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Road Usage Charges and Impacts on Rural and Disadvantaged Communities

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16. Abstract

This report examines the differences in what drivers would pay with a gasoline tax versus a revenue-neutral road user charge (RUC) and whether these differences are equitably distributed among rural vs. urban and disadvantaged vs. non-disadvantaged communities. The analysis uses vehicle registration data from the California Department of Motor Vehicles, vehicle attribute data from DataOne, and environmental and socioeconomic indicators from CalEnviroScreen. On average, a transition from a gas tax to an RUC would cause drivers in rural areas to pay less per mile and drivers in urban areas to pay more. This difference arises because vehicles registered in rural areas tend to have lower fuel efficiency than those in urban areas. However, the transition from gas tax to RUC would have a similar impact on average cost per mile for vehicles registered in disadvantaged communities (defined as the top 10% of census tracts in CalEnviroScreen) as in other communities.. This study indicates that RUCs are marginally less regressive than gas taxes.

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The transportation funding model in the United States—historically reliant on fuel excise taxes—faces structural challenges due to inflation, rising vehicle fuel efficiency, and the adoption of alternative fuel vehicles. In response, road usage charges (RUCs), also referred to as mileage-based fees, have emerged as a potential successor to the gasoline tax. These fees maintain adherence to the "user pays" principle while offering a path toward sustainable revenue collection as the vehicle fleet evolves.

This report investigates the potential impacts of RUC implementation in California, with a specific focus on equity outcomes for disadvantaged communities (DACs) and rural areas. Using vehicle registration data from the California Department of Motor Vehicles (DMV), vehicle attributes from the DataOne database, and socioeconomic and environmental indicators from CalEnviroScreen, the study estimates and compares per-mile cost burdens under the existing gasoline tax and a hypothetical revenue-neutral RUC system. The analysis is conducted at the census tract level to capture spatially granular effects.

Key findings reveal that the transition to a mileage-based fee would have modest yet heterogeneous effects across the state. Most census tracts experience cost differences within ±5% of the existing gas tax, although some areas see changes as large as 30% lower or 25% higher. On average, rural communities—characterized by lower vehicle fuel efficiency—would pay less under an RUC, benefiting from a shift away from the fuel-based taxation that penalizes inefficient vehicles. In contrast, DACs do not exhibit systematically higher or lower average fuel efficiency than the state as a whole and thus show no clear pattern of cost advantage or disadvantage under an RUC. These findings are consistent with prior research literature suggesting that fuel taxes are more regressive than RUCs in rural areas, but they challenge any assumption that disadvantaged communities uniformly benefit from a mileage-based system.

The report also examines implementation barriers and policy considerations. Administrative costs for RUC systems are significantly higher than those for gasoline taxes, driven by the need to collect fees from approximately 35 million individual passenger vehicles rather than a mere 100 bulk fuel terminals in California. While vehicle telematics may reduce these costs in the future, widespread deployment faces technical and political hurdles. Equity concerns, particularly regarding vertical equity across income groups, remain a prominent issue in both public discourse and legislative debate. Although evidence suggests that carefully designed RUC structures can be progressive—especially when incorporating income-based adjustments—such designs have yet to be widely tested. Additionally, privacy concerns associated with mileage tracking remain unresolved, and public resistance continues to constrain broader policy momentum.

This report underscores the need for nuanced policy design and further empirical analysis to support the implementation of equitable and administratively feasible RUC programs. As pilot programs expand and full-scale deployments increase across the United States—particularly in Oregon, Utah, and Virginia—

lessons learned from California's context can inform both local and national strategies. Crucially, as states and the federal government move toward performance-based pricing systems, equity must remain a central criterion in program evaluation and design.

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Introduction

Over the past decade, the landscape of transportation funding has been marked by substantial budget shortfalls, necessitating a reevaluation of traditional funding mechanisms. Between 2010 and 2020, the United States transportation infrastructure faced a cumulative funding gap exceeding $2 trillion, a deficit that has exerted profound impacts on the efficiency, safety, and sustainability of transportation systems (American Society of Civil Engineers, 2021). This shortfall has rendered the development and maintenance of critical infrastructure increasingly untenable. How did we arrive at this precarious juncture? The answer necessitates an examination of the history of transportation funding. The evolution of federal and state-level funding has been characterized by a reliance on traditional sources, such as the gas tax, which has remained largely stagnant at the federal level since 1993. Concurrently, the erosion of purchasing power, increasing fuel efficiency, and a shift towards alternative energy sources have further exacerbated the gap between funding needs and available resources. A transition towards new vehicle pricing mechanisms has emerged as a viable pathway, but it too comes with its own set of implementation challenges.

