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MTI MINETA TRANSPORTATION INSTITUTE

Charging Drivers by the Gallon vs. the Mile: An Equity Analysis by Geography and Income in California

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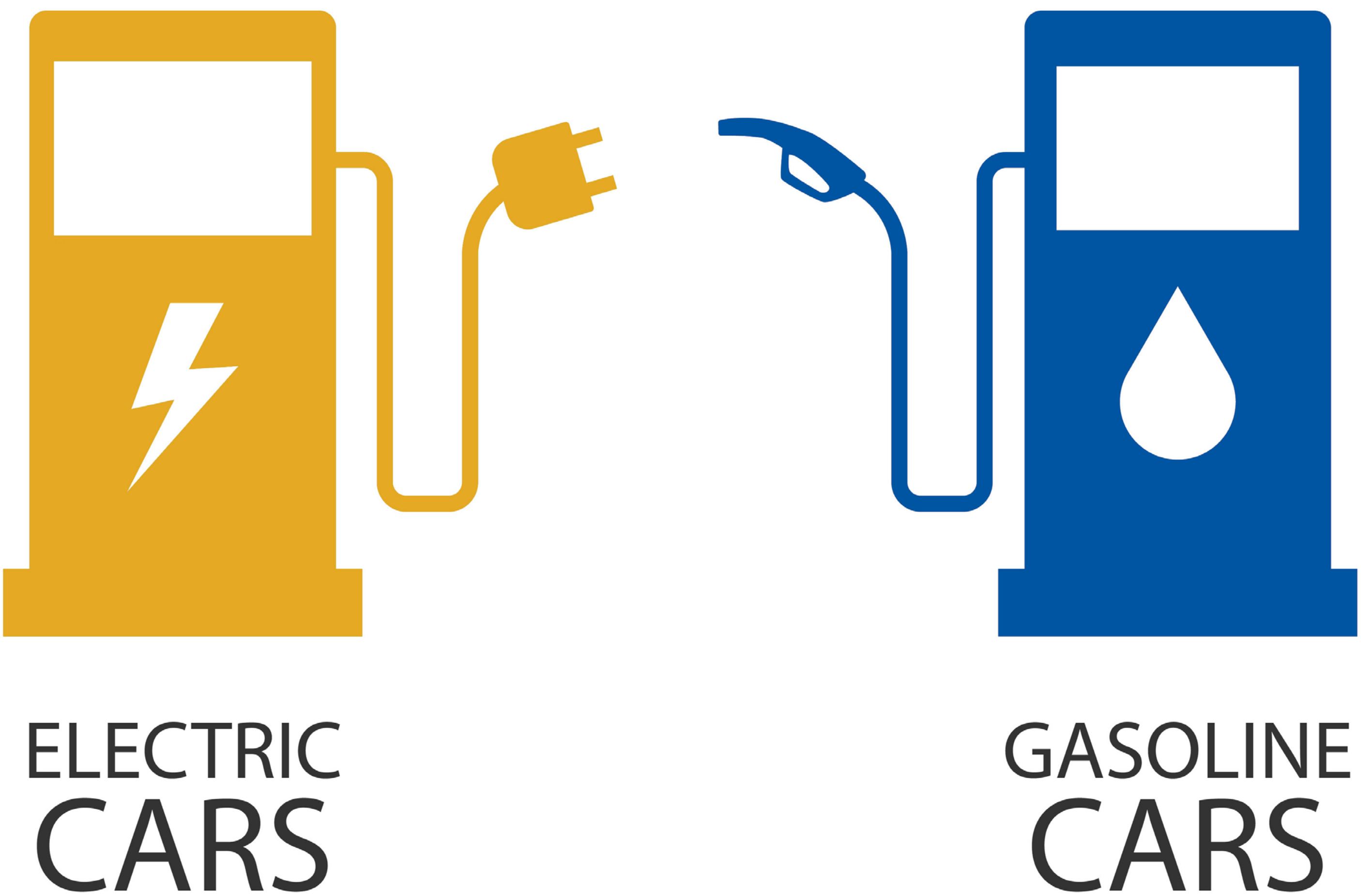

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REPORT 22-44

CHARGING DRIVERS BY THE GALLON VS. THE MILE: AN EQUITY ANALYSIS BY GEOGRAPHIC AND INCOME IN CALIFORNIA

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16. Abstract

This study used data from the 2017 National Household Travel Survey California Add-On sample to explore how replacing the current state vehicle fuel tax with a flat-per-mile-rate road-user charge (RUC) would affect costs for different kinds of households. We first estimated how household vehicle fuel efficiency, mileage, and fuel tax expenditures vary by geography (rural vs. urban) and by income. These findings were then used to estimate how much different types of households pay in the current per-gallon state fuel tax, what they would pay if the state were to replace fuel taxes with a flat-rate road-usage charge (RUC) that would generate revenues similar to the current state fuel tax (2.52¢ per mile driven), and the difference in household expenditures between the fuel tax and RUC.

We find that rural households tend to drive more miles and own less fuel-efficient vehicles than urban ones, so they pay comparatively more in fuel tax and would pay more with the RUC as well. However, this rural/urban variation is less for the RUC than the fuel tax, so moving to a flat-rate RUC would redistribute some of the overall tax burden from rural households (that drive more miles in fuel-thirsty vehicles) to urban households (that drive fewer miles in more fuel-efficient vehicles). Transitioning from the fuel tax to RUC would also generally shift the fuel tax burden from lower-income to higher-income households, with one exception: expenditures would rise for low-income urban households. However, the variation in the tax incidence between the gas tax and RUC is quite modest, amounting to less than one dollar per week for both urban and rural households at all income levels.

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EXECUTIVE SUMMARY

California, like many other states and the federal government, is actively exploring use of a road-user charge (RUC) to replace motor vehicle fuel excise taxes. This idea is motivated by the declining share of vehicles that burn gasoline or diesel fuel when they drive. Two equity concerns frequently raised in discussions about RUCs are whether they might disproportionately harm rural households and low-income households. This study used data about California households to explore how replacing the current state gas tax with a hypothetical per-mile road user charge (RUC) would affect household costs by geography and income.

DATA AND METHODS

We used data from the 2017 National Household Travel Survey California Add-On sample, which surveyed more than 24,000 California households. We first estimated how household vehicle fuel efficiency, weekly household mileage, and weekly fuel tax expenditures vary, on average, by geography (rural vs. urban) and by income. We then used these findings to estimate (1) fuel tax payments by types of households and (2) how much these households would pay if the state replaced fuel taxes with a hypothetical flat-rate RUC. We assumed the RUC would generate revenues similar to the current state fuel tax (2.52¢ per mile driven).

FINDINGS

The table below summarizes our key findings. Moving from the fuel tax to a revenue-neutral, flat-rate RUC would slightly lower costs for most rural households but raise them for urban households at all income levels. The differences are small, though — less than a dollar a week for every household group. The rural-to-urban burden shift for a RUC is largely explained by fuel efficiency: rural households tend to drive less fuel-efficient vehicles than do urban households.

Because the flat per-mile RUC would not account for fuel efficiency, households with less fuel-efficient vehicle fleets (up to 21.0 MPG) would see their tax burden reduced, while those with more fuel-efficient vehicle fleets (21.1 MPG or higher) would see their tax burden increase.

Table E1. Summary of Findings

Factor	Variation by geography	Variation by income
Fuel efficiency	Urban households own vehicles that are 12% more fuel-efficient vehicles than do rural households: 23.6 vs. 21.1 MPG	The highest-income households own vehicles that are 8% more efficient than those owned by the lowest-income households (24.2 vs. 22.4 MPG)
Mileage	Rural households drive 18% more miles weekly than urban households (503 vs. 427 miles).	The highest-income households drive 61% more miles per week than the lowest-income households (524 vs. 325 miles)
Fuel tax paid	Rural households pay $13.31 weekly vs. $10.10 for urban households, a difference of $3.21 per week.	The highest-income households pay $12.33 per week vs. $7.86 per week for the lowest-income households, a weekly difference of $4.47.
Shift to a RUC	Lowers costs for most rural households and raises them for all urban households.	Raises costs more for the wealthiest households than for lower-income ones

POLICY IMPLICATIONS

Although replacing the state fuel tax with a flat-rate RUC would not increase average costs for rural households, the study findings point to other policy implications that might concern policymakers:

- **Replacing the fuel tax with a flat-rate RUC would slightly increase costs for the poorest urban households.** Although the estimated increases are less than a dollar a week or $27 annually, the added cost is still a burden for those who can least afford it.

- **Replacing the fuel tax with a flat-rate RUC would run counter to state climate policy, which calls for reducing fuel consumption.** A flat-rate RUC of any price will shift the tax burden away from users of fuel-inefficient vehicles and onto users of fuel-efficient ones, thereby eliminating the fuel tax's fiscal incentive to consumers to purchase and drive more fuel efficient or zero-emissions vehicles.

Options for addressing these concerns include:

- **Differentiated rate structures that counteract these policy concerns.** One option is an increasing-block-pricing rate: a vehicle owner pays no RUC or a very low rate for the initial set of miles driven annually, and then higher rates for additional miles driven. Alternatively, the state could offer a lower RUC rate to qualifying low-income households, similar to the "lifeline" rates that utilities offer to low-income customers. Yet another option would be to set RUC rates higher for less-efficient vehicles and lower for more efficient vehicles.

- **Counterbalancing RUC costs with policies that help low-income families reduce other transportation costs.** Examples include policies to help low-income households reduce the number of miles they need to drive and/or purchase more fuel-efficient or zero-emissions vehicles.

1. INTRODUCTION

California, like many other states and the federal government, is actively exploring per-mile road user charges (RUCs) as a replacement for motor vehicle fuel excise taxes. Such a shift is motivated by the growing share of vehicles on the roads each year powered by electricity or hydrogen, and the gradually declining share that burn gasoline or diesel fuel when they drive. Two equity concerns frequently raised in discussions about RUCs are whether they might disproportionately harm rural households (compared to urban households) and low-income households (compared to higher-income ones). Despite the frequency of these two concerns, relatively little recent evidence is available to clarify whether these concerns are warranted.

This study informs debate on these questions by analyzing California data from the 2017 National Household Travel Survey. We first determined how household vehicle fuel efficiency, mileage, and fuel taxes paid varied by geography (rural vs. urban) and by income. Next, we used these findings to estimate how much households pay in fuel tax, what they would pay if the state were to replace fuel taxes with a hypothetical, revenue-neutral, flat-rate road-usage charge (RUC) of 2.52¢ per mile driven, and the difference in household costs between the fuel tax and RUC.

For half a century, transportation policymakers and analysts have predicted a gradual demise of the per-gallon vehicle fuel tax. Such predictions were initially prompted by the increasing fuel efficiency of vehicles beginning in the 1970s, which meant that drivers covered more miles for each dollar paid in fuel taxes. More recently, the rise of electric and hydrogen fuel cell vehicles has meant that increasing numbers of vehicles on the road pay no fuel taxes at all.

In response to concerns that inflation-adjusted fuel tax revenues were increasingly lagging behind vehicle travel, many transportation and finance analysts have suggested RUCs as a supplement to, and eventual replacement for, motor fuel taxes. While a RUC can take many forms, at its simplest it is a per-mile charge for the use of the road, instead of a per-gallon charge on fuel burned in the course of driving.

This study builds on a relatively small body of literature, mostly from the past decade, that explores the differences among households in mileage driven, vehicle fuel efficiency, fuel tax paid, and/or RUC costs (Fitzroy & Schroeckenthaler, 2018; Larsen et al., 2012; Mattson & Molina, 2022; Paz et al., 2014; Schroeckenthaler & Fitzroy, 2019; Washington State Transportation Commission, 2021; Weatherford, 2012; Zhou et al., 2021).

