15,247
Taxes Paid ($'s)	106.14	103.43	49.04	136.41
Welfare Change ($'s)	1.05	21.36	-5.32	7.14
Proposal 2: Match Current Federal Fuel Tax Revenue				
$\%\Delta ppm_i$	0.84	3.46	-1.04	1.64
Miles	11,866	11,563	5,482	15,250
Taxes Paid	105.37	102.69	48.68	135.42
Welfare Change ($'s)	0.63	21.35	-5.69	6.75
Proposal 3: Fund the Federal Highway Trust				
$\%\Delta ppm_i$	12.73	7.50	8.56	15.13
Miles	11,429	11,140	5,276	14,683
Taxes Paid	244.93	238.75	113.06	314.66
Welfare Change ($'s)	74.54	74.68	32.57	96.26

Notes: $\Delta ppm_i = 100 * (t^j - \tau_i)/(p_i)$

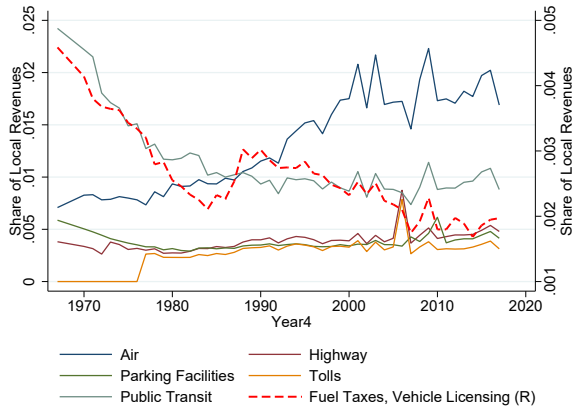
Table 3: Tradable Goods Categories with Expenditures and Shipping Characteristics

Commodity	NAICS	$\overline{exp}_{ics}$ ($'s)	$\overline{NonLocal}_{cs}$	$\overline{Truck}_{cs}$	$\overline{Mile}_{cs}$	$\overline{Value}_{cs}$ ($s)
Vehicle Purchases (New & Used)	4231	277	0.45	0.78	7.30	12,086
Housing (furniture & appliances)	4232	143	0.45	0.92	7.90	1,588
Entertainment (AV Equipment, Electronics, Toys)	4236	205	0.45	0.66	7.48	9,622
Pharmaceuticals and Medical Supplies	4242	34	0.36	0.50	4.44	13,442
Apparel	4243	82	0.12	0.64	6.75	2,452
Food at home	4244	470	0.53	0.90	11.94	16,951
Gasoline	4247	167	0.88	0.71	1.39	17,245

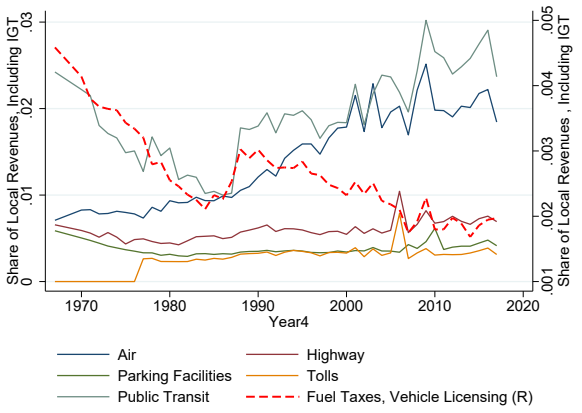
Notes: Expenditures, $\overline{exp}_{ics}$, measured quarterly. $\overline{Mile}_{cs}$ and $\overline{Value}_{cs}$ reported in millions.

Figures

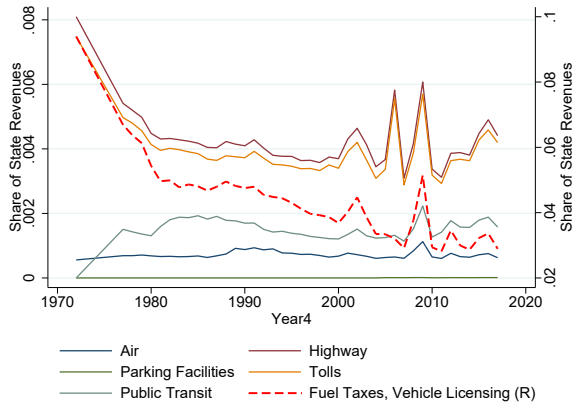
Figure 1: User Fees' Shares of Government Revenue