The history of federal transportation funding in the United States has been shaped by a series of legislative transformations designed to respond to the evolving needs and challenges of the nation's transportation infrastructure. Established under the Highway Revenue Act of 1956, the Highway Trust Fund (HTF) initially apportioned funds based on state population and cost of completing proposed highways. Over time, this mechanism has undergone significant modifications, reflecting a growing complexity in transportation demands and a recognition of diverse state needs. For example, the introduction of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991 marked a departure from a singular focus on highway costs to a more complex approach that considered factors such as vehicle miles traveled, air quality, and bridge conditions. Subsequent acts like TEA-21 and SAFETEA-LU further refined the apportionment formulas, introducing safeguards for smaller states and equity-based guarantees. However, the introduction of the Moving Ahead for Progress in the 21st Century Act (MAP-21) in 2012 and the Fixing America's Surface Transportation (FAST) Act in 2015 signaled a marked shift by locking in apportionments and disentangling performance metrics from distribution, reflecting a departure from formula-driven approaches.

Simultaneously, the fiscal underpinnings of the HTF have faced considerable challenges. The original funding mechanism, heavily reliant on federal gasoline and diesel taxes, has been undermined by stagnation in the gas tax rate since 1993, coupled with increased fuel efficiency and a shift towards alternative energy vehicles. This erosion of the traditional revenue base has led to recurring shortfalls, compelling Congress to supplement the HTF with transfers from general funds. From 2008 to 2020, more than $150 billion in general funds were transferred to the HTF to maintain its solvency (“The Outlook for Major Federal Trust Funds: 2020 to 2030,” 2020). Such a paradigm shift from user-pay principles to general fund reliance reveals a systemic vulnerability in transportation funding and raises vital questions regarding the sustainability, equity, and efficiency of the current approach. It also emphasizes the need for innovative financing solutions that can adapt to modern transportation trends and ensure a resilient and responsive infrastructure network.

In transportation infrastructure funding, states serve as vital stakeholders, supplementing federal allocations through an array of revenue mechanisms. Increased vehicle registration fees, fuel taxes, and mileage-based road usage charges (RUCs) are three prominent examples of funding mechanisms with the potential to reduce the transportation funding gap. Increased vehicle registration fees, especially for very fuel-efficient internal combustion vehicles, hybrid vehicles, plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs) are an option. However, these additional fees violate the "user-pays principle" because they charge the same fee to drivers regardless of miles driven. Recent research has found that these additional registration fees may significantly deter the uptake of more-efficient and less polluting vehicles (Jenn, 2018) Therefore, jurisdictions that charge these additional fees jeopardize greenhouse gas (McLaren et al., 2016) and public health benefits (Ferrero et al., 2016) of reduced pollution from more efficient and zero-tailpipe emission vehicles.

At present, 26 states charge additional annual BEV and PHEV registration fees. They range from $200 to $50 per year and are pervasive among West Coast states that have adopted aggressive vehicle electrification goals. In late 2018, the American Legislative Exchange Council passed a resolution advocating for "equal tax treatment for all vehicles" whose language likely inspired recent US state legislation mandating additional registration fees for BEVs and PHEVs.[1] The Natural Resources Defense Council (NRDC), the Sierra Club, and other environmental advocacy non-governmental organizations (NGOs) have criticized additional fees for BEVs and PHEVs for their potential to deter clean vehicle uptake by eroding the fuel cost savings associated with a transition away from internal combustion vehicles.[2,3] Additionally, the revenue deficits from other shortcomings of the existing fuel tax (inflation and improvements in overall fuel efficiency) remain unaddressed by measures charging EV registration fees. There may be a preference for applying the "user pays" principle in the political discussion that considers fairness of taxation, the growing electrification of passenger vehicles, and the existing approach to providing financial rewards for the use of more efficient vehicles.

