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The data associated with this publication are available at: https://github.com/i-am-Shuvro/Equity-Impacts-of-Vehicle-Miles-Traveled-Fee-in-Bay-Area-Cities

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Distributional Equity of Replacing Fuel Taxes with Vehicle Miles Traveled Fees: Evidence from Five San Francisco Bay Area Cities

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ABSTRACT
In a world where people are increasingly shifting from internal combustion engine (ICE) vehicles to electric vehicles, revenue from state fuel taxes has continued to decline. This has prompted policymakers to consider alternative mechanisms to fund transportation infrastructure, including the introduction of a Vehicle Miles Travelled (VMT) fee. However, these changes may have distributional consequences. This study examines the geographical equity impacts of a VMT fee on residents of five cities in the San Francisco Bay Area and compares the financial burdens of a VMT fee and the existing fuel tax for households living in urban and rural settings. Household-level travel, income, and residential location data were obtained from the 2017 National Household Travel Survey. Four scenarios were evaluated: the current fuel tax, a static VMT fee, a dynamic VMT fee with modified elasticities, and a dynamic VMT fee using raw elasticities. Equity was assessed using the Gini Index. Results show that rural households face consistently higher burdens across all scenarios. The static VMT fee produces small changes relative to the fuel tax, while the dynamic scenarios increase financial burdens; especially for lower-income households—due to behavioral adjustments. Overall, a VMT fee can serve as an alternative to the fuel tax, but behavioral responses and distributional differences remain important policy considerations.

Keywords: VMT Fee Impact, Transportation Equity, Tax Burden, Gini Index.

1. INTRODUCTION

The United States is a deeply car-centric culture, with 92 percent of Americans owning a car (*1*). Car culture has been deeply ingrained into the American ethos due to a mix of individualism and America's suburban sprawl (*1*). Infrastructure in the United States is geared towards cars, from the extensive highway system to the parking network across our major cities (1). The main method used in the past to fund the car-centered infrastructure network has been a fuel tax, meaning a tax added onto every gallon of gas purchased at a pump. However, in the United States and especially California, the popularity of electric vehicles (EVs) and hybrid vehicles (HVs) has exploded, meaning that the efficacy of a gas tax has reduced (2). Due to concerns about climate change, the automotive sector in the United States and across the world is transitioning to electric/hybrid vehicles, which has led to a significant transition to these powertrains as opposed to ICE vehicles. In California, 29.1 percent of new car sales in the third quarter of 2025 were electric vehicles, compared to 7.9 percent of new vehicle sales being electric vehicles across the United States in February 2025 (3). In order to address this issue, lawmakers and strategists have proposed a Vehicle Miles Travelled (VMT) fee instead, which charges drivers based on distance driven. Government agencies have reported difficulties maintaining revenue for infrastructure maintenance and repairs, as "vehicle miles travelled have doubled since 1980, while fuel consumption has only increased by 50 percent." (*4*). A combination of electric vehicles, fuel efficient ICE vehicles and hybrid vehicles have led to a large increase in road wear and tear and less revenue to maintain and repair infrastructure. Under the fuel tax regime, owners of fuel-efficient cars tended to have lower tax burdens overall, and those with fuel efficient cars tended to be urban (*4*).

In the Bay Area, the issue is compounded as electric vehicles have deeper market penetration here than in the rest of the country. The Bay Area acts as a test market for several technological and climate related innovations, and a VMT fee could be an excellent climate mitigation program. (*2*) Oregon was the first state to pilot a VMT trial, and it found that it was feasible; it conducted a second in 2013, which also yielded positive results (*5*). Our objective for this paper is to understand the feasibility of VMT vs a fuel tax across different locations (rural vs urban), as well as across income groups (low, low-mid, high-mid, high). We are analyzing four scenarios, which are a fuel tax, a static VMT tax, a modified dynamic VMT and a raw dynamic VMT.

2. BACKGROUND AND RELATED LITERATURE

Issues arise regarding the feasibility and equity of a VMT fee. Implementing any new fee or tax is extremely difficult under any type of government with democratic practices, and the heavy reliance on private vehicles in America only adds to the difficulties of adding a fee related to auto use. (*4*) We will review cases that have successfully implemented a VMT-based fee, and then we will review additional studies that present findings on the equity of a VMT fee concerning income and geographic settlement patterns, i.e., rural and urban residences.

Oregon became the first state in the United States to implement a VMT fee system under a voluntary program called "OReGO" in 2015. Volunteers pay a per-mile charge instead of a gas tax (5). Utah elected a similar RUC program enforced at the start of 2020 that allowed electric and hybrid vehicle users to optionally enroll to pay a per-mile charge to avoid the alternative vehicle fuel fee when a vehicle is registered. (6) Overseas, New Zealand implemented a road usage charge (RUC) program originally designed for diesel trucks, but eventually expanded to electric vehicles in 2024 (7). All EVs and PHEVs pay a charge based on distance driven to accommodate the lost revenue from reduced ICE vehicle fleet size. The cases of Oregon and Utah exhibit a trend of exchanging one fee for another, increasing the feasibility of a VMT fee system by providing users with the freedom of choice. A VMT fee program becomes more attractive when the choice to opt in can possibly save more money than the alternative. There are of course other factors which play into the feasibility of a VMT fee program such as, government policies, revenue goals, technology related to fee collection, and management of the VMT system (8). However, feasibility doesn't include the equity of such a system. More specifically, the tax burden of a gas tax and a VMT fee might be distributed differently among multiple demographics. The following studies provide greater insight into the equity impacts of a VMT fee.