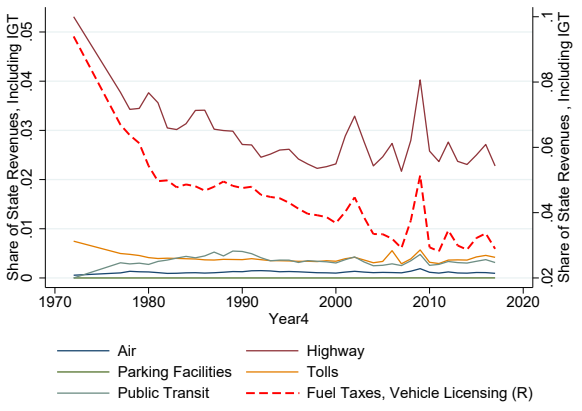
(a) Local



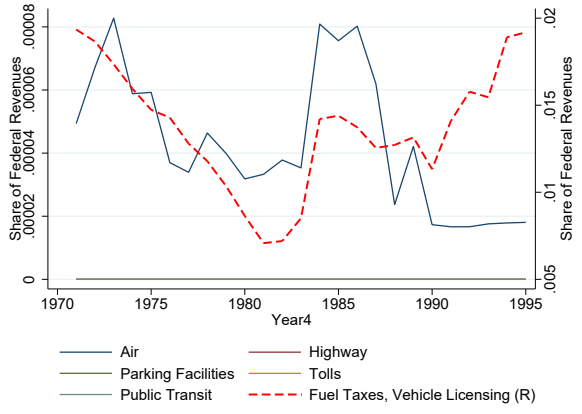
(b) Local + IGT



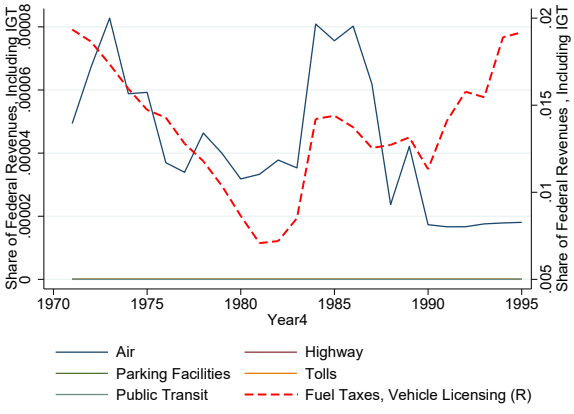
(c) State



(d) State + IGT



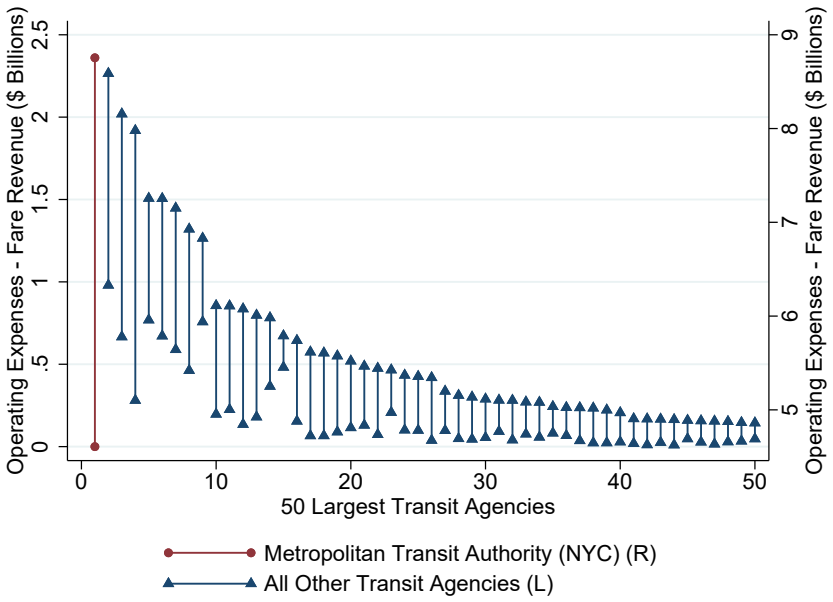
(e) Federal



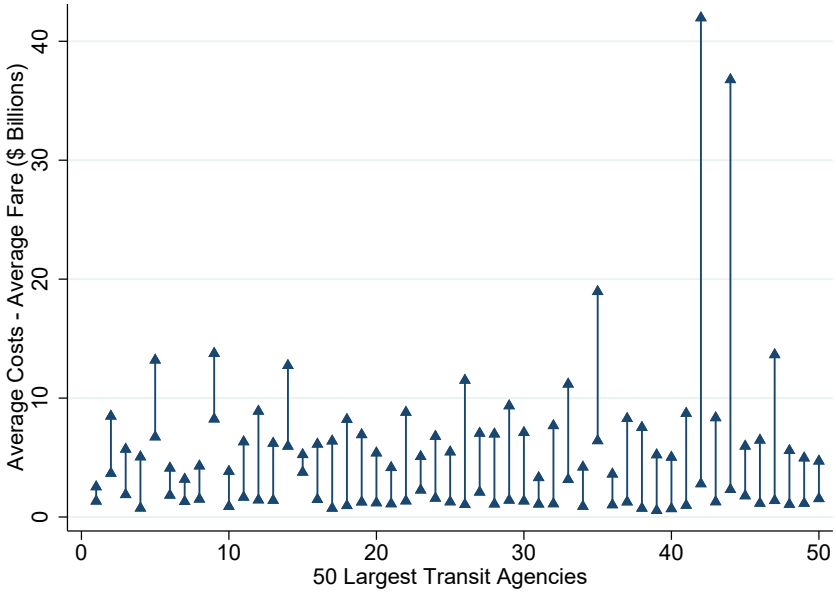
(f) Federal + IGT

Notes: Data from the Census of Governments, 1967-2017.

