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Effectiveness and Equity of Vehicle Mileage Fee at the Federal and State Levels

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Abstract

As Federal and State fuel tax rates stagnate in the United States and the average vehicle fuel efficiency increases, revenues from the fuel tax will likely decrease. An alternative source of revenue to a fuel tax should be considered and possibly implemented to avoid the risk that the Highway Trust Fund may become unable to function as a dedicated user-pay fund and may require yearly bailouts from the general fund. Practitioners and researchers have been considering alternatives to the gasoline tax for years, and the alternative revenue mechanism must ensure equity or else it will not be accepted as a politically viable option. It is the recommendation of the American Association of State Highway Transportation Officials and several Congressional Commissions that in the interim the federal gasoline tax is increased by 10 cents/gallon to ensure the Highway Trust Fund is able to continue to pay out its obligations, and that in the long run the gasoline tax can be replaced or supplemented by a mileage-based user charge.

This paper analyzes the distributional effects of an increased gasoline tax and vehicle mileage fees considering both their effectiveness in revenue generation and equity for different population groups at the Federal and State levels. Both horizontal and vertical equity are considered for age groups, income groups, ethnicity groups and geographic locations. The hope is that with a better understanding of the impact of alternative transportation financing options, the most effective policy can be designed/selected and the revenue generated used most effectively and equitably.

1. Introduction

Spending to operate, maintain and develop the highway system and road networks in the United States has exceeded Highway Trust Fund (HTF) receipts in recent years and threatens insolvency of the Fund. The HTF is set up as a pay-as-you-go system in that the users generate the funding to maintain and improve the highway system through a structure of taxes applied to the user. A series of surface transportation acts have authorized the use of a federal consumption tax on fuel, the topic of this paper. State and federal fuel taxes generated about 1/3 of the total revenue in 2001 to fund highway spending (Puentes 2003). However at the federal level, the tax imposed upon consumption of gasoline alone comprised of about 60 percent of HTF revenues (Puentes 2003). Since the HTF is not as diversified as all levels of road and transit spending, it is all the more dependent upon the revenue generated by fuel taxes. The federal gasoline tax rate is currently set at 18.4 cents per gallon and has not changed since 1993. When considering inflation, the current purchasing power in 2009 of this tax is 35 percent less than it was in 1993. We are not only faced with inflation depreciating the purchasing power of the gasoline tax, but potentially less revenue generation because VMT and fuel consumption may not increase at the same rate. In a time when the United States is trying to become less dependent upon foreign oil and decrease greenhouse gas emissions, there is a big push to increase corporate average fuel economy standards (CAFE). As CAFE standards increase, the HTF may find itself in a disadvantageous situation where households drive the same annual VMT or more but consume less fuel and pay less gasoline tax. As vehicles become more fuel efficient and eventually not powered by fossil fuel, the gasoline tax will become less effective and eventually obsolete.

Developing alternative transportation financing options to replace or supplement the gasoline tax is a complex task, as there are many considerations to be made. There are long-term solutions (e.g.

distance-based user charge, or vehicle-mileage fee) that will take time to implement due to policy and engineering constraints. There are short-term solutions (e.g. increasing the gasoline tax) that could alleviate some concerns immediately and buy more time for the implementation of longer-term solutions to be prudently planned and phased into place. Finance mechanisms to charge users must be fully considered and evaluated to determine effectiveness and fairness. The purpose of this paper is to analyze increased gasoline tax and vehicle mileage fees considering both their effectives in revenue generation and equity for different population groups at the Federal and State levels.

When predicting revenue generation of a consumption tax, changes in demand must be considered. Revenue from gasoline tax or a vehicle mileage fee is a function of not only the tax rate, but also vehicle miles traveled (VMT) and vehicle fuel efficiency that depend on household vehicle ownership and use decisions. As the cost of driving becomes more expensive due to changes in revenue policies, households may adjust to the cost increase by driving less and/or owning more fuel-efficient vehicles. The degree to which this occurs depends on the household characteristics. In this paper, these characteristics are represented in a demand model by several variables, which reflect a household's unique sensitivity to changes in transportation financing policies and cost of driving. Since households have varying degrees of sensitivity, this introduces issues of equity and fairness when evaluating a tax policy – which households will suffer the most and which will suffer the least or even benefit.

2. Background

2.1. Surface Transportation Financing in the U.S.: The Problem and Options

The Congressional Budget Office (CBO) has made astute observations over the past few decades regarding the potency of the Highway Trust Fund and its ability to provide funding to not only complete the highway system but to maintain it as well. The CBO Interstate Highway System – Issues and Options Reports provide an ominous picture of accumulating repairs, escalating construction costs, and declining revenue sources as vehicles become more fuel-efficient. These reports continuously identify these problems over time as "major problems". Highway Trust Fund Revenues are not sufficient to support program spending and the fund now faces a near-term insolvency crisis.

A report developed by the American Association of State Highway and Transportation Officials (AASHTO) called The Bottom Line Technical Report: Highway and Public Transportation Nation and State Investment Needs, approaches investment needs by first acknowledging that there are many challenges the nation currently faces in investing in its infrastructure. Challenges such as declining revenue at all levels of government, higher costs of capital construction, higher fuel costs, internal competitiveness and an overall weak economy are just a few that prove making the current authorization cycle particularly challenging.

The Bottom Line Report predicts the needed spending per year based on three scenarios. The first scenario is a 1.4 percent annual growth rate. The first scenario would require an investment of $166.8 billion (2006 dollars) a year from all levels of government to close the investment gap for highways and bridges. The second scenario considered is a VMT growth of just 1 percent

mirroring the population growth rate. The second scenario would require an annual investment of $132.4 billion (2006 dollars) per year from all levels of government to close the gap. Considering inflation, those values are $186.6 billion and $148.1 billion (in 2008 dollars) respectively. An important baseline to consider is to maintain the current physical condition and performance of the system. While this is not a useful goal for a system that already is not able to provide for an aging infrastructure system, it establishes the minimum investment required to prevent further degradation. The value determined in the AASHTO report for this baseline condition (a third scenario) is $93.3 billion per year. The current level of spending is $68 billion per year. These projections only consider investment in highways and bridges. There is no consideration for public transit, which is also funded by fuel taxes through the HTF.

Two commissions were created by the Congress under the Safe, Accountable, Flexible, Efficient Transportation Equity Act – a Legacy of Users (SAFETEA-LU): the National Surface Transportation Policy and Revenue Study Commission (referred to as the Revenue Commission hereafter) and the National Surface Transportation Infrastructure Financing Commission (the Finance Commission). The Revenue Commission focused on how investments should be prioritized and delivered. The Finance Commission focused on how revenues should be raised. Studies conducted by the Commission show that travel demand growth rates have exceeded population growth rates in part due to a shift to single occupant vehicles, and also due to increases in trip making, trip length, and a switch to the auto from other modes of transportation. The deterioration of our system is not only a result of under investing but also a result of overuse from being underpriced. Congestion has a large negative impact on our personal lives, security, and economy including lost time, long queues, and wasted fuel.

