A Data Driven Analysis of Rural Equity and Cost Concerns for Mileage-Based User Fees in Vermont

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A Data Driven Analysis of Rural Equity and Cost Concerns for Mileage-Based User Fees in Vermont

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ABSTRACT

Examining substitutes to the current state and federal gasoline and diesel fuel excise taxes has become a pressing issue, exacerbated by the rise of high efficiency and alternative fuel vehicles threatening the revenue generating capacity of these taxes. A mileage-based user fee has been frequently proposed in the literature as an alternative which would offer greater benefits to rural and low-income populations than to urban and higher income populations. However, most prior analyses relied on small data sets and aggregated data. This study examined the impact of replacing the Vermont state fuels tax with a revenue-neutral mileage-based user fee using mileage and fuel economy data for over 300,000 registered passenger vehicles. We find that, on average, Vermont households would pay an additional $23 per year, with rural households and low-income households facing smaller tax burdens than their urban and high-income counterparts. The impacts of a $180 flat fee replacing the Vermont state motor fuels tax was also examined due to state interest. Findings indicate a flat fee would result in much larger price fluctuations, with most households paying an additional $47 per year. The disaggregated data approach presented here directly addresses public misconceptions of inequitable cost differences and provides context for public education campaigns to garner mileage-based user fee policy support. Based on our results, there is political ground for further research into the implementation of a mileage-based user fee, including the logistics of an administrative transition to mileage charging and the associated program implementation and technological costs.

Keywords: Mileage-based user fees, gasoline tax, rurality, equity, highway financing
INTRODUCTION

There is consensus that the sustainability of transportation funding in the U.S. is at risk. Maintaining existing roadway networks is becoming a greater burden (1–3), and current revenue generation methods are failing to keep up. Currently, the motor fuels tax or “gas tax” is the largest proportion of funding for roadway maintenance and construction. In almost all states and at the federal level, the gas tax is an excise tax implemented as a flat tax per unit of gasoline or diesel fuel sold. As a flat per gallon tax, the revenue collected though the gas tax is unable to adjust for inflation without legislative action to increase the tax rate, which has been historically unpopular and difficult to achieve (4–8). Additionally, the rising adoption of more fuel efficient, hybrid, and electric vehicles has further eroded gas tax revenue (6, 9–11). With the current trajectory of rising inflation combined with state and federal policies aimed at further increasing the fuel efficiency of the vehicle fleet and electric vehicle adoption, the U.S. can expect a significant gap in transportation funding in the coming decades.

In addition to declining revenue and purchasing power, the gas tax is frequently found to be regressive and inequitable, with low income and rural households facing higher tax burdens due in part to their propensity to own less fuel efficient vehicles, and in some situations drive more (5, 12–15). In response to concerns over the gas tax, a variety of funding alternatives have been examined including congestion charging, tolling, and road-user fees (4, 16–19). States have also explored supplementing transportation funding through increases in local option taxes such as income, property and sales taxes, although there are concerns over the long-term financial viability of these options (16, 19).

Road user fees based on mileage, commonly referred to as a mileage-based user fee (MBUF), are actively being pursued by governing agencies as a more sustainable replacement for the gas tax. However, public concerns and misconceptions about MBUFs remain a significant implementation barrier (4, 20). Based on prior surveys and focus group efforts at local, state, and federal levels, public hesitancy mainly focuses on three main concepts; perceptions of personal tax burden (as in, believing a MBUF would be much more expensive than their current gas tax payments), perceptions of inequity (as in, believing a MBUF would be largely unfair to rural and low income communities), and privacy concerns (related to discomfort with any governing body or agency knowing or tracking their mileage). Studies estimating changes in tax burdens under a MBUFs find minimal differences in per household and per capita costs compared to the gas tax on both statewide and national scales (21–29). Several studies have also considered impacts on households in different community types, finding that rural households would tend to benefit more from a MBUF than urban households would (22–26, 30, 31). Studies also find that low income households would have lower tax burdens than higher income households (23, 27, 32).