The study closest to our own is an earlier Mineta Transportation Institute report by Ferrell and Reinke (2015), *Household Income and Vehicle Fuel Economy in California*, which analyzed data from the 2010-2012 California Household Travel Survey. A key reason to update that study is that both miles driven[1] and vehicle fuel efficiency[2] have changed in California during the 2010s, but it is not known how those changes have been distributed across different household groups.

The remainder of the report is organized as follows. Chapter 2 describes the data and analysis methods used. Chapter 3 presents findings on estimated vehicle fuel efficiency, vehicle miles traveled, and fuel consumption for different income groups and for rural vs. urban households. Chapter 4 presents findings on estimated weekly household costs of the fuel tax and hypothetical RUC. Finally, Chapter 5 summarizes and discusses the key findings, suggests implications for policymakers, and proposes future research needs.

1 Statewide vehicle miles travelled (VMT) changed considerably from 2010 to 2017. With the onset of the Great Recession in 2008, overall VMT fell annually from 2008 through 2010. Mileage remained relatively flat from 2011 through 2013, but then picked up starting in 2014 as the economy recovered (Davis, 2019).

2 In 2009, the Obama Administration instituted a sharp increase in Corporate Average Fuel Economy (CAFE) standards for light-duty vehicles, which led to the national fleet standard increasing from 25.4 MPG in 2010 to 33.8 MPG in 2017 (NHTSA, 2019). During that time, the number of zero-emission vehicles (ZEVs) that consume no gasoline or diesel fuel at all rose from 615 in 2010 to 162,076 in 2017 (California Energy Commission, 2021). These figures include battery-electric and fuel-cell vehicles, but not plug-in hybrid vehicles, since the latter consume some gasoline.

2. STUDY DATA AND METHODS

This study analyzes data from the 2017 National Household Travel Survey (NHTS) California Add-On sample to answer five research questions:

1. How does household vehicle fuel efficiency vary by income and geography?
2. How does household weekly vehicle mileage vary by income and geography?
3. How do weekly household fuel tax costs vary by income and geography?
4. How would weekly household charges for a flat-rate RUC vary by income and geography?
5. How would replacing the fuel tax with a RUC shift the cost burden according to income and rural vs. urban geography?

The NHTS California Add-On data are uniquely well suited for this study because the survey has a large number of California participants, is representative of all households in California, and includes detailed information about three essential factors: the household's vehicles, driving behavior, and income. Other sources of data offer more recent or otherwise higher quality information about one or two pieces of these factors, but not all three. For example, the State of California's vehicle registration data provides current and comprehensive data about what types of vehicles are owned and where the owners live, but registration records lack information about such factors as how much the vehicle is used and the personal characteristics of the owner. Other surveys, such as regional household travel surveys, contain detailed data on all three topics but do not allow for statewide analysis.

We constructed a data set with information for each household on the average fuel efficiency of all its internal combustion engine (ICE) vehicles, the number of miles driven weekly, and the number of gallons of gasoline-equivalent fuel purchased weekly. We then used the number of gallons of gasoline purchased to estimate the fuel tax each household paid, and the weekly mileage to estimate how much households would pay for a hypothetical, revenue-neutral, flat-rate RUC of 2.52¢ per mile.

This chapter describes the NHTS data used, lays out the steps used to estimate each household's average weekly gallons of fuel purchased and miles driven, explains the household income and geographic categories used, and lists the statistical methods used to determine whether differences between subgroups were significant.

2.1 ABOUT THE NHTS AND THE CALIFORNIA ADD-ON SAMPLE

The NHTS is a nationally-representative survey of U.S households that the Federal Highway Administration (FHWA) conducts periodically to analyze national trends in household travel behavior (Westat, 2019). In the 2017 survey, respondents reported their personal and household characteristics, socio-economic characteristics, vehicle ownership, and vehicle attributes, and they also completed a travel activity log for one day.

The State of California collaborated with FHWA to add to the national sample sufficient California households for a representative state sample. This 2017 NHTS California Add-On, conducted concurrently with the national sample, was a stratified random sample of 26,099 California households.[3]

Our analysis draws upon the NHTS vehicle data file, which includes household and vehicle information for the 24,929 California households in the sample that reported having access to a private vehicle. These households reported 52,215 vehicles.[4] We aggregate this file up to the household level, choosing households as the unit of analysis because household travel costs depend on all vehicles driven by all household members.

2.2 ASSEMBLING THE DATA SET

We created the data set used for analysis through a series of five primary steps:

1. Identify households that own a vehicle that requires the purchase of gasoline or diesel motor fuel
2. Estimate the fuel efficiency of each vehicle in the sample
3. Estimate the average vehicle fuel efficiency for each household
4. Estimate the total weekly mileage driven by each household
5. Estimate how many gallons of gasoline each household purchased in a week.

We defined eligible households for this study as those that (1) owned at least one internal-combustion engine (ICE) vehicle and therefore purchased gasoline or diesel motor fuel to operate it, and (2) provided all critical information used in the analysis, including annual household income. We excluded the 23 households (0.1% of the sample) that reported owning only electric vehicles (and therefore presumably paid no fuel tax), as well as the 735 households (2.8%) that did not report income. These exclusions reduced the working data set to records for 24,166 California households.

The next step was to assign a mean vehicle fuel efficiency for each vehicle in the sample. Version 1.2 of the public-release NHTS data matches each household vehicle to the vehicle fuel efficiency (VFE) estimates reported on the U.S. Environmental Protection Agency's Fueleconomy.gov website (FHWA, 2020).[5] Fueleconomy.gov provides miles-per-gallon VFE data for all makes and models of automobiles since 1985. These data, however, required further adjustments and assumptions for the following:

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[3] The California Add-On sample was stratified to ensure sufficient rural households for analysis.

[4] A total of 1,170 households, or 4.5% of the California Add-On sample, reported no vehicle: 35 rural households and 1,135 urban households.

[5] Matches between the NHTS and Fueleconomy.gov rely on NHTS survey respondents' reported vehicle information, which can vary in precision based on missing or misreported survey data and variations in vehicle models. Complete documentation on how the NHTS merges its vehicle data with Fueleconomy.gov data can be found on the NHTS website (FHWA, 2009, 2020).

1. Vehicles older than model year 1985: Because VFE data are not available in the NHTS for vehicles older than the 1985 model year, we assigned these older vehicles an estimated fuel efficiency of 14.6 MPG, which is the average annual fleet fuel efficiency for light-duty vehicles from model years 1949 to 1984 (U.S. Energy Information Administration, 2021). This adjustment applied to 2,023 vehicles (owned by 6.4% of households).

2. Diesel vehicles: The data file includes 1,638 diesel vehicles (owned by 6.8% of households). For these vehicles, we used the gasoline-equivalent MPG provided by the NHTS and Energy Information Administration (EIA) and annualized fuel consumption to approximate how much gasoline these light-duty diesel vehicles would have consumed, had they been gasoline vehicles (FHWA, 2009).[6]

3. Electric vehicles: We removed the 303 electric vehicles (0.6% of vehicles in the sample) owned by 287 eligible households (1.2%), since the households pay no fuel tax to drive their vehicles.

Third, we estimated the average VFE across all vehicles in each individual household. For example, a household with one 20 MPG vehicle and one 30 MPG vehicle would have a "household average vehicle fuel efficiency" of 25 MPG.[7]

Fourth, we estimated the weekly mileage driven by each household using the NHTS estimate for annual mileage driven, which assesses data quality, reported odometer reading, and time frame (Oak Ridge National Laboratory, 2019).[8] We aggregate these vehicle estimates by household and then divide by 52 to attain weekly estimates.

Last, we estimated the weekly number of gallons of gasoline each household purchased by dividing the NHTS variable for annual fuel consumption by 52 to obtain weekly estimates. The NHTS calculates annual fuel consumption as gallons of gasoline-equivalent consumed per year by multiplying its estimate for annual mileage by vehicle fuel efficiency (MPG) (Leckey & Schipper, 2011).

[6] The NHTS only provides estimated MPG in one variable that uses this conversion (FHWA, 2009, 2020).

[7] We also calculated household VFE with the vehicles weighted by their annual mileage driven. The differences between this and the simple mean value we use were extremely small and the standard errors were nearly identical. For all households in the state, the difference was only 0.23 MPG. For most subgroups, the difference was less than 0.4 MPG, and the single largest difference was 1.27 MPG. Given the small variation and the fact that all vehicles are theoretically equally available to household drivers at any time, we decided to use the simpler option: VFE that does not weight for mileage. Further, this choice does not affect any of our other calculations, as those are derived from a separate NHTS variable for gasoline-equivalent gallons consumed per year.

[8] Complete documentation on the NHTS "bestmile" estimate can be found on the Oak Ridge National Laboratory website (Oak Ridge National Laboratory, 2019).

2.3 CLASSIFYING HOUSEHOLDS BY GEOGRAPHY AND INCOME

We assigned each household to income and residential location classifications. The six income groups, shown in Table 1 (below), are based on NHTS household income categorizations.[9] For residential location, households are classified as either "urban" or "rural." Households located within a metropolitan statistical area (MSA) are classified as urban, and all households outside an MSA are classified as rural.

Table 1 shows the breakdown of households within those groupings. The majority of this sample — and of the population in California — lives in an urban area.

Table 1. Number of California Households in the Data Set in Each Income Group, by Geography (Unweighted Sample)

Annual Household Income	Rural	Urban	Total
≤$24,999	493	3,056	3,549
$25,000 – $49,999	729	4,041	4,770
$50,000 – $99,999	985	6,441	7,426
$100,000 – $149,999	496	3,955	4,451
$150,000 – $199,999	158	1,664	1,822
≥$200,000	228	1,920	2,148
All income levels	3,089	21,077	24,166

2.4 DATA WEIGHTS

Because the raw NHTS national and California Add-On samples are not exactly representative of the U.S. and California populations, the NHTS provides household-level weights that adjust the data to match to the American Community Survey data, so the NHTS and California add-on samples will broadly represent all households in the study area. These weights also adjust for potential non-response bias. Additionally, the NHTS provides so-called jackknife replicate weights to estimate variances as a way of indicating precision of population estimates based on the survey data (Roth et al., 2017). Replicate weights simulate multiple samples from the single NHTS sample. In short, using these two weights allow us to, respectively, (1) estimate the mean of the California population (urban, rural, and statewide) rather than just report the mean of the given NHTS sample, and (2) more precisely estimate the likelihood that those population estimates are correct based on which households were or were not included in the sample.

2.5 STATISTICAL ANALYSIS

Standard errors estimate how much the mean of a sample deviates from the true mean of the population, on average. To identify the standard errors for the estimates presented in the study, we calculated the weighted mean for each type of household (e.g., rural households earning less than $25,000 a year) by using the jackknife replicate weights

[9] To ensure adequate sample size, we combined the NHTS income categories into $50,000 intervals, but we separated the lowest $50,000 in income into two groups to better consider households living in poverty.

available from the NHTS. The figures below all show the standard errors as 95-percent confidence interval error bars. Because the rural sample is much smaller than the urban sample, the confidence intervals for the rural household groups are correspondingly larger.

To examine the overall relationships between household income categories and our variables of interest, we generated Kendall rank correlation coefficients separately for urban, rural, and all households. This analysis tests whether there are statistically significant correlations between income category and VMT and fuel consumption. The complete set of coefficients is shown in tables in the appendix.

We use Kendall rank coefficients (Kendall's tau-b) because the NHTS reports income by category. Thus, we are unable to derive precise estimates for each household's income, particularly at the low and high ends of the income spectrum. However, we are able to rank the categories one through six, and the Kendall rank test determines the significance, strength, and direction of a relationship between two variables by their rank. Accordingly, we use the income category ranks, and we rank the other relevant variable in each analysis to determine those traits of their relationship. A Kendall tau of 1 means the observations have a perfect positive correlation (e.g., that VFE rank rises perfectly with income rank), and the inverse is true for a Kendall tau of –1. Further, we can observe whether a Kendall tau is statistically significant to determine if there is a meaningful correlation between variables.