There were several studies that gave us better insight into whether VMT was equitable for lower-income and rural residents. A study on VMT that was conducted at the national level found that a VMT fee was better for lower income residents, as they were more likely to drive less fuel-efficient cars, and was also better for rural residents because their cars are also less fuel efficient (9). A study in Maryland proposed an income based VMT fee, which significantly reduced the tax burden on lower income drivers, with the fixed-interval VMT fee being the most equitable (each income group pays 1.28 cents more per mile than the previous) (10). A Texas-based study attempted to model a removal of the state fuel tax in favor of a VMT tax. The result was that higher income households still pay more, even though a VMT fee is slightly regressive. Additionally, rural households pay less under a VMT fee than urban households, although the dollar impact against higher income and urban households is small (4). A study in Vermont, a largely rural state, found that a mileage-based user fee increases the average household's annual payment by $30 compared to the current gas tax, with rural and middle-income households experiencing the smallest price changes and urban and high-income households experiencing the opposite (11).

Presently, there is very little research on the equity impact of a VMT fee in California. Caltrans has finished the pilot program for a VMT fee that took place between August 2024 and January 2025, known as the Road Charge Pilot, but a final report from Caltrans has not yet been released. A 2017 final report of the Road Charge Pilot by Caltrans is available, but only shares discoveries related to the feasibility of a VMT fee system (12). A share of the same authors from the previously mentioned 2023 Texas study expanded their research to include case studies for the states of Iowa, New York, and California. California saw the greatest reduction in VMT fee from the current gas tax due to the large share of EVs (13). Rural and low-to-high income households reduced their tax burden the most when shifting from a gas tax to a VMT fee for California. Rural households lowering their tax burden is more equitable because they currently face a higher tax burden than urban households under the current gas tax, but high income households reducing their tax burden is less equitable despite high income households still holding a heavier tax burden compared to low income households. While this study looks at combined 2009 and 2017 NHTS data for California as a whole, our study only looks at 2017 NHTS data and focuses on the Bay Area (14). Further details of our study will be provided in the following section.

This study pursues two primary research objectives:

- To assess the geographic distributional impacts of Vehicle Miles Traveled (VMT) fees across selected Bay Area municipalities, including San Francisco, Daly City, Oakland, Berkeley, and Alameda
- To analyze the distributional equity impacts of VMT fees across socioeconomic income groups within the Bay Area

To evaluate these impacts, this study employs a comparative scenario analysis framework examining two distinct policy scenarios: (*1*) a baseline scenario representing the current fuel tax regime, and (*2*) an alternative scenario implementing a VMT-based fee system. This methodological approach allows for a controlled comparison of tax burden distributions while holding other variables constant.

The analysis is grounded in two critical assumptions that shape the scope and interpretation of findings:

- **Travel Behavior Stability Assumption.** The first assumption posits that household travel behavior—including trip frequency, route choice, and vehicle utilization patterns—remains largely unchanged in response to VMT fee implementation. This assumption is justified given that preliminary economic analyses indicate the magnitude of price change would be modest relative to total household transportation expenditures. Previous research on travel demand elasticity supports this assumption for small-magnitude fee increases (*4*).
- **Tax Structure Assumption.** The second assumption restricts the analytical scope to state-level fuel taxation while treating federal fuel taxes as constant across scenarios. Specifically, only California's state fuel tax is substituted in the VMT scenario, while federal fuel excise taxes are held at current levels. This approach isolates the state-level policy variable of interest and permits federal tax effects to be controlled as a constant across scenarios.

3. METHODOLOGY

3.1 Comparative Analysis

Comparative analysis was undertaken to quantify how a transition from the existing fuel tax to a VMT-based fee alters the tax burden across income–location strata. For each combination of income group and residential context (urban or rural), the mean household tax burden under the fuel tax regime was compared to the corresponding mean burden under the VMT fee regime, and the difference between the two was computed. This stratified comparison provided evidence on the relative incidence of each policy across socioeconomic and spatial categories.

3.1.1 Current Fuel Tax Burden Calculation

Under the existing fuel tax system, the household tax burden was calculated by determining the fuel consumption associated with each household's vehicle miles traveled, then applying California's state fuel tax rates. The calculation employs the following formula:

$$Tax\ Burden\ per\ households\ = \frac{\sum_{j=1}^{m}\ \sum_{i=1}^{n}\ \frac{VMT_{ij}}{Fuel\ Economy_{ij}} \times Tax\ Rate_i}{m}$$

Variable Definitions:

- VMT_{ij} = Vehicle miles traveled for vehicle i in household j (miles per year)
- $Fuel\ Economy_{ij}$ = Fuel economy rating of vehicle i (miles per gallon)
- $Tax\ Rate_i$ = California state fuel tax rate specific to fuel type i (gasoline or diesel)
- i = Vehicle index within household (1, 2, 3, ..., n)
- j = Household index within income group (1, 2, 3, ..., m)

California's fuel tax rates were obtained from the California Department of Tax and Fee Administration and reflect rates effective July 1, 2025 (15), as mentioned in **TABLE 1**. The state fuel tax, combined with federal excise taxes, comprises the total per-gallon tax burden. Sales taxes, which are location-dependent and applied at the retail level, are excluded from this analysis to maintain consistency across geographies.