While these studies have begun to address public equity concerns revolving around MBUFs, there are potential pitfalls in their use of sparse and aggregate data to evaluate MBUF policies. In most cases, these studies used the National Household Travel Survey (NHTS) to examine tax burden. MBUF policy analyses based on NHTS data are limited by the survey’s aggregation of respondent locations and the small sample sizes for small and medium-sized communities. Resulting analyses are, therefore, limited in their ability to discern the full range of cost variation across the diverse range of community types within states. Additionally, the NHTS provides data from only one day of travel, so researchers must rely on extrapolation to assess monthly or annual household cost differences under a MBUF.

There are currently efforts to expand upon prior MBUF equity research with larger vehicle datasets. For example, the Hawaii road-user charge (HiRUC) study used state vehicle registration records to estimate tax payments for each registered vehicle in Hawaii. The HiRUC study found rural and low income households would, on average, save money compared to their urban and higher income counterparts (33).
These findings illustrate the value of using disaggregate data to explore the full range of costs experienced by households on the rural to urban and high to low-income spectrums.

Vermont Context
The Vermont Agency of Transportation (VTrans) is evaluating options to increase state transportation revenue through taxes on electric and hybrid vehicles. A recent study from VTrans confirms that Vermont will experience significant funding deficits if the gas tax is not increased, supplemented, or replaced in coming years. By assuming Vermont’s socioeconomic and geographical landscape is comparable to states that have previously studied the financial and equity implications of replacing the gas tax with a MBUF, the VTrans study concludes that a revenue-neutral MBUF ranging from 1.3 to 1.5 cents per mile is a reasonable replacement for the state gas tax and has the potential to bridge impending funding gaps (34).

Our study expands on state interest to perform a robust analysis of disaggregated vehicle data available from the Vermont Department of Motor vehicles (DMV). We overcome the prior limitations of research relying on small datasets and aggregated location information to provide novel insights into the true costs of replacing the gas tax with either a MBUF or a flat vehicle fee on the per vehicle, per household, and per capita level. Our focus on Vermont, a primarily rural state, directly addresses public concerns regarding the equity of a MBUF for populations residing in a wide range of communities with various levels of income from various racial and ethnic groups.

METHODS
The vehicle data we use in this study were originally collected by the UVM Transportation Research Center (TRC) for the 2021 Vermont Transportation Energy Profile (35). These data were further cleaned and analyzed for this report.

Data Source
Since 2016, Vermont has required all registered vehicles to be inspected every 365 days using a new electronic inspection reporting system. During each inspection, vehicle identification numbers (VINs) and odometer readings are recorded. Registration records are also available for each VIN, containing information about vehicle attributes and the registered vehicle address. We obtained additional details about each vehicle by querying a NHTSA database that decodes information contained within each VIN using an API developed for R (36).

Data Cleaning
We calculated annual vehicle miles travelled (VMT) for each vehicle using odometer readings from subsequent years and normalizing by the number of days between inspections. The inspection data were then merged with vehicle registration records using VINs which linked VMT data to home addresses. Detailed information about each vehicle obtained by decoding VINs was then used to pair vehicles with fuel economy ratings available from US EPA’s fuel economy database (37).

Publicly available Enhanced 911 (E911) data for Vermont contains additional information on each address in Vermont, including a commercial-residential address indicator. We identified and removed all vehicles registered at non-residential addresses from our data. We also removed vehicles with a gross vehicle weight greater than 14,000 lb (Class 3 and above), leaving us with a data set containing mostly light-duty personal vehicles. This allowed us to evaluate the impact of gas tax alternatives on individuals and households. After removing vehicles that could not be matched with fuel economy data, the final data set contained 310,661 vehicles across 189,251 households.
Each vehicle was geocoded to its registered home street address using ArcGIS. The geocoded vehicle point locations were then spatially intersected with race and income data from the 2019 American Community Survey as well as community-type indicators from the 2010 USDA Rural Urban Commuter Area Codes (RUCA Codes).

**Revenue Neutral Fee Calculation**

The final data were analyzed to identify financial inequities across Vermont populations if the Vermont state gas tax was replaced by either a MBUF or a flat fee.