2.6. LIMITATIONS TO THE METHODOLOGY

Several limitations to our data source and analysis techniques warrant mention.

First, while the 2017 NHTS data are in many ways an ideal source for the reasons discussed above, they also have limitations:

- One of the most obvious limitations is that the data are five years old. Household vehicle mileage traveled and the efficiency of California's household vehicle fleet have almost certainly changed since 2017, but we do not know how those changes have been distributed among households by income or geography. Key changes include a steep increase in the number of zero-emission vehicles, improved fuel efficiency for ICE vehicles, and changes in travel behaviors resulting from the COVID-19 pandemic. By the end of 2021, the number of registered light-duty ZEVs in California had grown to 532,572,[10] or 1.3% of the light-duty vehicle fleet (California Energy Commission, 2021). For that same year, however, ZEVs made up 9.3% of new vehicle sales in the state and the electric 2022 Tesla Model Y was the third best-selling car in California (California Energy Commission, 2021; Edmunds, 2021). With respect to ICE vehicles, both California and U.S. fuel efficiency standards have risen since 2017. Finally, the COVID-19 pandemic has also undoubtedly had some effect on driving behavior as well, including effects on residential location, employment, and remote work, but these effects are in many ways still uncertain (Loukaitou-Sideris et al., 2022).

- Like any survey, the NHTS is an imperfect representation of the full population of California households. The survey has relatively small numbers of respondents

[10] This was 522,445 BEVs and 10,127 FCEVs (California Energy Commission, 2021).

representing certain groups, including rural households, chiefly because these groups themselves are small in size. As the error bars on figures above indicate, the true values describing rural households fall within a large range.

- The fuel consumption data are imperfect. The NHTS data rely on estimated fuel consumption data, rather than records of actual fuel purchased. Further, FuelEconomy.gov estimates fuel consumption based on the manufacturer's advertised VFE, with 45% highway driving and 55% city driving. True VFE depends on factors such as vehicle load, driving behaviors, congestion, and weather.

In addition to limitations to the NHTS data, our analysis techniques have several limitations as well:

- We considered only a single, revenue-neutral, per-mile flat-rate RUC. There are many other possible RUC rate structures, each of which would affect travel, transportation systems, emissions, and households differently.

- The analysis does not consider how changing the tax burden on fuel and/or mileage might alter people's choices about what vehicles to drive or how many miles to drive. People might drive either more or less depending on the extent to which the shift to a RUC changes their costs, they might shift some household mileage from one vehicle to another, or they might purchase more or less fuel-efficient vehicles. Any such behavioral changes would influence RUC payments.

- Because we excluded ZEVs from the analysis, miles that households drove in a ZEV were not included in the estimated household RUC payment. Although there were very few ZEVs in 2017, as noted above, they have grown at an increasing rate.

- Our analysis presents the average values for each population group, which obscures the variety of experiences among households in each group. For example, research in Pennsylvania by Yuan, et al. (2021)to fund transportation infrastructure. To support the design and evaluation of MBUF programs, and compare them to the existing fuel tax, we leverage over 119 million records across a fifteen-year period, from annual vehicle inspections in Pennsylvania, to develop high-resolution estimates of the annual cost to vehicle owners of fuel taxes, and of MBUF's at various rates. Applying numerous data cleaning and analytical methods, we use odometer readings from subsequent vehicle inspection records to assess annual vehicle miles travelled (VMT found that fuel consumption varied considerably among individuals living in a particular area, and that there was also variation among rural counties, with some consuming less fuel than average but others consuming close to the state-wide average.

3. FINDINGS ON VEHICLE FUEL EFFICIENCY, MILEAGE, AND FUEL CONSUMPTION

This chapter presents the study findings on the three inputs we used to estimate weekly household fuel tax and RUC costs: household average vehicle fuel efficiency, household weekly VMT, and household weekly fuel consumption.

3.1. VEHICLE FUEL EFFICIENCY

Figure 1 shows the household average VFE for urban and rural households in each of the six income categories. Table A 4 in the Appendix presents standard errors and statewide means.

Average household VFE by income category and geography ranges from 19.7 to 24.3 MPG, a spread of 4.6 MPG. The least efficient vehicles (19.7 MPG) are owned by rural households in the lowest income category. The most efficient vehicles (24.3 MPG) belong to two groups with higher incomes: rural households with incomes from $150,000 - $199,999 and urban households with incomes over $200,000.

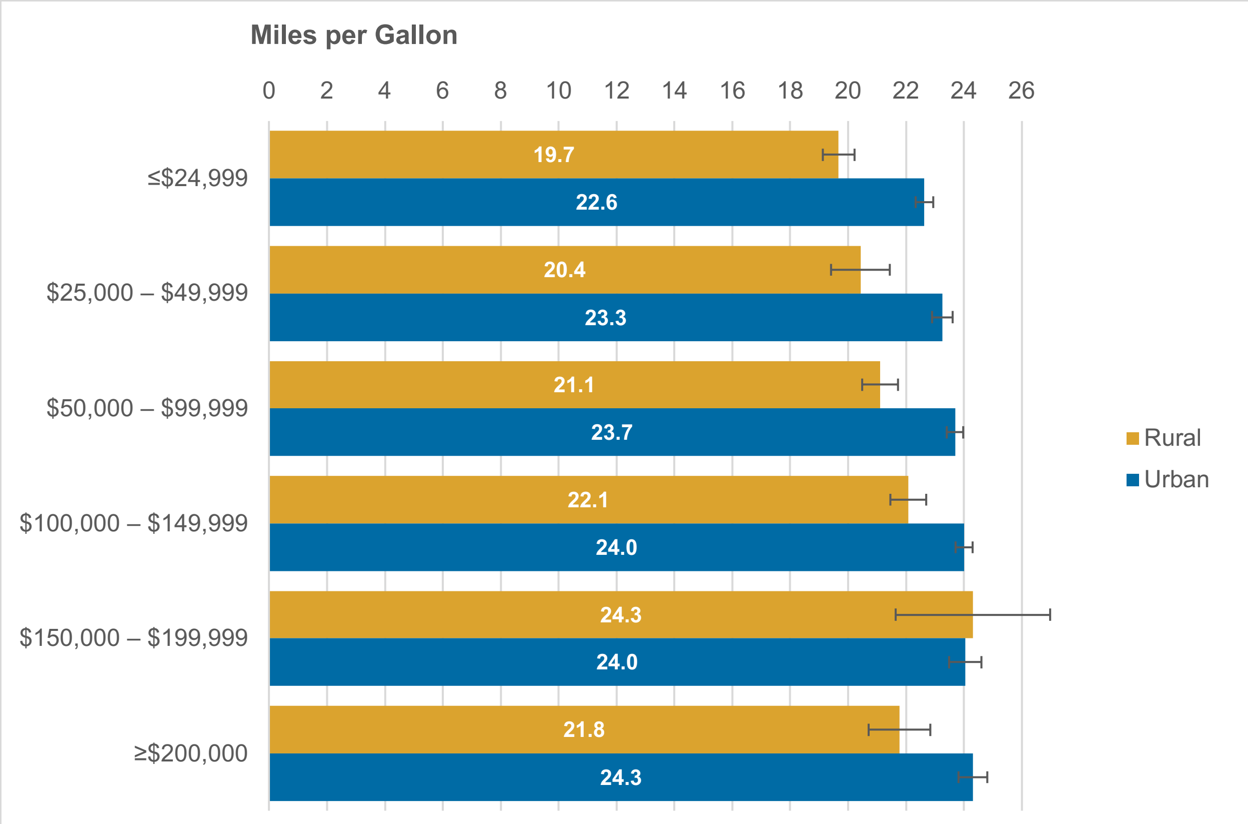

Figure 1. Household Average Vehicle Fuel Efficiency,[1] by Annual Household Income Group

Note: Error bars show the 95% confidence interval.
[1] The average fuel efficiency of all ICE vehicles in each household

The geographic comparison shows that urban households typically have more fuel-efficient vehicles than do rural households for any specific income group, though the difference is never more than 3 MPG. The only exception to this pattern is for the $150,000 through $199,999 income group. In this case, the rural household vehicles are, on average, one-third of a mile per gallon more efficient than the urban household vehicles. This very small difference is not statistically significant.[11]

There is a near-consistent increase in household average vehicle fuel efficiency as household income increases in both rural and urban areas. This overall positive relationship between vehicle fuel efficiency and household income is significant, although not strong, as indicated by its Kendall rank coefficient (see Appendix Table A 5).

Looking just at rural households, the estimated household average vehicle fuel efficiency rises with income from the lowest income group at 19.7 MPG up to 24.3 for the second-highest income group, and then dips back down by more than 2 MPG to 21.8 MPH for the highest-income rural households. Although the differences between rural households

[11] Very few rural households fell into this income group, creating a relatively larger margin of error and some additional uncertainty about the actual difference between rural and urban households in this income group.

in adjacent income groups are not statistically significant, rural households in the lowest income group (incomes of less than $25,000 per year) have significantly lower average VFE than all rural income groups $50,000 and above.

Like rural households, urban household VFE also rises with income, but the rise is smaller, climbing less than 2 MPG. VFE for the lowest-income households is 22.6 MPG, whereas for the highest income households it is 24.3 MPG. Most of this increase occurs between the lower income groups. The differences from one urban income group to the next are statistically significant through $100,000 - $149,000, but there is no significant difference between that group and the two higher-income ones.[12]

This relationship seems to be more a function of vehicle age than vehicle type. Table A 1 and Table A 2 in the Appendix show vehicle type (car, van, SUV, and pickup truck) among the various income and geographic groups. Although rural households are more likely to drive pickups and less likely to drive cars than urban households, cars are still the top vehicle type in both locations (40% rural and 58% urban). SUV use is nearly identical between the two locations and increases only modestly with income. However, as Table A 3 shows, there is a clear relationship between vehicle age and income; higher-income households drive newer vehicles (9 years old, on average), which tend to be more fuel-efficient, than lower-income households (13 years old, on average).

3.2. WEEKLY MILEAGE DRIVEN

Figure 2 presents findings about how the number of miles that households drive each week varies by income and geography. (Appendix Table A 6 presents additional detail, including standard errors and statewide values.)

[12] Substituting average VFE weighted by use results in very similar estimates but slightly less variability. Rural households in the lowest income group would have significantly lower VFE than all rural income groups $100,000 and above; urban households are not significant between groups, but the lowest urban income group has a significantly lower average VFE than urban households earning $50,000 or more.