TABLE 1: Tax and Fees Included in Retail Motor Fuel Prices (Effective from July 1, 2025)

Tax Component	Gasoline	Diesel
Federal Fuel Tax	\$0.184	\$0.244
State Fuel Tax	\$0.612	\$0.466
Sales Tax	Determined at Retail Location	

3.1.2 VMT-Based Fee System Burden Calculation

The VMT scenario models a hypothetical fee structure based directly on miles traveled, with rates varying by vehicle fuel economy class. This design reflects policy proposals aimed at creating stronger economic incentives for vehicle efficiency improvements. The calculation employs:

$$Tax\ Burden\ per\ households\ = \frac{\sum_{j=1}^{m}\ \sum_{i=1}^{n}\ VMT_{ij} \times VMT\ Fee\ Rate_i}{m}$$

Variable Definitions:

- VMT_{ij} = Vehicle miles traveled for vehicle i in household j (miles per year)
- $VMT\ Fee\ Rate_i$ = Fee rate applicable to fuel economy class of vehicle i (dollars per mile)
- i = Vehicle index within household (1, 2, 3, ..., n)
- j = Household index within income group (1, 2, 3, ..., m)

The VMT fee structure implements differentiated rates across three vehicle efficiency classes. This design creates fiscal incentives for vehicle purchases with higher fuel economy while providing modest rate concessions for the least efficient vehicles (*4*). The determined VMT fee rate is shown in **TABLE 2.**

TABLE 2: VMT Fee Rates by Vehicle Fuel Economy Class

Fuel Economy (mpg)	Fee Rate ($/mile)
Less than 19	0.0173
19 to 22	0.0123
Greater than 22	0.0073

3.2 Equity Analysis: Gini Index

To rigorously assess the equity implications of the VMT fee system, this analysis employs the Gini Index, a widely used summary statistic for measuring income and expenditure inequality. The Gini coefficient provides a single numerical measure synthesizing the complete distribution of tax burdens across households, enabling systematic comparison between the current and alternative policy regimes.

The Gini Index ranges continuously from 0 to 1, where 0 indicates perfect distributional equality (all households face identical tax burdens), and 1 represents perfect distributional inequality (the entire tax burden is concentrated on a single household). The coefficient is mathematically grounded in the Lorenz curve, a graphical representation of cumulative income or expenditure distribution, contrasted against a reference line of perfect equality (*16*).

For this study, the Gini Index is calculated using the rank-based Lorenz-area formulation:

$$G = \frac{2\sum_{i=1}^{n} i\, x_{(i)}}{n\sum_{i=1}^{n} x_{(i)}} - \frac{n+1}{n},$$

Variable Definitions:

- $x_{(i)}$: Annual tax or fee burden for the i-th household after sorting from lowest to highest burden (dollars per year).
- n: Total number of households included in the analysis sample.
- $\sum_{i=1}^{n} x_{(i)}$: Total annual burden across all sampled households.

The first term in the formula, $\frac{2\sum_{i=1}^{n} i\, x_{(i)}}{n\sum_{i=1}^{n} x_{(i)}}$, computes a normalized Lorenz-curve area by weighting each household's burden by its rank in the ordered distribution. The second term, $\frac{n+1}{n}$, adjusts the index so that a perfectly equal distribution yield $G = 0$.

The Gini Index will be computed separately for each jurisdiction and income group under both the existing fuel tax and the proposed VMT fee regime. Differences in Gini values across scenarios will be interpreted as changes in distributional equity: a lower Gini under VMT fees indicates a more even spreading of burdens (improved equity), whereas a higher Gini suggests more regressive outcomes with burdens increasingly concentrated among particular household groups.

A workflow diagram (**Figure 1**) is provided to visualize the whole study.

