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# Distributional impacts of changing from a gasoline tax to a vehicle-mile tax for light vehicles: A case study of Oregon

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ABSTRACT

A vehicle-miles traveled (VMT) tax is frequently mentioned as viable alternative to a fuel tax for collecting highway users fees from light vehicles. Both a static model and a regression based model are used here to assess the distributional impacts of a switch from a fuel tax to a VMT tax for the state of Oregon. The VMT tax is found to be slightly more regressive than the fuel tax and rural households are found to actually benefit relative to urban households under a VMT tax. Two alternative VMT structures that might increase incentives to use more fuel efficient vehicles are provided, but both are found to be even more regressive than a flat VMT tax.

## 1. Introduction

The current system of highway finance in the US is in crisis due largely to the failure of Federal and state governments to raise enough funds to cover highway costs with existing fuel taxes (Wachs (2003a); NSTIFC, 2009; Whitty, 2007). The Federal fuel tax has not changed since 1993 and the Federal gasoline tax has experienced a 33% reduction in real purchasing power since that date (NSTIFC, 2009). Compounding the situation is a predicted long run downward trend in revenues collected from fuel taxes as the popularity of fuel-efficient hybrid vehicles and alternative fuel vehicles continues to grow and fuel economies are predicted to improve for gasoline vehicles (Whitty, 2007). In recognition of this impending crisis, the US Congress established the National Surface Transportation Infrastructure Financing Committee (NSTIFC) to explore alternative financing solutions for highways. Their recommendation for future highway funding was a federal funding system based on more direct forms of “user pay” charges, in the form of a charge for each mile driven (commonly referred to as a vehicle miles traveled or VMT fee system) (NSTIFC, 2009).

The idea of distance based road use charges is not new for heavy vehicle (vehicles over 80,000 pounds) as it has long been recognized that fuel taxes do not accurately capture the costs these vehicles impose on the road system (Merriss et al., 1982). This is because the damage done to roads generally rises exponentially with equivalent single axle (ESAL) weight for heavy vehicles whereas fuel consumption rises much less slowly with vehicle weight (Small et.al., 1989).

In Europe the idea of national distance based fees for heavy trucks is getting serious attention with Germany adopting the first nation-wide system for such vehicles in 2005 (Nash et al., 2003; Ecola and Light, 2009). In the US there are four states (Oregon, New Mexico, New York, and Kentucky) that collect weight distance user fees from heavy trucks. Ironically, in the US, the trend over the last decade has been for states to move away from weight-mile taxes and towards fuel taxes and other fees (for instance in 1989 there were eleven states that had some form of a weight distance tax on heavy vehicles).

For light vehicles, the discussion of distance based taxes has taken place largely in the context of charging optimal emissions or insurance fees (Litman, 1999; Forkenbrock, 2002; West, 2005; Walls and Hanson, 1999). This is because until recently fuel taxes were thought to be a fairly good proxy for optimal road use fees that charge users based on the damage (or marginal costs) they impose on the road. For light vehicles road damage is directly related to miles driven and, despite increasing variance in vehicle weights, there is not much difference in the damage done to the road by different types of light vehicles (Merriss, 2004). When fuel taxes were first introduced for light vehicles (at the state level in Oregon in 1919 and at Federal level in 1932) all vehicles experienced similar fuel efficiencies (McMullen, 2005). This is no longer the case and the large differences in fuel economy observed in today’s vehicle fleet results in drivers paying widely varying user fees per mile depending on the vehicle they operate.

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Thus fuel taxes are clearly no longer a good proxy for the kind of marginal cost user fees that economists recommend to assure the efficient use of the road system and socially optimal outcomes (Small et.al., 1989; Litman, 1999; Wachs, 2003b; Parry and Small, 2005; Hensher and Puckett, 2005).

Oregon, one of the few states that has a weight-mile tax in place for heavy vehicles, is now is one of several states exploring the feasibility of a VMT tax for light vehicles. As of 2003 real Oregon gas tax revenues per vehicle mile traveled had decreased by half since 1971 despite increases in overall VMT during that period (Whitty, 2007). Further, the Oregon state fuel tax of 24 cents per gallon had been in effect since 1993 and voters seemed unwilling to pass fuel tax increases. Recognizing the potential for a finance crisis in the future, the Oregon legislature formed a Road User Task Force (RUFTF) to consider alternatives to the fuel tax. The RUFTF not only recommended a VMT tax, they commissioned studies to develop and test the technology. In 2006 Oregon became the first state to actually implement a pilot study of the VMT fee technology (Whitty, 2007). Similar federally funded pilot studies have since been conducted at various locations including the University of Iowa (Texas Department of Transportation (TxDOT), 2009) and the Puget Sound Regional Council's (PSRC) Areawide Pricing Project in Washington State (Puget Sound Regional Council (PSRC), 2008; TxDOT, 2009).

