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Comprehensive Equity Analysis of Mileage-Based User Fees: Taxation and Expenditures for Roadways and Transit

by Justin Carlton and Mark Burris

Using National Household Travel Survey data and information collected from over 100 agencies, transportation-related taxation and expenditures were assigned to individual households in the Houston Core Based Statistical Area (CBSA). Using Gini Coefficients and Theil Indices, the research demonstrated that implementation of a Mileage Based User Fee (MBUF) would not have a pronounced effect on the current distribution of what households pay versus what they receive in transportation expenditures. The relative winners are rural and high income urban households, while the relative losers are all other urban households.

INTRODUCTION

The fuel tax in the State of Texas, which consists of $0.20 applied to each gallon of gasoline purchased, has not increased since 1991. Both the Texas gasoline tax rate and the Texas diesel tax rate rank 40th in the country, with only 10 states having a lower tax rate (API 2013). From 1991 to 2013, the State of Texas fuel tax has lost 40% of its purchasing power due to inflation (BLS 2013). From 1980, the vehicle miles traveled in the Unites States increased by 95.5%, while the lane-miles have only increased by 8.8% (OHPI 2008). Even though mileage is increasing, experts estimate that average fuel consumption will drop by as much as 20% by 2025 due to increasing fuel efficiencies (TRB 2006). The Obama administration recently finalized regulations to increase the fuel efficiency of cars and light duty trucks to 55.4 mpg by 2025, which will only exacerbate the difficult financial situation (NHTSA 2012).

According to the Texas Transportation Needs 2030 Committee, it will take a total investment of $270 billion dollars by 2035 in order to maintain current conditions and avoid a devastating $1.7 trillion economic burden due to wasted fuel, time, and maintenance costs (Texas 2030 Committee 2011). While insufficient investment is a critical issue, it is not the only problem. The prices paid by users often do not reflect the true costs of that service nor do they reflect the true social costs in terms of delay and pollution. “This underpayment contributes to less efficient use of the system, increased pavement damage, capacity shortages, and congestion” (NSTIF 2009). An analysis of nine midwestern communities revealed that 80% of local funding was derived from mechanisms unrelated to road use (Forkenbrock 2004).

The issues presented demonstrate the primary weakness of the fuel tax as well as the issue with it going forward; it is not tied directly to roadway use. The lack of revenue sustainability has generated concern over the fuel tax’s ability to meet infrastructure needs, and the potential drastic consequences have prompted extensive research into funding alternatives for our transportation related infrastructure. One such option is the Mileage-Based User Fee (MBUF), often called the Vehicle Miles Traveled (VMT) Fee. A mileage based user fee would charge road users according to the number of miles they drive, thus holding them accountable by directly tying the costs of road use to the benefits received. Over time it has become the consensus of transportation experts and economists that a MBUF system should be considered the leading alternative to the fuel tax (CBO 2011). Previous MBUF initiatives demonstrate how such a system could work and show how it could lead to a more equitable and efficient use of the roadway (GAO 2012). Additionally, MBUFs may reduce congestion simply because the true cost of driving is more visible to drivers (NSTIF 2009). These are among the reasons why an MBUF is an attractive alternative.

As with any method of taxation, equity becomes a primary concern. Transportation equity is defined as the actual and perceived "fairness" of how cost and benefit impacts are distributed (Litman 2002). While numerous studies have evaluated MBUF equity, none have addressed or included transportation spending, only revenue generation. This means that the big picture of how transportation taxation and expenditures interrelate is not well understood, i.e., how much does each household pay in transportation-related taxes and how much do they benefit from roadway and transit expenditures? Understanding the myriad of potential equity issues involved in both transportation taxation and spending is critical due to the widespread public mistrust of governmental agencies' ability to handle money (Cronin 2012; Grant Thornton 2010). This paper addresses these issues by focusing on the relation between transportation taxation and spending in the Houston Core Based Statistical Area (CBSA).

LITERATURE REVIEW

Mileage-Based User Fees

MBUFs have become one of the most attractive alternatives to the fuel tax (CBO 2011; Larsen et al. 2012). Some of the benefits of MBUFs include increased cost recovery for new facilities, congestion management and traffic reduction, the ability to privately finance roadways, possible incentives for fuel efficient vehicles through lower rates, and a greater wealth of data for use in improving planning models (Forkenbrock and Hanley 2006).

There are several options for MBUF implementation, and they vary in complexity. Several factors are key in MBUF implementation, though privacy is often the primary concern of the public. Drivers in one study almost exclusively preferred the high privacy option (Hanley and Kuhl 2011). The appropriate application of technology is a struggle between accountability, flexibility, and privacy. Implementation methods include odometer readings (Kavalec and Setiawan 1997; NCHRP 2009; Whittey 2007), use of cell phone technology (Battelle 2013; NCHRP 2009; Whittey 2007), and onboard units (OBUs) utilizing global positioning systems (GPS) and radio frequency (RF) technology (Forkenbrock 2005; Hanley and Kuhl 2011; Puget Sound Regional Council 2008; Whittey 2007).

One of the most notable studies took place in Portland, Oregon. In the study, an onboard GPS receiver calculated the fees (rush hour miles, in-state miles, out-of-state miles) and transmitted them via RF to the fuel pump, which then charged the driver the required fee (Whittey 2007). One of the primary benefits of this system is that it can be easily fit into existing infrastructure and would allow drivers to pay their fees with their preferred payment method. It also eliminates the issue of interstate travel. Should someone from another state drive through Oregon, they would pay the fuel tax when refueling as they would do normally. Additionally, there is little incentive for tampering, since users will be charged the regular gas tax if the onboard device is not functional. This also allows for the system to be phased in slowly (Whittey 2007). As the system develops, charges could be implanted for local communities as well, potentially reducing property and other local taxes (Forkenbrock 2005).

These initiatives and studies listed above have demonstrated that current technology is mature, reliable, and capable of handling a MBUF system, making it a very possible reality. Given that implementation is technically feasible, the potential impacts of such a fee will receive greater scrutiny.

Equity

Equity concerning transportation usually refers to the actual and perceived "fairness" of how cost and benefit impacts are distributed. As would be expected, fairness is subjective and difficult to define. One must consider several types of equity, impacts, measures, and categories of people (Litman 2002).

There are two primary classifications of equity. Vertical equity concerns the distribution of impacts between individuals or groups with different needs and abilities. A policy is *progressive* if it favors disadvantaged groups since it makes up for existing inequities. A policy is *regressive* if it excessively burdens the disadvantaged (Litman 2002). Typically, when the type of equity is not specified, it usually concerns vertical equity. The income tax is considered vertically equitable since those with higher incomes are subject to a higher tax bracket. This type of equity is based on the "ability to pay" principle, which states that "consumers of governmental goods and services should pay according their ability to pay, with lower income individuals paying less relative to those with higher income" (Baker, Russ, and Goodin 2011). Public transit and paratransit address this type of equity (NSTIF 2009).