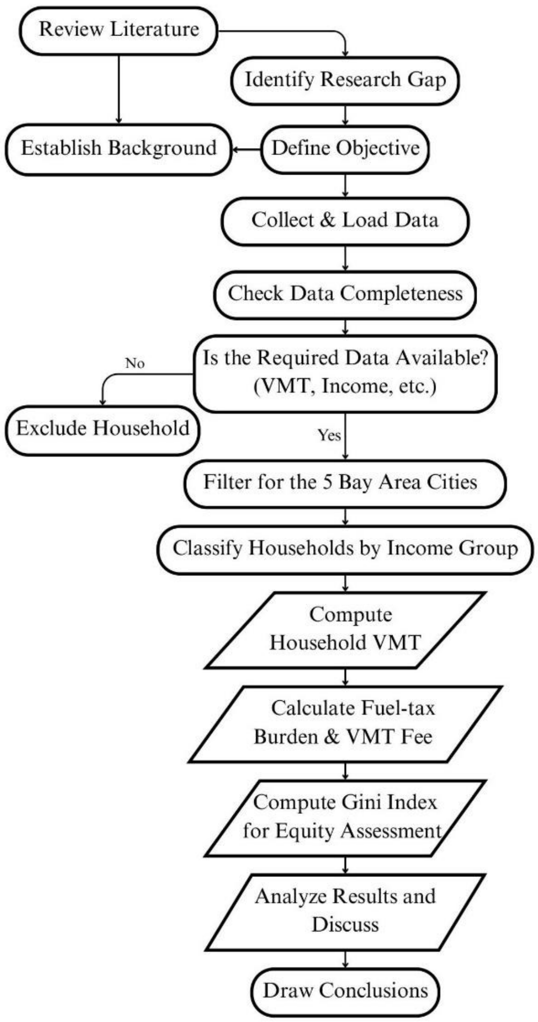


Figure 1 Overall Workflow of the Research

To ensure transparency and reproducibility, all raw data sources, cleaned datasets, and analysis scripts are publicly available at:
https://github.com/i-am-Shuvro/Equity-Impacts-of-Vehicle-Miles-Traveled-Fee-in-Bay-Area-Cities

4. RESULT ANALYSIS AND DISCUSSIONS

We analyzed a cleaned household travel dataset for five cities in the San Francisco Bay Area: Alameda, Berkeley, Daly City, Oakland, and San Francisco. These cities cover a broad range of travel conditions and represent households with different fuel economies, income levels and residential settings. To study the distributional effects of replacing the current state fuel tax with a per-mile fee, we developed four scenarios that show how the annual tax burden changes across households under different assumptions about driving behavior and fee structure. These scenarios form the basis of the results that follow, including comparisons across urban and rural households and across income groups.

The first scenario reflects the current California state fuel tax and provides a baseline for interpretation. In this case, each household's annual burden depends on the amount of fuel it uses and the state fuel tax rate. This scenario shows the levels of burden under the existing system and serves as the reference point for evaluating the effects of a VMT fee. The second scenario applies a static VMT fee, where each household pays a per-mile charge, and driving patterns remain unchanged. This scenario allows us to see how the burden shifts when the tax instrument changes but household travel remains the same.

The third and fourth scenarios introduce changes in driving behavior. In the dynamic modified scenario, households respond to a lower cost of travel after the fuel tax is removed, but only negative elasticities are used, which limits VMT changes to cases where the cost of travel falls. The dynamic raw scenario keeps all estimated elasticities, which shows the full behavioral response predicted by the model. These two scenarios help illustrate how VMT may change when households adjust to a new pricing system. A final summary of inequality is provided through the Gini coefficients, which give a simple measure of how evenly the burden is distributed across households in each scenario.

