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16. Abstract

The Texas state gas tax has been 20 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. This is forcing some transportation providers to increase their focus on spending for a more sustainable transportation system, thus shifting how tax revenues are spent. One proposed alternative to the gas tax is the creation of a mileage-based user fee (MBUF), which would then shift how revenues are collected. This research examined potential equity impacts of these shifts in the collection and disbursement of transportation funds.

This research used 2009 National Household Travel Survey (NHTS) Texas data along with detailed spending estimates from the Texas Department of Transportation to consider the equity impacts surrounding three MBUF and spending scenarios. NHTS data were weighted to reflect results representative of Texas vehicle-owning households. Each scenario was run both statically and dynamically under the assumption that the MBUF would replace the state gas tax. Results indicate that the impact of the MBUF on geographic equity can be different depending on allocation of transportation funding. However, the MBUF was essentially as equally vertically equitable as the current state gas tax.

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Equity Evaluation of Sustainable Mileage-Based User Fee Scenarios

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EXECUTIVE SUMMARY

The Texas state gas tax has been 20 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. This is forcing some transportation providers to increase their focus on spending for a more sustainable system (including maintenance), thus shifting how tax revenues are spent. Many industry experts are also proposing a shift in how taxes are collected, from the state gas tax to a mileage-based user fee (MBUF). This research examined the potential equity impacts of these two shifts.

This research used Texas data from the 2009 National Household Travel Survey along with detailed transportation spending estimates from the Texas Department of Transportation. This research developed four different scenarios to evaluate the equity impacts of the proposed funding shifts during the years 2012 to 2021. The first scenario analyzed was the current state gas tax and the current funding disbursement. The other scenarios examined equity impacts of shifting the state gas tax to an MBUF and adjusted funding disbursement, focusing on either additional maintenance or environmental funding. The rate of the MBUF was set as the rate that would generate roughly the same gross revenue in 2012 as the current gas tax. This rate was multiplied by the total mileage as given in the NHTS dataset during the years 2012 to 2021 to estimate the gross gas tax revenue by the MBUF.

Looking only at revenue collection, it was found that rural areas would pay a slightly increased share of taxes if the MBUF were implemented. This research also analyzed the planned transportation funding disbursement from 2012 to 2021 based on the Unified Transportation Program. The amounts and categories of funding disbursement changed depending on the scenarios examined.

The ratio of revenue to funding disbursement was used to evaluate geographic equity. Using this measure, the research found that a scenario where the MBUF is combined with a federal tax and focuses more on maintenance funding disbursement (Scenario 3) is the most geographically equitable transportation policy. This is because the additional maintenance funding spent in rural areas is greater than the increased amount of the revenue paid by rural areas under the MBUF.

Geographical equity was then examined in two ways using Gini coefficients. First, geographical equity of funding disbursement based on the percentage of urban and rural households was examined. For this measure, Scenario 3 was the least equitable because rural areas received a larger percentage of the funding compared to the percentage of rural households. The second type of geographical equity examined funding disbursement based on the percentage of tax burden for each area. Interestingly, Scenario 3 was the most equitable using this measure. Through the results of these measures, this research found that the equity of a transportation funding disbursement policy can be changed based on how equity is measured.

Next, vertical equity was examined using the Gini coefficient. The current gas tax was similar in vertical equity to that of the MBUF combined with a federal tax for all scenarios. This was because the rate of the MBUF was set as the rate that would generate roughly the same gross

revenue in 2012 as the current gas tax. Note that this meant the MBUF would generate more gross revenues than the gas tax in future years due to increased fuel economy of vehicles over time. Through these analyses, researchers found that considering funding disbursement when examining the effect of a shift to the MBUF may change the equity of a funding option.

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CHAPTER 1: INTRODUCTION

The funding challenge facing transportation investment in the United States is well documented. Two national commissions, the National Surface Transportation Infrastructure Financing Commission (NSTIFC) and the National Surface Transportation Policy and Revenue Study Commission (NSTPRSC), have looked into the problem. Both agreed that the long-term solution is likely a shift from the gas tax to a mileage-based user fee (MBUF) based on the vehicle miles traveled. However, the path from the current gas tax funding system to an MBUF funding system is unclear at best and will require extensive research, policy analysis, and outreach prior to implementation.

A key aspect of the shift to an MBUF is the impact it will have on travelers. This includes both the change in travel behavior and the change in the way taxes and fees are collected from, and spent on, these travelers. Burris and Larsen (2012) examined the equity impacts of an MBUF system in Texas but assumed no change in how revenues were spent. This approach, naively, assumed that despite adjustments in how revenues are collected, there is no shift in how they are spent. This project will examine equity impacts of implementing an MBUF in Texas but assumes changes in how those revenues are allocated, including a greater focus on asset management principles and reduction of environmental impacts.

1.1 Background

The Texas gas tax has been 20 cents per gallon since 1991, and the federal gas tax has been 18.4 cents per gallon since 1993. While the population, number of registered vehicles, and vehicle miles traveled (VMT) in Texas have all increased, funding for transportation has not kept pace due to inflation and the improved fuel efficiency of the vehicle fleet. As a result, while damage to infrastructure has increased due to increased VMT, the money available for maintaining and improving roadways is actually declining. If roadways are not well maintained and improved due to lack of transportation funding, congestion will not only increase, but mobility will also worsen. This also has an impact on the economic vitality and productivity of the state.

