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ARTICLE

Vehicle miles traveled fee to complement the gas tax and mitigate the local transportation finance deficit

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ABSTRACT

The objective of this research is to gather data for an urban area, evaluate, and assess the applicability of vehicle miles traveled (VMT) fee to replace or complement the gas tax, and mitigate the local transportation finance deficit. Vehicle data collected from three geographically distributed service stations in Charlotte, North Carolina were used to evaluate multiple VMT fee scenarios. The results indicate that charging 0.625 cents per each mile traveled or 1.00 cent per additional mile exceeding 5,000 miles per year, to complement the gas tax, could generate enough revenue to mitigate the transportation finance deficit estimated equal to $30 M to $35 M at the time of this research for the city of Charlotte, North Carolina. Furthermore, this research explored the gross vehicle weight (GVW) as a factor to account for pavement deterioration, emissions, and the effect of heavier vehicles on travel time and safety for charging vehicle owners. The cost to implement the recommended VMT fee is minimal, the driver's privacy is protected, and the VMT fee is less than $100 per year per vehicle for over 75% of the vehicle owners in the urban area.

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Vehicle miles traveled; VMT; gas tax; weight; finance; deficit

Introduction

The United States surface transportation infrastructure construction, operation, and maintenance expenditures have increased over time but have not kept pace with the demands of a growing nation. The federal contribution as a percentage of total spending has remained almost constant since the early nineties (Congress of the United States - Congressional Budget Office (CBO), 2010). The gas tax has been the primary source of revenue to support these expenditures for over 80 years. It has been widely adopted to generate revenue, for constructing, operating, and maintaining the surface transportation infrastructure, from vehicle owners without charging general taxes to the entire population. Also, the gas tax is easily payable by the vehicle owners as they are billed in small increments every time a vehicle owner purchases fuel. The administration of gas tax is easy and inexpensive. It has a low fraud potential (as gas tax is paid directly by the

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distributors) and protects the vehicle owners' privacy. The gas tax is, however, incapable of generating enough revenue for regional and local agencies to construct, operate, and maintain the surface transportation infrastructure. More than 48 billion dollars have been, therefore, used from the general fund to mitigate the deficit in the Highway Trust Fund since 2009 (Nevada Department of Transportation (NDOT), 2010).

There are three main issues with the gas tax. Firstly, there is a lack of regard for inflation. The gas tax is generally adjusted at the state-level from time to time, but the federal portion of the gas tax has remained the same for the past 30 years (Al-Deek & Moradi, 2013). Secondly, there is an increase in the use of alternative sources of energy in engine technology (hybrid, electric, natural gas, and other means of engine propulsion) and fuel efficiency standards in miles per gallon (MPG). In 1974, the average fuel efficiency from all new vehicles was 14.2 MPG; however, by the year 1997, it was 27.6 MPG (Wachs, 2001). The increasing demand for alternative sources of energy is diminishing the use of gasoline and diesel, and subsequently reducing the gas tax revenue. Thirdly, the gas tax rate is considered low. The current gas tax rate in the United States is estimated at two cents per mile (Parry & Small, 2005). Furthermore, the gas tax does not directly account for pollution caused by vehicles, congestion during the peak hours, pavement deterioration and surface transportation infrastructure maintenance needs due to the use of the system over time, and the effect of heavier vehicles on travel time and safety. The United States has the lowest gas tax rate among industrialized countries (Parry & Small, 2005). The gas tax in the United States will have to be approximately one dollar per gallon to account for the effect of the aforementioned factors (Parry & Small, 2005).

One solution to mitigate the problem of insufficient transportation revenue could be to redesign the existing gas tax. To make any real impact, a new gas tax would have to account for the full cost of vehicles and owners/drivers to the society and not just for road construction, operation, and maintenance. A new gas tax scheme will have to be based on a percentage of the cost of fuel rather than a fixed rate. However, a gas tax with these characteristics will have to be in the range of around \$1.50 to \$2.50 per gallon, depending on the cost of fuel. This idea is very unlikely to be approved for two main reasons; raising the gas tax is not a politically popular decision, and hardship would be brought to millions of Americans by increasing the federal gas tax from approximately eighteen cents to two dollars overnight.

In 2006, the Transportation Research Board (TRB) published a special report on the gas tax and other alternatives for transportation funding (Transportation Research Board of the National Academies (TRB), 2006). The main alternative discussed in their report to mitigate the transportation finance deficit is the vehicle miles traveled (VMT) fee. While increasing the gas tax may be a viable short-term strategy, implementing the VMT fee is generally considered as a long-term strategy (Costa et al., 2013).

Most of the past studies focused on national- or state-level policy recommendations and transportation finance deficit. The funds allocated for implementation of projects using currently adopted distribution methods may not cater to the needs at the regional and/or local level. Furthermore, the VMT fee to meet the needs and transportation finance deficit could differ when assessed at the regional and/or local level compared to state or national level. Besides, not much was done on whether to replace or complement the gas tax. Also, not much was done on charging by the vehicle type (for example, weight) as different types of vehicles have varying influence on the maintenance needs and operational performance (travel time and safety). As the estimated revenue from the gas tax required financial resources, and transportation finance deficit could differ from one urban area to another urban area, there is a need to define easily implementable urban area-specific scenarios, compare, and recommend a VMT fee that could generate enough revenue to mitigate the transportation finance deficit (for example, estimated equal to $30 M to $35 M at the time of this research for the city of Charlotte, North Carolina). Therefore, the objective of this research is to collect geographically distributed sample data for an urban area, to process the data, and to estimate the VMT fee specific to an urban area to mitigate the local transportation finance deficit. Such a methodology and analysis will help meet the regional/local transportation finance needs without burdening others who may not be directly associated with the subject surface transportation infrastructure.