4.1 Household Burden by Location and Income Group

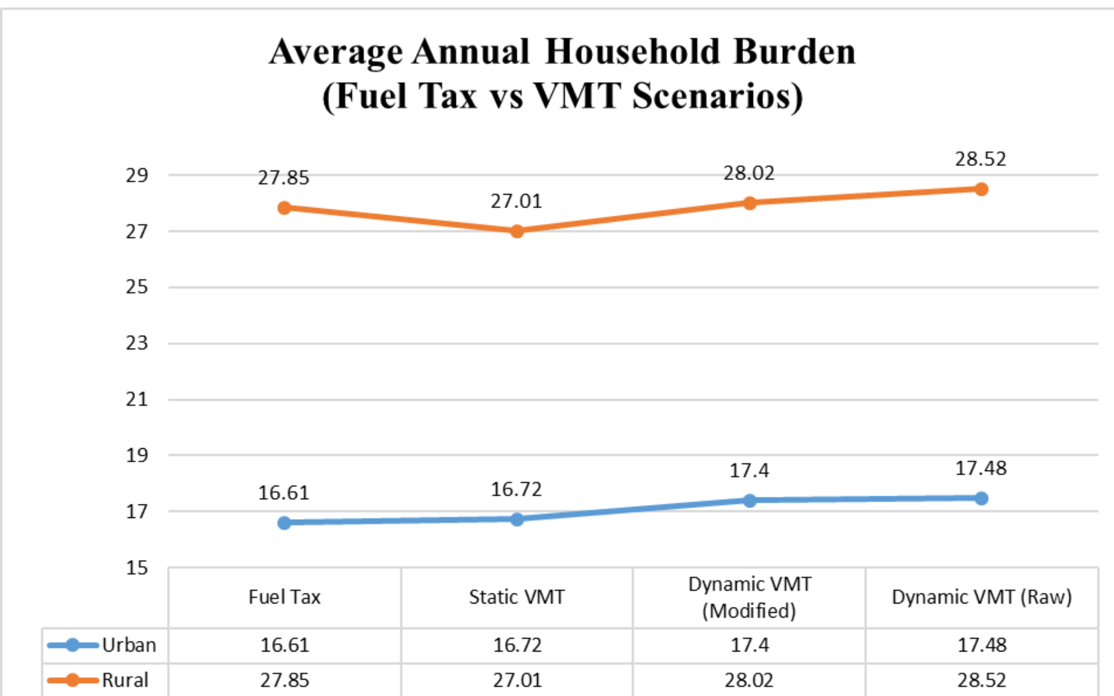
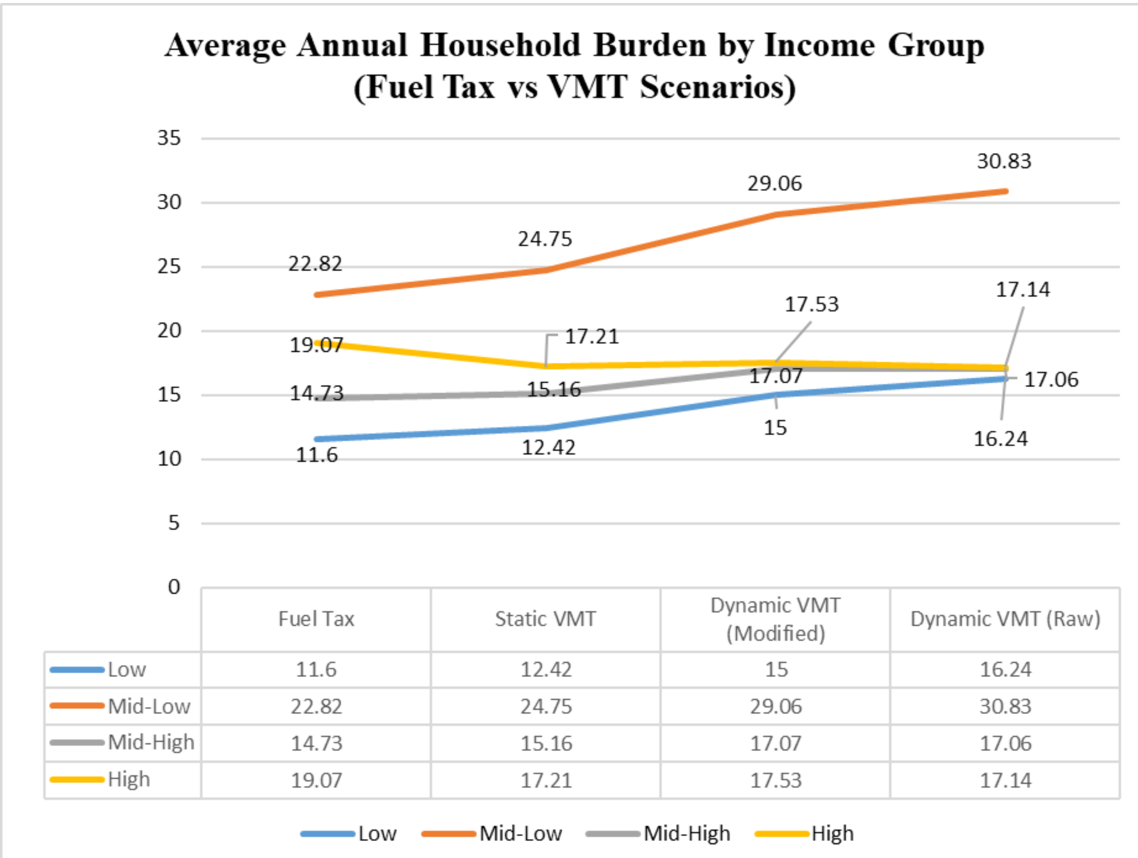


Figure 2 Average Tax Burden by Location

Figure 2 presents the average annual household burden for urban and rural households under the four pricing scenarios. The results show that rural households pay more than urban households in every case. Under the current fuel tax, urban households pay $16.61 per year, while rural households pay $27.85

per year. When the fuel tax is replaced with a static VMT fee, the average burden for urban households rises slightly to $16.72, while the rural burden falls to $27.01. These small changes suggest that switching from a fuel tax to a per-mile fee does not greatly alter the relative burdens across areas when driving behavior remains unchanged.

The dynamic scenarios show a different pattern. When households are allowed to adjust their VMT, both urban and rural burdens rise. In the dynamic modified scenario, urban households pay $17.40, and rural households pay $28.02. The dynamic raw scenario results in the highest burdens, with urban households paying $17.48 and rural households paying $28.52. These increases occur because removing the fuel tax lowers the cost of travel, which leads some households to drive more. The difference between the two dynamic scenarios reflects the role of elasticities. Removing positive elasticities limits the VMT response, while keeping all elasticities produces the full behavioral effect. A similar pattern appears when we examine differences by income group. **Figure 3** shows how the average annual burden changes across the four scenarios for low-, mid-low-, mid-high-, and high-income households.