Proposals to tax alternative fuel vehicles on an energy-equivalent basis (e.g., per kilowatt-hour of electricity for BEVs/PHEVs, per kilogram of hydrogen for fuel cell vehicles) would align with the user pays principle. The taxation mechanism can be designed to be revenue-neutral with fossil fuels taxes and, in theory, help jurisdictions maintain transportation funding stability. However, because around 85% of EV charging takes place at home (Tal et al., 2014), establishing a mechanism for electric utilities or other electricity service providers to meter home charging separately would require large infrastructure and administrative costs. The monetary investment in such metering could jeopardize program viability in terms of revenue per dollar-invested (Jenn, 2018).

RUCs (also known as road charges, distance-based fees (DBFs) and mileage-based fees (MBFs)) tax vehicles on a per-mile basis, align with the user pays principle and avoid the need for separate metering for home charging. These programs are likely a sustainable option to replace the gas tax. RUCs can charge non-fossil fuel propelled

[1] American Legislative Exchange Council, "Resolution Supporting Equal Tax Treatment for All Vehicles."

[2] Baumhefner, "A Simple Way to Fix the Gas Tax Forever."

[3] Lunetta, "Don't Be Fooled: Annual Fees on Electric Vehicle Drivers Are Not 'Fair.'"

vehicles the same per-mile fee as gas vehicles and thus represent an alternative to EV registration fees that aligns with the user pays principle and is potentially less regressive than existing gas taxes. Unlike fossil fuel taxes, RUC revenues per vehicle mile travelled (VMT) do not decline due to increased vehicle efficiency or a transition to zero emission vehicles (ZEVs) like BEVs and hydrogen fuel cell vehicles.

At the end of 2021, the Infrastructure Investment and Jobs Act (IIJA)[4] was passed and provided a massive funding package for infrastructure in the US. Part of the bill requires the US Department of Transportation to conduct a national RUC pilot with $10 million in annual funding between 2022 and 2026. Additionally, the bill established the Federal System Funding Alternative Advisory Board to provide guidance for the national RUC program.

At the state-level, the US federal government has provided grants for state and regional RUC pilots and programs since 2015, through the Federal Highway Administration's Surface Transportation System Funding Alternatives (STSFA) Program[5]. These pilots have mostly focused on implementation of RUC for passenger vehicles and have shed light on a set of shared technological, regulatory, and economic barriers and opportunities. Oregon has emerged as a leader in RUC design and is the first state to implement a working road charge program. As of 2024, US states are in varying stages of RUC rollout. States that are currently conducting research on RUC include Texas, New Mexico, Arizona, Oklahoma, Nebraska, Wyoming, Idaho, Montana, North Dakota, and Wisconsin; states that have active pilots or RUC demonstrations include: Hawaii, Delaware, Pennsylvania, Minnesota Colorado, Nevada, California, and Washington State; and only Oregon, Utah, and Viriginia have fully active RUC programs. In addition to state programs, several RUC coordinating organizations exist at regional levels. RUC West is a group of 16 western state transportation organizations that share RUC best practices. The I-95 Corridor Coalition is a group of transportation organizations from East Coast states exploring interstate RUC interoperability with a focus on commercial trucking.[6] The Mileage-Based User Fee Alliance (MBUFA) is an NGO that engages stakeholders in education and outreach activities around RUCs as a sustainable long-term roadway funding alternative.

The RUC has emerged as a pivotal topic in the discourse on transportation funding and equity. Studies on this topic distinguish between two types of equity: horizontal and vertical. Horizontal equity focuses on the distribution of impacts or benefits among groups perceived as equal in abilities and needs. This framework aligns more closely with the principle of equality rather than equity. Examples might include having drivers pay more according to how much transportation infrastructure they "use" (based on how much they drive) or how much they damage the road (based on the weight of their vehicle). In contrast, vertical equity is additionally concerned with the distribution of impacts or benefits among groups that differ in abilities and needs—groups that may be defined by income, social class, or access to transportation options. Regardless, the implementation of a new RUC mechanism is likely to be challenging: studies suggest that the concept of an

[4] H.R. 3684 "Infrastructure Investment and Jobs Act". 117th Congress (2021)

[5] US Department of Transportation. (2019). FAST Act Section 6020: Surface Transportation System Funding Alternatives (STSFA) Biennial Report. Washington DC: US Department of Transportation.

[6] The I-95 Corridor Coalition, "The I-95 Corridor Coalition MBUF Pilot."

