EQUITY EVALUATION OF

VEHICLE MILES TRAVELED FEES IN TEXAS

A Thesis

by

LISA KAY LARSEN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2011

Major Subject: Civil Engineering

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Approved by:

Chair of Committee,	Mark Burris
Committee Members,	Gene Hawkins
	David Pearson
	David Ellis
Head of Department,	John Niedzwecki

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ABSTRACT

Equity Evaluation of

Vehicle Miles Traveled Fees in Texas. (August 2011)

Lisa Kay Larsen,

B.S., Brigham Young University

Chair of Advisory Committee: Dr. Mark Burris

The Texas state gas tax has been 20.0 cents per gallon since 1991, and the federal gas tax has been 18.4 cents per gallon since 1993. The gas tax is not only stagnant, but depreciating in value due to inflation. Thus, damage is being done to the infrastructure but the money needed to maintain and improve roadways is not being adequately generated. One proposed alternative to the gas tax is the creation of a vehicle miles traveled (VMT) fee, with equity being a crucial issue to consider.

This research used 2009 National Household Travel Survey (NHTS) Texas data to consider the equity impacts surrounding four VMT fee scenarios. Data were filtered and weighted to reflect results representative of Texas vehicle-owning households in 2008. Each scenario was run both statically and dynamically under the assumption that the VMT fee would replace the state gas tax.

An assessment of the relative vertical equity of each scenario was made by calculating the Gini Coefficient associated with the proportion of state gas tax or VMT fee revenue generated by each household income level quintile. Results indicate that all

of the VMT fee scenarios are essentially as equally vertically equitable as the current state gas tax system. Scenario 4 was designed to be inherently horizontally equitable because the per mile fee associated with each roadway type (urban or rural) was assessed to all vehicles driven on these roadway types at a rate calculated to generate needed funds to address the mobility and infrastructure needs of that roadway type. Scenario 3, a scenario favoring vehicles with high fuel efficiency, was found to be the least horizontally equitable.

Scenarios 2-4 were able to generate additional revenue desired to meet the infrastructure and mobility needs of Texas set forth by the 2030 Texas Transportation Needs Committee. The large fee increase necessary to achieve the desired additional revenue may not be popular or possible. However, an evaluation of the philosophy governing each scenario designed to generate additional revenue is informative when it comes to equity impacts. No one VMT fee scenario affects all household income levels and geographic locations uniformly and it was not the goal of this research to design an equitable VMT fee scenario. Rather, the effect of each scenario on 2008 Texas vehicle-owning households disaggregated by household income level and geographic location are presented and left to the discretion of elected officials to decide which VMT fee, if any, would be best for their constituents.

DEDICATION

To my parents, Bryan and Debbie Larsen, for their unfailing love and support

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I would like to thank Dr. Mark Burris for his direction and insights throughout this research effort. Frequent meetings with him helped to keep the research effort on track and allowed me to continually refocus on what needed to be done to make progress towards the completion of this project. Likewise, I would like to thank Dr. Gene Hawkins, Dr. David Pearson, and Dr. David Ellis for serving on my thesis committee and lending their time and expertise in providing useful feedback.

Patti Ellis, from the Texas Transportation Institute, was instrumental in teaching me the process of raking data to obtain weights when survey data information is not initially available in its desired form, and in informing me about potentially useful datasets. I appreciate the SAS programming help of Siddharth Somayajula, a classmate at Texas A&M, in working to merge EPA fuel economies with the Texas NHTS vehicles; even though the release of Version 2.1 of the 2009 NHTS data later eliminated the need for this data. I would also like to thank the Texas Department of Transportation and the Texas Transportation Institute for granting me permission to use 2009 NHTS Texas Add-on data for my thesis. Funding received from the Southwest Region University Transportation Center to work on this project is greatly appreciated and helped facilitate the project's timely completion.

Last, but not least, I would like to thank my family for their love and support as I pursued my master's degree at Texas A&M University.

NOMENCLATURE

ACS	American Community Survey
ANNMILES	Self-Reported Annualized Mile Estimate
AR	Autoregressive
ASCE	American Society of Civil Engineers
ATS	American Travel Survey
AVI	Automatic Vehicle Identification
Caltrans	California Department of Transportation
CMPLTPCT	Percent of Household Members that Completed the Interview
CTPP	Census Transportation Planning Package
DOE	Department of Energy
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EIADMPG	EIA Derived Miles Per Gasoline-Equivalent Gallon Estimate
EPA	Environmental Protection Agency
FGLS	Feasible Generalized Least Squares
FHWA	Federal Highway Administration
FUELTYPE	Type of Fuel
GCOST	Fuel Cost in Nominal US Dollars Per Gasoline-Equivalent Gallon
GPS	Global Positioning System
HH_HISP	Hispanic Status of Household Respondent

HH_RACE	Race of Household Respondent
HHFAMINC	Derived Total Household Income
HHSIZE	Count of Household Members
HHSTATE	State Household Location
HHVEHCNT	Count of Household Vehicles
HOUSEID	Household Eight-Digit ID Number
HYBRID	Vehicle is Hybrid or uses Alternate Fuel
LIF_CYC	Life Cycle Classification for the Household
LPR	License Plate Reader
MPG	Miles Per Gallon
NHTS	National Household Travel Survey
NPTS	National Personal Transportation Survey
NSTIFC	National Surface Transportation Infrastructure Financing Commission
OLS	Ordinary Least Squares
RUFTF	Road User Fee Task Force
STIP	Statewide Transportation Improvement Program
SUR	Seemingly Unrelated Regression
TAZ	Transportation Analysis Zone
TIP	Transportation Improvement Program
TRB	Transportation Research Board
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation

URBRUR	Household in Urban/Rural Area
VEHTYPE	Vehicle Type
VEHYEAR	Vehicle Model Year
VMT	Vehicle Miles Traveled

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

LIST OF FIGURES

LIST OF TABLES

Page

Page

Page

LIST OF EQUATIONS

LIST OF EXAMPLES

CHAPTER I

INTRODUCTION

The Texas state gas tax is currently 20.0 cents per gallon, and has been since 1991. The federal gas tax is 18.4 cents per gallon and has not changed since 1993. The gas tax is not only stagnant but is depreciating in value. According to a front-page article in *USA Today* by Dennis Cauchon, "Although the federal gas tax—18.4 cents per gallon—hasn't changed since 1993, tax collections are down because today's vehicles go farther on a gallon of gas, cutting tax collections while increasing wear and tear on highways. Inflation since 1993 has eroded the value of the tax to maintain roads (Cauchon, 2010)." In this same vein, Cho and Powers state that, "The nation's population and number of vehicle miles traveled are increasing, yet the purchasing power of the highway trust fund's fuel tax revenue is decreasing (Cho and Powers, 2006)." The fuel efficiency of new vehicles on America's roadways is only going to improve. President Obama recently announced a new national fuel economy standard of 35.5 miles per gallon for new vehicles, effective 2016 (Broder, 2009). While this new standard will help contribute towards cleaner air stemming from fewer emissions, it negatively impacts transportation funding under the current gas tax funding system.

This thesis follows the journal style of the *Journal of Transportation Engineering.*

Additionally, the need for transportation funding has not remained constant. Rather, there is the growing need to maintain and improve the existing, aging infrastructure, while expanding and enhancing the facilities available to motorists. America's infrastructure received an overall D rating in the 2009 American Society of Civil Engineers (ASCE) report card, with roads receiving a D-, bridges receiving a C, and transit receiving a D (American Society of Civil Engineers, 2009). A variety of solutions have been theorized to help increase revenue available for transportation projects and make travelers more accountable for their use of the infrastructure; with solutions ranging from increasing the gas tax, expanding toll ways, and increasing the vehicle registration fee.

Recently, this issue has received national attention as various plans to help reduce, and eventually eliminate, the national debt have been proposed. One of the plans, championed by Senator Tom Carper of Delaware and Senator George Voinovich of Ohio, proposes incrementally raising the federal gas tax to eventually reach 43.4 cents per gallon. As noted by Dennison, "In total, the senators said in their letter, the 25-cent tax hike would generate $200 billion in revenue over five years. Of that, $117 billion would end up earmarked for transfer to the federal Highway Trust Fund, which Carper and Voinovich said is badly in need of funding (Denison, 2010)."

Similarly, suggestions made in December 2010 by the National Commission on Fiscal Responsibility and Reform included increasing the gas tax incrementally by 15-cents per gallon between 2013 and 2015. Additional recommendations included "limit[ing] spending to actual revenues collected by the trust fund in the prior year once the gas tax is fully phased in. Shortfalls up until that point would be financed by the general fund (National Commission on Fiscal Responsibility and Reform, 2010)." Infrastructure was listed among the important areas to invest in to "help our economy grow, keep us globally competitive, and make it easier for businesses to create jobs (National Commission on Fiscal Responsibility and Reform, 2010)."

However, the gas tax is often viewed as a "second-best" policy—which, although not able to best address any one issue, can simultaneously address multiple issues fairly well (Lin and Prince, 2009). Thus, while proposals to increase the gas tax have the potential to address the issue of generating the funds needed for infrastructure maintenance and improvements, this approach does not fully address the potential that improving vehicle fuel efficiencies will eventually minimize funds generated on a per gallon basis. As vehicle fuel economies continue to increase, motorists will gradually become less accountable for their use of the transportation system. According to McMullen et al., "Until recently fuel taxes were thought to be fairly good proxy for optimal road use fees that charge users based on the damage (or marginal costs) they impose on the road (McMullen, Zhang and Nakahara, 2010)." However, with vehicles becoming ever more fuel efficient, the gas tax is quickly losing its link to how much the infrastructure is used.

In the Final Report of the National Surface Transportation Infrastructure Financing Commission that was released in February 2009, the Commission described several funding options that are available to address growing infrastructure needs. The Committee expressed their opinion that short-term, increasing the current gas tax is the best option given large installation costs associated with implementing a new transportation fee system. However, the Commission also suggested that turning to a VMT fee system is the best option when looking past just the short-term situation, stating that, "The most viable approach to efficiently fund federal investment in surface transportation in the medium to long run will be a user charge system based more directly on miles driven (and potentially on factors such as time of day, type of road, and vehicle weight and fuel economy) rather than indirectly on fuel consumed (National Surface Transportation Infrastructure Financing Commission, 2009)."

RESEARCH PROBLEM

Given the recent interest in the possibility of a VMT fee system, research on this topic is timely. There are several questions to consider in the design and eventual implementation of a VMT fee scenario. How well will this scenario generate revenue? What logistical issues surround its implementation? What will be the public's reaction to the transportation fee change and to what extent will their travel patterns differ because of it? Who will pay more under the new system and who will pay less; will the new system be equitable? Equity is one VMT fee aspect that should be evaluated and presented to elected officials and policy-makers in deciding upon which VMT fee, if any, to implement. Equity impacts are also important for the public to understand. Evaluating the equity of several VMT fee scenarios was the focus of this research effort.

RESEARCH OBJECTIVES

The purpose of this research was to develop, test, and analyze four VMT fee scenarios with respect to equity. It is important to note that the objective was *not* to create and champion an equitable VMT fee scenario. Rather, an attempt was made to present the scenario results in a clear, concise manner that will enable elected officials and policy-makers to have access to equity impact information when making decisions on which VMT fee, if any, would be best for their constituents. The following section describes the research methodology and gives a brief summary of the scenarios that were analyzed.

RESEARCH METHODOLOGY AND SCENARIOS

Texas data from the 2009 National Household Travel Survey (NHTS) were available in two forms—the Texas Add-on dataset and the Texas survey data made available through the NHTS website (http://nhts.ornl.gov/index.shtml). Prior to performing any analysis it was necessary to merge needed variables from each dataset. Next, the data were filtered to only include complete and relevant household and vehicle information. The filtered data were then weighted to reflect 2008 Texas vehicle-owning households. Using the properly filtered, merged, and weighted data, four VMT fee scenarios were analyzed and compared to the current gas tax funding system using two different methodologies. First, a static model was considered, which assumed that no change in travel occurred as a result of implementing a new transportation fee. Next, a dynamic model was implemented using price elasticities disaggregated by household income level and geographic region. The dynamic model reflected changes in travel that were anticipated to stem from changes to the transportation fee. The filtering, merging, weighting, and scenario implementation process is further described in Chapter III. The four scenarios that were analyzed for equity are described below.

Scenario 1: Flat VMT Fee

This scenario established a flat per-mile VMT fee that generated a similar amount of net revenue as the amount already collected in Texas through the state gas tax. Although this scenario would not serve to increase the funds currently generated through the state gas tax, it could be used as a tool to familiarize drivers with the concept of a VMT fee.

Scenario 2: Flat VMT Fee for Added Revenue

Similar to Scenario 1, this scenario established a flat per-mile VMT fee. However, rather than simply generating a revenue similar to that currently collected through the Texas state gas tax, this scenario examined collecting the additional revenue needed to reach the infrastructure and mobility goals established by the 2030 Committee on Texas Transportation Needs—which totaled an additional $14.3 billion annually (Texas 2030 Committee, 2009).

Scenario 3: Three-Tier VMT Fee to Encourage "Green" Vehicles

This scenario was designed to develop a VMT fee system that would encourage the use of fuel-efficient vehicles. Initially, vehicles with a fuel economy less than the median fuel economy were charged a $0.020 per mile VMT fee; vehicles with a fuel economy between the median value and the mean value were charged a VMT fee of

$0.015 per mile; and vehicles with a fuel economy greater than the mean value were charged a VMT fee of $0.010 per mile. This scenario structure was designed under the assumption that the mean vehicle fuel economy is greater than the median vehicle fuel economy. The idea behind this scenario stems from a scenario implemented in research performed by Zhang and McMullen in their paper entitled, *Green Vehicle Mileage Fees: Concept, Evaluation Methodology, Revenue Impact, and User Responses* (Zhang and McMullen, 2010). Upon calculating the total revenue generated under this VMT fee scenario, the fees assessed to each fuel economy level were then scaled to more accurately meet the projected revenue needed to address Texas's infrastructure and mobility needs; with an additional $14.3 billion of revenue generated annually.

Scenario 4: Urban versus Rural Distinction

Urban roadways and rural roadways have different costs, characteristics and travelers. Urban roadways are generally more congested and serve higher volumes of vehicles often taking shorter (length-wise) trips. On the other hand, rural facilities allow for more direct travel between remote locations; though at times they are infrequently traveled. Given their different and distinct functions and costs, it may be more equitable to charge a different rate for urban and rural travel; as suggested by Mark Hornung through discussion boards posted by members of the Transportation Research Board (TRB) Freight Transportation Economics and Regulation Committee (unpublished work). This scenario assessed a different flat VMT fee for travel on urban roadways and travel on rural roadways.

All scenarios were based on the concept of keeping the federal gas tax unchanged, but replacing the Texas state gas tax with the proposed VMT fee scenarios for all gasoline-run vehicles included in this analysis. Transportation fees assessed to vehicles not running on gasoline and vehicle types not included in this analysis would continue to be assessed the state gas tax—rather than converting to the proposed VMT fees. The following section describes what each chapter within this thesis includes.

THESIS OUTLINE

Chapter I, **Introduction**, provides a background on the motivation behind considering potential VMT fee scenarios and the importance behind studying the equity impacts of the VMT scenarios. A brief description of the data used in the equity analysis is given. An introduction to the two data models used in this analysis—namely static and dynamic—is provided. Additionally, the four scenarios analyzed as part of this research effort are briefly outlined. Lastly, an outline of what is contained in the remainder of this thesis is provided.

Chapter II, **Literature Review,** includes background information on supporting topics ranging from VMT fee case studies, to issues surrounding the design and implementation of VMT fees, to equity, to model selection, to Texas infrastructure needs.

Chapter III, **Data Merging, Filtering, and Weighting,** begins by providing some background information on the NHTS. A description of the process used to merge data from both the Texas Add-on dataset and Version 2.1 of the publically available

NHTS dataset is given. The process and criteria used to filter the NHTS data to only include complete, relevant vehicle and household information is outlined. Additionally, a description is provided on the techniques used to weight the survey data to reflect the vehicle-owning households of Texas.

Chapter IV, **VMT Fee Scenario Structure, Analysis, and Results**, further describes the structure of each of the VMT fee scenarios considered in this analysis. Then, a description of how each of the four scenarios was applied to the weighted data—first using a static model and then using a dynamic model—is given. A discussion of differences in the results obtained using the two model types is provided. A list of potential VMT fee goals for policy-makers to use as a starting point in creating their own VMT fee goals is provided. Additionally, a comparison of the equity impacts for each scenario is presented.

Chapter V, **Conclusions and Recommendations**, supplies a discussion of conclusions that can be drawn from the equity results obtained for each scenario. Areas of future research that may stem from the work performed within this thesis are suggested.

CHAPTER II

LITERATURE REVIEW

In performing research on the equity of VMT fee scenarios in Texas, there are several related topics that deserve review. This chapter presents pertinent background information in areas related to this research effort. Included topics encompass VMT fee case studies illustrating the need for further research; issues related to VMT fee implementation; equity and how it is measured; model type selection and the strengths and weaknesses surrounding the use of a static model versus a dynamic model; as well as growing Texas infrastructure needs and how the VMT fee scenarios performed within this research can help address projected funding need estimates.

VMT FEES

VMT fees are viewed by many as an attractive option to replace the gas tax because of its ability to better hold motorists accountable for their use of the roadway and to foster the collection of funds needed to maintain and improve the infrastructure (Zhang and McMullen, 2010); (Forkenbrock and Hanley, 2006); (Lindsey, 2010); (Zhang, McMullen, Valluri and Nakahara, 2009); (McMullen, Zhang and Nakahara, 2010); (National Surface Transportation Infrastructure Financing Commission, 2009). Several states have experience with some form of implemented pilot studies of VMT fees. The next two sections review case studies and research related to VMT fees and the major issues surrounding their design and eventual implementation.

Case Studies: Oregon

The 2001 Oregon Road User Fee Task Force (RUFTF) was charged with brainstorming possible transportation fee ideas. As a result, a VMT fee pilot test was conducted in Oregon. The test involved over 200 vehicles and had two service stations equipped with the technology needed to communicate with those 200 participating Global Positioning System (GPS) equipped vehicles. The pilot test concluded that the implementation of a VMT fee scenario has potential, and would become increasingly feasible as technology improves. Until wide-spread technology for VMT fee collection becomes available, unequipped vehicles could continue to be charged the state gas tax (Rufolo and Kimpel, 2008). Additionally, the pilot test compared the effect that being charged a VMT fee equivalent to the amount paid under the state gas tax by a vehicle with average fuel efficiency, versus being charged a higher VMT fee during the peak-hour and a lower VMT fee during the off-peak hours, had on driving behavior. Compared to the control group that continued to be charged the state gas tax, persons charged a VMT fee drove less. Additionally, persons who had to pay a higher VMT fee in the peak period drove 20 percent less during the peak-hours when compared to the flat VMT category (Rufolo and Kimpel, 2008). This supports the idea that use of a dynamic model in assessing VMT fee impacts may be beneficial in reducing VMT—especially during peak-hours. However, it is difficult to say whether this result would be observed to the same extent if the subjects were not under experimental conditions.

Additional aspects of VMT fee experiments performed in Oregon have been the focus of several research papers within the literature. For instance, Kim et al. discuss the technology that was used in Oregon's VMT-fee pilot test in their article; focusing on the on-vehicle device technology, the service static technology, and the data storage and retrieval technology (Kim, Porter, Whitty, Svadlenak, Larsen, Capps, Imholt, Pearson and Hall, 2008). The authors remark that the pilot test showed that technology can enable VMT fees to be collected without drivers and system operators needing to spend extra time and effort in reporting and handling VMT fees. Additionally, the technology configuration used would allow VMT fees to be implemented gradually, in a manner that would allow for the dual operation of either the gas tax system or a VMT fee system—until all vehicles had the properly installed technology needed for VMT fee collection (Kim, Porter, Whitty, Svadlenak, Larsen, Capps, Imholt, Pearson and Hall, 2008).

Case Studies: Iowa

A large-scale study on mile-based fees is currently being conducted by the University of Iowa Public Policy Center (The University of Iowa Public Policy Center, 2011). As part of this road user study, an on-board computer capable of tracking VMT was installed in the vehicles of volunteers in twelve cities across America. The on-board computers were used to monitor motorist's travel for ten months. Participating vehicles continued to be charged the current gas tax—with the VMT fee being purely theoretical and tabulated only for research purposes. Participating vehicles were paid for their participation, contingent on their receiving training and on their duration of participation. The VMT fee rate varied based on the participant's jurisdiction location and the fuel efficiency of their vehicle. Results of the study are still being compiled, and upon their completion will be presented to the Department of Transportation.

Case Studies: I-95 Corridor Coalition

States along the eastern coast of the United States (who are part of the I-95 Corridor Coalition) have discussed the possibility of establishing a multi-state VMT revenue system. As part of an effort to examine legal issues surrounding the Coalition, surveys of eight of the entities involved in the Coalition (in addition to Oregon, given its vast VMT experience) were undertaken. Although issues such as revenue collection, system structure (fee, tax, toll), privacy concerns, revenue distribution, rate determination, and multi-state agreements were discussed, "None of the responses suggested a state-wide VMT-based system of charges would create insurmountable state constitutional or other legal issues (I-95 Corridor Coalition, 2011)."

VMT Fee Self-Financing Research: Indiana

As part of Indiana's efforts to develop VMT fee scenarios, research was conducted to determine the self-financing level of urban and rural roadway classifications. Options of simply maintaining the revenue level currently collected with the gas tax system or increasing the revenue to desired levels for future transportation infrastructure needs were considered. Scenarios replacing either the state gas tax or both the state and federal gas tax were tested. Oh et al. found that a cross-subsidy across different facility types occurs when a flat VMT fee is applied; with urban highways subsidizing rural non-interstate systems, rural interstate systems subsidizing rural non-interstate systems, and urban non-interstate systems subsidizing urban interstate systems.

Financing equity can be achieved across facility type when varying fees are paid on differing facilities (Oh, Labi and Sinha, 2007).

VMT Pollution Fee Research: California

Research was done by Kavalec and Setiawan on the possibility of a pollution fee in southern California charged on a VMT basis. Vehicles with different emission levels would be charged a different per mile fee rate. The simulation indicated that a pollution fee with this design may be regressive in nature because generally lower income households own older vehicles that produce more pollutants. However, the regressive nature of the pollution fee would likely diminish with time (Kavalec and Setiawan, 1997). The authors also indicated that keeping track of vehicle miles may be an issue, stating that, "preventing noncompliance, evasion, or fraud may be difficult (Kavalec and Setiawan, 1997)."

Case Studies: VMT Insurance

Some companies already offer per-mile insurance (i.e., MileMeter in Texas, Real Insurance PAYD in Australia, Nedbank Pay Per K Coverage in South Africa, PolisDirect in Holland, Progressive MyRate, etc.) (Litman, 2010). Litman argues that this type of insurance system, "Increases equity by making premiums more actuarially accurate. It makes vehicle ownership more affordable and provides financial savings, particularly for lower income motorists (Litman, 2010)." It is also argued that safety is closely linked to the number of miles driven; thus, if vehicles are driven less, the chance of an accident decreases. As with other VMT fee research, there are several areas of concern; including privacy, fraud, and administrative costs. Based on an analysis that considered the implementation costs and effectiveness of five different distance-based pricing options (mileage rate factor, pay-at the pump, per-mile premiums, per-minute premiums, and GPS-based pricing), Litman found that the mandatory per-mile premium "provide[d] the greatest net benefits (Litman, 2010)."

Issues Surrounding VMT Fees

As states continue to research the best course of action to take in the development of a transportation fee that will meet their future needs, there are a number of issues to address—many of which relate to VMT fee scenarios. Of paramount importance is how the proposed transportation fee will be able to capture needed revenue for transportation projects. As previously mentioned, America's infrastructure is deteriorating and is in need of additional funding. It may be prudent to initially establish a system that merely matches the amount currently collected through the gas tax, and then incrementally increase the amount charged to reach a desired sum needed to help bridge the current funding gap between available transportation funding and revenue needed to maintain and improve the transportation infrastructure.

However, in the process of striving to increase transportation revenue, it is important to consider the overarching goal of establishing a new transportation fee. As stated by former United States Transportation Secretary, Mary Peters, "It is far more critical that the federal government establish clear policies, providing appropriate incentives and allocating resources more efficiently, than it is for substantial increases in total federal spending (Koss, 2008)." The same could be said of transportation funds at the state level.

Another critical issue to consider is the method of fee collection. Technology continues to evolve and allow for more tasks to be performed better, faster, and cheaper. In the case of a VMT fee, there needs to be a method established to both collect mileage data and assess the proper charge to the vehicle owner. Odometer readings are one option. However, issues of mileage reporting integrity arise, as previously mentioned by Kavalec and Setiawan (Kavalec and Setiawan, 1997). Dishonest people will always find a way to beat the system; yet the vast majority would likely be honest in their mileage reporting, which could be collected during the yearly vehicle registration process (where that is done). Though feasible, using odometer readings as the means of collecting VMT fees would not allow charges to be linked to the facility type and location that each mile was driven on, and thus, make targeted fee scenarios impossible to implement. Plus, there are many locations that do not have annual inspections. However, in locations where annual vehicle inspections are required and where other technologies are not in place, use of odometer readings may be a more feasible, affordable option.

Technology continues to improve and expand; thus, the possible use of several technology-based collection options exist, including the use of GPS units, video tolling using a license plate reader (LPR), and automatic vehicle identification (AVI) using a transponder (Wells, 2010). A major concern with VMT fee collection technology is the cost of installation and subsequent collection. The more frequently mileage information is collected, the more expensive the collection proposition. In the case of a global positioning system (GPS) unit, the type of on-board unit (OBU) used for mileage tracking greatly affects the cost; with thick OBUs estimated at $650 and thin OBUs estimated at $195 (Wells, 2010). The term “thick” OBU is sometimes interchanged with the term “intelligent” OBU (Pickford and Blythe, 2006). “Although the definitions of thick and intelligent have not been standardized, it is generally accepted that an OBU that estimates position and matches this to the terrestrial data of road segments is known as an intelligent client (Pickford and Blythe, 2006).” Thick OBUs may also have the ability to internally keep track of the VMT fee price and subsequent total fees owed. On the other hand, a thin OBU sends information to a data center that stores the information and later bills the owner of the vehicle (Hassan, 2007). Thus, while the thin OBU itself is cheaper than the thick OBU, communication costs are higher when thin OBUs are implemented (Hassan, 2007).

The additional cost of the thick OBU itself offers the added benefit of reduced privacy concerns; however, the process of updating mapping software is more complicated than for thin OBUs (Wells, 2010). As suggested by Wells, OBU costs may be more justified if the point of the technology installation was not merely revenue based, but also facilitated the implementation of congestion pricing, emission fees, traffic data collection, and rates that vary based on road load-bearing capacity (Wells, 2010). The potential for VMT fee scenarios to not only address the issue of collecting revenue for the transportation infrastructure, but also to help mitigate congestion by creating incentives to travel during the off-peak hours, was previously described in the work of Rufolo and Kimpel (Rufolo and Kimpel, 2008). Regardless of the VMT fee scenario, technology is not perfect and problems with collection and mileage reporting may arise; with problems being minimized as technology improves (Oh, Labi and Sinha, 2007); (Wells, 2010). Research into developing an agile OBU that incorporates the best aspects of thin and thick OBUs has been performed and research into technology improvements are on-going (Hassan, 2007).

Privacy concerns are often linked to the expanse of technology. Individuals do not want to feel like they are constantly being watched and that their travel can be monitored. This concern was voiced by Senate Environment and Public Works Chair, Barbara Boxer, in response to recommendations made by the National Surface Transportation Policy and Revenue Study Commission in how to address transportation funding needs. According to an article by Koss that was paraphrasing Boxer, “[Boxer] would consider the study’s recommendations on tolling, the roles of private and municipal investment in infrastructure upgrades, and switching to a ‘vehicle miles traveled’ funding fee in 2025, if privacy concerns are addressed (Koss, 2008).” While it is understandable that individuals and policy-makers alike may be apprehensive about privacy concerns related to a VMT fee, these fears can be minimized by use of delayed GPS data reporting and minimal data storage.

Environmental concerns are also an issue that may shape transportation fee structure development. As previously mentioned, President Obama is pushing to increase the fuel economy standard of vehicles. Referring to these new standards, *The New York Times* quotes Daniel Becker, director of the Safe Climate Campaign, as saying, “This is the single biggest step the American government has ever taken to cut greenhouse gas emissions (Broder, 2009).” The transportation sector is the second leading contributor to greenhouse gas emissions—behind only the electric power sector

(Morrow, Gallagher, Collantes and Lee, 2010). While policies that help reduce greenhouse gas emissions from the transportation sector (largely stemming from carbon dioxide) are a benefit to the environment, the current gas tax system does not appear to be able to simultaneously remedy environmental concerns and revenue shortfalls.

On the one hand it may be argued that a new transportation fee system should not penalize those who buy hybrids and other fuel-efficient vehicles by charging them the same fee assessed to less environmentally-friendly, low fuel-efficient vehicles. After all, under the current gas tax system, the more fuel-efficient the vehicle, the less money paid in gas tax. In addition to benefits at the pump, incentives have been attached to the purchase of alternative fueled vehicles. Gallagher and Muehlegger researched hybrid incentives at the state level, using data from multiple states for the years 2000-2006. Interestingly, the authors found that, "The form of incentive is as important a factor in consumer adoption as incentive generosity (Gallagher and Muehlegger, 2010)." The authors further state that, "The results suggest that immediacy, transparency, and ease may be important attributes when designing incentives meant to affect consumer behavior (Gallagher and Muehlegger, 2010)." The same may be true of a transportation fee. Not only should the total transportation fee amount be considered, but also the form in which it is charged.

EQUITY

According to Oh et al., "The criterion of equity is a measure of the fairness of a pricing scheme to different user groups (Oh, Labi and Sinha, 2007)." User groups may be defined by household income level, household geographic location, vehicle type classification, or roadway facility type (Zhang and McMullen, 2010); (Oh, Labi and Sinha, 2007). As previously mentioned, Oh et al. addressed the issue of equity among roadway facility types; though not enough data were available to break the analysis down by vehicle class (Oh, Labi and Sinha, 2007). The research presented within this thesis uses 2009 NHTS Texas data, which allows for an equity analysis that produces results disaggregated by household income level and household geographic location based on results obtained using vehicle fuel economy data.

Equity pertains to multiple ideas presented among the VMT fee areas needing further research as suggested by the Joint Subcommittee on VMT Fee Revenues at the 2011 TRB annual meeting (Regan, 2011). Pertinent ideas include the following:

- "Determine how various rates affect equity and fairness amongst motorist classes, and assess whether the general public accepts subsidies for certain classes such as rural drivers and poorer drivers (Regan, 2011)."
- "Assess the socio-economic effects and the associated implications of moving from charging per gallon to charging by mile under various policy applications (Regan, 2011)."
- "Conduct an assessment of equity issues, comparing the existing system with a mileage-based system, and research fairness concerns such as those related to urban versus rural interests and the affects of a mileage-based fee system on lower income drivers (Regan, 2011)."

It is not surprising that investigation into the equity impacts surrounding VMT fee scenarios has surfaced as a critical area of research that must be addressed prior to implementing a new transportation funding system that has the potential to generate billions of dollars of additional annual revenue. Transportation projects often are required to address equity concerns. In fact, all transportation projects that receive federal funding require an Environmental Impact Statement (EIS); part of which includes an assessment of the project's Environmental Justice. As defined by the California Department of Transportation (Caltrans), "Environmental Justice in terms of transportation projects can be defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income, from the early stage of transportation planning and investment decision making through the construction, operations and maintenance (Caltrans, 2010)." This supports investigation into the equity impacts of VMT fees with respect to household socioeconomic and geographic location variables; as was done in this research. The following sections further define what equity is and provide examples of how equity has been addressed in past research.

Horizontal Equity

Two major subdivisions of equity exist; horizontal equity and vertical equity. Several different definitions of horizontal equity are found within the literature. According to Litman, "Horizontal equity is concerned with the distribution of impacts between individuals and groups considered equal in ability and need (Litman, 2002)." In other words, horizontal equity suggests that, "public policies should avoid favoring one individual or group over others (Litman, 2002)." As described by Toutkoushian and

Michael, horizontal equity is the "equal treatment of equals (Toutkoushian and Michael, 2007)." Similarly, Taylor and Norton state that, "Horizontal equity considers how members of the same group (the elderly, bus riders, etc.) fare relative to one another (Taylor and Norton, 2009)."

Vertical Equity

By contrast, "Vertical equity is concerned with the distribution of impacts between individuals and groups that differ in abilities and needs, in this case, by income or social class (Litman, 2002)." This implies that in order for equity to exist, poor or disadvantaged individuals should be charged less than their more wealthy counterparts (Litman, 2002). In other words, vertical equity suggests the "unequal treatment of unequals (Toutkoushian and Michael, 2007)." The consideration of horizontal equity and vertical equity is not unique to the field of transportation (Toutkoushian and Michael, 2007). However, within the transportation discipline there are a myriad of applications.