	Fuel Tax	Static VMT	Dynamic VMT (Modified)	Dynamic VMT (Raw)
Low	11.6	12.42	15	16.24
Mid-Low	22.82	24.75	29.06	30.83
Mid-High	14.73	15.16	17.07	17.06
High	19.07	17.21	17.53	17.14

Figure 3 Average Tax Burden by Income Group

Under the fuel tax, the lowest-income households pay $11.60, while mid-low households pay $22.82, mid-high households pay $14.73, and high-income households pay $19.07. These values reflect differences in VMT and vehicle fuel economy across income groups. Under the static VMT fee, the burden increases modestly for all groups except high-income households. The lowest-income group rises to $12.42, mid-low to $24.75, mid-high to $15.16, while high-income households fall to $17.21. This shift shows that the VMT fee slightly increases the burden for lower- and middle-income groups while reducing it for higher-income households.

The dynamic scenarios produce the largest increases among low- and mid-low-income households. In the dynamic modified scenario, the burden rises to $15.00 for low-income households and to $29.06 for mid-low households. Mid-high households increase to $17.07, while high-income households increase to $17.53. The dynamic raw scenario reveals even stronger responses. Low-income households rise to $16.24, mid-low households to $30.83, mid-high households remain close at $17.06, and high-income households increase to $17.14. These results suggest that lower-income groups are more sensitive to the change in travel cost when the fuel tax is removed, leading to higher VMT and higher annual fees under the VMT system. The dynamic raw scenario shows the full effect of this response, while the dynamic modified scenario shows a more limited version.

Together, Figures 1 and 2 show that the shift from a fuel tax to a VMT fee produces relatively small changes when driving behavior is fixed, but larger differences when households adjust their travel in response to lower operating costs. Rural households and mid-low-income households face the highest absolute burdens, and lower-income groups experience the largest percentage increases under the dynamic scenarios. These patterns help illustrate how location and income influence the distributional effects of alternative pricing systems in the Bay Area.

4.2 Distributional Inequality Across Scenarios

Table 3 reports the Gini Index for each scenario and provides a summary of how evenly the burden is distributed across households.

TABLE 3 Gini Index by Scenario

Scenario	Urban Gini	Rural Gini	Total Gini
Fuel Tax	0.7369	0.6497	0.7343
Static VMT	0.7362	0.6372	0.7331
Dynamic Modified	0.7367	0.6322	0.7334
Dynamic Raw	0.7373	0.6341	0.7341

The values change very little across the four cases, which suggests that the choice of policy instrument does not greatly alter the overall distribution of the burden. Under the fuel tax, the total Gini is 0.7343, with an urban Gini of 0.7369 and a rural Gini of 0.6497. These values indicate substantial variation in annual payments across households, which reflects differences in VMT and fuel economy. Replacing the fuel tax with a static VMT fee produces only a small change in the distribution. The total Gini falls slightly to 0.7331, the urban Gini falls to 0.7362, and the rural Gini falls to 0.6372. These small reductions show that the static VMT fee does not meaningfully increase or decrease inequality in the burden. The dynamic scenarios lead to similar results. The dynamic modified scenario has a total Gini of 0.7334, and the dynamic raw scenario has a total Gini of 0.7341. Both values are almost identical to the fuel-tax baseline. The urban Gini values remain tightly clustered between 0.7362 and 0.7373, and the rural Gini values range from 0.6322 to 0.6497.

Overall, the Gini results show that the distribution of the annual burden remains highly stable across the four pricing systems. Even when households adjust their travel, the differences in inequality remain small. This suggests that while the VMT fee changes the level of burden for some groups, it does not significantly change how the burden is distributed across households in the region.

4.3 Changes in Household Burden Under VMT Fee

Following the Gini comparison, we examine the burden for each income group and location under the four scenarios. **TABLE 4** reports these values. Under the current fuel tax, mid-low-income households carry the highest burden, paying $22.82 on average, with rural mid-low households paying the most at

$36.57 per year. High-income households also face a notable burden, with an average of $19.07. In contrast, the lowest-income households face the smallest burden, at $11.60 on average. These differences reflect the higher VMT and lower fuel efficiency among mid-low and high-income rural households in our sample.

TABLE 4 Bay Area State Fuel Tax Burden by Household ($/Household/Year)

Scenario 1: Current Tax System			
Income Group	**Urban**	**Rural**	**Average**
Lowest	10.42	12.59	11.6
Middle-low	18.22	36.57	22.82
Middle-high	14.87	11.5	14.73
Highest	17.81	29.7	19.07
Average	16.61	27.85	17.05
Scenario 2: Static VMT (% change from Scenario 1)			
Income Group	**Urban %**	**Rural %**	**Average %**
Lowest	0.20%	7.20%	7.10%
Middle-low	1.20%	4.70%	8.50%
Middle-high	2.00%	2.40%	3.00%
Highest	−0.3%	−10.5%	−9.8%
Average	0.70%	−3.0%	0.40%
Scenario 3: Dynamic VMT, Modified (% change from Scenario 1)			
Income Group	**Urban %**	**Rural %**	**Average %**
Lowest	19.30%	22.90%	29.30%
Middle-low	10.30%	12.20%	27.30%
Middle-high	13.40%	26.10%	15.90%
Highest	1.20%	−0.9%	−8.1%
Average	4.80%	0.60%	7.60%
Scenario 4: Dynamic VMT, Raw (% change from Scenario 1)			
Income Group	**Urban %**	**Rural %**	**Average %**
Lowest	47.80%	54.10%	40.00%
Middle-low	14.90%	19.10%	35.10%
Middle-high	16.70%	18.00%	15.90%
Highest	−6.2%	−3.8%	−10.1%
Average	3.10%	2.40%	5.10%