Figure 2: Public Transit Authorities: Costs and Revenues

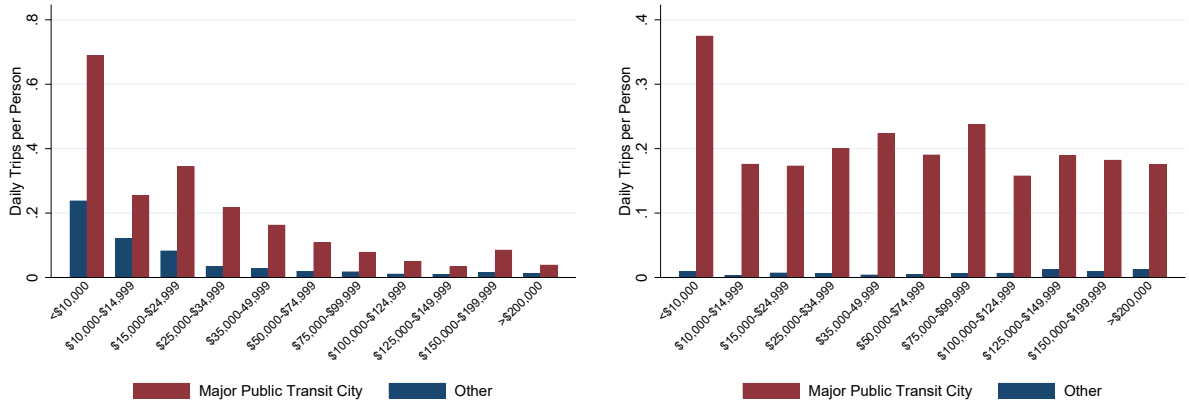


(a) Operating Costs and Revenues



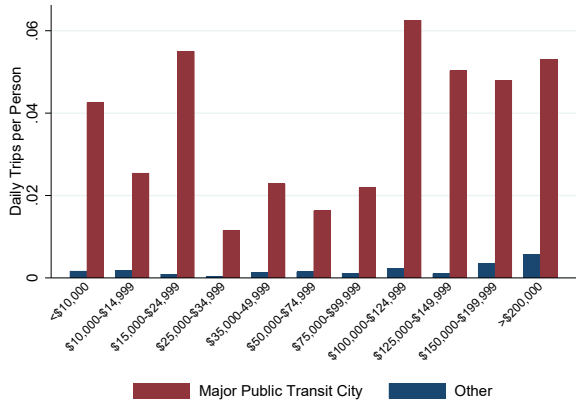
(b) Costs and Fares per Ride

Figure 3: Public Transit Utilization by Income

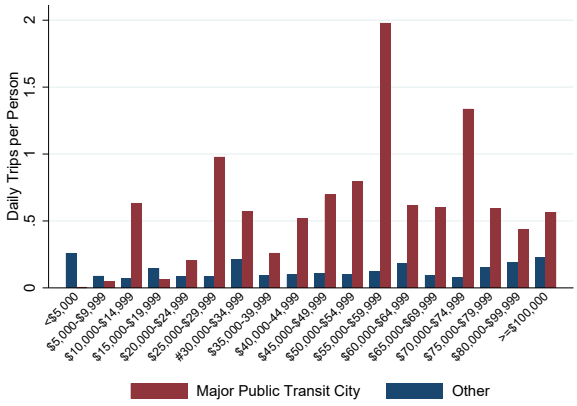


(a) Bus

(b) Subway

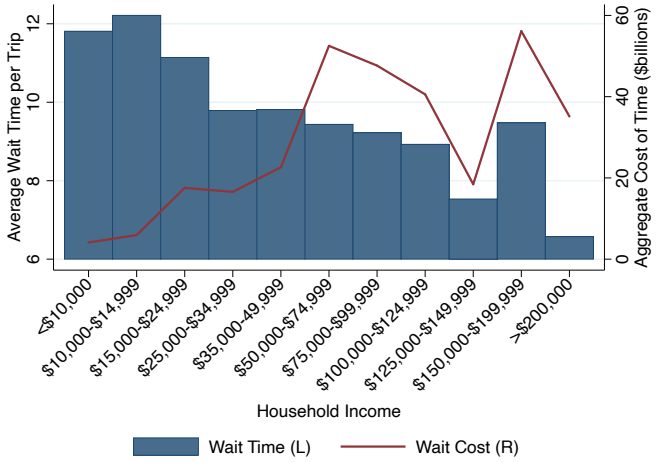


(c) Commuter Rail

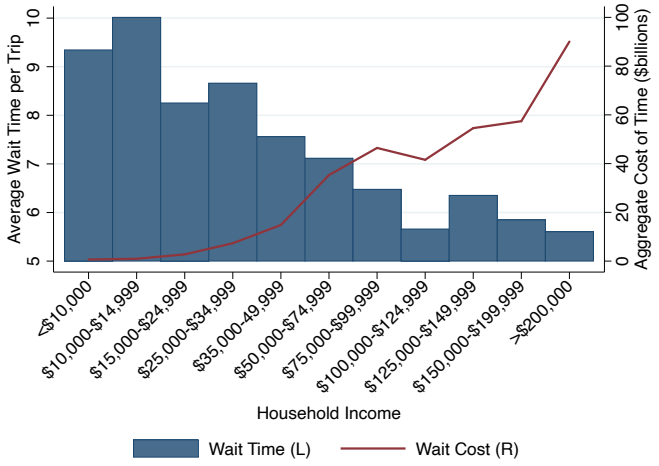


(d) Tolls

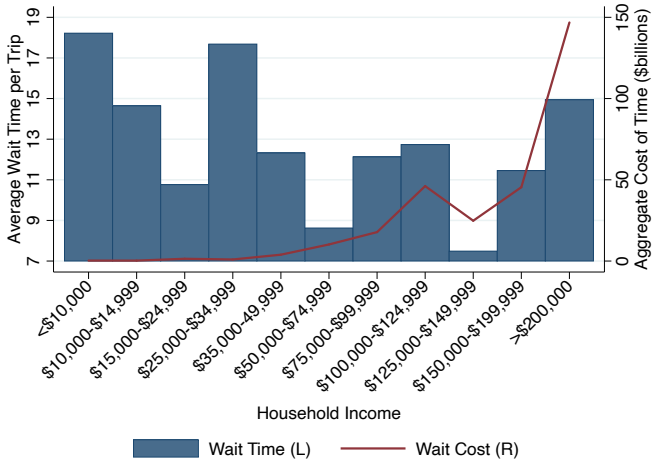
Figure 4: Public Transit Wait Times and Opportunity Cost