Literature review

A brief review of VMT fee studies and prototypes is presented in this section. It is followed by the limitations of past research and the contribution of the current research.

Vehicle miles traveled (VMT) fee studies and prototypes

Throughout the United States, there are several states, regional agencies, and local agencies as well as researchers that had conducted studies about the VMT fee. The first major VMT fee study was conducted by the Oregon Department of Transportation (ODOT) in 2001 and was completed in mid-2007 (Kim et al., 2008; Whitty, 2007). The results from their project and lessons learned demonstrated that a VMT fee could be implemented to replace the gas tax as the principal revenue source for surface transportation infrastructure funding. A high-level of public acceptance was observed as more than 90% of the participants said that they would agree to continue paying the VMT fee instead of the gas tax if the program was extended statewide (Whitty, 2007). However, the study showed that even with the initial capital (estimated $33 M solely for the state of Oregon at the time of their study) to implement the VMT fee collection system, it could take more than 20 years before it is fully operational (Whitty, 2007).

In spite of the challenges associated with the implementation of the VMT fee, charging the VMT fee could result in several benefits. Al-Deek and Moradi (2013) used data for the State of Florida and observed that a VMT fee will help generate substantially more revenues. Similarly, Vavrova et al. (2017) used data for the state of Texas and illustrated some of the potential revenues and benefits associated with a VMT fee. While virtually no differences in impacts to urban and rural areas may be seen statewide, certain rural counties may benefit from implementing the VMT fee (Matteson et al., 2016). Further, implementing a VMT fee could also reduce overall VMT/congestion and improve air quality in the study state or region (Al-Deek & Moradi, 2013; Boos & Moruza, 2008; Zhang & Lu, 2013). Implementing a VMT fee in a state or region could also affect the neighboring states or regions to varying degrees (Zhang & Lu, 2013), in particular along the state or region borders.

Bertini et al. (2002) discussed a wide area and data hub option for setting up fee collection centers. VMT or raw location data could be transmitted from the vehicle to collection centers using cellular communications in the case of the wide-area option, while VMT or raw location data could be transmitted from the vehicle to an intermediary reader located at the Department of Motor Vehicle (DMV) centers or fuel stations in the case of the data hub option.

Donath et al. (2006) described a system meant for near-term deployment through the use of an in-vehicle device that electronically computes the distance and then securely communicates relevant details to a server station or a specified location for processing and transferring accumulated fees from the vehicle owner. One of the unique ideas from their research was the application of zones and the strong argument that different fees should be charged depending on the type of road and its proximity to highly congested areas. Likewise, the Council of State Governments (Council of State Governments (CSG), 2010) discussed that fees could be charged for driving in different pricing zones at different times of the day. The pilot program testing the strategy produced a 22% decline in VMT during the peak periods.

Weatherford (2011) evaluated the implications of replacing the federal gas tax (per gallon) with an equivalent flat-rate VMT fee of 0.98 cents per mile. The phase 1 VMT fee study for the state of Nevada estimated the VMT fee as 2.33 cents per mile for passenger cars and 2.90 cents per mile for light trucks based on the gas tax rate of 52.205 cents per gallon at the time of their research (Nevada Department of Transportation (NDOT), 2010) While Paz et al. (2014) recommended charging 3.3 cents per mile as VMT fee than the then existing gas tax for the state of Nevada, Khau et al. (2014) estimated that a 2.1 cents per mile VMT fee would generate adequate revenue and could potentially be used as an alternative for the then gas tax in the state of California.

Some researchers have examined equity performance due to the implementation of the VMT fee (Kastrouni et al., 2015; Larsen et al., 2012; Matteson et al., 2016; Weatherford, 2011). Weatherford (2011) found that a VMT fee will be less regressive than the gas tax by shifting the burden of taxation from low-income households to high-income households. Larsen et al. (2012) observed that a VMT fee is more equitable than the current gas tax for the state of Texas.

Kastrouni et al. (2015) observed that households in states with lower gas tax operated lower fuel-efficient vehicles and contributed to a larger portion of revenues generated by the gas tax. Contrarily, households with higher fuel-efficient vehicles or with a higher average income generated more annual trips and may pay relatively more in VMT fees than gas taxes (Kastrouni et al., 2015; Matteson et al., 2016).

Yang et al. (2016) designed and evaluated equitable and progressive mileage-based VMT fee policies, focusing specifically on income-based fee rate structures. They found that income-based VMT fees can better protect lower-income households and generate additional revenue. Contrarily, the fixed-interval incremental fee structure is suitable across all income groups while ensuring that equity and revenue goals are met. Further, implementing an income-based VMT fee could be much more complicated and challenging than a flat-rate or fixed-interval incremental VMT fee.

A few researchers examined the effect of an increase in VMT fee on VMT and cost increase for various population groups. Larsen et al. (2012) researched using data for the state of Texas and observed that 0.3% of VMT will be reduced due to a 1% increase in

VMT fee. Though the VMT fee increase may have a slightly greater impact on various population groups, its equitable distribution of the tax burden among more than 70% of the households creates only a marginal cost increase per household (Paz et al., 2014).