Lorenz Curves (see Figure 1) and Gini Coefficients are common visual and quantitative methods respectively, used to assess vertical equity. By definition, the line representing equity on a Lorenz Curve is bounded by (0,0) and (1,1) (Drezner, Drezner and Guyse, 2009). Drezner et al. explain that the line of greatest equity is when "x% of the population has x% of the good (Drezner, Drezner and Guyse, 2009)." Research into methods of approximating the Lorenz Curve (Ogwang and Gouranga Rao, 1996) and developing hybrid curve approximations has been performed (Ogwang and Rao, 2000). Similarly, the Gini Coefficient can range from 0 to 1, with 0 indicating complete income equality and 1 indicating complete income inequality (Rock, 1982). Drezner et al. describe the calculation of the Gini Coefficient by stating, "The Gini coefficient (G) is the ratio of the area between the Lorenz Curve and the straight "equity" line to the entire area below the equity line with $0 \leq G \leq 1$ (Drezner, Drezner and Guyse, 2009)." This is shown mathematically in Equation (1) (see Figure 1).

$$G = \frac{A}{A + B} \tag{1}$$

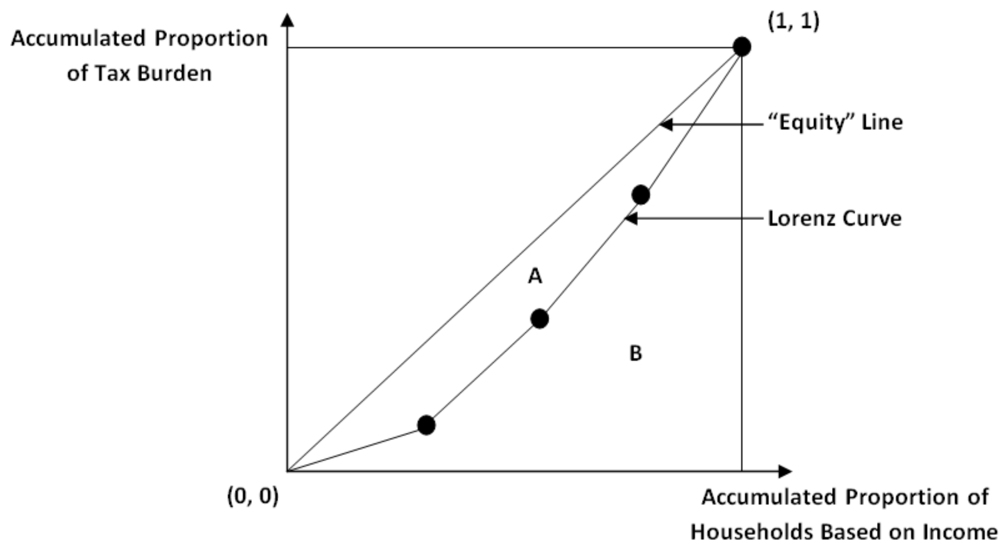

Figure 1. Lorenz curve plot (adjusted from a plot presented by Drezner, Drezner and Guyse, 2009)

Closely related to the concept of Lorenz Curves is the Suit Index, often referred to as the S-Index. Index values can range from -1 to 1; with -1 indicating absolute regressivity, 0 indicating proportionality, and +1 indicating absolute progressivity. Litman defines the meaning of progressive and regressive by stating that, “Policies favoring disadvantaged groups are called *progressive*, while those that excessively burden disadvantaged people are called *regressive* (Litman, 2002).” As stated by Rock, “To apply the S-index, families are ranked from lowest to highest income, and the accumulated percentage of tax burden associated with the corresponding accumulated percentage of income needs to be obtained (Rock, 1982).” A visual representation of how the S-Index is used is shown in Figure 2; with the difference between a progressive tax and a regressive tax illustrated. Rock investigated the S-Index for several transportation financing alternatives using 1972-1973 Bureau of Labor Statistics Consumer Expenditure Survey data and found that most transportation financing options were regressive (Rock, 1982).

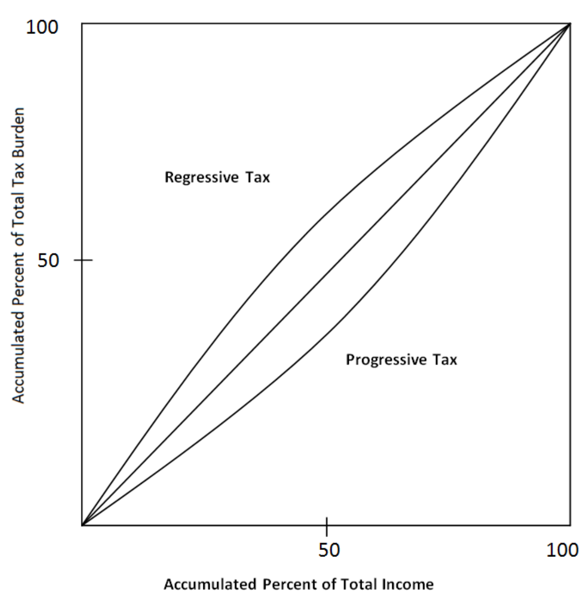

Figure 2. Tax burden versus income (Rock, 1982)

Equity Research

Taylor and Norton give an extensive description of the different types of equity that can be defined and measured within transportation (Taylor and Norton, 2009). They state that, "*Equity* gets defined quite differently by different interests at different times (Taylor and Norton, 2009)." This is an important point to realize because in evaluating equity it must be understood what exactly is being evaluated in order to get clear, meaningful results and to allow for comparisons between different transportation revenue scenarios. Another important point the authors discuss is the concept that as fees contributing towards transportation revenue become more and more distanced from a traveler's use of the transportation system, the less likely an individual is to consider the travel externalities they impose on the system when making decisions about trips (Taylor and Norton, 2009). Although the current gas tax is somewhat linked to how much a traveler uses the transportation system, as vehicles become increasingly more fuel efficient, the connection between usage and fee will weaken. A VMT system would help to solidify the concept that the more you use the transportation system, the more you pay. Taylor and Norman go on to list trips, passenger miles traveled, and a per capita basis as three common reference units used to evaluate equity—emphasizing that the reference units selected greatly impact the equity results (Taylor and Norton, 2009). Similarly, three main units of analysis exist—geographic, group, and individual. The geographic unit is commonly used by elected officials in the consideration of equity; the group unit is often used by advocates and activists; and the unit of individual is the typical domain of social science scholars (Taylor and Norton, 2009).

Lari and Iacono investigated vertical equity issues using data from the Twin City area of Minnesota. The authors describe vertical equity as relating to "the equity of a policy with respect to groups of users with different economic circumstances (ability to pay) (Lari and Iacono, 2006)." Interestingly, they note that, "Among the taxes used to finance transportation, most are moderately regressive, with the motor fuel tax being the most regressive (Lari and Iacono, 2006)." However, the authors also found that higher income households generally make not only more trips but also longer trips. Thus, in order to make funding the infrastructure less regressive, the authors propose shifting more towards fees, such as the motor fuel tax, that are more closely related to use of the system and move away from taxes that are not closely linked to usage (Lari and Iacono, 2006). VMT fees may be even more closely linked to usage than the motor fuel tax. One of the objectives of this thesis was to investigate the validity of this statement by comparing the distributional equity impacts of the current state gas tax in Texas to several VMT fee scenarios.

Evaluating Equity

Based on the equity definitions and research presented to this point, it is evident that there are many different available methods to evaluate equity (Lorenz Curves, Gini Coefficients, Suit Index, etc.). The Gini Coefficient was used in this analysis to quantitatively evaluate the vertical equity of each VMT fee scenario relative to the vertical equity of the current state gas tax. Due to such subtle differences in Lorenz Curve points for each scenario, it was determined that this type of visual representation would not be as effective as a mathematical comparison (the Gini Coefficient).

However, as a point of reference, the Lorenz Curve for the Texas state gas tax is shown in Figure 3.

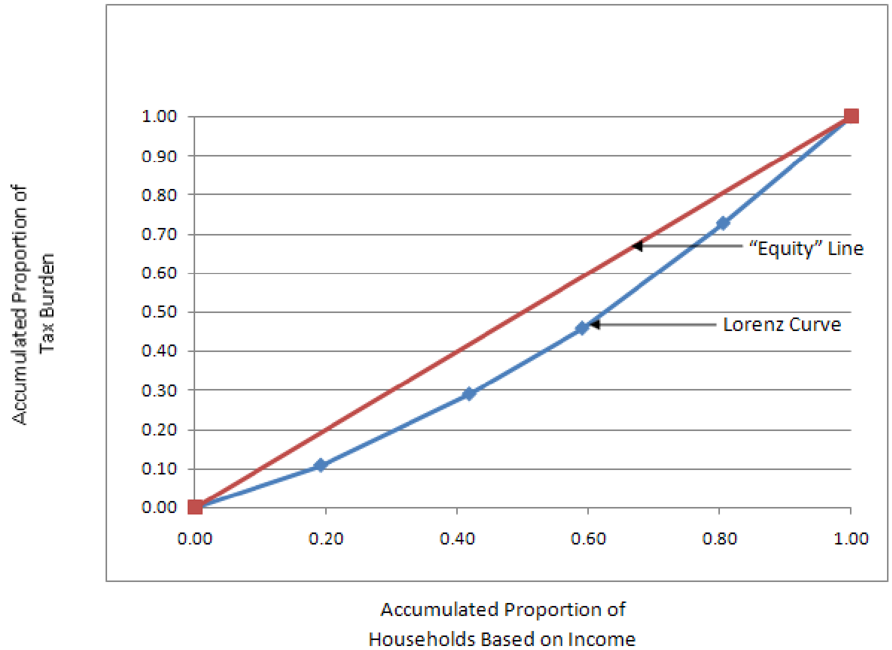

Figure 3. Lorenz curve for Texas state gas tax in 2008

As for the Suit Index, household income level data were only available in an aggregated form. Therefore, it would not have been possible to rank individual households by household income level and would have yielded results similar to the Lorenz Curve. Chapter IV includes and discusses the Gini Coefficients calculated in this research.

Another important point to note in the evaluation of equity within this analysis is how the terms "progressive" and "regressive" were used. As suggested previously, the term regressive generally implies that low income households spend a higher percentage of their total household income on a specific fee category. However, given that for all VMT fee scenarios included in this analysis it was assumed that the VMT fee would only replace the state gas tax (which is merely a fraction of the overall price of gasoline), regressivity comparisons did not consider overall changes. Rather, this analysis focused more on the *relative* change in the weighted average amount collected under the current state gas tax compared to each VMT fee scenario. In other words, the interest was in whether a given VMT fee scenario placed a higher percent burden on low income households (defined to be more regressive) or more of a burden on high income households (defined to be more progressive) than the current state gas tax.

Horizontal equity was evaluated by comparing the percent of the total state gas tax or VMT fee assessed to urban households versus rural households. Scenario 4, which was briefly described in Chapter I, was designed to create horizontal equity—establishing different VMT fees for different roadway types by assuming the percent of urban household and rural household VMT and charging a rate that would raise funds needed for the corresponding shared improvement costs (needed for both urban roadways and rural roadways) or infrastructure and mobility costs unique to a given roadway type (Texas 2030 Committee, 2009). With Scenario 4 deemed to display perfect horizontal equity, all other scenarios—including the current state gas tax—were compared to this standard in order to determine their relative horizontal equity.

MODEL SELECTION: STATIC VERSUS DYNAMIC

Though many different types of models can be used to assess the equity impacts of a VMT fee, each model broadly falls into either the category of static or dynamic. A good example of where both types of models were used to assess equity can be seen in research conducted by Zhang and McMullen (Zhang and McMullen, 2010). Data used by Zhang and McMullen were obtained from the 2001 Oregon National Household Travel Survey (NHTS) data. Four-hundred seven Oregon households were included in the survey; though only households containing all of the relevant information needed for a given model were included within the analysis of that model (Zhang and McMullen, 2010). Zhang and McMullen tested a flat VMT fee, along with two “green VMT fee” scenarios based on vehicle fuel economy; considering equity impacts based on household income levels and geographic locations in Oregon, through the use of four different models—static, regression, simultaneous, and discrete. A distinguishing feature of the static model is that it “assumes no behavioral changes by vehicle owners in response to the change in tax, which essentially assumes that the price elasticity of demand for miles is zero (Zhang and McMullen, 2010).” The static model is also the easiest for elected officials to understand (Zhang and McMullen, 2010).

The other models Zhang and McMullen considered are dynamic in nature. The regression model assumes that several factors, including “fuel cost per mile, household income, household location, number of vehicles currently owned by the household, and a vector of other household characteristics” affect the miles a household drives (Zhang and McMullen, 2010). The simultaneous model assumes that the number of vehicles a household owns, those vehicles' fuel economies, and the number of vehicle miles driven are interconnected and decided simultaneously with a change in the transportation fee. The discrete model considers the effects of changes in both vehicle quantity and vehicle type; with the two behaviors determined independently (Zhang and McMullen, 2010). The authors found that the static model overestimated revenue increases for their scenarios labeled 1 and 2; though not in a uniform manner among income groups, which produced biased distributional effects (Zhang and McMullen, 2010). However, given the relatively small changes caused by alterations to the transportation fee, the long-term behavioral changes are relatively minimal. Thus, it may not be worth the extra time and money to develop and use a model that considers long-term behavioral changes in response to a VMT fee scenario being implemented (Zhang and McMullen, 2010).

When deciding whether to use a static model or a dynamic model when modeling the short-term travel impacts of a VMT fee, the researcher should consider the ultimate purpose of the model. If it is vital that elected officials be able to easily understand the results, a static model may be advisable. However, if useful and relevant price elasticities are available, doing a comparison of static and dynamic results could be beneficial; but an important caveat to consider in the design of dynamic models is balancing simplicity with fit. In other words, even though a highly complex dynamic model may have the potential to consider a host of variables—and thus generate output that more accurately mirrors traveler response—the usefulness of the output may be masked by its complexity. Therefore, the researcher should use common sense and strive to achieve the proper balance between creating a detailed model and creating a useful model.

For the purposes of this research, both static and dynamic results were obtained and compared for each scenario. Elasticities used in the dynamic model were disaggregated by both household income level and household geographic location (Wadud, Graham and Noland, 2009). The dynamic model assumed that no households would change their vehicle fleet composition due to changes in the transportation fee. Rather, under the dynamic model, a short-term response was assumed—implying that the only change brought about by the change in transportation fee was a change in a vehicle's VMT. Further discussion on the elasticities used in the dynamic model is provided in Chapter IV.

TEXAS INFRASTRUCTURE NEEDS

One of the most important factors motivating the study of VMT fees is the need to obtain more funding to support the maintenance and improvement of Texas's infrastructure. Funding for highways is a major concern. As of 2003, Texas estimates were put at, "a staggering $179-billion transportation need in the next 25 years [and] another $79 billion needed to alleviate peak hour demand (Powers, 2004)."

Concerns about revenue available for Texas's infrastructure have been voiced throughout the past decade. In 2007, Ric Williamson, Texas Transportation Commissioner, was quoted as saying, "The estimated revenue from the state gas tax does not even cover our state's maintenance budget for the next biennium (Williamson, 2007)." The fact that the transportation sector is competing for funding with so many other worthwhile causes increases the difficulty in successfully championing the effort to increase transportation funds. However, there are many factors that contribute to the importance of the transportation infrastructure quality; among them travel time, travel comfort, vehicle maintenance needs, and safety.

Receiving funding needed for the infrastructure is not the only issue to consider; a plan of how available funds will be used is also necessary for success. On the state level, this is closely linked to the Statewide Transportation Improvement Program (STIP), which includes a plan detailing which projects will receive federal funding for a given range of fiscal years. The Transportation Improvement Plan (TIP) for each transportation district within the state is compiled into the statewide document known as the STIP. For instance, in Texas, the Bryan District TIP for fiscal years 2008-2011 details projects slated to receive federal funding, the budgeted amount for that project, and all highway or transit categories that apply to the project (Texas Department of Transportation, 2007). It is important that states have a plan in place of how money for the transportation infrastructure, once received, will be used. Concerns over this issue surfaced in the shipping industry in early 2009 as the federal government made plans to allocate $85 billion to $150 billion dollars to infrastructure improvements. Many did not feel that an adequate plan was in place on how states should use this allocated money (Hoffman, 2009).

As mentioned in the brief overview given of Scenario 2 in Chapter I, a committee was formed to address the 2030 infrastructure needs of Texas. The results of the efforts of the Committee represent progress towards effectively allocating resources if and when they are received. The paper summarizing the findings of the Committee states that, “As a result of use and age, Texas’ highway infrastructure is showing signs of deterioration (Texas 2030 Committee, 2009).” Infrastructure deterioration issues are in and of themselves cause for concern, but additional problems are also linked to infrastructure needs. The summary goes on to say that, “Driving on roads that are in disrepair accelerates vehicle deterioration, escalates roadway maintenance costs and increases fuel consumption (Texas 2030 Committee, 2009).” Thus, charging a VMT fee in place of the current state gas tax would not only hold motorists accountable for their use of the infrastructure, but may actually decrease money wasted on fuel during congestion. The Committee established investment levels needed to reach both mobility and infrastructure goals. For 2009-2030, an annual investment of $14.3 billion is needed to fund improvements to pavements, bridges, urban mobility, rural mobility, and safety (Texas 2030 Committee, 2009). Given that this is a staggering amount of revenue—especially when considering that state highway fund revenue coming from motor fuel tax allocations in the year 2008 totaled $2.3 billion (Combs, 2011)—it is important to plan for how this additional revenue could be generated. Scenarios 2-4 included in this analysis were designed to generate these additional funds—as further described in Chapter IV.

SUMMARY

As evidenced by a review of the literature, further investigation into VMT fees is both timely and critical given their potential to help address Texas's infrastructure and mobility needs. Past case studies and reviews outlining VMT fee concerns provide a framework for future study. Equity is one of the important issues that should be addressed. This research effort compared the equity impacts related to four proposed VMT fee scenarios, as well as the current state gas tax, as further described in Chapters III, IV, and V.

CHAPTER III

DATA MERGING, FILTERING, AND WEIGHTING

The data used in this research effort were obtained from the 2009 NHTS dataset. Data pertinent to Texas were obtained from information supplied as part of Texas's Add-on participation in the 2009 NHTS. Permission to use these data was granted by the Texas Transportation Institute (TTI) and the Texas Department of Transportation (TxDOT). Some additional variables used in the analysis were obtained from Version 2.1 of the 2009 NHTS dataset provided through the NHTS website (http://nhts.ornl.gov/index.shtml). It was necessary to merge variables obtained from both the Texas Add-on deliverables and Version 2.1 of the NHTS publically available dataset. The data were then filtered to only include survey data for vehicle records containing all of the information deemed necessary for analysis. After filtering was implemented, the data were weighted to reflect all 2008 Texas vehicle-owning households; with a distinction made between urban households and rural households. This chapter further describes the NHTS dataset, and explains the data merging, data filtering, and data weighting processes.

NHTS

The NHTS is a large-scale, nationwide survey that provides planners and researchers with information relevant to the travel patterns of Americans, as well as demographic information that may affect travel (U.S. Department of Transportation,

2010) (see Appendix A for the 2009 NHTS Household Screener Interview and Appendix B for the 2009 NHTS Extended Interview). Some form of the NHTS has been administered every five to seven years since 1969 (Oak Ridge National Laboratory, 2004)—with the most recent NHTS being conducted from March 2008 to May 2009 (U.S. Department of Transportation Federal Highway Administration, 2011). Its two predecessor surveys—the National Personal Transportation Survey (NPTS) which focused on short trips and the American Travel Survey (ATS) which focused on long trips—were first combined in 2001 (Oak Ridge National Laboratory, 2004). However, the 2009 NHTS moved away from the collection of detailed information about long-distance trips—which is one example of how although common threads exist between each NHTS and its predecessors, each new survey reflects changes from past surveys (U.S. Department of Transportation Federal Highway Administration, 2011). Previous data collected through the NHTS and its predecessors have been used in the study of a wide range of topics (Zhang and McMullen, 2010); (Pucher and Renne, 2004); (Tal and Handy, 2010); (Ouimet, Simons-Morton, Zador, Lerner, Freedman, Duncan and Wang, 2010); (Collia, Sharp and Giesbrecht, 2003).

In the 2009 NHTS, over 150,000 households nationwide were included. Many of these were obtained as part of Add-on surveys sponsored by various agencies, often state DOTs (U.S. Department of Transportation Federal Highway Administration, 2011). As the largest Add-on constituent, TxDOT paid for roughly 20,000 additional household surveys to be performed in Texas, beyond those already included as part of the national sample (U.S. Department of Transportation Federal Highway Administration, 2011).

The data distributed to the Add-on participants were classified into five files; namely person, household, vehicle, trip, and location (Federal Highway Administration, 2009); with common variables amongst the files making it possible to merge data between the files. The vehicle files included as part of Version 2.1 and the Texas Add-on specific data contained all of the Add-on data relevant to this research. Pertinent variables and their definition are presented in Table 1.

Table 1. Relevant NHTS Variables and Descriptions

NHTS Variable	Variable Definition
ANNMILES	Self-reported annualized mile estimate
CMPLTPCT	Percent of household members that completed the interview
EIADMPG	EIA derived miles per gasoline-equivalent gallon estimate
FUELTYPE	Type of fuel
GCOST	Fuel cost in nominal US dollars per gasoline-equivalent gallon
HHFAMINC	Derived total household income
HH_HISP	Hispanic status of household respondent
HHSIZE	Count of household members
HHSTATE	State household location
HH_RACE	Race of household respondent
HHVEHCNT	Count of household vehicles

Table 1. cont.

NHTS Variable	Variable Definition
HOUSEID	Household eight-digit ID number
HYBRID	Vehicle is hybrid or uses alternate fuel
LIF_CYC	Life cycle classification for the household
URBRUR	Household in urban/rural area
VEHTYPE	Vehicle type
VEHYEAR	Vehicle model year

MERGING THE DATA

Some of the variables relevant to this analysis were specific to the Texas Add-on vehicle file, while other variables were filtered from the vehicle file of Version 2.1 of the 2009 NHTS dataset obtained from the NHTS website (http://nhts.ornl.gov/index.shtml). It was necessary to merge variables from both datasets. The files were matched based on the unique HOUSEID variable.

For the most part, conformity between common variables was realized. However, the coding of some variables was redefined in Version 2.1; contributing to some differences in values found between the datasets. Most notably, Version 2.1 of the national dataset aggregated VEHYEAR for all vehicles built between 1924 to1984 by simply displaying the year 1974 for all such vehicles. This change largely stemmed from a lack of dependable fuel economy data provided for vehicles built prior to 1985. An additional reason for this vehicle year aggregation stemmed from a desire to protect against the potential for confidential responses and information being linked to a specific household in cases where very few households share a given household or vehicle characteristic. Vehicles with years ranging from 1924-1984 compose only a small percentage of the total vehicles included within the 2009 NHTS, and an even smaller percentage of total ANNMILES (see Table 2). Therefore, aggregation of vehicle years prior to 1985 for the purposes of fuel economy reporting had little effect on the analysis.

Table 2. Comparison of Un-weighted Number of Vehicles and their Associated VMT by Vehicle Year after Initial Filtering

Vehicles Included	Number of Vehicles	Percentage of Total Vehicles After Filtering	VMT	Percentage of Total VMT
Vehicle Years from 1924-1984:	838	2.87	2,468,701	0.80
Vehicle Years from 1985-2009:	28,324	97.13	305,996,862	99.20
All Vehicle Years from 1924-2009:	29,162	100.00	308,465,563	100.00

These 29,162 vehicles remaining after filtering were used in the analysis. The filtering process is explained in the next section. All information related specifically to the NHTS vehicles was taken from Version 2.1 of the publically available NHTS data. Thus, although a relatively small percentage of vehicles displayed discrepancies in vehicle type (824 vehicles, 2.8 percent of vehicles) and vehicle model code (1,198 vehicles, 4.1 percent of vehicles), this was a non-issue that stemmed from slight coding differences between data sources. In other words, based on these checks it was assumed that all of the vehicle variable matches made between the two NHTS sources corresponded to information on the same vehicle.

FILTERING THE DATA

After merging relevant variables from both the 2009 Texas Add-on deliverables and the vehicle file of Version 2.1 of the 2009 publically available NHTS data, the next step was to filter the original data. Filtering was done to ensure that the households being considered in the analysis were complete enough to allow for the analysis of the four scenarios to be implemented and analyzed. The initial filtering that was implemented is shown in Table 3.

Table 3. Initial Filtering Specifications

Variable	Filter Specification		Further Filter Explanation
CMPLTCT	Equal to	1	Ensuring household 100% complete (i.e., all adults in household interviewed)
HHFAMINC	Greater than or equal to	1	Ensuring HHFAMINC was listed
HYBRID	Not equal to	-7, -8, -9	Ensuring HYBRID response was not "Refused", "Don't Know", or "Not Ascertained" respectively
VEHYEAR	Greater than	0	Ensuring vehicle year was listed
HHSTATE	Equal to	TX	Ensuring HHTATE was marked as Texas

Table 3. cont.

Variable	Filter Specification		Further Filter Explanation
FUELTYPE	Equal to	4	Ensuring FUELTYPE was listed as Motor Gasoline
ANNMILES	Not equal to	-1, -7, -8, -9	Ensuring ANNMILES was listed
URBRUR	Not equal to	-9	Ensuring URBRUR was listed
HH_RACE	Not equal to	-7, -8, -9	Ensuring HH_RACE response was not "Refused", "Don't Know", or "Not Ascertained" respectively
HH_HISP	Not equal to	-7, -8	Ensuring HH_HISP was listed
VEHTYPE	Not equal to	-8, -9, 8, 97	Ensuring VEHTYPE values remaining were listed as 1,2,3,4,6 or 7

This filtering process left 32,113 vehicles and 16,315 households. With this initial filtering done, it left some households with fewer vehicles remaining than the number of vehicles listed under the variable HHVEHCNT. These 1,720 households were eliminated. Thus, no vehicles associated with households containing vehicles with incomplete information or irrelevant vehicle types were included in the analysis. This filtering requirement ensured that the average transportation fee calculated for a given household classification (i.e., 0 Employees, Household Size 2, Income Level 3) was not biased downward by only including some of the gasoline-run, pertinent vehicles belonging to a household. For example, consider a household owning two gasoline-run vehicles but only having one vehicle available for analysis after initial filtering. If their one remaining household vehicle were included in the analysis, the average annual transportation fee calculated for this household would be lower than reality because the vehicles miles driven in their second vehicle would not be included in the calculations.

On the other hand, it may be argued that by eliminating vehicles corresponding to households with at least one of their vehicles filtered out, the results were biased downward because the more vehicles a household owned, the more likely it was that at least one of their vehicles was eliminated through filtering. However, households with a large number of vehicles were not common (see Table 4). Therefore, it was assumed that this latter concern was minimal compared to the alternative of including vehicles from households no longer having all of their vehicles after filtering.

Table 4. Number of 2008 Texas Households by HHVEHCNT

HHVEHCNT	Number of Households Prior to Any Filtering	Number of Households After Initial Filtering	Number of Households After Eliminating Households Where HHVEHCNT Did Not Match The Number of Vehicle Records Remaining
0	17	0	0
1	5,838	4,465	4,465
2	10,052	7,721	6,919
3	3,776	2,866	2,330
4	1,188	872	626
5	375	267	184
6	117	88	59
7	29	22	7
8	10	8	4
9	3	2	0
10	2	1	1

Table 4. **cont.**

HHVEHCNT	Number of Households Prior to Any Filtering	Number of Households After Initial Filtering	Number of Households After Eliminating Households Where HHVEHCNT Did Not Match The Number of Vehicle Records Remaining
11	2	2	0
12	0	0	0
13	1	1	0
Total	21,410	16,315	14,595

As can be seen in Table 4, 17 households had vehicle information provided, even though their HHVEHCNT value corresponded to 0. Initially, this finding seemed counter-intuitive. However, as clarified by Federal Highway Administration (FHWA) NHTS statisticians, this result was caused by differences in definition of what defines a household vehicle. “Vehicles” such as jet skis and snowmobiles were considered household vehicles and thus information on them was included in the vehicle file. However, when defining HHVEHCNT, a listed vehicle was only included in the count if it was a motorized vehicle that could be driven on streets and highways. Therefore, golf carts and vehicles with vehicle types described as “Other” were not included within the HHVEHCNT summation. As can be seen from Table 4, those households with a HHVEHCNT value of 0 were automatically eliminated during the initial filtering process. Households in a similar situation, where more vehicle records were initially provided than the HHVEHCNT value reflected (i.e. three vehicle records were provided for the households but the HHVEHCNT had a value of 2) would have been eliminated by the final filtering step if all vehicles remained after initial filtering. However, as in the example provided, if one of the three vehicles was eliminated during the initial filtering process, that household and its remaining vehicles would remain in the analysis (since HHVEHCNT would now match the number of vehicle records). It was assumed that this situation was rare, and that in many such cases the vehicle record removed during the initial filtering process was in fact the vehicle record not initially counted in the HHVEHCNT. A summary of the number of households and the number of vehicles remaining after each filtering step is provided in Table 5.

Table 5. Filtering Process and Associated Number of Households and Number of Vehicles

Filtering Step	Number of Households	Number of Vehicles
Prior to Any Filtering	21,410	45,122
After Initial Filtering to Only Include Vehicles with All Information Deemed Necessary	16,315	32,113
After Removal of Vehicles Belonging to Households No Longer Listing All Vehicles After Prior Filtering	14,595	29,162

After the filtering process there were 779 hybrid vehicles left in the dataset (see Table 6). Hybrid vehicles equate to 2.7 percent of the vehicles included in the analysis. Although this is a relatively small percentage, it is anticipated that advances in hybrid technology will cause hybrids to become more widespread in the future. Thus, their inclusion in this analysis was important.

Table 6. Number of Hybrid Vehicles and Non-Hybrid Vehicles after Proper Filtering

Hybrid Vehicles	779
Non-Hybrid Vehicles	28,383
Total	29,162

One-hundred and thirty-seven of the 29,162 vehicles included in the analysis did not include an EIADMPG fuel economy. To remedy this fact, the average un-weighted fuel economy of each vehicle type was calculated based on those vehicles with a provided EIADMPG fuel economy (see Table 7). The VEHTYPE variable was supplied within the NHTS data—making this process relatively simple. Hybrid vehicles were considered to be their own vehicle type. Two logical methods of calculating the average fuel economy by vehicle type were possible; either the weighted or the un-weighted sample average fuel economy of matched vehicles could be used. An explanation of how the un-weighted and weighted fuel economy of each vehicle type was calculated is shown in Equation (2) and Equation (3) respectively.

$$\text{Un-weighted Avg. Fuel Economy} = \frac{\sum_{\text{VehType}} \text{EIADMPG}}{\text{NUMVEH}_{\text{VehType}}} \tag{2}$$

where

EIADMPG$\neq$-9

NUMVEH=Number of vehicles included in the survey

VehType=Type of vehicle

$$\text{Wegihted Avg. Fuel Economy} \tag{3}$$

$$= \frac{\sum_{\text{VehType}} (\text{EIADMPG} \cdot \text{WEIGHT})}{\sum_{\text{VehType}} \text{WEIGHT}}$$

where

WEIGHT=Weight calculated for each vehicle so that the sum of the weighted households adds-up up to desired control totals for all vehicle-owning household in Texas in the year 2008

Both methods of calculating the average fuel economy of each vehicle type were compared. From Table 7 it is apparent that the difference between the un-weighted and the weighted results is minimal. Thus, the un-weighted average was used to fill-in the corresponding originally blank EIADMPG fuel economies. Therefore, the dataset consisted of 14,595 Texas households with 29,162 vehicles. As previously mentioned, almost all vehicles records (29,025) included the vehicle fuel economy in the 2009 NHTS; with 137 vehicle fuel economies calculated based on the average fuel economy for that vehicle type. Recall that only gasoline-run (or at least partially gasoline-run) vehicles were included in this analysis.

Table 7. Comparison of Un-weighted Average Fuel Economy and Weighted Average Fuel Economy

NHTS VEHTYPE	VEHTYPE Code	Number of Vehicles Included After Filtering with Listed EIADMPG	Un-weighted Average Fuel Economy Based on Those Sample Vehicles with a Paired EIADMPG Fuel Economy (MPG)	Weighted Average Fuel Economy Based on Those Sample Vehicles with a Paired EIADMPG Fuel Economy (MPG)	Differences Between Un-weighted Average Fuel Economy and Weighted Average Fuel Economy (MPG)
Automobile/ Car/Station Wagon	01	12,637	22.56	23.05	-0.49
Van (Mini, Cargo, Passenger)	02	2,048	19.08	19.03	0.05
Sports Utility Vehicle	03	6,052	17.68	17.72	-0.04
Pickup Truck	04	6,657	16.24	16.45	-0.21
RV (Recreational Vehicle)	06	138	6.4	6.4	0
Motorcycle	07	714	56.5	56.5	0
Hybrid	HYBRID=1	779	26.44	26.12	0.32
All Vehicles	NA	29,025	20.71	20.96	-0.25

WEIGHTING THE DATA

The next step in preparing the data for analysis was weighing the data. The goal was to develop weights such that the data reflected vehicle-owning Texas households in the year 2008 disaggregated by

- a) Household Income Level (5 classes)
- b) Household Size (1 to 4+)
- c) Number of Household Employees (0,1,2+)

- d) Household Geographic Location (Urban, Rural)

The criterion of household income level, household size, and number of household employees is a fairly standard weighting approach used in Texas survey data analysis. Further disaggregation by household geographic location was necessary in order to effectively use elasticities needed for the dynamic models, which were disaggregated not only by household income level, but also by the household's geographic location classification.