In addition to technological considerations, debate on the replacement of the gasoline tax with a vehicle mile fee often involves discussion and debate regarding the following three issues: whether the change from a vehicle mile tax would place a disproportionate burden on those with lower incomes, whether a VMT tax would adversely impact those in rural locations who often drive long distances and may not have public transit alternatives (Hering, 2008, TxDOT, 2009; Whitty, 2007), and whether substituting the VMT fee for a fuel tax would discourage adoption of more fuel-efficient vehicles (TxDOT, 1999).

Replacing the gasoline tax with a VMT fee has not the focus of previous studies but several have explored the regressivity of VMT based emissions taxes (West, 2005; Kavalec and Setiawan, 1997; Walls and Hanson, 1999). Although most studies have found VMT emissions taxes to be somewhat regressive, the VMT tax may be less regressive than a straight emissions tax is levied as a flat per mile tax that does not vary by the type of vehicle. This is because low income households tend to own vehicles that produce more emissions (West, 2005; Kavalec and Setiawan, 1997).

As a case study, this paper provides an analysis of the distributional impacts (by income and location) that would result from the replacement of the current fuel tax in Oregon (24 cents per gallon) with a "revenue neutral" flat VMT tax of 1.2 cents per mile (this assumes an average fuel efficiency of 20 miles per gallon from the vehicle fleet). Once a flat VMT tax is considered, we look at the distributional impacts of alternative tax structures that might be proposed to deal with the perceived adverse incentives for adoption of fuel efficient vehicles. This study provides a starting place for discussion of distributional impacts of changes in the structure of highway user fees for light vehicles that play a role in the public acceptance of a VMT based highway user fee in the future.

## 2. Measuring the distributional impacts: models and methodology

The first step in the analysis of incidence for a vehicle-mile tax is to calculate and compare the incidence of the current fuel tax and the proposed VMT tax of 1.2 cents per gallon using a "static" model. Static measures of incidence are calculated assuming that all vehicle drivers drive exactly the same vehicles for exactly the same distances both before and after the change in tax structure. This method implicitly assumes that the price elasticity of demand for miles is zero. Although this method is known to overstate increases in tax burden and understate decreases in tax burden, the US Congress Joint Committee on Taxation (JCT) advocates this approach largely on the grounds that it is easily understood by policymakers who may get lost in details of more complex analyses. This is particularly appropriate if the changes are likely to be very small (CBO, 1990). (For details of the static model calculations, see Appendix A.)

Economists prefer to use a model that controls for the demand side response to changes in user fees and the results may differ from those found using a static model. Accordingly, we develop a simple OLS regression model to estimate demand for VMT and use those results to assess the impacts once behavioral demand responses are considered. Interestingly, in this case of changing from a fuel tax to a VMT tax in Oregon, the results are very close to those using the static model. This supports the JCT's use of a static model for analysis of the distributional impact, at least in the short run.

### 2.1. The regression model

Total vehicle use at the household level is defined as the total annual VMT on all household vehicles. This is a function of the per-mile driving cost, household income, household location, current vehicles owned by the household (number and type), and other household characteristics. The true per-mile driving cost borne by a household contains vehicle depreciation cost, operating cost, maintenance cost, insurance cost, and fuel cost including all applicable taxes. Many of these cost components are affected by vehicle choice and type of vehicle—all of which are assumed fixed in this analysis.[2] We include fuel cost in this analysis since it is the only cost variable that will be affected by a change to a VMT tax in the short run.

The OLS model for estimation is specified as

$$M = f(P_M, I, P_M{*}I, U, C, SUB, P_M{*}SUB, \overrightarrow{HH}_M) \tag{1}$$

where $M$ is the total annual miles driven by the household, $P_M$ the fuel cost per mile including either the fuel tax or the VMT tax, $I$ the annual household income, $U$ a dummy variable equal to one if the household is located in an urban area, and zero otherwise, and $C$ the number of vehicles the household owns. $SUB$ is a dummy variable that takes the value of one if the household has more than one type of vehicle such as a car and truck and zero otherwise, $P_M{*}I$ is an interaction term between the fuel cost per mile and income, and similarly $P_M{*}$SUB is an interaction term between the fuel cost per mile and the substitution dummy variable. $\overrightarrow{HH}_M$ is a vector of household characteristics that includes the number of children (CHILD), number of workers (WORK) and a dummy variable that takes the value of one if the household respondent is male and zero otherwise (MALE).