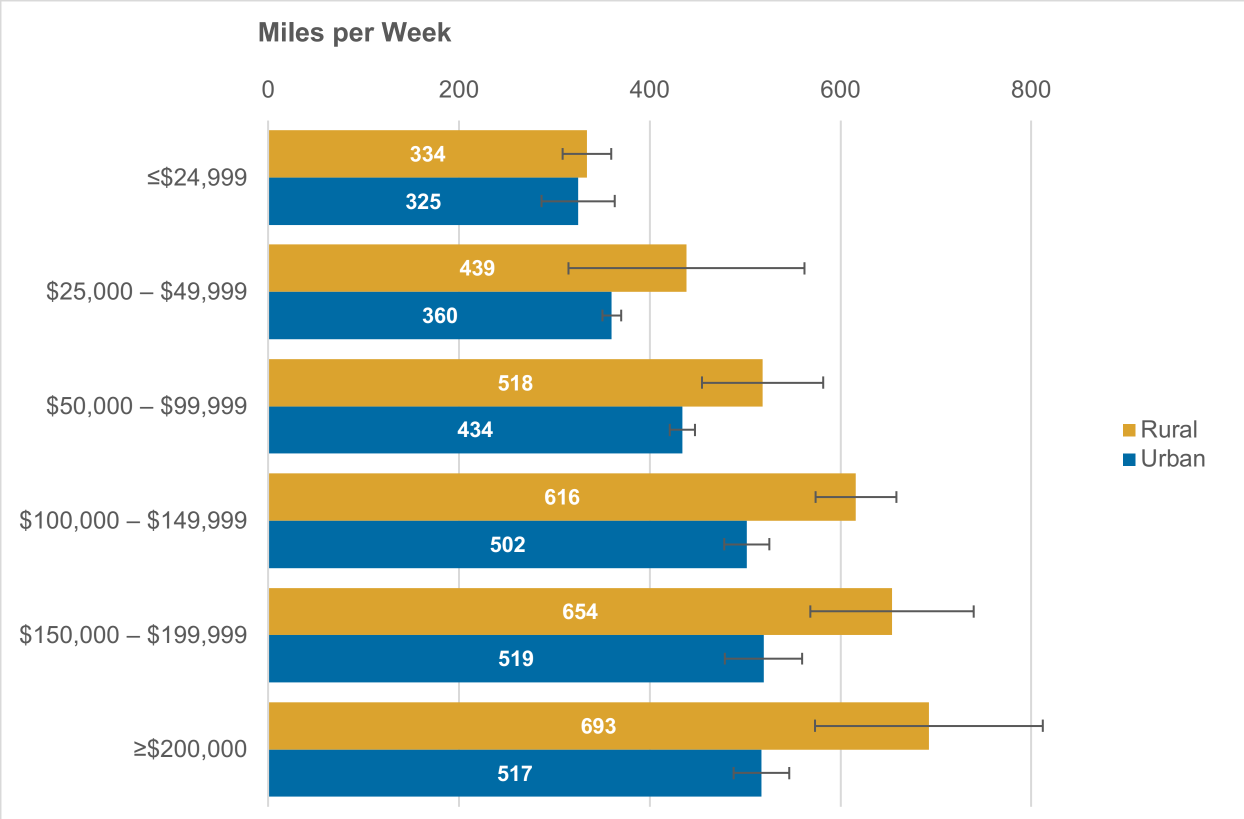

Figure 2. Weekly Household Vehicle Miles Traveled, by Annual Household Income Group

Note: Error bars show the 95% confidence interval.

Weekly mileage varies greatly across the groups, from a low of 325 miles per week for the lowest-income urban households, to 693 miles per week for the highest-income rural households. The highest mileage group travels more than twice as many miles as the lowest mileage group (a spread of 368 miles per week).

The rural vs. urban comparison shows that rural households tend to drive more miles per week than do urban households. Rural households drive 503 miles per week on average, while urban households log 427 miles per week, a difference of 76 miles. The same pattern holds for rural-urban pairings in each income group, though for the lowest two income groups the differences are small and not statistically significant. For example, the difference is only 9 miles per week for households earning less than $25,000 annually: these rural households drive an average of 334 miles weekly, and their urban counterparts drive an average of 325 miles weekly. The rural-urban spread grows steadily with income, peaking at a difference of 176 miles for households earning $200,000 or more (693 weekly miles for rural households vs. 517 weekly miles for urban households).

There is a positive relationship between income and VMT for both rural and urban households, especially for poorer households. As household income rises, so too does a household's weekly miles driven in their vehicles, though the variation tapers off for groups earning $100,000 or more. For both rural and urban households there is a statistically significant difference in VMT between households earning less than $25,000 and those earning at least $50,000. This trend of VMT rising along with income is statistically significant across rural, urban, and all households, and substantially stronger than the relationship between income and VFE. (See Appendix Table A 7 for Kendall rank coefficients.)

3.3. WEEKLY FUEL CONSUMPTION

Household fuel consumption is determined by a combination of vehicle fuel efficiency and household VMT. Figure 3 shows the gallons of fuel each household type consumes in an average week, and Table A 8 presents standard errors and statewide means.

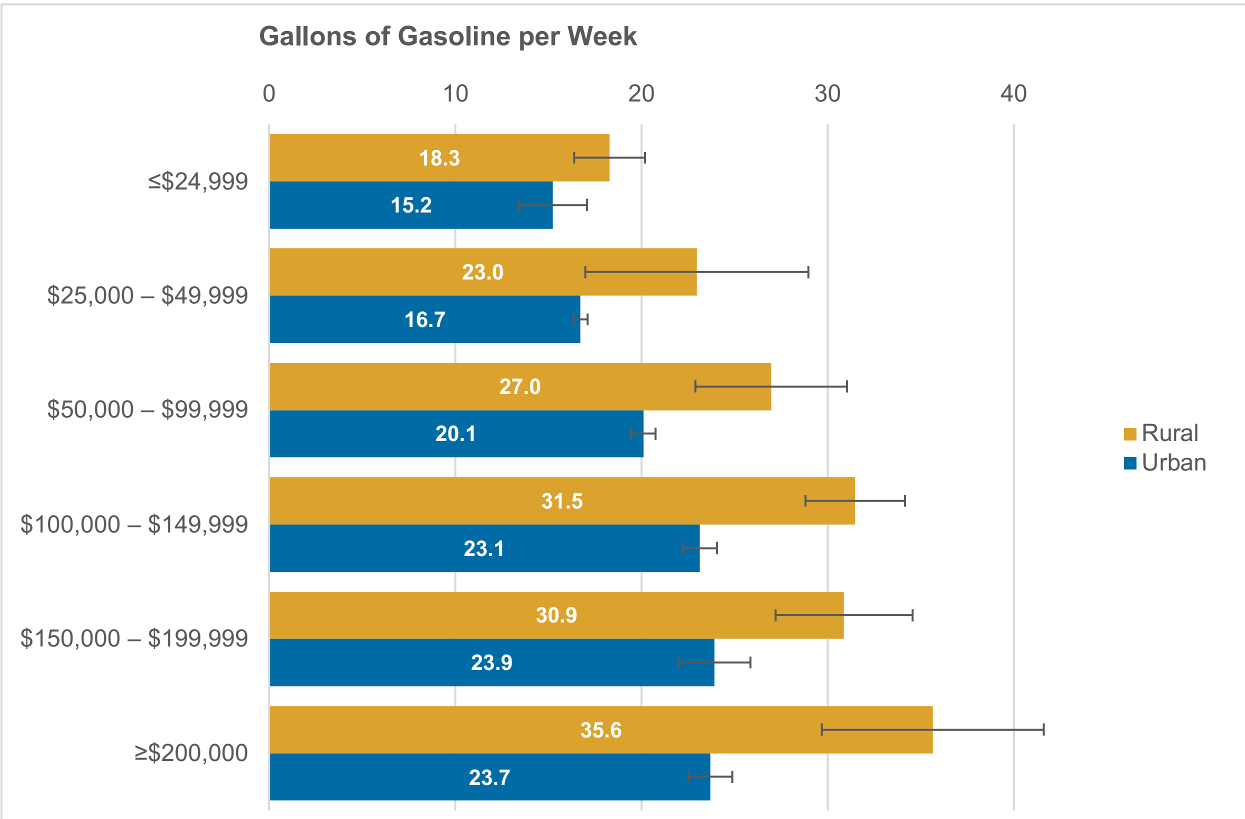

Figure 3. Weekly Household Motor Vehicle Fuel Consumption in Gasoline-Equivalent Gallons, by Annual Household Income Group

Note: Error bars represent the 95% confidence interval.

The findings for fuel consumption mirror those for VFE and weekly miles driven: there are significant differences between rural and urban households, and a clear correlation with income. However, since fuel consumption is a multiplication of those two factors, the effects compound: rural households consume more fuel than urban households, and fuel consumption rises with income for both rural and urban households.

Weekly fuel consumption ranges from a low of 15 gallons for the lowest-income urban households to 36 gallons per week for the highest-income rural households, a spread of 20 gallons. The households that, on average, consume the most fuel (the highest income rural households) consume about 2.3 times more fuel than do the households consuming the least fuel (the lowest-income urban households).

Rural households consume more fuel than urban households at every income level. The differences range from 3 gallons per week for the lowest-income households to 12 gallons per week for the highest-income households, a spread of 9 gallons. High-income rural households are thus consuming four times as many gallons weekly as the lowest-income households. The differences between rural and urban consumption are significantly different for the top four income categories (households earning at least $100,000).

For both rural and urban households, fuel consumption generally increases with income. The only exception is that rural households earning $150,000 - $199,000 consume slightly less fuel than rural households earning $100,000 - $149,999. Both groups also see consumption rise more quickly among the lower income groups and then level off beginning with incomes of $100,000. This trend of fuel consumption rising along with income is statistically significant across both all rural households and all urban households (see Appendix Table A 9 for Kendall rank coefficients), even though the differences are not statistically significant between any adjacent income groups for rural households. Logically, this relationship is slightly weaker than VMT, but much stronger than VFE, as again, this measure is a mixture of those two calculations.

4. COMPARING THE TAX BURDEN FROM CURRENT FUEL TAXES AND A HYPOTHETICAL RUC

This chapter explores how the variations in weekly mileage and fuel consumption translate to variations in the tax burden for rural and urban drivers at different income levels. The first section presents the weekly fuel tax paid, and the second section estimates what households might pay under a hypothetical new mileage fee. The third section compares the two.

4.1. WEEKLY FUEL TAX PAID

To estimate the household weekly cost of paying the state fuel tax, we multiplied household fuel consumption by the 2021-2022 California fuel tax rate of $0.511 per gallon.[13] Figure 4 presents the results, and Appendix Table A 10 presents standard errors and statewide means. As Figure 4 shows, household weekly state fuel tax costs are relatively modest, and they mirror the distribution for fuel consumption in that fuel tax payments generally increase with household income for both rural and urban households.

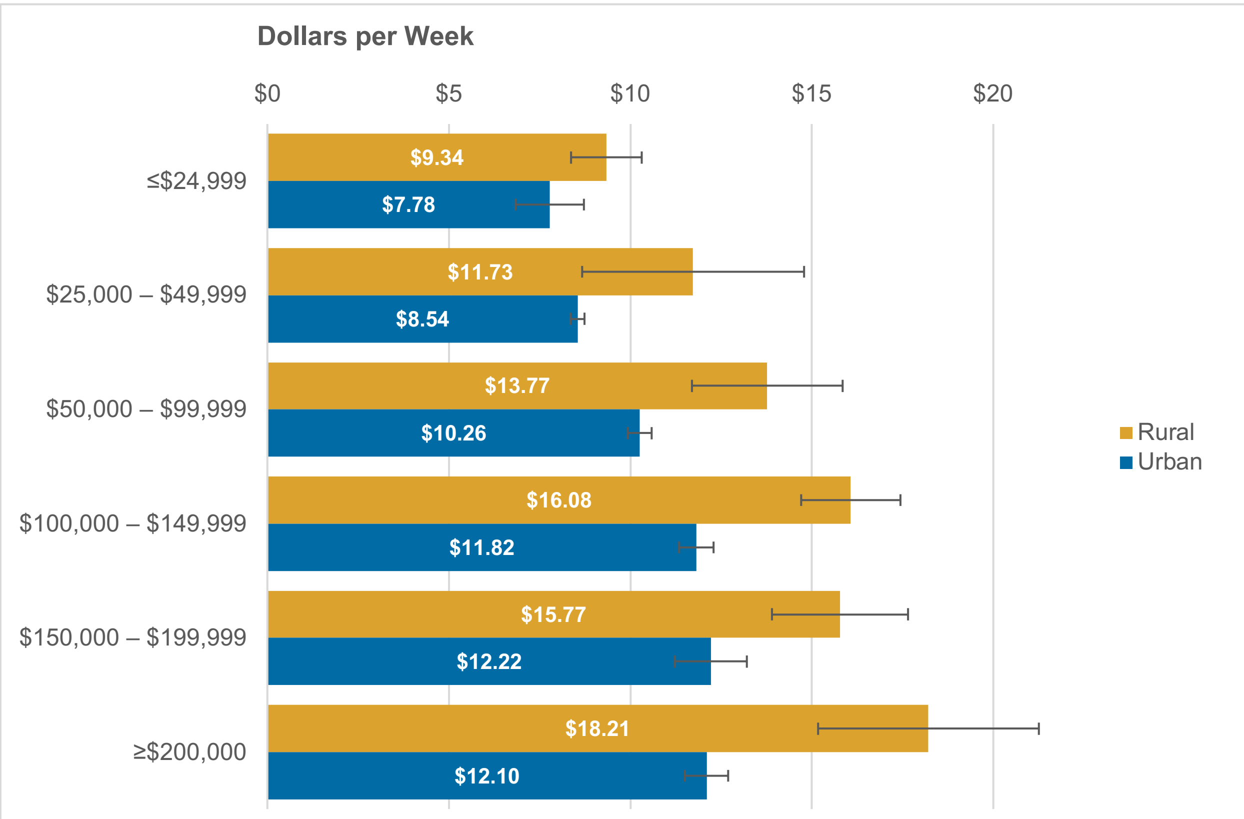

Figure 4. Household Weekly Fuel Tax Cost, by Annual Household Income Group

Note: Error bars represent the 95% confidence interval.