A small percentage of Texas vehicle-owning households may only own vehicles that are powered by a source of energy other than gasoline. While it is difficult to accurately estimate the exact percentage of households that fit into this category, the fact that only 739 household vehicles of the 45,122 household vehicles included in the 2008 Texas survey (1.6 percent) have a fuel type other than gasoline (which contribute less than 2.0 percent of the reported ANNMILES for Texas vehicles included in the 2009 NHTS) indicates that fuel type of household vehicles is predominantly gasoline. It was assumed that the percentage of households *only* owning vehicles that run on a source of energy other than gasoline would be even smaller because households that own multiple vehicles become increasingly more likely to own at least one gasoline-powered vehicle. Therefore, it was assumed that the percentage of Texas households only owning vehicles powered by a source of energy other than gasoline was minimal. Thus, the 2008 Texas vehicle-owning household control totals could be used to weight results with little negative effect.

In order to create weights that could be applied to each sub-cell within both the urban household and rural household 3-way cross-classification tables, it was necessary to determine the total number of 2008 Texas households with these characteristics. Given the multiple disaggregated classifications that were desired, it was not possible to obtain a pre-made table meeting every household characteristic disaggregation requirement. However, some useful control totals were obtained using the American Fact Finder website (http://factfinder.census.gov/home/saff/main.html?_lang=en), which supplies information from a number of surveys—including the American Community Survey (ACS). The control totals that were obtained from 2008 ACS 1-Year Estimates are shown in Table 8. The ACS table numbers from which the control totals were obtained are also provided.

Table 8. List and Description of ACS Tables Used to Get Control Values Used in Weighting

Table Name	Description of Control Total
B08201. HOUSEHOLD SIZE BY VEHICLES AVAILABLE-Universe: HOUSEHOLDS	Total number of 2008 Texas vehicle-owning households by household size and household urban/rural classification.
B08203. NUMBER OF WORKERS IN HOUSEHOLD BY VEHICLES AVAILABLE-Universe: HOUSEHOLDS	Total number of 2008 Texas vehicle-owning households by number of household workers and household urban/rural classification.

A summary of the two types of control totals used for both urban vehicle-owning households (see Table 9 and Table 10) and rural vehicle-owning households (see Table 11 and Table 12) is provided below.

Table 9. Urban Vehicle-Owning Household Number of Employed Household Members Control Total Values

Control Total Type	Control Total Value
0 Employed Household	1,065,731 Households
1 Employed Household	2,763,161 Households
2+ Employed Household	2,370,977 Households
All Urban Vehicle-Owning Households	6,199,869 Households

Table 10. Urban Vehicle-Owning Households by Household Size Control Total Values

Control Total Type	Control Total Value
Household Size 1	1,544,414 Households
Household Size 2	1,877,375 Households
Household Size 3	1,048,873 Households
Household Size 4+	1,729,207 Households
All Urban Vehicle-Owning Households	6,199,869 Households

Table 11. Rural Vehicle-Owning Household Number of Employed Household Members Control Total Values

Control Total Type	Control Total Value
0 Employed Household	359,356 Households
1 Employed Household	643,533 Households
2+ Employed Household	711,565 Households
All Rural Vehicle-Owning Households	1,714,454 Households

Table 12. Rural Vehicle-Owning Households by Household Size Control Total Values

Control Total Type	Control Total Value
Household Size 1	317,451 Households
Household Size 2	613,235 Households
Household Size 3	288,366 Households
Household Size 4+	495,402 Households
All Rural Vehicle-Owning Households	1,714,454 Households

Tables indicating the number of urban and rural vehicle-owning households by size and employed household members were available. Unfortunately, the desired control totals showing the number of urban and rural vehicle-owning households in terms of household income level were not available. Therefore, it was necessary to make an initial assumption regarding the household income distribution for both urban households and rural households.

One option was to assume that the ratio of urban households to rural households was the same for all sub-cells within the 3-way classification. However, this goes against logic because household income level likely varies with household size, the number of household employees, and whether the household is urban or rural. Another option was to assume that the same household income ratio for urban households and rural households that existed in the surveyed households after filtering was applied was identical to the household income distribution of the population. However, this approach was not chosen because inherently, surveys cannot ensure that every possible demographic or household characteristic of interest is captured in exact proportion to the population as a whole. Even if the true disaggregation could be captured within the survey, the fact that households and vehicles originally included in the 2009 NHTS dataset were filtered to ensure that all of the desired variables were available prior to analysis would distort the original ratio of households in each sub-cell.

Preliminary results using the two weighting methods described thus far were calculated for comparison purposes. Not surprisingly, the results within each sub-cell of the two 3-way tables varied noticeably between the two methods—demonstrating the importance of the selected weighting methodology. Thus, a third method, thought to be a better basis for estimating the household income distribution of 2008 Texas vehicle-owning households, was employed. This method involved using the household weights provided as a variable within Version 2.1 of the NHTS data. The household weights associated with all households that did not have a HHVEHCNT value of 0 were summed for each category within the 3-way cross-classification table. This became the starting point for the raking process (an iterative process of smoothing data to simultaneously fit multiple control total criteria); which involved iteratively making the ACS control totals for household size and number of household employees match. See Table 13 and Table 14 for the summed household weights used as a starting point for urban vehicle-owning households and rural vehicle-owning households respectively.

Table 13. Starting Point for Urban Vehicle-Owning Households (Based on Sum of Household Weights for Non 0 HHVEHCNT Households)

0 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	240,416.73	150,856.66	44,891.64	89,018.47	525,183.50
20-40	139,475.10	123,858.01	23,752.15	40,555.05	327,640.32
40-60	50,819.29	72,688.70	10,236.50	14,887.46	148,631.94
60-100	23,723.47	59,838.50	7,022.13	10,685.73	101,269.84
100+	11,486.78	40,122.11	8,456.51	13,943.71	74,009.10
Total	465,921.36	447,363.97	94,358.94	169,090.43	1,176,734.71
1 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	155,581.25	119,262.09	90,345.85	196,571.79	561,760.97
20-40	311,905.79	168,439.93	117,789.87	197,996.24	796,131.83
40-60	223,881.16	163,140.93	76,471.66	89,598.96	553,092.71
60-100	204,484.32	153,887.90	102,232.55	115,580.04	576,184.82
100+	880,28.94	143,682.18	71,395.58	115,731.06	418,837.76
Total	983,881.46	748,413.02	458,235.52	715,478.09	2,906,008.09
2+ Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	28,535.00	42,508.52	110,987.24	182,030.75
20-40	NA	69,461.09	66,271.16	148,607.70	284,339.95
40-60	NA	117,722.95	81,071.00	127,076.43	325,870.37
60-100	NA	175,059.24	161,880.16	192,795.88	529,735.28
100+	NA	213,348.64	157,253.18	207,897.96	578,499.78
Total	NA	604,126.91	508,984.01	787,365.21	1,900,476.13

Table 13. cont.

Total	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	395,997.97	298,653.74	177,746.01	396,577.50	1,268,975.23
20-40	451,380.90	361,759.02	207,813.18	387,158.99	1,408,112.09
40-60	274,700.45	353,552.57	167,779.16	231,562.85	1,027,595.03
60-100	228,207.79	388,785.64	271,134.85	319,061.66	1,207,189.94
100+	99,515.72	397,152.92	237,105.26	337,572.73	1,071,346.63
Total	1,449,802.82	1,799,903.90	1,061,578.46	1,671,933.74	5,983,218.92

Table 14. Starting Point for Rural Vehicle-Owning Households (Based on Sum of Household Weights for Non 0 HHVEHCNT Households)

0 Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	57,351.40	38,236.35	7,647.84	9,550.06	112,785.64
20-40	28,973.55	43,592.13	3,749.70	7,214.37	83,529.75
40-60	10,163.77	24,890.83	1,693.05	4,297.14	41,044.80
60-100	6,375.91	20,404.10	3,600.27	6,014.87	36,395.15
100+	2,827.83	10,986.78	1,593.93	3,432.33	18,840.86
Total	105,692.45	138,110.18	18,284.78	30,508.79	292,596.20
1 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	37,677.85	21,810.47	22,699.69	26,834.36	109,022.36
20-40	55,354.38	45,452.69	19,316.89	35,771.61	155,895.56
40-60	50,192.39	46,153.14	14,869.05	19,668.24	130,882.82
60-100	29,783.41	46,540.87	23,750.01	43,541.67	143,615.96
100+	13,586.30	42,271.79	22,137.48	37,247.66	115,243.24
Total	186,594.34	202,228.95	102,773.11	163,063.53	654,659.94

Table 14. cont.

2+ Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	4,385.44	5,909.24	21,133.51	31,428.18
20-40	NA	20,461.10	16,082.97	60,003.60	96,547.67
40-60	NA	30,077.20	15,839.70	40,902.15	86,819.04
60-100	NA	67,984.33	32,776.24	72,495.87	173,256.44
100+	NA	62,918.39	42,965.28	78,476.36	184,360.02
Total	NA	185,826.45	113,573.43	273,011.48	572,411.36
Total	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	95,029.25	64,432.25	36,256.76	57,517.93	253,236.19
20-40	84,327.93	109,505.91	39,149.56	102,989.58	335,972.98
40-60	60,356.17	101,121.17	32,401.79	64,867.53	258,746.66
60-100	36,159.31	134,929.29	60,126.53	122,052.41	353,267.54
100+	16,414.13	116,176.95	66,696.68	119,156.36	318,444.12
Total	292,286.79	526,165.59	234,631.33	466,583.80	1,519,667.50

Each cell within Table 13 and Table14 was then scaled so that overall total number of households within the respective matrix summed to the known total urban vehicle-owning households and rural vehicle-owning households of 6,199,869 households and 1,714,454 households respectively. These scaled values were then used as the original vehicle-owning household distributions for the raking process. The urban vehicle-owning household results and rural vehicle-owning household results are shown in Table 15 and Table 16 respectively. An example calculation of how the cell in Table

15 corresponding to urban households with Household Income Level <$20,000, Household Size 1, and Number of Employees 0 is provided in Example 1.

Example 1

$$\text{New Subtotal} = \text{Old Subtotal} \cdot \left(\frac{\text{New Total}}{\text{Old Total}} \right)$$

$$249{,}122 = 240{,}416.73 \cdot \left(\frac{6{,}194{,}869}{5{,}983{,}218.92} \right)$$

where

New Subtotal=Cell in Table 15 which is the number of vehicle-owning urban households with Household Income Level <$20,000, Household Size 1, and Number of Employees 0
=249,122 Households

Old Subtotal= Cell in Table 13 which is the number of vehicle-owning urban households with Household Income Level <$20,000, Household Size 1, and Number of Employees 0

=240,416.73 Households

New Total=All vehicle-owning urban households, as shown in Table 15 (Total of Total)

=6,194,869 Households

Old Total= All vehicle-owning urban households, as shown in Table 13 (Total of Total)

=5,983,218.92 Households

Table 15. Weighted Number of 2008 Vehicle-Owning Urban Households in Texas in 2008 Prior to Iterating between Control Totals

0 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	249,122	156,319	46,517	92,242	544,200
20-40	144,525	128,343	24,612	42,024	339,504
40-60	52,659	75,321	10,607	15,427	154,014
60-100	24,582	62,005	7,276	11,073	104,937
100+	11,903	41,575	8,763	14,449	76,689
Total	482,792	463,563	97,776	175,213	1,219,344
1 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	161,215	123,581	93,617	203,690	582,102
20-40	323,200	174,539	122,055	205,166	824,959
40-60	231,988	169,048	79,241	92,843	573,120
60-100	211,889	159,460	105,934	119,765	597,048
100+	91,216	148,885	73,981	119,922	434,004
Total	1,019,507	775,513	474,828	741,385	3,011,234
2+ Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	29,568	44,048	115,006	188,622
20-40	NA	71,976	68,671	153,989	294,636
40-60	NA	121,986	84,007	131,678	337,670
60-100	NA	181,398	167,742	199,777	548,917
100+	NA	221,074	162,947	215,426	599,447
Total	NA	626,002	527,414	815,875	1,969,292

Table 15. cont.

Total	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	410,337	309,468	184,182	410,937	1,314,924
20-40	467,725	374,858	215,338	401,178	1,459,099
40-60	284,647	366,355	173,854	239,948	1,064,804
60-100	236,471	402,863	280,953	330,615	1,250,902
100+	103,119	411,534	245,691	349,796	1,110,140
Total	1,502,300	1,865,078	1,100,018	1,732,474	6,199,869

Table 16. Weighted Number of 2008 Vehicle-Owning Rural Households in Texas in 2008 Prior to Iterating between Control Totals

0 Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	64,703	43,137	8,628	10,774	127,242
20-40	32,687	49,180	4,230	8,139	94,236
40-60	11,467	28,081	1,910	4,848	46,306
60-100	7,193	23,019	4,062	6,786	41,060
100+	3,190	12,395	1,798	3,872	21,256
Total	119,240	155,813	20,628	34,419	330,100
1 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	42,507	24,606	25,609	30,274	122,997
20-40	62,450	51,279	21,793	40,357	175,878
40-60	56,626	52,069	16,775	22,189	147,659
60-100	33,601	52,506	26,794	49,123	162,024
100+	15,328	47,690	24,975	42,022	130,015
Total	210,511	228,150	115,946	183,965	738,572

Table 16. cont.

2+ Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	4,948	6,667	23,842	35,457
20-40	NA	23,084	18,144	67,695	108,923
40-60	NA	33,932	17,870	46,145	97,947
60-100	NA	76,698	36,977	81,788	195,464
100+	NA	70,983	48,472	88,535	207,991
Total	NA	209,645	128,131	308,005	645,781
Total	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	107,210	72,691	40,904	64,890	285,695
20-40	95,137	123,542	44,168	116,190	379,037
40-60	68,092	114,083	36,555	73,182	291,912
60-100	40,794	152,224	67,833	137,697	398,548
100+	18,518	131,068	75,246	134,429	359,261
Total	329,751	593,608	264,706	526,389	1,714,454

Each subsequent raking iteration that was performed resulted in values that were increasingly closer to satisfying both the household size and number of household employee control totals. A total of 16 additional raking iterations (eight satisfying each control total specification type) were performed (similar to the process shown in Example 1); at which point the resulting matrix values were deemed to fit the control totals reasonably close. The control totals for number of household employees were achieved exactly and the control totals for household size differed with a magnitude of no greater than 0.001 percent. The resulting estimated weighted number of 2008 Texas vehicle-owning households disaggregated by geographic location, household income level, household size, and number of household employees are shown in Table 17 and Table 18 for urban vehicle-owning households and rural vehicle-owning households respectively. The number of households remaining in each sub-cell after filtering was performed was then divided into these weighted totals to obtain the desired weights (see Table 19 for urban vehicle-owning household weights and Table 20 for rural vehicle-owning household weights). The weights were then applied to relevant NHTS variables, such as ANNMILES, to make the results more reflective of all gasoline-run vehicles owned by Texas in 2008.

Table 17. Number of Vehicle-Owning Urban Households in Texas in 2008

0 Emp	Household Size				
Household Income Level ($1,000s)	1	2	3	4+	Total
<20	243,698	129,446	34,222	71,347	478,713
20-40	141,379	106,850	18,243	32,745	299,217
40-60	51,513	62,707	7,862	12,020	134,102
60-100	24,047	51,621	5,393	8,628	89,689
100+	11,644	34,613	6,495	11,258	64,010
Total	472,281	385,237	72,215	135,998	1,065,731

Table 17. cont.

1 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	169,534	110,012	74,039	169,367	522,952
20-40	339,878	156,209	97,257	171,856	765,200
40-60	243,959	151,295	63,141	77,770	536,165
60-100	222,823	142,714	84,411	100,321	550,269
100+	95,924	133,249	58,950	100,452	388,575
Total	1,072,118	693,479	377,798	619,766	2,763,161
2+ Emp	**Household Size**				
Household Income Level ($1,000s)	1	2	3	4+	Total
<20	NA	37,532	49,672	136,352	223,556
20-40	NA	91,851	78,022	183,921	353,794
40-60	NA	155,670	95,446	157,273	408,389
60-100	NA	231,488	190,584	238,609	660,681
100+	NA	282,120	185,137	257,300	724,557
Total	NA	798,661	598,861	973,455	2,370,977
Total	**Household Size**				
Household Income Level ($1,000s)	1	2	3	4+	Total
<20	413,232	276,990	157,933	377,066	1,225,221
20-40	481,257	354,910	193,522	388,522	1,418,211
40-60	295,472	369,672	166,449	247,063	1,078,656
60-100	246,870	425,823	280,388	347,558	1,300,639
100+	107,568	449,982	250,582	369,010	1,177,142
Total	1,544,399	1,877,377	1,048,874	1,729,219	6,199,869

Table 18. Number of Vehicle-Owning Rural Households in Texas in 2008

0 Emp	**Household Size**				
Household Income Level ($1,000s)	1	2	3	4+	Total
<20	70,872	47,138	9,985	10,525	138,520
20-40	35,913	53,997	4,923	7,999	102,832
40-60	12,598	30,832	2,223	4,765	50,418
60-100	7,903	25,274	4,727	6,669	44,573
100+	3,505	13,609	2,093	3,806	23,013
Total	130,791	170,850	23,951	33,764	359,356
1 Emp	**Household Size**				
Household Income Level ($1,000s)	1	2	3	4+	Total
<20	37,599	21,713	23,933	23,883	107,128
20-40	55,407	45,465	20,481	32,030	153,383
40-60	50,241	46,166	15,765	17,611	129,783
60-100	29,812	46,554	25,181	38,986	140,533
100+	13,599	42,284	23,472	33,351	112,706
Total	186,658	202,182	108,832	145,861	643,533
2+ Emp	**Household Size**				
Household Income Level ($1,000s)	1	2	3	4+	Total
<20	NA	5,642	8,052	24,309	38,003
20-40	NA	26,451	22,038	69,436	117,925
40-60	NA	38,883	21,705	47,332	107,920
60-100	NA	87,887	44,913	83,892	216,692
100+	NA	81,338	58,875	90,812	231,025
Total	NA	240,201	155,583	315,781	711,565

Table 18. cont.

Total	Household Size				
Household Income Level ($1,000s)	1	2	3	4+	Total
<20	108,471	74,493	41,970	58,717	283,651
20-40	91,320	125,913	47,442	109,465	374,140
40-60	62,839	115,881	39,693	69,708	288,121
60-100	37,715	159,715	74,821	129,547	401,798
100+	17,104	137,231	84,440	127,969	366,744
Total	317,449	613,233	288,366	495,406	1,714,454

Table 19. Weights for Vehicle-Owning Urban Households in Texas in 2008

0 Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	370.93	441.8	1,368.88	3,243.05	480.15
20-40	238.01	205.09	380.06	1,423.70	252.29
40-60	237.39	156.38	357.36	1,202.00	206.31
60-100	178.13	147.07	299.61	1,078.50	175.17
100+	207.93	177.50	499.62	938.17	231.92
Total	284.68	218.76	573.13	1,813.31	294.32
1 Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	1,130.23	846.25	1,322.13	2,731.73	1,313.95
20-40	1,075.56	503.9	917.52	1,481.52	902.36
40-60	906.91	457.08	650.94	733.68	667.70
60-100	831.43	376.55	594.44	583.26	572.60
100+	841.44	326.59	398.31	446.45	434.16
Total	959.82	445.11	688.16	910.08	707.60

Table 19. cont.

2+ Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	1,103.88	1,910.46	2,901.11	2,089.31
20-40	NA	874.77	1,200.34	1,768.47	1,291.22
40-60	NA	786.21	926.66	1,219.17	949.74
60-100	NA	570.17	762.34	745.65	676.93
100+	NA	483.91	557.64	620.00	544.78
Total	NA	602.31	771.73	959.07	760.66
Total	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	512.06	606.11	1,476.01	2,878.37	815.73
20-40	528.85	379.18	883.66	1,598.86	614.48
40-60	607.97	397.50	749.77	1,008.42	572.84
60-100	612.58	374.84	683.87	695.12	531.09
100+	632.75	379.41	508.28	565.97	470.67
Total	556.34	404.17	722.86	976.41	582.53

Table 20. Weights for Vehicle-Owning Rural Households in Texas in 2008

0 Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	281.24	359.83	624.06	2,105.00	342.87
20-40	221.69	204.53	378.69	1,599.80	231.60
40-60	203.19	176.18	741.00	1,191.25	206.63
60-100	164.65	179.25	472.70	1,111.50	217.43
100+	219.06	189.01	348.83	1,903.00	239.72
Total	242.21	218.20	498.98	1,534.73	257.97

Table 20. cont.

1 Emp	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	783.31	417.56	1,087.86	995.13	733.75
20-40	644.27	341.84	640.03	781.22	525.28
40-60	717.73	311.93	630.60	503.17	466.85
60-100	608.41	290.96	503.62	448.11	406.16
100+	523.04	302.03	558.86	456.86	401.09
Total	669.03	319.40	636.44	561.00	479.18
2+ Emp	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	434.00	1,610.40	2,430.90	1,357.25
20-40	NA	480.93	881.52	2,239.87	1,062.39
40-60	NA	441.85	700.16	676.17	571.01
60-100	NA	441.64	615.25	603.54	527.23
100+	NA	398.72	588.75	524.92	484.33
Total	NA	429.70	664.88	746.53	585.17
Total	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	361.57	380.07	976.05	1,505.56	490.75
20-40	368.23	278.57	677.74	1,421.62	441.72
40-60	476.05	281.95	672.76	639.52	405.23
60-100	388.81	319.43	562.56	558.39	417.67
100+	407.24	329.88	570.54	516.00	429.44
Total	387.61	310.50	636.57	702.70	433.82

SUMMARY

The results obtained in this filtering and weighting process were used in Chapter IV to calculate the average household fee associated with either the current state gas tax or the VMT fees associated with each scenario. By using the weights shown in Table 19 and Table 20, the results were weighted to reflect revenues of all gasoline-run household vehicles in Texas. Chapter IV includes an examination of the results and the equity impacts associated with each.

CHAPTER IV

VMT FEE SCENARIO STRUCTURE, ANALYSIS, AND RESULTS

Having merged, filtered, and weighted the data as described in Chapter III, the next step was to analyze and compare the results obtained from the current gas tax transportation funding system, as well as each of the four VMT fee scenarios. The analysis of the four VMT fee scenarios took into consideration anticipated initial set-up costs, revenue lost due to those cheating the system (leakage), and the cost of operating the system. Each scenario was analyzed twice; once using a static model and once using a dynamic model. For the dynamic model it was necessary to obtain elasticity estimates. This chapter describes the process taken to obtain the revenue results for each scenario, with these issues taken into consideration. The following section provides a discussion of the anticipated costs associated with switching from the current gas tax transportation funding system to a VMT fee system and how these anticipated costs were considered in the analysis.

COSTS FOR A VMT FEE SYSTEM

Transitioning from the current gas tax transportation funding system to a VMT fee system would have some initial set-up costs. These costs would vary greatly depending on the depth, breadth, and speed of the new technology implementation. As technology improves, set-up costs are likely to decrease. As mentioned in the literature review, it has been suggested that a VMT fee system could be implemented gradually;

with those vehicles that were not equipped with the VMT fee technology continuing to be charged under the current state gas tax system. However, for the purposes of this research, it was assumed that all gasoline-run vehicles being included in this analysis (a weighted total of 15,913,212 vehicles in Texas) would be provided a thin OBU immediately, at the assumed cost of $195 per unit (Wells, 2010). Likewise, it was assumed that 16,000 service stations in Texas would be equipped with the equipment needed to process VMT fees. This service station estimate was based on an estimate that there were16,500 service stations in Texas as of 2006 (Answers.com) and the fact that 16,000 service stations belong to the Texas Petroleum Marketers and Convenience Store Association that "own, operate, or supply approximately 16,000 convenience stores, service stations, and other retail motor fuel outlets in Texas and the southwest United States (Texas Petroleum Marketers and Convenience Store Association, 2011)." The estimated cost was $15,000 per station (Peters and Gordon, 2009).

Given that the timeframe of this analysis was from 2009 to 2030, in an attempt to meet the needs described by the 2030 Texas Transportation Needs Commission by 2030, the implementation costs were spread-out over the 22 year time period under consideration (2009-2030). Even after the initial implementation costs, there would be yearly operating costs associated with a VMT fee system. The 2005 National Surface Transportation Infrastructure Financing Commission (NSTIFC) report states that, "The aim should be for the total annual net cost of operation to be less than 10 percent of the total revenue collected within a few years of implementation and less than 5 percent in the longer term (National Surface Transportation Infrastructure Financing Commission, 2009)." This analysis assumed an operating cost of 10 percent of the *gross* generated revenue, rather than the 10 percent *net* operating cost suggested in the NSTIFC report, which seems conservative.

In addition to implementation costs and operating costs, it is assumed that some individuals will try to cheat the system by either tampering with their OBU, misrepresenting their VMT, or altogether not reporting their VMT. A wide-scale VMT fee system has not yet been implemented in the United States; therefore, it is difficult to estimate what percentage of drivers would cheat the system (the amount of 'leakage'). Smaller scale pilot tests—such as those performed in Oregon—are not a good source for estimating this leakage because individuals knowingly participating in such a closely monitored testing situation likely behave differently than the general public. Given this lack of a dependable estimate, it was assumed that the leakage under a VMT fee system may be comparable to the percentage of HOV lane violators. Therefore, the leakage was estimated to be 10 percent for this analysis—which is within the estimated range of HOV violators nationwide (Jones, 2009). The cost estimates that were taken into consideration are shown in Table 21. It was assumed that the life-span of the thin OBUs and the service station equipment spanned the duration of the 22-years being considered in the analysis (2009-2030).

Table 21. Estimated Expenses Associated with Switching from the Current State Gas Tax Transportation Funding System to a VMT Fee System

Itemized Expense	Number	Estimated Cost	Estimated Total Cost
Thin OBU	15,913,212 OBUs	$195 per OBU	$3,103,076,340
Service Station Equipment	16,000 Stations	$15,000 per Fuel Station	$240,000,000
Operating Cost	NA	10 Percent of Gross Revenue	Varies with Scenario
Leakage	NA	10 Percent of Gross Revenue	Varies with Scenario

However, the installation costs of both the thin OBUs and the fuel station equipment was assumed to be paid for up front through bond proceeds in the amount of $3,343,076,340. A coupon rate of 4.5 percent was assumed based on the recent state of Texas bond sales. Thus, the annual cost of the system was calculated using Equations (4) and (5).

$$Cost_{Install} = \frac{C}{1+y} + \frac{C}{(1+y)^2} + ... + \frac{C}{(1+y)^n} + \frac{Cost_{Install}}{(1+y)^n} \tag{4}$$

where

$\mathbf{Cost_{Install}}$=$3,103,076,340+$240,000,000=$3,343,075,340

C=**Coupon**= $(0.045 \cdot Cost_{Install})$ =$150,438,435.30

y=Yield=0.045

n=Life-span of investment (22 years in this analysis)

$$Cost_{Install-Annual} = C + \frac{Cost_{Install} \cdot y}{(1+y)^n - 1} \tag{5}$$

where

$$\textbf{Cost}_{\textbf{Install-Annual}} = \$242{,}525{,}632.92$$

The summation of all of the costs associated with installing a VMT fee create the need to raise funds in addition to those already collected from the state gas tax in order to achieve the same net revenue as the current state gas tax. Scenario 1, as discussed later in this chapter, provides a summary of these additional revenue needs.

ELASTICITIES

Each scenario was examined assuming (a) no change in driver behavior due to the VMT fee (static) and (b) a change in VMT due to the VMT fee (dynamic). In order to estimate the change in driver behavior due to the new VMT fee for the dynamic scenarios, it was necessary to determine reasonable elasticities. Elasticity is defined as, "the percentage change in consumption of a good caused by a one-percent change in its price or other characteristics (such as traffic speed or road capacity) (Litman, 2011)." For example, in this analysis, an elasticity of -0.3 implies that a one percent increase in the price of gas/VMT fees would lead to a 0.3 percent decrease in VMT. Elasticity in terms of VMT and the associated price of gas/VMT fees is shown mathematically in Equation (6).

$$\text{Elasticity} = \frac{\%\ \text{Change in VMT}}{\%\ \text{Change in Total Cost of Gas and/or VMT Fee}} = \frac{\dfrac{\text{VMT}_2 - \text{VMT}_1}{\text{VMT}_1}}{\dfrac{\text{P}_2 - \text{P}_1}{\text{P}_1}} \qquad (6)$$

where

$\mathbf{VMT_1}$ = Original Vehicle Miles Traveled
$\mathbf{VMT_2}$ = New Vehicle Miles Traveled
$\mathbf{P_1}$ = Original Price of Gas
$\mathbf{P_2}$ = New Price of Gas (No State Tax) Plus VMT Fee

In cases where VMT fee scenarios have actually been implemented, it would be possible to directly calculate the elasticity associated with a given VMT fee scenario. However, for VMT fee research still in the theoretical stage, researchers often rely on the elasticities obtained from previous studies of a similar nature. Gasoline price elasticities are assumed to be similar to VMT fee scenario elasticities. Although a review of the literature on gasoline price elasticities yielded several elasticity results, it was difficult to find elasticities that were disaggregated by household income level and geographic location. However, Wadud et al. provide this type of elasticity disaggregation (Wadud, Graham and Noland, 2009), as shown in Table 22 and Table 23. Wadud et al. recommend that the Seemingly Unrelated Regression Feasible Generalized Least Squares Autoregressive (SUR-FGLS with AR (1)) method results be used for the income quintiles and the Log-linear SUR-FGLS with AR (1) values with dummies for years 1985 and 1988 be used for the geographic location. Thus, these are the values that were utilized in calculating the elasticities to be used in this analysis.

Table 22. Price Elasticities by Household Income Quintile

Income Quintile	SUR-FGLS with AR (1) Elasticities
1 (lowest income)	-0.351
2	-0.219
3	-0.203
4	-0.263
5 (highest income)	-0.293

Table 23. Price Elasticities by Geographic Location

Geographic Location	SUR-FGLS with AR (1) Log-linear with Dummies for 1985 and 1988 Elasticities
Urban	-0.301
Rural	-0.171

Obtaining elasticities that were disaggregated in this manner was critical for this research effort because, as explained by Lindsey, the response to a VMT fee should not be assumed to be uniform. Thus, care should be taken in the analysis process to ensure that averages do not mask the overall response (Lindsey, 2010). For Scenario 4, it was necessary to obtain price elasticities disaggregated simultaneously by both household income level and geographic location. Using the separate results of the price elasticities obtained for household income level and geographic location (Table 22 and Table 23 respectively), estimated elasticities taking both subcategories into account were calculated—resulting in ten unique elasticity groups. These elasticities were calculated under two constraints. First of all, the average of the urban and rural price elasticities for a given household income level needed to sum to the household income level aggregated total. Additionally, the urban and rural price elasticity ratio had to be the same for each household income level as it was for the aggregated data. The results are shown in Table 24.

Table 24. Price Elasticities by Household Income Level and Geographic Location

Household Income Level ($1,000s)	Urban	Rural
<20	-0.447	-0.254
20-40	-0.280	-0.159
40-60	-0.259	-0.147
60-100	-0.335	-0.191
100+	-0.373	-0.212
Total (Weighted Average)	-0.339	-0.192

These elasticities were used in calculating the anticipated change in annual VMT for households within each subcategory of the three-way cross-classification matrices. The process was somewhat iterative because vehicles within each household were anticipated to be driven less each year with an increase in the transportation fee associated with their travel. This meant that the initial revenue estimate based on initial VMT would decrease—making it necessary to increase the transportation fee needed to secure the desired revenue total in spite of changes in travel patterns. Interestingly, for each income level the elasticity magnitude is larger for urban households than for rural households. This may be an indication of urban households having more travel options other than driving. However, when considering either urban household elasticities or rural household elasticities separately, it is interesting to note that the largest elasticity magnitudes are seen in household income level quintiles 1 and 5—with household income level quintile 3 having the smallest elasticity magnitude. This U-shaped patterns in is an indication that the poorest household income level quintile and the wealthiest household income level quintile will decrease their VMT more drastically as the price of gas increases. For low income households, this may be because of switching to other modes, while for high income households this may be an indication that they had more discretionary travel to begin with that could be eliminated as the price of gas increases (Wadud, Graham and Noland, 2009).

Elasticities are based on the percent change in the total price of gas—not just the change in the state gas tax portion of the price. As mentioned previously, it was assumed that only the state gas tax portion would be replaced with a VMT fee for each scenario. An example of how the elasticities were applied in determining the new VMT anticipated after the first dynamic iteration of Scenario 1 is provided for a single urban household in household income level quintile 2 in Example 2.