The MBUF and flat fee were calculated as revenue-neutral fees to discern the baseline impacts of a change in transportation revenue collection. From the latest Federal Highway Administration (FHWA) Highway Statistics report (38–41), 289.164 million gallons of gasoline and 72.796 million gallons of diesel were purchased in Vermont in 2018. The annual Vermont gas tax revenue was calculated by multiplying each quantity of purchased fuel by their respective state taxes ($0.307 per gallon of gasoline purchased and $0.31 per gallon of diesel purchased). This annual revenue was then divided by the estimated total annual Vermont VMT (7.346 billion miles) to calculate the MBUF and divided by the total number of registered vehicles in Vermont to calculate the flat fee. The resulting revenue neutral taxes were determined to be $0.015 per mile or $180 per vehicle per year. The calculation for the revenue neutral MBUF is shown in **Equation 1**.

\[
MBUF = \frac{T_{gas} Q_{gas} + T_{diesel} Q_{diesel}}{VMT_{total}} \tag{Eq. 1}
\]

where,
- MBUF = Revenue-neutral MBUF
- \(T_{gas}\) = Vermont state gas tax
- \(Q_{gas}\) = Total gallons of gasoline fuel purchased in Vermont
- \(T_{diesel}\) = Vermont state diesel tax
- \(Q_{diesel}\) = Total gallons of diesel fuel purchased in Vermont
- \(VMT_{total}\) = Total annual Vermont VMT estimate

**Financial Impact**

The tax burden of switching to both a MBUF and a flat fee were calculated as dollar and percent differences relative to current gas tax spending. Negative tax burdens translate to lower annual costs (saving money) while positive tax burdens translate to higher annual costs (spending more money).

\[
TB_{veh} = C_{gas} - C_{MBUF} \tag{Eq. 2}
\]

\[
TB_{hh} = \sum_i (TB_{veh})_i \tag{Eq. 3}
\]

\[
TB_{cap} = \frac{\sum_i(TB_{veh})_i}{HHS_j} \tag{Eq. 4}
\]

where,
- \(TB_{veh}\) = tax burden for a vehicle
- \(TB_{hh}\) = tax burden for a household
- \(TB_{cap}\) = tax burden per capita
- \(C_{gas}\) = annual gas tax costs for a vehicle
- \(C_{MBUF}\) = annual MBUF costs for a vehicle
- \(i\) = household (i.e., residential address)
- \(j\) = census block group
- \(HHS\) = average household size in a census block
This analysis was performed on a per vehicle, per household, and per capita level. Calculations for per vehicle, per household, and per capita costs are shown in Equations 2, 3, and 4 respectively. Household gas tax, flat fee and MBUF costs were calculated by summing the per vehicle tax burden at each address. Household costs were then normalized by the average household size in their census block to generate per capita gas tax, flat fee, and MBUF cost estimates.

Spatial Analysis
The large number of vehicles and households used in the analysis were difficult to visualize at a state-wide scale when using points. Spatial trends in tax burden were discerned by aggregating vehicle point data and, separately, aggregating household point data onto a state-wide grid using a two square-kilometer cell size. The resulting 2,919 grid cells contained the mean gas tax, flat fee and MBUF costs per vehicle, household, and capita within each cell. Out of the 2,919 grid cells, 512 did not contain any vehicles. These “holes” on the map are mostly due to the Green Mountains and other unpopulated natural areas, either privately owned or protected.

Equity Analysis
The tax incidence of a mileage-based user fee and a flat fee were examined across 10 income quantiles using the full data set (unaggregated). Tax burdens were assessed per vehicle, per household, and per capita. Incomes were obtained from median household income data available at the census block group level. Race and ethnicity data were obtained at the census block level. Population weighted household costs were calculated for each racial and ethnic group, as shown in Equation 4.

\[
C_{rg} = \frac{\sum_j C_j P_j}{\sum_j P_j}
\]

where,
\(C_{rg}\) = population weighted household cost for a racial and ethnic group
\(C\) = mean annual household cost in a census block (either gas tax, flat fee or MBUF)
\(P\) = the population of a racial and ethnic group in a census block
\(j\) = census block

Tax incidence was also evaluated across 10 distinct Rural Urban Commuter Area Codes (RUCA Codes), which describe the way the single largest commuting share in a census tract. To reduce the number of variables, these codes were aggregated into four categories: area core, high-commuting, low-commuting, and rural (Table 1). When a tract is defined as an area core, it means more than 30% of the tract population is in an urbanized area and the primary flow is within the tract. When a tract is defined as high commuting, it means the primary flow (accounting for over 30% of the tract population) is to a tract defined as an area core. When a tract is defined as low commuting, it means the primary flow (accounting for less than 30% of the tract population) is to a tract defined as an area core. When a tract is defined as rural, it means the primary flow is within the tract or to other rural tracts.