Horizontal equity concerns the distribution of impacts between individuals or groups with equal ability and need. In other words, "equal individuals and groups should receive equal shares of resources, bear equal costs, and in other ways be treated the same" (Litman 2002). Therefore, no individuals or groups should be favored over others. The income tax is criticized in this area because there are various exemptions that allow households with the same income to pay different amounts. The "benefits" principle is the basis for this type of equity, which states that "those who pay a tax should be those that benefit from the public goods and/or services that are received" (Baker, Russ, and Goodin 2011). Geographic equity falls into this category and "refers to the extent to which users and beneficiaries bear the cost burden for the portions of the system they use or benefit from, based on their geographic proximity to those portions" (NSTIF 2009).

Studies show the fuel tax to be regressive when compared to driver income (CBO 2011; Larsen et al. 2012; Weatherford 2012). Additionally, those studies suggest that an increase in either fuel tax or MBUFs would be less regressive. One study indicated that low-income drivers pay more through a flat sales tax than they would through an MBUF (Schweitzer and Taylor 2008). A recent study by Larsen applied different MBUF rate structures for fuel efficiencies as well as for urban and rural driving for Texas travelers (Larsen et al. 2012). Results demonstrated that vertical equity changes were minor. These results were similar to a previous study of Oregon drivers by Zhang (Zhang et al. 2009). MBUF tax structures that take into account fuel efficiency, weight, and other measures may not be worth implementing simply because the differences are very small on a per-month basis for users (Whittey 2007). Another important finding is that increasing the revenue may make the tax more regressive (Larsen et al. 2012; NSTIF 2009). There is also evidence to suggest that rural households would pay less under a mileage fee system (CBO 2011, McMullen et al. 2010).

DATA

National Household Travel Survey

The 2009 National Household Travel Survey (NHTS) is a compilation of data collected from over 150,000 households across the United States and is available for download on its website (nhts.ornl.gov). The Texas Department of Transportation (TxDOT) paid for 20,000 add-on surveys, bringing the total for the State of Texas to 22,255 households and over 45,000 vehicles. Included in the survey data are variables for household income, vehicle type, vehicle fuel efficiency, annual vehicle miles traveled, average price of fuel, and other important data that allow for easy computations without relying heavily on estimation (NHTS 2011). Additionally, the NHTS data include weights so each household in the survey is representative of the population.

Missing values throughout the data set are perhaps the primary obstacle to its effective use. In order to perform an analysis, these missing values need to be addressed. Additionally, according to the NHTS weighting report, the Texas data were weighted to reflect the state as a whole, without any subareas. Since the analysis in this research concerned only the Houston CBSA, these existing weights may not properly reflect the demographics in the area (Rizzo et al. 2010). For this reason, the survey was filtered and re-weighted.

Filtering. The first step in the filtering procedure was to eliminate golf carts, jet skis, or other non-roadway vehicles. Consequently, this also means that households with zero vehicles were removed from the vehicle survey file, leaving 44,964 valid vehicle surveys.

Missing data were addressed using pairwise deletion, where only surveys with missing variables relevant to the analysis were removed. Following this, any surveys with negative values for the income, race, Hispanic status, urban/rural, best mile (VMT), fuel economy, or hybrid variables were eliminated. Several variables, such as household size, were not missing any values due to their having been hot deck imputed for the original NHTS weighting (Rizzo et al. 2010). When using hot deck imputation, a missing entry is randomly assigned a value from a non-missing donor entry. These donors are selected from a group based on eligible criteria that prevents unrealistic combinations (for example, no seven-year-old drivers). The "Other Trucks" vehicle type variable category was also filtered out, as it could include any number of vehicle types. Since the survey focused on households, it was not practical to include large trucks because they are more often associated with commercial businesses. Additionally, large trucks pay very different fees compared with regular vehicles. For these reasons, the survey would not be representative of the population, thus large trucks were not included. Finally, incomplete surveys (where not all eligible household residents filled out the survey) were filtered out in order to ensure that any unknown bias would not influence the analysis (for example, ensure public transit use was accurate to the household). Table 1 displays the surveys before and after filtering for each area. The percent of retained surveys suggests uniformity across the CBSAs, indicating that no area is substantially different in terms of survey completion.

Table 1: NHTS Surveys Before and After Filtering by Area

Area	Survey Households Before Filtering	Survey Households After Filtering	Surveys Retained	Survey Vehicles Before Filtering	Survey Vehicles After Filtering	Survey Vehicles Retained
State of Texas	22,255	16,978	76.3%	44,964	33,287	74.0%
Austin CBSA	1,543	1,211	78.5%	3,073	2,340	76.2%
Dallas/Fort Worth CBSA	5,875	4,521	77.0%	11,971	8,962	74.9%
Houston CBSA	4,043	3,004	74.3%	8,054	5,828	72.4%
San Antonio CBSA	2,054	1,590	77.4%	4,099	3,107	75.8%

Weighting. The filtered results (Table 1) needed to be re-weighted to better represent vehicle owning households in Texas. An iterative raking method was used for the weighting procedure, often called proportional fitting, where weights are iteratively adjusted to independent control totals for various demographic categories. Control totals are simply the total number of households in a given strata. For example, in 2008 there were 695,170 households in the Houston CBSA with one vehicle. The original NHTS weights for each household were used as the default starting values.

Due to the data filtering, the summation of these weights, broken down into their respective strata, don't equal the control totals. For each iteration, these weights were multiplied by the average fraction required to cause them to sum to their respective strata control totals. This in turn causes the required fraction to change. Over many iterations, the fractions converge to a value of 1, yielding a set of household survey weights representative of the general population. The final weights were accurately disaggregated by household size, family income, race, Hispanic status, vehicle count, worker count, urban/rural location, home ownership, and CBSA location. The average weights for each area are shown in Table 2.

Table 2: Average Survey Weight by Area

Area	**Households in Area**	**Number of Surveyed Households (After Filtering)**	**Average Number of Households Each Survey Represents (Total Households / Surveyed Households)**
State of Texas	8,527,938	16,978	502
Austin CBSA	637,229	1,211	526
Dallas/Fort Worth CBSA	2,201,105	4,521	487
Houston CBSA	2,004,427	3,004	667
San Antonio CBSA	738,162	1,590	464

The control totals utilized in the weighting procedure were obtained from the American Community Survey (ACS) through the American Fact Finder website of the United States Census Bureau (factfinder2.census.gov). Control totals for the number of urban and rural households were determined based on data from the 2000 and 2010 United States Census. Since census years (2000 and 2010) were different from the ACS year (2008), the number of urban and rural households in 2008 was interpolated from the 2000 and 2010 census numbers.

The NHTS variable categories were adjusted to match the ACS categories. For example, any NHTS entry with four or five plus workers per household was considered a three plus worker household, as the ACS survey only had groups for one, two, and three plus workers per household. This effort provided the control totals (actual number of households in each strata). Maximum and minimum weights were set in order to prevent over sensitivity to a specific strata (Battaglia et al. 2004). The values for the maximum and minimum weights were 3,500 and 70, respectively. A total of 2.0% of the households exceeded the maximum weight and were thus given a weight of 3,500. A total of 5.6% of the households were below the minimum weight and were thus given a weight of 70. The final weighted totals closely matched the ACS control totals. Dallas/Fort Worth, Houston, and San Antonio were within two households of their respective variable category control totals for all variables.