(a) Bus



(b) Subway



(c) Commuter Rail

Figure 5: Expenditure on Public Transportation

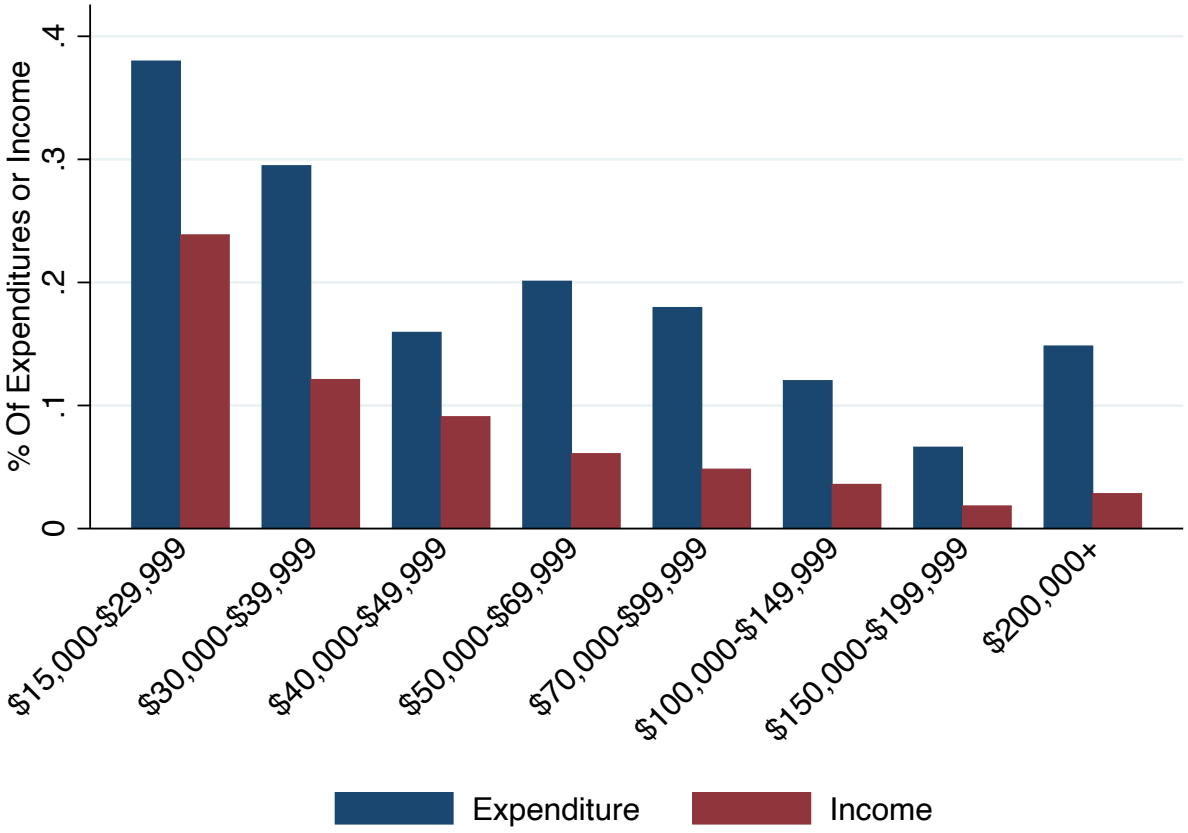
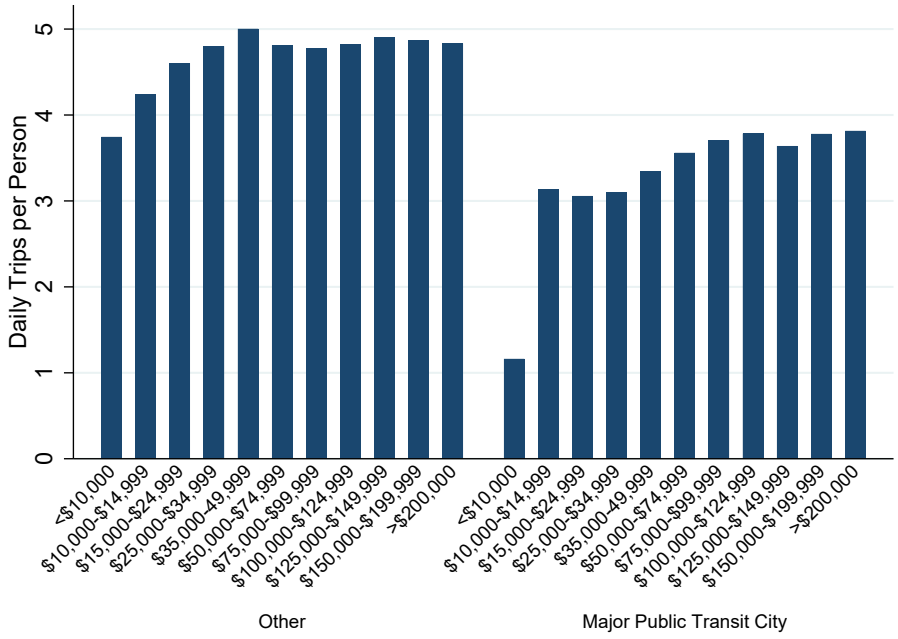
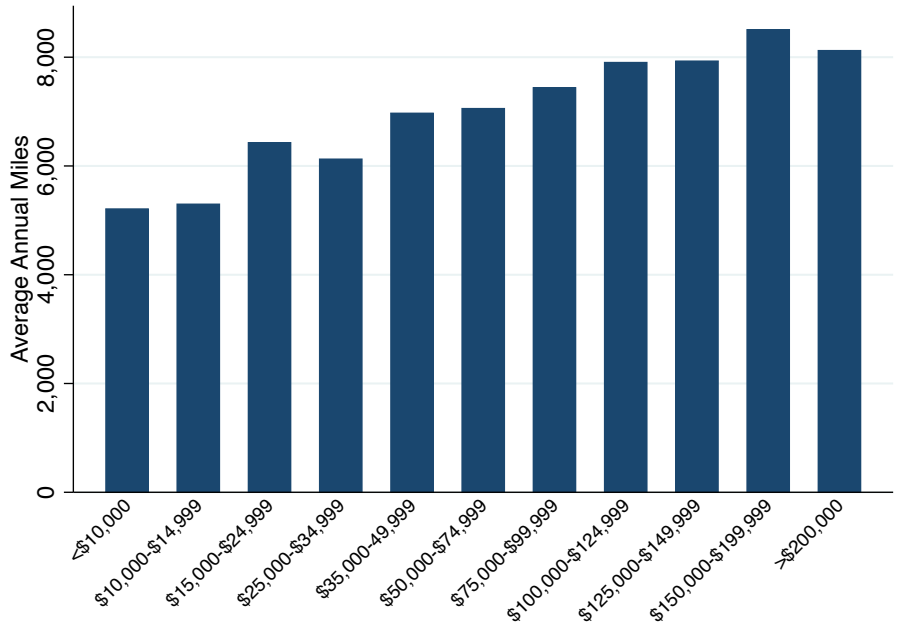