[13] Although the NHTS data are from 2016-2017, we use the current (2021-2022) fuel tax rate to account for changes since California Senate Bill 1 was passed in 2017 and dramatically altered the state fuel tax rate. We also estimate households' fuel tax cost in 2016-2017, which we include in the appendix.

Weekly fuel tax cost ranges from a low of $7.78 for the lowest-income urban households to $18.21 for the highest-income rural households, a spread of $10.43. The households spending the most on fuel (the highest income rural households) thus spend about 2.3 times more than do the households who spend the least on fuel (the lowest-income urban households).

Rural households pay more than urban households at all income levels. Comparing all rural and urban households, rural households pay an extra $3.21 weekly, or about a third more ($13.31 vs. $10.10). Rural households again pay more than urban households when looking by income group. These differences range from $1.56 more in the lowest income rural group (a 20% difference) to $6.11 in the highest income rural group. The difference between rural and urban grows from about 20% more ($3.21) for the lowest income households to about 50% more for the highest income households ($6.11).

Again, mirroring fuel consumption, this trend of fuel tax payment rising along with income is statistically significant across both all rural households and all urban households, even though the differences are not statistically significant between any adjacent income groups for rural households. (See Appendix Table A 9 for Kendall rank coefficients. The test results are the same for the analyses of both fuel consumption and fuel tax paid, since the tax paid is simply a multiple of fuel consumption.) The variation is large in percentage terms, but relatively modest in actual dollar costs. The highest-income households as a whole pay 57% more than do the lowest-income households. The weekly cost differs by $4.47 weekly ($12.33 vs. $7.86).

To better understand how much weekly fuel tax costs affect household budgets, we estimated the proportion of overall weekly income households spent on fuel taxes (see Figure 5). Because the NHTS only provides household income in categories, we approximated weekly income for each of the household income groups as follows: for the lowest income group, we divided the top annual income ($24,999) by 52, for the highest income group we divided the lowest annual income ($200,000) by 52, and for the other four groups we divided the midpoint value in the income range by 52. Because we make these approximations, we do not include standard errors in the analysis or error bars in the figures, as the data do not allow us to calculate a margin of error on these weekly income assumptions.

The analysis shows that the California state gasoline tax, like virtually all consumption taxes, is regressive: the percentage of household income paid toward fuel tax decreases as income rises, even though higher-income households pay more fuel tax in absolute terms. For example, the $9.34 per week that the lowest-income rural households spend on state fuel tax is just under two percent of their income. In contrast, the highest income rural households spend less than half a percent of weekly income on state fuel tax. For urban households, the fuel tax is similarly regressive: low-income households pay 1.6% of their income in fuel tax, whereas high-income urban households pay 0.3%.

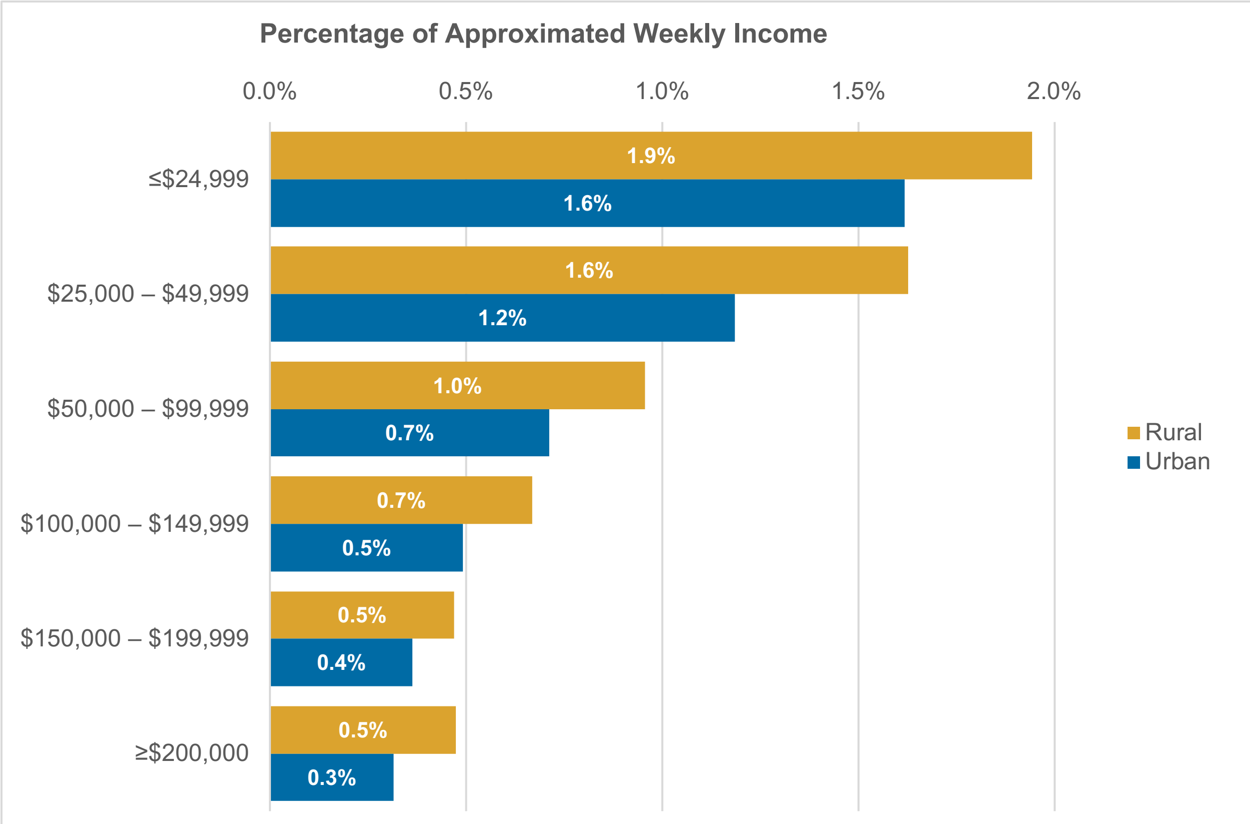

Figure 5. Fuel Tax Burden as a Percentage of Weekly Income, by Annual Household Income Group

* Weekly income estimated as follows: for the lowest income group, we divided the top annual income ($24,999) by 52, for the highest income group we divided the lowest annual income ($200,000) by 52, and for the other four groups we divided the midpoint value in the income range by 52.

4.2. WEEKLY COST FOR A HYPOTHETICAL RUC

We now turn to exploring what California households would pay if the state were to adopt a flat-rate RUC designed to generate the same amount of revenue for transportation as the current state fuel tax.

The first step was to identify an appropriate RUC rate. While the state might ultimately wish to create a RUC rate system that varies the charges by vehicle type, vehicle occupancy, driver income, or travel location in order to better manage the road system, better apportion fees among users, or some combination of these, for simplicity's sake (and not because we endorse such a fee structure) we estimated the costs using a flat-rate RUC paid for all household driving in personal vehicles. To determine the rate, we followed these steps:

1. **Estimate how much total revenue to collect:** To estimate the aggregate amount of fuel tax paid by California households, we first multiplied the estimated fuel consumption by the 2021-2022 gasoline excise tax rate of $0.511 per gallon for each household. Then, we calculated the weighted sum of annual tax paid among all households as represented by our data. This generates roughly $6.2

billion.[14] However, simply recouping the same revenue from a RUC would not sufficiently generate similar funds for the state, because a RUC would be a much more complex and expensive program to administer than fuel taxes. As a rough estimate, we assume that a RUC will need to collect an additional 6% for collection and administration, or a total of $6.6 billion.[15]

2. **Identify the rate required to collect $6.6 billion:** To identify the rate, we divided $6.6 billion by our calculated weighted sum of fuel-consuming vehicle travel for all California households: 260 billion miles. To collect $6.6 billion from 260 billion miles driven, the per-mile road user charge would need to be approximately 2.52 cents per mile.

Figure 6 presents the findings for this analysis, and Appendix Table A 11 presents standard errors and statewide means. Similar to actual weekly fuel tax payments, the estimated RUC cost to households would be small, the weekly costs would increase with income, and rural households would pay more than urban ones.

[14] In comparison to our estimate, in 2020-21 California collected $6.5 billion in state gasoline excise tax revenue (email to the authors from Frank Jimenez, California Legislative Analyst's Office, July 26, 2022). We chose not to use the actual value, however, because the NHTS data only account for household travel taken in personal vehicles registered in California. It does not account for gasoline purchased for commercial vehicles, nor does it account for gasoline purchased for vehicles registered out of state.

[15] The actual collection cost will vary greatly depending on how a RUC program is structured. Six percent is typical for recent industry estimates.