Most of the past studies, in general, indicate that implementing any type of VMT fee is a viable alternative but will take several decades to replace the gas tax. However, a VMT fee itself is not significant in either the short or long run, and should not be a hindering factor in the implementation of the VMT fee (Zhang et al., 2009).

Limitations of past research and the contribution of the current research

Charging vehicle owners a VMT fee based on how many miles they travel during a pre-set period appears to be the most reasonable and efficient alternative to generate revenue and mitigate the transportation finance deficit. Yet, many states and agencies in the United States are not inclined to implement or incorporate the VMT fee at the time of this research. This could be because, most of the systems recommended for implementing a VMT fee in the past are associated with some type of GPS or tracking device technology, and the public and society reject such a system due to concerns with privacy and government surveillance in their daily lives. The initial cost or capital investment to launch the system also seem to be prohibitively expensive. Regardless as to whether adding a device in every vehicle will be part of the initial cost; there is another investment – the setup for the service stations or the creation of fee collection centers. The fact is that exchanging the gas tax for another method will require millions of dollars in investment. Besides, the time frame for the full adoption of a VMT fee is estimated to be between 20 to 30 years from the initial time of implementation.

There are no studies proposing a short-term solution or focusing specifically on VMT fee to mitigate transportation finance deficit at the regional or local level. There is also an uncertainty of how much to charge to be fair to the vehicle owners and the surface transportation infrastructure. This could vary from one region/locality to another region/locality and depends on the vehicle types using the regional/local surface transportation infrastructure and their average fuel efficiency. Besides, there is not much research documenting if the VMT fee would mitigate the transportation finance deficit or if it should be replacing or complementing the gas tax when implemented at the regional or local level. Additionally, most of the past VMT fee studies/prototypes do not account for the effect of the vehicle type on pavement deterioration, emissions, and operational performance (for example, the effect of heavier vehicles on travel time and safety).

This research contributes by proposing a method to gather and evaluate data for an urban area, explore various scenarios, and establish a VMT fee to replace or complement the gas tax. It could be implemented in conjunction with the annual vehicle state safety inspection in which the odometer reading is recorded and the VMT during the year made available to the state, regional, or local tax office for processing and billing.

Methodology

The city of Charlotte, North Carolina was considered as the study area. The methodology to estimate a VMT fee at the regional or local level requires a thorough understanding of regional/local financial data, types of vehicles using the regional/local surface transportation infrastructure, their fuel efficiency, and the average VMT per year per vehicle. Therefore, the methodological approach adopted includes 1) collecting financial information for the city of Charlotte, North Carolina, 2) gathering vehicle data to assess VMT per year as well as to estimate fuel consumed and gas tax contributed per year by each vehicle, and 3) identifying VMT fee scenarios for assessment. They are discussed next in detail.

Financial information and data

The focus of this task was to obtain financial information and data for the city of Charlotte, North Carolina. The financial data obtained for this research came from two main sources. The first source was the 2012–2013 Strategic Operating and Capital Investment Plan for the city of Charlotte, North Carolina. The second source was the 2013 city of Charlotte Department of Transportation (CDoT) Strategic Operating Plan. These reports included the revenues and expenditures for the city and the transportation department, amongst other information. Such information is critical to assess the financial situation and to estimate a typical urban area's debts and annual obligations. Likewise, this is vital information to make short- and long-term budgetary predictions. Besides, discussions with the staff of regional or local agency could provide vital insights related to their financial structure and limitations.

Vehicle data

Unlike previous studies that were based on National Household Travel Survey (Kastrouni et al., 2015; Larsen et al., 2012; Paz et al., 2014; Weatherford, 2011) or participant survey data (Kim et al., 2008; Whitty, 2007; Zhang et al., 2009), vehicle data gathered for the study area was used in this research. This data was obtained from three geographically distributed field locations and from the annual Fuel Economy Guide (FEG) reports on the Environmental Protection Agency (EPA) website. The fuel economy reports were used to capture each vehicle fuel efficiency rating or MPG by make, model, and year of manufacture.

The three service stations were strategically selected to better represent the city of Charlotte, North Carolina. The first station was the Tire Kingdom Store located on University City Blvd in Charlotte, North Carolina (north-east quadrant of the study area). This location was able to provide a total of 1,017 observations from August 7 to September 19 of 2012. The second station was the Meineke Car Care Center located on East Independence Blvd in Charlotte, North Carolina (south-east quadrant of the study area), which provided a total of 1,110 observations from August 6 to September 19 of 2012. The third station was the Jiffy Lube Store located on South Blvd in Charlotte, North Carolina (south-west quadrant of the study area). This station provided a total of 1,247 observations from August 7 to September 23 of 2012. The following information was requested at each location.

(1) Make
(2) Model
(3) Year

(4) Body style (two or four doors)
(5) Class (compact, mid-size, full-size, luxury, etc.)
(6) Odometer reading
(7) City
(8) State
(9) Zip-code

The next step was to combine and organize the data, as well as to ensure that incorrect and missing records are removed. Samples with missing class or body-style information were kept while a sample was removed if any other information was missing or incorrect (model year 0000, odometer reading 999,999, etc.). Each station provided a file, and each file was organized separately. Then, the files were imported into an Excel sheet and organized in ascending order by make and model. The corresponding fuel efficiency rating or MPG of each vehicle from the Fuel Economy Guides (FEG), by make, model, and year of manufacture was then added to the database. The MPG used for this research was taken as the combined MPG, which according to the FEG reports is derived from 55% of the city MPG and 45% of the highway MPG. In addition to the MPG, each vehicle was assigned its gross weight. The gross weight was obtained from the National Automobile Dealerships Association (NADA) guides under the consumer section.