The NHTS data set includes a set of 100 replicate weights, which are used to calculate more accurate standard errors when doing statistical analysis of weighted survey data. These replicate weights were put through the same weighting procedure as the survey data. These revised replicate weights are used in this research whenever standard errors and confidence intervals of the survey results are reported. For further information on how to calculate standard errors using the NHTS dataset, consult chapter seven of the NHTS User Guide (NHTS 2011).

Based on the re-weighted data set, there was no statistical difference between the demographics of the four Texas CBSAs (Austin, Dallas/Fort Worth, Houston, and San Antonio). For example, the average fuel efficiency for low income households was the same in each of the four CBSAs. For this reason, the results of the analysis are likely applicable to the other CBSAs in Texas with public transit services.

Transportation Taxation and Spending in the Houston Area

In order to provide a complete perspective for a MBUF, the entire system in which it operates needs to be understood. To achieve this aim, transportation related taxation and spending information was collected from the sources listed in Table 3 and is presented in Table 4.

State Level. The State of Texas imposes a tax on motor fuel purchases of $0.20 per gallon. Additionally, the US Government imposes a $0.184 and $0.244 per gallon tax on gasoline and diesel, respectively. Fuel tax is reported directly to the state by individual businesses, thus no information is collected disaggregated at the county level (David Reed pers. comm.). As the NHTS data allow the fuel tax to be directly calculated, total fuel revenues were not required. In addition to this, Texas collects a 6.25% sales and use tax on motor vehicles as well as a tax on motor oil (Texas Comptroller of Public Accounts 2013). The State also collects a motor vehicle registration fee. In 2008 this fee was $40.80, $50.80, and $58.80 for 2002 and older models, 2003-2005 models, and 2006 and newer models, respectively. All of these are deposited into the State Highway Fund, 25% of which is then deposited into the school fund. The remaining amount is available for use by TxDOT.

Drivers license fees, vehicle inspection fees, driver record request fees, motor carrier penalties, state traffic fines, and proceeds from the driver responsibility program are deposited into the Texas Mobility Fund, which TxDOT uses to finance mobility related projects (Legislative Budget Board 2006). TxDOT also distributes grants for small transit related entireties (TxDOT 2008). The average inspection fee per vehicle was $4.62, which was determined by dividing the total Texas revenue from inspections ($86,166,829) by the total registered vehicles in Texas (18,647,093). This is just the fee collected by the state; actual inspection prices reflect the respective businesses' charge for the service and are not included. The average fee for drivers licenses and driver record requests was $11.69, which was determined by dividing the total Texas revenue from fees ($179,667,613) by the total number of registered drivers in the state (15,374,063). As drivers licenses are not a regular annual expense, an average is appropriate.

County Level. The Texas Constitution allows for local entities to collect up to a combined 2% sales tax (Texas Comptroller of Public Accounts 2013). Austin, Brazoria, Liberty, and San Jacinto counties collect a 0.5% sales tax while the municipalities collected an average sales tax of 1.43% (www.window.state.tx.us/ taxinfo/local/city.html). Texas also allows counties, which are often in charge of collections, to add an additional fee to their vehicle registrations (See Table 4). Property taxes ($/$100 of assessed value) are set by the local entity and stack on top of each other. For example, one household may pay property taxes to the county, the city, a school district, utility districts, and a special development district.

Some counties and cities have a designated fund or department devoted to transportation, though this does not always include all their transportation spending (overhead and grants are often not included). In order to obtain a reasonable estimate for county level transportation-related taxation, the total county tax rates were multiplied by the percent of total revenue spent on transportation. This information is also presented in Table 4. For example, the property tax for Brazoria County, not including school or other districts, was .39000$^{\$/\$100}$, and the county spent 18.79% of its total revenue on transportation. Multiplying the two yields .07329$^{\$/\$100}$, which is an estimate of the average tax paid toward transportation expenditures. Additionally, the county sales tax was multiplied by the 18.77% spent on transportation to get 0.094%, which is the average sales tax diverted to transportation.

Table 3: Data Sources

Data	Source	Web Address
Population	United States Census Bureau	factfinder2.census.gov
TxDOT Spending, Registered Vehicles	TxDOT's District and County Statistics (DISCOS)	www.txdot.gov/inside-txdot/division/finance/discos.html
Daily Vehicle Miles	Roadway Inventory Database (TxDOT Planning Department)	www.txdot.gov/inside-txdot/division/transportation-planning.html
Vehicle Registration Fee, Drivers License Fee Revenue, Vehicle Inspection Revenue	Texas Department of Motor Vehicles, Open Records Requests	www.txdmv.gov
Licensed Drivers	FHWA Highway Statistics	www.fhwa.dot.gov/policyinformation/statistics.cfm
Fuel Stations	County Business Patterns (GBP) (United States Census Bureau)	www.census.gov/econ/cbp
County and Local Property Tax	County Appraisal Districts, Personal Communication	www.austincad.net, www.brazoriacad.org, www.chamberscad.org, www.fbcad.org, www.galvestoncad.org, www.hcad.org, www.libertycad.com, www.mcad-tx.org, www.sjcad.org, www.waller-cad.org
County and Local Sales Tax	Texas Comptroller Window on State Government Website	www.window.state.tx.us/taxinfo/local/city.html
County Revenue, County Transportation Spending	County Websites, Personal Communication	www.austincounty.com, www.brazoria-county.com, www.co.chambers.tx.us, www.fortbendcountytx.gov, www.galvestoncountytx.gov, www.harriscountytx.gov, www.co.liberty.tx.us, www.co.montgomery.tx.us, www.co.san-jacinto.tx.us, www.wallercounty.org
Local Revenue, Local Transportation Spending	Municipal Websites, Personal Communication	See Texas Comptroller Link for List of Municipalities
Metro Sales Tax	Metropolitan Transit Authority of Harris County (Metro)	www.ridemetro.org
Transit Revenue Miles	National Transit Database	www.ntdprogram.gov/ntdprogram/

Local Level. For municipalities however, the method needed to be modified as only county level resolution was available for each entry in the NHTS survey. Certain issues were encountered when collecting the required information from the local level. Each city has different accounting standards, given they would provide any financial documents at all. Some have separate departments for transportation, while smaller cities only have line items, which required estimation for transportation spending. The earliest available data closest to the year 2008 were used. As revenues and expenditures tend not to change dramatically from year to year, the numbers are assumed to average to a reasonable estimate. Where information was not available, municipal revenue was estimated based on linear regression of revenues versus population of known cities (Using data from latest available census). Revenues and expenditures were only calculated if the municipality had a sales or property tax on record.

Weighted average sales and property taxes were calculated based on the population of all cities and towns in the county. The assumption for sales tax was that the majority of spending occurs in one of these locations, with relatively little spending occurring in completely rural areas. Weighted average property taxes were calculated the same way. However, they were only applied to urban households, as few rural municipalities impose property taxes. Additionally, these small municipalities are vastly outweighed by the larger cities. Next, the weighted averages were multiplied by the average percent of local transportation-related spending in order to obtain an estimate for the tax rate devoted to transportation. The results are listed in Table 4.