Figure 6: Driving Characteristics by Income



(a) Daily Trips per Person



(b) Annual Miles Driven

Figure 7: Expenditure on Gasoline, Other Fuels, and Motor Oils

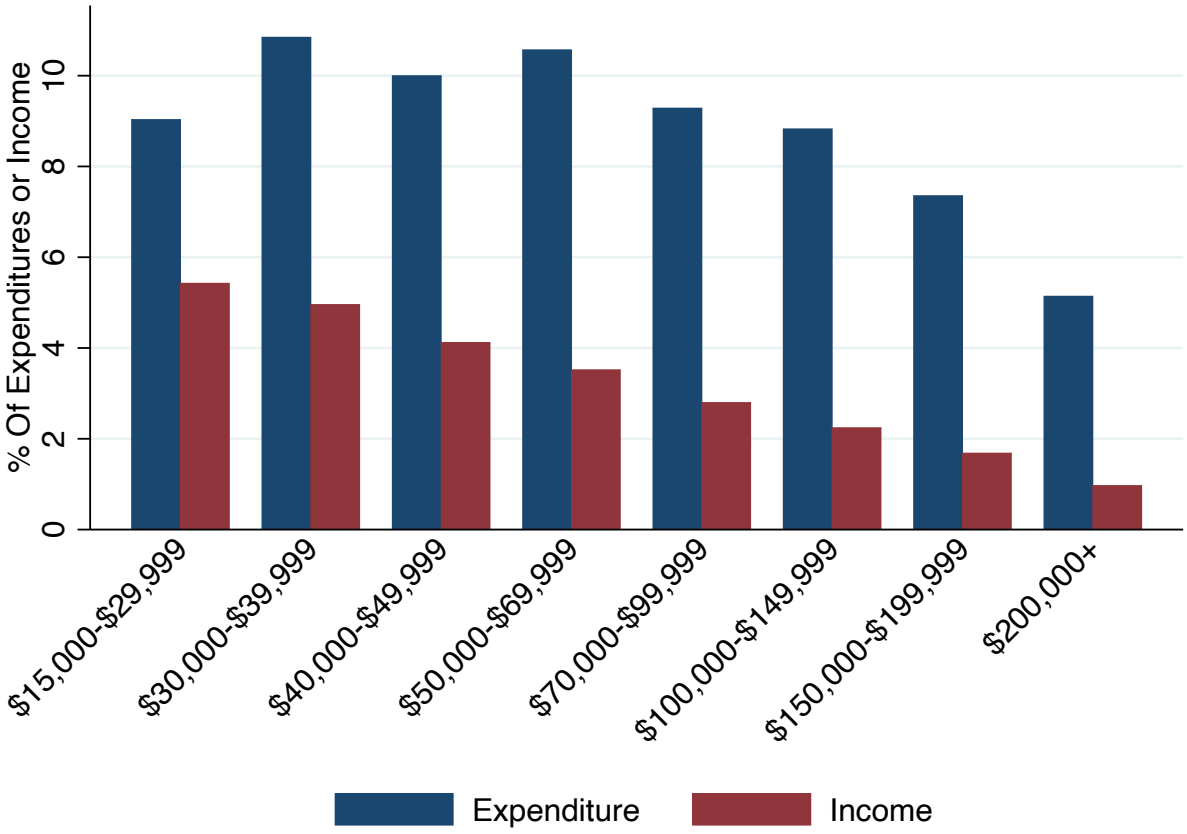
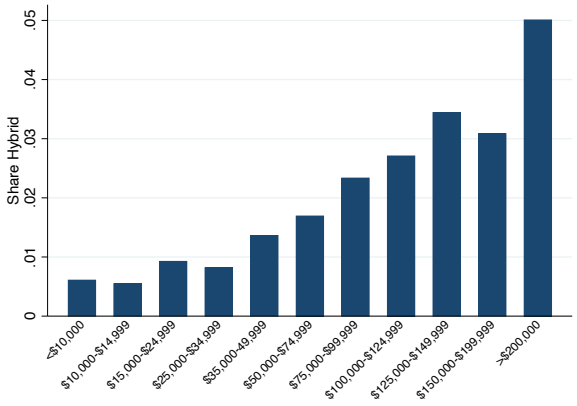
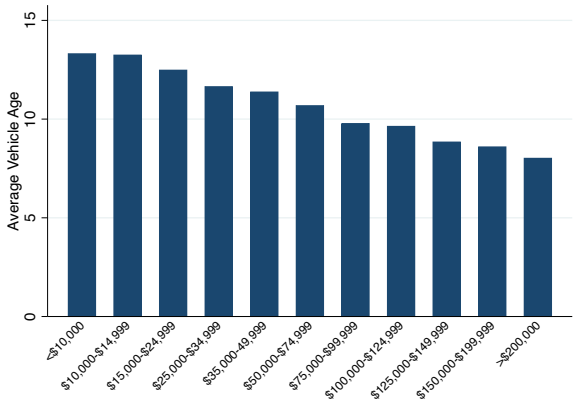