Example 2

Determining the anticipated VMT after the First Dynamic Iteration of Scenario 1 for an Urban Household in Household Income Level Quintile 2:

- **Initial VMT (calculated under the static model):** 10,000 miles
- **Household Weight:** 1,076.56
- **Initial Weighted VMT (calculated under the static model):**

  = (Initial VMT (calculated under the static model)) $\cdot$ (Household Weight)

  = (10,000 miles) $\cdot$ (1,075.56) =10,755,632.91 miles
- **EIADMPG :** 22.8 MPG
- **Texas State Gas Tax:** \$0.20 per gallon
- **Price of Gas:** \$2.92 per gallon
- **Initial Revenue from State Gas Tax:**

$$= \frac{(\text{Texas State Gas Tax})}{(\text{EIADMPG})}$$

$$\cdot (\text{Initial Weighted VMT (calculated under the static model)})$$

$$= \frac{(\$0.20)}{(22.8\,\text{MPG})} \cdot (10{,}755{,}632.91\,\text{miles}) = \$94{,}347.66$$

- **Initial Revenue from the Rest of the Price of Gas:**

$$= \frac{(\text{Price of Gas} - \text{Texas State Gas Tax})}{(\text{EIADMPG})} \cdot$$

$$(\text{Initial Weighted VMT (calculated under the static model)})$$

$$= \frac{(\$2.92 - \$0.20)}{(22.8\,\text{MPG})} \cdot (10{,}755{,}632.91\,\text{miles}) = \$1{,}283{,}128.14$$

- **Initial Revenue from All of Gas:**

$$= (\text{Initial Revenue from State Gas Tax}) +$$
$$(\text{Initial Revenue from the Rest of the Price of Gas})$$

$$= \$94{,}347.66 + \$1{,}283{,}128.14 = \$1{,}377{,}475.79$$

- **Flat VMT Fee:**

$$= \frac{(\text{Collected Amount with Same Net Revenue as State Gas Tax})}{(\text{Total VMT under State Gas Tax})}$$

$$= \frac{\$2{,}515{,}974{,}912}{176{,}389{,}021{,}988\,\text{miles}} = \$0.014264 \text{ per mile}$$

- **Scenario 1 VMT Fee Revenue:**

$$= (\text{Initial Weighted VMT (calculated under the static model)}) \cdot$$
$$(\text{Flat VMT Fee})$$

$$= (10{,}755{,}632.91 \text{ miles}) \cdot (\$014264 \text{ per mile}) = \$153{,}416.02$$

- **Scenario 1 VMT Fee Revenue Plus the Cost of Gas:**

  = (Scenario 1 VMT Fee Revenue)+
  (Initial Cost of the Rest of the Price of Gas)

  =\$153,416.02+\$1,283,128.14=\$1,436,544.16

- **Percent Change in Overall Price of Gas When Switching from State Gas Tax System to Scenario 1:**

$$=100\cdot\left(\frac{\text{(Scenario 1 VMT Fee Revenue Plus the Rest of the Cost of Gas)} - \text{(Initial Cost of all of Gas)}}{\text{(Initial Cost of all Gas)}}\right)$$

$$=100\cdot\left(\frac{(\$1{,}436{,}544.16-\$1{,}377{,}475.79)}{(\$1{,}377{,}475.79)}\right)=4.29\%$$

- **Elasticity for Urban Households in Household Income Level Quintile 2:** -0.280

- **Percent Change in VMT (%):**

  = (Percent Change in Overall Price of Gas When Switching from State Gas Tax System to Scenario 1)-(Elasticity for Urban Households in Household Income Level Quintile 2)

  = $(4.29\cdot -0.280)$ =-1.20

- **New VMT:**

$$=\text{(Initial Weighted VMT (calculated under the static model))}\cdot\left(\frac{\text{(Percent Change in VMT)}}{(100)}\right)$$

$$=(10{,}755{,}632.91\text{ miles})\cdot\left(\frac{(-1.20)}{(100)}\right)=10{,}626{,}491.66\text{ miles}$$

This same procedure was performed for all weighted vehicles included in the analysis after filtering; with pertinent, aggregated results used in obtaining desired results. Note that the elasticities used are based on household income level quintiles, which implies that the population is grouped to capture 20 percent of the population in each household income level. The percentage of the 2008 Texas vehicle-owning households disaggregated by household income level is shown in Table 25. Although not exactly 20 percent of the vehicle-owning households fall into each household income level, the actual household income level distribution was assumed to be close enough to true quintile distributions for the purposes of this analysis. The following section describes the structure of each VMT fee scenario.

Table 25. Percentage of 2008 Texas Vehicle-Owning Households Disaggregated by Household Income Level

Household Income Level ($1,000s)	Percentage of Vehicle-Owning Population of Texas (%)
<20	19.1
20-40	22.7
40-60	17.3
60-100	21.5
100+	19.5
Total	100.0

SCENARIO STRUCTURE

This section provides a detailed description of how each of the scenarios were structured and highlights pivotal equations used to obtain the scenario results presented later in the chapter. First, a description of the current Texas state gas tax is given;

followed by an explanation of how each scenario was designed and implemented both statically and dynamically.

Current Texas State Gas Tax Structure

As a reference point for each scenario, the weighted average annual household revenue generated by the Texas state gas tax from vehicles included in this analysis was estimated for each household income level and geographic location group, as shown in Equation (7).

$$\text{Avg. Annual Household Cost of State Gas Tax}_{i,l,w,j} = \frac{\sum_{j=1}^{n}\left(\frac{\text{ANNMILES}_{i,l,w,j}}{\text{EIADMPG}_{i,l,w,j}}\cdot \$0.20\right)\cdot \text{Weight}_{i,l,w}}{\sum_{k=1}^{p}\text{Weight}_{i,l,w}} \tag{7}$$

where

i=Household Income Level Quintile; 1 through 5

l=Location; Urban or Rural

w=Number Employed in Household; 0, 1 or 2+

j=Number of Vehicles in Group i, l, w, j

k=Number of Households in Group i, l, w

For the purposes of determining the percent change in price needed to implement the dynamic model associated with the four VMT fees considered in this analysis, it was also necessary to determine annual average total amount spent on gas excluding the state gas tax, as well as the annual average total amount spent on the price of gas including the state gas tax. These two calculations are presented in Equation (8) and Equation (9) respectively.

$$\text{Annual Avg. Household Cost of Gas Excluding State Gas Tax}_{i,l,w} = \frac{\sum_{j=1}^{n}\left(\frac{\text{ANNMILES}_{i,l,w,j}}{\text{EIADMPG}_{i,l,w,j}}\cdot(X-\$0.20)\right)\cdot \text{Weight}_{i,l,w}}{\sum_{k=1}^{p}\text{Weight}_{i,l,w}} \quad (8)$$

where

X=Price of a Gallon of Gas ($) Including Taxes

Annual Avg. Household Total Cost of Gas (9)

$$= \frac{\sum_{j=1}^{n}\left(\frac{\text{ANNMILES}_{i,l,w,j}}{\text{EIADMPG}_{i,l,w,j}}\cdot(X)\right)\cdot \text{Weight}_{i,l,w}}{\sum_{k=1}^{p}\text{Weight}_{i,l,w}}$$

The cost of gasoline can vary by region, time of year, and gasoline grade. Wherever possible, the price of gas (X) was obtained for each vehicle from the NHTS variable GCOST. For those vehicles that were originally without a GCOST listed, this value was estimated by calculating the average weekly price of all grades of retail gasoline for the state of Texas from March 26, 2007 to May 4, 2009—which encompassed the dates during which the 2009 NHTS was administered (Energy Information Administration, 2010). The average weekly Texas price of all grades and all formulations of retail gasoline during this time period was $2.84 per gallon.

Scenario 1 Structure

The goal of Scenario 1 was to replace the state gas tax calculated for all weighted vehicles included in this analysis with a flat VMT fee that would generate roughly the same net revenue as the current state gas tax from these vehicles. This amount was calculated to be $1,770,254,297 using the data that was weighted to reflect vehicle-owning Texas households in the year 2008. However, the total revenue that needed to be generated after considering the costs associated with VMT fees discussed previously in this chapter (i.e. installation costs, operating costs, leakage costs) was actually greater than under the current gas tax system. The new target revenue from the flat VMT fee designed to generate a similar amount of revenue to that currently collected under the state gas tax was calculated using Equation (10).

$$\text{New Target Revenue}_{\text{Scenario1}} = \frac{\begin{array}{c}(\text{Current State Gas Tax Annual Revenue} + \\ \text{Annual Costs of Implementation of VMT Fees})\end{array}}{\begin{pmatrix}1 - \text{Percent Increase in Operating Costs} \\ \text{with Switch to VMT Fee} - \text{Percent Leakage}\end{pmatrix}} \tag{10}$$

where

$$\textbf{New Target Revenue}_{\textbf{Scenario1}} = \$2{,}515{,}974{,}912.40$$

Current State Gas Tax Annual Revenue=$1,770,254,297.00

Annual Costs of Implementation of VMT Fees=$242,525,632.92

Percent Increase in Operating Costs with Switch to VMT Fee=0.10

Percent Leakage=0.10

It follows that the flat VMT fee was calculated using Equation (11).

Scenario 1 $$\text{Flat VMT Fee}_{\text{ModelType}} = \frac{\text{New Target Revenue}}{\sum \text{Weighted ANNMILES}} \quad (11)$$

where

Model Type=Static or Dynamic

$$\text{Flat VMT Fee}_{\text{Static Scenario1}}$$

$$= \frac{\text{New Target Revenue}_{\text{Scenario1}}}{\sum \text{Weighted ANNMILES}_{\text{Static Scenario1}}}$$

$$= \frac{\$2{,}515{,}974{,}912.40}{176{,}389{,}021{,}987.66 \text{ miles}}$$

$$= \$0.01426 \text{ per mile}$$

$$\text{Flat VMT Fee}_{\text{Dynamic Scenario1}}$$

$$= \frac{\text{New Target Revenue}_{\text{Scenario1}}}{\sum \text{Weighted ANNMILES}_{\text{DynamicScenario1}}}$$

$$= \frac{\$2{,}515{,}974{,}912.40}{174{,}496{,}070{,}959.35 \text{ miles}}$$

$$= \$0.01442 \text{ per mile}$$

Scenario 2 Structure

Scenario 2 was similar to Scenario 1; the only difference being that the goal was to charge a higher flat VMT fee in order to generate additional net revenue needed to help maintain and improve Texas infrastructure and mobility in the amount of $14.3 billion dollars annually. This new target revenue was calculated as shown by Equation (12).

$$\text{New Target Revenue} = \frac{\begin{array}{l}(\text{Current State Gas Tax Annual Revenue} + \\ \text{Annual Installation Costs} + \\ \text{Additional Desired Revenue Annually})\end{array}}{(1 - \text{Percent Operating Cost} - \text{Percent Leakage})} \qquad (12)$$

where

New Target Revenue = $20,390,974,912.40

Additional Desired Revenue Annually = $14.3 billion

Thus, the flat VMT fee associated with the static model of Scenario 2 was calculated as shown in Equation (13).

$$\text{Scenario 2 } \text{Flat VMT Fee}_{\text{ModelType}} = \frac{\text{New Target Revenue}_{\text{Scenario 2}}}{\sum \text{Weighted ANNMILES}} \tag{13}$$

where

Model Type=Static or Dynamic

$$\text{Flat VMT Fee}_{\text{Static Scenario 2}}$$

$$= \frac{\text{New Target Revenue}_{\text{Scenario 2}}}{\sum \text{Weighted ANNMILES}_{\text{Static Scenario 2}}}$$

$$= \frac{\$20{,}390{,}974{,}912.40}{176{,}389{,}021{,}987.66 \text{ miles}}$$

$$= \$0.1156 \text{ per mile}$$

$$\text{Flat VMT Fee}_{\text{Dynamic Scenario 2}}$$

$$= \frac{\text{New Target Revenue}_{\text{Scenario 2}}}{\sum \text{Weighted ANNMILES}_{\text{Dynamic Scenario 2}}}$$

$$= \frac{\$20{,}390{,}974{,}912.40}{135{,}645{,}497{,}379.79 \text{ miles}}$$

$$= \$0.1503 \text{ per mile}$$

For all scenarios designed to generate the additional net revenue of $14.3 billion desired for addressing Texas's infrastructure and mobility needs, it was assumed that this revenue increase would be strictly earmarked for transportation use. The revenue amount currently dedicated to schools would not change.

Scenario 3 Structure

Scenario 3 was a three-tier system geared towards encouraging the use of more fuel efficient vehicles. Initially, vehicles were placed into one of three categories based upon their fuel economy in the same manner outlined by Zhang and McMullen in their paper entitled, *Green Vehicle Mileage Fees: Concept, Evaluation Methodology, Revenue Impact, and User Responses* (Zhang and McMullen, 2010). Categories were delineated using the following system (Zhang and McMullen, 2010):

- **MPG $\leq$ Median Fuel Economy:** $0.020 per mile fee
- **Median Fuel Economy<MPG $<$ Mean Fuel Economy:** $0.015 per mile fee
- **MPG $\geq$ Mean Fuel Economy:** $0.010 per mile fee

Thus, it was necessary to determine both the median and mean fuel economy for the data that was weighted to reflect vehicle-owning Texas households in the year 2008 (see Table 26).

Table 26. Weighted Average and Median Vehicle Fuel Economy

Average Vehicle Fuel Economy (MPG)	21.02
Median Vehicle Fuel Economy (MPG)	19.60

After the initial scenario was run and the VMT fee revenue generated was calculated, Scenario 3 was then scaled to better meet the need for additional revenue;

keeping the original fee ratio. The same new target revenue as that calculated in Equation (12) for Scenario 2 was used for Scenario 3. The resulting fees under the static model and the dynamic model are shown below.

Static Model

- **MPG $\leq$ Median Fuel Economy:** $0.1541 per mile fee
- **Median Fuel Economy<MPG $<$ Mean Fuel Economy:** $0.1156 per mile fee
- **MPG $\geq$ Mean Fuel Economy:** $0.07706 per mile fee

Dynamic Model

- **MPG $\leq$ Median Fuel Economy:** $0.1974 per mile fee
- **Median Fuel Economy<MPG $<$ Mean Fuel Economy:** $0.1480 per mile fee
- **MPG $\geq$ Mean Fuel Economy:** $0.09868 per mile fee

Scenario 4 Structure

Under Scenario 4, a different VMT fee was assessed to miles traveled on urban roadways versus rural roadways. The goal was to raise the additional revenue needed to meet the infrastructure and mobility needs established by the 2030 Committee, with travel fees disaggregated to allow urban roadway travel to pay for urban needs, rural roadway travel to pay for rural needs, and to have the shared costs be paid for by funds collected on all roadway types. The Texas infrastructure and mobility needs are disaggregated by need type in Table 27 (Texas 2030 Committee, 2009).

Table 27. Disaggregated Texas Infrastructure Needs and Associated Needed Revenue

Cost Type	**Description**	**Annual Amount ($)**
Urban Cost	Urban Mobility	7.8 Billion
Rural Cost	Rural Mobility and Safety	0.9 Billion
Shared Cost	Pavement Maintenance	4.0 Billion
Shared Cost	Bridge Maintenance	1.6 Billion

It was challenging to determine the average annual fee for urban households and rural households because it was unknown what percentage of travel by urban households was on urban roadways or what percentage of travel by rural households was on rural roadways. Logically, it was assumed that urban households travel more on urban roadways and rural households travel more on rural roadways. For the purposes of this research two logical combinations were assumed.

- **80/20:** 80 percent of urban household travel was assumed to be on urban roadways and 20 percent of urban household travel was assumed to be on rural roadways. Conversely, 20 percent of rural household travel was assumed to be on urban roadways and 80 percent of rural household travel was assumed to be on rural roadways.
- **70/30:** 70 percent of urban household travel was assumed to be on urban roadways and 30 percent of urban households travel was assumed to be on rural roadways. Conversely, 30 percent of rural household travel was assumed to be on urban roadways and 70 percent of rural household travel was assumed to be on rural roadways.

These assumptions seem reasonable based on rough estimates obtained by Mark Ojah of TTI (Ojah, pers. comm.). Using second-by-second GPS vehicle tracking data for 159 vehicles in Waco, Texas, Ojah estimated the percentage of urban household travel on urban roadways to be 77.75 percent and the percentage of rural household travel on rural roadways to be 58.68 percent in terms of distance. It is assumed that the rural household percentage of travel on rural roadways may be even higher when taking travel by rural households in more remote areas than the rural Waco area into consideration. Additional differences between these estimates and the actual urban household versus rural household road type travel breakdown may stem from the fact that the delineation of urban versus rural used in Ojah's analysis was based on Transportation Analysis Zone (TAZ) (households and travel outside a TAZ were considered rural), which does not directly correspond to the census definition used in this analysis (Ojah, pers. comm.). However, these rough estimate values are at least similar to the estimates of 80/20 and 70/30 used in this analysis. Further research into a more exact estimate may be useful in future research. The resulting urban roadway fee and rural roadway fee for the static model and dynamic model associated with the 80/20 assumption and the 70/30 assumption are shown below.

Static Model under 80/20 Assumption

- **Urban Roadway Fee:** \$0.1325 per mile fee
- **Rural Roadway Fee:** \$0.08621 per mile fee

Static Model under 70/30 Assumption

- **Urban Roadway Fee:** \$0.1415 per mile fee

- **Rural Roadway Fee:** $0.07827 per mile fee

Dynamic Model under 80/20 Assumption

- **Urban Roadway Fee:** $0.1799 per mile fee
- **Rural Roadway Fee:** $0.1072 per mile fee

Dynamic Model under 70/30 Assumption

- **Urban Roadway Fee:** $0.1899 per mile fee
- **Rural Roadway Fee:** $0.09956 per mile fee

POTENTIAL VMT FEE GOALS

Establishing desired goals for VMT fee scenarios is an important component that policy-makers should consider prior to evaluating how a proposed scenario would affect their constituents. In the evaluation of equity, VMT fee scenario goals could take many forms. The following list gives a brief overview of a few possibilities. Policy-makers may use this list as a starting-point as they brainstorm their own goal ideas.

- Establish Horizontal Equity
- Establish Vertical Equity
- Familiarize travelers with the VMT fee concept
- Implement a VMT fee collection and monitoring system that is easy to understand
- Generate additional revenue to address mobility and infrastructure needs
- Encourage the use of more fuel efficient vehicles
- More closely link travel to use of infrastructure

- Make the transition from the current state gas tax system to a VMT fee timely and affordable

An evaluation of how each of these potential goals were reached (or not reached) within the framework of this analysis is provided in Chapter V. The following section includes the analysis results and provides results discussion.

RESULTS AND DISCUSSION

As mentioned previously, each VMT fee scenario considered in this analysis assumed that the VMT fee would only replace the state gas tax of the included vehicles; with both the federal gas tax and the rest of the price of gas unchanged. The state gas tax is only a fraction (approximately 7 percent) of the total cost of gasoline. In order to more easily see and analyze changes brought about under each scenario, the results only reflect the revenue associated with either the current state gas tax or the VMT fees suggested in each scenario. However, it is important to note that when calculating the percent change in price stemming from a shift in VMT anticipated in the dynamic models based on elasticities, the entire price of gasoline and/or VMT fees was considered (as shown previously in Example 2). This was because the whole price of gas was associated with the gas price elasticities obtained for the analysis.

Current Texas State Gas Tax

The average revenue generated per household from the current state gas tax is provided in Table 28. Note that for each income level, the household average is higher for rural households than for urban households. Possible explanations for this finding vary. First of all, it may be that rural households drive more on average than their urban household counterparts. Another possible explanation may be that the average fuel economy of rural household vehicles is lower than urban household vehicles—causing them to buy more gas to travel the same distance as urban households with more fuel efficient vehicles. Still another reason may be that rural households own more vehicles than urban households falling within the same household income level.

Table 28. Current State Gas Tax: Weighted Average Annual State Gas Tax Paid by Each Vehicle-Owning Household

Household Income Level ($1,000s)	All Vehicle-Owning Households ($ per year)	All Vehicle-Owning Urban Households ($ per year)	All Vehicle-Owning Rural Households ($ per year)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	126.51	122.43	144.17	17.8
20-40	179.34	162.82	241.95	48.6
40-60	218.32	202.18	278.74	37.9
60-100	279.65	257.15	352.45	37.1
100+	313.14	289.60	388.70	34.2
Total	223.68	205.55	289.25	40.7

Since this research is focused on the equity of a VMT fee scenario it is critical to both calculate and understand current expenditures on the state gas tax. Therefore, the potential reasons for the differences in state gas tax paid by urban and rural households (evident in Table 28) were investigated. The weighted average fuel economy for both rural households and urban households used in this analysis were compared (see Table 29). It can be seen that for each household income level, the weighted average vehicle fuel economy is lower for rural households than for urban households—contributing to the higher weighted average annual revenue collected under the current state gas tax for rural households when compared to their urban household counterparts. Similarly, as seen in Table 29, the weighted average fuel economy increases as household income level increases.

Table 29. Weighted Average Vehicle Fuel Economy

Household Income Level ($1,000s)	All Vehicles (MPG)	Urban Household Vehicles (MPG)	Rural Household Vehicles (MPG)	Percent Higher Average Vehicle Fuel Economy of Urban Households than Rural Households (%)
<20	19.76	19.83	19.48	1.8
20-40	20.58	20.78	19.98	4.0
40-60	21.25	21.43	20.67	3.7
60-100	21.43	21.44	21.41	0.1
100+	21.55	21.60	21.42	0.8
Total	21.02	21.10	20.77	1.6

The weighted average vehicle year for all vehicle-owning households is shown in Table 30; with a distinction made between rural households and urban households. As household income level increases, the weighted average vehicle year also increases. This may point to the households' ability to pay for newer vehicles and indicates that higher income households tend to own newer vehicles on average. The difference in rural households versus urban households in the same household income level is not as drastic. In fact, for household income levels 3 and 4, rural households actually have slightly newer vehicles on average than their urban household counterparts. Therefore, it does not appear that vehicle year differences in rural household vehicles and urban household vehicles contribute much to the higher weighted average state gas tax paid.

Table 30. Weighted Average Vehicle Year

Household Income Level ($1,000s)	All Vehicle-Owning Households	Urban Vehicle-Owning Households	Rural Vehicle-Owning Households	Percent Higher Weighted Average Vehicle Year of Rural Households than Urban Households (%)
<20	1997.57	1997.60	1997.42	0.18
20-40	1999.51	1999.73	1998.85	0.88
40-60	2000.52	2000.50	2000.61	-0.11
60-100	2001.47	2001.42	2001.62	-0.20
100+	2002.25	2002.27	2002.17	0.10
Total	2000.54	2000.54	2000.53	0.01

Next, an investigation into the differences in the weighted average annual VMT between urban households and rural households was performed. The weighted average annual VMT per household is shown in Table 31, while the weighted average annual VMT per vehicle is provided in Table 32. The average annual revenue per vehicle disaggregated by household income level and household geographic location is shown in Table 33. Interestingly, it can be seen that for all household income levels, the weighted average annual VMT per vehicle-owning household is considerably higher for rural households than for urban households. This finding was to be expected, given the need for rural households to travel farther to have access to goods, services, school, and work that are more prevalent in urban areas. On a per vehicle basis, rural vehicle-owning households still have higher weighted average annual VMT values than urban vehicle-owning households in the same household income level. The fact that the difference between rural households and urban households on a per household basis is higher percentage-wise than on a per vehicle basis suggests that on average, rural vehicle-owning households own more vehicles than urban vehicle-owning households with the same household income level.

Table 31. Current Gas Tax System: Weighted Average Annual VMT per Vehicle-Owning Household

Household Income Level ($1,000s)	All Vehicle-Owning Households (miles)	Urban Vehicle-Owning Households (miles)	Rural Vehicle-Owning Households (miles)	Percent More Miles Driven by Rural Vehicle-Owning Households than Urban Vehicle-Owning Households (%)
<20	12,480	12,127	14,005	15.5
20-40	17,907	16,530	23,124	39.9
40-60	21,809	20,330	27,347	34.5
60-100	27,835	25,798	34,429	33.5
100+	31,263	29,100	38,207	31.3
Total	22,287	20,652	28,201	36.6

Table 32. Weighted Average Annual VMT per Vehicle

Household Income Level ($1,000s)	All Vehicles (miles)	Urban Household Vehicles (miles)	Rural Household Vehicles (miles)	Percent More that Rural Vehicles are Driven than Urban Vehicles (%)
<20	8,305	8,184	8,790	7.4
20-40	9,957	9,681	10,790	11.5
40-60	10,820	10,377	12,282	18.4
60-100	12,298	11,771	13,795	17.2
100+	12,654	12,047	14,431	19.8
Total	11,084	10,631	12,496	17.5

Table 33. Average State Gas Tax Paid per Vehicle

Household Income Level ($1,000s)	All Vehicles ($)	Urban Household Vehicles ($)	Rural Household Vehicles ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households per Vehicle (%)
<20	84.19	82.62	90.49	9.5
20-40	99.72	95.35	112.90	18.4
40-60	108.32	103.20	125.19	21.3
60-100	123.55	117.34	141.22	20.4
100+	126.75	119.89	146.82	22.5
Total	111.24	105.81	128.17	21.1

A summary of the findings from the weighted annual average state gas tax is provided in Table 34 on a per vehicle basis and in Table 35 on a per household basis.

Table 34. Summary of Weighted Annual Average State Gas Tax Findings on a per Vehicle Basis

Household Income Level ($1,000s)	Percentage More that Rural Vehicle-Owning Households Pay per Vehicle than Urban Vehicle-Owning Households Pay per Vehicle (Weighted Average) (%)	Percentage More that Rural Households Drive per Vehicle than Urban Households Drive per Vehicle (%)	Percentage Worse Gas Mileage that Rural Household Vehicles Have Compared to their Urban Household Counterparts (%)	Percentage More that Rural Vehicle-Owning Households Pay per Vehicle than Urban Vehicle-Owning Households Pay per Vehicle (Unweighted Average) (%)
<20	9.5	7.4	1.8	9.3
20-40	18.4	11.5	4.0	16.0
40-60	21.3	18.4	3.7	22.8
60-100	20.4	17.2	0.1	17.4
100+	22.5	19.8	0.8	20.8
Total	21.1	17.5	1.6	19.4

An example calculation used to obtain the last column in Table 34 (Percent More Gasoline that Rural Households Spend per Vehicle Compared to their Urban Household Counterparts (Unweighted Average) (%)) is shown below in Example 3:

Example 3

Per Vehicle: Household Income Level <$20,000

- Rural households pay 9.5 % more per vehicle
- Rural households drive 7.4 % more per vehicle
- Rural household vehicles have a 1.8 % worse average gas mileage

Urban Households	Rural Households
100 miles	107.4 miles
19.83 MPG	19.48 MPG

Required Gallons of Gasoline:

Urban Households= $\frac{100\text{ miles}}{19.83\text{ MPG}} = 5.04286\text{ gallons}$

Rural Households= $\frac{107.4\text{ miles}}{19.48\text{ MPG}} = 5.51335\text{ gallons}$

Percent More Gasoline that Rural Households Spend per Vehicle Compared to their Urban Household Counterparts (%):

$$\frac{5.51\text{ gallons}}{5.04\text{ gallons}} = 1.093$$

$(1.093\text{-}1)\cdot 100 =$ **9.3%**

Table 35. Summary of Weighted Annual Average State Gas Tax Findings on a per Household Basis

Household Income Level ($1,000s)	Percentage More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households Pay per Household (Weighted Average) (%)	Percentage More that Rural Vehicle-Owning Households Drive than Urban Vehicle-Owning Households Drive per Household (%)	Percentage Worse Gas Mileage that Rural Vehicle-Owning Households Have Compared to their Urban Household Counterparts (%)	Percentage More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households Pay per Household (Unweighted Average) (%)
<20	17.8	15.5	1.8	17.6
20-40	48.6	39.9	4.0	45.5
40-60	37.9	34.5	3.7	39.4
60-100	37.1	33.5	0.1	33.7
100+	34.2	31.3	0.8	32.4
Total	40.7	36.6	1.6	38.8

An example calculation used to obtain the last column in Table 35 (Percent More Gasoline that Rural Households Spend per Household Compared to their Urban Household Counterparts (Unweighted Average)) (%)) is shown below in Example 4:

Example 4

Per Household: Household Income Level <$20,000

- Rural Households pay 17.8 % more per household
- Rural Households drive 15.5 % more per household
- Rural Household have a 1.8 % worse average gas mileage

<u>**Urban Households**</u>	<u>**Rural Households**</u>
100 miles	115.5 miles
19.83 MPG	19.48 MPG

Required Gallons of Gasoline:

$$\textbf{Urban Households=}\frac{100\text{ miles}}{19.83\text{ MPG}}=5.04\text{ gallons}$$

$$\textbf{Rural Households=}\frac{115.5\text{ miles}}{19.48\text{ MPG}}=5.93\text{ gallons}$$

Percent More Gasoline that Rural Households Spend per Vehicle Compared to their Urban Household Counterparts (%):

$$\frac{5.93\text{ gallons}}{5.04\text{ gallons}}=1.176$$

$(1.176\text{-}1)\cdot 100=\mathbf{17.6\%}$

Note that columns one and four of Table 34 and columns one and four of Table 35 are similar, yet slightly different. Differences stem from the fact that the fourth column does *not* take into consideration which vehicles (and their corresponding vehicle gas mileage) are driven what proportion of the ANNMILES. As a simplified, theoretical example, consider Example 5; which helps to illustrate the reason for these differences.

Example 5

Urban Households

	ANNMILES	Vehicle Gas Mileage
Vehicle 1:	100 Miles	25 MPG
Vehicle 2:	50 Miles	30 MPG
Vehicle 3:	25 Miles	15 MPG
		23.33 MPG (unweighted average)
		25 MPG (weighted average)

Rural Households

	ANNMILES	Vehicle Gas Mileage
Vehicle 1:	107.4 Miles	20 MPG
Vehicle 2:	53.7 Miles	25 MPG
Vehicle 3:	26.85 Mile	23.76 MPG
		22.92 MPG (unweighted average)
		21.97 MPG (weighted average)

Summary

- Rural households drive 7.4 % more per vehicle
- Rural household vehicles have a 1.8 % worse average gas mileage (unweighted by ANNMILES)
- Rural household vehicle have a 13.8 % worse average gas mileage (weighted by ANNMILES)

Although the GCOST varied slightly for different vehicles included in the survey, the GCOST value ranges were small, and thus were assumed to have little effect on differences in the unweighted average column and weighted average column.

To summarize Table 34, it appears that on average, rural households pay more in gasoline per vehicle, drive their vehicles more miles, and have slightly worse gas mileage than urban households. The fact that the overall percentage more that rural households pay per vehicle is higher for the weighted average than the unweighted average is an indication that rural households tend to drive their less fuel efficient vehicles more than their more fuel efficient vehicles. Differences between urban households and rural households are magnified in Table 35 when compared to Table 34, which supports the notion that rural households own more vehicles, on average, than urban households.

Static Scenario 1

The goal of Scenario 1 was to collect a similar amount of revenue as is currently collected through the state gas tax by charging a flat VMT fee in place of the current state gas tax. However, as was mentioned previously, costs associated with changing to a VMT fee system were considered in adjusting the projected revenue needed to generate a similar amount to that collected under the current state gas tax after these additional costs were accounted for. Inherently, switching to a flat VMT fee would cause the amount charged in VMT fees relative to the amount charged through the state gas tax to decrease for vehicles with low fuel economies and to increase for highly fuel efficient vehicles. The new expected weighted average annual household expenditure on gasoline and the cost incurred from the flat VMT fee implemented as part of Scenario 1, disaggregated in terms of household income level and household geographic location is shown in Table 36. Not surprisingly, rural households pay more per household than their urban household counterparts in every household income level range as was seen under the current state gas tax. Likewise, households with higher income levels pay increasingly more per household on average.

Table 36. Static Scenario 1: Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	178.02	172.98	199.76	15.5
20-40	255.42	235.79	329.84	39.9
40-60	311.08	289.98	390.07	34.5
60-100	397.03	367.98	491.08	33.5
100+	445.94	415.08	544.98	31.3
Total	317.90	294.58	402.25	36.6

A side-by-side comparison of the current state gas tax results to the Static Scenario 1 results is shown in Table 37. Though all household classifications would pay more on average than under the current state gas tax due to installation costs, operation costs, and leakage, the percent increase would be lower for rural household when compared to their urban household counterparts in every household income level.

Table 37. Comparison of per Household Weighted Average Annual State Gas Tax Paid versus from VMT Fee Paid

Household Income Level ($1,000s)	All Urban Vehicle-Owning Households under Current Gas Tax ($)	All Urban Vehicle-Owning Households under VMT Fee Static Scenario 1 ($)	Percent Change in Weighted Average Cost per Urban Household (%)	All Rural Vehicle-Owning Households under Current Gas Tax ($)	All Rural Vehicle-Owning Households under VMT Fee Static Scenario 1 ($)	Percent Change in Weighted Average Cost per Rural Household (%)
<20	122.43	172.98	41.29	144.17	199.76	38.6

Table 37. cont.

Household Income Level ($1,000s)	All Urban Vehicle-Owning Households under Current Gas Tax ($)	All Urban Vehicle-Owning Households under VMT Fee Static Scenario 1 ($)	Percent Change in Weighted Average Cost per Urban Household (%)	All Rural Vehicle-Owning Households under Current Gas Tax ($)	All Rural Vehicle-Owning Households under VMT Fee Static Scenario 1 ($)	Percent Change in Weighted Average Cost per Rural Household (%)
20-40	162.82	235.79	44.82	241.95	329.84	36.3
40-60	202.18	289.98	43.43	278.74	390.07	39.9
60-100	257.15	367.98	43.10	352.45	491.08	39.3
100+	289.60	415.08	43.33	388.70	544.98	40.2
Total	205.55	294.58	43.31	289.25	402.25	39.1

The percent increase experienced by each household income level amongst urban households of all household income levels ranges from 41.29 percent to 44.82 percent. The percent increase experienced by each rural household income level is similar; ranging from 36.3 percent to 40.2 percent. On average, urban households experience a higher percent increase. For urban households the second lowest income level experiences the highest percent increase when changing to the flat VMT fee. While for rural households, the lower household income levels generally experience a lower percent increase than the higher income rural households. For urban households the smallest percent increase is experienced by household income level quintile 1 and for rural households the smallest percent increase is experienced by household income level quintile 2. The reason that a sequentially increasing percentage is not seen for either urban households or rural households based on household income level is that even though the weighted average fuel economy increases as household income level increases the average vehicle fuel economy of a household income level does not reflect how many miles a vehicle was driven. This helps to explain why the highest percent increase for urban households is experienced by household income level quintile 2, even though the average fuel economy of vehicles within this subcategory is not the highest of all urban household income level quintiles. Rather, this result is an indication that urban households within household income level quintile 2 drove their more fuel efficient vehicles more extensively than their less fuel efficient vehicles.