The next step was to compute the age of the vehicle and the average VMT per year. The age of the vehicle was obtained from subtracting the model year from 2013, assuming that all vehicles were sold and placed in operation by the August–September time frame of the vehicle's model year. For each vehicle, the average VMT per year was computed by dividing the odometer reading by the vehicle's age.

$$A = 2013 - Year \qquad \text{Eq.(1)}$$

$$\mathrm{M}' = \mathrm{Odometerreading}/\mathrm{A} \qquad \text{Eq.(2)}$$

where A = age of the vehicle, Year = model year of the vehicle, and, M′ = average VMT per year.

VMT fee scenarios

Multiple VMT fee scenarios were identified and considered in this research. They are discussed in this sub-section.

Gas tax and VMT scenarios

The first scenario (base scenario) was to compute the existing gas tax paid from the data gathered to compare against the VMT fee scenarios. This scenario is labeled as NC Gas Tax Scenario.

CDoT is one of the transportation agencies in the United States that had considered the implementation of a VMT fee to generate funds for surface transportation infrastructure construction, operation, and maintenance. CDoT has proposed two rates depending on approval by Charlotte's City Council. The rate is proposed to be either one or two cents per mile traveled for every vehicle registered in the city of Charlotte, North Carolina. The total estimated revenue could be $72 M per year for the one-cent

VMT fee and $144 M per year for the two-cent VMT fee (Committee of 21, 2009). These two VMT scenarios are considered as a replacement for the gas tax in this research.

Miles-based complement scenarios

In addition to the gas tax and VMT fee scenarios, three other VMT fee scenarios based on the miles driven were considered as complement scenarios. The first of these three scenarios (Scenario #1) consists of the VMT per year with a deduction for the first 10,000 miles, where vehicle owners who exceed 10,000 VMT per year will be charged a fee of 1.25 cents per mile. The rationale for this scenario of charging miles exceeding 10,000 is to account for the VMT per year an average vehicle owner travels on state-maintained roads to provide funds to a local transportation agency. In Scenario #2, the VMT rate was reduced to 1.00 cent per mile, to match the proposed CDoT rate, with a deduction of 5,000 miles, which is 50% of the estimated VMT an average vehicle owner drives on state-maintained roads. The 10,000 miles and 5,000 miles are approximately two-thirds and one-third of the expected VMT per year for a vehicle (on all roads) in the city of Charlotte, North Carolina (observed to be 13,000 from the sample data). In Scenario #3, the VMT rate was reduced to 0.625 cents per mile, but no deduction was applied and every VMT is charged. The rationale for charging higher in case of scenarios 1 and 2 is to limit and discourage driving beyond a certain limit by a vehicle owner. These scenarios are particularly used to complement rather than replace the gas tax. A potential problem with the first two scenarios is that families with more than one vehicle could take advantage of these reductions and use multiple vehicles to reduce or be exempt from paying a VMT fee; therefore, these vehicles would not contribute to the VMT fee-based revenue. In other words, scenarios 1 and 2 may result in inequality or bias towards some vehicle owners (demographic/socio-economic groups) and need to be adopted with caution and additional planning (to be fair to everyone).

Weight-based complement scenarios

Vavrova et al. (2017) differentiated VMT fees by axles (an indicator of road damage) and by vehicle emission class (an indicator of pollution). Similarly, in this research, the GVW was considered as a factor to account for pavement deterioration, emissions, and operational performance. This is like the weight-distance tolls directly charged to heavy vehicles, trucks, and trailers. Under the weight-distance toll system, drivers of heavy vehicles, trucks, and trailers must pay a fee to use the surface transportation infrastructure based on the vehicle's weight and distance traveled. Depending on the specific program, the measurement of weight may be based on actual weight, maximum laden weight, or axle configuration (Sorensen & Taylor, 2005).

Three weight-based complement scenarios were proposed and considered in this research. The rationale for using the GVW is to account for the effect of vehicle weight on the gas tax, VMT fee, and surface transportation infrastructure maintenance needs. Additionally, GVW is included in the vehicle registration information, which means less administrative work (no need to add a new variable for each vehicle).

The weight factor was computed and applied to scenario #3. From the vehicle sample data, it was found that the average and median gross weight was around 3,600 lbs and 3,400 lbs, respectively. Therefore, in scenario #4, the weight factor was computed using an overweight threshold of 3,500 lbs. This overweight threshold was increased to 4,000 lbs and 4,500 lbs for scenario #5 and #6, respectively, to check how sensitive the estimates would be based on the weight.

Equation 3 summarizes the relation between VMT and GVW obtained from the sample data. Equations 4 and 5 summarize the computation of the weight factor. If the weight factor is equal to or less than zero, the factor applied to the VMT fee is one (Equation 4); otherwise, the factor is based on Equation 5.

$$\mathrm{VMT} = 10,549 + 0.681(2\mathrm{GVW}) \qquad \text{Eq.(3)}$$

$$\mathrm{WF} = [(\mathrm{GVW} - \mathrm{w}')\mathrm{x}0.681]/\mathrm{w}' \leq 0, \mathrm{then} 1 \qquad \text{Eq.(4)}$$

$$\mathrm{WF} = [(\mathrm{GVW} - \mathrm{w}')\mathrm{x}0.681]/\mathrm{w}' > 0, \mathrm{then} 1 + (\mathrm{WF}/100) \qquad \text{Eq.(5)}$$

where WF = weight factor,

GVW = gross vehicle weight, and,

w′ = overweight threshold (3,500, 4,000 or 4,500 lbs based on the selected scenario).