The Final Report of the Revenue Commission takes a look at several options from both a short term and long term perspective. Admitting that alternatives to the gasoline tax must be considered down the road, the federal gasoline tax is currently an attractive source of revenue. The Revenue Commission lists 4 reasons: 1) low administrative and compliance costs, 2) ability to generate substantial amounts of revenue, 3) relative stability and predictability, and 4) ease of implementation. They recommend indexing the tax to inflation in order to protect the purchasing power of the tax. After reviewing many alternatives, the Finance Commission, with support from Transportation Research Board (TRB) and AASHTO studies, concluded that the consensus choice for a federal funding system in the future, based on "user pay" charges is the distance-based, VMT fee. However, they suggest this to be a medium to long-term solution as there are many physical and political barriers that would require time to implement a mileage-based user fee system and the Finance Commission doesn't expect a full implementation until the year 2020. In the meantime the Finance Commission, and the Revenue Commission's assertion of the attractiveness of the current mechanisms of the federal gasoline tax, makes such recommendations as to increase the current federal gasoline tax 10 cents to $0.284 per gallon (The Financing Commission, 2009).

2.2. Considerations for Efficiency and Fairness in Previous Research and Practices

Optimal solutions for road pricing need to be both economically efficient and equitable. The current pricing mechanism of fuel tax is not optimal since it does not reflect many of the factors that affect vehicle costs. The gasoline tax is the most commonly used distance-based user tax (Litman 1999). The gasoline tax is also the simplest of all regulatory measures (Truelove 2008). One study suggests that evaluating equity based on a percent of total expenditures rather than

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income provides a different, a more equitable perspective on the distribution of costs and benefits of a fuel tax (Poterba 1991). Despite arguments that the gasoline tax is more equitable, that is neither here nor there when considering economic efficiency (Ungemah 2007).

Looking at two, well established, industrialized countries: one has an average gasoline tax, considering both state and federal tax, of $.40 per gallon (2001 USD, the United States) and one has a gasoline tax of $2.80 per gallon (2001 USD, the United Kingdom) – which country has the right gasoline tax (Parry and Small 2010)? Under the authors' assumptions, they determine the optimal tax to be $1.01 for the US, more than twice the current tax rate, and $1.34 for the U.K., slightly less than half of the current fuel tax. It looks like neither country has the right tax but due to political constraints neither country expects that to change in the near future. Using simulation, the paper did determine that both countries, by converting their current fuel tax system to a more efficient VMT fee system, would see welfare gains.

A major concern with increasing the price of driving is that many politicians consider this inequitable. Equity is a major hurtle to public and political acceptance of increasing or changing road usage taxes (Levinson 2002). Recent road user charge experiments in Hong Kong, Cambridge, and central London (Ison and Rye 2005) have demonstrated the importance of pricing scheme design and public acceptance. The distributional effects of vehicle mileage fees among different income groups and among urban and rural households are focal issues in the Oregon mileage-based fee debates (Whitty 2007, Zhang et al. 2009, McMullen and Zhang 2010, Zhang and McMullen 2010). Viegas (2001) recommends easy-to-understand terms that could serve as targets for mobility managers; i.e. increasing the level-of-service. Researchers also have warned against any drastic changes that may disrupt existing balances, believing that policy changes should occur gradually (Truelove 2008).

3. Data and Methodology

The dataset we used to perform our analysis is the 2001 National Household Travel Survey (NHTS); the most recent nationwide travel survey, at the time this research was conducted, that captures driver and household characteristics. To perform our analysis we needed to create a model that would predict how drivers within a household would react to changes in tax policy. To do this, a multiple regression model with interaction variables to allow for the heterogeneous demand responses to policy changes was developed. Only households that were surveyed in the national survey and households with complete information were used within our model. Each characteristic identified in the survey was considered as to whether or not it would contribute to the accuracy of our VMT demand model. The dataset was reduced to the variables that would influence VMT in theory, and then were further scrutinized for political relevancy and statistical significance.

Caution was taken to avoid multi-collinearity and causality issues. Variables that are highly correlated and are used in the same model will display a false depiction of their contribution to the results of the model and this can be easily misinterpreted. In the case of causality, variables that seemingly contribute to the prediction of the dependent variable can create false predictions; changes in these variables may not actually cause changes to the dependent variable. For example, higher levels of education reported at households also reported higher VMT. It's not actually the higher level of education that causes households to drive more, but a higher level of education

results with households earning higher income and having a higher income makes a household less sensitive to changes in the price of fuel.

Our resulting model uses 15,902 households from all 50 states, plus Washington, D.C., and includes 20 independent variables capturing 17 household characteristics. Figure 1 presents the distributions of income, level of urbanization, VMT, and vehicle fuel efficiency of the households in this sample. The dependent variable of the model is measured as the natural log of the household's total VMT. For the continuous independent variables we took the natural log, except those where zero was a possible answer; for example, number of children was treated as simply a continuous variable. Of the independent variables used, 9 were dummy variables and 2 were interaction variables. The R-squared value for the model was 0.7116 and the adjusted R-squared value was 0.7113. Please refer to Table 1a for all of the variables used in the regression model, the variable type, estimated coefficient value, t-value and statistical significance, and Table 1b for further explanation of each variable.

This model represents a short run analysis and therefore some variables are held constant. For example, individual households do not have the ability to change vehicle ownership, the veh_count variable remains constant. However, in our model individual households do have the ability to substitute driving a less fuel-efficient vehicle with a more fuel-efficient vehicle if the vehicle is already in the household's possession, lessening the impact of the increase in tax. The only independent variable that is allowed to change for the policy analysis, is the fuel cost per mile for individual households, including gasoline tax or vehicle mileage fees.

The use of interaction-variables allows for an independent variable to behave differently when the independent variable they are interacting with changes. For this model, we use two interaction variables with the price of fuel: one variable that will interact with fuel price is the dummy variable, substitute and the other is household income. Consequently, a household's sensitivity to the cost of driving varies when incomes are different or if the household has the option to substitute driving between multiple vehicle types.

The following paragraphs interpret selected model coefficients (one for each variable category) and demonstrate the reasonableness of the model sensitivities.

Unlogged Continuous variables
Example – Children_count: All other things being equal, compared to a no-child household, a one-child household drives 4.1 percent (derived from: $e^{0.04 \times 1}/e^{0.04 \times 0} - 1$) more VMT, and a four-children household drives 17.4% more ($e^{0.04 \times 4}/e^{0.04 \times 0} - 1$).

Natural Log of Continuous Variables
Example – Ln(pop_density): All other things being equal, a one-percent increase in population density in the census tract/group where the household resides will lead to 0.061 percent reduction in household VMT.

Dummy Variables
Example – Resp_age_16_35: all other things equal, a young household headed by someone between 16 and 35 years old drives 49 percent or ($e^{0.398} - 1$) more than a senior household headed by someone who is over 65 years old (the reference age group).

Coefficients of the fuel-cost-per-mile variable and the two interaction variables determine the demand elasticity of VMT with respect to the cost of driving. The demand sensitivity ranges from -1.82 (highly sensitive) to about 0 (not sensitive at all). This indicates if the cost of driving is increased by 1 percent and all other variables held constant, households with the highest sensitivity (those with low income and a single type of vehicle) would drive 1.82% less, while lowest-sensitivity households (those with highest income and multiple types of vehicles) would essentially not change their driving pattern.

Variables such as the number of drivers per household, children, and workers were predicted to be factors that would increase the number of vehicle miles traveled. Testing variables found that certain ethnic groups such as Asian and Hispanic households drove significantly different (Asian: less; Hispanic: more) annual VMTs than other ethnically defined households. Age group dummy variables were introduced to represent at what stage in life the household was in. Both age group dummy variables were found to drive more than households that would be at or near retirement.