RUC remains unpopular with the general populace, irrespective of its design mechanism (Duncan et al., 2020, 2017). However, within the scope of horizontal equity or the “user pays” principle, mileage-based fees are generally considered to be more equitable than traditional fuel taxes (Larsen et al., 2012; Levinson, 2010).

The difference in impact of RUCs on urban versus rural areas is a critical area of study. The classification of “urban” and “rural” zones varies across studies, potentially leading to opposing research outcomes. Research literature shows that rural households generally contribute more than urban households do to infrastructure funding, due to higher mileage and less fuel-efficient vehicles (Kastrouni et al., 2015; Larsen et al., 2012). Because rural households tend to have less fuel-efficient vehicles, a revenue-neutral RUC system would cost them less than a traditional gas tax (Fitzroy and Schroeckenthaler, 2018; Robitaille et al., 2011; RUC America, 2022; Schroeckenthaler and Fitzroy, 2019; University of California, Los Angeles et al., 2022; Weatherford, 2012). However, a few studies counter this conclusion, indicating that RUC mechanisms may increase financial burdens on rural communities. For instance, a study by Burris et al. suggests that payments from rural areas would increase under an RUC system (2015). Similarly, another study found that RUCs lead to a minimal increase in total annual payments for rural drivers in the long run (Zhang et al., 2009).

Beyond the burden to rural versus urban communities, studies have also examined the distributional effects of RUC programs based on income. Glaeser (2023) asserts that transitioning to a vehicle miles traveled (VMT) fee, an alternative name for a RUC, can mitigate the regressive nature of fuel taxation, with the tax burden generally increasing for higher income groups while decreasing for lower income communities (Glaeser et al., 2023). Yang et al. (2016) builds upon this conclusion by evaluating a variety of income-based VMT fee structures including Ramsey pricing, fixed-interval incremental, and fixed percentage incremental fees. Yang's research concludes that fixed interval incremental fee structures are progressive across all income brackets, thereby offering better financial protection for lower-income households. On the other hand, Zhang et al. (2009) concluded that changing from gas taxation to VMT fees would have a minimal impact on the distribution of fees across income groups in the short and long term and should not deter the implementation of RUC systems. While Zhang et al. aligns with the finding that most income groups stand to benefit from a VMT fee, they find that, counter to prevailing literature, the fee system could be more regressive than a gas tax—in other words have a greater impact on lower income groups.

Data and Methods

This analysis leverages three key datasets to investigate the equity impacts of an RUC in California. These datasets provide complementary information, enabling a detailed and geographically precise assessment.

1. **California Department of Motor Vehicles (DMV) Vehicle Registration Data**
   The DMV vehicle registration database includes detailed records of all vehicles registered in California. Each record contains a vehicle identification numbers (VINs), model year, registration status, and geographic identifiers, such as census tract codes. This dataset forms the foundation for the analysis, offering a complete view of the vehicle fleet across the state. We leverage VINs to obtain additional details about vehicle attributes, such as fuel efficiency and engine type, which are necessary for calculating the financial impacts of transitioning from the gasoline tax to an RUC.
2. **DataOne Vehicle Attributes Database**
   The DataOne database is a commercial VIN decoder and vehicle attribute repository that provides an extensive set of detailed information about vehicles. This includes specifications such as fuel efficiency (measured in miles per gallon, mpg), engine size, fuel type, drive type (e.g., two-wheel or all-wheel drive), and vehicle class. This dataset is combined with the DMV vehicle registration records to spatially locate vehicles across the state. Its comprehensive coverage ensures that even niche or less common vehicles are accurately represented, allowing for precise aggregation of average fuel efficiencies at the census tract level.
3. **CalEnviroScreen Data**
   CalEnviroScreen, developed by the California Environmental Protection Agency (CalEPA), identifies census tracts most burdened by a combination of environmental, health, and socio-economic factors. This dataset scores census tracts based on metrics such as pollution exposure, proximity to hazardous sites, and population vulnerability (e.g., poverty levels and linguistic isolation). For this study, CalEnviroScreen is used to delineate disadvantaged communities (DACs), defined as the top 10% of census tracts with the highest overall burden scores. It is also used to identify rural census tracts, based on population density thresholds.

To evaluate the equity impacts of an RUC in California, we used the above combination of vehicle registration data, vehicle attribute data, and environmental and socio-economic community classification data. We conducted the analysis at the census tract level to enable a spatially precise and context-sensitive comparison of financial impacts under current gasoline tax and hypothetical RUC regimes.