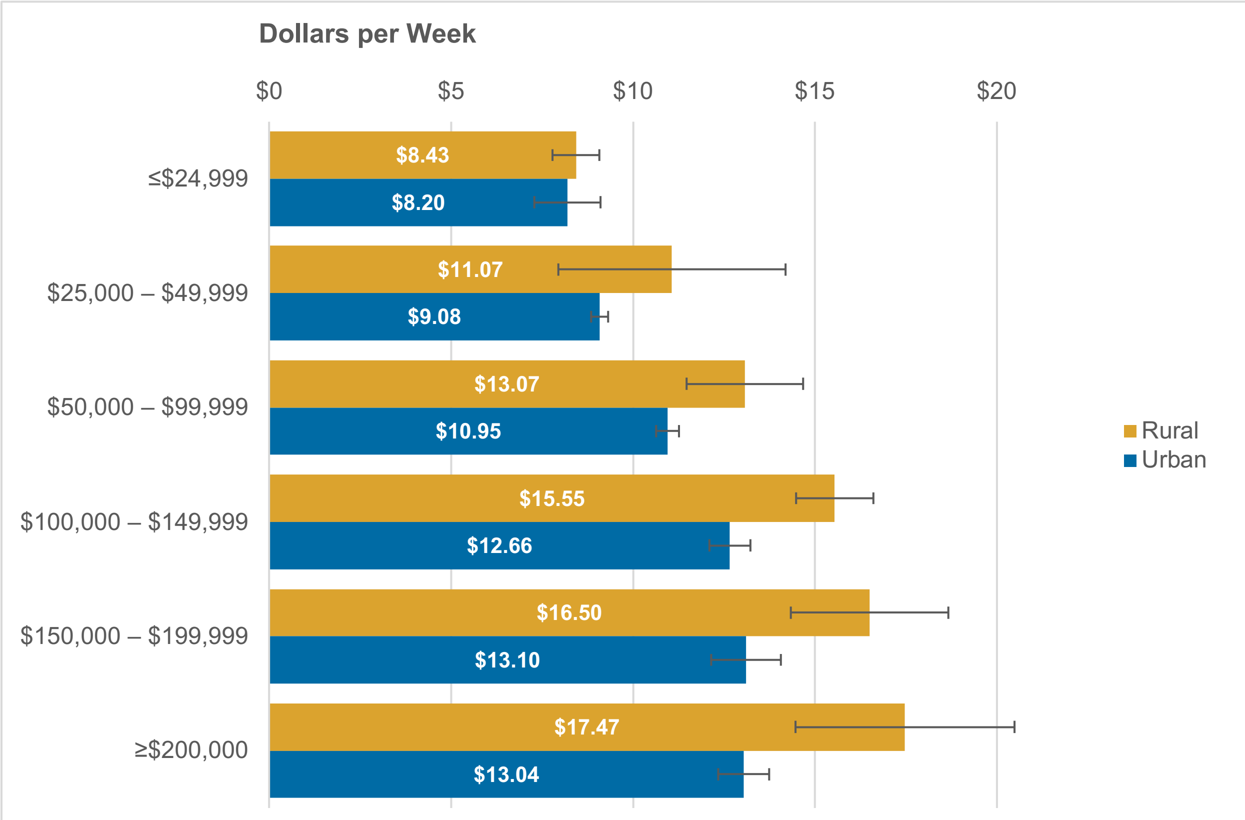

Figure 6. Household Weekly[a] RUC Cost, by Annual Household Income Group

[a] Weekly income estimated as follows: for the lowest income group, we divided the top annual income ($24,999) by 52, for the highest income group we divided the lowest annual income ($200,000) by 52, and for the other four groups we divided the midpoint value in the income range by 52.

The weekly RUC cost ranges from a low of $8.20 dollars a week for the lowest income urban households to $17.47 a week for the highest-income rural households, a spread of $9.27. The households that spend the most (the highest income rural households) thus spend about 2.1 times as much, on average, as those that spend the least.

As was the case with fuel taxes, rural households at all income levels would pay more in RUC than urban households. Comparing all rural to all urban households, rural households pay $1.91 (18%) more weekly than urban households ($12.69 vs. $10.78). Comparing the rural and urban weekly household costs for different income groups, the difference starts out very small for the lowest-income group—just $0.23 weekly—and grows to $4.45 weekly for the highest income groups. The differences between rural households and urban households with incomes above $50,000 are statistically significant, whereas the differences between rural and urban households with incomes below $50,000 are not statistically significant.

To better understand how much the weekly RUC cost would affect household budgets, we estimated the proportion of overall weekly income that households would spend on the RUC. Figure 7 presents these results. (As with Figure 5, our household income data preclude us from including error bars.)

As with the current fuel tax, the hypothetical RUC would be regressive: poorer households would pay a larger share of their income than would higher-income households, even though higher-income households pay more in absolute terms. This finding holds for both urban and rural households. For example, the lowest-income rural households would spend 1.8% of their income on the RUC. In contrast, the highest income rural households spend 0.5% percent of weekly income on the RUC. For urban households, the fuel tax is similarly regressive: low-income households spend 1.7% of their income on fuel tax, whereas high-income urban households spend 0.3%.

Rural households would spend a slightly higher percentage of their income on the RUC than would urban households, but the differences are very small. They range from just one-tenth to two-tenths of a percentage point.

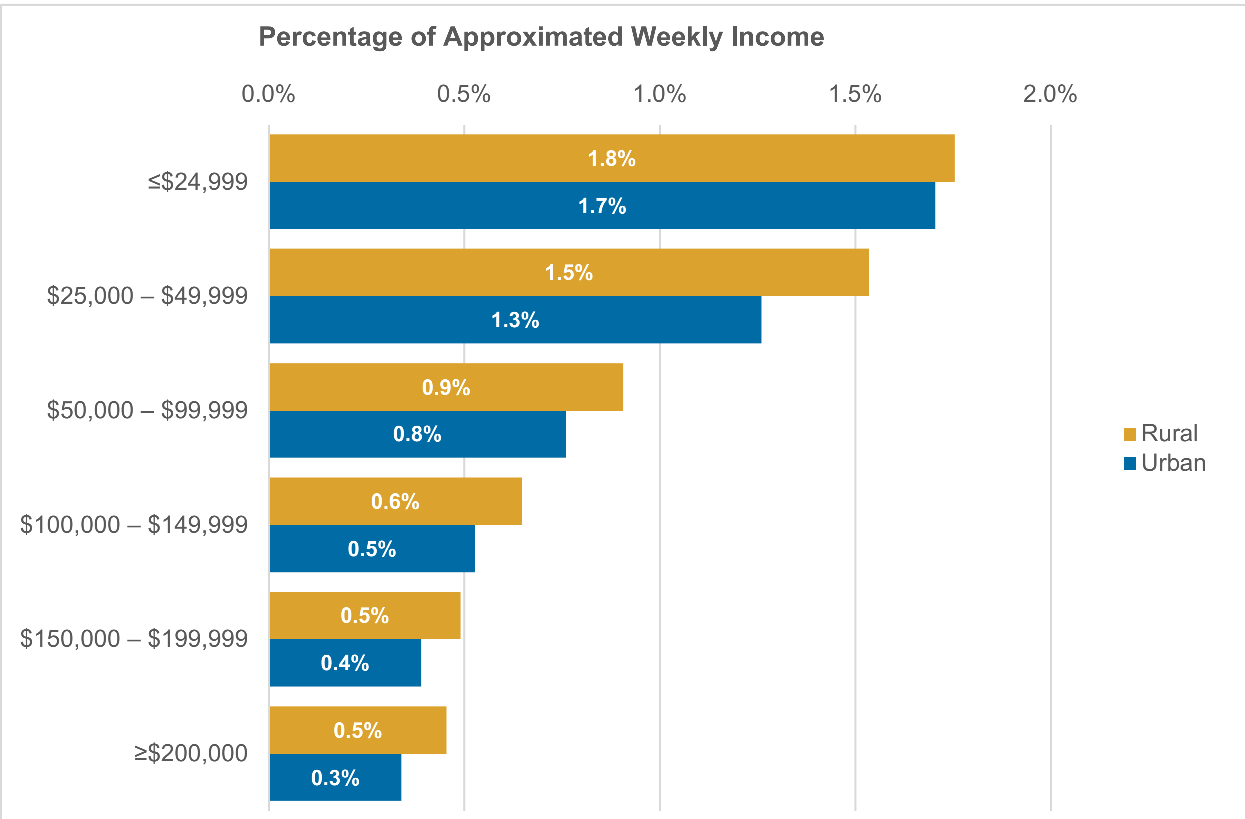

Figure 7. RUC Burden as Percentage of Weekly[a] Income, by Annual Household Income Group

[a] Weekly income estimated as follows: for the lowest income group, we divided the top annual income ($24,999) by 52, for the highest income group we divided the lowest annual income ($200,000) by 52, and for the other four groups we divided the midpoint value in the income range by 52.

4.3. COMPARING THE COST FOR FUEL TAXES AND THE HYPOTHETICAL RUC

Figure 8 presents the weekly fuel tax and hypothetical RUC costs next to one another, and Figure 9 presents the fuel tax and RUC as a percentage of weekly income. In both figures, the pale-colored bars show the household fuel tax cost, and the dark-colored bars show the RUC cost. In addition, Table 2 calculates the difference in cost between the fuel tax and hypothetical RUC. The grey shading indicates household groups that would see their weekly cost fall, while the red shading indicates household groups that would pay more under a RUC than they currently do in fuel tax.

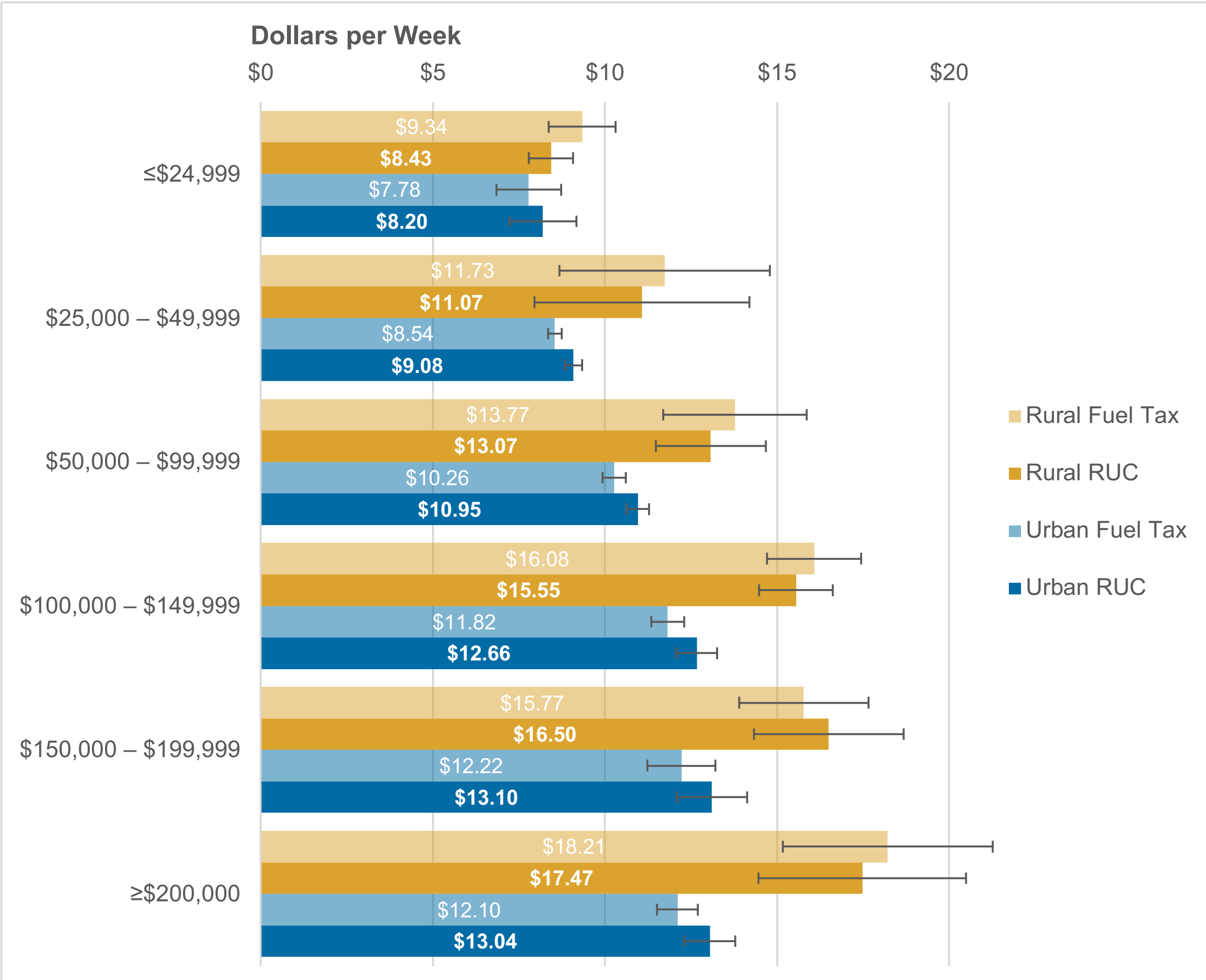

Figure 8. Household Weekly Fuel Tax Cost vs. Household Weekly RUC Cost, by Annual Household Income Group

Note: Error bars represent the 95% confidence interval.