Transit. Information collected for transit agencies is presented in Table 5. Since 1978, METRO has imposed a 1% sales tax on its constituent service areas (METRO 2013). By voter mandate, METRO must appropriate 25% of this sales tax to its constituents for roadway-related improvements. The same weighting method used for local level taxes was used for the 1% METRO sales tax, as a few of its constituents were not wholly within Harris County. Colorado Valley Transit and The District serve a few counties inside the Houston CBSA, though most of their service counties are not. Their numbers in the table below are a weighted average based on population for the counties they service within the Houston CBSA. By looking at the numbers presented, it is clear that METRO dominates the totals. For this reason, an error in estimation for the smaller agencies will not have a substantial impact as most effort focused on obtaining accurate data for METRO. The average expenditure per unlinked trip was $5.39. Revenue miles per county are listed in Table 4.

Table 5: Transit Agency Data (Numbers are Restricted to Houston CBSA)

Agency	Total Fares Collected	Total Unlinked Trips	Total Expenditure	Total Revenue Miles
METRO	$56,701,736	125,080,144	$665,537,067	63,110,626
Galveston Island Transit	$208,726	499,920	$3,323,955	423,749
Fort Bend	$237,840	165,386	$3,086,912	767,725
Gulf Coast Center	$61,922	50,912	$2,357,046	514,883
Colorado Val-ley Transit	$40,000	30,500	$373,380	69,191
The District	$1,727,727	738,226	$6,879,468	1,593,112
Total	$58,977,951	126,565,088	681,557,828	66,479,286

For the purposes of this research, transit fares were considered a private cost, similar to how an individual's vehicle maintenance is a privately incurred cost. As the analysis focuses on taxation, fares were not included. However, they were used to determine the increase in transit expenditures due to increased ridership. This was included in case the analysis demonstrated a dramatic increase in transit usage.

Table 4: Taxation and Spending by County and Governmental Level

		Austin	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	San Jacinto	Waller
STATE	Daily Vehicle Miles	1,269,543	4,560,600	2,420,542	6,556,343	4,670,684	56,245,209	1,892,604	8,552,671	705,745	1,745,771
	TxDOT Spending	$10,200,209	$43,658,438	$59,083,813	$135,429,001	$109,429,821	$698,574,728	$46,308,786	$228,228,197	$21,671,778	$8,613,283
	Spending / Annual DVM	$0.02	$0.03	$0.07	$0.06	$0.06	$0.03	$0.07	$0.07	$0.08	$0.01
COUNTY	Population	26,610	294,233	28,771	509,822	283,987	3,935,855	75,434	412,638	24,818	35,933
	Registered Vehicles	37,076	279,616	38,468	429,422	259,329	3,076,623	76,252	385,240	26,042	42,665
	Fuel Stations	22	136	25	181	129	1,529	34	151	7	26
	Total Revenue	$16,224,143	$141,294,435	$72,422,527	$273,440,458	$164,577,238	$2,469,793,493	$42,291,838	$261,537,623	$16,628,937	$19,126,890
	Revenue per Person	$610	$480	$2,517	$536	$580	$628	$561	$634	$670	$532
	Daily Vehicle Miles	104,280	1,153,050	112,749	1,997,908	1,112,898	15,423,961	295,613	1,617,060	43,103	140,815
	Transportation Spending	$5,218,685	$26,550,726	$8,166,697	$19,208,682	$12,206,563	$373,484,374	$9,102,163	$76,212,732	$3,240,545	$3,937,295
	% Transportation Spending	32.17%	18.79%	11.28%	7.02%	7.42%	15.12%	21.52%	29.14%	19.49%	20.59%
	Spending / Annual DVM	$0.14	$0.06	$0.20	$0.03	$0.03	$0.09	$0.08	$0.13	$0.21	$0.08
	Sales Tax	0.50%	0.50%	–	–	–	–	0.50%	–	0.50%	–
	Adjusted Based on Transportation Spending	0.16%	0.09%	–	–	–	–	0.11%	–	0.10%	–
	Property Tax ($/$100)	0.4796	0.39	0.52214	0.55	0.5586	0.38923	0.56	0.4888	0.6287	0.64253
	Adjusted Based on Transportation Spending	0.15427	0.07329	0.05888	0.03864	0.04143	0.05886	0.12052	0.14244	0.12252	0.13227
	Vehicle Registration Fee	$10.00	$10.00	$10.00	$11.50	$10.00	$11.50	$10.00	$10.00	$11.50	$10.00
LOCAL	Municipal Urban Population with Taxation	10,116	204,510	15,787	243,421	245,364	2,773,932	21,347	170,581	0	17,329
	Municipal Rural Population with Taxation	2,468	10,007	2,210	5,230	3,488	6,619	3,385	11,020	2,029	2,327
	Town Population without Taxation	6,537	28,405	6,353	18,886	1,063	214,413	3,076	9,029	2,531	447
	Daily Vehicle Miles	113,326	1,931,851	162,073	2,239,243	2,241,053	25,089,105	222,726	1,635,423	18,272	177,005
	Transportation Spending	$882,075	$22,774,262	$2,606,164	$32,811,793	$37,134,394	$390,198,463	$3,714,527	$23,024,474	$179,074	$2,652,955
	% Transportation Spending	5.59%	7.73%	7.45%	9.71%	9.63%	8.66%	8.37%	11.72%	8.51%	10.16%
	Spending / Annual DVM	$0.02	$0.03	$0.04	$0.04	$0.05	$0.04	$0.05	$0.04	$0.03	$0.04
	Weighted Average Sales Tax Adjusted Based on Transportation Spending	0.06%	0.10%	0.09%	0.15%	0.17%	0.08%	0.11%	0.09%	0.07%	0.18%
	Weighted Average Property Tax Adjusted Based on Transportation Spending	0.01169	0.04394	0.03177	0.04322	0.05034	0.04939	0.04536	0.04213	0.01002	0.0533
	Metro Sales Tax	–	–	–	0.14%	–	0.62%	–	–	–	0.10%
	All Transit Revenue Miles	14,765	0	0	767,725	938,632	63,110,626	0	1,390,034	83,603	19,938

Daily Vehicle Miles

In order to assign roadway expenditures to individuals, the total use of the system needs to be determined. The daily vehicle miles (DVM) for a road segment is simply the annual average daily traffic (AADT) multiplied by the length of the segment, meaning it is an estimate of the total daily vehicle miles traveled (VMT). Information from the TxDOT Planning Department's roadway inventory database was used to create an estimate for the total DVM on state, county, and local roadways disaggregated by county. For details on the estimation, the full report may be accessed online (https://ceprofs.tamu.edu/mburris/ publications.htm).