4. Policy Scenarios and Results

Different policy scenarios were applied to the model to estimate changes in behavior and consequently estimate more accurately the tax revenue that would be generated by the policy change. To measure distributional impacts, we looked at change in consumer surplus, change in total revenue/payment, and change in total welfare.

- Consumer surplus is defined in economics as the difference between what the consumer is willing to pay for a good and what the consumer actually pays. Increasing the price of a good will result in a loss of consumer surplus. Consumer surplus takes into account the change in price of the fuel and the change in the number of vehicle miles driven.

- Total revenue is the total amount of money generated by the tax; change in total revenue is the difference between the existing policy and the proposed policy in comparison.

- Change in total social welfare is a measurement of the ability for the producer (in this case the government) to compensate the consumers for their loss in consumer surplus by spending the revenue on services that benefit the consumer. Since the spending of gas tax revenue is not modeled in this paper, we compute the change in total social welfare as the sum of the change in consumer surplus and the change in producer surplus (the revenue generated from the tax in this case). Social welfare is an indicator of the overall policy effectiveness and net social benefits.

Each economic attribute is presented as they relate to household income groupings, location, household head's age, and ethnicity. Household characteristics such as income, ethnicity and age were examined, permitting us to determine which groupings within these characteristics were the most and least affected by these policy changes.

Regional impacts were considered acknowledging that land use patterns, income distribution, and the existing vehicle fleets vary throughout the country. We lastly considered the impacts changing federal tax rates would have on state transportation revenue. If drivers were to decrease their annual VMT due to federal tax rate increases, this would reduce fuel consumption and

consequently state gasoline tax revenue. States' net total revenues may still increase after increased contributions to the Federal Highway Trust Fund are allocated back to the States.

4.1. Converting the Existing Federal Gasoline Tax to a Revenue-Neutral VMT Fee

The first policy that we consider is converting the current gasoline tax to a revenue neutral Vehicle-Miles-Traveled or VMT fee. In order to apply the VMT fee to the model, the federal gasoline tax had to be subtracted from the total price of gasoline. The remaining price of gasoline was then converted to a price per vehicle mile traveled for each individual household by dividing the remaining price for gallon by the household's weighted (by VMT on individual vehicles) average vehicle fuel efficiency rate. The revenue-neutral VMT fee was then added to the true fuel cost per mile to determine the total fuel price per mile including the Federal VMT fee.

We used the model to determine what the revenue-neutral mileage fee would need to be and what the distributional impacts of using a VMT fee would be. Using a flat VMT fee, the revenue-neutral fee to the current gasoline tax was calculated to be .90 cent per mile. It was expected that using a flat VMT fee would assist those households that have lower average household fuel efficiency than the national average, what the VMT fee is loosely based on. Households with higher average fuel efficiency will be worse off in this scenario relative to the gasoline tax. Policy scenarios involving graduated VMT fees that vary by vehicle fuel efficiency, green house gas and pollution emissions, and congestion are analyzed in a separate paper (Zhang *et al.* 2010).

While there were minimal impacts on each household as a percent of total income, total VMT decreased by 0.4 percent upon the conversion to a VMT fee while keeping the fee revenue-neutral to the current gasoline tax. Overall on a percent basis the effect to VMT was small but speaking on absolute terms, this is a large quantity. The average changes in household consumer surplus, federal revenue, and social welfare were all less than one dollar per year per household and all changes as a percent of total household income were negligible.

Once the income, age, location, and ethnic groups were evaluated individually we saw slight variations in the impacts. What we found was that the two older age groups (36~63, and >64) would actually see a positive increase in consumer surplus. Rural areas also saw, on average, an increase in consumer surplus. Asian households were affected the most by this policy change, decreasing household VMT by 1.2 percent and suffering a loss of $10.07 in consumer surplus per household. This is due to the significantly higher fuel efficiency of their vehicles and the increase in the average Asian household price of fuel per mile traveled by 1.0 percent under the VMT fee.

4.2. Increasing the Federal Gasoline Tax by $0.10/Gallon:

The second policy scenario evaluated was to increase the federal gasoline tax by 10 cents, as recommended by The Finance Commission in their final report – Paying Our Way (The Financing Commission 2009), to a total of $0.284 per gallon of gasoline. According to our model results, this 54.3 percent increase in tax rate would increase tax revenue by 50.5 percent while decreasing total VMT by 2.5 percent. As anticipated we found that all of the households would decrease the number of annual vehicle miles traveled but their individual circumstances would determine to what extent they would be affected. The average household loss of consumer surplus was -

$104.38 per year; the average increase of federal gasoline tax paid was $98.25 per household; and the average loss in total social welfare per household was $6.13. Please refer to table 2 for the overall household distributional impacts. It should be noted that these results are computed without considerations for the reinvestment of the increase federal gasoline tax revenue. It is hypothesized that once the revenue reallocation is considered, most households will observe welfare increases because increased transportation investments should mitigate congestion, improve safety, and support economic development. We are currently integrating revenue and investment models to test this hypothesis, and will present our findings in a future paper.

What we found after applying this gasoline tax increase to the model was that households in rural areas suffered larger decreases in consumer surplus, made larger contributions to federal tax revenue, and made a significantly higher total gasoline tax payment as a percentage of household income. Rural areas also had the largest percent decrease in total VMT. While it should be kept in mind that the impacts on a household are on the scale of 0.2 to 0.3 percent of total household annual income, a significant discovery is the difference between rural and urban impacts relative to the difference in their income. Urban households take home annually 41 percent higher incomes than rural households, but rural households will suffer a 15 percent larger loss in consumer surplus than urban households.

Rural households in region 3 (West North Central) suffered the most. Not too far behind rural households in region 6 (East South Central). Within both of the regions households would experience an average loss in consumer surplus of about $127.50 annually; costing each household on average about $95 additional tax payment; and suffer an average loss in social welfare of approximately $7 per household annually. The households that suffered the least are urban households in Region 8 (Mid-Atlantic) and Region 7 (New England). Households within Region 8 suffered an average loss of consumer surplus equivalent to $91 annually while Region 7 has an average loss of $95 annually. Urban households in Region 8 forfeited $86 annually in federal tax revenue while Region 7 forfeited $90 annually. The total loss in social welfare for each region is approximately $5 per household for both Region 8 and Region 7. The region with the largest disparity between urban and rural households was Region 2 (Mountain). There was a total loss of consumer surplus in rural households equivalent to about 27 percent more than the average household loss of consumer surplus in urban households. The remaining regions were between 16 and 24 percent. Region 9 (South Atlantic) had the lowest difference of 16 percent. Please refer to Table 3 for additional details of the regional distributional impacts of a 10-cent gasoline tax increase.

Households that were classified as Asian were impacted significantly less than other ethnicities. Their percent change in VMT was lower as was their change in revenue generation as a percent of total household income. These households reported an average 7 percent better fuel efficiency and also a 26 percent higher income than the averages for other ethnicities. The higher income lowers their sensitivity to increases in the price of fuel. Please refer to Tables 5a and 5b for distributional effects to households of different age groups and ethnicities.

For the different age groups, households that were in or near retirement reduced annual VMT the most but suffered the smallest changes in consumer surplus, revenue generation, and total welfare. These houses are characterized as driving less and having significantly lower household incomes. It should be noted that their reported annual VMT was about 20 percent less than the other age

group categories. These households may have a fixed income post-retirement and may be already reduced to driving a minimal amount.