Figure 8: Wealthy Drivers Likely Pay Less Gas Tax per Mile Traveled

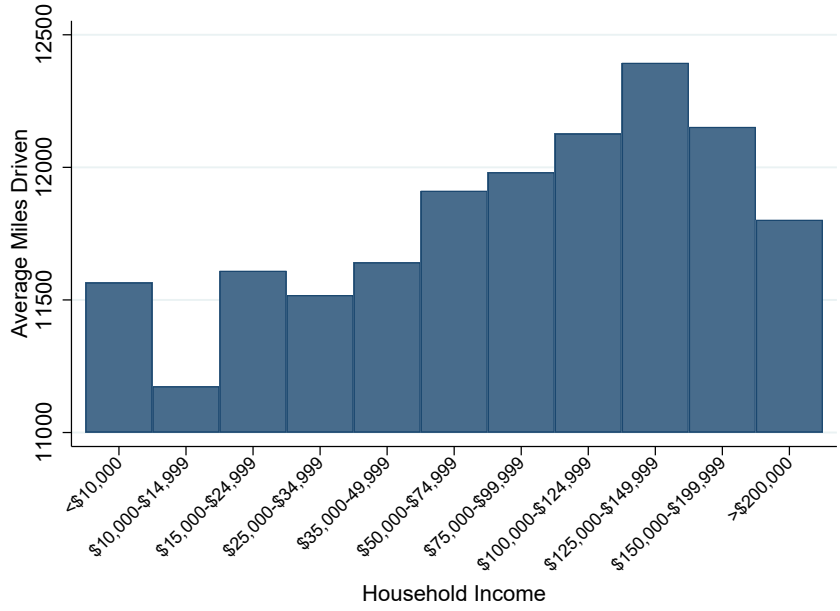


(a) Share of Hybrid Vehicles

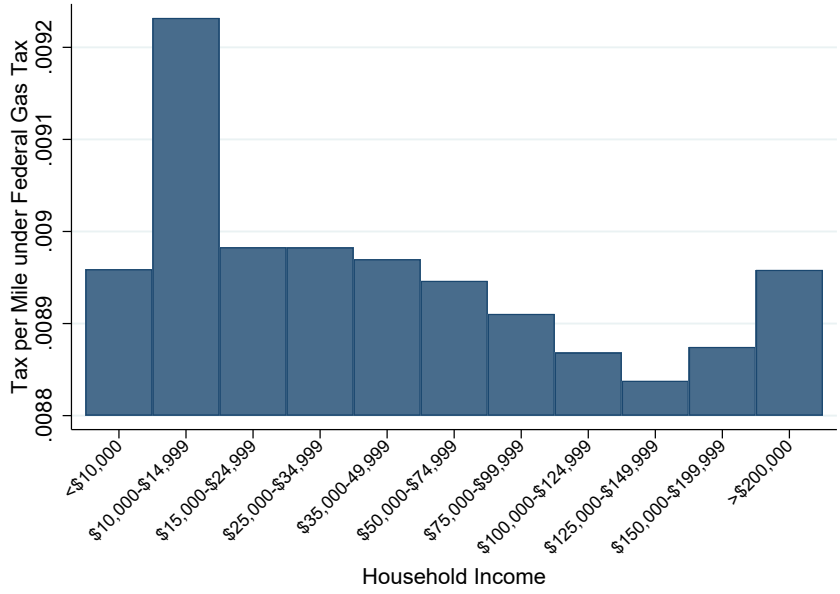


(b) Average Vehicle Age

Figure 9: Miles Driven under Current Federal Gas Tax

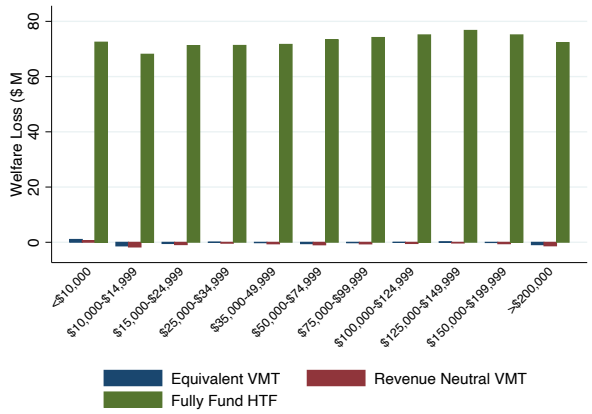


(a) Mean Miles Driven

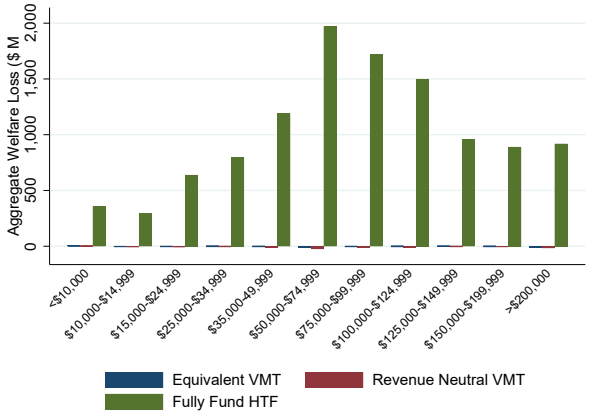


(b) Mean Tax Paid per Mile, Gas

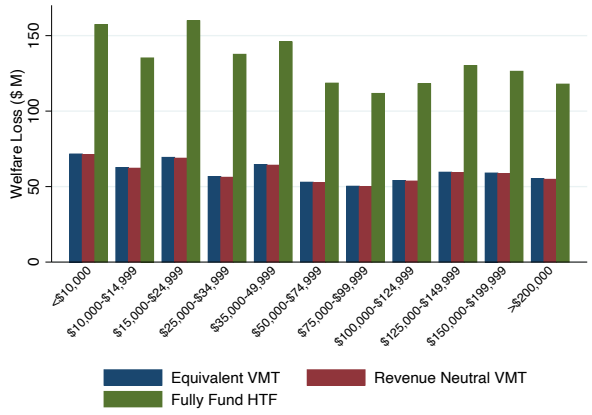
Figure 10: Welfare Loss under Different VMT Proposals