The estimates created are presented in Table 6 and make intuitive sense. Counties with large urban populations like Brazoria, Fort Bend, Harris, and Montgomery have a large number of local miles driven, while rural counties such as San Jacinto have few. Estimates were also created for the percentage of DVM driven on urban and rural roadways, which are shown in Table 7. Note that San Jacinto has no urban areas, therefore no urban DVM. Based on the estimates, the total yearly mileage for the Houston CBSA was 51.1 billion. The total mileage according to the NHTS data was 42.7 billion, or 85% of the estimated total, which leaves 15% of total mileage driven by trucks and other commercial vehicles.

Table 6: Estimated DVM by Road Ownership

Owner	**Austin**	**Brazoria**	**Chambers**	**Fort Bend**	**Galveston**
State	1,269,543	4,560,600	2,420,542	6,556,343	4,670,684
County	104,280	1,153,050	112,749	1,997,908	1,112,898
Local	113,326	1,931,851	162,073	2,239,243	2,241,053
Owner	**Harris**	**Liberty**	**Montgomery**	**San Jacinto**	**Waller**
State	56,245,209	1,892,604	8,552,671	705,745	1,745,771
County	15,423,961	295,613	1,617,060	43,103	140,815
Local	25,089,105	222,726	1,635,423	18,272	177,005

Table 7: Percent DVM by Geographic Location

County	**Urban Area**			**Rural Area**		
	State Roads	**County Roads**	**Local Roads**	**State Roads**	**County Roads**	**Local Roads**
Austin	72%	8%	19%	91%	6%	2%
Brazoria	52%	15%	33%	79%	16%	4%
Chambers	61%	12%	27%	97%	2%	1%
Fort Bend	63%	11%	26%	54%	44%	2%
Galveston	58%	13%	29%	54%	38%	8%
Harris	60%	12%	28%	23%	76%	1%
Liberty	65%	11%	25%	85%	13%	2%
Montgomery	70%	9%	21%	77%	21%	2%
San Jacinto	0%	0%	0%	92%	6%	2%
Waller	4%	29%	67%	95%	4%	1%

Consumer Spending

In order to apply sales taxes to individual households, disaggregated consumer spending habits are required. Information from the Bureau of Labor and Statistic's 2008 Consumer Spending survey is presented in Table 8 (www.bls.gov/cex). The BLS consumer survey contains expenditures by line item disaggregated by income level. To estimate sales taxable expenditures, exempt line items were removed based on Subchapter H of the Texas Tax Code (www.statutes.legis.state.tx.us/ Docs/ TX/htm/TX.151.htm). The average taxable auto purchases were included as well. This information represents vehicle purchases only, not other related vehicle spending. Unfortunately, the survey combined motor oil purchases with fuel purchases. For this reason, motor oil was not included in the analysis, as the bulk of this line item (fuel expenditures) are calculated elsewhere in this research.

Table 8: Consumer Spending with Taxable Estimation

Household Income	Total Consumer Spending	Total Sales Taxable Consumer Spending	Total Taxable Auto Purchases
Less than $5,000	$23,036	$12,514	$430
$5,000 to $9,999	$19,125	$9,521	$810
$10,000 to $14,999	$21,120	$10,547	$606
$15,000 to 19,999	$25,536	$12,968	$1,346
$20,000 to $29,999	$30,367	$15,966	$1,770
$30,000 to $39,999	$35,778	$18,974	$2,069
$40,000 to $49,999	$40,527	$21,900	$2,098
$50,000 to $69,999	$50,465	$28,625	$3,093
$70,000 to $79,999	$58,742	$33,269	$3,114
$80,000 to $99,999	$67,180	$38,619	$3,916
$100,000 and more	$100,065	$59,140	$5,450

Household Property Values

In order to apply the property taxes previously calculated, property values are required. Home values broken down by income were available for the American Community Survey (factfinder2.census.gov). The average values are presented in Table 9. The Harris County Appraisal District determines replacement values (new value per square foot) for use in their appraisals (www.hcad.org/pdf/ Resources/ 2013_Mass_Appraisal_Report_final_20130620.pdf). The values per square foot (by quality class) for single family units, duplexes, townhomes, and apartments are similar (~10%). Therefore, the correlation between income and home values presented in Table 9 will likely be representative of other housing types as well. For mobile homes, however, the values are not comparable. Because they account for 0.01% of all households in the Houston CBSA, they were assumed to follow the correlation in Table 9 as well.

Table 9: Average Home Values by Household Income

Household Income	Average Home Value
Less than $10,000	134,460
$10,000 to $19,999	112,570
$20,000 to $34,999	131,140
$35,000 to $49,999	137,830
$50,000 to $74,999	155,150
$75,000 to $99,999	184,760
$100,000 or More	282,040

Elasticity

An elasticity is defined as the percent change in consumption resulting from a percent change in price (Litman 2013). For the purposes of this paper, elasticities will refer to the percent change in either miles traveled or transit ridership based on the percent change in the cost of travel. For example, using an elasticity of -0.15, a 6% increase in the cost of travel would result in a 0.9% reduction in miles traveled. Wadud et al. (2009) modeled disaggregated fuel price elasticities of travel demand for income quintiles via the Seemingly Unrelated Regression Feasible Generalized Least Squares Autoregressive (SUR-FGLS with AR (1)) model and for geographic distinction via Log-linear SUR-FGLS with AR (1) values (Wadud, Graham, and Noland 2009). Larsen combined these values into a cross classification table for urban and rural income quintiles, which are presented in Table 10 (Larsen et al. 2012).

Table 10: Fuel Price Elasticity of Travel Demand (VMT)

Household Income Quintile	Urban	Rural
Lowest	-0.447	-0.254
Lower Middle	-0.280	-0.159
Middle	-0.259	-0.147
Upper Middle	-0.335	-0.191
Highest	-0.373	-0.212
Total (Weighted Average)	-0.339	-0.192

Unfortunately, elasticities disaggregated by income and geographic location were not available for public transit ridership. Based on literature presented by the American Public Transportation Association, 0.185 was the average transit trip to fuel price elasticity (APTA 2011). As noted by APTA, this elasticity only represents areas where public transportation is available. The author of a recent thesis found a statistically significant elasticity of 0.096 specifically for the Houston CBSA (Lee 2012). While this may not be as reliable as other estimations, it shows that the Houston area may be less responsive compared with other areas. For this reason, the APTA elasticity will be considered to yield a high range number, while Lee's elasticity will be considered the lower range. We felt the elasticities obtained from the literature on fuel prices were better indicators of real world reaction to a change in fuel price than linear regression of Texas NHTS data. The disaggregated elasticities by income and location are consistent with average elasticities found in large scale studies (Goodwin, P.B. 1992).

METHODOLOGY

For the analysis, there were three different MBUF funding scenarios. The first was meant to be tax neutral, meaning that the MBUF would create the same gross revenue as the state fuel tax (it would ignore implementation costs). This scenario was meant to analyze any distributional impacts inherent in changing to an MBUF. The primary difference between the MBUF and the fuel tax when it comes to total taxes paid would be the fuel efficiency of each vehicle. This scenario would isolate that effect. The next scenario raises the MBUF based on the estimated increase in revenue required for implementation, including GPS unit purchases for vehicle tracking, installation costs, operational costs, and individuals misreporting miles. This scenario provides a more realistic look at the MBUF. The final scenario increases the net revenue in order to meet Texas 2030 needs. This scenario will demonstrate any distributional changes with an increase in fees. Additionally, it will provide a relatable visualization of the true required cost of transportation moving into the future. MATLAB software was utilized in order to perform the analysis.