The current gas tax system is based on the premise that travelers who use roadways more frequently will purchase more fuel and thus be charged more for that use. However, the relationship between the gas tax and infrastructure use is weakening due to increased vehicle fuel efficiency. Vehicles are able to travel a greater distance while consuming less fuel. In addition, non-gasoline-powered vehicles do not pay any gas tax. Therefore, the current gas tax system is at odds with other policy objectives such as sustainability and reduced dependence on foreign oil.

Several solutions for increasing revenue have been proposed, such as increasing the gas tax, indexing the gas tax, expanding toll ways, and increasing the vehicle registration fee. NSTIFC provided several funding options to satisfy growing funding needs but identified an MBUF as the best long-term strategy. Based on this background, this project will focus on the effect of an MBUF on equity.

1.2 Objectives of This Study

The objective of this project is to examine the equity impacts resulting from not only a change in how transportation funding is assessed and collected but also in how it is spent. This project used the data collected and research methods developed in a previous Southwest Region University Transportation Center (SWUTC) project on MBUFs (Burris and Larsen 2012) combined with transportation funding knowledge gained as part of a University Transportation Center for Mobility (UTCM) project (http://utcm.tamu.edu/tfo, headed by Tina Geiselbrecht). Based on this, several likely funding scenarios were developed, focusing on asset management and environmental sustainability.

For example, one scenario directs a much larger portion of revenues to the repair and maintenance of transportation infrastructure than the currently planned distribution of transportation funding. This scenario is actually possible regardless of which fee is used—gas tax or MBUF. In fact, there is current consideration to allow lower-functional-classification roads be maintained at a lower pavement score than those in a higher functional class in order to preserve maintenance funds. The impact of diverting a larger portion of transportation funding to maintenance was examined with respect to geographic equity using both a Gini coefficient and a ratio of tax burden to allocated funding for each area.

A second scenario charges vehicles an MBUF while focusing more spending on environmentally beneficial projects such as transit system expansion projects. Thus, the second example scenario would entail a significant shift from how revenues are currently spent and could cause considerable equity implications. Research has shown that MBUFs could improve the vertical equity of the transportation funding system by shifting more of the funding burden to high-income travelers.

These were the two primary scenarios examined. These scenarios were compared to using the gas tax for projects as projected in the Texas Department of Transportation's (TxDOT's) unified planning program document. With National Household Travel Survey (NHTS) data for Texas, the change in user fees for travelers under the new fee systems was estimated. By combining this with how the new funding will be allocated, the research team determined how much travelers are spending on MBUFs and what portion of these revenues benefitted them. In this manner, a full picture of the equity impacts, both costs and benefits, was obtained.

These analyses will help advance the understanding of the impacts of an MBUF. Understanding the impact of different MBUF scenarios and revenue allocation options on travelers will help transportation planners and policy makers better understand and shape future transportation funding.

1.3 Outline of the Report

Chapter 2 reviews the literature surrounding transportation funding, MBUFs, and equity. Chapter 3 examines TxDOT's planned future spending, by category, for the next decade. This research breaks the funding into six categories:

- Urban construction funding.

- Rural construction funding.
- Urban maintenance funding.
- Rural maintenance funding.
- Urban environmental funding.
- Rural environmental funding.

These categories are useful for examining equity when funding amounts shift between these six categories. Chapter 4 discusses the traveler data obtained from the NHTS. Chapter 5 discusses the analysis methodology and results from several scenarios examined. Chapter 6 contains the conclusions and recommendations based on this research.

CHAPTER 2: LITERATURE REVIEW

This research estimates potential equity changes when the transportation funding method and spending allocations are changed. In this research, the new funding focus area is sustainability, which includes social, economic, and environmental progress of society. Thus, equity (sustainability in terms of social progress of society) is examined from the perspective of shifts in funding to asset management and protection of the environment (the other two types of progress). The literature review examines issues surrounding these three concepts of sustainability along with the current funding allocation.

2.1 Sustainability

The United Nations Conference on Environment and Development (UNCED) held in 1992 in Rio de Janeiro, Brazil, dealt with sustainability for the first time on a global scale. Sustainable development can be defined as "…providing for a secure and satisfying material future for everyone, in a society that is equitable, caring, and attentive to basic human needs" (Litman 1999). Development in this context means increases in the quality of development as distinguished from an increase in the quantity of growth (Litman 2009). Thus, sustainability includes a holistic consideration of economic, social, and environmental progress with a long-term perspective (Zietsman et al. 2011). Social progress focuses on social welfare outcomes, such as human health and education attainment, rather than on material wealth, while economic progress is related to the increase of quantity (the growth), such as the gross domestic product that measures the quantity but not the quality of market activities (Litman 2009). Environmental improvement emphasizes a conservation ethic and the policies that reduce waste of resources such as air, water, and land.

The principles of sustainable development have significant implications for transportation planning because transport activities tend to be resource intensive, have numerous external costs, and frequently distribute impacts and benefits inequitably. Therefore, when sustainability is applied to transportation planning, the impacts need to be considered in the perspective of economic, social, and environmental views (Litman 2010a). Table 1 represents the common impacts of sustainable transportation on these three dimensions.