Dynamic Scenario 1

Implementing a dynamic model was an iterative process. Based on the definition of elasticity previously given, it was anticipated that as the total transportation fee amount increases for a given vehicle, the vehicle would be driven less. As the total VMT fluctuated, the flat VMT fee was adjusted so that the amount of revenue collected still met the desired total VMT fee net revenue. The iterative approach was performed until the largest percent change in VMT was calculated to have a magnitude of less than 0.01 percent. A summary of the largest magnitude percent change in total VMT calculated for each of Scenario 1's iterations, along with the flat VMT fee to be assessed is provided in Table 38. A microscopic household example illustrating the calculations incorporated in the first iteration of the dynamic model of Scenario 1 was provided previously in Example 2. Aggregated results were obtained by summing the weighted VMT changes and their associated revenues for every vehicle included in the analysis.

Table 38. Summary of Dynamic Scenario 1 Iteration Results

Iteration Number	Largest Magnitude Percent Change in VMT (%)	Flat Fee Assessed ($)
1	-9.45	0.014264
2	0.88	0.014420
3	-0.084	0.014418
4	0.0081	0.014419

The weighted average annual cost per household associated with the flat VMT fee anticipated after accounting for changes in driver behavior caused by fluctuations in the total cost of gas is shown in Table 39. Note that when compared to the static model results for Scenario 1, the dynamic model results indicate an increase in the percent difference in the weighted average annual VMT fee assessed to rural households and urban households. This increase is a reflection of the fact that for a given household income level, rural households have a lower elasticity magnitude than their urban household counterparts—indicating that rural households tend to have less of a propensity to change their VMT when the cost associated with gas and/or VMT fee increases. A side-by-side comparison of the percent difference between rural vehicle-owning households and urban vehicle-owning households associated with both the static model and dynamic model of Scenario 1 is provided in Table 40.

Table 39. Dynamic Scenario 1: Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	177.43	172.17	200.18	16.3
20-40	255.82	235.81	331.69	40.7
40-60	311.79	290.30	392.23	35.1
60-100	397.03	367.40	492.98	34.2
100+	445.41	413.85	546.69	32.1
Total	317.90	294.12	403.90	37.3

Table 40. Comparison of Percent Difference between Rural Vehicle-Owning Households and Urban Vehicle-Owning Households for Static Model and Dynamic Model of Scenario 1

Household Income Level ($1,000s)	Static Scenario 1 Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)	Dynamic Scenario 1 Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	15.5	16.3
20-40	39.9	40.7
40-60	34.5	35.1
60-100	33.5	34.2
100+	31.3	32.1
Total	36.6	37.3

For both the static and dynamic scenarios, the lowest revenue discrepancy between urban households and rural households is experienced by the lowest household income level quintile. This may be an indication that although rural households travel more than urban households at all household income levels, the combination of vehicle fuel economy, household VMT, and proportion of vehicle type usage cause this discrepancy to peak somewhere within the household income level 2 quintile and then gradually taper off as household income level increases. Interestingly, the overall percent increase seen in Table 40 when comparing the static model and the dynamic model of Scenario 1 is between 0.6 percent and 0.8 percent for all household income level. Thus, although the relative impact of this increase differs with household income level, there is a large amount of uniformity in absolute percentage terms.

Static Scenario 2

Given the large sum of additional revenue that was desired under Scenarios 2-4, it is difficult to directly compare the results from these scenarios to results obtained with either the current state gas tax or the flat VMT fee designed for in Scenario 1. However, in spite of the drastic difference in the weighted average annual cost per household corresponding to either the state gas tax or the proposed VMT fee scenario, it is still possible to compare the results between Scenarios 2-4 with the results of the current state gas tax and Scenario 1 in relative terms. In other words, it is still possible to assess how different household income levels and different geographic location combinations are affected relative to other household income level and geographic location combinations for a given scenario.

The weighted average annual cost per household associated with the static model of Scenario 2's flat VMT fee is provided in Table 41. Note that the percent difference in weighted average annual VMT fee revenue for rural vehicle-owning household versus urban vehicle-owning households is the same as the values obtained in the static model of Scenario 1.

Table 41. Static Scenario 2: Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,442.75	1,401.95	1,619.00	15.5
20-40	2,070.07	1,910.96	2,673.19	39.9
40-60	2,521.17	2,350.16	3,161.37	34.5
60-100	3,217.79	2,982.31	3,980.04	33.5
100+	3,614.13	3,364.05	4,416.81	31.3
Total	2,576.46	2,387.43	3,260.07	36.6

Dynamic Scenario 2

As described for Scenario 1, an iterative process was performed when implementing the dynamic model. However, it took seven iterations to reach a point where the percent change in VMT for all vehicles was 0.01 or less. The larger number of iterations needed for the implementation of Scenario 2 likely stemmed from the fact that the percent change in the total price of gasoline (including either the current state gas tax or the flat VMT fee) was much greater under Scenario 2 than Scenario 1 because of the additional revenue for which the scenario was designed. The largest magnitude percent change in total VMT calculated for each of Scenario 2's iterations, along with the associated flat VMT fee is listed in Table 42.

Table 42. Summary of Dynamic Scenario 2 Iteration Results

Iteration Number	Largest Magnitude Percent Change in VMT (%)	Flat Fee Assessed ($)
1	-98.48	0.115602
2	31.08	0.150590
3	-3.31	0.150256
4	0.61	0.150335
5	-0.12	0.150324
6	0.02	0.150326
7	-.005	0.150325

The weighted average annual cost per household associated with the dynamic model of Scenario 2's flat VMT fee is shown in Table 43, while a side-by-side comparison of the static versus dynamic Scenario 2 results and the dynamic results of Scenario 1 and Scenario 2 are provided in Table 44 and Table 45 respectively.

Table 43. Dynamic Scenario 2: Weighted Average Annual VMT Fees Paid by Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,308.80	1,221.07	1,687.73	38.2
20-40	2,157.75	1,927.11	3,032.01	57.3
40-60	2,671.16	2,420.95	3,607.91	49.0
60-100	3,220.65	2,866.78	4,366.12	52.3
100+	3,507.32	3,117.59	4,758.22	52.6
Total	2,576.46	2,296.66	3,588.31	56.2

Table 44. Difference between Rural Vehicle-Owning Households and Urban Vehicle-Owning Households for the Static and Dynamic Model of Scenario 2

Household Income Level ($1,000s)	Static Scenario 2 Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)	Dynamic Scenario 2 Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	15.5	38.2
20-40	39.9	57.3
40-60	34.5	49.0
60-100	33.5	52.3
100+	31.3	52.6
Total	36.6	56.2

Table 45. Difference between Rural Vehicle-Owning Households and Urban Vehicle-Owning Households for the Dynamic Model of Scenarios 1 and 2

Household Income Level ($1,000s)	Dynamic Scenario 1 Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)	Dynamic Scenario 2 Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	16.3	38.2
20-40	40.7	57.3
40-60	35.1	49.0
60-100	34.2	52.3
100+	32.1	52.6
Total	37.3	56.2

Based on the results displayed in Table 44 and Table 45 it is evident that rural vehicle-owning households pay more than their urban vehicle-owning household counterparts within the same household income level. The comparison illustrated in Table 44 indicates that the difference is more exaggerated under the dynamic model than under the static model—largely because urban households tend to have larger elasticity magnitudes than their rural household counterparts in the same household income level. Thus, their larger percentage decrease in travel contributes toward them paying less per household. The reason that percent differences in household pay is more exaggerated in dynamic model results of Scenario 2 than Scenario1 also stems from the larger elasticity magnitude associated with urban households. As the total price of gasoline (including the VMT fee) increases more drastically, households with large elasticities will decrease their VMT more drastically than those households with small elasticities.

Static Scenario 3

The weighted average annual VMT fee revenue from vehicle-owning households under the static model of Scenario 3 is shown in Table 46.

Table 46. Static Scenario 3: Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,438.69	1,383.95	1,675.12	21.0
20-40	2,039.97	1,843.33	2,785.37	51.1
40-60	2,502.18	2,308.13	3,228.67	39.9
60-100	3,247.02	2,971.96	4,137.39	39.2
100+	3,637.62	3,355.51	4,543.12	35.4
Total	2,576.46	2,357.29	3,369.05	42.9

Dynamic Scenario 3

The weighted average annual VMT fee revenue from vehicle-owning households under the dynamic model of Scenario 3 is presented in Table 47 and the result of each iteration included in the dynamic model of Scenario 3 are provided in Table 48.

Table 47. Dynamic Scenario 3: Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,314.39	1,218.66	1,727.89	41.8
20-40	2,129.93	1,870.37	3,113.82	66.5
40-60	2,644.93	2,378.13	3,643.78	53.2
60-100	3,245.63	2,861.56	4,488.87	56.9
100+	3,529.82	3,119.92	4,845.46	55.3
Total	2,576.46	2,275.10	3,666.26	61.2

Table 48. VMT Fee Assessed as Part of Scenario 3 by Iteration and Fuel Economy

Iteration Number	Fee Assessed to Vehicles with Fuel Economy Lower than the Median ($)	Fee Assessed to Vehicles with Fuel Economy Greater Than or Equal to the Median and Less or Equal to the Mean ($)	Fee Assessed to Vehicles with Fuel Economy Higher than the Mean ($)
Original	0.020	0.015	0.010
1	0.1541176	0.1155882	0.0770588
2	0.1977567	0.1483175	0.0988784
3	0.1972839	0.1479629	0.0986420
4	0.1973691	0.1480268	0.0986845
5	0.1973570	0.1480178	0.0986785
6	0.1973589	0.1480192	0.0986795
7	0.1973586	0.1480190	0.0986793

Static Scenario 4

The weighted average annual VMT fee revenue per vehicle-owning household with the static model—under the 80/20 Scenario 4 assumption—is presented in Table 49. Recall that the 80/20 assumption implies that 80 percent of urban household travel is assumed to be on urban roadways and 80 percent of rural household travel is assumed to be on rural household roadways.

Table 49. Static Scenario 4 (80/20 Assumption): Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,464.62	1,494.20	1,336.87	-10.5
20-40	2,072.33	2,036.71	2,207.36	8.4
40-60	2,527.08	2,504.81	2,610.46	4.2
60-100	3,204.02	3,178.55	3,286.47	3.4
100+	3,600.07	3,585.41	3,647.13	1.7
Total	2,576.46	2,544.52	2,691.97	5.8

The weighted average annual VMT fee revenue per vehicle-owning household obtained using the static model for Scenario 4 under the 70/30 assumption are shown in Table 50. Recall that similar to the 80/20 assumption description given previously, the 70/30 assumption implies that 70 percent of urban household travel is on urban roadways while 70 percent of rural household travel is on rural roadways.

Table 50. Static Scenario 4 (70/30 Assumption): Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,462.69	1,486.03	1,361.86	-8.4
20-40	2,072.13	2,025.56	2,248.63	11.0
40-60	2,526.56	2,491.11	2,659.27	6.8
60-100	3,205.24	3,161.17	3,347.92	5.9
100+	3,601.32	3,565.80	3,715.32	4.2
Total	2,576.46	2,530.61	2,742.30	8.4

Dynamic Scenario 4

The dynamic model results for Scenario 4 showing the weighted average annual VMT fee revenue from vehicle-owning households included in this analysis under the 80/20 assumption are shown in Table 51. The VMT fees established for both urban roadways and rural roadways after each iteration of the dynamic model under the 80/20 assumption are summarized in Table 52. Note that a constraint was implemented to ensure that the largest magnitude percent change in VMT was 100 percent. This ensured that changes in travel behavior more closely reflected reality; with vehicles unable to drive negative miles. This constraint was not necessary in dynamic scenarios other than Scenario 4 because dynamic changes in VMT magnitude did not exceed 100 percent.

Table 51. Dynamic Scenario 4 (80/20 Assumption): Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,318.83	1,293.79	1,427.02	10.3
20-40	2,166.52	2,073.07	2,520.74	21.6
40-60	2,690.86	2,609.41	2,995.79	14.8
60-100	3,207.31	3,069.40	3,653.73	19.0
100+	3,484.60	3,325.17	3,996.34	20.2
Total	2,576.46	2,459.12	3,000.80	22.0

Table 52. Urban Roadway VMT Fee and Rural Roadway VMT Fee by Iteration under the 80/20 Assumption

Iteration Number	Urban Roadway VMT Fee ($)	Rural Roadway VMT Fee ($)	Largest Magnitude Percent Change in VMT	Percent Higher the Urban Roadway Fee is than the Rural Roadway Fee (%)
1	0.1324599	0.0862066	-100.00	53.7
2	0.1805112	0.1069447	32.29	68.8
3	0.1797693	0.1072499	-3.33	67.6
4	0.1798953	0.1072489	0.62	67.7
5	0.1798788	0.1072481	-0.12	67.7
6	0.1798814	0.1072484	0.02	67.7
7	0.1798810	0.1072483	-0.005	67.7

The results for Scenario 4 are provided in Table 53—showing the weighted average annual VMT fee revenue from vehicle-owning vehicles included in this analysis under the 70/30 assumption. The VMT fees established for both urban roadways and rural roadways after each iteration of the dynamic model under the 70/30 assumption are outlined in Table 54. Note that the same constraint described previously for Table 52 was also applied to Table 54. Scenario 4 was designed to inherently possess horizontal equity, by more closely linking fees to type of roadway use, as will be further discussed later in this chapter.

Table 53. Dynamic Scenario 4 (70/30 Assumption): Weighted Average Annual VMT Fee Revenue from Vehicle-Owning Households

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)	Percent More that Rural Vehicle-Owning Households Pay than Urban Vehicle-Owning Households (%)
<20	1,316.49	1,279.58	1,475.88	15.3
20-40	2,165.14	2,047.14	2,612.44	27.6
40-60	2,687.76	2,576.21	3,105.34	20.5
60-100	3,209.82	3,032.55	3,783.64	24.8
100+	3,488.47	3,286.55	4,136.56	25.9
Total	2,576.46	2,429.55	3,107.74	27.9

Table 54. Urban Roadway VMT Fee and Rural Roadway VMT Fee by Iteration under the 70/30 Assumption

Iteration Number	Urban Roadway VMT Fee ($)	Rural Roadway VMT Fee ($)	Largest Magnitude Percent Change in VMT	Percent Higher the Urban Roadway Fee is than the Rural Roadway Fee (%)
1	0.1415052	0.0782721	-100.00	80.8
2	0.1905643	0.0994015	32.24	91.7
3	0.1898089	0.0995447	-3.33	90.7
4	0.1899498	0.0995569	0.62	90.8
5	0.1899310	0.0995547	-0.12	90.8
6	0.1899340	0.0995552	0.02	90.8
7	0.1899335	0.0995551	-0.005	90.8

The percent increase in the average annual amount assessed per household in the form of a VMT fee versus the state gas tax is shown in Table 55 for the static results and in Table 56 for the dynamic results. The scenario with the smallest percent increase experienced by each household income level quintile coincides with the results explained later in Table 57 and Table 58.

Table 55. Percent Increase in the Average Annual Amount Assessed per Household in the Form of a VMT Fee versus the State Gas Tax for the Static Models (%)

Household Income Level ($1,000s)	Scenario 1		Scenario 2		Scenario 3		Scenario 4 under 80/20 Assumption		Scenario 4 under 70/30 Assumption	
	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur
<20	41.3	38.6	1,045.1	1,023.0	1,030.4	1,061.9	1,120.5	827.3	1,113.8	844.6
20-40	44.8	36.3	1,073.7	1,004.9	1,032.1	1,051.2	1,150.9	812.3	1,144.0	829.4
40-60	43.4	39.9	1,062.4	1,034.2	1,041.6	1,058.3	1,138.9	836.5	1,132.1	854.0
60-100	43.1	39.3	1,059.8	1,029.2	1,055.7	1,073.9	1,136.1	832.5	1,129.3	849.9
100+	43.3	40.2	1,061.6	1,036.3	1,058.7	1,068.8	1,138.1	838.3	1,131.3	855.8
Total	43.3	39.1	1,061.5	1,027.1	1,046.8	1,064.8	1,137.9	830.7	1,131.1	848.1

Table 56. Percent Increase in the Average Annual Amount Assessed per Household in the Form of a VMT Fee versus the State Gas Tax for the Dynamic Models (%)

Household Income Level ($1,000s)	Scenario 1		Scenario 2		Scenario 3		Scenario 4 under 80/20 Assumption		Scenario 4 under 70/30 Assumption	
	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur
<20	40.6	38.8	897.4	1,070.7	895.4	1,098.5	956.8	889.8	945.2	923.7
20-40	44.8	37.1	1,083.6	1,153.2	1,048.7	1,187.0	1,173.2	941.8	1,157.3	979.7
40-60	43.6	40.7	1,097.4	1,194.4	1,076.2	1,207.2	1,190.6	974.8	1,174.2	1,014.1
60-100	42.9	39.9	1,014.8	1,138.8	1,012.8	1,173.6	1,093.6	936.7	1,079.3	973.5
100+	42.9	40.6	976.5	1,124.1	977.3	1,146.6	1,048.2	928.1	1,034.9	964.2
Total	43.1	39.6	1,017.3	1,140.6	1,006.8	1,167.5	1,096.4	937.4	1,082.0	974.4

An overall "winners" and "losers" summary for the static results and the dynamic results are shown in Table 57 and Table 58, respectively—where winners coincide to the scenario where a given household type experiences the smallest percent increase in annual average VMT fee as compared to the state gas tax. As with Table 55 and Table 56, these findings coincide with the results presented in the next section where only the scenarios designed to generate additional net revenue are considered (Scenarios 2-4).

Table 57. "Winners" and "Losers" for the Static Models
(1= "Winner" and 5= "Loser")

Household Income Level ($1,000s)	Scenario 1		Scenario 2		Scenario 3		Scenario 4 under 80/20 Assumption		Scenario 4 under 70/30 Assumption	
	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur
<20	1	1	3	4	2	5	5	2	4	3
20-40	1	1	3	4	2	5	5	2	4	3
40-60	1	1	3	4	2	5	5	2	4	3
60-100	1	1	3	4	2	5	5	2	4	3
100+	1	1	3	4	2	5	5	2	4	3
Total	1	1	3	4	2	5	5	2	4	3

Table 58. "Winners" and "Losers" for the Dynamic Models
(1= "Winner" and 5= "Loser")

Household Income Level ($1,000s)	Scenario 1		Scenario 2		Scenario 3		Scenario 4 under 80/20 Assumption		Scenario 4 under 70/30 Assumption	
	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur
<20	1	1	3	4	2	5	5	2	4	3
20-40	1	1	3	4	2	5	5	2	4	3
40-60	1	1	3	4	2	5	5	2	4	3
60-100	1	1	3	4	2	5	5	2	4	3
100+	1	1	2	4	3	5	5	2	4	3
Total	1	1	3	4	2	5	5	2	4	3

COMPARISON OF ADDITIONAL REVENUE SCENARIOS

A closer comparison of Scenarios 2-4 is merited because even though all of these scenarios generate the same total amount of revenue, their underlying philosophies vary greatly and their impacts vary by household geographic location. In essence, their equity impacts differ. The static scenario that results in the lowest weighted average annual household VMT fee from vehicle-owning households, disaggregated by both household income level and household geographic location is shown in Table 59.

Table 59. Most Favorable Static Scenario—Disaggregated by Household Income Level and Household Geographic Location—Designed to Increase Revenue

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)
<20	Scenario 3	Scenario 3	Scenario 4 80/20 Assumption
20-40	Scenario 3	Scenario 3	Scenario 4 80/20 Assumption
40-60	Scenario 3	Scenario 3	Scenario 4 80/20 Assumption
60-100	Scenario 4 80/20 Assumption	Scenario 3	Scenario 4 80/20 Assumption
100+	Scenario 4 80/20 Assumption	Scenario 3	Scenario 4 80/20 Assumption
Total	Same for All Scenarios	Scenario 3	Scenario 4 80/20 Assumption

First of all, note that the total weighted average annual vehicle-owning household VMT fee revenue is the same for all four scenarios designed to generate revenue in addition to that already collected through the state gas tax from the vehicles included in the analysis. What differs is that each scenario results in different changes to the household tax/fee paid. Interestingly, across all vehicle-owning urban household income levels, Scenario 3 in the smallest increase. Because Scenario 3 is designed to reward and encourage the use of fuel-efficient vehicles, this supports the idea that urban households tend to drive more fuel-efficient vehicles.

By contrast, the most beneficial revenue generating static scenario for rural households was Scenario 4 with the 80/20 assumption. A larger ratio of the desired annual $14.3 billion increase in revenue was earmarked to urban roadways fees. Under both the 80/20 assumption and the 70/30 assumption, the urban roadway VMT fee was calculated to be higher than the rural roadway VMT fee. Urban households were assumed to drive a larger percentage of their VMT on urban roadways and rural households were assumed to drive a larger percentage of their VMT on rural roadways. Thus, it makes sense that the lower VMT fee assigned to rural roadways would contribute towards an economically beneficial scenario for rural households. The results also indicate that under the static model assumption, rural households benefitted from the lower VMT fee assigned to rural roadways more under the 80/20 assumption than under the 70/30 assumption—indicating that the 10 percent increase in urban roadway travel resulted in less of a benefit to rural households.

The same results shown in Table 60 are shown in Table 59; with the only difference being that the Table 60 results correspond to the dynamic model rather than the static model. Vehicle-owning urban households have a greater propensity to lower their VMT as the total price of gas (including the cost of the proposed VMT fees) increases, when compared to vehicle-owning rural households. Therefore, it is not surprising that greater disparity in the weighted average annual VMT fee revenue is seen between vehicle-owning urban households and vehicle-owning rural households within the same household income level under the dynamic model versus the static model. While Scenario 3 is still the most beneficial for vehicle-owning urban households overall, vehicle-owning urban households within household income level quintile 5 actually benefit the most from Scenario 2 under the dynamic model (although the difference between Scenario 2 and Scenario 3 is small). This may be a reflection of the percentage of miles that fuel efficient vehicles are driven by high income urban vehicle-owning households. Just because this household subcategory has a higher average vehicle fuel-economy than households with a lower household income level, does not necessarily dictate how much they use their fuel efficient vehicles.

Interestingly, Scenario 2 is the most beneficial dynamic model when considering all vehicle-owning households with household income level quintile 1, even though Scenario 2 is not the most beneficial for this lowest household income level for either vehicle-owning urban households or vehicle-owning rural households considered separately. This is an indication that while Scenario 3 benefited vehicle-owning urban households with household income level quintile 1 the most monetarily, it had the most negative monetary impact on vehicle-owning rural households within the same household income level when considering the four scenarios designed to generate additional revenue. Likewise, while Scenario 4 under the 80/20 assumption benefited vehicle-owning rural households the most monetarily, it was the most monetarily hurtful revenue generating scenario for vehicle-owning urban households. Thus, as a more moderate scenario for all vehicle-owning households with household income level quintile 1, Scenario 2 is the most monetarily desirable scenario designed to generate additional net revenue when considering dynamic models.

Table 60. Most Favorable Dynamic Scenario—Disaggregated by Household Income Level and Household Geographic Location—Designed to Increase Revenue

Household Income Level ($1,000s)	All Vehicle-Owning Households ($)	All Vehicle-Owning Urban Households ($)	All Vehicle-Owning Rural Households ($)
<20	Scenario 2	Scenario 3	Scenario 4 80/20 Assumption
20-40	Scenario 3	Scenario 3	Scenario 4 80/20 Assumption
40-60	Scenario 3	Scenario 3	Scenario 4 80/20 Assumption
60-100	Scenario 4 80/20 Assumption	Scenario 3	Scenario 4 80/20 Assumption
100+	Scenario 4 80/20 Assumption	Scenario 2	Scenario 4 80/20 Assumption
Total	Same for All Scenarios	Scenario 3	Scenario 4 80/20 Assumption

GINI COEFFICIENTS AND VERTICAL EQUITY

As mentioned in Chapter II, the Gini Coefficient (G) was calculated for each scenario and compared relative to the state gas tax to determine whether it was quantitatively more or less vertically equitable than the current state gas tax system. Recall that a G value close to 0 is indicative that the Lorenz Curve plot is close to the line of equity. By contrast, the closer G is to 1 the further the Lorenz Curve is from the line of equity and the more progressive the scenario (see Equation (1) and Figure 1 for relevant calculation explanations and schematics). The results are shown in Table 61.

Table 61. Gini Coefficients for Texas Vehicle-Owning Households in 2008 under Various Transportation Fee Scenarios

Scenario	Gini Coefficient (G)	Description of Results
Static Scenario 3	0.1734	Most Progressive (Scenario where high income households pay larger percentage of state gas tax or VMT fees than any other scenario)
Dynamic Scenario 3	0.1712	
Static Scenario 1	0.1697	
Static Scenario 2	0.1697	
Dynamic Scenario 1	0.1692	
Gas Tax	0.1687	
Dynamic Scenario 2	0.1684	
Static Scenario 4, 70/30	0.1672	
Static Scenario 4, 80/20	0.1670	
Dynamic Scenario 4, 70/30	0.1661	
Dynamic Scenario 4, 80/20	0.1656	Most Regressive (Scenario where high income households pay smaller percentage of state gas tax or VMT fees than any other scenario)

The information displayed in Table 61 is especially useful if analyzed in relation to the current state gas tax. As seen in Table 61, it appears that half of the VMT fee scenarios are more progressive than the current state gas tax system, while half are more regressive than the current state gas tax system. All variations of Scenario 4, as well as Dynamic Scenario 2 are more regressive than the state gas tax. Scenario 3 is the most progressive scenario. Note that Static Scenario 1 and Static Scenario 2 have the same G value—as is to be expected given that the only difference between the two scenarios is a scaling factor. Although the results shown in Table 61 make it possible to compare the vertical equity of each scenario, conclusions should be drawn from a practical standpoint. The tight range of G values (difference between max and min values totaling 0.0078) is an indication that all of the analyzed VMT fee scenarios are essentially as equally vertically equitable as the current state gas tax system. All scenarios (including the state gas tax) are progressive in nature, largely due to the fact that higher income households own more vehicles, and thus contribute more towards the total state gas tax revenue. However, it is important to understand that the term "progressive" in this case is used to indicate that higher income household quintiles pay more of the overall state gas tax revenue; not the broader meaning that lower income households pay a lower percentage of their overall household income on the transportation fee.

HORIZONTAL EQUITY

Scenario 4 was designed to inherently achieve horizontal equity because all vehicles, regardless of which type of household they belong to, pay the designated fees unique to urban roadways and rural roadways. In turn, the revenue from each roadway fee goes back to improving the mobility and infrastructure of that area type with the revenue amount dictated by the disaggregation of roadway type needs (urban roadway, rural roadway, shared). Thus, this type of design is one form of the "equal treatment of equals (Toutkoushian and Michael, 2007)". Scenario 4 was used as the benchmark in quantitatively assessing the relative horizontal equity of each scenario, disaggregated in terms of household geographic location. The horizontal equity results corresponding to the static models are shown in Table 62, while the horizontal equity results corresponding to the dynamic models are shown in Table 63. The actual revenue totals generated under the state gas tax and the VMT fee scenarios are presented in Table 64.

Table 62. Horizontal Equity Comparison of Urban Households and Rural Households for Static Models

Scenario	Percentage of Total Revenue Collected from Urban Households	Percentage of Total Revenue Collected from Rural Households	Comments	Increase in Percent Rural Households Pay versus Scenario 4 (80/20, 70/30) (%)
Static Scenario 4 80/20	77.4	22.6	Horizontally Equitable under Scenario 4 80/20 Assumption	(0,-0.5)
Static Scenario 4 70/30	76.9	23.1	Horizontally Equitable under Scenario 4 70/30 Assumption	(0.5,0)
Static Scenario 2	72.6	27.4		(4.8,4.3)
Static Scenario 1	72.6	27.4		(4.8,4.3)
State Gas Tax	72.0	28.0		(5.4,4.9)
Static Scenario 3	71.7	28.3	Rural Households Affected Most Negatively	(5.7,5.2)

Table 63. Horizontal Equity Comparison of Urban Households and Rural Households for Dynamic Models

Scenario	Percentage of Total Revenue Collected from Urban Households	Percentage of Total Revenue Collected from Rural Households	Comments	Increase in Percent Rural Households Pay versus Scenario 4 (80/20, 70/30) (%)
Dynamic Scenario 4 80/20	74.8	25.2	Horizontally Equitable under Scenario 4 80/20 Assumption	(0,-0.9)

Table 63. cont.

Scenario	Percentage of Total Revenue Collected from Urban Households	Percentage of Total Revenue Collected from Rural Households	Comments	Difference in Percentage of Rural Household Revenue under Scenario 4 (80/20, 70/30) versus the Scenario in Question (%)
Dynamic Scenario 4 70/30	73.9	26.1	Horizontally Equitable under Scenario 4 70/30 Assumption	(0.9,0)
Dynamic Scenario 1	72.5	27.5		(2.3,1.4)
Dynamic Scenario 2	69.8	30.2		(5.0,4.1)
Dynamic Scenario 3	69.2	30.8	Rural Households Affected Most Negatively	(5.6,4.7)

Table 64. Total Revenue Generated by Urban Households and Rural Households

Scenario	Total Revenue Generated from Either State Gas Tax or VMT Fee from All Households ($)	Total Revenue Generated from Either State Gas Tax or VMT Fee from Urban Households ($)	Total Revenue Generated from Either State Gas Tax or VMT Fee from Rural Households ($)	Difference in Total Revenue Generated by Urban Households versus Rural Households ($)
State Gas Tax	1,770,254,297	1,274,355,697	495,898,600	778,457,097
Static Scenario 1	2,515,974,912	1,826,336,305	689,638,607	1,136,697,698
Dynamic Scenario 1	2,515,974,912	1,823,514,940	692,459,972	1,131,054,968
Static Scenario 2	20,390,974,912	14,801,728,586	5,589,246,326	9,212,482,260
Dynamic Scenario 2	20,390,974,912	14,238,989,580	6,151,985,332	8,087,004,248
Static Scenario 3	20,390,974,912	14,614,900,960	5,776,073,952	8,838,827,008
Dynamic Scenario 3	20,390,974,912	14,105,345,464	6,285,629,449	7,819,716,015
Static Scenario 4 (80/20 Assumption)	20,390,974,912	15,775,719,071	4,615,255,841	11,160,463,230
Dynamic Scenario 4 (80/20 Assumption)	20,390,974,912	15,246,247,536	5,144,727,376	10,101,520,160

Table 64. cont.

Scenario	Total Revenue Generated from Either State Gas Tax or VMT Fee from All Households ($)	Total Revenue Generated from Either State Gas Tax or VMT Fee from Urban Households ($)	Total Revenue Generated from Either State Gas Tax or VMT Fee from Rural Households ($)	Difference in Total Revenue Generated by Urban Households versus Rural Households ($)
Static Scenario 4 (70/30 Assumption)	20,390,974,912	15,689,428,332	4,701,546,580	10,987,881,752
Dynamic Scenario 4 (70/30 Assumption)	20,390,974,912	15,062,890,024	5,328,084,888	9,734,805,136

For both the static model (Table 62) and the dynamic model (Table 63), Scenario 3 causes rural households to pay the largest percentage of the total revenue collected under any scenario of the same model type. Additionally, both the static model and the dynamic model of Scenario 3 are less horizontally equitable than the state gas tax, under the 80/20 assumption. Likewise, the static model of Scenario 3 is less horizontally equitable that the state gas tax under the 70/30 assumption. Scenario 1 and Scenario 2 are equally horizontally equitable under the static model because the only difference between the structure of Scenario 1 and Scenario 2 is a scaling factor, which does not affect revenue percentages. However, under the dynamic model Scenario 2 displays less horizontal equity than Scenario 1, as rural households pay a higher percentage under Scenario 2. This observation is largely explained by the fact that larger elasticities are associated with urban households. Therefore, urban households tend to decrease their VMT more drastically than rural households when the cost of travel increases (as was the case for all scenarios), which decreases the amount of revenue generated from urban households and subsequently increases the percentage of the total revenue collected from rural households.

COMPARATIVE REVENUE AND VMT

The vehicle miles traveled by each household type, disaggregated by household income level and household geographic location, are provided in Tables 65-70. The total VMT is identical under the state gas tax system and the static VMT fee scenarios because, by definition, the static models assume no change in VMT due to changes in the transportation fee. Notice that the dynamic model total VMT values are lower for the dynamic models of Scenarios 2-4 than for the dynamic model of Scenario 1. This is because the fees imposed on households to achieve additional revenue desired for mobility and infrastructure improvements result in a decrease in VMT.