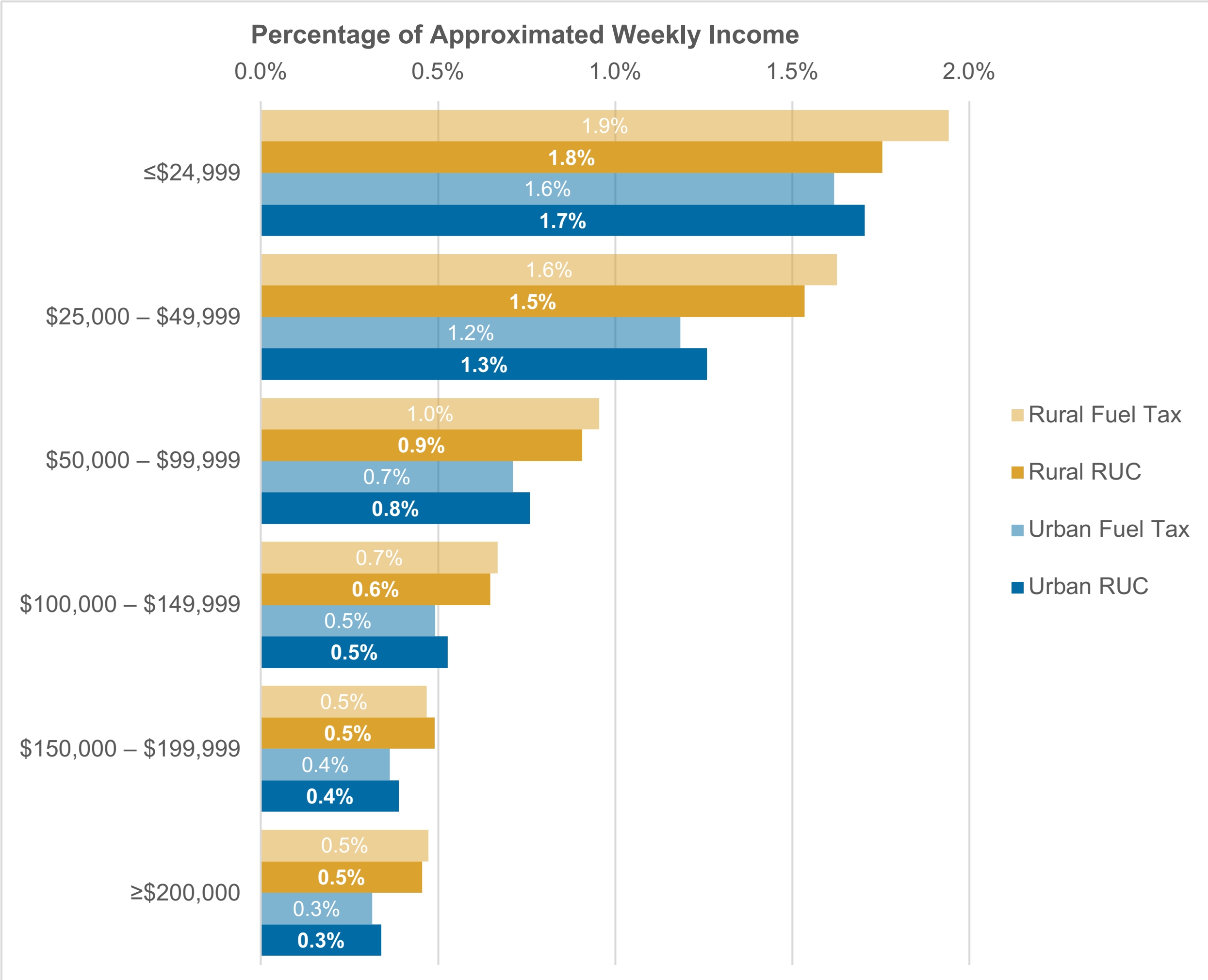

Figure 9. RUC vs. Fuel Tax Burden as Percentage of Weekly Income,[a] by Annual Household Income Group

[a] Weekly income estimated as follows: for the lowest income group, we divided the top annual income ($24,999) by 52, for the highest income group we divided the lowest annual income ($200,000) by 52, and for the other four groups we divided the midpoint value in the income range by 52.

Table 2. Comparison of Hypothetical RUC vs. Fuel Tax Weekly Cost and Income Burden[a] (gray = savings, red = increased cost)

	Rural		Urban		Statewide	
Income Group	Change in weekly cost	Percentage point change in income burden	Change in weekly cost	Percentage point change in income burden	Change in weekly cost	Percentage point change in income burden
≤$24,999	–$0.91	-0.19%	+$0.42	0.09%	+$0.35	0.07%
$25,000 – $49,999	–$0.66	-0.09%	+$0.54	0.07%	+$0.48	0.07%
$50,000 – $99,999	–$0.70	-0.05%	+$0.69	0.05%	+$0.62	0.04%
$100,000 – $149,999	–$0.53	-0.02%	+$0.84	0.04%	+$0.79	0.03%
$150,000 – $199,999	+$0.73	0.02%	+$0.88	0.03%	+$0.88	0.03%
≥$200,000	–$0.74	-0.02%	+$0.94	0.02%	+$0.88	0.02%
All income groups	–$0.62	--[b]	+$0.68	--[b]	+$0.62	--[b]

[a] Weekly income estimated as follows: for the lowest income group, we divided the top annual income ($24,999) by 52, for the highest income group we divided the lowest annual income ($200,000) by 52, and for the other four groups we divided the midpoint value in the income range by 52.

[b] Because NHTS household income data are categorical with no upper bound, we cannot approximate a midpoint household weekly income to calculate burdens for all households.

As Table 2 shows, shifting from a fuel tax to the revenue-neutral, flat-rate RUC would lower costs for rural households and raise them for urban households. The only exception to this pattern is that rural households earning $150,000 - $199,999 would pay $0.73 more per week under the RUC option. The difference between the fuel tax and RUC costs is less than a dollar a week for every household income group in both rural and urban areas, and none of these differences is statistically significant.

This rural-to-urban burden shift is largely explained by VFE: rural households tend to drive less fuel-efficient vehicles than do urban households. Because the flat per-mile RUC would not account for fuel efficiency, as the current fuel tax does, households with less fuel-efficient vehicle fleets would see their tax burden reduced, while those with more fuel-efficient vehicle fleets would see their tax burden increase. As discussed earlier, rural households have less fuel-efficient fleets (21.1 MPG) than urban household fleets (23.6 MPG). So, in addition to the rural vs. urban and income tax burden shifts with a move to a RUC analyzed here, the flat-rate RUC analyzed here would also shift the tax burden away from drivers of gas-guzzlers and onto drivers of fuel-efficient vehicles. VFE also explains why rural households in the $150,000 - $199,999 income category would see a cost increase with the RUC; they are the rural income group with the most fuel-efficient vehicles. Indeed, as Table 3 shows, costs drop for the households with lower average VFE (VFE up to 21.0 MPG) and rise for the households with more efficient vehicles (VFE of 21.1 MPG or higher).

Table 3. Comparison of Hypothetical RUC vs. Fuel Tax Costs, by Household Average Vehicle Fuel Efficiency

VFE Quintile	Weekly Fuel Tax		Weekly RUC		Change (Fuel Tax – RUC)	
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
< 19 MPG	$11.61	0.15	$9.26	0.12	-$2.35	0.05
19 – 21 MPG	$11.87	0.31	$10.96	0.28	-$0.91	0.05
21.1 – 23.4 MPG	$10.45	0.19	$10.60	0.17	+$0.15	0.05
23.5 – 27 MPG	$9.77	0.46	$10.95	0.48	+$1.18	0.03
> 27 MPG	$7.39	0.11	$9.75	0.16	+$2.36	0.07

5. CONCLUSION

This study used data from the 2017 National Household Travel Survey to compare how fuel taxes and a revenue-neutral RUC would impact California households of different income levels, as well as the impact on rural vs. urban households. We first estimated average household VFE and weekly mileage, and then used these findings to estimate weekly fuel tax cost, weekly cost for a hypothetical, revenue-neutral, flat-rate RUC (2.52¢ per mile). Last, we compared the fuel tax and RUC costs to explore how the cost burden would shift across households of different income groups and between rural and urban households.

The chapter begins with a summary and discussion of key findings, then identifies policy implications that flow from the study results, and finally recommends additional research options that would improve upon some limitations to the data source and methods used in this study.

5.1. KEY FINDINGS

Our findings with respect to the study research questions described in Chapter 2 are as follows:

1. **Urban households own more fuel-efficient vehicles than do rural households, and higher-income households own more efficient vehicles than lower-income households. For example, urban household vehicles are 12% more efficient than rural household vehicles:** 23.6 vs. 21.1 MPG, a difference of 2.4 MPG. With respect to income, the highest-income households own vehicles that are 8% more efficient than those owned by the lowest-income households: 24.2 vs. 22.5 MPG, a difference of 1.7 MPG. Because there are more urban than rural households in California, the statewide average household fuel efficiency (23.5 MPG) is closer to the urban than the rural average.

2. **Rural households drive more than do urban households, and higher-income drivers drive more than do lower-income drivers. For example, rural households drive 18% more miles weekly than urban households:** 503 vs. 427, a difference of 76 miles per week. With respect to income, the highest-income households as a group drive 61% more miles per week than the lowest-income households: 524 vs. 325 miles, a difference of 199 miles per week. Again, because there are more urban than rural households in California, the average statewide weekly mileage (431 miles) is closer to the urban than the rural average.

3. **Higher-income households pay more in state fuel taxes than lower-income households, and rural households pay more than urban households.** Higher-income households pay more fuel tax than lower-income households because although the former drive more fuel-efficient vehicles, they also drive more miles. The variation is large in percentage terms, though modest in dollar costs. The highest-income households pay 57% more in state fuel tax than do the lowest-income households ($12.33 vs. $7.86, or a weekly difference of $4.47). With respect to geography, rural households pay 32% more than do urban households because they

both drive more miles and tend to own less fuel-efficient vehicles. Rural households pay $13.31 weekly vs. $10.10 for urban households, a difference of $3.21 per week. The difference between rural and urban households grows along with income, from about 20% more (a difference of $1.56) for the lowest-income households to about 50% more (a difference of $6.11) for the highest-income households. The average weekly household fuel tax cost is $10.24.

4. **The general distribution of road user charges (RUCs) by income and geography would be similar to that of fuel tax costs: higher income households would pay more than would lower-income households, and rural households would pay more than urban households, on average.** The highest income households would pay 60% more than would the lowest-income households: $13.21 vs. $8.21, a weekly difference of $5.00. With respect to geography, rural households would pay 18% more than urban ones: $12.69 vs. $10.78, a weekly difference of $1.91. These variations are driven purely by the differences in weekly miles, unlike fuel tax costs, which are a function of both mileage and VFE. The average weekly household cost for a revenue-neutral, flat-rate RUC of 2.25¢ per mile is $10.86.

5. **Moving from a fuel tax to a revenue-neutral, flat-rate mileage fee would slightly lower costs for most rural households but raise them for all urban households. The differences are small, though, at less than a dollar a week for every household income group in both rural and urban areas. This rural-to-urban burden shift is largely explained by VFE:** rural households tend to drive less fuel-efficient vehicles than do urban households. Because the flat per-mile RUC would not account for fuel efficiency (although a RUC rate could certainly be designed to do this), households with less fuel-efficient vehicle fleets (up to 21.0 MPG) would see their tax burden reduced, while those with more fuel-efficient vehicle fleets (21.1 MPG or higher) would see their tax burden increase.

Ultimately, we find only minor differences between the two tax options explored and no evidence that transitioning to the revenue-neutral, flat-rate RUC would significantly harm rural households or low-income households, the groups of particular interest.