<table>
<thead>
<tr>
<th>RUCA Code</th>
<th>Description</th>
<th>Aggregated RUCA Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Metropolitan area core: primary flow within urbanized area</td>
<td>Area core</td>
</tr>
<tr>
<td>2</td>
<td>Metropolitan area high commuting: primary flow 30% or more to a UA</td>
<td>High commuting</td>
</tr>
<tr>
<td>3</td>
<td>Metropolitan area low commuting: primary flow 10% to 30% to a UA</td>
<td>Low commuting</td>
</tr>
<tr>
<td>4</td>
<td>Micropolitan area core: primary flow within an urban cluster of 10,000 to 49,999 (large UC)</td>
<td>Area core</td>
</tr>
<tr>
<td>5</td>
<td>Micropolitan area high commuting: primary flow 30% or more to a large UC</td>
<td>High commuting</td>
</tr>
</tbody>
</table>
Nelson and Rowangould

| Micropolitan area low commuting: primary flow 10% to 30% to a large UC | Low commuting |
| Small town core: primary flow within an urban cluster of 2,500 to 9,999 (UC) | Area core |
| Small town high commuting: primary flow 30% or more to a UC | High commuting |
| Small town low commuting: primary flow 10% to 30% to a UC | Low commuting |
| Rural areas: primary flow to a tract outside a UA or UC | Rural |

Figure 1 provides spatial context for current vehicle use and ownership in Vermont. Annual gas tax payments were calculated using vehicle specific vehicle miles travelled (VMT) and fuel efficiency. For easier visualization, mean values of VMT and fuel efficiency were estimated for each 2 km² grid cell in Figure 1. All maps also note the locations of major highways and interstates running through Vermont as well as three Vermont cities: Burlington, Montpelier (the state capital), and Rutland.

Figure 1 Vermont spatial trends using mean values per 2 km² grid cell. a) Annual VMT per vehicle and b) Fuel economy in miles per gallon [mpg]. Interstates running through Vermont are shown as white lines.

RESULTS
In Vermont, annual gas tax payments average $150 per vehicle, $250 per household, and $131 per capita. Household gas tax expenditure tends to increase with distance from city centers. As Figure 2 shows, households near denser areas such as Burlington, Montpelier, and Rutland pay less in gas taxes compared to rural households. Annual household gas tax payments show a slightly progressive trend at the lowest income brackets (less than $55,000 per year), but Vermont households making anywhere from $55,000 per year to millions per year see little to no difference in costs.
Two alternatives to this current taxing scheme were examined: a mileage-based user fee and a flat fee.

**Alternative 1: A revenue neutral flat fee of $180 per vehicle per year replaces the VT gas tax.**

Under a revenue neutral flat fee alternative, every vehicle owner (residential and commercial) pays $180 per vehicle per year in taxes. The following analysis only includes personal light-duty vehicles to understand the impact on Vermont households.

Compared to the gas tax, a flat fee of $180 per vehicle per year results in higher annual payments on average when examined at the per vehicle, per household, and per capita level. On average, each household would see a $50 increase in annual payments. Only 30% of Vermont residential households save money. Most households (75%) see changes in tax burdens ranging from saving $19 per year to paying $131 more per year. This scenario creates extreme cost differences across Vermont, with 12% of households saving over $100 per year, but 36% of households spending an additional $100 per year or more. Full summary statistics for flat fee costs and tax burdens relative to annual gas tax costs are in Table 2.