Overall, the following six VMT and weight-based fee scenarios were identified, considered, and evaluated in this research.

(1) Scenario 1–1.25 cents per mile; deduction for first 10,000 miles
(2) Scenario 2–1.00 cent per mile; deduction for first 5,000 miles
(3) Scenario 3–0.625 cents per mile; no deduction
(4) Scenario 4–0.625 cents per mile × weight factor based on 3,500 lbs
(5) Scenario 5–0.625 cents per mile × weight factor based on 4,000 lbs
(6) Scenario 6–0.625 cents per mile × weight factor based on 4,500 lbs

Results

A review of financial information collected for the city of Charlotte, North Carolina and discussions with CDoT staff indicates that the approved expenditures for the fiscal year 2013 were equal to $61.8 M while the actual expenditures for the fiscal year 2012 were equal to $55.5 M. The total revenue from the gas tax was estimated equal to $28.8 M, while the projected transportation finance deficit could range from $30 M to $35 M. State funds, grant funds, and other taxes/fees are traditionally used to minimize the transportation finance deficit and build/maintain the surface transportation infrastructure.

Approximately 73% of the sampled vehicles are registered with owners' residence in the city of Charlotte, North Carolina while 80% of the sampled vehicles are registered with owners' residence in Mecklenburg County (in which Charlotte, North Carolina is located). Overall, 27% of the sampled vehicles are not registered with owners' residence in the city limits of Charlotte, North Carolina. Therefore, one in three vehicles driving on Charlotte, North Carolina roads may not contribute to the VMT fee revenue of Charlotte, North Carolina. Most of these vehicle owners' may be living in surrounding counties (Cabarrus County, Gaston County, Union County and York County) and using freeways/expressways/highways which are state-maintained roads.

The average and median MPG from the samples collected for the city of Charlotte, North Carolina was 19.99 and 19.00, respectively. This is relatively lower than the national average (22 MPG at the time of this research). The average and median North Carolina gas tax per vehicle was estimated to be $257 and $233 per year, respectively. This is comparable to approximately two cents per mile, as was also stated in or observed from past studies (Khau et al., 2014; Nevada Department of Transportation (NDOT), 2010; Parry & Small, 2005).

The sample collected for this research shows that the average VMT per vehicle is approximately 13,000 miles per year. Likewise, the number of registered vehicles in Charlotte, North Carolina is 550,000 at the time of this research, and the estimated total VMT is approximately 7.15 billion miles per year. At a rate of one cent per mile, the total estimated revenue for Charlotte would be $71.5 M per year. It would be $143 M per year if the rate is two cents per mile. These values are similar to the total revenue projected by the Committee of 21 (2009).

The VMT fee ranges from $10 to $416 with 55.5% of the vehicles estimated to pay between $100 to $199 per year per vehicle. These values were computed using one cent per mile and the number of miles per year for each vehicle in the data sample.

For example: 12,000 miles per year × $0.01 = $120 VMT fee per year

A similar procedure was used for all other scenarios. No other factors are accounted for or considered in these scenarios. Tables 1–3 show the vehicle distributions and percentages for each scenario. The total estimated revenue at the bottom of each table was computed from the average VMT fee, for each scenario, for the 3,200 samples and applied to the 550,000 registered vehicles in the city of Charlotte, North Carolina.

The results indicate that the two cents per mile scenario could generate more revenue than the current gas tax for CDoT. Figure 1 shows the estimated revenue from the gas tax and both VMT fee scenarios.

Table 1. Vehicle distribution and percentages for the gas tax and CDoT scenarios.

	Vehicle Distribution			Percentage		
Fee ($)	Gas Tax	VMT @ 1 cent/ mile	VMT @ 2 cents/ mile	Gas Tax	VMT @ 1 cent/ mile	VMT @ 2 cents/ mile
>1,000	2			0.1%	0.0%	0.0%
900–999	2			0.1%	0.0%	0.0%
800–899	6		3	0.2%	0.0%	0.1%
700–799	24		7	0.8%	0.0%	0.2%
600–699	43		36	1.3%	0.0%	1.1%
500–599	112		75	3.5%	0.0%	2.3%
400–499	213		261	6.7%	0.1%	8.2%
300–399	564	38	610	17.6%	1.2%	19.1%
200–299	1,023	329	1,162	32.0%	10.3%	36.3%
100–199	994	1,777	885	31.1%	55.5%	27.7%
50–99	185	891	132	5.8%	27.8%	4.1%
>1–49	32	162	29	1.0%	5.1%	0.9%
0				0.0%	0.0%	0.0%
# of Observations	3,200	3,200	3,200	100%	100%	100%
Average (Per Vehicle)	$257	$130	$260			
Median (Per Vehicle)	$233	$122	$244			
Total Est. Revenue	$141.0 M	$71.5 M	$143.0 M			

Table 2. Vehicle distribution and percentages for scenarios 1, 2, and 3.