TABLE 1 **Sustainable Transportation Impacts**

Economic	Social	Environmental
Traffic congestion	Equity/fairness	Air pollution
Infrastructure costs	Impacts on mobility disadvantaged	Climate change
Consumer costs	Human health impacts	Noise and water pollution
Mobility barriers	Community cohesion	Habitat loss
Accident damages	Community livability	Hydrologic impacts
Depletion of nonrenewable resources	Aesthetics	Depletion of nonrenewable resources

Source: Litman (2010a)

The U.S. government has made an effort to consider these ideas in transportation legislation. In the Intermodal Surface Transportation Efficiency Act (ISTEA), mobility needs and environmental issues were addressed (U.S. Department of Transportation 1991). The legislation governing the transportation system in the United States for many years, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) addressed many challenges facing the transportation system today. It focused on a strong fundamental program, with directives specifically to address safety, equity, congestion relief, mobility and productivity, efficiency, environmental stewardship and streamlining, and innovative finance (U.S. Department of Transportation 2012a). Thus, sustainable transportation is an important issue facing society and has been legislated in transportation policy. Therefore, this research focuses on funding that is disbursed for a sustainable transportation system. If a sustainable transportation policy becomes a primary determinant in the allocation of transportation funding, then transportation funds will be used to increase mobility, improve equity, and reduce environmental impacts. For example, the funds can be used to provide alternative transportation modes (such as paratransit for people with disabilities) to disadvantaged groups to improve equity. Transit projects can also reduce the negative environmental impacts of transportation.

Finally, an MBUF can change a traveler's behavior by changing travel costs, which in turn can affect energy consumption and emissions for each traveler. Thus, MBUF strategies can be designed to reduce environmental emissions. This would include lower MBUF rates for vehicles with high fuel efficiencies. In addition, the funds can be allocated for environmentally friendly transportation policies such as public transportation and non-motorized modes. The equity impacts of such shifts are the focus of this research.

2.2 Asset Management

According to the American Association of State Highway and Transportation Officials (AASHTO) (1997), "Asset management is an effort to integrate finance, planning, engineering, personnel, and information management to assist agencies in managing assets cost-effectively." As a part of asset management, transportation asset management is a decision-making procedure for making cost-effective decisions about the design, construction, maintenance, rehabilitation, retrofit, replacement, and abandonment of transportation assets, with the purpose of maintaining or improving the value of these assets over time (Meyer and Miller 2001). In recent years, the national costs of preserving and operating the current $1.75 trillion in infrastructure investments have increased largely. If current trends continue into the future, state departments of transportation (DOTs) and other public-sector owners of highway infrastructure will be unable to afford to maintain the transportation system, let alone construct additional capacity. Therefore, a transportation asset management strategy can play an important role in improving efficiency and productivity and increasing the value of services and products to transportation users (U.S. Department of Transportation 2007). Thus, it can be a primary concern for allocating transportation funds through an MBUF policy. This research focuses on increasing the amount of funds spent on maintenance and assumes that funds will be spent using the best asset management techniques.

2.3 Equity of Transportation Funding

Equity refers to the distribution of impacts and benefits. Transportation planning and funding decisions have significant and various equity impacts. In this section, the definition of equity and ways to analyze it are reviewed. In addition, previous research into the equity of MBUFs is reviewed.

2.3.1 Discussion of Equity

Analysis of equity in transportation can be difficult because there are several types of equity, various ways to classify people for equity analysis, numerous impacts to consider, and different ways of measuring these impacts. Despite these difficulties, transportation equity is an extremely crucial issue in transportation planning because transportation planning decisions can be interrupted by equity concerns, and otherwise justified policies and programs delayed or eliminated by debates about their potential equity impacts (Litman 2012).

Transportation equity is commonly classified into two types of equity: horizontal and vertical. Horizontal equity has to do with the distribution of impacts and benefits between individuals and groups considered equal in ability and need. That is, horizontal equity means that equal individuals and groups should receive equal shares of resources, bear similar costs, and be treated the same in other ways. Public policies should avoid favoring one individual or group over another. On the other hand, vertical equity has to do with the distribution of impacts and benefits among individuals and groups considered different in abilities and needs. These differences may be based on income, social class, transportation ability, need, etc. Policies that favor disadvantaged groups are called progressive, while those that excessively burden disadvantaged groups are called regressive. Thus, vertical equity is used to promote transportation policies that favor disadvantaged groups, such as special transportation services or subsidies for disadvantaged groups (Litman 2012).

This research focuses on examining vertical equity with respect to household income, and horizontal equity with respect to geographic location (urban and rural residents). The methods used to measure equity impacts of each variable are reviewed in the following section.

2.3.2 Equity Impacts

Equity impacts are typically associated with transport costs (such as fare structure and tax burdens) and revenue allocation. If two geographic areas are similar in terms of the populations' income and travel needs, then horizontal equity in revenue allocation would dictate that those areas should receive equivalent per-capita transportation funding. However, this does not always happen (Litman 2012). Chen (1996) found that since Georgia state law requires that state highway funds be allocated equally among the state's 13 congressional districts, more funds per capita are allocated for rural areas. In addition, cities receive far less transportation funding per capita due to planning practices that favor the automobile (Chen 1996).

The Federal Highway Administration (FHWA) evaluated fare structure equity for different transportation modes (U.S. Department of Transportation 1997). The research analyzed the costs imposed by various types of vehicles and the degree to which they are recovered by user fees. The results found that users bear different costs according to vehicle type based on roadway cost responsibility. Table 2 provides the results of transportation cost equity among transportation modes.