To prepare the DMV dataset for analysis, invalid or incomplete VINs, duplicate records, and vehicles with expired registrations were removed. Each vehicle record was geocoded using its corresponding census tract identifier, providing a geographic basis for the analysis. The VINs were then decoded using The DataOne Vehicle Attributes database was used to decode the VINS and gather information on vehicle fuel efficiency (in mpg), fuel type, engine size, and vehicle class. For vehicles lacking mpg data, such as certain electric vehicles, representative fuel efficiency values were imputed based on manufacturer specifications and attributes of similar models in the database.

Community designations, including disadvantaged communities (DACs) and rural areas, were identified using the CalEnviroScreen dataset. The analysis accounts for variations in community vulnerability and geographic context by integrating these classifications into the geocoded vehicle registration dataset.

The average fuel efficiency for each census tract was calculated by aggregating vehicle-level mpg values. Weighting by vehicle counts ensured that census tract averages accurately reflected the number of registered vehicles. The average fuel efficiencies were subsequently used to estimate per mile costs under the gasoline tax. The current gasoline tax rate in California, $0.539 per gallon, was used for these calculations. RUC costs were determined with a rate calibrated to achieve revenue neutrality with the gasoline tax at the state level. The difference between gasoline tax costs and RUC costs was computed for each census tract to identify regions that would experience higher or lower costs under the RUC system. We examined the distribution of these cost differences among DACs vs. non-DACs and rural vs. urban census tracts.

Equity Impacts Analysis: A Case Study of a California RUC

One of the central tenets echoed by multiple RUC program managers in different states is how mileage fees would be less regressive than gasoline taxes. Generally, the argument is that mileage fees tend to favor drivers in rural areas (they would end up paying less than a gasoline tax) because drivers in these regions tend to drive less fuel-efficient vehicles. We conducted an empirical examination of the change in fees that drivers would expect to pay in a revenue neutral program in California. By coupling these records with a VIN decoder, we determined the average fuel efficiency of every vehicle registered in California aggregated at the census tract level (see **Figure 1**). While vehicle fuel efficiencies can vary dramatically at the individual vehicle level, when aggregated to the census tract, the average fuel efficiency is fairly constant and ranges between 17 and 27 mpg in most regions. Also, fuel efficiencies for disadvantaged communities do not differ substantially from other regions in California.