For the different income groups, the changes in consumer surplus, revenue generation, and total welfare all increased, as the income group was higher. Incomes above $80,000 a year suffered the largest loss of consumer surplus and change in revenue generated while incomes less than $10,000 per year suffered the largest loss in social welfare despite having the smallest loss in consumer surplus and the smallest increase in revenue contribution. When considering these changes relative to income, the lowest income group (<$10,000/year) suffered the largest impacts – reducing their annual VMT by 9.5 percent and experiencing a change in revenue contribution equivalent to 0.6 percent of the total household income. While 0.6 percent of total income may be small, it is the disparity between the lowest income group and the other income groups that is striking. Households with a total annual income between $10,000 and $20,000 will only lose 0.3 percent of their total income, and this percentage continues to drop as household income increases. The largest income group contributes only 0.17 percent of their total income in additional tax revenue. Please refer to Table 4 and Figure 2 for distributional effects across different income groups.

Another thought that should be considered is the impact of a federal gasoline tax increase upon state transportation revenue. If annual mileage is going to decrease, gasoline consumption will also decrease. If state tax rates are not raised simultaneously, they would experience a negative impact equivalent to their tax rate times the amount of fuel no longer consumed. States also use gasoline taxes to collect revenue for road projects. Virginia, for example, would suffer a total loss approximately 2.6 percent of their state gasoline tax revenue. However, after considering the increase in contributions to the HTF and the reallocation of federal HTF back to states, Virginia will see a net increase in available transportation funding of approximately 18 percent more than before the tax increase. The point to take away from this is that state revenue is impacted and this must be taken into account when making federal tax policy decisions. Please refer to Figure 3 and Table 6 for the net revenue impacts to all 50 states and DC resulting from a 10-cent increase in the Federal Gasoline Tax.

4.3 Converting the Increased Federal Gasoline Tax to an Equivalent VMT Fee

For the last policy we consider, we determined that the flat VMT fee needed to generate a 50.5 percent increase in revenue (equivalent to that generated by the $0.284/gallon federal gasoline tax) would be $0.015 per mile. This equivalent fee was determined under the assumptions that collection costs would be equivalent and that there is no loss in revenue due to tax evasion. The average loss of consumer surplus for individual households in the model is $105.33 annually; the average increase in tax revenue is $98.33 annually per household; and the average loss of total social welfare is -$7.00 annually per household. Again, please refer to Table 2 for additional details on the general welfare impact. Overall, these numbers are worse than those for a 10-cent gasoline tax increase but never more than $1 difference. The conversion from a gasoline tax to a VMT fee results in households with a lower than average fuel efficiency rate seeing a reduction in their loss of consumer surplus (an average of $67.24 annually); a reduction in their increased tax contribution (an average of $63.64 annually); and also a smaller decrease in their net social welfare (an average of $3.60 annually). The opposite holds true for households with higher than average fuel efficiency; having an average loss of consumer surplus of $146.66 annually, additional tax of $135.97 annually, and an average loss of total social welfare of $10.69.

The only groups that benefit from a flat VMT fee are those households living in rural areas, households characterized as in the age group 36-64 and those at or near retirement, and lastly households characterized ethnically as "other" (Caucasian and other non-African-American, non-Hispanic, and non-Asian households). These groups will have a smaller loss of consumer surplus, pay less annually, but as a result have a larger decrease in social welfare. The households hit the worst are young households and households characterized as Asian and African American with significant losses in consumer surplus, tax contributions, losses in social welfare and lastly reductions in annual VMT.

Comparing the gasoline tax increase to the revenue-neutral VMT fee, one can find that there is a larger reduction in VMT when using the VMT fee equal to about a half a percent of total national annual VMT. The impacts of using a VMT fee instead of a gasoline tax increase would reduce total annual VMT by 3.0 percent instead of 2.5 percent while generating the same amount of revenue. The loss of consumer surplus, previously mentioned to be $105.33, is minimally more than the loss of consumer surplus of a $0.10 gasoline tax increase at $104.38 annually per household. The average additional revenue generated is the same by the revenue neutral design, but this means that the flat VMT fee also has a greater loss of social welfare, although minor.

For different ethnicities, while Hispanic households will reduce VMT by 4.6 percent on average, one percent less than a gasoline tax increase, it is Asian households who will see the biggest negative impact reducing VMT from a 2.6 percent reduction with gasoline tax increase to a 4.1 percent reduction with a VMT fee. Hispanic and African American households are slightly negatively impacted, African American households more so than Hispanic households. "Other" households are impacted the least, seeing a slight further reduction in VMT from 2.42 percent to 2.88 percent. Even though Hispanic and African American households see larger losses in consumer surplus as a percent of total household income, it is Asian households that see the largest reduction in consumer surplus when converting from a 10-cent gasoline tax to a flat VMT fee reducing consumer surplus as a percent of income from 0.23 percent from the gasoline tax increase to 0.31 percent. Please refer to tables 5a and 5b for the distributional effects felt by households of different ages and ethnicities.

All groups subjected to a flat VMT fee, including income groups, will experience a reduction in annual VMT when compared to a gasoline tax. All groups will experience losses in total social welfare and higher tax contributions except that households with incomes higher than $60,000/year will experience a slightly reduced loss of consumer surplus with the VMT fee than with the gasoline tax. Please refer to Table 4 and Figure 2 for the distributional effects felt throughout different income groups under the equivalent VMT fee.

5. Conclusions

When comparing the three policies discussed within this paper, we found the gasoline tax increase proves to have the smaller average decrease in consumer surplus for households. The average loss of consumer surplus for the gasoline tax increase is $104.38 per household. Increasing the gasoline tax causes a total decrease of 2.5 percent in total annual VMT from our model and creates the largest disparity between different income, age, and ethnic groups but reduces overall average consumer surplus the least. Converting to an equivalent VMT fee generates the same amount of

revenue as the gasoline tax but increases the reduction in household VMT to 3.0 percent. The flat VMT fee creates a larger decrease in consumer surplus ($105.33 – just slightly more than a dollar) consequently the VMT fee will create a slightly (0.9 percent) larger loss of social welfare.

It is important to remember that these numbers represent the average household and while some households will see positive changes in consumer surplus, decreases in revenue contribution, and positive changes in social welfare when converting to a VMT-based policy, these households are outweighed by those experiencing negative impacts. The variances between these two policies are only slight because of the revenue neutrality and small value in which the tax is increased, which is an important conclusion as well – there is a greater loss of consumer surplus and social welfare by converting to a flat VMT fee, but the difference are not as vast as some may have assumed. The policies are actually relatively similar. The largest difference is seen in the reduction of annual household VMT. These distinctions are important for policy-making decisions.

There is no difference in the revenue generated by increased gasoline tax and the equivalent VMT fee as the foundation for designing these two policies is revenue neutrality. It should be noted however that if one were to assume zero price elasticity, or that households will not change their behavior if taxes were increased, there would be significant differences in revenue on the scale of about $800 million or 2.5 percent of the behavior-adjusted revenue estimation for the gasoline tax and about $850 million or 2.6 percent of the behavior-adjusted revenue estimation for the VMT fee policy. These are significant numbers and show how easily revenue can be overestimated if price elasticity is not considered.