Where Vermonters live (their community type) and their income significantly impact their annual tax burden if the gas tax is replaced with a flat fee. For example, high-income urban households typically pay...
$75 more than medium-income low-commuting households (Table 3). On average, residents of urban areas see cost increases double that of their rural counterparts. Middle income households ($40,000 to $85,000) generally see the smallest price changes, and high-income earners (over $85,000) see the largest price increases. However, in high commuting and urban areas, the lowest income earners are responsible for the highest average costs per capita.

FIGURE 3 Annual flat fee tax burdens for Vermont households in 2019 (a) Spatial distribution using mean values per 2 km² grid cell. Interstates running through Vermont are shown as white lines. (b) Income distribution using median census block group household incomes, with means for each income decile represented as a white dot

Alternative 2: A revenue neutral mileage-based user fee of $0.015 per mile replaces the VT gas tax. Under a revenue neutral MBUF scenario, every vehicle would be assessed a $0.015 per mile fee. The following analysis only includes light-duty vehicles registered at residential addresses to understand the impact on Vermont households. Most Vermont households pay between $130 and $350 in annual MBUF payments. This translates to most households paying somewhere between an additional $50 per year to $5 less. On average, this is a $30 increase in annual tax burden and only 30% of Vermont residential households save money. The cost differences at the high and low ends of the spectrum, however, were small compared to cost differences associated with a flat fee, with only a few extreme cases of high savings (2%) and high losses (8%). Full summary statistics for mileage-based user fee costs and tax burdens compared to annual gas tax costs are in Table 2. The variation in annual costs across income and community types is minimal for MBUFs. For example, the largest annual cost difference is between low-income low commuting households and low-income rural households, with the former paying $15 more on average (Table 3).
## TABLE 2 Summary Statistics for Annual Tax Burdens under the Gas Tax, a MBUF, or a Flat Fee

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Q1</th>
<th>Median</th>
<th>Mean</th>
<th>Q3</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Economy [mpg]</td>
<td>11</td>
<td>19</td>
<td>22.5</td>
<td>23.6</td>
<td>26.8</td>
<td>124.8</td>
</tr>
<tr>
<td>Annual VMT</td>
<td>0</td>
<td>6,162</td>
<td>9,949</td>
<td>11,003</td>
<td>14,418</td>
<td>99,905</td>
</tr>
<tr>
<td>Cost [$]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Tax</td>
<td>0</td>
<td>79.69</td>
<td>131.7</td>
<td>151.2</td>
<td>197.8</td>
<td>2,277</td>
</tr>
<tr>
<td>MBUF</td>
<td>0</td>
<td>92.44</td>
<td>149.2</td>
<td>165.0</td>
<td>216.3</td>
<td>1,499</td>
</tr>
<tr>
<td>Flat Fee</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>Cost Difference from Gas Tax [$$]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MBUF</td>
<td>-915.0</td>
<td>-7.90</td>
<td>9.99</td>
<td>13.83</td>
<td>34.51</td>
<td>1,485.88</td>
</tr>
<tr>
<td>Flat Fee</td>
<td>-2,097</td>
<td>-17.78</td>
<td>48.26</td>
<td>28.79</td>
<td>100.3</td>
<td>180</td>
</tr>
<tr>
<td>Percent Cost Difference from Gas Tax [%]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MBUF</td>
<td>-46.25</td>
<td>-7.17</td>
<td>9.93</td>
<td>83.54</td>
<td>30.94</td>
<td>10,000</td>
</tr>
<tr>
<td>Flat Fee</td>
<td>-92.09</td>
<td>-8.99</td>
<td>36.64</td>
<td>309.8</td>
<td>125.9</td>
<td>3,389,811</td>
</tr>
</tbody>
</table>