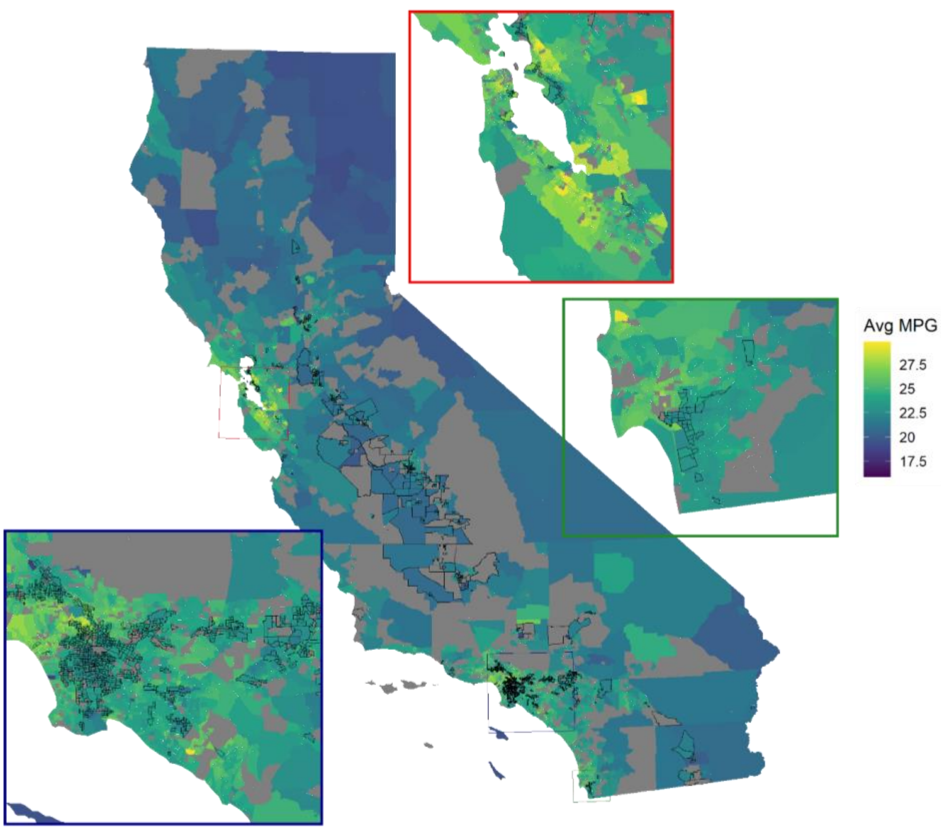

Figure 1. Average fuel efficiency of registered vehicles in California by census tract, with disadvantaged communities outlined in black.

By determining the average fuel efficiency associated with each region, we calculated the difference that drivers in those regions would pay with a mileage fee compared to a gas tax. These differentials are shown in **Figure 2**. While the mileage fee is designed to be revenue neutral with the current gasoline tax in California, the variation in regional fuel efficiencies means that there will be "winners" and "losers" with respect to the relative amount paid per mile across different census tracts in California. **Figure 2** also shows differences highlighting specific regions including DACs (outlined in black) and rural communities (outlined in blue). Note that differences in the cost ranges from 30% cheaper to 20% more expensive.