	Vehicle Distribution				Percentage			
Fee ($)	VMT @ 1 cent/mile	Scenario 1	Scenario 2	Scenario 3	VMT @ 1 cent/mile	Scenario 1	Scenario 2	Scenario 3
>400	3				0.1%	0.0%	0.0%	0.0%
300–399	38	16	10		1.2%	0.5%	0.3%	0.0%
200–299	329	78	105	30	10.3%	2.4%	3.3%	0.9%
100–199	1,777	466	876	796	55.5%	14.6%	27.4%	24.9%
50–99	891	649	1,168	1,812	27.8%	20.3%	36.5%	56.6%
>0–49	162	937	879	562	5.1%	29.3%	27.5%	17.6%
0		1,054	162		0.0%	32.9%	5.1%	0.0%
# of Observations	3,200	3,200	3,200	3,200	100%	100%	100%	100%
Average (Per Vehicle)	$130	$49	$81	$81				
Median (Per Vehicle)	$122	$28	$72	$76				
Total Est. Revenue	$71.5 M	$30.0 M	$44.5 M	$44.5 M				

Table 3. Vehicle distribution and percentages for scenarios 4, 5, and 6.

	Vehicle Distribution				Percentage			
Fee ($)	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 3	Scenario 4	Scenario 5	Scenario 6
>400					0.0%	0.0%	0.0%	0.0%
300–399		2	1	1	0.0%	0.1%	0.0%	0.0%
200–299	30	63	46	39	0.9%	2.0%	1.4%	1.2%
100–199	796	986	880	808	24.9%	30.8%	27.5%	25.3%
50–99	1,812	1,646	1,734	1,786	56.6%	51.4%	54.2%	55.8%
>0–49	562	503	539	566	17.6%	15.7%	16.8%	17.7%
0					0.0%	0.0%	0.0%	0.0%
# of Observations	3,200	3,200	3,200	3,200	100%	100%	100%	100%
Average (Per Vehicle)	$81	$89	$85	$83				
Median (Per Vehicle)	$67	$82	$79	$77				
Total Est. Revenue	$44.5 M	$48.9 M	$46.7 M	$45.6 M				

In scenarios 1 and 2, a deduction of 10,000 miles and 5,000 miles, respectively, was used for each vehicle; therefore, only miles over these limits were accounted towards the VMT fee. About 25% do not pay VMT fees in the case of scenario 1 while about 5% do not pay VMT fees in the case of scenario 2.

In the case of scenario 3, every vehicle is charged 0.625 cents per mile, and no reduction is applied. This scenario has better distribution and smaller range area. The maximum fee per year per vehicle is $260 compared to $395 and $366 from scenario 1 and scenario 2, respectively. As the VMT fee in these scenarios is meant to complement the deficit created by the gas tax, having higher VMT fees could produce several vehicle owners to delinquent payment. Figure 2 shows plots summarizing results from scenarios 1 through 3.

The scenarios 4, 5, and 6 are based on a weight factor with an overweight threshold of 3,500 lbs, 4,000 lbs, and 4,500 lbs, respectively. The results are relatively similar for these three scenarios. The majority of the VMT fee ranges in the $50 to $99 range, with both the mean and the median equal to $80 per year per vehicle. Furthermore, less than 1% of

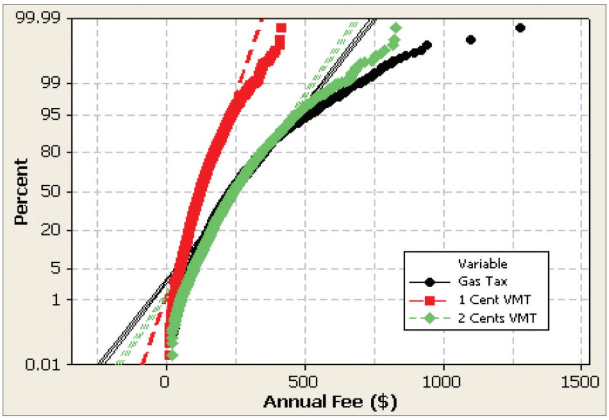

Figure 1. VMT fee comparison plot for gas tax and VMT fee scenarios.

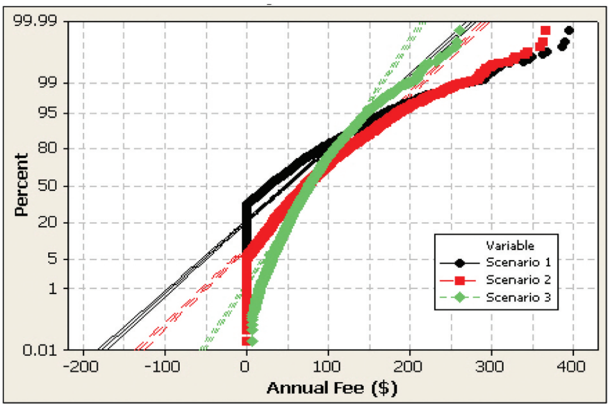

Figure 2. VMT fee comparison plots for scenarios 1, 2 and 3.

the vehicle owners are charged over $200 in comparison to the previously discussed scenarios where more than 4% of the vehicle owners are charged $300 or higher per year per vehicle in VMT fees.

Discussion

The current gas tax, though incapable of generating enough revenue to keep up with inflation and growing needs does provide a good amount of revenue to the CDoT. It amounts to more than $28.8 M per year (Table 4). Besides, it also provides millions of dollars for the construction, operation, and maintenance of the federal and state roads (I-77, I-85, NC-49, US-74, etc.). Additionally, the gas tax provides revenues to the Charlotte Area Transit System, the light rail transit system, and the airport, among others. Therefore, implementing a VMT fee for an urban area like Charlotte, North Carolina shall be more suitable and practical with the objective of complementing and mitigating the transportation finance deficit, as opposed to replacing the gas tax.