When we replace the fuel tax with a static VMT fee, the changes relative to the baseline are small but directionally important. The lowest-income group sees an average increase of 7.10%, and the mid-low group increases by 8.50%. Mid-high-income households face an increase of 3.00%, while high-income households show a decrease of 9.80%. These results suggest that the VMT fee slightly shifts the burden toward lower- and middle-income groups, while easing the burden for the highest-income households. Rural households drive this pattern: high-income rural households experience a 10.5% reduction, while rural low-income households face a 7.20% increase. This illustrates how a VMT fee changes the relative burden across the income distribution even when VMT remains constant.

The dynamic scenarios amplify these shifts. When households adjust their travel after the fuel tax is removed, the lowest-income group experiences an average increase of 29.30% under the modified elasticity case, and 40.00% under the raw elasticity case. The mid-low group shows increases of 27.30% in the modified scenario and 35.10% in the raw scenario. These increases are larger for rural households, which reflects stronger VMT responses when operating costs fall. High-income households show a smaller change, with a decrease of 8.10% in the modified case and 10.10% in the raw case. This pattern shows that lower-income households are more sensitive to cost reductions and drive more under the VMT system, leading to a higher annual burden.

To make these results more concrete, **TABLE 5** reports the dollar changes in annual payment under the static and dynamic VMT scenarios. Under the static VMT fee, the lowest-income households pay $0.02 more in urban areas and $0.91 more in rural areas. Mid-low households see increases of $0.21 and $1.72, while mid-high households see increases of $0.30 and $0.28. High-income households see reductions of $0.05 in urban areas and $3.13 in rural areas. These small values confirm that the static VMT fee is close to revenue-neutral and does not create large shifts in burden.

TABLE 5 Change in Annual Burden Across Income Groups Under VMT Fee Scenarios

Static VMT Fee (No Behavioral Response)		
Income Group	**Urban Δ (USD)**	**Rural Δ (USD)**
Low	+ 0.02	+ 0.91
Mid-Low	+ 0.21	+ 1.72
Mid-High	+ 0.30	+ 0.28
High	- 0.05	- 3.13
Dynamic VMT Fee (With Behavioral Response)		
Income Group	**Urban Δ (USD)**	**Rural Δ (USD)**
Low	+ 4.98	+ 6.82
Mid-Low	+ 2.72	+ 6.94
Mid-High	+ 0.65	+ 0.68
High	- 1.11	- 4.46

The dynamic VMT system leads to larger changes. Low-income households see increases of $4.98 in urban areas and $6.82 in rural areas. Mid-low households see increases of $2.72 and $6.94, while mid-high households see smaller increases of about $0.65 and $0.68. High-income households again see reductions, with decreases of $1.11 in urban areas and $4.46 in rural areas. These values show that behavioral changes matter more than the fee structure itself. Once travel costs fall, lower-income groups tend to increase their VMT more than higher-income groups, which leads to higher payments under the VMT fee.

In summary, the results show that replacing the California state fuel tax with a VMT fee in the Bay Area would not dramatically change the overall distribution of the tax burden, but it would shift who pays slightly more and who pays slightly less. Rural and mid-low-income households bear the highest absolute burdens under all scenarios, reflecting their higher VMT and vehicle characteristics, while high-income households experience small reductions in burden under the VMT fee, especially when travel behavior is allowed to change. The static VMT scenario produces only minor changes relative to the fuel-tax baseline, but the dynamic scenarios reveal that lower-income households increase their travel more when the fuel tax is removed and therefore face larger percentage and dollar increases in annual payments. Despite these shifts, the Gini indices remain almost unchanged across the four systems, indicating that the VMT fee is roughly as unequal as the current fuel tax. Overall, the analysis suggests that a VMT fee calibrated to replace the state fuel tax can be close to revenue neutral and only modestly redistributive, but careful attention is needed to the behavioral responses of lower-income and rural households when designing and evaluating such policies.

5. CONCLUSIONS

This study evaluated four pricing scenarios: the current California state fuel tax, a static VMT fee, a dynamic VMT fee with modified elasticities, and a dynamic VMT fee using raw elasticities; to assess the distributional equity implications of transitioning to a vehicle miles traveled fee system in five Bay Area cities.