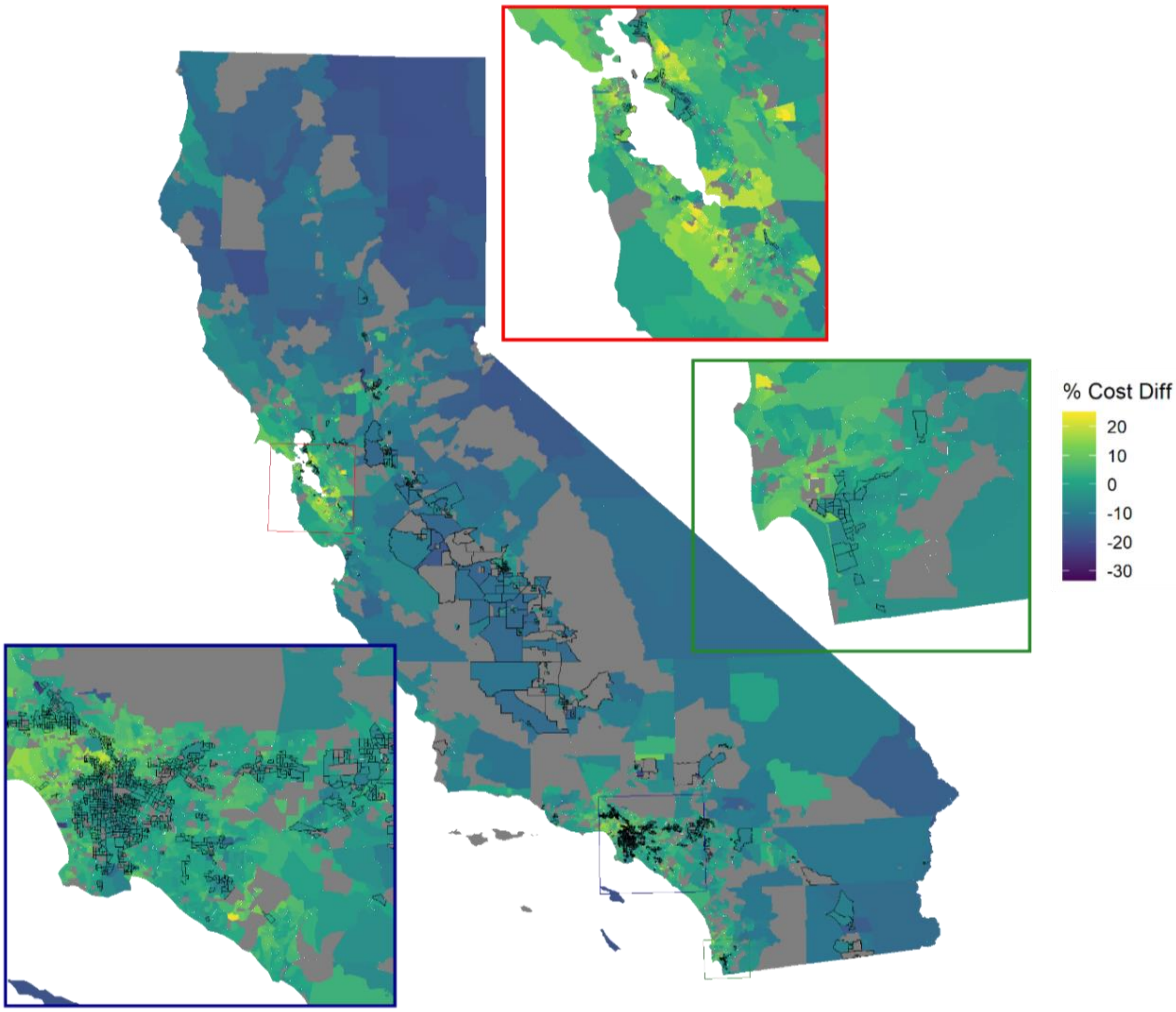

Figure 2. Differential in per mile cost to drivers by switching to a mileage-based fee (compared to a gasoline tax) at the census level. Disadvantaged communities (based on top 10% of DACs in CalEnviroScreen) outlined in black and rural regions are outlined in blue.

While **Figure 2** shows the geographical breakdown of cost changes for drivers in California, it can be difficult to determine whether the regional differences are statistically significant. Therefore, in **Figure 3** we provide insight into the trend of the cost comparison as a function of population density. Here we are able to observe a clear trend, though with a large amount of heterogeneity, that lower population density areas (typically corresponding to rural regions) tend to pay less on average per mile under a road usage charge compared to a gas tax, while higher population density areas (corresponding with more urban locations) tend to pay more on average under a road usage charge. This is a function of the fuel efficiency of vehicles in those locations, with rural regions tending to have less fuel-efficient vehicles on average. The difference in cost ranges from 30% cheaper to 25% greater than the gasoline tax, though the difference is only +/-5% in most areas, a difference of only a few dollars over the course of the entire year.