Our research concludes that neither an increase in the gasoline tax nor an equivalent flat VMT fee is an equitable tax increase, having large disparities between income groups, ethnic groups, and regions. Both taxes have proven to be regressive. They both are able to produce the same revenue while the VMT fee further reduces VMT. This is important to consider when looking at the goals of a policy, for example, if the goal were to reduce fuel consumption and annual VMT. If the policy is to simply increase revenue, then the gasoline tax is the better choice of the two having less of a burden on drivers. It is important to note that this research is based on 2001 NHTS data and while 2008 data was not available at the time, as it becomes available it should be applied to the model to understand how increases in the price of fuel and changes in the economy situations would affect households' responses to alternative transportation financing policies.

To be fair, no transportation financing policy will be perfectly equitable, and winners and losers will always be created. There is hope that if the distributional impacts of alternative financing options at the revenue-generation stage, such as those discovered in this paper, are considered in revenue reallocation and reinvestment, a Pareto-improving alternative to the gasoline tax can be designed at least in theory. As mentioned in the paper, this equitable policy design issue requires the development of an integrated transportation financing model that considers revenue generation and reinvestment at the federal and state levels. For instance, since the lowest income groups are hurt the most by the policies discussed herein, an investment policy that favors transportation options for these lowest income groups can make the overall transportation financing mechanism progressive. Our results also show that owners of fuel-efficient and alternative-fuel vehicles suffer larger losses under the flat VMT fee. This can be addressed by tax credits and other incentives for these vehicles funded by the VMT fee revenue.

However these conclusions do not protect the gasoline tax from its possible fate. As previously discussed, the gasoline tax may become obsolete as fuel efficiency continues to increase and politicians find it increasingly more difficult to increase taxes. A tax on fuel consumption may not be the most economically efficient way to tax road users.

We recommend continuous research in the area of VMT fees. While a flat VMT fee can generate sufficient revenue, it is not the most equitable option and does not consider the congestion and environmental externalities of driving. Variable VMT fees should be further explored, as they may be more effective at improving equity and also reducing congestion, green house gas and pollution emissions, and fuel consumption. Green transportation financing policies may also be more acceptable by the general public, a key element in transportation financing policy reform in the U.S and elsewhere. Also, the analysis in this paper does not consider the redistribution of gas tax or VMT fee revenue for transportation investment, which can produce additional user benefits. Excluding revenue redistribution underestimates total user benefits (or overestimates user loss) from transportation financing policies. Future research should combine revenue generation and revenue redistribution/spending to more comprehensively analyze alternative transportation financing policies at the federal and state levels.