TABLE 2 Roadway Cost Responsibility

Vehicle Class	VMT (Million Miles)	Federal Costs ($/Mile)	State Costs ($/Mile)	Local Costs ($/Mile)	Total Costs ($/Mile)	Total User Payments ($/Mile)	External Costs ($/Mile)
Automobiles	1,818,461	0.007	0.020	0.009	0.035	0.026	0.009
Pickups and Vans	669,198	0.007	0.020	0.009	0.037	0.034	0.003
Single-Unit Trucks	83,100	0.038	0.067	0.041	0.146	0.112	0.034
Combination Trucks	115,688	0.071	0.095	0.035	0.202	0.157	0.044
Buses	7,397	0.030	0.052	0.036	0.118	0.046	0.072
All Vehicles	2,693,844	0.011	0.025	0.011	0.047	0.036	0.010

Source: U.S. Department of Transportation (1997)

2.4 MBUF Research

The gas tax is the primary revenue source for funding transportation infrastructure. The current gas tax is charged based on the amount of gas purchased (paid in cents per gallon). The current federal gasoline tax is 18.4 cents per gallon, and the diesel gas tax is 22.4 cents per gallon. The Texas state gas tax has been 20 cents per gallon since 1991. These fixed amounts per gallon have resulted in additional difficulties generating sufficient revenue for transportation infrastructure investments because inflation erodes the purchasing power of those taxes. In addition, since revenue is collected in proportion to fuel consumption, and not in proportion to marginal cost to roadway depreciation, as shown in Table 2, the increase in fuel efficiency of vehicles also reduces the revenues collected. The Corporate Average Fuel Economy (CAFE) Standards dictates the fuel efficiency of vehicles produced for sale in the United States. The standards have been recently increased to an average fuel efficiency of 35.5 miles per gallon for vehicles produced beginning in 2016 (Eilperin 2010). Even with projected increases in total VMT, the rapid increases in fuel efficiency will erode the amount of revenues available for transportation. Lastly, the use of alternative-fuel vehicles, including electric vehicles, has increased in proportion to all vehicles used. These alternative-fuel vehicles pay much less in gas taxes or do not pay the gas tax at all, continuing to negatively impact transportation funding.

MBUFs are considered by many as a possible alternative to the current gas tax system. An MBUF would charge a fee in proportion to the amount of roadway used. It could also be set to increase the amount of transportation funds collected in order to meet system needs. MBUFs have been referred to by many different names: vehicle mileage (VM) fees, vehicle miles

traveled fees, time-distance-place (TDP) charging, or simply mileage fees. MBUF systems have been recommended for further study and evaluation as the long-term solution to provide continuous transportation funding by the Transportation Research Board (Committee for the Study of the Long Term Viability of Fuel Taxes for Transportation Finance 2006), the National Surface Transportation Infrastructure Financing Commission (2009), the National Surface Transportation Policy and Revenue Study Commission (2007), the Bipartisan Policy Center (2009), and AASHTO (2008). Several state-level transportation funding task forces (such as those in Oregon, Washington, and Minnesota) have also recommended MBUF systems as a potential long-term funding source worthy of further study.

Motorists in an MBUF system are charged with a tax that is assessed based on the distance traveled. Thus, as travel distance increases, the amount of tax assessed and paid also increases. The MBUF rate can vary based on the goal of the MBUF policy. Many policy goals could be incorporated into an MBUF depending on how it is structured. For example, with the use of specific travel information, congestion pricing policies can be incorporated into MBUFs. Generally, an MBUF can be implemented to achieve two main goals: revenue generation and system management (Farzaneh et al. 2012). The primary goal of the MBUF examined in this research was replacement of the state gas tax.

MBUFs can also be used for system management to influence travel behavior. System management may include detailed objectives such as reducing congestion; reducing traffic volumes; reducing travel demand; optimizing capacity; increasing vehicle speeds; improving user access to the transportation network, inducing modal shift to transit, rail, or some other alternative; and restricting unnecessary vehicle access. MBUFs with the goal of system management can incorporate a congestion pricing or a value pricing element, where fees for access to the roadway increase as volume increases. This can be used to mitigate traffic congestion by shifting travelers to other modes, other times of travel, or other facilities, or to even cancel trips in order to maximize overall system performance. The goal of system management is usually adopted for small-scale pricing systems with only a few facilities (Farzaneh et al. 2012). The research performed here does not use a differential MBUF to encourage specific travel behavior, but some scenarios do use MBUF revenues to encourage travel in off-peak periods or mode shifts away from single-occupant vehicles.

2.4.1 Technology Issues Surrounding MBUF Systems

Even though MBUFs can be implemented by a simple reading of the odometer, more complex technologies would be required to achieve multiple policy goals. There are three basic technological elements of an MBUF system: road use assessment, charge computation, and vehicle to back office (Farzaneh et al. 2012).

Road Use Assessment

Road use assessment is the stage during which raw data describing vehicular movement are collected. There are several options for road use assessment. First, simple odometer readings are the easiest way of determining how much travel has occurred. These provide direct, reliable, and accurate distance measurement. However, these cannot provide concrete information on which

roadways were used and when vehicles were driven. In this research, the MBUF will replace the current state gas tax system. Therefore, information regarding where vehicles were driven is needed to avoid charging fees for mileage generated outside of the state. Thus, MBUFs using a simple odometer reading would not be sufficient for the research in this report.

Vehicle-speed-based distance measurement is another method by which roadway use can be assessed. This method can be implemented through connection with the vehicle's onboard diagnostic (OBD II) port and includes detailed records of vehicle starts, stops, and speeds during trips, which allow for the calculation of distance. However, this method does not include location and again would not be used for this research.

A beacon-based location stamping method can be implemented to account for where vehicles were driven. In this method, a location stamp is recorded in road usage data through the use of roadside beacons. However, this method requires a network of roadside beacons that covers the entire roadway network where the MBUF system is implemented and requires maintaining a connection between beacons and vehicles. Thus, this method is not appropriate to implement for a large-scale (statewide) MBUF system.