## TABLE 3 Annual Change in Tax Burdens for Flat Fees and MBUFs Replacing the Gas Tax by Community Type and Income Level

<table>
<thead>
<tr>
<th>Income Type</th>
<th>Community Type</th>
<th>Number Households</th>
<th>Flat Fee Cost Difference [$$]</th>
<th>MBUF Cost Difference [$$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income</td>
<td>Rural</td>
<td>2707</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Low commuting</td>
<td>64</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>High commuting</td>
<td>0</td>
<td>--</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>14,277</td>
<td>44</td>
<td>17</td>
</tr>
<tr>
<td>Medium Income</td>
<td>Rural</td>
<td>40,655</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Low commuting</td>
<td>2,992</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>High commuting</td>
<td>37,243</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>53,722</td>
<td>49</td>
<td>25</td>
</tr>
<tr>
<td>High Income</td>
<td>Rural</td>
<td>3,716</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Low commuting</td>
<td>0</td>
<td>--</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>High commuting</td>
<td>13,003</td>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>20,872</td>
<td>49</td>
<td>30</td>
</tr>
</tbody>
</table>

*Low income = less than $40,000/year, Medium Income = $40,000 to $85,000/year, High Income = more than $85,000/year*
Keeping these small numbers in mind, residents of urban areas pay up to 1.5 times the costs of their rural counterparts. Those living in commuting areas, also referred to as suburbs, see similar or slightly larger price increases compared to urban residents. Middle income households ($40,000 to $85,000) experience the smallest price changes, while the highest income households (over $85,000) see the largest price increases.

FIGURE 4 Annual MBUF tax burdens for Vermont households in 2019 (a) Spatial distribution using mean values per 2 km² grid cell. Interstates running through Vermont are shown as white lines. (b) Income distribution using median census block group household incomes, with means for each income decile represented as a white dot

Cost Variation Across Vermont Communities
When spatially examining policy alternatives to the gas tax across the state of Vermont, differences in costs between community types are evident (Figures 5 and 6). Areas farther from main city centers, generally considered rural areas, are more likely to save money. The impact of community type is further examined in Figure 7. In all cases, those located in urban areas see the largest cost increases.

Figures 5 and 6 contain box plots depicting flat fee and mileage-based user fee cost impacts varying with income. The general trend reveals that flat fees are more regressive, with either stable or decreasing cost differences (lower costs) as income increases. MBUFs are more progressive, with either stable or increasing cost differences (higher costs) as income increases.

Cost Variation by Race and Ethnicity
Flat fee and mileage-based user fee cost impacts varying with race and ethnicity were also examined (Table 4). There was little to no difference in annual household cost payments between all race and ethnicity categories described by the census. Compared to the largest group in Vermont, meaning white and non-Hispanic/Latino/Spanish, most other groups paid similar amounts or less per household per year.
for both flat fees and mileage-based user fees. Non-Hispanic Native Hawaiian / Pacific Islanders, pay more than other race and ethnicity groups when transitioning to a MBUF or flat fee. Their overall tax burden is approximately $5 per year higher under a MBUF than the second highest paying group (Non-Hispanic Caucasian / White). Based on this analysis, there is little evidence to suggest there is a racial disparity in cost variation under a MBUF.

**TABLE 4 Mean Tax Burdens for the Gas Tax, Flat Fees, and MBUFs by Race and Ethnicity**

<table>
<thead>
<tr>
<th>Race</th>
<th>Gas Tax</th>
<th>MBUF</th>
<th>Flat Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic / Latino / Spanish</td>
<td>$243.27</td>
<td>$266.78</td>
<td>$294.76</td>
</tr>
<tr>
<td>Caucasian / White (alone)</td>
<td>$255.34</td>
<td>$277.12</td>
<td>$299.38</td>
</tr>
<tr>
<td>African American / Black (alone)</td>
<td>$211.11</td>
<td>$236.22</td>
<td>$280.78</td>
</tr>
<tr>
<td>Asian (alone)</td>
<td>$215.89</td>
<td>$242.04</td>
<td>$289.72</td>
</tr>
<tr>
<td>Native American / Indian (alone)</td>
<td>$247.50</td>
<td>$268.91</td>
<td>$290.03</td>
</tr>
<tr>
<td>Native Hawaiian / Pacific Islander (alone)</td>
<td>$251.74</td>
<td>$283.13</td>
<td>$301.17</td>
</tr>
<tr>
<td>Other Race (alone)</td>
<td>$231.01</td>
<td>$250.96</td>
<td>$282.35</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>$239.48</td>
<td>$261.76</td>
<td>$290.27</td>
</tr>
</tbody>
</table>
Nelson and Rowangould