Fuel cost per mile for household vehicle $v$ ($P_{M,v}$) is determined by the fuel price without state gasoline tax ($P_F$, \$/gallon), vehicle fuel efficiency ($E$, miles per gallon), and in our alternate scenarios state fuel tax ($T_G$, \$/gallon), and VMT tax ($T_M$, \$/mile)

$$P_{M,v} = \frac{P_F + T_G}{E} + T_M \tag{2}$$

If a household owns multiple vehicles, $P_M$ is defined as the weighted average of all household vehicles with the

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[2] Note that this means that we are ignoring the endogeneity that arises as cars become more fuel efficient, lowering the per mile cost of driving and increasing vehicle miles driven. This effect has been referred to in the literature as the "rebound effect" (Small and Van Dender 2007).

miles driven on individual vehicles ($M$) serving as the basis for weight.

$$P_M = \frac{\Sigma_{v=1}^{V}(M_v \cdot P_{M,v})}{M} \tag{3}$$

As the fuel cost per mile, $P_M$, increases, one would expect households to reduce miles driven; so the expected coefficient on $P_M$, is negative. Assuming miles driven is a normal good, one expects the sign on income, $I$, to be positive: as household income increases, more is spent on miles. The coefficient on location, $U$, is expected to be negative as households in urban areas typically drive less than those in rural areas due to shorter commutes to work and the availability of alternate modes, especially transit.

Households with more than one vehicle are hypothesized to drive more miles so the estimated coefficient on $C$ is expected to be positive. Households with multiple types of vehicles are able to substitute between vehicles in response to other variables, such as the fuel cost per mile. This flexibility may encourage them to drive more, relative to other households that are not able to substitute between vehicles. This is especially true if one type of vehicle gets significantly different fuel efficiency. Thus, we expected the coefficient on *SUB* to be positive. Households with children have to travel to more activities, increasing miles traveled and finds that male-headed households drive more miles than those headed by females (West, 2005). Thus, we expect the coefficients on MALE and CHILD to be positive.

The interaction term between the fuel cost per mile and income ($P_M I$) allows for different impacts on different income groups. As the fuel cost per mile increases, households with higher incomes may drive more than those with lower incomes as the burden of driving expenses constitutes a greater proportion of their income. This is consistent with previous findings that those in higher income groups have a more inelastic demand, as demonstrated by West (2002). Similarly, the interaction term between the fuel cost per mile and the substitution dummy variables ($P_M SUB$) allows for differential impacts on those with multiple vehicle types and those without. Relative to households who cannot substitute between vehicle types as the $P_M$ increases, households with multiple vehicle types are able to substitute towards the more fuel efficient vehicles and thus drive more miles. The interaction terms allow households in the sample to have different sensitivity to fuel cost changes.

### 2.2. *Data*

The data used for this study come from the 2001 National Household Travel Survey (NHTS) sample of Oregon households. There were 407 households in the Oregon sample for the static model. Due to the additional data required for the OLS regression estimation, the number of households for that analysis included only the 339 Oregon households from the 2001 National Household Travel Survey (NHTS) for which complete data were available. Since household income in the NHTS is reported in one of eighteen income groups rather than as dollar amounts, we assign the median value for the income group as the income for each household in the group. The highest reported income group for the NHTS sample is defined as a household with income greater than or equal to $100,000. The 2000 Oregon Census reported only 1.8% of all Oregon households with an income greater than $200,000 (with no upper bound). Accordingly, we assigned $200,000 as the upper bound for the highest income group and assigned this group an average income of $150,000. This is not optimal, but it is all that can be done with the data, and it follows others (Zupnick, 1975) who have used similar data sets with similar measures of income. All of the other data used in this analysis comes from the NHTS data set.

West (2005) points out that that incidence is less regressive if all households are included, not just those that have vehicles. For the purposes of assessing the impact of a change in tax structure, including the zero vehicle households is problematic as they spend nothing on fuel in either case. Since none of the zero vehicle households in our NHTS data set reported either vehicle-miles driven or expenditures for fuel, we chose to exclude zero vehicle households from this analysis.

Rather than using the EPA fuel efficiency estimates, which are known to be overstated, we use Energy Information Administration (EIA) fuel efficiency measures from the NTHS data. These efficiency measures result in average fuel efficiency for the Oregon 2001 NHTS sample of 20.75 miles per gallon—fairly close to the 20 mile per gallon estimate used by the RUFTF in suggesting a 1.2 cent per mile revenue neutral mileage tax. Note that vehicles that get less than 20 miles per gallon will pay less under the vehicle mile tax; those that get over 20 miles per gallon will pay more.

Given the above mentioned fact that the NHTS Oregon data sample exhibits an average fuel efficiency of 20.75 miles per gallon, if all vehicles are driven the same number of miles as before the change, we would expect a decrease in overall expenditures on road use taxes. The actual impact will depend on the relative number of miles driven by vehicles of differing fuel efficiencies.