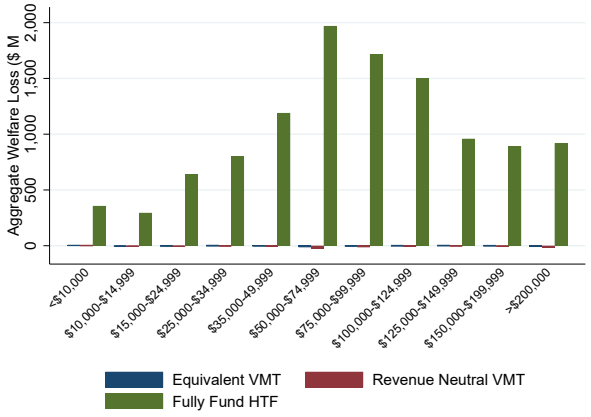
(a) Mean Welfare Loss, Gas



(b) Total Welfare Loss, Gas

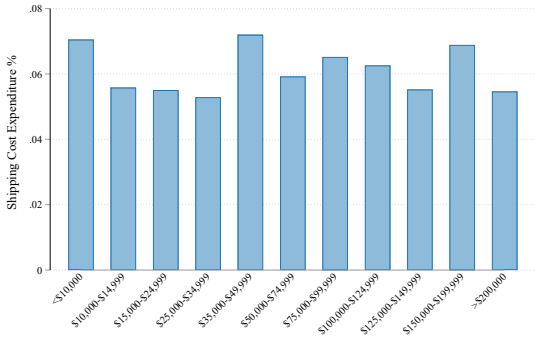


(c) Mean Welfare Loss, Hybrid/Electric

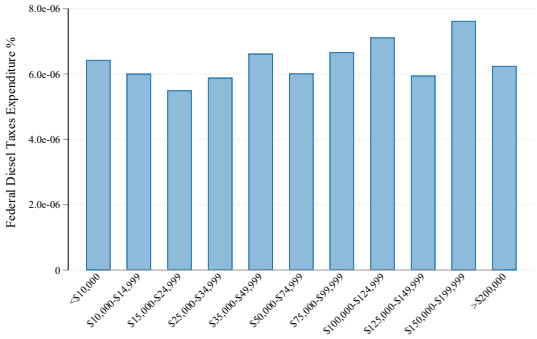


(d) Total Welfare Loss, Hybrid/Electric

Figure 11: Shipping Cost and Diesel Tax Share of Expenditures by Income

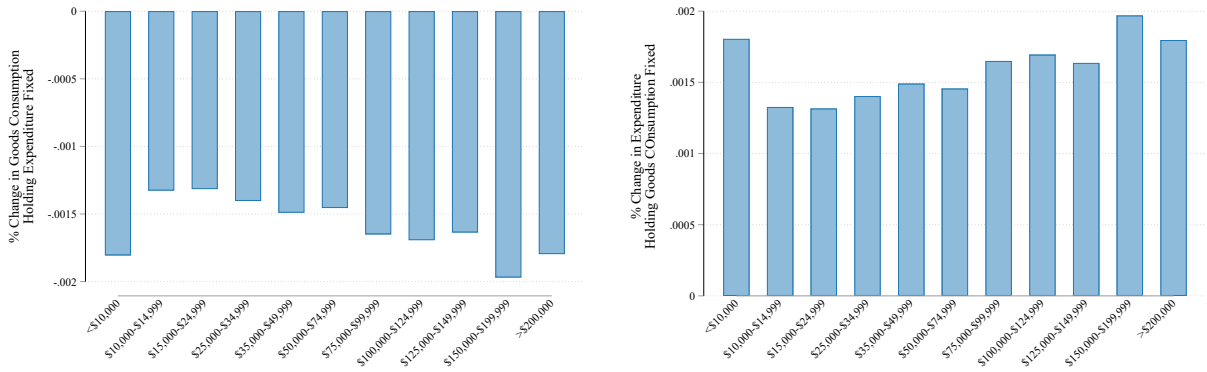


(a) γ_{cs}^1



(b) γ_{cs}^2

Figure 12: Implications of a $0.03 Commercial VMT



(a) Change in Consumption

(b) Change in Expenditure