Shifting from a fuel tax to a RUC would *lower* road user payments for all rural households except those earning $150,000-$199,999 and *increase* costs for urban households in every income group. In effect, this shifts the cost burden away from households that tend to drive more in fuel-inefficient vehicles and onto households that drive more fuel-efficient vehicles. However, this transfer in burden is modest at the household level. The savings or increased cost is less than a dollar per week per household across all groups analyzed.

With respect to income groups, shifting from a fuel tax to a RUC would raise the weekly cost for all income groups. However, as with the geographic analysis, the change would be less than a dollar per week for any income group. For example, the highest-income drivers, who see the biggest change in cost, would only pay $0.94 more per week.

A larger (though still modest) equity impact emerges if one looks at the shift in costs according to VFE quintiles. Households with the least fuel-efficient vehicles would pay

$2.35 less each week, while households with the most efficient vehicles (28+ MPG) would pay $2.36 more per week.

Finally, the study findings highlight that while both fuel taxes and the RUC are relatively small weekly costs in terms of dollars, they nevertheless make up a notable fraction of household budgets for low-income families. For the poorest rural and urban households earning less than $25,000 annually, the cost of the state fuel tax alone is less than $10 per week, but that cost is equivalent to 1.9% and 1.6%, respectively, of their weekly income.

In a broad sense, the study findings are similar to results from other analyses of how fuel taxes and RUCs vary by geography and income. Other researchers have also generally found that switching from fuel taxes to a RUC would transfer costs from rural to urban households, and from the drivers of gas guzzlers to the drivers of fuel-efficient vehicles, but that the sums are small. One difference in our work as compared to the earlier California study, Ferrell and Reinke's analysis of 2010-2012 California households, is that we found a significant and meaningful difference in VMT and fuel consumption for rural vs. urban households, while Ferrell and Reinke did not. This difference in our findings is at least partly explained by the fact that we looked at weekly costs, while they looked at daily costs.

5.2. IMPLICATIONS FOR POLICYMAKERS

The analysis points to several implications of replacing the current fuel tax with a flat-rate, revenue-neutral RUC that might lead policymakers to prefer a different funding approach. For each, we suggest policy options to address the concerns raised.

- **Replacing the fuel tax with a flat-rate RUC would run counter to state climate policy, which calls for reducing fossil fuel consumption.** A flat-rate RUC would shift the tax burden away from users of fuel-inefficient vehicles and onto users of fuel-efficient or zero-emission vehicles, eliminating the fuel tax's fiscal incentive to consumers to purchase and drive more efficient ICE or ZEV vehicles. By taxing fuel purchases and—by extension—consumption, the fuel tax incentivizes vehicle owners to drive more fuel-efficient vehicles, and although the fiscal incentives are subtle, taxes on burning fuel explicitly support state environmental and climate goals. Options for addressing these concerns include adding a RUC on top of the fuel tax, so that fuel-inefficient vehicles still pay comparatively more per mile driven than efficient vehicles. Alternatively, the state could create a variable RUC rate scheme that charges higher rates per mile for gas-guzzling vehicles and lower rates per mile for gas-sipping vehicles. Schroeckenthaler and Fitzroy (2019) model the comparative costs to drivers of flat-rate vs. fuel- efficiency RUCs and find that the latter rate structure reduces the cost transfers among drivers that comes if a state switches from the fuel tax to a flat-rate RUC.

- **Replacing the fuel tax with a flat-rate revenue-neutral RUC will necessitate a small increase the statewide average weekly payment, since RUCs are more expensive to administer and collect than fuel taxes.** Regardless of whether the 6% collection cost estimate used in this study proves too low or too high, there is general agreement among RUC proponents and opponents alike that for the time being a RUC will not enjoy the low administrative burden and collection costs of fuel taxes. One justification for this extra cost could be designing the RUC to achieve policy objectives beyond just raising revenue. RUC rates designed to reflect vehicle fuel efficiency of vehicles would retain the fuel tax's fiscal motivation to reduce fossil fuel consumption. Also, RUC rates could be structured so that they reduce the cost of driving for low-income drivers even below current fuel tax costs.

- **Replacing the fuel tax with a flat-rate RUC that is at least revenue neutral would slightly increase the cost to the poorest urban households.** Although the estimated increases are less than a dollar a week, or $27 annually, for the very poorest urban households, the added cost is still a burden. Various rate structure options could counteract that trend. One option would be an increasing-block-pricing scheme: the vehicle owner pays no RUC or a very low rate for the initial set of miles driven annually, and then higher rates for additional miles driven. For example, vehicle owners might pay just a penny per mile for the first 5,000 miles driven in a year (or the first 417 miles each month), 3¢ per mile for miles 5,001 – 10,000, and 5¢ per mile for any additional miles. Alternatively, the state could offer a lower RUC rate to qualifying low-income households, similar to the "lifeline" rates that utilities offer to low-income customers. Finally, policymakers could consider solutions more broadly than just reducing taxes on driving. For example, helping low-income families reduce the number of miles they need to drive would likely reduce their travel costs far more than any increase in driving costs stemming from a RUC. Similarly, helping low-income families to purchase more fuel-efficient vehicles or electric vehicles could help them to reduce their transportation costs substantially, even if the state were to implement a high RUC.

In conclusion, we also recommend that California conduct state-level travel surveys on a regular schedule, every three to four years. This ongoing data collection will permit policymakers to understand how the incidence of road-user charges and other transportation costs changes in response to emerging vehicle technologies and other societal changes. Most notably, ZEV numbers will likely grow exponentially in the coming years, a change driven by California Air Resources Board regulations adopted in August 2022 that mandate that all new vehicles sold in the state be zero-emission as of 2035 (California Air Resources Board, 2022). Further, both state and federal regulations will require further efficiency improvements in new ICE vehicles. Finally, as illustrated by the COVID-19 pandemic, travel behavior and residential location choices can change rapidly in response to major economic or other shocks. An ongoing program of statewide travel survey data collection will permit policymakers to identify and address evolving equity road user fee considerations in a timely way.

APPENDIX: DATA TABLES

This appendix presents the detailed values used to produce the figures in chapters 3 and 4, as well as the detailed values for the Kendall rank coefficients.

Table A1: Percentage of Vehicle Types by Household Income Group

Income Level	Car	Van	SUV	Pickup Truck	Other
≤$24,999	62%	7%	17%	12%	3%
$25,000 – $49,999	60%	6%	17%	13%	3%
$50,000 – $99,999	57%	5%	20%	14%	4%
$100,000 – $149,999	55%	6%	21%	12%	5%
$150,000 – $199,999	56%	5%	24%	10%	5%
≥$200,000	57%	5%	27%	7%	5%
All income groups	58%	6%	20%	12%	4%

Note: Rows many not sum to 100% due to rounding.

Table A2: Percentage of Vehicle Types by Geography

Geography	Car	Van	SUV	Pickup Truck	Other
Rural	40%	5%	19%	27%	8%
Urban	58%	6%	20%	11%	4%
Statewide	57%	6%	20%	12%	4%

Note: Rows many not sum to 100% due to rounding.

Table A3: Vehicle Age (Years)

Income Level	Rural	Urban	Statewide
≤$24,999	16	13	13
$25,000 – $49,999	15	12	12
$50,000 – $99,999	13	11	11
$100,000 – $149,999	12	10	10
$150,000 – $199,999	11	10	10
≥$200,000	10	9	9
All income groups	13	11	11

Table A4: Household Average Vehicle Fuel Efficiency

	Rural		Urban		Statewide	
Income Level	**Mean**	**Std. Err.**	**Mean**	**Std. Err.**	**Mean**	**Std. Err.**
≤$24,999	19.67	0.28	22.63	0.15	22.49	0.15
$25,000 – $49,999	20.43	0.51	23.26	0.18	23.13	0.17
$50,000 – $99,999	21.10	0.31	23.69	0.14	23.58	0.14
$100,000 – $149,999	22.08	0.31	24.01	0.15	23.94	0.14
$150,000 – $199,999	24.31	1.34	24.05	0.29	24.06	0.26
≥$200,000	21.77	0.54	24.31	0.25	24.22	0.24
All income groups	21.08	0.22	23.57	0.08	23.46	0.09

Table A5: Correlations between Household Average Vehicle Fuel Efficiency and Household Income Groups

Area Type	Kendall τ b	P > |z|
Rural	0.068	0.000
Urban	0.046	0.000
All	0.054	0.000

Table A6: Weekly Household VMT

	Rural		Urban		Statewide	
Income Level	**Mean**	**Std. Err.**	**Mean**	**Std. Err.**	**Mean**	**Std. Err.**
≤$24,999	334	12.8	325	19.3	325	18.3
$25,000 – $49,999	439	62.4	360	4.9	364	5.7
$50,000 – $99,999	518	32.0	434	6.6	438	6.2
$100,000 – $149,999	616	21.3	502	11.9	506	11.3
$150,000 – $199,999	654	43.3	519	20.4	524	20.0
≥$200,000	693	60.1	517	14.8	524	13.7
All income groups	503	17.1	427	4.0	431	3.8

Table A7: Correlations between Average Weekly VMT and Household Income Groups

Area Type	Kendall τ b	P > |z|
Rural	0.309	0.000
Urban	0.248	0.000
All	0.250	0.000

Table A8: Weekly Household Motor Vehicle Fuel Consumption in Gallons of Gasoline-Equivalent

	Rural		Urban		Statewide	
Income Level	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
≤$24,999	18.27	0.96	15.22	0.93	15.38	0.87
$25,000 – $49,999	22.95	3.02	16.72	0.20	17.01	0.25
$50,000 – $99,999	26.95	2.05	20.08	0.33	20.40	0.30
$100,000 – $149,999	31.46	1.35	23.13	0.47	23.45	0.45
$150,000 – $199,999	30.86	1.85	23.91	0.98	24.14	0.98
≥$200,000	35.64	3.00	23.68	0.59	24.13	0.56
All income groups	26.04	0.91	19.77	0.17	20.04	0.16

Table A9: Correlations between Weekly Motor Fuel Consumption and Household Income Groups

Area Type	Kendall τ b	P > |z|
Rural	0.281	0.000
Urban	0.229	0.000
All	0.228	0.000

Table A10: Household Weekly Fuel Tax Cost

	Rural		Urban		Statewide	
Income Level	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
≤$24,999	$9.34	0.49	$7.78	0.47	$7.86	0.45
$25,000 – $49,999	$11.73	1.54	$8.54	0.10	$8.69	0.13
$50,000 – $99,999	$13.77	1.05	$10.26	0.17	$10.42	0.15
$100,000 – $149,999	$16.08	0.69	$11.82	0.24	$11.98	0.23
$150,000 – $199,999	$15.77	0.95	$12.22	0.50	$12.34	0.50
≥$200,000	$18.21	1.53	$12.10	0.30	$12.33	0.29
All income groups	$13.31	0.47	$10.10	0.09	$10.24	0.08

Table A11: Household Weekly Road User Charge Cost ($0.0252/mile)

	Rural		Urban		Statewide	
Income Level	Mean (Change)	Std. Err.	Mean (Change)	Std. Err.	Mean (Change)	Std. Err.
≤$24,999	$8.43	0.32	$8.20	0.49	$8.21	0.46
$25,000 – $49,999	$11.07	1.57	$9.08	0.12	$9.18	0.14
$50,000 – $99,999	$13.07	0.81	$10.95	0.17	$11.05	0.16
$100,000 – $149,999	$15.55	0.54	$12.66	0.30	$12.77	0.29
$150,000 – $199,999	$16.50	1.09	$13.10	0.51	$13.21	0.51
≥$200,000	$17.47	1.52	$13.04	0.37	$13.21	0.34
All income groups	$12.69	0.43	$10.78	0.10	$10.86	0.10

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