Table 4. Summary of VMT scenarios.

	Gas Tax	VMT @ 1 cent/mile	VMT @ 2 cents/mile	Scenario 1	2	3	4	5	6
Per Vehicle (Based on the Collected Sample)									
Minimum	$22	$10	$21			$7	$7	$7	$7
Average	$257	$130	$260	$49	$81	$81	$89	$85	$83
Median	$233	$122	$244	$28	$72	$76	$82	$79	$77
Maximum	$1,278	$416	$832	$395	$366	$260	$390	$351	$321
Total for the City of Charlotte, North Carolina									
Total Estimated Revenue	$141.0 M	$71.5 M	$143.0 M	$30.0 M	$44.5 M	$44.5 M	$48.9 M	$46.7 M	$45.6 M
Projected Revenue	$28.8 M*	$53.3 M	$107.3 M	$22.5 M	$33.4 M	$33.4 M	$36.7 M	$35.0 M	$34.2 M

*= Actual gas tax funds
Projected revenue = 75% of the total estimated revenue
Scenario 1 = 1.25 cents per mile after 10,000 miles
Scenario 2 = 1.00 cent per mile after 5,000 miles
Scenario 3 = 0.625 cents per mile
Scenario 4 = 0.625 cents per mile × weight factor based on 3,500 lbs
Scenario 5 = 0.625 cents per mile × weight factor based on 4,000 lbs
Scenario 6 = 0.625 cents per mile × weight factor based on 4,500 lbs

It was observed from the vehicle data that the gas tax can generate about $140 M. The combined total from the 3,200 observations can generate $822,000 to the North Carolina gas tax (Powell Bill). Using these values, on average, each vehicle owner in Charlotte, North Carolina pays approximately $245 per year per vehicle. Due to the Highway Trust Fund distribution formula to distribute funds back to each municipality based on multiple factors and purposes within each transportation agency, the CDoT gets a relatively small portion compared to the amount contributed from the gas taxes. The Highway Trust Fund distribution is a battle many such metropolitan cities and states throughout the United States have been fighting and disputing for decades without any success. The main argument for maintaining this distribution method is equality. The reason for equality in the distribution of the gas tax is to support rural areas and roads outside metropolitan areas, which could not support themselves otherwise.

VMT fees and allocation for transportation infrastructure projects

Based on the results, one cent per mile fee would be able to replace the gas tax, assuming a 75% return from the collections. It would be able to generate a projected revenue of $53.3 M per year (Table 4), which is twice as much as that generated by the gas tax. To prevent the issue of misdistribution from the gas tax, it would be critical to outline the process for the collection and distribution of any of the VMT scenarios. The best way to prevent this issue is by imposing a VMT fee at the regional or local level and redistributing the funds to the same location where they came from.

More than 60% of Charlotte, North Carolina vehicle owners pay $100 to $300 per year per vehicle on North Carolina gas taxes. Each of the scenarios considered in this research could generate more money than the gas tax if the revenue is implemented exclusively for CDoT and the Charlotte surface transportation infrastructure. Both VMT fee scenarios proposed by CDoT and the Committee of 21 (2009) are composed of a flat-rate fee for all vehicles and all miles traveled, regardless of any other considerations. One important aspect is to see how fair the model will be to all vehicle owners. If the VMT-based fee model does not account for fairness, it is going to be less likely to be approved by voters.

Table 4 shows a summary of the gas tax, VMT fee scenarios, and all six scenarios examined in this research. Assuming the projected revenue for each scenario is 75% due to the cost of operation, collection, maintenance, and the likelihood of a drop in the average VMT per vehicle, scenario #1 is estimated to generate ~$22 M per year. However, this scenario exempts over 30% of all vehicles and nearly 1% would have to pay bills of over $400 per year per vehicle. A similar situation occurs with scenario #2. The main issue with both these scenarios is the deduction in the number of miles traveled. The best way to account for the VMT outside city-maintained roads is by adjusting the rate per mile, which is implemented in scenarios 3 through 6. For all these scenarios, the total estimated revenue was over $44 M per year. The projected revenue exceeds $33 M and helps mitigate the transportation finance deficit.

Table 5 shows the number of vehicles charged and additional revenue under each of the scenarios based on the weight criteria. When accounting for GVW, scenario #4 generates an additional 9% (when compared to scenario # 3) because of the extra fee for vehicles weighing over 3,500 lbs. Furthermore, this scenario affects almost 38% of all vehicles registered in the city of Charlotte, North Carolina. Scenario #5 and Scenario #6 affect relatively fewer numbers of vehicles and could generate an additional 5% and 2.5% more than scenario #3. The additional revenue for scenarios 5 and 6 may be considered as marginal when compared to scenario 4.

Implementation plan

Research and studies conducted in the past proposed the use of technology and will require a large amount of time and money for implementation. It is important to explore and adopt such technology to estimate a VMT fee for each vehicle owner based on their use of a road in a particular locality, region, or state. This research proposes to implement a VMT system where the fee is charged along with the annual vehicle safety and emission inspection as a short-term solution. All vehicles in the state of North Carolina are subject to a safety inspection at approved and authorized locations once every 12 months. The odometer reading captured during this inspection will be submitted to the state, regional, or local tax office for processing and billing purposes.

As such, privacy concerns regarding the VMT fee payment will not be an issue. The only issue to overcome are the political and distribution aspects and making sure the VMT fee is used for surface transportation infrastructure projects of the region/locality and not for other purposes. Besides, the research methodology will serve as a foundation for economic models that can be modified on an annual or regular basis depending on the need. It will allow for an easier transition from the gas tax into an acceptable VMT fee

Table 5. Vehicles charged and additional revenue – Scenarios 4, 5, and 6.