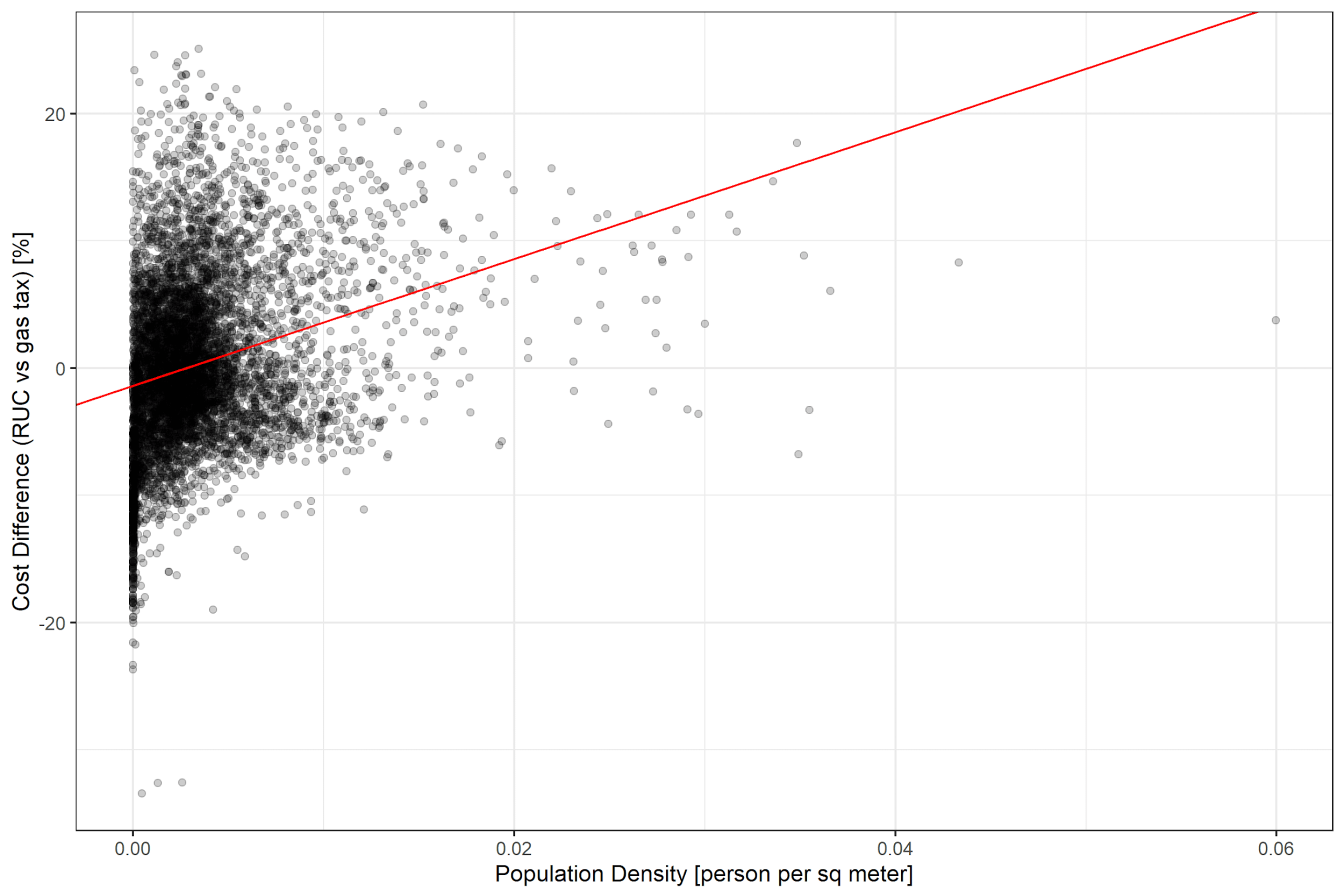

Figure 3. Distributions of change in per-mile cost to drivers switching from a gasoline tax to a mileage-based fee.

Future Considerations for Mileage Fees

As transportation infrastructure revenues from gasoline taxes continue to decrease due to pressures from inflation, improving fuel economy, and shifts to alternative fuel vehicles, mileage-based fees/road user charges will become an increasingly compelling funding source. Oregon, Utah, and Virginia have already implemented mileage fees, and a handful of other states have followed suit in developing and running pilot programs to test the viability of the new funding mechanism. Despite the unique state contexts that influence the design and structure of each road charge program, certain common lessons can be drawn from these and from our study.

1. **Administrative costs** – A common issue facing all programs implemented in the US thus far is the relatively high administrative costs of a mileage fee compared to the status quo gasoline tax. Administering a gasoline tax is extremely efficient. The fees are typically collected at fuel terminals, of which there are only several hundred throughout the United States. Contrast this with a mileage fee which essentially requires a separate collection point for every individual vehicle, numbering in the millions for each state. Each vehicle owner would need to report their miles travelled, and while this can be done in a variety of ways, the number of collection points in many orders of magnitude higher than gasoline taxes. While costs will inevitably come down as administrators learn how to implement the program more efficiently, the hardware requirements for every vehicle will inevitably lead to higher costs than the gas tax. This is reflected by comments from many DOTs that administrative costs are not anticipated to fall below 5-10% of the revenues raised (compared to 1% of gasoline tax revenues). However, one promising technology that has been brought up in many of our interviews are vehicle telematics. It is not clear by how much telematics can reduce administrative costs, but by removing the separate hardware requirements required to collect VMT information that is necessary for a RUC (such as an on-board diagnostics device that could collect and transmit mileage information), costs could be decreased further. However, implementation could be challenging due to opposition from automakers.
2. **Equity issues** – A significant concern with RUCs is how the fees may differ from the gasoline tax, among various demographic groups. Previous pilot program reports from Oregon and California have pointed to benefits for rural communities in switching from a gas tax to a mileage fee—under the assumption that rural areas tend to drive less fuel-efficient vehicles (which would amplify the costs of the gas tax). Our analysis confirms these findings, and we identify rural areas tend to have less fuel-efficient vehicles, which means that those communities would pay less under an RUC than a gasoline tax. Additionally, we analyzed disadvantaged communities according to CalEnviroScreen classification, but found that DACs, unlike rural communities, are indistinguishable from other regions in California in terms of the change in fee.

RUC or mileage-based fees have long been discussed as a pricing mechanism in the academic literature, but are now beginning to take hold as a potential solution to some of the pitfalls of gasoline taxes. Already, numerous pilot programs have launched by state DOTs across the United States, with full-fledged programs launched in

Utah, Hawaii, and Virginia. As these programs continue to develop, issues of equitable impacts need to be considered to ensure that RUCs can minimize the regressivity of their fees.

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