Across all scenarios, rural households consistently bear higher annual burdens than urban households, paying roughly \$10–11 more per year regardless of the pricing instrument applied. Among income groups, mid-low-income households face the highest absolute burdens under every scenario, rising from \$22.82 under the fuel tax to \$30.83 under the dynamic raw VMT scenario. Low-income households exhibit the greatest sensitivity to behavioral change: when the fuel tax is removed and travel costs fall, this group increases its VMT more sharply than others, resulting in annual burden increases of up to 40 percent in the raw elasticity case. High-income households, by contrast, experience modest reductions in burden across the VMT scenarios, reflecting their lower travel elasticity and better vehicle fuel economy. Despite these group-level differences, the Gini index remains nearly stable across all four scenarios, ranging from 0.7331 to 0.7343 for the total sample. This indicates that a VMT fee, as modeled here, is only modestly redistributive relative to the current fuel tax and does not substantially alter the overall degree of inequality in the distribution of household burdens.

These findings carry important policy implications. While a VMT fee can be designed to be broadly revenue-neutral and structurally similar to the existing fuel tax, the results demonstrate that rural and mid-low-income households remain disproportionately exposed to higher burdens; particularly under dynamic behavioral conditions. Careful policy design, including tiered fee structures, income-sensitive adjustments, or targeted exemptions, will be necessary to prevent these groups from bearing a systematically larger share of the cost.

However, technical calibration alone is insufficient for the successful implementation of pricing reforms of this nature. The transition from a fuel tax to a VMT-based system represents a fundamental change in how road users are charged, and its viability depends not only on the soundness of its design but also on the degree of understanding and alignment between transportation planners and the general public. Communities that perceive such policies as opaque, inequitable, or imposed without meaningful input are unlikely to accept them, regardless of their technical merits. This points to the need for more advanced public engagement tools that can communicate policy tradeoffs, equity concerns, and distributional consequences in ways that are accessible to non-specialist audiences. In this regard, digital storytelling has been proposed as a promising transportation planning tool for bridging the gap between technical policy analysis and participatory public discourse, enabling planners to convey complex equity narratives in more relatable and comprehensible formats (*17*). Integrating such engagement approaches into the VMT policy development process could help build the public trust and shared understanding necessary for equitable and durable implementation.

Taken together, the findings of this study suggest that a VMT fee is a technically feasible alternative to the current fuel tax in the Bay Area context, but its equitable implementation requires both careful attention to the distributional impacts on vulnerable groups and a sustained commitment to meaningful public communication and engagement.

5.1 Limitations

The analysis was subject to several limitations:

- The equity analysis scope covered only five Bay Area cities: Alameda, Berkeley, Daly City, Oakland, and San Francisco. That is mainly because the project scope focused on San Francisco and the surrounding cities, meaning the results may not fully represent the Bay Area region.
- An older version of the National Household Travel Survey was used in the analysis. The dataset used was produced in 2017, whereas the latest version was created in 2022. This is because the 2022 dataset did not include the accompanying documentation needed to clearly understand the meaning of each attribute. As a result, it was more practical to rely on the 2017 version of the NHTS (Federal Highway Administration, 2017). Consequently, the findings may not be fully representative of the status quo.

- The fuel economy (in miles per gallon) data for each household vehicle was estimated because the dataset did not provide MPG values directly. Although vehicle age, fuel type, and vehicle type were available, MPG was not, so the data relied on fuel-economy standards from the Code of Federal Regulations to approximate these values (*17*).
- The selected cities in this study had fewer rural households than expected, which made it difficult to analyze rural equity levels accurately, as they comprised only 3.9% of the sample. Together, these limitations suggest that the results should be interpreted with caution, as larger datasets would lead to more precise equity insights.

5.2 Future Scope

Several directions could meaningfully extend this work. First, expanding the geographic scope beyond these five cities to the full Bay Area would improve representativeness and reduce the geographic bias introduced by the underrepresentation of rural households, which comprised only 3.9 percent of the current sample. Second, future analyses should incorporate more advanced equity metrics alongside the Gini index. The Lorenz curve, in particular, offers a complementary visual and analytical tool for assessing the cumulative distribution of tax burdens across households and has been effectively applied in prior transportation equity research to reveal distributional patterns that aggregate indices can obscure (*19*). Third, modeling a broader set of VMT fee structures, including income graduated and location adjusted rates, would help identify which designs produce the most equitable outcomes across the rural and low-income groups identified as most vulnerable in this study.

Beyond data and methodology, future work should also address the behavioral and political dimensions of VMT fee implementation. The finding that rural and mid low-income households face the highest burdens raises substantive questions about public acceptance and perceived fairness that distributional analysis alone cannot resolve. Game theoretic frameworks that incorporate public sentiment and model the strategic interaction between policymakers and affected road users offer a promising complementary approach for examining these dynamics (*20*). Integrating such frameworks with equity focused distributional analysis could help researchers and policymakers better anticipate public resistance, design more acceptable fee structures, and develop reform strategies that are accountable to both technical performance and public legitimacy. Taken together, these extensions would move the research from a localized distributional snapshot toward a more comprehensive foundation for VMT policy design in California.

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7. AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: P. Luengjitvatana; data collection: P. Luengjitvatana; framework: S. Albreiki and M. S. Shahriar; analysis and interpretation of results: M. S. Shahriar; draft manuscript preparation: A. Luther, M. S. A. Baig, S. Albreiki, P. Luengjitvatana and M. S. Shahriar. All the authors reviewed the results and approved the final version of the manuscript.

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