Table 65. State Gas Tax and Static Models' Annual VMT

Household Income Level ($1,000s)	Total VMT for All Households (miles)	Total VMT for Urban Households (miles)	Total VMT for Rural Households (miles)
<20	18,831,170,512	14,858,666,451	3,972,504,061
20-40	32,095,312,144	23,443,683,443	8,651,628,700
40-60	29,808,015,562	21,928,785,374	7,879,230,187
60-100	47,387,290,767	33,553,900,976	13,833,389,791
100+	48,267,233,003	34,255,061,899	14,012,171,104
Total	176,389,021,988	128,040,098,144	48,348,923,844

Table 66. Dynamic Scenario 1 Annual VMT

Household Income Level ($1,000s)	Total VMT for All Households (miles)	Total VMT for Urban Households (miles)	Total VMT for Rural Households (miles)
<20	18,567,889,623	14,629,844,025	3,938,045,599
20-40	31,801,161,527	23,194,393,559	8,606,767,968
40-60	29,555,407,730	21,717,517,730	7,837,890,000
60-100	46,879,022,290	33,141,360,004	13,737,662,286
100+	47,692,634,464	33,787,269,407	13,905,365,056
Total	174,496,115,634	126,470,384,725	48,025,730,909

Table 67. Dynamic Scenario 2 Annual VMT

Household Income Level ($1,000s)	Total VMT for All Households (miles)	Total VMT for Urban Households (miles)	Total VMT for Rural Households (miles)
<20	13,136,792,949	9,952,198,843	3,184,594,106
20-40	25,727,121,625	18,180,853,245	7,546,268,379
40-60	24,286,561,504	17,371,460,682	6,915,100,822
60-100	36,473,852,291	24,803,843,005	11,670,010,286
100+	36,021,121,573	24,412,642,804	11,608,478,769
Total	135,645,449,942	94,720,997,580	40,924,452,362

Table 68. Dynamic Scenario 3 Annual VMT

Household Income Level ($1,000s)	Total VMT for All Households (miles)	Total VMT for Urban Households (miles)	Total VMT for Rural Households (miles)
<20	13,586,975,970	10,367,862,758	3,219,113,212
20-40	26,311,963,039	18,729,298,792	7,582,664,247
40-60	24,747,718,177	17,778,017,986	6,969,700,190
60-100	37,252,383,978	25,483,938,167	11,768,445,810
100+	36,897,620,413	25,166,492,302	11,731,128,111
Total	138,796,661,576	97,525,610,005	41,271,051,572

Table 69. Dynamic Scenario 4 under 80/20 Assumption Annual VMT

Household Income Level ($1,000s)	Total VMT for All Households (miles)	Total VMT for Urban Households (miles)	Total VMT for Rural Households (miles)
<20	12,910,398,406	9,586,436,214	3,323,962,192
20-40	25,524,987,819	17,780,294,024	7,744,693,795
40-60	24,110,035,065	17,021,942,495	7,088,092,570
60-100	36,198,714,049	24,143,184,544	12,055,529,505
100+	35,707,116,387	23,671,526,617	12,035,589,770
Total	134,451,251,726	92,203,383,894	42,247,867,832

Table 70. Dynamic Scenario 4 under 70/30 Assumption Annual VMT

Household Income Level ($1,000s)	Total VMT for All Households (miles)	Total VMT for Urban Households (miles)	Total VMT for Rural Households (miles)
<20	12,933,768,333	9,628,796,123	3,304,972,210
20-40	25,547,547,530	17,831,211,701	7,716,335,829
40-60	24,130,443,684	17,067,019,460	7,063,424,224
60-100	36,226,508,242	24,224,647,732	12,001,860,510
100+	35,737,423,257	23,760,817,244	11,976,606,013
Total	134,575,691,046	92,512,492,260	42,063,198,786

The ranking from lowest to highest (1=lowest) of total household VMT for all households are shown in Table 71. The overall ranking results were the same regardless of household income level. It could be argued that the scenario that causes the total household VMT to decrease most drastically is the most detrimental to a particular household type because it is causing the households to limit their travel, and is therefore inconveniencing them. However, for the purposes of this analysis this level of equity analysis was not considered, but the rankings based on VMT are provided for comparison purposes (see Table 71).

From Table 71 it is evident that the dynamic model of Scenario 4 causes the largest decrease in the VMT of all households; with a more drastic decrease in overall VMT experienced under the 80/20 assumption than the 70/30 assumption. The same result can be seen when only considering urban households. These identical rankings for all households and just urban households is not surprising because urban households make-up a majority of the vehicle-owning population in Texas, which causes the urban household ranking results to more heavily affect the overall results. Of all the dynamic models designed to generate additional revenue needed for improvements, Scenario 3 causes the smallest decrease in urban household VMT. For rural households, the dynamic model of Scenario 2 causes the greatest decrease in VMT, while Scenario 4 under the 80/20 assumption causes the smallest decrease in rural household VMT of all of the dynamic models designed to generate revenue needed for improvements.

Table 71. Ranking of Lowest to Highest VMT for All Households (1=Lowest)

Households Considered in Ranking	State Gas Tax	Dynamic Scenario 1	Dynamic Scenario 2	Dynamic Scenario 3	Dynamic Scenario 4 under 80/20 Assumption	Dynamic Scenario 4 under 70/30 Assumption
All	6	5	3	4	1	2
Urban	6	5	3	4	1	2
Rural	6	5	1	2	4	3

SUMMARY

Chapter IV has explained the structure of each VMT fee scenario, the anticipated costs of converting to a VMT fee system in place of the state gas tax, and how elasticities were obtained for use in calculating the dynamic model results. Tables displaying comparative results were presented and discussed. Specifically, differences between Scenarios 2-4 were examined, and analysis into the most beneficial scenario for each household type was presented. From a quantitative perspective the vertical equity of each scenario was assessed by calculating the scenario's Gini Coefficients—which seem to indicate that all proposed scenarios are essentially just as vertically equitable as the current state gas tax system. The relative horizontal equity was assessed for each scenario, under the assumption that Scenario 4 was inherently designed to be horizontally equitable. Scenario 3 is less horizontally equitable than the current state gas tax system under the 80/20 assumption for both the static and dynamic models; and under the 70/30 assumption for the static model.

CHAPTER V

CONCLUSIONS AND RECOMMENDATONS

Replacing the gas tax with a VMT fee is under serious consideration as policy-makers work to establish a transportation fee system that (a) holds motorists more accountable for their use of the infrastructure and (b) provides the funding required to keep the transportation system functioning effectively. As with any new idea, there is the need to examine potential issues with VMT fee scenarios. These include, but are not limited to, the fee system's ability to capture needed revenue, the method of fee collection, privacy concerns in the VMT fee collection process, the anticipated impact on the environment, and equity impacts. This research utilized 2009 NHTS data to analyze the equity impacts associated with replacing the Texas state gas tax with a VMT fee for gasoline-run vehicles. Four different general scenarios were implemented and the resulting changes in fees for households grouped by both household income level and household geographic location were estimated. The results were weighted to reflect all Texas vehicle-owning households for the year 2008.

CONCLUSIONS

No one proposed VMT fee scenario affects all households uniformly. Thus, it is imperative that VMT fee goals be adequately determined prior to assessing the equity impacts of proposed VMT fee scenarios. A list of potential VMT fee scenario goals for policy-makers to use as a starting point in creating their own goals was provided in

Chapter IV. The following section briefly addresses each of these goals and in the process highlights some of the pros and cons associated with each VMT fee scenario.

EVALUATION OF POTENTIAL VMT FEE GOALS

- **Establish Horizontal Equity:** As explained in Chapter IV, Scenario 4 was designed to be inherently horizontally equitable. The VMT fee associated with each roadway type is reflective of the revenue desired for mobility and infrastructure improvements either specific to that roadway type or that address a shared need. Scenario 3, a scenario that favored vehicles with high fuel efficiency, was found to be the least horizontally equitable.
- **Establish Vertical Equity:** The Gini Coefficient was calculated for each scenario and compared relative to the current state gas tax to assess whether each VMT fee scenario was more or less vertically equitable. The similar Gini Coefficients obtained for each scenario were an indication that all of the VMT fee scenarios were essentially as equally vertically equitable as the current state gas tax system.
- **Familiarize travelers with the VMT fee concept:** This goal would likely be achieved under Scenario 1, because although no additional net revenue would be generated, it would help motorists become familiar with the VMT fee system. As motorists become more accepting of the VMT fee system, the potential would increase for changes in the design of the fee system that would allow for increased revenue to be addressed.

- **Implement a VMT fee collection and monitoring system that is easy to understand**: It is anticipated that with the equipment costs accounted for in this analysis (GPS for all vehicles currently on the roadway and VMT fee collection equipment at widespread service stations in Texas), motorists would not need to exert any additional effort in being charged a VMT fee in place of the state gas tax. Motorists may be more likely to understand the VMT process if service station receipts were designed to report the total VMT fee amount charged to motorists, rather than merely including it in the total cost of gas as presently done.
- **Generate additional revenue to address mobility and infrastructure needs:** Though likely not popular, this goal could be achieved under Scenarios 2-4.
- **Encourage the use of more fuel efficient vehicles:** This goal corresponds to the design of Scenario 3, in which fuel efficient vehicles are rewarded by being charged a lower per mile rate than vehicles with poor fuel efficiency.
- **More closely link travel to use of infrastructure:** While it is anticipated that this goal would be achieved under all of the proposed VMT fees, Scenario 4, in particular, links VMT fees to the type of roadway being traveled on, which in turn allows the VMT fee revenue to be used in addressing the mobility and infrastructure needs related to that roadway type.
- **Make the transition from the current state gas tax system to a VMT fee timely and affordable:** Installation of thin OBUs would be more affordable than installing thick OBUs in terms of the cost of the OBU unit. In terms of the

transition to a VMT fee system, a widespread, upfront conversion to the VMT fee system, rather than a more gradual transition, was assumed in this analysis. Though costly, this fast conversion approach may make the transportation fee system less complicated in the long-run because all gasoline-run vehicles would be under the same system.

RESEARCH LIMITATIONS SUMMARY

Several assumptions were made in performing this analysis. First of all, only household gasoline-run vehicles were included in the analysis under the assumption that vehicles dependent on a different source of energy composed only a small percentage of all household vehicles. Additionally, the breakdown of road-type travel by both urban households and rural households was based on an educated estimate. Although an effort was made to obtain rough estimates of the actual disaggregation (by analysis performed by Mark Ojah), they are merely estimates based off of a small sample population. Data obtained through the use of readings from more vehicles in more locations may help to eliminate uncertainty in these assumptions and may even eliminate the need to make any assumption at all through the use of accurate, up-to-date GPS readings. It was also assumed that the filtered, weighted data used in this analysis were representative of the vehicle-owning population of Texas in the year 2008, although only select control totals were known concretely for the weighted totals of urban vehicle-owning households and rural vehicle-owning households. In the future it may be possible to obtain more accurate estimates of the installation costs, operating costs, and leakage costs associated with a VMT fee system. It was assumed that the GPS and service station equipment installed up-front would span the whole 22 years ranging from 2009 to 2030, which encompass the analysis timeframe.

RECOMMENDATIONS FOR FUTURE RESEARCH

The vehicle data available as part of the 2009 NHTS present an opportunity to further explore VMT fee scenarios in the future. For example, because the cost of gas is provided for several of the NHTS vehicles, there is the potential to develop gas price elasticities that consider the effects of household demographic data ranging from household respondent race, to household life cycle, to household income level, to household geographic location. Such an effort would likely be best served by using data from all states, rather than vehicles specific to Texas, given the broader range of gas prices listed across the nation than in Texas specifically.

Future studies could also include diesel vehicles—and potentially even vehicles with other forms of energy such as electricity and natural gas. However, such an analysis would only include vehicles running on sources of fuel other than gasoline if they were listed among a household's vehicles. Thus, some commercial vehicles that are owned by the household may be included but most large diesel trucks would be excluded because they are generally not owned on the household level. Additional research could investigate how travel by Texas households outside of the state of Texas should be addressed, as well as how non-Texas vehicles traveling on Texas roadways should be treated.

Another possible avenue of research could involve tweaking the set 4:3:2 ratios established in Scenario 3 in an attempt to analyze the equity impacts associated with different ratios based on vehicle fuel-economy. In terms of Scenario 4, research could be done to better estimate or track the actual percentage of miles spent on urban roadways versus rural roadways by urban vehicle-owning households and rural vehicle-owning households. Alternatively, the VMT fee rate could be indexed based on household income level (similar to the U.S. income tax system) to reduce the regressive nature of a transportation fee system.

As advances in technology continue to progress, it will become increasingly feasible and less costly to implement a VMT fee scenario in place of the current state gas tax, which could hold motorists more accountable for their use of the infrastructure. Research into VMT fees and their equity impacts are timely given their recent discussion on both state and federal levels. The VMT fee scenarios analyzed as part of this research illustrate the varying equity impacts that can be achieved under different philosophies governing VMT fee design. Pros and cons are associated with each of the scenarios included in this analysis. The results of each scenario have been presented in the hope that they will be used as a tool by elected officials and policy-makers in evaluating the impact each scenario would have on their constituents as they work to achieve a bright future for the state of Texas.

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APPENDIX A

2009 NHTS HOUSEHOLD SCREENER INTERVIEW

NATIONAL HOUSEHOLD TRAVEL SURVEY

Telephone (CATI) Questionnaire

SECTION A: TELEPHONE NUMBER SCREENING

A1.
Hello, this is {INTERVIEWER'S NAME} and I'm calling for the U .S. Department of Transportation. We are conducting the National Household Travel Survey.

(RESIDENTIAL)
Are you a member of this household and at least 18 years old?
[A1_QUEST]

YES	1	GO TO BUSINESS
NO	2	GO TO A2
PROBABLE BUSINESS	3	GO TO BUSINESS
ANSWERING MACHINE	AM	GO TO READMSG
RETRY AUTODIALER	RT	GO TO AUTODIALER
NONWORKING, DISCONNECTED, CHANGED	NW	GO TO WORK A CASE
GO TO RESULT	GT	GO TO RESULT

(BUSINESS)
Is this phone number used for...
[PHONEUSE]

Home use,	4	GO TO BINTRO
Home and business use, or	5	GO TO BINTRO
Business use only?	6	GO TO THANK01
GO TO RESULT	GT	GO TO RESULT

[HOME USE EXCLUDES MOTELS, HOTELS, GROUP QUARTERS SUCH AS NURSING HOMES, PRISONS, BARRACKS, CONVENTS, MONASTERIES AND UNITS OF 10 > UNRELATED ROOMMATES.]

A2. May I please speak with a household member who is at least 18 years old?
(SRAVAIL)

AVAILABLE	1	GO TO A4
NOT AVAILABLE	2	GO TO RESULT
THERE ARE NONE	3	GO TO A3
GO TO RESULT	GT	GO TO RESULT

[HH) MEMBERS INCLUDE PEOPLE WHO THINK OF THIS HH AS THEIR PRIMARY PLACE OF RESIDENCE, INCLUDING PERSONS WHO STAY IN THE HH BUT ARE TEMPORARILY AWAY ON BUSINESS, VACATION, OR IN A HOSPITAL. IT DOES NOT INCLUDE SOMEONE JUST VISITING, SUCH AS A COLLEGE STUDENT WHO NORMALLY HAS BEEN LIVING AWAY AT SCHOOL.]

A3. **[IF RESPONDENT IS A CHILD, ASK FOR AN OLDER HOUSEHOLD MEMBER.]**
(SUNDRAGE)

NO ONE LIVING IN HH IS 18 OR OLDER	1	END & CODE IE
THERE ARE HH MEMBERS 18 OR OLDER	2	GO TO A2
GO TO RESULT	GT	GO TO RESULT

A4.Hello, this is {INTERVIEWER'S NAME} and I'm calling for the U.S. Department of Transportation.

We are conducting the National Household Travel Survey. Are you a member of this household and at least 18 years old?
(SRELIG2)

YES	1	
NO	2	REPEAT A2 (S3A)
GO TO RESULT	GT	GO TO RESULT
REFUSED	-7	GO TO REFUSAL NIRF
DON'T KNOW	-8	GO TO REFUSAL NIRF

A5. Is this phone number used for...
[PHONEUSE]

Home use, ...	1	
Home and Business use, or	2	
Business use only?	3	GO TO THANK01
GO TO RESULT	GT	GO TO RESULT

SECTION B: VEHICLE DATA

BINTRO The purpose of this survey is to understand your travel, help reduce congestion and improve transportation safety in {ADD-ON/your area}.

Your participation is voluntary, and your answers will be completely confidential.

{[IF ASKED: The survey has been authorized by Title 23, United States Code. The OMB clearance number is 2125-0545 with an expiration date of February 28, 2011.]}

C3. To help us understand the things that impact your travel choices, I have a few questions about your household. Including yourself, how many people live in your household? Please do not include anyone who usually lives somewhere else or is just visiting, such as a college student away at school.
(HHNUMPPL)

NUMBER OF PEOPLE	|___|___|
REFUSED	-7
DON'T KNOW	-8

C4. Are any of these people related to each other?
(HHRELATD)

YES	1	
NO	2	GO TO THANK02
REFUSED	-7	
DON'T KNOW	-8	

B1. How many vehicles are owned, leased, or available for **regular use** by the people who currently live in your household? Please be sure to include motorcycles, mopeds and RVs.
(HHNUMVEH)

[INCLUDE LEASED OR COMPANY-OWNED MOTORIZED VEHICLES IF THEY ARE USED BY HOUSEHOLD MEMBERS ON A REGULAR BASIS.]

NUMBER OF VEHICLES	|___|___|	
NONE	0	GO TO C1
REFUSED	-7	GO TO C1
DON'T KNOW	-8	GO TO C1

B2.
{I have a few questions about each of these vehicles. Let's start with the newest vehicle.} What is the make, model and year of this vehicle?

KEY **(MAKEALPH)**	MAKE **(MAKECODE)**	MODEL **(MODLCODE)**	YEAR **(VEHYEAR)**	TYP **(VEHTYPE)**
01				
02				
03				
04				
05				
thru' 99				

(VMAT6) What type of vehicle is it?
(VEHTYPE)

1. AUTOMOBILE/CAR/STATION WAGON
2. VAN [MINI, CARGO, PASSENGER]
3. SPORTS UTILITY VEHICLE [BRONCO, BLAZER, 4RUNNER, PATHFINDER, JEEP, ETC.]
4. PICKUP TRUCK
5. OTHER TRUCK
6. RV [RECREATIONAL VEHICLE]
7. MOTORCYCLE/MOTORBIKE
97. OTHER? **(VEHTYOS)** (SPECIFY) ________________

B4. I have recorded {SCRN.VEHICNT} vehicles.

Are these all of the vehicles that are available to the people that currently live in your household?
(VEHIYN)

YES	1	GO TO C1
NO	2	RETURN TO MATRIX
GO TO RESULT	GT	

SECTION C: PERSON DATA FOR EACH HOUSEHOLD MEMBER

C1. Now I have a few questions about your home. Do you live in a...
(HOMETYPE)

Single family detached house, ... 1
Single family attached house, ... 2
A building with 2 or more apartments
or condos, or 3
A mobile home or trailer?, ... 4
BOAT, RV, VAN, ETC.......................... 5
DORM ROOM, FRATERNITY OR
SORORITY HOUSE............................ 6
OTHER **(HOMETYOS)**......................... 97
(SPECIFY) ____________________
REFUSED .... -7
DON'T KNOW .... -8

C2. Is your home owned or rented?
(HOMEOWN)
[

OWNED 1
RENTED 2
OCCUPIED WITHOUT PAYMENT OF RENT 3
OTHER **(HOMEOWOS)**....................... 97
[SPECIFY] ____________________
REFUSED .... -7
DON'T KNOW .... -8

SE1. How many months of the year do you live in {Florida/Arizona}?
(FL1, AZ1)

NUMBER OF MONTHS ....|___|___|

JUST MOVED TO THE STATE 99
REFUSED .... -7
DON'T KNOW .... -8

SE2. How long ago did you move to this home?
(FL2_YR, FL2_MO, AZ2_YR, AZ2_MO)

NUMBER OF YEARS ....|___|___|

NUMBER OF MONTHS ....|___|___|

REFUSED .... -7
DON'T KNOW .... -8

SE3a. What is the most important reason you chose your current home location?
(FL3A, AZ3A)

COST/PRICE OF HOME	1
QUALITY OF HOME	2
HOME OR LOT SIZE	3
SCHOOL SYSTEM	4
NEIGHBORHOOD QUALITY	5
CONVENIENT TO WORK	6
CONVENIENT TO SCHOOL	7
CONVENIENT TO RETAIL (SHOPPING, ENTERTAINMENT, RESTAURANTS)	8
CLOSE TO FRIENDS & FAMILY	9
CLOSE TO PUBLIC TRANSPORTATION	10
CLOSE TO SCENIC LOCATIONS (BEACH, LAKE, GOLF COURSES) .	11
OTHER **(FL3A_O,AZ3A_O)**	97
[SPECIFY] ____________________	
REFUSED	-7
DON'T KNOW	-8

SE3b. Were there any other important reasons? CODE UP TO 3 THAT APPLY
(FL3B1-12, 97, AZ3B1-12, 97 – YES/NO VARIABLES)
(FL3BAR1-3, AZ3BAR1-3 – ARRAY VARIABLES)

COST/PRICE OF HOME	1
QUALITY OF HOME	2
HOME OR LOT SIZE	3
SCHOOL SYSTEM	4
NEIGHBORHOOD QUALITY	5
CONVENIENT TO WORK	6
CONVENIENT TO SCHOOL	7
CONVENIENT TO RETAIL (SHOPPING, ENTERTAINMENT, RESTAURANTS)	8
CLOSE TO FRIENDS & FAMILY	9
CLOSE TO PUBLIC TRANSPORTATION	10
CLOSE TO SCENIC LOCATIONS (BEACH, LAKE, GOLF COURSES) .	11
NO OTHER REASON	12
OTHER **(FL3B_O, AZ3B_O)**	97
[SPECIFY] ____________________	
REFUSED	-7
DON'T KNOW	-8

SE4a. What is the most important reason you have stayed in your current home?
(FL4A, AZ4A)

COST/PRICE OF HOME	1
QUALITY OF HOME	2
HOME OR LOT SIZE	3
SCHOOL SYSTEM	4
NEIGHBORHOOD QUALITY	5
CONVENIENT TO WORK	6
CONVENIENT TO SCHOOL	7
CONVENIENT TO RETAIL (SHOPPING, ENTERTAINMENT, RESTAURANTS)	8
CLOSE TO FRIENDS & FAMILY	9
CLOSE TO PUBLIC TRANSPORTATION	10
CLOSE TO SCENIC LOCATIONS (BEACH, LAKE, GOLF COURSES)	11
HAVE ROOTS IN COMMUNITY	12
MOVING IS TOO DIFFICULT	13
MOVING IS TOO EXPENSIVE	14
OTHER **(FL4A_O, AZ4A_O)**	97
[SPECIFY] ____________	
REFUSED	-7
DON'T KNOW	-8

SE4b. Were there any other important reasons? CODE UP TO 3 THAT APPLY
(FL4B1-15, 97, AZ4B1-15, 97 – YES/NO VARIABLES)
(FL4BAR1-3, AZ4BAR1-3 – ARRAY VARIABLES)

COST/PRICE OF HOME	1
QUALITY OF HOME	2
HOME OR LOT SIZE	3
SCHOOL SYSTEM	4
NEIGHBORHOOD QUALITY	5
CONVENIENT TO WORK	6
CONVENIENT TO SCHOOL	7
CONVENIENT TO RETAIL (SHOPPING, ENTERTAINMENT, RESTAURANTS)	8
CLOSE TO FRIENDS & FAMILY	9
CLOSE TO PUBLIC TRANSPORTATION	10
CLOSE TO SCENIC LOCATIONS (BEACH, LAKE, GOLF COURSES)	11
HAVE ROOTS IN COMMUNITY	12
MOVING IS TOO DIFFICULT	13
MOVING IS TOO EXPENSIVE	14
NO OTHER REASONS	15
OTHER **(FL4B_O, AZ4B_O)**	97
[SPECIFY] ____________	
REFUSED	-7
DON'T KNOW	-8

C5. Please tell me your first name, age and gender.
(FNAME, R_AGE, R_SEX)

FIRST NAME: ______________

AGE: _________

GENDER: _________ [M=MALE, F=FEMALE]

REFUSED .... -7
DON'T KNOW .... -8

C6. Are you of Hispanic, Latino, or Spanish origin?
(HH_HISP)

YES 1
NO 2
REFUSED .... -7
DON'T KNOW .... -8

C7. I'm going to read a list of races. {In addition to being Hispanic, please/Please} tell me which best describes your race. Are you…
(HH_RACE)

White, ... 1
African American, Black, ... 2
Asian, ... 3
American Indian, Alaskan Native, ... 4
Native Hawaiian, or other Pacific Islander? 5
MULTIRACIAL 6
HISPANIC/MEXICAN 7
OTHER **(HH_RACOS)** 97
[SPECIFY] ____________________
REFUSED .... -7
DON'T KNOW .... -8

C8. Please tell me the first name and age of everyone living in the household.

[What is {FNAME/AGE/SEX OF NEXT HHM}'s relationship to {you/FNAME/AGE/SEX OF 1ST SCREENER RESPONDENT}?]

{[Are you/Is {FNAME/AGE/SEX}} a driver?}

{

{Have you/Has FNAME/AGE/SEX}} ever been a driver?}

[ENTER AGE AS 0 FOR EVERYONE UNDER ONE YEAR.]

(FNAME) FIRST NAME	(R_AGE) AGE	(R_SEX) M/F	(SCRESP) X BY SCREENER RESPONDENT	(R_RELAT) RELATIONSHIP TO REFERENCE PERSON	[1=YES, 2=NO] (DRVR) DRIVER	(EVERDROV) EVER
01						
02						
03						
04						
05						
thru' 99						

1. REFERENCE PERSON
2. SPOUSE
3. CHILD
4. PARENT
5. BROTHER/SISTER
6. OTHER RELATIVE
7. UNMARRIED PARTNER
8. NON-RELATIVE

C9. I have recorded {SCRN.SELCTCNT} {people/person}. Have we missed anyone else who usually lives there but is temporarily away on business, vacation, or in the hospital?
(C9_QUEST)

NUMBER OF HOUSEHOLD MEMBERS IN MATRIX CORRECT............................	1	
RETURN TO MATRIX............................	2	SKIP TO MATRIX
GO TO RESULT	GT	GO TO RESULT

C10. Going back to the ages of the members of your household, is {FNAME/AGE/SEX} 18 years or older?
(AGERANGE)

YES (18 OR OLDER)............................	1	GO TO BOX BEFORE Ca
NO (UNDER 18)............................	2	
REFUSED	-7	GO TO BOX BEFORE Ca
DON'T KNOW	-8	GO TO BOX BEFORE Ca

SC20a. Is {FNAME/AGE/SEX} between 5 and 16 years old?
(AGE5PLUS)

YES (5-16 YEARS OLD)............................	1
NO	2
REFUSED	-7
DON'T KNOW	-8

Ca. {Do you/Does FNAME/AGE/SEX} have a job?
(WRKR)

YES	1
NO............................	2
REFUSED	-7
DON'T KNOW	-8

M7. What is the highest grade or year of school {you have/FNAME/AGE/SEX has } completed?
(EDUC)

LESS THAN HIGH SCHOOL GRADUATE.. 1
HIGH SCHOOL GRADUATE, INCLUDING GED 2
SOME COLLEGE OR ASSOCIATE'S DEGREE (FOR EXAMPLE, AA ALSO INCLUDES VOCATIONAL, BUSINESS OR TRADE SCHOOL) 3
BACHELOR'S DEGREE (FOR EXAMPLE, BA, AB, BS) 4
GRADUATE OR PROFESSIONAL SCHOOL DEGREE (FOR EXAMPLE, MA, MS, MBA, MD, DDS, PHD, EdD, JD)................................ 5
REFUSED................................ -7
DON'T KNOW................................ -8

C12. [Now, about the household vehicle(s) you told me about earlier,] who drives the {VEHYEAR, MAKECODE, AND MODLCODE} most of the time?
(WHOMAIN)

[IF NO MAIN DRIVER, ENTER 99]

|___|___|

NO MAIN DRIVER 99
REFUSED -7
DON'T KNOW -8

C13. Should {FNAME/AGE/SEX} have been recorded as a driver?
(C13_DRVR)

YES................................ 1
NO................................ 2
REFUSED................................ -7
DON'T KNOW................................ -8

C22b. Does the {VEHYEAR, MAKECODE, AND MODLCODE} have a commercial license plate?
(VEHCOMM)

[IF NEEDED: Commercial license plates are obtained if you registered your vehicle as a business vehicle.]

YES................................ 1
NO................................ 2
REFUSED................................ -7
DON'T KNOW -8

C22c. Is it a hybrid or alternative fuel use vehicle?
(HYBRID)

[EXAMPLES OF ALTERNATIVE FUELS INCLUDE:
ETHANOL, BIODIESEL, NATURAL GAS, PROPANE, HYDROGEN]

YES 1
NO 2
REFUSED .... -7
DON'T KNOW -8

C15. How many home telephone numbers does your household have in addition to {BASE.BASEAREA, BASE.BASEEXCH, BASE.BASELOCL}?
(OTHRPHON)

NUMBER OF ADDITIONAL HOME TELEPHONE
NUMBERS ....|___|___|
REFUSED .... -7
DON'T KNOW .... -8

C16. How many of these {OTHRPHON} telephone numbers excluding cellular phones are used **exclusively** for business, fax or computer modems?
(NONVOICE)

NUMBER OF TELEPHONE
NUMBERS ....|___|___| GO TO BOX BEFORE D1
REFUSED .... -7 GO TO BOX BEFORE D1
DON'T KNOW .... -8 GO TO BOX BEFORE D1

C17. Is that telephone number used exclusively for business, fax or computer modem?
(NONVOX1)

YES 1
NO 2
REFUSED .... -7
DON'T KNOW .... -8

SECTION D. DIARY REQUEST

D1. Understanding {your travel/travel by you and each member of your household} is very important for improving transportation in your area. We would like to send {you/each of you} a diary for you to record your travel for just one day {TRDDATE}. The diary packet we mail you will include a small monetary incentive, information about the study, and your trip {diary/diaries}.
(D1_QUEST)

CONTINUE .... 1 GO TO D4
RESPONDENT UNSURE ABOUT PARTICIPATION 2

D2. This study is vital to reducing congestion and improving transportation safety. We want to make sure that your household is represented in this important survey. No one else can substitute for you. Will you help the Department of Transportation by participating in this national survey?
(D2_QUEST)

AGREE TO PARTICIPATE.................... 1
REFUSAL.. GT

D4. In order to mail the {diary/diaries} to you, I need to verify that your address is...
(MAILADDR, MAILAPT, MAILCITY, MAILSTAT, MAILZIP)

STREET ADDRESS _______________ APT # _______

CITY/TOWN _______________ STATE _______ ZIP CODE _______

REFUSED.. -7
DON'T KNOW... -8

D5. In order to mail the {diary/diaries} to you, could you please tell me your mailing address?
(MAILADDR, MAILAPT, MAILCITY, MAILSTAT, MAILZIP)

STREET ADDRESS _______________ APT # _______

CITY/TOWN _______________ STATE _______ ZIP CODE _______

REFUSED.. -7
DON'T KNOW... -8

D6. Is this your home address?
(HOME)

YES... 1
NO... 2 GO TO D3
REFUSED.. -7 GO TO D3
DON'T KNOW.. -8 GO TO D3

D7. STREET ADDRESS:
APARTMENT NUMBER:
CITY:
STATE:
ZIP CODE:

RECORD IF THE STREET ADDRESS DISPLAYED IS A:
(D7_QUEST)

NORMAL STREET ADDRESS [NOT A PO BOX, RURAL ROUTE/RR, RURAL DELIVERY/RD, OR RFD].............. 1
PO BOX, RR, RD, OR RFD............................ 2

D3. To whom should we address the envelope?
(MAILFNAM, MAILLNAM)

____________________ FIRST NAME   ____________________ LAST NAME

REFUSED .... -7
DON'T KNOW .... -8

D8. Travel patterns are affected by where people choose to live. It is important that we get at least a general location of your household. {Would you please give me the name of the street or road you live on?}
(HHRD1)

[IF NEEDED: Transportation planners use data from this survey to assess current travel patterns and anticipate new ones. These patterns are affected by where people choose to live.]

____________________ FIRST CROSS ROAD

{And what is the name of the nearest intersecting street or road?}
(HHRD2)

____________________ SECOND CROSS ROAD

REFUSED .... -7
DON'T KNOW .... -8

D9. What is the ZIP Code for where your home is located?
(HHZIP)

[IF NEEDED: Transportation planners use data from this survey to assess current travel patterns and anticipate new ones. These patterns are affected by where people choose to live.]

____________________ ZIP CODE

REFUSED .... -7
DON'T KNOW .... -8

D10. In what borough or county do you live?
(COUNTY)

____

97. OTHER (SPECIFY) **(CNTYNYOS)** ____________________
REFUSED .... -7
DON'T KNOW .... -8

D11. We will mail the {diary/diaries} to you in a few days and will call you again on {REM1DATE}, to make sure you have received your {diary/diaries} and answer any questions.

Then we will call to ask about your travel on {BEGCDATE}. What would be a good time to reach you?

DATE:	________ **(HHCALLMM)** MONTH	________ **(HHCALLDD)** DAY	________ **(HHCALLYY)** YEAR
TIME:	________ **(HHCALLHR)** HOUR	________ **(HHCALLMN)** MINUTES	________ **(HHCALLAP)** AM/PM

D12. When we call back to collect your diary information, we will not ask to speak to anyone under 16 years old, but we would like to ask about their travel. Who would be the best person to give the information about them?
(WHOPROXY)

|___|___|

D13. Thank you for agreeing to take part in this important national travel study sponsored by the Department of Transportation. {Please tell the other members of your household how important their participation is.} We look forward to talking with you again.