Global positioning system (GPS) technology can be used for road use assessment. This technique provides specific time and location information in roadway usage data. In this method, a GPS receiver located within a vehicular onboard unit (OBU) receives location data and calculates vehicular position on a network map. Use of specific roadways is determined based on changes in location. Since this method uses wide-area satellite technology to collect time and location information, this method is the most appropriate for use in a large-scale MBUF system, and this research assumes the use of such a system.

Charge Computation

Once roadway usage data are collected through the road use assessment procedure, a charge computation procedure is needed to determine an amount owed. There are two main assessment configurations: "thin" client and "thick" client.

In a thin client configuration, aggregated travel data are transmitted out of the vehicle and processed at another location, whereas in a thick client configuration, charge computation is conducted within the vehicle OBU (Farzaneh et al. 2012). Both configurations have advantages and drawbacks. Thin configuration requires only a simple OBU that collects location and possibly time of travel data. Very little data processing occurs within the OBU because raw data can be transmitted for calculation. This makes it easy to audit the vehicle OBU because the raw travel data are readily available. On the other hand, thick client configuration has additional privacy for drivers because there is significant processing of travel data within the OBU, and very little information is transmitted out of the vehicle. For example, a thick configuration could transmit only the calculated charge to system administrators without providing detailed travel records. However, to accomplish this, thick OBUs must have data that would allow them to use the location data gathered in order to calculate a charge, such as jurisdictional boundaries and fee schedules. It becomes necessary to periodically update these units, which limits their flexibility. In addition, it is not easy to use for various policy goals related to specific travel information (Farzaneh et al. 2012).

It costs $195 to equip a vehicle with a thin OBU with a GPS unit, whereas it costs $650 to equip a vehicle with a thick OBU with a GPS unit (Wells 2010). Even though the installation cost of a thin OBU is cheaper than that of a thick OBU, thin OBUs require higher transmission costs because the data from a thin OBU are less processed than under a thick configuration. A thin OBU can be easily used for many policies such as congestion mitigation policies with a revenue collection purpose. Thus, it is more advantageous to use a thin OBU in the MBUF system discussed in this research.

Vehicle to Back Office

Vehicle to back office is the procedure for transmitting the data or an amount owed from the vehicle to a back office for the computation. The simplest method for this procedure is a manual reading of the odometer. A more technology-intensive option is to employ a localized, detection-based transmission system such as dedicated short range communication (DSRC) technology. This technology requires a network of roadside readers as well as in-vehicle technology. Thus, it can be of limited use for a wide-area charging system. In a statewide application, an online wider-area data transmission system, such as cellular, can be used to transmit data from vehicles to a back office. The global system for mobile communications (GSM) is a typical data transmission system for wide-area communication (Farzaneh et al. 2012).

2.4.2 MBUF Case Studies

There are only a handful of studies related to the potential equity impacts of an MBUF. Thus, this section will also provide highlights from some of the case studies of MBUF system implementation together with MBUF equity impact studies.

Burris and Larsen (2012) recently examined potential equity impacts of MBUFs. Their research focused on equity of funding collection. In their research, Texas data from the 2009 NHTS were used to examine the equity impacts of four MBUF scenarios:

1. Flat MBUF scenario.
2. Flat MBUF for added revenue scenario.
3. Three-tier MBUF scenario to encourage “green” vehicles.
4. Urban versus rural distinction scenario.

In the first scenario, a flat MBUF scenario, the rate of the MBUF was set without considering revenue needed to make up for the projected lack of transportation funds. An MBUF rate to make up for a lack of transportation funds was set in the second scenario. In the third scenario, “green” vehicles, which have good fuel efficiency, paid a lower MBUF than less fuel-efficient vehicles. Lastly, since urban roadways and rural roadways have different costs, characteristics, and travelers, rural and urban roadway users were charged a different MBUF in the fourth scenario.

Each scenario was analyzed both statically and dynamically under the assumption that an MBUF would replace the state gas tax. The vertical equity of all MBUF scenarios was similar to the vertical equity of the current gas tax. In terms of horizontal equity, the urban versus rural

scenario was more geographically equitable, and a three-tier MBUF scenario to encourage "green" vehicles was found to be the least horizontally equitable. In all other scenarios, the horizontal equity was more equitable than the horizontal equity of the current gas tax. The cost needed to build an MBUF system and a 10 percent "leakage" cost were considered in the research; the authors expected that $3.34 billion would be needed to construct the system.

Oregon conducted an MBUF pilot study in 2006 (Rufolo and Kimpel 2008). Over 200 vehicles equipped with GPS and two service stations equipped with the technology needed to communicate with these vehicles participated in the test. An OBU in the vehicle recorded mileage driven within specified zones using a GPS signal. Recorded data with total mileage driven were transmitted to a billing center whenever a participating vehicle was fueled at a participating service station. The pilot study compared driver behavior under two scenarios:

- Being charged an MBUF equivalent to the amount paid under the state gas tax.
- Being charged a higher MBUF during the peak hours and a lower MBUF during the off-peak hours.

Over 90 percent of participants stated that they would agree to replace the current gas tax with an MBUF. It was also found that a dynamic MBUF where the rate increases during peak periods is useful to reduce the VMT during peak hours.