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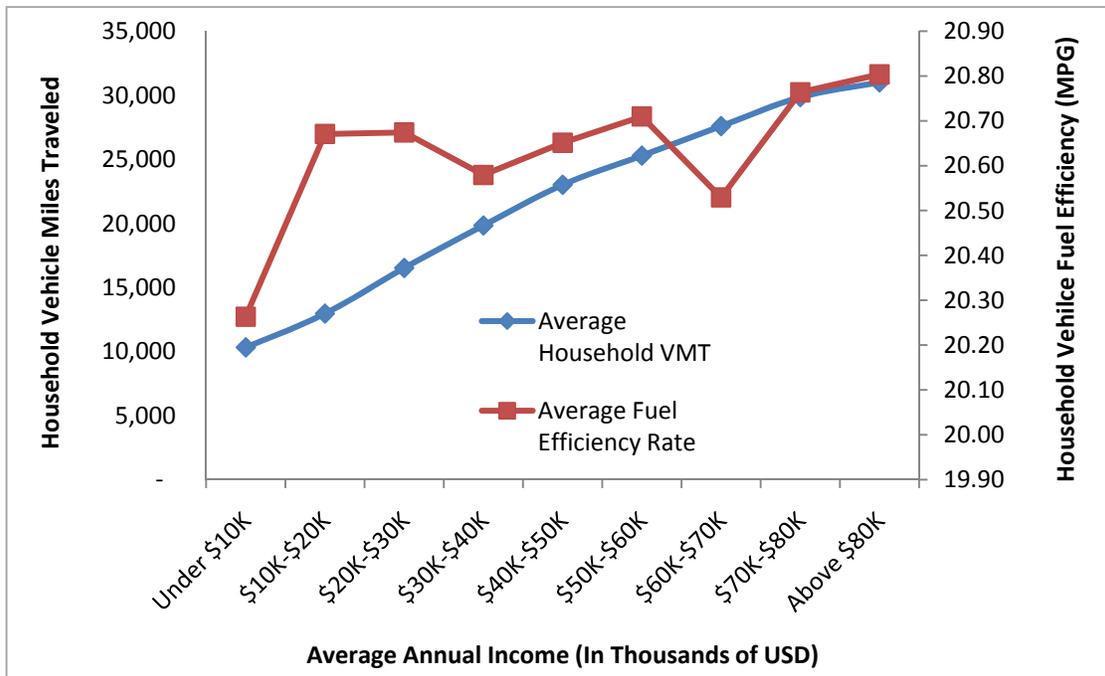
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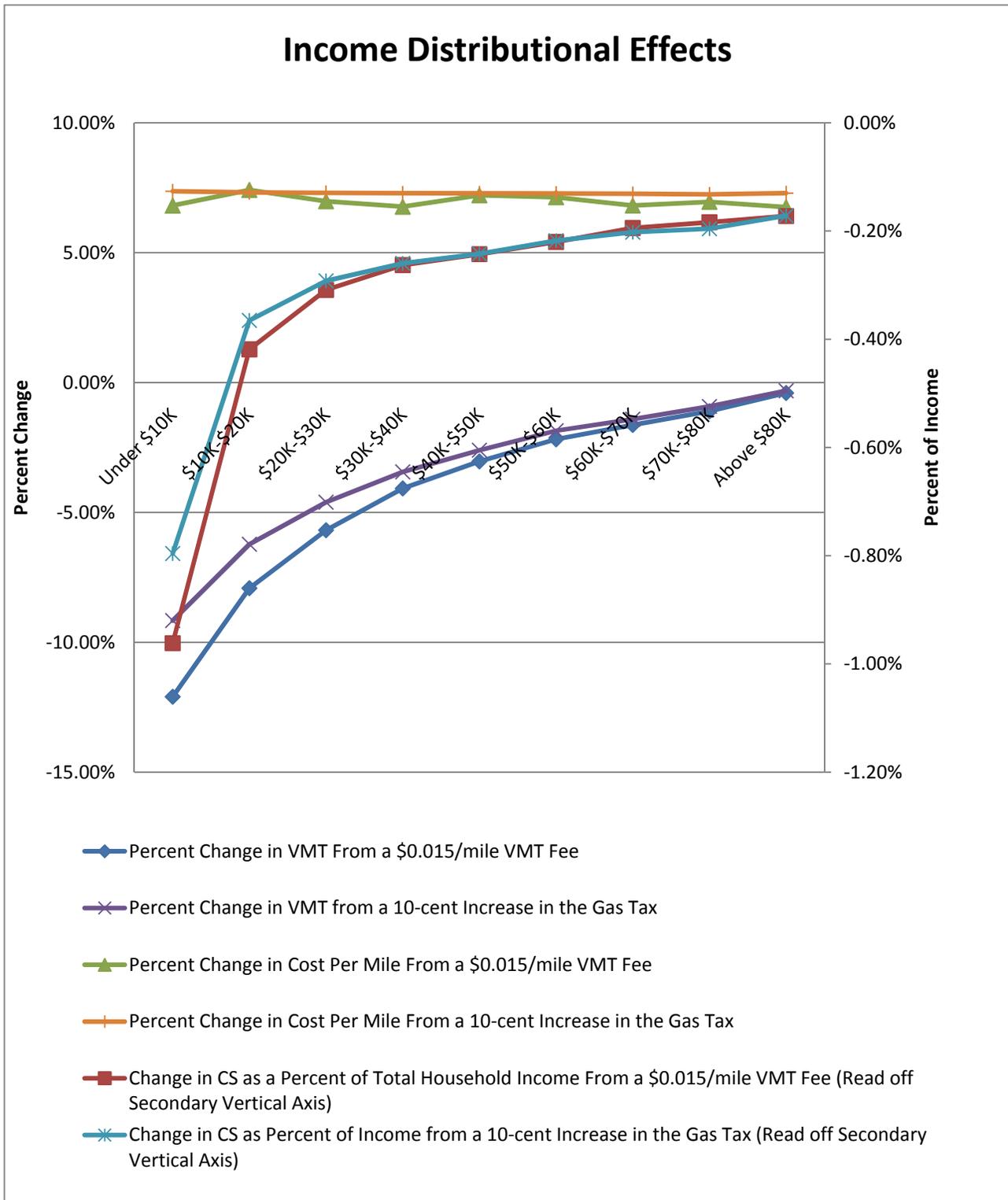
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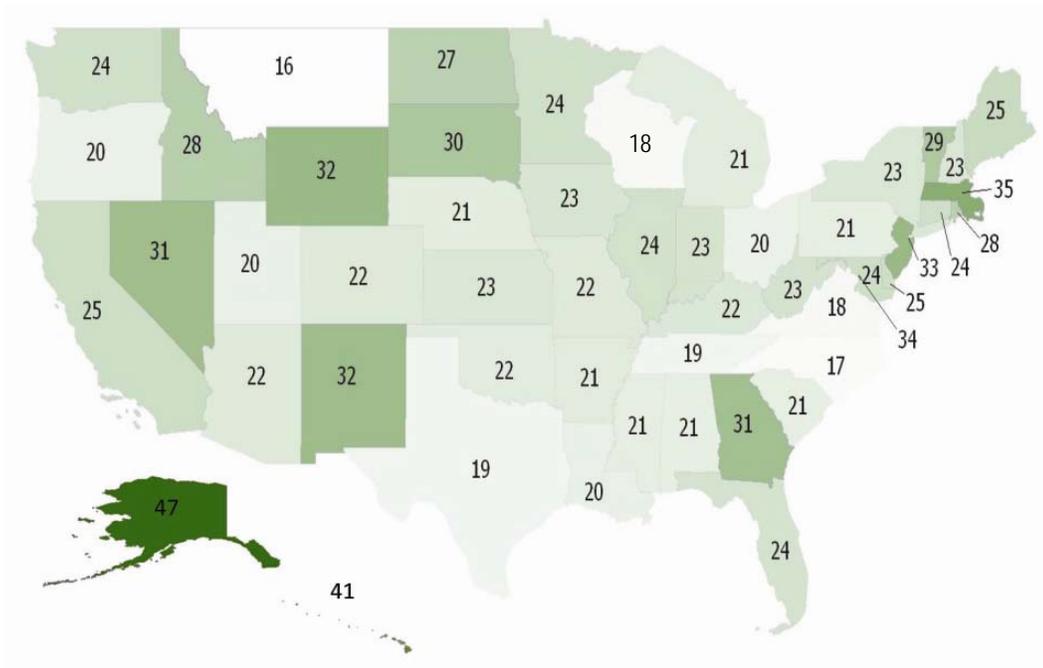
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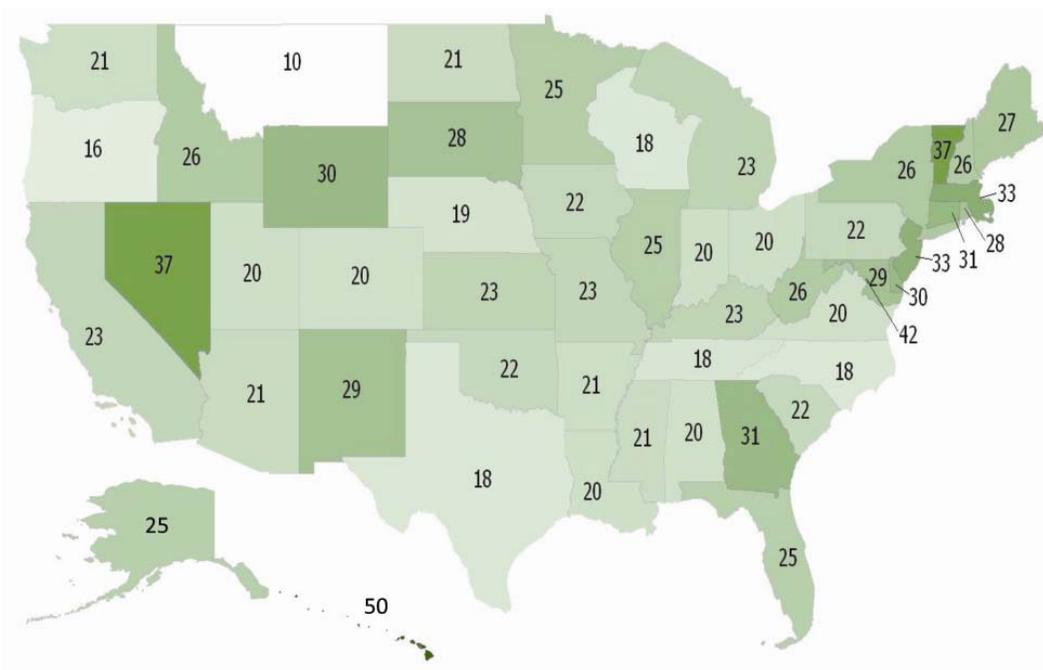
b. $0.015/mile Vehicle Mileage Travel Fee (average increase: 25%)

Figure 3. Percent Change in Net Annual [1]Tax Revenue to States

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[1] For projected tax revenue in USD, please refer to Table 6 on page 25.

Table 1. Model Estimation Results

Variable	Variable Type		Coefficient Value	T-statistical significance	P>t
ln(fuel cost/mile)	ln(cont var)	β_1	-5.111	-26.36	0
ln(household income)	ln(cont var)	β_2	1.341	26.99	0
ln(income)*ln(fuel cost/mile)	Interact var	β_3	0.420	22.86	0
ln(fuel cost /mile)*substitute	Interact var	β_4	0.421	14.85	0
ln(vehicle count)	ln(cont var)	β_5	0.746	71.39	0
Substitute[2]	dummy var	β_6	1.164	15.19	0
Male household head	dummy var	β_7	0.089	13.16	0
Worker Count	cont var	β_8	0.085	15.73	0
Driver Count	cont var	β_9	0.102	14.66	0
Children Count	cont var	β_{10}	0.039	11.5	0
African American Household	dummy var	β_{11}	-0.012	-0.87	0.384
Asian Household	dummy var	β_{12}	-0.094	-3.56	0
Hispanic Household	dummy var	β_{13}	0.041	2.04	0.042
Household head age 16~35	dummy var	β_{14}	0.398	32.75	0
Household head age 36-64	dummy var	β_{15}	0.266	25.75	0
ln(Population density)	ln(cont var)	β_{16}	-0.061	-26.25	0
Large urban area with rail transit	dummy var	β_{17}	0.016	1.29	0.196
Large urban area without rail	dummy var	β_{18}	0.029	2.69	0.007
Small urban area	dummy var	B_{19}	-0.025	-2.55	0.011
Transit usage (trips/day)	cont var	β_{20}	-0.134	-7.23	0
Constant	-		-6.924	-13.23	0

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[2] If a household can substitute driving between a less fuel-efficient vehicle with a more fuel-efficient vehicle, this dummy variable is one; and otherwise, zero.