### 2.3. *Impact of the change in tax structure: the static model*

In the Oregon 2001 NHTS data set, the average gasoline price paid per gallon was $1.46, which included the 24 cent per gallon fuel tax. Thus, the average price of gasoline net of the fuel tax (*NETPGAS*) was $1.22 per gallon. To update the results to a more realistic gasoline price, we later do the same calculations using a price of $2.64 per gallon (which yields a *NETPGAS* of $2.40 per gallon).

We first examine the impact on total household fuel expenditures, including taxes, by income group using the static model.

Table 1 shows that, on average, those in the lowest income group would pay $7.82 more per year in fuel expenditures under the VMT tax and the second lowest income group would pay an additional $5.19 per year. The group with the highest average benefit from the change would be the $60,000–$74,999 income group, which would see, on average, a reduction in gasoline expenditures of about $25 per year, followed by those with incomes over $75,000, that gain about $6.00 per year, and then those in the $30,000–$44,999 income group that gain about $4.40.

To get a better idea of the impact of this change on the regressivity of fuel expenditures including the tax, we calculate incidence as a percent of average annual income for each group (Table 2). The Congressional Budget Office found that Federal fuel taxes were regressive with respect to annual income, but

**Table 1**
Change in average annual household expenditures when switching from a gasoline tax to a vehicle-mile tax by income group (*NETPGAS*=$1.22).

| Income group | #HHs | Average fuel Expenditures with gas tax | Average fuel expenditure with VMT tax | Change in expenditure |
|---|---|---|---|---|
| 0–14,999 | 39 | 658.90 | 666.72 | 7.82 |
| $15,000–$29,999 | 75 | 917.84 | 923.03 | 5.19 |
| $30,000–44,999 | 65 | 1174.01 | 1169.61 | −4.40 |
| $45,000–59,999 | 62 | 1595.10 | 1595.33 | 0.23 |
| $60,000–74,999 | 40 | 1858.85 | 1833.51 | −25.34 |
| $75,000–$200,000 | 67 | 1992.60 | 1986.60 | −6.00 |

**Table 2**
Comparison of incidence of gasoline expenditures under a fuel tax of 24 cents per gallon and a vehicle-mile tax of 1.2 cents/mile (*NETPGAS*=$1.22) for households by income group.

| Income group | With fuel tax of 24 cent/s gallon (%) | With VMT tax of 1.2 cents/ mile (%) | Change in incidence as % of income |
|---|---|---|---|
| 0–14,999 | 6.63 | 6.71 | +0.08 |
| $15,000–$29,999 | 4.09 | 4.11 | +0.02 |
| $30,000–44,999 | 3.17 | 3.16 | +0.01 |
| $45,000–59,999 | 3.06 | 3.06 | 0.0 |
| $60,000–74,999 | 2.75 | 2.72 | −03 |
| $75,000–$200,000 | 1.81 | 1.81 | 0.0 |

**Table 3**
Comparison of incidence of gasoline expenditures under a fuel tax of 24 cents/gallon and a vehicle-mile tax of 1.2 cents/mile (*NETPGAS*=$2.40).

| Income group | With fuel tax of 24 cent/s gallon (%) | With VMT tax of 1.2 cents/mile (%) |
|---|---|---|
| (0-$14,999) | 11.99 | 12.07 |
| ($15,000–$29,999) | 7.40 | 7.42 |
| ($30,000–44,999) | 5.73 | 5.72 |
| ($45,000–59,999) | 5.54 | 5.54 |
| ($60,000–74,999) | 4.98 | 4.94 |
| ($75,000–$200,000) | 3.28 | 3.27 |

**Table 4**
Change in average annual household expenditures when switching from the fuel tax to a VMT tax: urban vs. rural Oregon (*NETPGAS*=$1.22).

| | #HHs | Avg. fuel tax expenditures | Avg. vehicle-mile tax expenditures | Net change in expenditure |
|---|---|---|---|---|
| Urban | 258 | $1,188.11 | $1,188.02 | −$0.09 |
| Rural | 108 | $1,456.18 | $1,438.49 | −$17.69 |

proportionate with respect to total household expenditures (CBO, 1990).

Poterba (1991) and West (2001) argue that expenditures are a better measure of lifetime income (Friedman, 1957) and find that fuel taxes are progressive over lower income groups and regressive at higher income levels when expenditures rather than annual income is used to measure regressivity. These studies examine incidence for the entire US using the measure of consumption expenditure from the Consumer Expenditure Survey (CES). For the state of Oregon, however, the CES does not provide a large enough data set for our study. Accordingly, we use average annual household income to calculate incidence. Interestingly, an earlier study by Zupnick (1975) looked at the incidence of gasoline taxes during 1969–70 period using annual income data (rather than consumer expenditures) and a static model and also found results to West (2001)and Poterba (1991) that the gasoline tax was progressive over lower income groups and then turned regressive for upper middle and upper income groups. VMT taxes have also been found to be somewhat regressive (West, 2005; Walls and Hanson, 1999; Parry and Small, 2005).