The University of Iowa recently concluded a large-scale study focusing on the technology and pricing options for a potential VMT-based fee (Hanley and Khul 2011). GPS was used to determine the vehicle's location, and this information was stored to geographic information system (GIS) files in the onboard computer. A price per mile was then applied to each particular trip. When the vehicle entered into a new area with a different price per mile, the previous price per mile was replaced with the new price per mile. In the research, VMT fee rates were differently applied based on the vehicle's fuel efficiency and the jurisdiction of participants. The data stored in the onboard computer were transmitted to a billing and dispersal center on a planned schedule using cellular technology. Participating vehicles continued to be charged the current gas tax while the VMT fee was theoretically applied for research purpose. The results of the study are still being compiled and will be presented to the U.S. Department of Transportation.

Weatherford (2011) evaluated the equity impacts of a flat MBUF using the 2001 NHTS. This research suggested a rate of 0.98 cents per mile to replace the current federal gas tax. This VMT fee structure would lead to less of a transportation tax burden on low-income households, rural households, and retired households. However, this research noted that overall changes related to equity are relatively minimal. This research also recommended that any future MBUF scenario needs to consider a policy to promote the use of fuel-efficient vehicles.

2.5 Funding Disbursement in Relation to Scenario Development

This research aims to evaluate equity impacts of an MBUF and associated revenue disbursement focus areas with the assumption that the MBUF will replace the existing Texas gas tax. Through the literature review, six funding disbursement focus areas were identified. Transportation funds will therefore be allocated among these six categories:

- Urban construction funding.
- Rural construction funding.
- Urban maintenance funding.
- Rural maintenance funding.
- Urban environmental funding.
- Rural environmental funding.

CHAPTER 3: TRANSPORTATION FUNDING COLLECTION AND DISBURSEMENT IN TEXAS

This chapter examines estimates of future transportation funding for the period of 2012 to 2021 and is based on the data from the 2012 Unified Transportation Program (UTP) (http://ftp.dot.state.tx.us/pub/txdot-info/fin/utp/2012_utp_052611.pdf). Due to the uncertainty of future funding, this analysis makes several assumptions detailed in this chapter.

Among the sustainability principles discussed in Chapter 2, only economic and environmental sustainability dimensions are examined in relation to fund allocation. The reallocation of available funding based on social sustainability (or equity) is analyzed separately. Most transportation projects related to economic sustainability are concerned with:

- The enhancement of travelers' mobility and reduction in travel costs, which can also be viewed primarily in terms of construction projects; and
- Maintenance or asset management projects that economically prolong the useful life of an existing system.

Inflation and improved fuel efficiency standards will continue to erode tax revenue for future transportation improvements, so maintenance projects may demand higher portions of the budget just to keep the system operational. In this research, environmental funding is classified as the funding for transportation projects that aim to improve or preserve the environment even though they accompany either construction or maintenance works. Funding for construction of bike/pedestrian paths and transit rehabilitation and improvement programs is included in environmental funding.

Future funding is categorized according to sustainability, as well as the region where the funding is allocated:

- Urban construction funding,
- Rural construction funding,
- Urban maintenance funding,
- Rural maintenance funding,
- Urban environmental funding, and
- Rural environmental funding.

3.1 Transportation Funding Sources

The 2012 UTP provides information on Texas transportation funding sources from 2008 to 2021 (Texas Department of Transportation 2012a). Funding sources from 2008 to 2011 are based on what was actually collected, while funding sources from 2012 to 2021 are forecasted. TxDOT predicts that $105 billion will be collected during this period (see Table 3 and Figure 1). The largest portion of transportation funding, 77 percent, will be deposited to the State Highway Fund. The State Highway Fund is funded from the state motor fuels tax, registration fees, FHWA reimbursements, other federal reimbursements, Build America bonds, and short-term borrowing.

TABLE 3 Transportation Funding Sources in Texas from 2008 to 2021

Funding Source	Amount ($)	Portion
State Highway Fund	81,340,256,312	77%
Texas Mobility Fund—bond proceeds	3,071,301,574	3%
Texas Mobility Fund—taxes and fees	4,489,799,655	4%
Proposition 14	4,356,233,721	4%
Proposition 12	3,107,864,016	3%
SH 121	3,432,344,680	3%
SH 130 (Seg. 5 & 6)	71,800,000	0%
Federal economic stimulus (American Recovery and Reinvestment Act)	2,257,415,146	2%
Build America bond subsidies	688,866,101	1%
General Revenue (GR)—debt service	2,159,902,104	2%
GR	32,008,981	0%
Total funds	105,007,792,282	100%

Source: Texas Department of Transportation (2012a)