Table 2: Overall Average Annual Impacts from a $0.10 increase in Federal Gasoline Tax and a $0.015/mile VMT Fee

Measurement	$0.10 increase in Federal Gasoline Tax		$0.015/mile VMT Fee	
	Household Average for Total Survey	As a percent of Average Total Household Income	Household Average for Total Survey	As a Percent of Average Total Household Income
Change in Consumer Surplus	-$104.38	-0.27%	-$105.33	-0.29%
Change in Federal Revenue	$98.25	0.25%	$98.33	0.25%
Change in Total Social Welfare	-$6.13	-0.03%	-$7.00	-0.03%

Table 3: Average Annual Regional Distributional Effects - Rural V. Urban Households

Region	(R)ural (U)rban	10-cent Increase in the Gasoline Tax			$0.015/mile VMT Fee		
		Average Household Change in CS (USD) Per Household	Average Change in Revenue (USD) Per Household	Average Change in Total Social Welfare (USD) Per Household	Average Change in CS (USD) Per Household	Average Change in Revenue (USD) Per Household	Average Change in Total Social Welfare (USD) Per Household
1	R	-$119.76	$112.81	-$6.95	-$105.01	$98.39	-$6.62
	U	-$98.16	$93.45	-$4.71	-$88.73	$82.96	-$5.77
2	R	-$128.37	$120.57	-$7.79	-$103.98	$97.67	-$6.31
	U	-$100.93	$95.67	-$5.26	-$99.34	$93.42	-$5.91
3	R	-$125.48	$117.69	-$7.80	-$114.91	$107.57	-$7.34
	U	-$103.77	$98.26	-$5.50	-$111.55	$104.98	-$6.56
4	R	-$122.15	$113.25	-$8.90	-$103.93	$95.77	-$8.15
	U	-$98.61	$91.91	-$6.70	-$99.78	$92.46	-$7.32
5	R	-$123.10	$116.00	-$7.11	-$119.77	$112.26	-$7.52
	U	-$103.44	$98.14	-$5.30	-$107.31	$101.01	-$6.30
6	R	-$126.92	$118.06	-$8.85	-$117.05	$107.98	-$9.07
	U	-$105.78	$99.13	-$6.65	-$111.74	$104.28	-$7.46
7	R	-$117.76	$111.66	-$6.10	-$134.60	$126.86	-$7.74
	U	-$95.31	$90.40	-$4.91	-$101.75	$95.42	-$6.33
8	R	-$109.02	$102.06	-$6.96	-$126.53	$118.02	-$8.51
	U	-$90.81	$85.67	-$5.14	-$98.49	$92.06	-$6.42
9	R	-$113.24	$104.90	-$8.34	-$114.14	$104.81	-$9.33
	U	-$97.84	$91.42	-$6.42	-$106.80	$98.90	-$7.90

Region	Name	States
1	Pacific	Alaska, California, Hawaii, Oregon, Washington
2	Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
3	West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
4	West South Central	Arkansas, Louisiana, Oklahoma, Texas
5	East North Central	Illinois, Indiana, Michigan, Ohio, Wisconsin
6	East South Central	Alabama, Kentucky, Mississippi, Tennessee
7	New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
8	Middle Atlantic	New Jersey, New York, Pennsylvania
9	South Atlantic	Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, Washington D.C., West Virginia

Table 4: Annual Household Income Effects from New Tax Policies

Income Group	$0.10 Gasoline Tax Increase			$0.015/mile VMT Fee		
	Change in Consumer Surplus	Change in Revenue Generated	Change in Social Welfare	Change in Consumer Surplus	Change in Revenue Generated	Change in Social Welfare
Under $10K	-$40.49	$31.40	-$9.09	-$48.38	$36.33	-$1.21
$10K - $20K	-$55.56	$47.19	-$8.36	-$63.64	$53.15	-$10.50
$20K - $30K	-$74.33	$66.15	-$8.18	-$78.67	$69.02	-$9.65
$30K - $40K	-$92.34	$84.74	-$7.60	-$93.41	$85.02	-$8.39
$40K - $50K	-$110.26	$103.44	-$6.82	-$110.27	$102.84	-$7.44
$50K,<$60K	-$121.14	$115.78	-$5.36	-$122.12	$116.30	-$5.82
$60K,<$70K	-$132.60	$128.13	-$4.47	-$127.27	$122.64	-$4.63
$70K, <$80K	-$148.02	$144.85	-$3.17	-$138.79	$135.34	-$3.45
Above $80K	-$154.49	$153.20	-$1.28	-$155.10	$153.89	-$1.21

Table 5a: Average Annual Distributional Effects by Ethnicity – 10-cent Federal Gasoline Tax Increase vs. $0.015/mile VMT Fee

Ethnicity	Fuel Efficiency Rate (MPG)	Total Annual Household Income (USD)	10-cent Gasoline Tax Increase				$0.015/mile VMT Fee			
			Change in Consumer Surplus (USD)	Household Revenue Generation (USD)	Change in Total Social Welfare (USD)	Percent Reduction in Annual VMT	Change in Consumer Surplus (USD)	Change in Revenue Per Household (USD)	Change in Total Social Welfare (USD)	Percent Reduction in Annual VMT
Hispanic	21.15	$35,445	-$97.08	$88.88	-$8.20	-3.57%	-$108.77	$98.37	-$10.40	-4.64%
African American	21.47	$39,843	-$82.28	$75.92	-$6.36	-3.27%	-$101.42	$92.62	-$8.81	-4.46%
Asian	22.98	$51,467	-$88.65	$83.73	-$4.92	-2.55%	-$103.58	$95.35	-$8.23	-4.11%
Other	20.54	$47,023	-$106.37	$100.31	-$6.06	-2.42%	-$105.50	$98.76	-$6.74	-2.88%

Table 5b: Average Annual Distributional Effects by Age Group – 10-cent Federal Gasoline Tax Increase vs. $0.015/mile VMT Fee

Age Group	Fuel Efficiency Rate (MPG)	Total Annual Household Income (USD)	10-cent Gasoline Tax Increase				$0.015/mile VMT Fee			
			Change in Consumer Surplus (USD)	Household Revenue Generation (USD)	Change in Total Social Welfare (USD)	Percent Change in Annual VMT	Change in Consumer Surplus (USD)	Household Revenue Generation (USD)	Change in Total Social Welfare (USD)	Percent Reduction in Annual VMT
Age Group 16-35	21.54	$45,954	-$118.99	$111.36	-$7.63	-2.78%	-$129.88	$119.79	-$10.09	-3.77%
Age Group 36-63	20.65	$51,122	-$117.17	$111.24	-$5.94	-2.15%	-$115.26	$108.77	-$6.49	-2.53%
Age Group 64+	19.59	$33,458	-$51.63	$46.75	-$4.88	-3.92%	-$48.73	$43.97	-$4.76	-4.12%