The lowest two income groups show slight increase in incidence of 0.08% and 0.02% of income while the $30,000–$44,999 and $60,000–$74,999 income groups show slight decrease of 0.01% and 0.03% of income. The over $75,000 income group shows no change in incidence. These very small changes in incidence reflect the fact that the taxes themselves represent a very small portion of total household expenditures—much smaller than the cost of fuel itself.

To demonstrate how small the impact of the change in tax structure is relative to the effect of a change in the price of gasoline between 2001 and 2006, we recalculate the above using a gasoline price of $2.64 per gallon (a $2.40 gas price net of the gasoline tax). These results are shown in Table 3.

What becomes immediately obvious is that the regressivity of fuel expenditures has increased substantially from that shown in Table 2. While moving from a fuel tax to a VMT tax when the net gasoline price was $1.22 per gallon produced an increase in incidence for the lowest income group of 0.08%, the near doubling of gasoline prices has increased incidence with the fuel tax from 6.63% to 11.99%—an increase in incidence of 5.33% for the lowest income group!

From this analysis it becomes clear that while a change from a gasoline tax of 24 cents per gallon to a VMT tax of 1.2 cents per mile has a slightly regressive impact, it is miniscule compared to the impact on regressivity caused by the general rise in gasoline prices over time.

Finally, the results for urban and rural vehicle expenditures under the two tax structures (fuel tax and VMT tax) are shown in Table 4.

Since the sample had an average of 20.75 miles per gallon (mpg) instead of the 20 mpg required for the 1.2 cents per mile to be revenue neutral, the change from a fuel tax to a VMT tax had the net result of reducing average expenditure for all households. However, the average savings from the conversion would be *greater* for the average rural household than for the average urban household. This is attributable to the fact that on average rural households drive vehicles with lower mpg than those driven in urban areas. Also, the average rural household in our sample drives more miles than the average urban household. Thus, the concern that the average rural household in Oregon would be adversely impacted to a greater extent than an urban household, is unfounded.

The results of this static model assume that the change in tax structure have no impact on driving behavior and thus are likely to overstate the regressivity (West and Williams, 2007). The ultimate distribution of the incidence will depend on how responsive miles driven by people in different income groups are to changes in the tax (the price of gasoline). It will also depend on the type of vehicle and the number of miles driven by people in the different income groups. For instance, West (2005) argues that those in lower income groups often drive less fuel efficient vehicles and have higher elasticities of demand for vehicle mile with respect to changes in the cost of driving. In the long run changes in the cost of driving can also impact vehicle choice (Busse et al., 2009; Zhang et al., 2009). The following section uses a simple regression model to assess some of these impacts on the distributional impact of the proposed change to a VMT tax. Given the small sample size we have for Oregon, we cannot assess the long run impacts on vehicle choice here.

### 2.4. Regression model results

The regression model from Eq. (1) was estimated using a log–log functional form. The results are shown in Table 5. All signs were as expected, based on economic theory and the findings in previous studies. All interpretations are based on a 10% significance level. The adjusted $R^2$ for the model is 0.46.

The coefficient of the interaction term $P_M{*}SUB$ allowed the elasticity of demand to vary between households that were able to substitute between vehicle types, and those that had only one vehicle type. Though not statistically significant, this coefficient was of the expected sign and indicates that households that were unable to substitute between vehicle types had a more elastic demand, as expected. Using the interaction terms, we calculated the elasticities of demand for different income groups as reported in Table 6. Higher income groups, on average, were less

**Table 5**
Dependent variable—annual household miles (logarithmic).

| Variable name | Coefficient | Standard error | T-statistic |
|---|---|---|---|
| Constant | −17.72 | 6.239724 | −2.84 |
| $P_M$ | −8.76 | 2.388977 | −3.67 |
| $I$ | 2.21 | 0.613436 | 3.60 |
| $P_M{*}I$ | 0.72 | 0.2352192 | 3.05 |
| $P_M{*}SUB$ | 0.44 | 0.4005742 | 1.09 |
| U | −0.16 | 0.0950097 | −1.67 |
| $C$ | 0.54 | 0.1290508 | 4.18 |
| SUB | 1.39 | 1.050415 | 1.32 |
| MALE | 0.17 | 0.0874272 | 1.94 |
| WORK | 0.21 | 0.0528672 | 3.95 |
| CHILD | 0.04 | 0.0393044 | 0.91 |

Note: Italicized variables are logarithmic.