TERMINATIONS:

READMSG **[PLEASE READ THE FOLLOWING MESSAGE INTO THE ANSWERING MACHINE.]**

This is {INTERVIEWER'S NAME} calling for the National Household Travel Survey that is being conducted by the U.S. Department of Transportation. We would like to talk to you about your household's travel. Your participation is extremely important to the success of this survey. We will try to reach you again in the next few days.

THANK 01 Thank you, but we are only interviewing in private residences.

THANK 02 Thank you very much. Those are all the questions that I have at this time.

APPENDIX B

2009 NHTS EXTENDED INTERVIEW

NATIONAL HOUSEHOLD TRAVEL SURVEY

Telephone (CATI) Questionnaire

EXTENDED INTERVIEW

SECTION E: TRAVEL TO WORK

INTRO2. Hello, may I please speak to {SUBJECT/WHOPROXY (WHOPROXY IS THE PROXY FOR SUBJECT/AGE/SEX)}?

[Hello, this is {INTERVIEWER'S NAME} and I am calling for the U.S. Department of Transportation. We recently spoke with {SCRESP} about the National Household Travel Survey. We're calling back now to complete the interview.

SUBJECT SPEAKING/COMING TO THE PHONE......	1	GO TO E1
SUBJECT LIVES HERE, NEEDS APPOINTMENT.	2	APPT SCREENS
SUBJECT KNOWN, LIVES AT ANOTHER NUMBER..	3	RECORDN1
NEVER HEARD OF SUBJECT	4	CHECKNO
TELEPHONE COMPANY RECORDING	5	RECORD
ANSWERING MACHINE..	AM	GO TO READMSG
RETRY AUTODIALER	RT	GO TO AUTODIAL
GO TO RESULT..	GT	GO TO RESULT

RESTART2. Hello, may I please speak to {SUBJECT/WHOPROXY}?

This is {INTERVIEWER'S NAME} and I am calling back for the U.S. Department of Transportation. We recently spoke with {you/SCRESP} about the National Household Travel Survey. We're calling back now to complete the interview.

SUBJECT AVAILABLE/COMING TO PHONE.............	1	GO TO E1 (E2)
SUBJECT LIVES HERE - NEEDS APPOINTMENT. ...	2	APPT SCREENS
SUBJECT KNOWN LIVES AT ANOTHER NUMBER...	3	RECORDN1
NEVER HEARD OF SUBJECT	4	CHECKNO
TELEPHONE COMPANY RECORDING	5	RECORD
ANSWERING MACHINE..	AM	GO TO READMSG
RETRY DIALING	RT	GO TO AUTODIAL
GO TO RESULT..	GT	GO TO RESULT

E1. [YOU ARE IN {SUBJECT'S NAME/AGE/SEX}'S CASE.]

(PROXY)

SUBJECT..	1
PROXY..	2

E2. A couple of weeks ago we spoke with {you/SCRESP} about the National Household Travel Survey. We sent you a diary to record your travel on {TRDDATE}. I'd like to collect {your/SUBJECT's} information now.

Let's start with some general questions about {you/SUBJECT}.

[IF NEEDED: All of your answers will be kept confidential; your participation is voluntary.]

L3. In **the past week**, how many times did {you/SUBJECT} take a walk outside including walking the dog and walks for exercise?
(NWALKTRP)

WALKS OUTSIDE IN PAST WEEK............|___|___|

REFUSED .... -7
DON'T KNOW .... -8

LCA1. And in the past week, how much total time did {you/SUBJECT} spend walking?
(CA1_HR, CA1_MIN)

HOURS .... |___|___|

MINUTES .... |___|___|

REFUSED .... -7
DON'T KNOW .... -8

L4. In **the past week**, how many times did {you/SUBJECT} ride a bicycle outside including bicycling for exercise?
(NBIKETRP)

BIKE RIDES .... |___|___|

REFUSED .... -7
DON'T KNOW .... -8

LCA2. And in the past week, how much total time did {you/SUBJECT} spend biking?
(CA2_HR, CA2_MIN)

HOURS .... |___|___|

MINUTES .... |___|___|

REFUSED .... -7
DON'T KNOW .... -8

LCA3. Were any of these bike rides {you/SUBJECT} took…

		YES	NO	REF	DK
a.	On the way to or from work? **(LCA3_A)**	1	2	-7	-8
b.	On the way to or from public transportation? **(LCA3_B)**	1	2	-7	-8
c.	Escorting children to or from school? **(LCA3_C)**	1	2	-7	-8
d.	Running errands or shopping? **(LCA3_D)**	1	2	-7	-8
e.	For exercise? **(LCA3_E)**	1	2	-7	-8
f.	To exercise the dog? **(LCA3_F)**	1	2	-7	-8
g.	For any other reasons? [SPECIFY]: **(LCA3_G)**	1	2	-7	-8
	______________________ **(LCA3_OTH)**				

LCA4. Now I'd like you to think about things that may keep you from doing more biking. Please tell me if any of the following keep {you/SUBJECT} from doing more biking? Would you say it's because…

		YES	NO	REF	DK
a.	You're too busy? **(BIKE_A)**	1	2	-7	-8
b.	You have poor health? **(BIKE_B)**	1	2	-7	-8
c.	You have no one to bike with? **(BIKE_C)**	1	2	-7	-8
d.	There are no nearby paths or trails? **(BIKE_D)**	1	2	-7	-8
e.	There are not enough bike or wide curb lanes? **(BIKE_E)**	1	2	-7	-8
f.	There are no sidewalks or the sidewalks are in poor condition **(BIKE_F)**	1	2	-7	-8
g.	Street crossings are unsafe? **(BIKE_G)**	1	2	-7	-8
h.	There are no shops or other interesting places to go? **(BIKE_H)**	1	2	-7	-8
i.	There are not enough people around? **(BIKE_I)**	1	2	-7	-8
j.	You fear street crime? **(BIKE_J)**	1	2	-7	-8
k.	There are too many cars? **(BIKE_K)**	1	2	-7	-8
l.	Of fast traffic? **(BIKE_L)**	1	2	-7	-8
m.	Of air pollution? **(BIKE_M)**	1	2	-7	-8
n.	You have too many things to carry? **(BIKE_N)**	1	2	-7	-8
o.	You have small children along? **(BIKE_O)**	1	2	-7	-8
p.	There is not enough light at night? **(BIKE_P)**	1	2	-7	-8

LCA5. {You/SUBJECT} mentioned that you walked outside in the past week. Were any of these walks {you/SUBJECT} took…

		YES	NO	REF	DK
a.	To walk or exercise the dog? (LCA5_A)	1	2	-7	-8
b.	On the way to or from work? (LCA5_B)	1	2	-7	-8
c.	On the way to or from public transportation? (LCA5_C)	1	2	-7	-8
d.	Escorting children to or from school? (LCA5_D)	1	2	-7	-8
e.	Running errands or shopping? (LCA5_E)	1	2	-7	-8
f.	For exercise? (LCA5_F)	1	2	-7	-8
g.	For any other reasons? [SPECIFY]: (LCA5_G)	1	2	-7	-8
	____________________ (LCA5_OTH)				

LCA6. Now I'd like you to think about things that may keep you from doing more walking. Please tell me if any of the following keep {you/SUBJECT} from doing more walking? Would you say it's because…

		YES	NO	REF	DK
a.	You're too busy? (WALK_A)	1	2	-7	-8
b.	You have poor health? (WALK_B)	1	2	-7	-8
c.	You have no one to walk with? (WALK_C)	1	2	-7	-8
d.	There are no nearby paths or trails? (WALK_D)	1	2	-7	-8
e.	There are no nearby parks? (WALK_E)	1	2	-7	-8
f.	There are no sidewalks or the sidewalks are in poor condition? (WALK_F)	1	2	-7	-8
g.	Street crossings are unsafe? (WALK_G)	1	2	-7	-8
h.	There are no shops or other interesting places to go? (WALK_H)	1	2	-7	-8
i.	There are not enough people walking around? (WALK_I)	1	2	-7	-8
j.	You fear street crime? (WALK_J)	1	2	-7	-8
k.	There are too many cars? (WALK_K)	1	2	-7	-8
l.	Of fast traffic? (WALK_L)	1	2	-7	-8
m.	Of air pollution? (WALK_M)	1	2	-7	-8
n.	Streets are too wide? (WALK_N)	1	2	-7	-8
o.	You have things to carry? (WALK_O)	1	2	-7	-8
p.	You have small children along? (WALK_P)	1	2	-7	-8
q.	There is not enough light at night? (WALK_Q)				

EVA6. Thinking about your area, please tell me if you agree or disagree with the following statements about walking and biking.
(EVA6a-EVA6d)

		AGREE	DISAGREE	REF	DK
a.	Improving bicycle and walking facilities is a good investment	1	2	-7	-8
b.	I would walk more if sidewalks were better	1	2	-7	-8
c.	Improving bicycle and walking facilities is important to help reduce traffic congestion	1	2	-7	-8
d.	I would bike more if the bike facilities were better	1	2	-7	-8

E3. During most of last week, {were you/was SUBJECT}...
(PRMACT)

working,	1	GO TO BOX BEFORE Ea
temporarily absent from a job or business,	2	GO TO BOX BEFORE Ea
looking for work,	3	
a homemaker,	4	
going to school,	5	
retired,	6	
or doing something else?	7	
REFUSED	-7	
DON'T KNOW	-8	

E4. Last week, did {you/SUBJECT} do any work for either pay or profit?
(PAYPROF)

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

Ea. {Are you/Is SUBJECT} self-employed?
(SELF_EMP)

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

E5. {Do you/Does SUBJECT} work.. [A full time job is at least 35 hours per week.]
(WKFTPT)

full-time, or	1
part-time?	2
MULTIPLE JOBS	3
REFUSED	-7
DON'T KNOW	-8

E6. {Do you/Does {SUBJECT}} have more than one job?
(GT1JBLWK)
[IF NEEDED: We mean more than one employer, not just multiple job sites.]

YES 1
NO 2
REFUSED .... -7
DON'T KNOW .... -8

E7. I am going to read {some/four} categories of occupations. Please tell me which one {your/SUBJECT'S} {primary} job falls under.
(JOBCATEG - JOBCATAZ)

Sales or service, ... 1
Clerical or administrative support, ... 2
Manufacturing, construction, maintenance, or farming, or 3
Professional, managerial, or technical? 4
OTHER 97
(SPECIFY) ____________
(JOBCATOS)
REFUSED .... -7
DON'T KNOW .... -8

E7.

Sales or Marketing, ... 1
Clerical, Administrative, or Retail, ... 2
Production, Construction, Farming, or Transport, 3
Professional, Managerial, or Technical 4
Personal Care and Services, or 5
Some other type of employment? 97
(SPECIFY) ____________
(JOBCATOZ)
REFUSED .... -7
DON'T KNOW .... -8

E12. What is the name of {your/SUBJECT'S} {employer/company} ?
(EMPLOYER)

[IF NEEDED: We are not going to contact {you/SUBJECT} there. Transportation planners are interested in workplace location because travel to work often affects other daily travel.]

____
NAME OF EMPLOYER

REFUSED .... -7
DON'T KNOW .... -8

E10. What is the street address of {your/SUBJECT'S} {primary} workplace?
(WKSTNUM, WKSTNAME, WKCITY,) **WORKSTAT WORKZIP**

[IF NEEDED: We are <u>not</u> going to contact you there. Transportation planners are interested in workplace location because travel to work often affects other daily travel.]

_____ STREET NUMBER _____ STREET NAME

_____ CITY _____ STATE _____ ZIP CODE

REFUSED .... -7
DON'T KNOW .... -8

E11. {We would like to know the approximate location of {your/SUBJECT'S} {primary} workplace. What is the name of the street or road nearest {your/SUBJECT'S} {primary} workplace?}

{I have recorded that your {primary} workplace is on…

(WKROAD1)

FIRST ROAD: {WKSTNAME} _____

{What is the name of the nearest intersecting street or road?}
(WKROAD2)

SECOND ROAD: _____

REFUSED .... -7
DON'T KNOW .... -8

E13. Would you please provide a landmark that is close to {your/his/her} {primary} workplace? This could be a well-known building, park, monument, or school.
(WKLDMRK1-3)

[IF NEEDED: Transportation planners are interested in workplace location because travel to work often affects other daily travel.]

_____ NAME OF A LANDMARK

REFUSED .... -7
DON'T KNOW .... -8

E14. What is the one-way distance from {your/SUBJECT'S} home to {your/his/her} {primary} workplace?
(DISTTOWK, DISTUNIT)

[IF LESS THAN 1 BLOCK, ENTER O BLOCKS. IF LESS THAN 1 MILE ENTER AS BLOCKS.]
[¼ MILE = 2 BLOCKS
½ MILE = 5 BLOCKS
¾ MILE = 7 BLOCKS]

NUMBER.................................. |___|___|___|
UNIT.. |___|
1 = BLOCKS
2 = MILES
REFUSED.. -7
DON'T KNOW.. -8

E15. How many minutes did it usually take {you/SUBJECT} to get from home to work last week?
(TIMETOWK)

MINUTES.................................. |___|___|___|
DID NOT WORK IN USUAL
WORKPLACE LAST WEEK........................998 GO TO BOX BEFORE E5
DID NOT WORK LAST WEEK....................999 GO TO BOX BEFORE E5
REFUSED.. -7
DON'T KNOW.. -8

E16. How did {you/SUBJECT} **usually** get to work last week?
(WRKTRANS)

[IF NEEDED: That is, the one used for most of the distance?]

PERSONAL VEHICLES
CAR.. 1
VAN.. 2
SUV.. 3
PICKUP TRUCK.. 4
OTHER TRUCK.. 5
RV.. 6
MOTORCYCLE.. 7
LIGHT ELECTRIC VEHICLE (GOLF CART) 8
BUS TRAVEL
LOCAL PUBLIC TRANSIT........................... 9
COMMUTER BUS.. 10
SCHOOL BUS.. 11
CHARTER/TOUR BUS................................ 12
CITY TO CITY (GREYHOUND/PETERPAN) 13
SHUTTLE BUS (SUCH AS A SENIOR
OR AIRPORT SHUTTLE)....................... 14

TRAIN TRAVEL

AMTRAK/INTER CITY	15
COMMUTER TRAIN	16
SUBWAY/ELEVATED	17
STREET CAR/TROLLEY	18

OTHER

TAXICAB	19
FERRY	20
AIRPLANE	21
BICYCLE	22
WALK	23
SPECIAL TRANSIT FOR PEOPLE WITH DISABILITIES (DIAL-A-RIDE)	24
OTHER?	97
(SPECIFY)________ **(WRKTRNOS)**	
REFUSED	-7
DON'T KNOW	-8

IF OUT OF RANGE, DISPLAY:

"I have recorded that {you/SUBJECT} usually {get/gets} to work by {WRKTRANS}. {Your/His/Her} workplace is {DISTTOWK, DISTUNIT} from home and it takes {you/SUBJECT} {TIMETOWK} to get to work. Is that correct?"
(F567CHK)

YES	**1**	**GO TO E18**
NO	**2**	

IF NO, DISPLAY "Okay, please let me verify that information.

E18. How many people, including {yourself/SUBJECT}, **usually** rode in the vehicle last week?
(CARRODE)

[IF S DID NOT WORK LAST WEEK ENTER 99.]

NUMBER OF PEOPLE	|___|___|
REFUSED	-7
DON'T KNOW	-8

EVA1. {Do you/Does SUBJECT} usually park {your/his/her} vehicle more than one block from {your/their} workplace?
(EVA1)

YES	1	
NO	2	GO TO Eb
REFUSED	-7	GO TO Eb
DON'T KNOW	-8	GO TO Eb

EVA2. How many minutes does it take {you/SUBJECT} to walk from where {you park/he/she parks} to {your/their} workplace?
(EVA2)

NUMBER OF MINUTES .... |___|___|
REFUSED .... -7
DON'T KNOW .... -8

E5. For public transit like a bus, the subway, or a train to be a good option for {your/FNAME/AGE/SEX's} commute, which of the following would be most important to you? Would you say that it's…
(FL5, AZ5)

a. Close to work and home, ... 1
b. Faster than driving, ... 2
c. Reasonable in cost, ... 3
d. Consistently on time, or 4
e. Fits your schedule. 5
REFUSED .... -7
DON'T KNOW .... -8

E5a. For public transit like a bus, the subway, or a train to be a good option for the trips {you make/FNAME/AGE/SEX makes} most frequently, which of the following would be most important to you? Would you say that it's…
(FL6, AZ6)

a. Close to work and home, ... 1
b. Faster than driving, ... 2
c. Reasonable in cost, ... 3
d. Consistently on time, or 4
e. Fits your schedule. 5
REFUSED .... -7
DON'T KNOW .... -8

Eb. What time {do you/does SUBJECT} usually arrive at work?
(WRKHR, WRKMIN, WRKAMPM – DERIVE WRKTIME AS HR:MINAM/PM)

HOUR .... |___|___|
TIME OF DAY .... |___|
1 = AM
2 = PM
REFUSED .... -7
DON'T KNOW .... -8

EVA3. Which of the following best describes {your/SUBJECT's} current work schedule on a weekly basis? Would you say…
(EVA3)

a. {I work/SUBJECT works} the same schedule every week, ...	1
b. {I often work/SUBJECT often works} a different schedule from week to week, or	2
c. {My/SUBJECT's} work schedule changes once in a while?	3
REFUSED	-7
DON'T KNOW	-8

Ec. {Do you/Does SUBJECT} have the ability to set or change your own start work time?
(FLEXTIME)

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

Ed. {Do you/Does SUBJECT} have the option of working at home instead of going into your primary workplace?
(WKRMHM)

YES	1	
NO	2	GO TO BOX BEFORE F1
REFUSED	-7	GO TO BOX BEFORE F1
DON'T KNOW	-8	GO TO BOX BEFORE F1

E20. How many times in the last month did {you/SUBJECT} work only at home for an entire work day instead of traveling to your usual {primary} workplace?
(WKFMHMXX)

TIMES	|___|___|
REFUSED	-7
DON'T KNOW	-8

SECTION F - TRAVEL TO SCHOOL

F1. The Department of Transportation and your local community are interested in providing safe routes to school. My next questions will help identify issues that children might face while traveling to school.

{Does FNAME/AGE/SEX/Do you} attend a public or private school?
(SCHTYPE)

PUBLIC	1	
PRIVATE	2	
HOME SCHOOLED	3	GO TO STHANK
NOT IN SCHOOL	4	GO TO STHANK
REFUSED	-7	
DON'T KNOW	-8	

F2. What is the name of the school {FNAME/AGE/SEX attends/you attend}?
(SCHNAME)

[SCHOOL NAME] ______________________________

REFUSED	-7
DON'T KNOW	-8

[**IF NEEDED**: Knowing the name of your child's school will help identify issues that children might face traveling to school.]

F3. How far {does FNAME/AGE/SEX/do you} live from school? Would you say…
(DISTTOSC)

Less than ¼ mile,	1
Between a ¼ to ½ mile,	2
½ mile to 1 mile,	3
1 mile to 2 miles, or	4
More than 2 miles from school?	5
REFUSED	-7
DON'T KNOW	-8

F4. On most school days, {does FNAME/AGE/SEX/do you} go to before or after-school care outside the home?
(SCHCARE)

BEFORE	1
AFTER	2
BOTH	3
NEITHER	4
REFUSED	-7
DON'T KNOW	-8

F5. On most school days, how {does FNAME/AGE/SEX/do you} usually get to school? **(SCHTRN1)**

PERSONAL VEHICLES

CAR	1
VAN	2
SUV	3
PICKUP TRUCK	4
OTHER TRUCK	5
RV	6
MOTORCYCLE	7
LIGHT ELECTRIC VEHICLE (GOLF CART)	8
BUS TRAVEL	
LOCAL PUBLIC TRANSIT	9
COMMUTER BUS	10
SCHOOL BUS	11
CHARTER/TOUR BUS	12
CITY TO CITY (GREYHOUND/PETERPAN)	13
SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE)	14
TRAIN TRAVEL	
AMTRAK/INTER CITY	15
COMMUTER TRAIN	16
SUBWAY/ELEVATED	17
STREET CAR/TROLLEY	18
OTHER	
TAXICAB	19
FERRY	20
AIRPLANE	21
BICYCLE	22
WALK	23
SPECIAL TRANSIT FOR PEOPLE WITH DISABILITIES (DIAL-A-RIDE)	24
OTHER?	97
(SPECIFY)________ **(SCHTRN1O)**	
REFUSED	-7
DON'T KNOW	-8

F6. How many people {does FNAME/AGE/SEX/do you} usually {walk/bike} to school with? **(TOSCSIZE)**

NUMBER |___|___|

REFUSED .... -7
DON'T KNOW .... -8

F7. On most school days, how {does FNAME/AGE/SEX/do you} usually leave school?
(SCHTRN2)

PERSONAL VEHICLES	
CAR	1
VAN	2
SUV	3
PICKUP TRUCK	4
OTHER TRUCK	5
RV	6
MOTORCYCLE	7
LIGHT ELECTRIC VEHICLE (GOLF CART)	8
BUS TRAVEL	
LOCAL PUBLIC TRANSIT	9
COMMUTER BUS	10
SCHOOL BUS	11
CHARTER/TOUR BUS	12
CITY TO CITY (GREYHOUND/PETERPAN)	13
SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE)	14
TRAIN TRAVEL	
AMTRAK/INTER CITY	15
COMMUTER TRAIN	16
SUBWAY/ELEVATED	17
STREET CAR/TROLLEY	18
OTHER	
TAXICAB	19
FERRY	20
AIRPLANE	21
BICYCLE	22
WALK	23
SPECIAL TRANSIT FOR PEOPLE WITH DISABILITIES (DIAL-A-RIDE)	24
OTHER?	97
(SPECIFY)________________ **(SCHTRN2O)**	
REFUSED	-7
DON'T KNOW	-8

F8. How many people {does FNAME/AGE/SEX/do you} usually {walk/bike} from school with?
(FMSCSIZE)

NUMBER |___|___|

REFUSED .... -7
DON'T KNOW .... -8

F9. How long does it normally take {FNAME/AGE/SEX/you} to get to school?
(TIMETOSC)

MINUTES .... |___|___|___|
REFUSED .... -7
DON'T KNOW .... -8

F10. At what grade {would you allow FNAME/AGE/SEX/did you allow FNAME/AGE/SEX/would you be allowed/were you allowed} to walk or bike to or from school without an adult?
(GRADE)

[ENTER 0 FOR KINDERGARTEN]

GRADE K-12................................. |___|___|
NEVER... 99
REFUSED .... -7
DON'T KNOW .... -8

F11. On a scale of 1 to 5, where 1 means "not an issue" and 5 means "a serious issue" , please tell me how much each of the following affects your decision to allow {FNAME/AGE/SEX} to walk or bike to or from school. On a scale of 1 to 5, how much of an issue is…

	NOT AN ISSUE	A LITTLE BIT OF AN ISSUE	SOMEWHAT OF AN ISSUE	VERY MUCH AN ISSUE	A SERIOUS ISSUE	RF	DK
a. the distance between home and school? Would you say it's not an issue, a little bit of an issue, somewhat of an issue, very much an issue, or a serious issue? **(SCHDIST)**	1	2	3	4	5	-7	-8
b. the amount of traffic along the route? [Would you say it's not an issue, a little bit of an issue, somewhat of an issue, very much an issue, or a serious issue?] **(SCHTRAF)**	1	2	3	4	5	-7	-8
c. the speed of traffic along route? **(SCHSPD)**	1	2	3	4	5	-7	-8
d. violence or crime along route? **(SCHCRIM)**	1	2	3	4	5	-7	-8
e. poor weather or climate in your area? **(SCHWTHR)**	1	2	3	4	5	-7	-8

F12. Are there any other issues that affect your decision to allow or not allow your child to walk or bike to or from school?
(F12, F12_01 – F12_05)

<OPEN RESPONSE>

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

STHANK

My school questions are about travel to school. Because your child is {home schooled/not in school} I will skip that section.

SECTION G - TRAVEL DAY

G1. [Now I'd like to talk about the trips {you/SUBJECT} recorded in the diary we sent.]

[Now] I have some questions about all trips {you/SUBJECT} took on {TRIPDATE}. {Even though {your/his/her} travel on this day may have been unusual for some reason, we still want to know about {your/SUBJECT'S} trips on this particular day.}

G2. Did {you/someone/SUBJECT} fill-out the diary {for SUBJECT}?
(DIARYCMP)

YES [COMPLETED]	1	
NO [NOT COMPLETED]	2	GO TO G4
DID NOT RECEIVE MATERIALS	3	GO TO G4
REFUSED	-7	GO TO G4
DON'T KNOW	-8	GO TO G4

G3. Do you have {your/SUBJECT'S} completed diary with you now?
(DIARYHAV)

YES	1	GO TO BOX BEFORE G8
NO	2	
REFUSED	-7	
DON'T KNOW	-8	

G4. Let's continue with the interview anyway. Information on {your/SUBJECT'S} travel is important to us. Please try to recall the information as best you can.

G8. To be sure we include all the trips {you/SUBJECT} took during {your/his/her} travel day, we'll list all {your/SUBJECT'S} trips that occurred between 4 in the morning on {TRDDATE} and 4 the next morning.

On {TRIPDATE} at 4 in the morning, {were you/was SUBJECT} at home or someplace else?
(FRSTHM)

HOME	1	GO TO G11
SOMEPLACE ELSE	2	
REFUSED	-7	
DON'T KNOW	-8	

G9. {Were you/Was SUBJECT} out of town for the **entire travel day**?
(OUTOFTWN)

YES	1	
NO	2	GO TO G11
REFUSED	-7	GO TO G11
DON'T KNOW	-8	GO TO G11

G14. {Were you/Was SUBJECT} out of the country for the entire travel day?
(OUTCNTRY)

YES	1	GO TO BOX BEFORE L1
NO	2	
REFUSED	-7	
DON'T KNOW	-8	

G11. For the next questions, a "trip" is any time {you/SUBJECT} went from one address to another. Be sure to include stops made for any reason, such as buying gas or taking someone somewhere. However, do not include stops made just to change {your/his/her} type of transportation.

G12. Where did {you/SUBJECT} go first/next on {TRIPDATE}?
(WHERE)

HOME	1	GO TO BOX BEFORE G16
WORK	2	GO TO BOX BEFORE G16
NOWHERE	3	
NO MORE TRIPS TAKEN ON TRAVEL DAY	4	GO TO BOX BEFORE G18
OTHER	97	
(SPECIFY) **(WHEREOS)**		GO TO BOX BEFORE G16
REFUSED	-7	
DON'T KNOW	-8	

G13. Does this mean {you/SUBJECT} stayed at {the same place/home} all day?
(SAMEPLC)

YES	1	
NO	2	RE-ASK G12
REFUSED	-7	RE-ASK G12
DON'T KNOW	-8	RE-ASK G12

G15. About how long ago before {TRIPDATE} did {you/SUBJECT} last take a trip to another address?
(LASTRPNU, LASTRPUT)

NUMBER................................ |___|___|___|
UNIT.. |___|
1 = DAYS
2 = WEEKS
3 = MONTHS
4 = YEARS
REFUSED .... -7
DON'T KNOW.. -8

Ga. Would you like to get out more often?
(MOROFTEN)

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

G16. What time did this trip begin?
(STRTHR, STRTMIN, STRTAMPM)

(A) (B)
TIME............................ |___|___| : |___|___|
UNIT.. |___| (C)
1 = AM
2 = PM
REFUSED .... -7
DON'T KNOW.. -8

G17. What time did {you/SUBJECT} arrive?
(ENDHOUR, ENDMINTE, ENDAMPM)

(D) (E)
TIME............................ |___|___| : |___|___| (F)
UNIT.. |___|
1 = AM
2 = PM
REFUSED .... -7
DON'T KNOW.. -8

G18. So far, I have recorded {N} trip(s). Before we continue, did {you/SUBJECT} take any other walks, bike rides, or drives on {TRIPDATE}? Please include any other trips where {you/SUBJECT} used public transit or started and ended in the same place.

CONTINUE.. 1
ADD MORE TRIPS .... 2 RETURN TO MATRIX

RECORD TRIPS WHERE PREVIOUS SUBJECTS SAID THE CURRENT SUBJECT WENT ON THE TRIP TOO.:

I also show a trip to {PLACE} at {TIME} reported by {NAME}. Did you take this trip?

YES .... 1 ADD THIS TRIP TO LIST OF TRIPS
NO.. 2

"While I read the trips I've recorded, please think back to see if there were any additional ones."

IF TWO TRIPS HAVE THE SAME TIME, SAY: "I have recorded that {you/SUBJECT} left for {PLACE1} and {PLACE2} at {TIME}. Which place did {you/s(he)} leave for at {TIME}?

Start Time
PLACE 1 ...... |___|___| : |___|___| AM/PM

PLACE 2 ...... |___|___| : |___|___| AM/PM

At what time did {you/SUBJECT} begin {your/his/her} trip to ?"

PLACE .... |___|___| : |___|___| AM/PM

THEY ARE THE SAME TRIP 99

N_G19. Did {you/SUBJECT} use an interstate or turnpike during any part of these trips?
(USEINTST)

YES 1
NO.. 2
REFUSED .... -7
DON'T KNOW .... -8

G19. Did {you/SUBJECT} use a bus, subway, train, or some other type of public transportation during any part of these trips?
(USEPUBTR)

YES 1
NO.. 2
REFUSED .... -7
DON'T KNOW .... -8

G20. [Now I have a few questions about each trip.] I have recorded that {you/SUBJECT} went to…
(PLACNAME)

[IF NAME OF LOCATION, NOT PROVIDED PROBE.]
{WHERE}

NAME OF PLACE: ______________________________

G21. What is the address of {PLACNAME}?
(PLSTNUM, PLSTNAME, PLCITY, PLSTATE, PLZIP)

STREET NUMBER ______ STREET NAME ______

CITY/TOWN/VILLAGE/BOROUGH ______ STATE ______ ZIP CODE ______

REFUSED .... -7
DON'T KNOW .... -8

G22. {What is the name of the street or road that {PLACNAME} is on?/I have recorded that {PLACNAME} is on {PLSTNAME/PLADDR}.

{PLSTNAME/PLADDR}

____
STREET NAME
(PLROAD1)

What is the name of the nearest intersecting street or road?

____
STREET NAME
(PLROAD2)

REFUSED .... -7
DON'T KNOW .... -8

G23. Would you please provide a landmark that is close to {PLACNAME}? [This could be a well-known building, park, monument, or school.]
(PLLNMRK1-3)

____

REFUSED .... -7
DON'T KNOW .... -8

G24. What {borough or} county is {PLACNAME} in?
(PLCNTYNY, PLCNTYWI)

97. OTHER SPECIFY **(PLCYNYOS, PLCYWIOS)**____________________

G25. Now I have a few questions about each trip.

You told me the first place {you/SUBJECT} went was home. What was the main reason {you were/SUBJECT was} away from home?
(AWAYHOME)

10 WORK	GO TO G25A
20 SCHOOL/DAYCARE/RELIGIOUS ACTIVITY	GO TO G25B
30 MEDICAL/DENTAL SERVICES	GO TO BOX BEFORE G26
40 SHOPPING/ERRANDS	GO TO G25C
50 SOCIAL/RECREATIONAL	GO TO G25D
60 FAMILY PERSONAL BUSINESS/OBLIGATIONS	GO TO G25C
70 TRANSPORT SOMEONE	GO TO G25E
80 MEALS	GO TO G25D
97 MISC REASONS **(AWAYHMSP)**	GO TO BOX BEFORE G26
-7 REFUSED	GO TO BOX BEFORE G26
-8 DON'T KNOW	GO TO BOX BEFORE G26

G25A. [Now I have a few questions about each trip.

You told me the first place {you/SUBJECT} went was home. What was the main reason {you were/SUBJECT was} away from home?]
(AWAYHOME)

11 GO TO WORK	GO TO BOX BEFORE G26
12 RETURN TO WORK	GO TO BOX BEFORE G26
13 ATTEND BUSINESS MEETING/TRIP	GO TO BOX BEFORE G26
14 OTHER WORK RELATED	GO TO BOX BEFORE G26
99 RETURN TO MAIN SCREEN	GO TO G25

G25B. [Now I have a few questions about each trip.

You told me the first place {you/SUBJECT} went was home. What was the main reason {you were/SUBJECT was} away from home?]
(AWAYHOME)

20 SCHOOL/RELIGIOUS ACTIVITY	GO TO BOX BEFORE G26
21 GO TO SCHOOL AS A STUDENT	GO TO BOX BEFORE G26
22 GO TO RELIGIOUS ACTIVITY	GO TO BOX BEFORE G26
23 GO TO LIBRARY: SCHOOL RELATED	GO TO BOX BEFORE G26
24 GO TO DAYCARE/BEFORE OR AFTER SCHOOL CARE	GO TO BOX BEFORE G26
99 RETURN TO MAIN SCREEN	GO TO G25 (N_G21)

G25C. [Now I have a few questions about each trip.