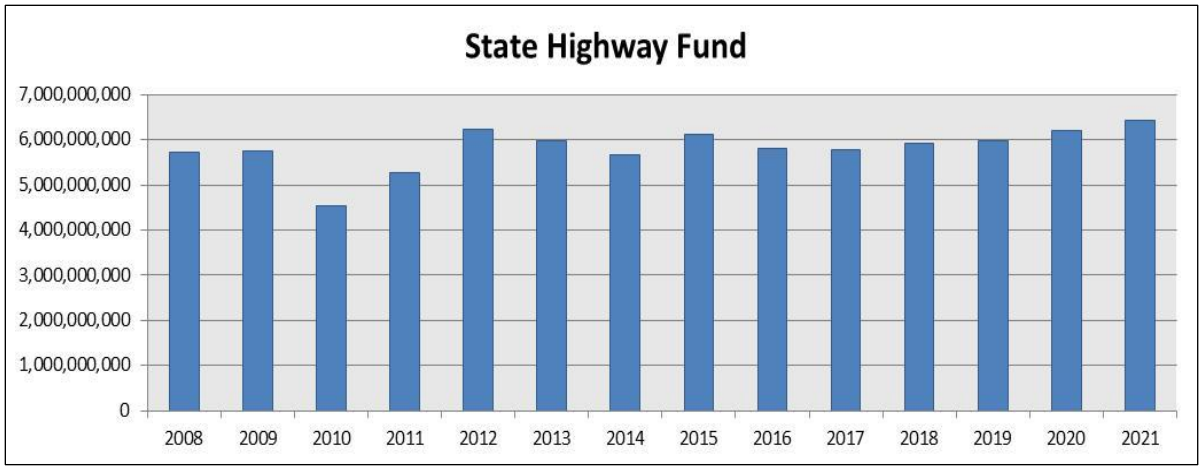


FIGURE 1 State Highway Fund Estimates

3.2 Geographic Classification of Funds

The geographical distribution, rural versus urban, of future transportation funding was also examined. There is some difficulty in categorizing urban and rural geographies due to different definitions within the data sets. For example, the Texas Statewide Long Range Transportation Plan 2035 (SLRTP) uses a county as the geographical boundary to divide rural and urban areas (Texas Department of Transportation 2010b), while the 2009 National Household Travel Survey (NHTS) data set (which will be used to analyze the travelers' characteristics related to the MBUF) uses cartographic boundaries. The cartographic boundaries only consider urbanized areas, which consist of the built-up area surrounding a central city with a population density of at least 1,000 people per square mile (U.S. Department of Transportation 2012b). Therefore, the boundaries were not consistent with the county boundary used in the SLRTP.

The Census Bureau defines two types of urban areas: urbanized areas (UAs) with populations of 50,000 or more, and urban clusters (UCs), where the population is at least 2,500 and less than 50,000 (U.S. Census Bureau 2012). Additionally, "rural" encompasses all population, housing, and territory not included within an urban area. Geographic categorization using these criteria is imprecise due to the different geographic boundaries chosen by the different agencies supplying the funding data.

A review of how detailed funding estimates are provided in terms of geographical boundaries shows the SLRTP, the Metropolitan Transportation Plan (MTP), the Texas Rural Transportation Plan (TRTP), and UTP use the county boundary. Thus, this research also uses the county boundary to delineate between a rural and urban area. Furthermore, according to the Census Bureau's definition of an urban area, if a county has a population greater than 50,000 people and is contained within the metropolitan planning organization (MPO) boundary, this research considers the area to be an urban area. As a result, 54 of the 254 counties within Texas are considered urban areas, and 200 counties are considered rural areas. More detailed information about the criteria of geographic classification and a list of counties with their urban or rural designation are provided in Appendix A.

3.3 Future Transportation Funding Resources

As shown in Table 4, many statewide transportation plans contain transportation funding estimates for Texas.

The SLRTP, UTP, MTP, and TRTP were selected to estimate statewide long-range transportation funding because they provide relatively comprehensive transportation plans over longer periods of time. However, each source had issues regarding the classification of future funds into six identified categories (see Table 5). The following is a discussion of these issues.

3.3.1 SLRTP Issues

The SLRTP provides highway and public transportation funding needs for urban and rural areas. However, it does not provide actual planned transportation funding. Planned funding is the funding approved by commissioners or transportation planning departments, while funding needs include additional (unfunded) projects that would be beneficial for the transportation systems. Therefore, planned funding is different from funding needs. In addition, not all projects in the SLRTP are approved by the Texas Transportation Commission, so using these funding figures would lead to an overestimation of future funding.

3.3.2 TRTP Issues

The TRTP only provides highway and public transportation funding needs for rural areas. Additionally, about 600 highway projects planned in the TRTP are not currently funded in the UTP.

TABLE 4 Texas Transportation Plans and Programs

Plan/Program	Who Develops?	Who Approves?	Time Period	Content
Statewide Long-Range Transportation Plan	**TxDOT**	**Texas Transportation Commission**	**24 years**	**Future goals, strategies, and performance measures**
TxDOT Strategic Plan	TxDOT	Texas Transportation Commission	5 years	TxDOT's operational goals and strategies
Statewide Transportation Improvement Program	TxDOT	U.S. Department of Transportation	4 years	Transportation investments
Unified Transportation Program	**TxDOT**	**Texas Transportation Commission**	**Current year + 10 years**	**Projects to be funded/built in a 10-year period**
Metropolitan Transportation Plan	**MPOs**	**MPOs**	**20+ years**	**Future goals, strategies, and projects**
Texas Rural Transportation Plan	**TxDOT**	**Texas Transportation Commission**	**24 years**	**Future goals, strategies, and performance measures**
Transportation Improvement Programs	MPO and TxDOT Districts	Governor*/MPOs	4 years	Transportation investments (projects)
Corridor studies (e.g., MY-35)	TxDOT	Texas Transportation Commission	NA	Benefit-cost analysis and feasibility
Texas Rail Plan	TxDOT	Texas Transportation Commission	5 and 20 years	Future goals and strategies
Texas Airport System Plan	TxDOT	Texas Transportation Commission	5, 10, and 20 years	Focus on general aviation needs
Texas Port 2010–2011 Capital Plan	Port Authority Advisory Committee	Texas Transportation Commission	2 years	Goals, objectives, and projects
Texas Transit Statistics	TxDOT	TxDOT	1 year	Public transportation operation statistics

* The governor delegates his authority to TxDOT.

Note: Shaded and bold rows indicate resources selected for this research.