**Table 6**
Elasticity by income group—based on average income.

| Average income | Elasticity w/ SUB | Elasticity w/o SUB |
|---|---|---|
| $9,055.90 | 1.79 | 2.23 |
| $21,983.11 | 1.16 | 1.59 |
| $36,899.07 | 0.78 | 1.22 |
| $51,952.61 | 0.54 | 0.98 |
| $67,394.80 | 0.35 | 0.79 |
| $106,043.36 | 0.03 | 0.47 |

responsive to changes in the fuel cost per mile as were those who had an alternative type of vehicle available for use.

### 2.5. *The impact of the change in tax structure using regression model results*

In the static analysis results presented in Section 2.3, any gain in tax revenues to the government agency was exactly equal to the loss to consumers. In welfare parlance, the loss in consumer surplus is exactly equal to the producer surplus gain (increase in tax revenue here) in the static model because consumers are assumed to have a totally inelastic demand and do not change their driving in response to a change in the price of driving. Once we have a demand response, however, the consumer surplus change may deviate from the change in tax revenue. This is because a consumer who faces a higher price of driving due to the tax chance will usually respond by driving less (assuming that driving is a normal good) , making the increase in revenue to the government agency less than in the case of totally inelastic demand (which is the underlying assumption in the static model).[3]

The overall impact on social welfare once demand response is introduced in the dynamic model is the sum of the change in consumer surplus (*SURPLUS*) and the change in producer surplus, which in this case is the change in revenue to the government (*REVENUE*)

$$WELFARE = SURPLUS + REVENUE \tag{4}$$

The change in consumer surplus is calculated as

$$SURPLUS = \frac{1}{2}\{(P_M - P_{VMT}){*}(MILES_{GAS} + MILES_{VMT})\} \tag{5}$$

**Table 7**
Average changes in consumer surplus, tax revenue and welfare by income ($/household).

| Income group | Average change in consumer surplus | Average change in taxes paid | Average change in welfare |
|---|---|---|---|
| (0–$14,999) | −7.51 | 5.03 | −2.48 |
| ($15,000–$29,999) | −6.47 | 6.13 | −0.34 |
| ($30,000–44,999) | 9.36 | −4.24 | 5.12 |
| ($45,000–59,999) | −2.41 | 8.06 | 5.57 |
| ($60,000–74,999) | 28.48 | −12.92 | 15.56 |
| ($75,000–$200,000) | 12.77 | −2.60 | 10.17 |

The difference $(P_M - P_{VMT})$ determines the sign of the change. If the fuel cost per mile under the VMT ($P_{VMT}$) fee exceeds the fuel cost per mile under the gasoline tax ($P_M$), we expect a reduction in total consumer surplus as we move upward along the demand curve and consumers drive less. Some of the loss in consumer surplus goes to the producer (government) in the form of taxes[4] and some is lost to both the consumer and the government as consumers drive less. Similarly, if the fuel cost per mile decreases under the new policy, we expect household miles to increase as it becomes cheaper for households to drive and thus, increase the total consumer surplus as we move downward along the linear demand curve.

Revenue collected by the state agency after the change to the VMT tax for each household is calculated using the following Eq.:

$$REVENUE = 0.012{*}MILES_{VMT} - \left[\left(\frac{0.24}{HHMPG}\right){*}MILES_{GAS}\right] \tag{6}$$

Household miles are based on the predicted (fitted) values estimated by the model, first under the fuel tax ($MILES_{GAS}$), then under the VMT tax ($MILES_{VMT}$). To calculate the net fuel taxes collected, we consider only the $0.24 collected per gallon sold. Since we do not estimate the miles driven on individual vehicles, we cannot calculate the fuel tax revenue collected by vehicle. Instead, we use the weighted average household fuel efficiency (*HHMPG*) to calculate the per-mile cost in terms of the gasoline tax. We consider only a flat-rate VMT tax, and we calculate the revenue collected by multiplying the per-mile fee ($0.012) by the predicted household miles under the VMT tax.

Table 7 reports the average changes in consumer surplus and in taxes paid (which is the change in REVENUE and also the change in producer surplus) by income group.

As expected, the changes in tax revenue collected by the state agency as a result of a change from a gas to a VMT fee are smaller than in the static model which did not account for the reduction in miles driven in response to the increased average cost of driving for this group. For example, households in the lowest income group only pay $5.03 more in taxes here whereas this group paid an average of $7.82 per year more in the static model. However, the change in tax revenue paid by a consumer only tells part of the story. In the case of the lowest income group, there would be an average loss in consumer surplus of $7.51 that represents both the additional amount paid in taxes and the value of the reduced travel that would be caused by the increase in the cost of driving. This amount is very close to the $7.82 increase in

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[3] Of course, it is possible that a higher cost of driving may result in switching to a more fuel-efficient vehicle or cutting back on expenditures in other area. The variable SUB is included in the regression analysis specifically to capture this possible short run response.