**FIGURE Annual Change in Tax Burdens for Flat Fees Replacing the Gas Tax**
FIGURE 6 Annual Change in Tax Burdens for MBUFs Replacing the Gas Tax
FIGURE 7 Annual Change in Tax Burdens for Flat Fees and MBUFs Replacing the Gas Tax by Community Type
CONCLUSIONS
We conclude that a MBUF fee would be a viable alternative to the gas tax in Vermont. Most households would see very small changes to their current annual gas tax payments. On average, Vermont households would pay an extra $23 per year. Rural and lower income households would generally see the smallest increases while urban and higher income households would see somewhat larger increases. Since rural households on average have much higher gas tax burdens than urban households, a MBUF would result in a somewhat more equitable distribution in rural user fees across community types. A MBUF is also somewhat more progressive (or less regressive) than the gas tax since lower income households would generally pay less than higher income households, although this varies across community types. These findings align with those of past MBUF studies that have considered cost burdens across income groups and urban and rural communities; however, our results using a larger and more spatially refined dataset reveals the heterogeneity in costs across the urban to rural continuum and the factors contributing to the broad spatial patterns we find.

We find that flat fees, on the other hand, would cause more extreme price variations, with the average Vermont household paying $47 more per year and larger incidences of extreme savings and losses. Furthermore, a flat fee would be a departure from the intent of the current gas tax to act as a road user fee and raises equity concerns insofar as it would charge vehicle owners the same user fee regardless of their use of public roads, including those who have minimized the among they drive, to save money or reduce their environmental impact. In this way, a flat fee fails to meet the benefit principle of equity.

While a MBUF is attractive from a revenue generation and user fee perspective, implementation faces numerous challenges including various equity concerns. The public alongside state and federal policy makers are concerned about impacts on rural and low-income communities. With our robust and data-driven analysis it may be possible to “myth-bust” these general misperceptions. For example, it’s possible to see on a map at a very fine spatial scale the expected change in costs in every community across the state using real data about the actual travel and vehicle ownership of individual Vermont households. This information could be used, as demonstrated in the Hawaii HiRUC study, in public education campaigns as a means of increasing support for a MBUF program.

Our findings also point to an additional concern with the design of revenue neutral MBUF programs. A revenue neutral MBUF in Vermont would, on average, increase the tax burden for most Vermont households. This occurs because commercial, medium, and heavy-duty vehicles would on average pay less. Commercial vehicles have much lower fuel economies than personal vehicles, a factor that is not used in the calculation of a MBUF. Future efforts to develop fair and equitable MBUF policies may consider separate personal and commercial MBUF rates that aim for revenue neutrality within each category to minimize impacts on households.

Overall, the gas tax, as it stands, does not provide a reliable source of transportation funding due to its inability to adjust to inflation and failure to collect revenue from the exponentially increasing proportion of fuel-efficient vehicles. Finding a viable solution to the funding gap is an urgent matter. This analysis found that a switch from the Vermont state gas tax to a MBUF offers minimal cost differences for households, is more progressive than the gas tax, and reveals no pressing equity concerns across communities or racial-ethnic groups. However, other implementation barriers remain before a MBUF can be set into policy, many of which revolve around public attitudes and assumptions about MBUFs. For one, many believe that switching from a fuel-consumption based tax to a mileage-based tax will deter more fuel-efficient vehicle purchases. Additionally, many in the public see MBUFs as an invasion of privacy and are concerned about being tracked, which results in political apprehension to move forwards with the policy. Furthermore, our analysis did not consider any additional administrative costs related to...
implementing a MBUF. These costs could increase the relative costs of a MBUF compared to the gas tax. Future research and pilot programs should focus on addressing these additional barriers.

ACKNOWLEDGMENTS
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AUTHOR CONTRIBUTIONS
The authors confirm contribution to the paper as follows: study conception and design: Nelson, Rowangould; data collection: Nelson, Rowangould; analysis and interpretation of results: Nelson, Rowangould; draft manuscript preparation: Nelson, Rowangould. All authors reviewed the results and approved the final version of the manuscript.
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