		Vehicles to be Charged		
Scenario	Criteria (lbs)	Units	%	Additional Revenue
4	3,500	1,260	38%	$4.4 M
5	4,000	892	28%	$2.2 M
6	4,500	398	12%	$1.1 M

in the future. Therefore, whenever connected and automated vehicles become more dominant or other related technologies become more prominent, it will be easier and less expensive to build upon and implement based on the proposed method.

Commercial vehicles and future research

Commercial vehicles are excluded from this research. For these types of vehicles, the damage and thus the cost they incur to the surface transportation infrastructure is far more than the gas tax they pay. Therefore, the rate of VMT fee for commercial vehicles should not be determined in the same way as for personal vehicles. Furthermore, charging a VMT fee to commercial vehicles will increase business costs, hurting local businesses. Consumers will be affected because they will have to pay a higher price caused by the transfer of a VMT fee into a product price.

It is estimated that about 3% to 7% of the total traffic is composed of large trucks, buses, and other types of commercial vehicles. Since this rate is relatively low compared to the total number of passenger vehicles, commercial vehicles could thus be exempt from paying the VMT fee, and a large percent of the vehicle owners would still be contributing to the usage of local roads. The situation could be different for Interstate and state highways where the percentage of heavy vehicles is estimated to be up to 20% (United States Department of Transportation (USDoT), 2009). As a result, due to this immense difference in the percentage of heavy vehicles, state, and federally maintained roads should be funded with a different method or approach than that which regional-, city- and local-maintained roads utilize.

Conclusions and recommendations

The city of Charlotte, North Carolina, and other urban areas could benefit from implementing a VMT fee either as a method to complement or to replace the existing gas tax. Multiple scenarios were evaluated using sample data for the city of Charlotte, North Carolina. The VMT fee for complement scenarios proposed through this research is between $50 and $100 per year per vehicle, compared to the VMT fee scenarios (meant for replacing the gas tax) where over 60% of the vehicle owners are charged around $100 to $300 per year per vehicle. Therefore, charging 0.625 cents per each mile traveled or 1.00 cent per additional mile exceeding 5,000 miles per year, to complement the gas tax, could generate enough revenue to mitigate the transportation finance deficit estimated equal to $30 M to $35 M at the time of research for the city of Charlotte, North Carolina.

A factor for vehicles' weight could be used to account for the surface transportation infrastructure construction and maintenance costs as well as the operational effects. The 4,000 lbs weight criteria would affect approximately 28% of all vehicle owners from the data sample, stemming mainly from large size sports utility vehicles (SUVs), light trucks, and vans. Having a weight factor associated with the VMT fee could encourage vehicle owners to switch from such vehicles to smaller and lighter vehicles, hence lowering the negative effects on the fuel consumption, environment, noise level, pavement, and operational aspects (travel time and safety).

It is unlikely that the gas tax would be eliminated for good in the short term, and the fact is that the gas tax does serve some areas with low population density or extensive road networks. The likelihood of the Highway Trust Fund to modify their distribution mechanism is unlikely in the short term; therefore, this research concludes that the best method for a successful VMT fee system is for it to be implemented as a complement to the gas tax and to be collected at a regional/local level to mitigate the local deficits in transportation finances.

The proposed VMT fee could be implemented in conjunction with the annual vehicle state safety inspection in which the odometer reading is recorded and the number of miles is submitted to the transportation agency or local tax office for processing and billing. This way the cost to implement the VMT fee system is minimal, driver's privacy is protected by not tracking people's location, and the fee is less than $100 per year per vehicle for over 75% of the vehicles.

About 27% of the vehicles are not registered with owners' residence in the city limits of Charlotte, North Carolina. Most of these vehicles are registered with owners' residence in surrounding counties. Therefore, defining the boundary to capture data, collecting the VMT fee, and redistributing or using it for surface transportation infrastructure projects plays an important role in the process.

The political and public acceptance is the greatest challenge to overcome. The key to winning acceptance from the political and public sector is through public education and good planning procedures. If the system demonstrates to the public what the charge will be based on and where/how it will be utilized, people will be most likely accept such a system.

The objective of this research is to collect geographically distributed sample vehicle data for an urban area and to estimate a VMT fee specific to an urban area to mitigate the local transportation finance deficit. The VMT per vehicle is expected to be higher in rural areas due to the lack of adequate connectivity and density of the surface transportation infrastructure. The vehicle owners of rural areas may, therefore, have to pay higher VMT fees if the VMT fee recommended from this research is used. The applicability of the method and VMT fee specific to a rural area to mitigate the local transportation finance deficit merits an investigation.

Past research showed that a VMT fee would be more equitable and less regressive than the gas tax by shifting the burden of taxation from low-income households to high-income households. In general, the VMT fee paid by a vehicle owner depends on the VMT and his/her residence, while the increase or decrease in cost for a vehicle owner (VMT fee compared to the gas tax) and the associated burden depends on the VMT, fuel efficiency of the vehicle, and owners' residence as well as household income. The age and type of vehicle owned (and, hence, the fuel efficiency of the vehicle and cost incurred) could differ for low-, medium, and high-income households. This could not be explored due to the unavailability of data. Capturing household income details, location details, and ensuring equity when determining the VMT fee for urban and rural areas also merits an investigation.

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