You told me the first place {you/SUBJECT} went was home. What was the main reason {you were/SUBJECT was} away from home?]
(AWAYHOME)

40 SHOPPING/ERRANDS	GO TO BOX BEFORE G26
41 BUY GOODS: GROCERIES/CLOTHING/ HARDWARE STORE	GO TO BOX BEFORE G26
42 BUY SERVICES: VIDEO RENTALS/DRY CLEANER/POST OFFICE/ CAR SERVICE/BANK	GO TO BOX BEFORE G26
43 BUY GAS	GO TO BOX BEFORE G26
60 FAMILY PERSONAL BUSINESS/OBLIGATIONS	GO TO BOX BEFORE G26
61 USE PROFESSIONAL SERVICES: ATTORNEY/ACCOUNTANT	GO TO BOX BEFORE G26
62 ATTEND FUNERAL/WEDDING	GO TO BOX BEFORE G26
63 USE PERSONAL SERVICES: GROOMING/ HAIRCUT/NAILS	GO TO BOX BEFORE G26
64 PET CARE: WALK THE DOG/VET VISITS	GO TO BOX BEFORE G26
65 ATTEND MEETING: PTA/HOME OWNERS ASSOCIATION/LOCAL GOVERNMENT	GO TO BOX BEFORE G26
99 RETURN TO MAIN SCREEN	GO TO G25

G25D. [Now I have a few questions about each trip.

You told me the first place {you/SUBJECT} went was home. What was the main reason {you were/SUBJECT was} away from home?]
(AWAYHOME)

50 SOCIAL/RECREATIONAL	GO TO BOX BEFORE G26
51 GO TO GYM/EXERCISE/PLAY SPORTS	GO TO BOX BEFORE G26
52 REST OR RELAXATION/VACATION	GO TO BOX BEFORE G26
53 VISIT FRIENDS/RELATIVES	GO TO BOX BEFORE G26
54 GO OUT/HANG OUT: ENTERTAINMENT/ THEATER/SPORTS EVENT/GO TO BAR	GO TO BOX BEFORE G26
55 VISIT PUBLIC PLACE: HISTORICAL SITE/ MUSEUM/PARK/LIBRARY	GO TO BOX BEFORE G26
80 MEALS	GO TO BOX BEFORE G26
81 SOCIAL EVENT	GO TO BOX BEFORE G26
82 GET/EAT MEAL	GO TO BOX BEFORE G26
83 COFFEE/ICE CREAM/SNACKS	GO TO BOX BEFORE G26
99 RETURN TO MAIN SCREEN	GO TO G25

G25E. [Now I have a few questions about each trip.

You told me the first place {you/SUBJECT} went was home. What was the main reason {you were/SUBJECT was} away from home?]
(AWAYHOME)

70 TRANSPORT SOMEONE	GO TO BOX BEFORE G26
71 PICKUP SOMEONE	GO TO BOX BEFORE G26
72 TAKE AND WAIT	GO TO BOX BEFORE G26
73 DROP SOMEONE OFF	GO TO BOX BEFORE G26
99 RETURN TO MAIN SCREEN	GO TO G25

G26. {Now I have a few questions about each trip.}

What was the main reason for the trip to {DISPLAY CURRENT TRIP DESTINATION}?
(WHYTO)

1 HOME	GO TO BOX BEFORE G28
10 WORK	GO TO G26A
20 SCHOOL/DAYCARE/RELIGIOUS ACTIVITY	GO TO G26B
30 MEDICAL/DENTAL SERVICES	GO TO BOX BEFORE G28
40 SHOPPING/ERRANDS	GO TO G26C
50 SOCIAL/RECREATIONAL	GO TO G26D
60 FAMILY PERSONAL BUSINESS/OBLIGATIONS	GO TO G26C
70 TRANSPORT SOMEONE	GO TO G26E
80 MEALS	GO TO G26D
97 MISC REASONS **(WHYTRPSP)**	GO TO BOX BEFORE G28
-7 REFUSED	GO TO BOX BEFORE G28
-8 DON'T KNOW	GO TO BOX BEFORE G28

G26A. [Now I have a few questions about each trip.

What was the main reason for the trip to {DISPLAY CURRENT TRIP DESTINATION}?]
(WHYTO)

11 GO TO WORK	GO TO BOX BEFORE G28
12 RETURN TO WORK	GO TO BOX BEFORE G28
13 ATTEND BUSINESS MEETING/TRIP	GO TO BOX BEFORE G28
14 OTHER WORK RELATED	GO TO BOX BEFORE G28
99 RETURN TO MAIN SCREEN	GO TO G26

G26B. [Now I have a few questions about each trip.

What was the main reason for the trip to {DISPLAY CURRENT TRIP DESTINATION}?]
(WHYTO)

20 SCHOOL/RELIGIOUS ACTIVITY	GO TO BOX BEFORE G28
21 GO TO SCHOOL AS A STUDENT	GO TO BOX BEFORE G28
22 GO TO RELIGIOUS ACTIVITY	GO TO BOX BEFORE G28
23 GO TO LIBRARY: SCHOOL RELATED	GO TO BOX BEFORE G28
24 GO TO DAYCARE/BEFORE OR AFTER SCHOOL CARE	GO TO BOX BEFORE G28
99 RETURN TO MAIN SCREEN	GO TO G26

G26C. [Now I have a few questions about each trip.

What was the main reason for the trip to {DISPLAY CURRENT TRIP DESTINATION}?]
(WHYTO)

40 SHOPPING/ERRANDS	GO TO BOX BEFORE G28
41 BUY GOODS: GROCERIES/CLOTHING/ HARDWARE STORE	GO TO BOX BEFORE G28
42 BUY SERVICES: VIDEO RENTALS/DRY CLEANER/POST OFFICE/CAR SERVICE/ BANK	GO TO BOX BEFORE G28
43 BUY GAS	GO TO BOX BEFORE G28
60 FAMILY PERSONAL BUSINESS/OBLIGATIONS	GO TO BOX BEFORE G28
61 USE PROFESSIONAL SERVICES: ATTORNEY/ACCOUNTANT	GO TO BOX BEFORE G28
62 ATTEND FUNERAL/WEDDING	GO TO BOX BEFORE G28
63 USE PERSONAL SERVICES: GROOMING/ HAIRCUT/NAILS	GO TO BOX BEFORE G28
64 PET CARE: WALK THE DOG/VET VISITS	GO TO BOX BEFORE G28
65 ATTEND MEETING: PTA/HOME OWNERS ASSOCIATION/LOCAL GOVERNMENT	GO TO BOX BEFORE G28
99 RETURN TO MAIN SCREEN	GO TO G26

G26D. [Now I have a few questions about each trip.

What was the main reason for the trip to {DISPLAY CURRENT TRIP DESTINATION}?]
(WHYTO)

50 SOCIAL/RECREATIONAL	GO TO BOX BEFORE G28
51 GO TO GYM/EXERCISE/PLAY SPORTS	GO TO BOX BEFORE G28
52 REST OR RELAXATION/VACATION	GO TO BOX BEFORE G28
53 VISIT FRIENDS/RELATIVES	GO TO BOX BEFORE G28
54 GO OUT/HANG OUT: ENTERTAINMENT/ THEATER/SPORTS EVENT/GO TO BAR	GO TO BOX BEFORE G28
55 VISIT PUBLIC PLACE: HISTORICAL SITE/ MUSEUM/PARK/LIBRARY	GO TO BOX BEFORE G28

80 MEALS .... GO TO BOX BEFORE G28
81 SOCIAL EVENT .... GO TO BOX BEFORE G28
82 GET/EAT MEAL .... GO TO BOX BEFORE G28
83 COFFEE/ICE CREAM/SNACKS .... GO TO BOX BEFORE G28
99 RETURN TO MAIN SCREEN .... GO TO G26

G26E. [Now I have a few questions about each trip.

What was the main reason for the trip to {DISPLAY CURRENT TRIP DESTINATION}?]
(WHYTO)

70 TRANSPORT SOMEONE .... GO TO BOX BEFORE G28
71 PICKUP SOMEONE .... GO TO BOX BEFORE G28
72 TAKE AND WAIT .... GO TO BOX BEFORE G28
73 DROP SOMEONE OFF .... GO TO BOX BEFORE G28
99 RETURN TO MAIN SCREEN .... GO TO G26

G28. I've recorded {your/SUBJECT's} next trip was from {ORIGINATION} to home.

[

G29. Was the {VEHICLE} used on this trip?
(VEHSAME)

YES .... 1 AUTOCODE G30 & G31 & GOTO BOX BEFORE G32
NO 2
REFUSED .... -7
DON'T KNOW .... -8

G30. Was a household vehicle used for this trip?
(TRPHHVEH)

YES 1
NO .... 2 GO TO BOX BEFORE G32
REFUSED .... -7 GO TO BOX BEFORE G32
DON'T KNOW .... -8 GO TO BOX BEFORE G32

G31. Which vehicle?
(VEHID)

[IF NEEDED: Which one was used for the longest distance?]

VEHICLE NUMBER .... |___|___|

VEHICLE NOT ON LIST .... 99 ADD VEHICLE TO HH. RECORD MAKE, MODEL AND YEAR OF NEW VEHICLE
REFUSED .... -7
DON'T KNOW .... -8

G32. Did {you/SUBJECT} take a bus, subway, train, or some other type of public transportation during this trip?
(TRPPUB)

YES	1	
NO	2	GO TO G34
REFUSED	-7	GO TO G34
DON'T KNOW	-8	GO TO G34

G33. Which one?
(PUBTYPE)

[

BUS	1
SUBWAY/TRAIN	2
FERRY/BOAT	3
REFUSED	-7
DON'T KNOW	-8

G34. How did {you/SUBJECT} get to {CURRENT TRIP DESTINATION}?
(TRPTRANS)

[IF NEEDED: That is, what means of transportation did {you/SUBJECT} use for this trip?]

PERSONAL VEHICLES		
CAR	1	
VAN	2	
SUV	3	
PICKUP TRUCK	4	
OTHER TRUCK	5	
RV	6	
MOTORCYCLE	7	
LIGHT ELECTRIC VEHICLE (GOLF CART)	8	
BUS TRAVEL		
LOCAL PUBLIC TRANSIT	9	GO TO NY_G27a
COMMUTER BUS	10	GO TO NY_G27a
SCHOOL BUS	11	
CHARTER/TOUR BUS	12	
CITY TO CITY (GREYHOUND/PETERPAN)	13	
SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE)	14	
TRAIN TRAVEL		
AMTRAK/INTER CITY	15	
COMMUTER TRAIN	16	GO TO NY_G27b
SUBWAY/ELEVATED	17	GO TO NY_G27c
STREET CAR/TROLLEY	18	

OTHER

TAXICAB	19	
FERRY	20	GO TO NY_G27d
AIRPLANE	21	GO TO NY_G27e
BICYCLE	22	
WALK	23	
SPECIAL TRANSIT FOR PEOPLE WITH DISABILITIES (DIAL-A-RIDE)	24	
OTHER?	97	
(SPECIFY)________ **(TRPTRNOS)**		
REFUSED	-7	
DON'T KNOW	-8	

NY1

Which bus system did {you/SUBJECT} use?

NY1

MTA (METROPOLITAN TRANSIT AUTHORITY)	1	GO TO BOX BEFORE Gb
NJ TRANSIT	2	GO TO BOX BEFORE Gb
REFUSED	-7	GO TO BOX BEFORE Gb
DON'T KNOW	-8	GO TO BOX BEFORE Gb

NY2

Which train did {you/SUBJECT} use?

NY2

LIRR (LONG ISLAND RAILROAD)	1	GO TO BOX BEFORE Gb
NJ TRANSIT	2	GO TO BOX BEFORE Gb
METRO NORTH	3	GO TO BOX BEFORE Gb
REFUSED	-7	GO TO BOX BEFORE Gb
DON'T KNOW	-8	GO TO BOX BEFORE Gb

NY3.

Which train did {you/SUBJECT} use?

NY3

PATH	1	GO TO BOX BEFORE Gb
NYCTA SUBWAY (NY CITY TRANSIT AUTHORITY)	2	GO TO BOX BEFORE Gb
SI RAPID TRANSIT	3	GO TO BOX BEFORE Gb
NJ TRANSIT	4	GO TO BOX BEFORE Gb
REFUSED	-7	GO TO BOX BEFORE Gb
DON'T KNOW	-8	GO TO BOX BEFORE Gb

NY4.

Which ferry did {you/SUBJECT} use?

NY4

HUDSON RIVER	1	GO TO BOX BEFORE Gb
STATEN ISLAND	2	GO TO BOX BEFORE Gb
OTHER	3	GO TO BOX BEFORE Gb
REFUSED	-7	GO TO BOX BEFORE Gb
DON'T KNOW	-8	GO TO BOX BEFORE Gb

NY5.

NY5 Which airport did {you/SUBJECT} use?

JFK	1	GO TO BOX BEFORE Gb
LAGUARDIA	2	GO TO BOX BEFORE Gb
NEWARK	3	GO TO BOX BEFORE Gb
NEWBURG	4	GO TO BOX BEFORE Gb
OTHER	5	GO TO BOX BEFORE Gb
REFUSED	-7	GO TO BOX BEFORE Gb
DON'T KNOW	-8	GO TO BOX BEFORE Gb

Gb. Was any part of this trip made on an interstate or turnpike?
INTSTATE

YES	1	
NO	2	GO TO BOX AFTER Gc
REFUSED	-7	GO TO BOX AFTER Gc
DON'T KNOW	-8	GO TO BOX AFTER Gc

Gc. Did {you/SUBJECT} pay a toll while traveling on this interstate?
PAYTOLL

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

G35. How did {you/SUBJECT} get to the {bus/train/subway/street car/pier/terminal}? {Anything else?}
(TRACC1-5)

[CODE ALL THAT APPLY.]

PERSONAL VEHICLES

CAR	1
VAN	2
SUV	3
PICKUP TRUCK	4
OTHER TRUCK	5
RV	6
MOTORCYCLE	7
LIGHT ELECTRIC VEHICLE (GOLF CART)	8

BUS TRAVEL

LOCAL PUBLIC TRANSIT	9
COMMUTER BUS	10
SCHOOL BUS	11
CHARTER/TOUR BUS	12
CITY TO CITY (GREYHOUND/PETERPAN)	13
SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE)	14

TRAIN TRAVEL

AMTRAK/INTER CITY	15
COMMUTER TRAIN	16
SUBWAY/ELEVATED	17
STREET CAR/TROLLEY	18
OTHER	
TAXICAB	19
FERRY	20
AIRPLANE	21
BICYCLE	22
WALK	23
SPECIAL TRANSIT FOR PEOPLE WITH DISABILITIES (DIAL-A-RIDE)	24
OTHER?	97
(SPECIFY)________________ **(HOWPUBOS)**	
REFUSED	-7
DON'T KNOW	-8

G35a. Did you park at the {bus/train/subway/street car/pier/terminal} or were {you/he/she} dropped off?
(DROP_PRK)

PARKED	1
DROPPED OFF	2
REFUSED	-7
DON'T KNOW	-8

G36. How long did it take {you/SUBJECT} to get to the {bus/train/subway/street car/pier/terminal}?
(LONGTOHR, LONGTOMN)

HOURS |___|___|
MINUTES |___|___|___|

REFUSED	-7
DON'T KNOW	-8

G37. How long did {you/SUBJECT} have to wait for the {bus/train/subway/street car/boat or ferry/transportation}?
(WAIT_HR, WAIT_MIN)

HOURS |___|___|
MINUTES |___|___|___|

REFUSED	-7
DON'T KNOW	-8

G38. How did {you/SUBJECT} get from the {bus/train/subway/street car/pier/terminal} to {DESTINATION}? {Anything else?}
(HOWFRP1-5) (delivered as: TREGR1-5) [CODE ALL THAT APPLY.]

PERSONAL VEHICLES	
CAR	1
VAN	2
SUV	3
PICKUP TRUCK	4
OTHER TRUCK	5
RV	6
MOTORCYCLE	7
LIGHT ELECTRIC VEHICLE (GOLF CART)	8
BUS TRAVEL	
LOCAL PUBLIC TRANSIT	9
COMMUTER BUS	10
SCHOOL BUS	11
CHARTER/TOUR BUS	12
CITY TO CITY (GREYHOUND/PETERPAN)	13
SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE)	14
TRAIN TRAVEL	
AMTRAK/INTER CITY	15
COMMUTER TRAIN	16
SUBWAY/ELEVATED	17
STREET CAR/TROLLEY	18
OTHER	
TAXICAB	19
FERRY	20
AIRPLANE	21
BICYCLE	22
WALK	23
SPECIAL TRANSIT FOR PEOPLE WITH DISABILITIES (DIAL-A-RIDE)	24
OTHER?	97
(SPECIFY)__________ **(HOWFRPOS)**	
REFUSED	-7
DON'T KNOW	-8

G39. How long did it take {you/SUBJECT} to get to {DESTINATION from the {bus/train/subway/street car/pier/terminal/airport}?
(LONGFRHR, LONGFRMN)

HOURS |___|___|
MINUTES |___|___|___|

REFUSED .... -7
DON'T KNOW .... -8

G40. How far is it from {LAST DESTINATION} to {CURRENT DESTINATION}?
(TRIPDIST, TRIPUNIT - TRAVTIME)

[IF LESS THAN 1 BLOCK ENTER 0. IF LESS THAN 1 MILE ENTER AS BLOCKS.]

[¼ MILE = 2 BLOCKS
½ MILE = 5 BLOCKS
¾ MILE = 7 BLOCKS]

IF ASKED, RECORD ACTUAL DISTANCE TRAVELED, NOT DISTANCE "AS THE CROW FLIES."]

NUMBER.................. |___|___|___|___|___|
UNIT.. |___|
1 = BLOCKS
2 = MILES
REFUSED .... -7
DON'T KNOW... -8

G41. Earlier I recorded this entire trip took you {TIME}. Is that about right?
(TRIPTIME)

YES 1
NO... 2
REFUSED .... -7
DON'T KNOW... -8

G42. {About how long did this trip take?/About how long did the entire trip to {CURRENT TRIP DESTINATION} take you?}
(TRVLHR, TRVLMIN)

[IF LESS THAN 1 MINUTE, ENTER 1]

HOURS |___|___|
MINUTES |___|___|___|

REFUSED .... -7
DON'T KNOW... -8

G43. How many people went with {you/SUBJECT} on this trip?
(TRPACCMP)

PEOPLE |___|___|

REFUSED .... -7
DON'T KNOW... -8

G44. Not counting {yourself/SUBJECT}, how many of the other people were household members?
(TRPHHACC_C)

HOUSEHOLD MEMBERS |___|___|

REFUSED .... -7 GO TO BOX AFTER G45
DON'T KNOW .... -8 GO TO BOX AFTER G45

G45. Which household members?
(WHOACC1_15)

ENTER ROSTER NUMBER(S):

NO HHM ON THE TRIP 98
RECORD NEW HHM 99

G48. Did {you/SUBJECT/a member of the household} drive on the trip?
(HHMEMDRV)

YES 1
NO .... 2 GO TO BOX AFTER G49
PART OF TRIP 3
REFUSED .... -7 GO TO BOX AFTER G49
DON'T KNOW .... -8 GO TO BOX AFTER G49

G49. Who was the driver?
(DRVR_FLG, WHODROVE)

[IF NEEDED: Which one drove the longest distance?]

ENTER 1 FOR DRIVER

REFUSED .... -7
DON'T KNOW .... -8

SECTION L: GENERAL TRAVEL AND VEHICLE MILEAGE

L1. Now I just have some final question related to you and your travel.

L2a. Of the following issues, please tell me which one is the most important to you. Would you say…
(ISSUE)

a. highway congestion,	1
b access to or availability of public transit,	2
c. lack of walkways or sidewalks,	3
d. the price of travel including things like transit fees, tolls and the cost of gasoline,	4
e. aggressive or distracted drivers, {or}	5
f. safety concerns, like worrying about being in a traffic accident?	6
REFUSED	-7
DON'T KNOW	-8

L2. How much of an issue {is/are} {RESPONSE FROM L2a} to you? Would you say…
(VARIABLES LISTED IN BOX ABOVE)

A little issue,	1
A moderate issue,	2
A big issue,	3
REFUSED	**-7**
DON'T KNOW	**-8**

L5. About how many miles did {you/SUBJECT} personally drive during the past 12 months in all motorized vehicles?
(YEARMILE)

[INCLUDE MILES DRIVEN AS A PART OF WORK.]

MILES........... |___|___|___|,|___|___|___|

REFUSED .... -7
DON'T KNOW .... -8

L5A. I recorded that {you/she/he} drove a total of about {YEARMILE} miles during the past year. Is that correct?
(VERYRMIL)

YES .... 1 GO TO BOX BEFORE L6
NO.. 2
REFUSED ....-7
DON'T KNOW................................-8

L5B. Would you say it was…
(YEARMIL2)

5,000 miles or less,	1
5,001 to 10,000 miles,	2
10,001 to 15,000 miles,	3
15,001 to 20,000 miles, or	4
More than 20,000 miles?	5
REFUSED	-7
DON'T KNOW	-8

L6. Now we'd like to ask a few questions about the household {vehicle/vehicles} {for which you are the primary driver.}

L7. Please verify that you have a . . .
(L_MAKE, L_MODEL, L_VYEAR)

KEY	MAKE	MODEL	YEAR	TYP
____	____________	______________________	_____	____

L8. How long have you had the {VEHYEAR, MAKECODE, MODLCODE}?
(VEHOWNED, OWNUNIT)

NUMBER .... |___|___|
UNIT .... |___|___|

DAYS	1
WEEKS	2
MONTHS	3
YEARS	4
REFUSED	-7
DON'T KNOW	-8

L9. During the past 12 months, about how many miles was the {VEHYEAR, MAKECODE, MODLCODE} driven by all drivers?
(VEHMILES)

MILES .... |___|___|___|,|___|___|___|

REFUSED	-7
DON'T KNOW	-8

L9A. I recorded that this vehicle was driven a total of about {VEHMILES} miles by all drivers during the past year. Is that correct?
(VERMILES)

YES .... 1 GO TO L11
NO 2
REFUSED .... -7
DON'T KNOW .... -8

L9B. Would you say it was…
(VEHMILE2)

5,000 miles or less, ... 1
5,001 to 10,000 miles, ... 2
10,001 to 15,000 miles, ... 3
15,001 to 20,000 miles, or 4
More than 20,000 miles? 5
REFUSED .... -7
DON'T KNOW .... -8

L10. About how many miles has this vehicle been driven since you've had it?
(ESTMILES)

MILES .... |___|___|___|,|___|___|___|
REFUSED .... -7
DON'T KNOW .... -8

L10A. I recorded that this vehicle was driven a total of about {ESTMILES} miles by all drivers since you've had it. Is that correct?
(VERESTML)

YES .... 1 GO TO L11
NO 2
REFUSED .... -7
DON'T KNOW .... -8

L10B. Would you say it was…
(ESTMILE2)

5,000 miles or less, ... 1
5,001 to 10,000 miles, ... 2
10,001 to 15,000 miles, ... 3
15,001 to 20,000 miles, or 4
More than 20,000 miles? 5
REFUSED .... -7
DON'T KNOW .... -8

L11. In the past month, about how often {have you/has SUBJECT} used public transportation such as buses, subways, streetcars, or commuter trains?
(PTUSED)

[IF R ANSWERS NONE OR ZERO, PROBE "Is it available to you?"]

NUMBER |___|___|___|

NOT AVAILABLE .... 999 GO TO BOX BEFORE La
REFUSED .... -7
DON'T KNOW .... -8

EVA5. Thinking about travel on public transit in your area, please tell me if you agree or disagree with the following statements.
(EVA5a-EVA5f)

		AGREE	DISAGREE	REF	DK
a.	Local public transit provides a good travel experience	1	2	-7	-8
b.	Local public transit service is reliable	1	2	-7	-8
c.	Local public transit service is safe from crime	1	2	-7	-8
d.	Local public transit service is easy to use	1	2	-7	-8
e.	The cost of local public transit is reasonable	1	2	-7	-8
f.	Local public transit service is fast enough for my needs	1	2	-7	-8

La. In the past month, about how many times {have you/has SUBJECT} driven a motorcycle or moped on public roadways?
(MCUSED)

NUMBER |___|___|___|

NOT AVAILABLE 999
REFUSED .... -7
DON'T KNOW .... -8

SECTION M: INTERNET USAGE AND DEMOGRAPHIC INFORMATION

M2. In the past month, how often {have you/has SUBJECT} used the Internet? Would you say…
(WEBUSE)

almost everyday,	1	
several times a week,	2	
once a week,	3	
once a month, or	4	
never?	5	GO TO M4
REFUSED	-7	GO TO M4
DON'T KNOW	-8	GO TO M4

Ma. In the past month, how many times did {you/SUBJECT} personally purchase something through the Internet?
(PURCHASE)

NUMBER OF TIMES |___|___|___|

REFUSED	-7
DON'T KNOW	-8

Mb. How many of these purchases were delivered to your home?
(DELIVER)

NUMBER OF DELIVERIES TO HOME |___|___|___|

REFUSED	-7
DON'T KNOW	-8

M4. Now I'd like to ask a few background questions about {yourself/SUBJECT}.
{Do you/Does SUBJECT} have a temporary or permanent condition or handicap that makes it difficult to travel outside of the home?
(MEDCOND)

YES	1	
NO	2	GO TO M8
REFUSED	-7	GO TO M8
DON'T KNOW	-8	GO TO M8

M5. How long {have you/has SUBJECT} had this condition?
(MEDCOND6)

0 - 5 MONTHS	1
6 – 11 MONTHS	2
1 – 4 YEARS	3
5 – 9 YEARS	4
10 YEARS OR MORE	5
ALL HIS/HER LIFE	6
REFUSED	-7
DON'T KNOW	-8

MCA7. {Do you/Does SUBJECT} use anything to help {you/him/her} walk or get around, such as a cane, seeing-eye dog, or wheelchair?
(WALKHELP)

YES	1	
NO	2	GO TO M6
REFUSED	-7	GO TO M6
DON'T KNOW	-8	GO TO M6

MCA8. {Do you/Does SUBJECT} use a…

		YES	NO	DK	REF
a.	Cane? **(W_CANE)**	1	2	-7	-8
b.	Walker? **(W_WLKR)**	1	2	-7	-8
c.	White cane? **(W_WHCANE)**	1	2	-7	-8
d.	Seeing-eye dog or other K-9 assistance? **(W_DOG)**	1	2	-7	-8
e.	Crutches **(W_CRUTCH)**	1	2	-7	-8
f.	Motorized Scooter? **(W_SCOOTR)**	1	2	-7	-8
g.	Manual Wheelchair? **(W_CHAIR)**	1	2	-7	-8
h.	Motorized Wheelchair? **(W_MTRCHR)**	1	2	-7	-8
i.	Anything else? ________________________ **(MCA8_OS)** **(MCA8_0TH)**	1	2	-7	-8

M6. Because of this condition, {have you/has SUBJECT}...

		YES	NO	RF	DK
(CONDTRAV)	a) reduced {your/his/her} day-to-day travel?	1	2	-7	-8
(CONDRIDE)	b) asked others for rides?	1	2	-7	-8
(CONDNIGH)	c) limited driving to daytime?	1	2	-7	-8
(CONDRIVE)	d) given up driving altogether?	1	2	-7	-8
(CONDPUB)	e) used the bus or subway less frequently?	1	2	-7	-8
(CONDSPEC)	f) used special transportation services such as dial-a-ride?	1	2	-7	-8
(CONDTAX)	g) used a reduced fare taxi	1	2	-7	-8

M8. {Were you/Was SUBJECT} born in the United States? [IF NEEDED: Sometimes people who have immigrated to the United States have unique travel difficulties and we want to understand this.]
(BORNINUS)

YES	1	GO TO BOX BEFORE M11
NO	2	
REFUSED	-7	
DON'T KNOW	-8	

M10. In what year did {you/SUBJECT} come to the United States?
(YRTOUS)

[IF NEEDED: Sometimes people who have immigrated to the United States have unique travel difficulties and we want to understand this.]

YEAR.............................. |__|__|__|__|

REFUSED .... -7
DON'T KNOW .... -8

M11. Transportation planners use data from this survey to assess current travel patterns and anticipate new ones. These patterns are affected by where people choose to live. Would you please tell me the address of your home?
(HMSTNAME, HMAPTNUM, HMCITY, HMSTATE, HMZIP)

[IF NEEDED: It is important that we get at least a general location of your household. Would you please identify the intersection of roads which is closest to your home?]

____________________ STREET ADDRESS ____________ APT#

____________________ CITY/TOWN ________ STATE ________ ZIP CODE

REFUSED .... -7
DON'T KNOW .... -8

M12. What is the name of the street or road that {you live/SUBJECT lives} on?
(HMROAD1)

FIRST ROAD: ______________________________

What is the name of the nearest intersecting street or road?
(HMROAD2)

SECOND ROAD: ______________________________

REFUSED .... -7
DON'T KNOW .... -8

M13. In surveys like these, households are sometimes grouped according to income. Please stop me when I get to the category that best describes your total household income, before taxes, in the past 12 months.
(HHFAMINC_C)

[IF NEEDED: We want to include income from sources such as wages and salaries, income from a business or a farm, Social Security, pensions, dividends, interest, rent, and any other income received.]

Less than $10,000,	1	GO TO M14
$10,000 to $20,000,	2	GO TO M15
$20,000 to $30,000,	3	GO TO M16
$30,000 to $40,000,	4	GO TO M17
$40,000 to $50,000,	5	GO TO M18
$50,000 to $60,000,	6	GO TO M19
$60,000 to $70,000,	7	GO TO M20
$70,000 to $80,000,	8	GO TO M21
$80,000 to $100,000, or	9	GO TO BOX BEFORE M22
$100,000 or more?	10	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M14. Was your household income more or less than $5,000?
(HHINC_C)

$5,000 OR MORE	1	GO TO BOX BEFORE M22
LESS THAN $5,000	2	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M15. Was your household income more or less than $15,000?
(HHINC_C)

$15,000 OR MORE	1	GO TO BOX BEFORE M22
LESS THAN $15,000	2	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M16. Was your household income more or less than $25,000?
(HHINC_C)

$25,000 OR MORE	1	GO TO BOX BEFORE M22
LESS THAN $25,000	2	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M17. Was your household income more or less than $35,000?
(HHINC_C)

$35,000 OR MORE	1	GO TO BOX BEFORE M22
LESS THAN $35,000	2	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M18. Was your household income more or less than $45,000?
(HHINC_C)

$45,000 OR MORE	1	GO TO BOX BEFORE M22
LESS THAN $45,000	2	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M19. Was your household income more or less than $55,000?
(HHINC_C)

$55,000 OR MORE	1	GO TO BOX BEFORE M22
LESS THAN $55,000	2	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M20. Was your household income more or less than $65,000?
(HHINC_C)

$65,000 OR MORE	1	GO TO BOX BEFORE M22
LESS THAN $65,000	2	GO TO BOX BEFORE M22
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M21. Was your household income more or less than $75,000?
(HHINC_C)

$75,000 OR MORE	1	
LESS THAN $75,000	2	
REFUSED	-7	GO TO BOX BEFORE N1
DON'T KNOW	-8	GO TO BOX BEFORE N1

M22. Does this include income of all household members?
(NONFMFLG)

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

SECTION N: COLLECTION OF ODOMETER READINGS

N1. In the packet we sent to {you/your household}, there was a form to record the odometer reading(s) for your vehicle(s).

{Is the reading/Are any of the readings} available now?
(READINGS)

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

N2. (VEHOD) **[RECORD THE ODOMETER MILEAGE FOR VEHICLES.]**

MAKE	MODEL	YEAR	ODOMETER READING **(OD_READ)**	DATE/READING MON/DAY/YEAR **(OD_MONTH/OD_YEAR/OD_DAY)**

N3. (ODVERF) **[RECORD THE ODOMETER MILEAGE FOR VEHICLES.]**

MAKE	MODEL	YEAR	ODOMETER READING **(OD_READ)**	DATE/READING MON/DAY/YEAR **(OD_MONTH/OD_YEAR/OD_DAY)**

Is that all of the readings?

1. YES
2. NO RETURN TO MATRIX

CLOSE1

Thank you very much for your cooperation. Your assistance has been very helpful.

APPENDIX C

2009 NHTS INTERVIEW QUESTIONS

ESPECIALLY RELEVANT TO ANALYSIS

C3. To help us understand the things that impact your travel choices, I have a few questions about your household. Including yourself, how many people live in your household? Please do not include anyone who usually lives somewhere else or is just vesting, such as a college student away at school.

B1. How many vehicles are owned, leased, or available for regular use by the people who currently live in your household? Please be sure to include motorcycles, mopeds and RVs. (HHNUMVEH)

B2. {I have a few questions about each of these vehicles. Let's start with the newest vehicle.} What is the make, model and year of this vehicle?

C7. I'm going to read a list of races. {In addition to being Hispanic, please/Please} tell me which best describes your race.

Ca. {Do you/Does FNAME/AGE/SEX} have a job? (WRKR)

C22b. Does the {VEHYEAR, MAKECODE, AND MODLCODE} have a commercial license plate? (VEHCOMM)

C22c. Is it a hybrid or alternative fuel use vehicle? (HYBRID)

L7. Please verify that you have a…{L_MAKE, L_MODEL, L_VYEAR}
L9. During the past 12 months, about how many miles was the {VEHYEAR, MAKECODE, MODLCODE} driven by all drivers? (VEHMILES)

L10. About how many miles has this vehicle been driven since you've had it? (ESTMILES)

M13. In surveys like these, households are sometimes grouped according to income. Please stop me when I get to the category that best describes your total household income, before taxes, in the past 12 months. (HHFAMINC_C)

VITA

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