[4] Note that in this analysis we treat the revenues collected by the government as pure rent, ignoring the distribution of revenues and only focus on the distribution of costs. In particular, we do not consider the distributional effects of rebating tax revenue or using it to reduce other taxes. This paper follows others such as West (2005) by concentrating only on the cost side. The information provided here should help policymakers develop revenue distribution mechanisms that achieve the ultimate societal distributional—which may differ from place to place.

tax paid which represented the loss of consumer surplus to this household in the static case.

Part of this would be transferred to the government agency in the form of increased revenue of $5.03 so the net impact on social welfare is a loss equal to $7.51–$5.03 = $2.48 (−$2.48 in Table 7). Note that in the static case, there was no net social welfare loss as there was simply a transfer from consumers to the government.

Overall those in the highest income groups would still have a net gain: they would pay less to drive and this would stimulate additional travel that benefits them. Further, for the two highest income groups, the change in tax structure would constitute a reduction in taxes paid. However, note that the net decrease in taxes paid by these groups is *smaller* than in the static model. This is because the lower price of driving induces them to drive more—and thus pay more total in taxes than in the static model. Their increase in consumer surplus comes from the additional benefit they derive from driving more.

The regression model based results for the urban/rural impacts were again similar to the static result although urban household would pay slightly more under the VMT tax and rural household would pay less (Table 8, column 2). However, again the average change in consumer surplus for both groups in the dynamic model are very close to the change taxes paid in the static model.

From a conceptual point of view, it is the change in consumer surplus that reflects the net impact on households and the change in consumer surplus in the static model (the change in tax revenue) is virtually identical to the change in consumer surplus for each income group in the dynamic model. Even the change in taxes paid for each group is very close in both two models. This suggests that policymakers who just need a "ballpark" estimate of the impact of a change in highway user fees could use the results provided by the static model, which requires less data analysis than calculations based on the OLS regression model.

## 3. Alternative VMT tax scenarios

As mentioned earlier, a change to a VMT tax regularly raises concerns because the change in tax structure would effectively lower the cost of driving for "gas guzzlers" and increase the total amount paid by those driving more fuel efficient cars (although the changes are likely to be very small compared to the overall cost of gasoline). Thus, such a change is seen as being in conflict with alternate goals of increasing the use of hybrid vehicles and reducing the dependence on fossil fuels.

**Table 8**
Average changes in consumer surplus, tax revenue and welfare by location ($/household).

| Location group | Average change in consumer surplus | Average change in Tax revenue | Average change in welfare |
|---|---|---|---|
| Rural | 17.40 | −9.46 | 7.93 |
| Urban | −0.62 | 4.89 | 4.27 |

A VMT tax could be formulated in a way that minimizes or reverses this unintentional impact of the policy change. Sample Scenario #1 would be a VMT tax structure that maintains the gasoline tax for those vehicles with fuel efficiency of less than 20 miles per gallon and charges a flat 1.2 cents per mile those vehicles with fuel efficiency over 20 miles per gallon. This policy would keep "gas guzzlers" from realizing a lower cost of driving (which could encourage them to drive even more). Whereas a VMT of 1.2 cents per gallon would be approximate a revenue neutral change in fee structure, Sample Scenario #1 would result in an increase in revenues collected by the state. If Sample Scenario #1 does not provide enough of an incentive for people to purchase more fuel efficient vehicles, policymakers could alternatively consider a "step" fee policy whereby vehicles would incur increasingly higher VMT taxes the lower the fuel efficiency of the vehicle. In Sample Scenario #2, vehicles that achieve less than the median fuel efficiency (approximately 18 mpg) would pay 2 cents per mile; those between the median efficiency and 20 mpg would pay 1.5 cents per mile; and those with a fuel efficiency of above 20 mpg would pay only 1 cent per mile in VMT taxes.

Note that this analysis uses the static model since the results presented earlier indicates that the qualitative impacts are very similar regardless of which model is used. Since the static model requires less data and therefore we have more observations, we report results using the static model methodology used in the previous section.

The incidence of these two scenarios on households by income group is shown in Table 9:

Both Scenario #1 and Scenario #2 result in all income groups paying more than they would under either the fuel tax or a flat VMT tax, but the increase in fees paid is represents a much larger increase in incidence—as a percent of income—for the two lower income groups than it is for households in higher income groups. Thus, while the alternate scenarios may be seen as promoting more fuel efficient vehicles, they do so at the expense of making the tax structure even more regressive than under a flat VMT tax.