Implementation Cost and Additional Revenue

An implementation similar to the Oregon study was assumed, where gas stations read on board GPS units in order to ensure that the user is charged the appropriate fee (Whittey 2007). The same process as described by Larsen et al. (2012) will be used in this research with a few changes. According to Battelle, units may be purchased for under \$100, though they may not have the accuracy and reliability needed for street level tracking (Battelle 2013). They list \$150 for units better equipped for the task at hand, which provides a more conservative estimate for their cost. As noted by several authors, all the costs associated with the MBUF will likely become cheaper if mass produced and as technology improves (Battelle 2013; Forkenbrock and Hanley 2006). With 3,547,500 vehicles in the Houston area, the total cost of outfitting all vehicles would be \$532.1 million. According to the 2008 County Business Patterns (CBP) series of the United States Census Bureau (www.census.gov/econ/cbp), there were 2,240 gasoline stations in the Houston CBSA. With an installation price of \$15,000 per station (Larsen et al. 2012), the total cost to outfit all gas stations in the Houston CBSA would be \$33.6 million. In order to be consistent with the revenue increase scenario (discussed below), 22 years was used for the total life span of the system, with the upfront cost paid for incrementally each year. With a 22-year yield of 4.5%, the total annual cost of installation would be \$41 million.

According to the Texas 2030 Committee, \$14.1 billion in additional revenue per year will be required for the State of Texas to maintain current traffic and roadway conditions. This figure includes pavement maintenance, bridge maintenance, urban mobility, rural mobility, and safety. Additionally, the figure was determined based on the period of time between 2008 and 2030 (22 years). The required revenue increase for the Houston area (\$3.29 billion) was determined based on its share of total NHTS miles driven. The additional revenue was assigned based on the breakdown of current state expenditures for each county. The assumption was that TxDOT will not dramatically alter their allocation process.

Taxation Calculations

The fuel taxes were calculated based on NHTS variables for vehicle miles traveled and each vehicle's fuel economy. Sales taxes were determined based on the consumer spending habits in Table 8 and the weighted average sales taxes listed in Table 4. Property taxes were determined based on property values listed in Table 9 and the weighted average property taxes listed in Table 4. The average vehicle inspection fee and drivers license fee was applied using the NHTS household vehicle count variable and the household driver count variable, respectively. Automobile registration fees were applied based on the vehicle age NHTS variable and the county of residence. After the all taxes were assigned for each vehicle, they were summed with the respective household taxes based on the HOUSEID variable. The result was a total for all transportation related taxes paid by each household.

MBUF Calculation

The required MBUF was determined iteratively, as a driver's fuel price travel demand elasticity will alter the number of miles they drive as the cost of fuel changes. First, the initial MBUF is calculated based on the target revenue, which is the sum of the state fuel tax it will be replacing. This included any revenue increases or implementation costs depending on the scenario.

$$(1)\quad MBUF = \frac{Target\ Revenue}{\Sigma\ (VMT * HH\ Weight)'}$$

Where:

VMT is the NHTS mileage driven by each individual vehicle

HH Weight is the final household survey weight (from the weighting procedure) for the household the vehicle belongs to.

The total annual MBUF paid by each vehicle was then added to the total annual fuel purchase (not including fuel tax) in order to obtain a new "cost of fuel" for each vehicle. The disaggregated fuel price elasticities from Table 10 were then used to determine the change in annual VMT for each vehicle. This in turn changes the required MBUF to meet revenue criteria, and the process repeats until the calculated total revenue is within $1 of the target revenue. Then, the change in transit ridership was calculated using the transit demand fuel price elasticities.

Expenditure Assignment

As both the fuel tax and the MBUF tie taxation to road use, then following the benefits principle, transportation spending should also reflect an individual's use of the roadway. Multiplying a household's VMT by the average expenditure per daily vehicle mile (DVM) provides a reasonable estimate of the benefit received. However, the NHTS survey does not provide the geographic location for household miles driven. As discussed previously, the breakdown of total miles driven on urban state, county, and local roads as well as rural state, county, and local roads was determined using TxDOT DVM data and some estimation. It is assumed that a generic urban or rural mile driven by a household would follow this average DVM distribution (See Table 7). However, urban and rural households do not have the same distribution of miles traveled on urban and rural roadways (Larsen et al. 2012). As the NHTS survey contains the urban and rural location of each household, these different distributions can be accounted for. The average urban roadway expenditure per DVM for a generic urban mile driven and the average rural roadway expenditure per DVM for a generic rural mile driven are calculated as follows:

$$(2) \qquad U_{Exp} = S_{Exp} * \%SU_{DVM} + C_{Exp} * \%CU_{DVM} + L_{Exp} * \%LU_{DVM}$$

$$(3) \qquad R_{Exp} = S_{Exp} * \%SR_{DVM} + C_{Exp} * \%CR_{DVM} + L_{Exp} * \%LR_{DVM}$$

Where:

S = state, C = county, L = local, U = urban, R = rural

Exp = expenditures per mile, *DVM* = Daily Vehicle Miles

For example, $\%SU_{DMV}$ = the percentage of miles traveled on state-owned urban roadways

The previous two equations are calculated for each county separately. A mileage split for urban and rural locations was used by Larsen et al. (2012) based on GPS tracking in the Waco area (Larsen et al. 2012). The number of miles driven by urban households on urban roadways was 78%, while the number of miles driven by rural households on urban roadways was 41%. For the purposes of this research, 80% and 40% were used for urban and rural household miles driven on urban roadways, respectively. The city of Waco may not be representative of the city of Houston, but should be a reasonable estimate as no other data is available. Using these percentages, the miles driven by each vehicle can be broken down into urban and rural miles. The average urban and rural expenditure can then be tied to the vehicle. The total benefit received by each vehicle from all levels of governmental expenditure is calculated as follows:

$$(4) \quad User\ Benefit = \left[(VMT * U_{Split}) * \frac{U_{Exp}}{1 + \%VMT}\right] + \left[(VMT * R_{Split}) * \frac{R_{Exp}}{1 + \%VMT}\right]$$

Where:

VMT is the annual VMT for each individual vehicle (Adjusted based on MBUF elasticity impact)

U_{split} / R_{split} is the percentage of miles traveled on urban/rural roadways (80%/20% for urban households or 40%/60% for rural households)

U_{Exp} and R_{Exp} are the urban and rural expenditures per mile (for the vehicle's respective county) calculated in Equations (2) and (3)

%VMT is the percent change in total annual mileage for all vehicles under a MBUF

If the total mileage driven by all vehicles under a MBUF system were to decrease *(%VMT* is negative) while spending remains the same, the average expenditure per DVM (U_{Exp} and R_{Exp}) should increase.