Table 6: Annual Impacts of Alternative Financing Policies on Total Transportation Revenue by State

State	10-cent Increase in Gasoline Tax			$0.015/mile VMT Fee		
	Loss in State Tax Revenue (USD in Millions)	**Gain** in HTF Reimbursement (USD in Millions)	**Net** Change in Revenue (USD in Millions)	**Loss** in State Tax Revenue (USD in Millions)	**Gain** in HTF Reimbursement (USD in Millions)	**Net** Change in Revenue (USD in Millions)
Alaska	$ 0.5	$ 155.1	$ 154.6	$ 0.1	$ 81.2	$ 81.1
California	$ 41.2	$ 1,060.5	$ 1,019.3	$ 46.4	$ 978.2	$ 932.8
Hawaii	$ 1.3	$ 114.8	$ 113.6	$ 1.6	$ 137.8	$ 136.2
Oregon	$ 8.2	$ 136.7	$ 128.4	$ 7.2	$ 108.5	$ 101.3
Washington	$ 12.7	$ 291.4	$ 278.7	$ 9.7	$ 249.3	$ 239.6
Arizona	$ 8.2	$ 139.7	$ 131.5	$ 8.1	$ 136.2	$ 238.1
Colorado	$ 8.7	$ 187.3	$ 178.6	$ 7.2	$ 168.4	$ 161.2
Idaho	$ 3.1	$ 89.6	$ 86.5	$ 2.6	$ 82.9	$ 80.3
Montana	$ 3.1	$ 37.9	$ 34.8	$ 1.8	$ 22.8	$ 20.9
New Mexico	$ 2.2	$ 74.1	$ 71.8	$ 1.7	$ 65.7	$ 64.1
Nevada	$ 1.6	$ 63.9	$ 62.3	$ 1.7	$ 74.3	$ 72.6
Utah	$ 4.9	$ 81.4	$ 76.5	$ 4.6	$ 81.3	$ 76.7
Wyoming	$ 0.8	$ 30.5	$ 29.7	$ 0.7	$ 28.7	$ 27.9
Iowa	$ 6.7	$ 123.1	$ 116.4	$ 6.2	$ 118.7	$ 112.5
Kansas	$ 6.1	$ 110.1	$ 104.0	$ 6.1	$ 112.3	$ 106.2
Minnesota	$ 8.9	$ 213.3	$ 204.4	$ 9.0	$ 224.4	$ 215.4
Missouri	$ 11.0	$ 185.8	$ 174.8	$ 11.2	$ 190.7	$ 179.5
North Dakota	$ 2.2	$ 48.5	$ 46.3	$ 2.0	$ 38.4	$ 36.4

State	10-cent Increase in Gasoline Tax			$0.015/mile VMT Fee		
	Loss in State Tax Revenue (USD in Millions)	**Gain** in HTF Reimbursement (USD in Millions)	**Net** Change in Revenue (USD in Millions)	**Loss** in State Tax Revenue (USD in Millions)	**Gain** in HTF Reimbursement (USD in Millions)	**Net** Change in Revenue (USD in Millions)
Nebraska	$ 5.2	$ 99.6	$ 83.4	$ 3.9	$ 79.0	$ 75.0
South Dakota	$ 1.6	$ 53.4	$ 51.8	$ 1.2	$ 50.1	$ 48.9
Arkansas	$ 18.5	$ 235.7	$ 217.2	$ 17.9	$ 228.0	$ 210.1
Louisiana	$ 9.5	$ 133.5	$ 124.0	$ 8.1	$ 131.5	$ 123.4
Oklahoma	$ 7.3	$ 107.2	$ 99.9	$ 7.3	$ 109.0	$ 101.6
Texas	$ 45.5	$ 560.5	$ 514.9	$ 42.6	$ 524.9	$ 482.2
Illinois	$ 19.4	$ 424.6	$ 405.2	$ 21.7	$ 451.1	$ 429.4
Indiana	$ 10.3	$ 205.4	$ 195.1	$ 9.1	$ 178.7	$ 169.7
Michigan	$ 17.5	$ 327.1	$ 309.6	$ 18.4	$ 357.1	$ 338.7
Ohio	$ 24.6	$ 394.9	$ 370.3	$ 25.6	$ 400.9	$ 375.3
Wisconsin	$ 13.6	$ 196.7	$ 183.1	$13.3	$ 191.2	$ 177.9
Alabama	$ 10.7	$ 148.1	$ 137.4	$ 10.3	$ 142.7	$ 132.5
Kentucky	$ 7.2	$ 133.9	$126.7	$ 7.5	$ 139.8	$ 132.3
Mississippi	$ 7.0	$ 95.7	$ 88.7	$ 7.8	$ 97.9	$ 90.2
Tennessee	$ 15.2	$ 181.1	$ 165.9	$ 12.8	$ 170.6	$ 157.7
Connecticut	$ 7.2	$ 185.4	$ 178.2	$ 9.1	$ 236.6	$ 227.5
Massachusetts	$ 10.6	$ 559.5	$ 548.9	$ 11.5	$ 536.3	$ 524.8
Maine	$ 2.7	$ 62.0	$ 59.3	$ 3.0	$ 65.9	$ 62.9
New Hampshire	$ 2.8	$ 63.4	$ 60.6	$ 2.9	$ 71.6	$ 68.7

State	10-cent Increase in Gasoline Tax			$0.015/mile VMT Fee		
	Loss in State Tax Revenue (USD in Millions)	**Gain** in HTF Reimbursement (USD in Millions)	**Net** Change in Revenue (USD in Millions)	**Loss** in State Tax Revenue (USD in Millions)	**Gain** in HTF Reimbursement (USD in Millions)	**Net** Change in Revenue (USD in Millions)
Rhode Island	$ 2.8	$ 74.6	$ 71.7	$ 2.8	$ 75.1	$ 72.3
Vermont	$ 1.2	$ 37.3	$ 36.1	$ 1.4	$ 47.4	$ 46.0
New Jersey	$ 7.8	$ 297.6	$ 289.9	$ 8.2	$ 298.5	$ 290.3
New York	$ 32.3	$ 630.0	$ 597.7	$ 37.6	$ 723.3	$ 685.7
Pennsylvania	$ 31.0	$ 490.9	$ 459.9	$ 32.2	$ 526.0	$ 493.8
Washington, DC	$ 0.9	$ 49.7	$ 48.7	$ 1.4	$ 60.8	$ 59.4
Deleware	$ 1.5	$ 30.5	$ 29.0	$ 1.9	$ 37.3	$ 35.4
Florida	$ 25.8	$ 409.3	$ 383.5	$ 27.3	$ 429.7	$ 402.4
Georgia	$ 8.1	$ 251.1	$ 243.0	$ 7.8	$ 246.7	$ 238.9
Maryland	$ 9.4	$ 207.0	$ 197.6	$ 11.3	$ 242.6	$ 231.3
North Carolina	$ 22.9	$ 261.5	$ 238.6	$ 23.9	$ 271.4	$ 247.5
South Carolina	$ 7.5	$ 100.1	$ 92.6	$ 7.9	$ 107.3	$ 99.3
Virginia	$ 18.6	$ 230.1	$ 211.5	$ 18.6	$ 251.0	$ 232.4
West Virginia	$ 5.1	$ 92.4	$ 87.3	$ 5.6	$ 102.2	$ 96.7