## 4. Conclusions

Proposals to change the current structure of highway user fees for light vehicles from a fuel tax to a VMT tax have often met with resistance based on arguments that such a change would adversely impact low income groups, would place a substantial

**Table 9**
Average change in household annual expenditures on gasoline under: (1) Flat VMT of 1.2 cents per mile, (2) sample scenario #1: gasoline tax of $0.024 for vehicle with mpg $<$ 20; VMT of $0.012 for vehicles with mpg $>$ 20 and (3) sample scenario #2: (a) mpg $<$ median mpg pays 2 cents cents/mile (b) between median mpg to 20 pays 1.5 cents/mile.

| Income group | (1) Average change in user fee paid under vehicle-mile tax of $0.012/mile | Change in incidence as % of income | (2) Average change in fee paid under sample scenario #1 | Change in incidence as % of income | (3) Average change in user fee paid under sample scenario #2 | Change in incidence as % of income |
|---|---|---|---|---|---|---|
| (0–$14,999) | $7.82 | +0.08 | $16.46 | +1.66 | $15.29 | +1.54 |
| ($15,000–$29,999) | $5.19 | +0.02 | $17.17 | +0.08 | $25.78 | +1.15 |
| ($30,000–44,999) | −$4.40 | −01 | $17.90 | +0.05 | $30.89 | +0.08 |
| ($45,000–59,999) | $0.23 | 0.0 | $28.47 | +0.06 | $43.11 | +0.08 |
| ($60,000–74,999) | −$25.34 | −03 | $22.40 | +0.03 | $74.71 | +0.11 |
| ($75,000–$200,000) | −$6.00 | 0.0 | $31.08 | +0.03 | $76.56 | +0.07 |

burden on rural versus urban drivers, and that such a tax would discourage the adoption of hybrid vehicles. This paper provides a quantitative analysis of the impact of switching from a fuel tax of 24 cents per mile to a flat 1.2 cent per mile VMT tax using the example of the state of Oregon.

While results confirm that a change from a fuel tax to a VMT tax would increase the regressivity of an already regressive fuel tax system, the impact is very small. This is especially true when compared to the increase in regressivity of total fuel expenditures that has been caused by an increase in the retail price of fuel from about $1.46 in 2001 to over $2.64 by 2008.

Contrary to expectation, results here find that households in rural areas would actually benefit from a change in tax regimes from a fuel tax to a VMT tax. This is due to the fact that on average, rural households own vehicles that have lower mpg even though they drive more miles than urban households.

Since the models and data used here for Oregon here could not deal with issues of long run vehicle choice, we analyze the distributional impact of two alternative VMT tax scenarios that might be suggested to discourage the use of less fuel efficient vehicles (and presumably encourage changing to a more efficient vehicle). The bottom line is that although such alternate structures may provide incentive to purchase a more fuel efficient vehicle, these policies have an even larger negative impact on those in lower income groups, than a flat VMT tax.

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## Appendix A. The static model

We calculate total household expenditures on gasoline (including taxes) under the fuel tax of 24 cents per gallon and then again under the proposed 1.2 cent per gallon VMT tax. For the calculation of fuel tax expenditures, we take the number of miles driven by the household (*MILES*) and divide this by the weighted average fuel efficiency for the household vehicles (average miles per gallon, *MPG*), to get the number of gallons of fuel purchased by the household (*GALLONS*):

$$GALLONS = \frac{MILES}{MPG}$$

To get total expenditures (*GASTOTEX*) under the fuel tax, we multiply the number of gallons (*GALLONS*) by the average price paid for fuel (*PGAS*) where *PGAS* includes the current fuel tax of 24 cents per gallon.

$$GASTOTEX = (PGAS)(GALLONS)$$

The calculation for total expenditures under a vehicle mile tax of 1.2 cents per gallon is made by taking the current gas price (*PGAS*) and subtracting the 24 cent per gallon fuel tax to get the net price of gasoline, *NETPGAS*

$$NETPGAS = PGAS - 0.24$$

We then multiply *NETPGAS* by the number of gallons for the household (*GALLONS)* and add in the amount spent on the vehicle mile tax by multiplying 1.2 times the number of miles (*MILES*) driven:

$$VMTTOTEX = ETPGAS \bullet GALLONS + 0.012 \bullet MILES$$

The net change in household expenditures is calculated as the difference between household expenditures under the two tax regimes

$$EXCHANGE = VMTTOTEX - GASTOTEX$$

A negative value for *EXCHANGE* indicates that the change to a vehicle mile tax reduces household expenditures on gasoline and road taxes; a positive value indicates that there would be an increase in expenditures when switching to the VMT tax.

To get incidence measures for the aggregate of households in various groups (such as income or rural/urban groups), we simply aggregate relevant measures over households in the group. So, for instance, to get a measure of the incidence of fuel taxes by income group *j*, we sum the total fuel tax paid by each of the *i* households in income group *j*:

$$\sum_{i=1}^{I} \frac{TOTALGASTAX_i}{INCOME_i}$$

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