In order to determine how much a household receives from public transit expenditures, the average expenditure per trip was used. In 2008, the total expenditures for all transit agencies in the Houston BCSA was $681.6 million and the total number of recorded unlinked trips was 126.6 million. There are several ways an MBUF would impact transit expenditures. First, transit agencies benefit from roadway expenditures, as bus service comprises the majority of total unlinked trips (84%). Next, transit agencies do not receive reimbursements for what they pay in fuel tax. As this is the case, they were not be exempted from the MBUF in this analysis. Finally, an increase in transit usage will increase the total revenue from fares. As this analysis attempts to estimate the total user benefit received from all transportation taxation and expenditure, all of these factors were included.

RESULTS AND DISCUSSION

Demographic variations from the average calculated with the filtered and weighted NHTS data set are presented in Table 11. Low and high income represent the bottom and top quintiles, respectively. These geographic and income relationships will aid in the interpretation of the equity analysis.

Table 11: Variations from the Average for Select Demographics

	Low Income	High Income	Urban	Rural
Fuel Efficiency	-4.3%	+1.8%	+0.7%	-3.1%
VMT by Vehicle	-11.7%	+5.6%	-2.4%	+10.5%
VMT by HH	-50.5%	+43.1%	-5.3%	+27.7%
% Hybrids	-1.1%	+1.0%	Not Significant	Not Significant

Displayed in Table 12 are the fees ($/mile) required to meet the target revenue. In their respective tables, *Lower* indicates the lower 95% confidence bound while *Upper* indicates the upper 95% confidence bound for testing statistical significance. These bounds were obtained using standard errors derived from the NHTS replicate weights. With reasonable costs for implementation, operation, maintenance, and leakage included, the fee would be 1.3 cents per mile, which shows that the overhead required for implementing a VMT scenario upfront is quite costly, especially considering that one cent per mile would completely replace the state fuel tax. In order to meet the Texas 2030 Committee's goals, which would prevent worsening roadway and traffic conditions, the total fee required would be 13.9 cents per mile. The dramatic increase in the fee for this scenario helps visualize how underfunded the current system is based on the 2030 Committee.

The decrease in total mileage under the first two scenarios was negligible. However, the revenue increase scenario would decrease total miles traveled by 22.8%. This reduction closely matches finding from the Oregon study, where congestion pricing (10 cents per mile) reduced miles traveled by 22% (Whittey 2007). Additionally, the visibility of the MBUF may further reduce the total miles driven. When considering vehicle miles traveled disaggregated into income quintiles and geographic distinction, the results were as expected based on the elasticities. Low income households reduced their mileage by the greatest amount, while high income households reduced their mileage slightly more than medium income households. Again, as expected, urban households decreased their mileage to a greater degree than rural households. Considering that rural households already drive more miles than urban households, the MBUF may further increase the gap between the two. This should be kept in mind for equity comparisons.

Table 12: Mileage-Based User Fee by Scenario (cents/mile)

Scenario	MBUF	Lower 95%	Upper 95%
Gross Revenue	0.970	0.960	0.981
Net Revenue	1.342	1.328	1.356
Revenue Increase	13.922	13.506	14.337

A 1.3 cent/mile MBUF would increase transit ridership 0.2% to 0.4%. This would result in an increase of 170,000 to 320,000 total annual trips. More substantial is the increase to a 13.9 cent/mile MBUF, which would result in a 5.3% to 10.3% increase in transit ridership. This would mean 3.9 to 7.5 million additional annual trips. Such a large increase in the mileage-based user fee for the revenue increase scenario may be high enough to encourage a very large increase in transit ridership, increasing the number of transit vehicles and making the mode more attractive. For this reason, the low end estimate (Lee 2012) is likely more accurate for the net revenue scenario, while the high end estimate (APTA 2011) may be more accurate for the revenue increases scenario.

An important finding was the average benefit (or expenditure) to taxation ratio for all households. The results are displayed in Table 13. Even though NHTS vehicle miles traveled accounted for roughly 85% of the total estimated DVM, more was spent on the transportation households used than what households paid in taxes for all scenarios except the revenue increase scenario. This suggests that other groups such as businesses, most likely through property and sales tax, finance more than their share of the transportation network. The confidence interval for the revenue increase scenario does not overlap any of the other scenarios, indicating that the scenario statistically decreases the benefit to taxation ratio. This means that increasing an MBUF while the other taxes and fees remain in place may cause households to receive less than the pay in taxes (less is spent on transportation compared with what they paid in taxes).

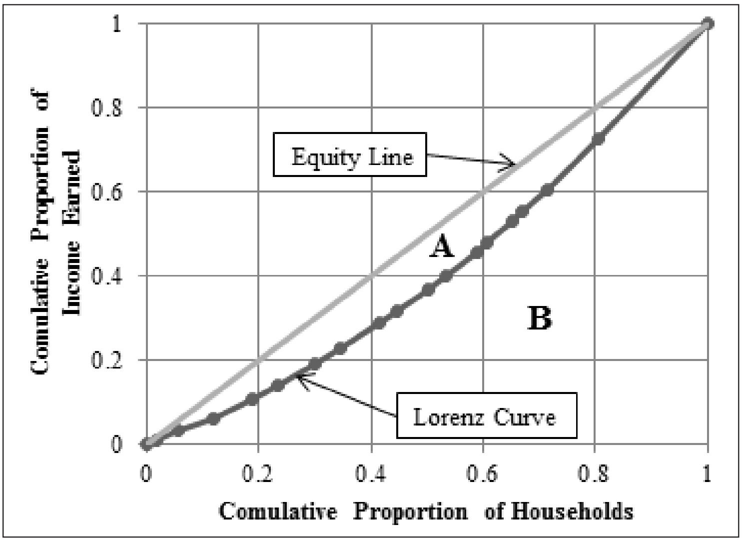
Table 13: Average Benefit/Taxation Ratio

Scenario	Average Ratio	Lower 95%	Upper 95%
Fuel Tax	1.1424	1.012	1.272
Gross Revenue	1.1407	1.011	1.271
Net Revenue	1.0568	0.936	1.177
Revenue Increase	0.8015	0.709	0.894

The Gini Coefficient

In order to analyze equity, one needs to apply objective measures that are directly comparable. The most commonly used measure, the Gini coefficient, is often considered to be the gold standard for vertical equity (De Maio 2007). The Gini coefficient is calculated based on the Lorenz curve, which is a plot of the cumulative proportion of benefits received versus the cumulative proportion of households, with absolute equality represented by a line bound by the points (0,0) and (1,1). An example Lorenz curve is shown in Figure 1.

Figure 1: Example Lorenz Curve



The Gini coefficient, which ranges from zero to one, is a measure of inequity used to determine benefits distribution, shown mathematically in Equation 5. If each member of a society receives the same share of wealth, then the Gini coefficient will be equal to zero, indicating complete equality. If one individual holds all the wealth, then the coefficient would be equal to one, indicating complete inequality (Drezner, Drezner, and Guyse 2009).

(5) $$G = \frac{A}{A+B} \; or \; 2 * A$$

Three different Gini Coefficients are presented for each revenue scenario in Table 14. The first is for taxation, the second for benefits received (expenditures), and the third for the ratio between the two. The taxation Gini coefficients are similar to the ones obtained by Larsen, who also used NHTS data (Larsen et. al. 2012). The ratio coefficients are negative due to the lower two quintiles receiving a greater percentage of the distribution than higher quintiles. Notably, there was no statistical difference between any of the coefficients, which suggests that an MBUF would not have a pronounced effect on the current distribution of what households pay versus what they receive in transportation expenditures. This is similar to results from the literature (McMullen et al. 2010, Zhang et al. 2009). Additionally, it suggests that fuel efficiencies do not play a dramatic role in equity when considering the system as a whole. The revenue increase ratio was close to being statistically significant, which suggests that low income households would receive less than they do under the fuel tax.

Despite the lack of a statistical difference between scenarios, there appears to be a trend. For the revenue increase scenario, the lower taxation coefficient and the higher benefit and ratio coefficients are less desirable from a vertical equity standpoint, though expected since a user fee would inherently move the Lorenz curve closer to the equity line. When public transit expenditures were excluded from the analysis, the ratio Gini coefficient for the fuel tax was -0.033, which is statistically different than the -.089 coefficient in the table below, indicating that public transit has a progressive effect on equity. While this result is not surprising, it is good to see it reflected in the numbers.

Table 14: Gini Coefficients

Scenario	Taxation			Benefit			Ratio (Benefit/Tax)		
	Gini	Lower 95%	Upper 95%	Gini	Lower 95%	Upper 95%	Gini	Lower 95%	Upper 95%
Fuel Tax	0.179	0.170	0.188	0.137	0.113	0.160	-0.089	-0.109	-0.069
Gross Revenue	0.177	0.169	0.186	0.137	0.113	0.160	-0.088	-0.108	-0.068
Net Revenue	0.177	0.167	0.186	0.137	0.113	0.160	-0.089	-0.109	-0.069
Revenue Increase	0.170	0.155	0.185	0.162	0.142	0.182	-0.054	-0.070	-0.039

The Theil Index

An important drawback of the Gini coefficient is that it is not decomposable, meaning that Gini coefficients for groups within the population do not combine to form a coefficient for the total population, which is an attribute of the Theil Index (De Maio 2007). The Theil index can be broken down into two parts, the within group components and the between group components. When summed together, they equal the Theil index of the entire population. The within group components are simply the Theil Indices of each of the subgroups. The between group components are a measure of the relative income of each subgroup compared to all other subgroups (Conceicao, Galbraith, and Bradford 2001). The within group component and the between group component are calculated as follows:

$$(6)\quad T'_g = \sum_{i=1}^{m} \left(\frac{Y_i}{Y}\right) * \ln\left(\frac{Y_i}{Y} / \frac{n_i}{n}\right)$$

Where:

Y is the population's total income
Y_i is the total income for the i^{th} group in the population
n is the number of individuals in the population
n_i is the number of individuals in the i^{th} group of the population

$$(7)\quad T_g^w = \sum_{i=1}^{m} \left[\left(\frac{Y_i}{Y}\right) * \sum_{p=1}^{n}\left(\frac{y_p}{Y_i}\right) * \ln\left(\frac{y_p}{Y_i} / \frac{1}{n_i}\right)\right]$$

Where:

y_p is the income of the p^{th} member of the group

According to the Theil Indices for the entire population, the lack of a statistical difference between scenarios indicated that whatever disparity exists will not be changed by an MBUF. Additionally, there was no statistical difference between the MBUF alternatives for the within group components, further reinforcing that a MBUF would not alter existing inequalities. The between group components revealed that the relative winners are rural and high income urban households, while the relative losers are all other urban households. Keep in mind that each household still receives more in benefits than they pay into the system (except for the revenue increase scenario). For this reason, all households can be considered winners, with some receiving a greater share than others. The greater number of miles driven by rural and higher income urban households may be the reason why they are the relative winners. Driving more miles decreases the effective average tax per mile due to fixed rate costs such as vehicle registration and property taxes, which must be paid regardless of the number of miles driven. It should be noted that all of the between group indices were very close to zero, indicating that the relative winners and losers are determined by a narrow margin. The detailed indices are available in the full report, which may be accessed online (https://ceprofs.tamu.edu/mburris/publications.htm).

While nearing the end of this research effort, there were a couple times that we received updated data from cities or counties after we had run the analysis. This meant replacing our estimated values with true values, which were quite close to our estimates. This caused almost no change in the results. Through further experimentation with input data, it became clear that the results do not change substantially without major changes in assumptions, such as excluding public transit entirely.

SUMMARY AND CONCLUSIONS

Lack of sustainable revenue generation for transportation infrastructure has created a need to examine potential alternative funding sources. The most prominent of which is the Mileage-Based User Fee (MBUF), where drivers would be charged based on the number of miles they drive, thus holding them accountable for their use of the roadway. While numerous equity-related issues have been addressed, the interrelation of transportation taxation and expenditures on all levels of government (state, county, and local) is not well understood.

Using National Household Travel Survey data and information collected from over 100 agencies, roadway taxation and expenditures were assigned to individual households in the Houston core based statistical area (CBSA). Using Gini Coefficients and Theil Indices, the research demonstrated that implementation of an MBUF would not have a pronounced effect on the current distribution of what households pay versus what they receive in transportation expenditures. Increasing the MBUF to meet the Texas 2030 Committee recommendations would decrease the average benefit to taxation ratio, causing households to receive less than they pay into the system. Additionally, it would decrease the total number of miles traveled by 22.8% and increase transit ridership by as much as 10.2%. Even with the drastic impact, the relative distribution of transportation taxation and expenditures did not change significantly compared to the other scenarios. However, this is purely for taxation and spending, which does not reflect the true total cost (including external costs) of using the transportation system (vehicle maintenance, transit fares, pollution, congestion). Excluding public transit expenditures resulted in a statistically significant and undesirable (regressive) change in the Gini Coefficient, indicating that public transit has a positive impact on equity when considering the transportation system as a whole.

Due to relatively fixed rate taxes (vehicle registration, property tax, and sales tax), the higher the miles driven, the lower the effective tax is per mile. When miles traveled are decreased by 22.8%, the effective tax per mile increases, which is the reason why the average benefit to taxation ratio was reduced. Therefore, increasing the MBUF (or the fuel tax) while other methods of taxation remain the same may disadvantage most households (less is spent on transportation than they paid in taxes). If transportation-related taxation were to shift toward user-based methods, then the benefit to taxation ratio should tend towards a value of one, indicating that all users receive exactly the value they pay for.

Research Limitation

The research did not include trucks or commercial vehicles. However, based on NHTS data and the daily vehicle mile estimate, they only account for roughly 15% of total miles driven. Due to the lack of available information, several other estimations needed to be made, most of which are believed to have yielded reasonable results. However, there was little confidence in the total daily vehicle miles driven on county roads. The state reported DVM was accurate and the local DVM could be reasonably estimated, but the county DVM estimation resulted in some deviation between the 10 counties when it came to county expenditure per DVM. However, when combining the numbers into urban and rural expenditures, the county variations were no longer pronounced.

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