Source: Texas Department of Transportation (2010b)

TABLE 5 Summary of Information Contained in Each Report

Information	SLRTP	TRTP	MTP	UTP
Urban versus rural funding estimates	X	X	X	Δ
Maintenance, construction, and environmental funding	X	X	✓	✓
Future funding estimates	Δ	Δ	✓	✓

X = There is no information. Δ = There is partial information. ✓ = There is detailed information.

3.3.3 MTP Issues

Study areas in the MTP are locations that are currently considered urbanized or are expected to become urbanized by the year 2030. Thus, any transportation plan for a rural area is not included in this plan. Since the MTP is developed separately by each MPO, not all MTPs use the same funding categories to classify future transportation funding. Thus, it is difficult to consistently classify the funding estimates of each MTP into the six categories used in this research. Lastly, some MTPs include projects that are funded by local funding sources. The MBUF is related to state funding sources (the gas tax), so it is necessary to exclude local funding in the analysis. However, since several MTPs did not provide detailed information regarding funding sources, it was not always be possible to exclude them.

3.3.4 UTP Issues

The UTP provides a list of projects and programs that are planned for construction and/or development within the first 10 years of the 24-year SLRTP. The Texas Transportation Commission also approves the UTP and authorizes those projects for development (Texas Department of Transportation 2012a). The UTP includes the total amount of funding estimates for projects in 12 categories, 2 additional categories (see Table 6 for a description of the 14 categories), and 4 programs (Aviation, Railroad, Transit, and State Waterway and Coastal Waters Programs). Detailed explanations of these 14 categories and 4 programs are provided in the next section. Thus, funding estimates in the report can be roughly categorized into maintenance, construction, and environmental transportation funding based on the characteristics of the projects included in each category/program or a description of each category/program. Furthermore, detailed information including a description, location, and scheduled date of projects is also provided in the project list of the UTP. Through analyzing a project list, funding estimates for an urban area and a rural area can be classified. However, the UTP has some limitations as a future funding information source. The biggest issue of the UTP is that not all categories/programs provide their project lists. Project lists for seven categories and two programs were not provided. In this case, since detailed information on projects within those categories is not provided, those categories cannot be clearly classified into rural and urban funding even though those categories could be classified into maintenance, construction, or environmental funding through the descriptions of those categories. Another limitation is also related to project lists. Even though other categories/programs provide their project lists, not all projects were detailed in their project lists. (Some detailed information of projects for future years is omitted from their lists.) Thus, for categories/programs that do not provide their detailed project lists, researchers used a reasonable assumption or other information sources to classify funding estimates into urban and rural funding in this research.

Based on review of the SLRTP, UTP, MTP, and TRTP, researchers concluded that the 2012 UTP is the most reliable source to use for statewide future transportation funding estimates, even if the UTP has some limitations. Thus, this analysis uses the funding information from the UTP. Table 6 provides the comprehensive statewide transportation funding estimates for the next 10 years as outlined in the UTP. The Texas Transportation Commission approved $29.43 billion in transportation funding in the UTP from 2012 to 2021. This research classified the funding estimates in Table 6 into the six categories used in this research.

TABLE 6 Fiscal Year Funding Summary (Unit: Thousands)

Category/Program	FY2012 ($)	FY2013 ($)	FY2014 ($)	FY2015 ($)	FY2016 ($)	FY2017 ($)	FY2018 ($)	FY2019 ($)	FY2020 ($)	FY2021 ($)	Total ($)
1: Preventive Maintenance and Rehabilitation	917,950	1,043,950	979,560	1,007,540	1,118,320	1,205,320	1,082,860	1,043,970	1,278,810	1,278,810	10,957,090
2: Metropolitan and Urban Corridor Projects	59,980	120,820	196,470	263,960	267,790	225,190	315,910	382,630	153,560	0	1,986,310
3: Non-traditional Funded Transportation Projects	1,399,360	1,591,890	216,200	995,060	23,510	5,000	2,000	0	174,000	0	4,407,020
4: Statewide Connectivity Corridor Projects	19,000	0	0	0	0	0	0	0	0	0	19,000
5: Congestion Mitigation and Air Quality Improvement	80,830	106,000	110,610	113,800	115,040	116,310	117,600	118,930	120,270	121,650	1,121,040
6: Structures Replacement and Rehabilitation	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,500,000
7: Metropolitan Mobility/ Rehabilitation	178,650	202,720	224,790	196,780	198,950	201,130	203,370	205,650	207,990	210,370	2,030,400
8: Safety	120,000	124,000	124,000	124,000	124,000	124,000	124,000	124,000	124,000	124,000	1,236,000
9: Transportation Enhancement	61,640	62,300	62,960	63,640	64,330	65,040	65,770	66,510	67,260	68,030	647,480
10: Supplemental Transportation Projects	98,450	85,920	54,610	53,520	61,650	57,900	57,910	57,850	59,920	42,990	630,720
11: District Discretionary	72,220	72,770	62,500	62,500	62,500	62,500	62,500	62,500	62,500	62,500	644,990
12: Strategic Priority	721,230	163,540	142,920	427,180	109,390	94,180	150,850	146,880	164,610	347,570	2,468,350
Category 8: Prop. 14 Safety Bond	79,770	40,870	0	1,360	0	0	0	0	0	0	122,000
Category 10: Earmarks—Fed. Share	106,530	105,870	15,720	27,790	5,330	800	850	580	8,880	1,580	273,930
Aviation	86,130	72,030	0	0	0	0	0	0	0	0	158,160
Railroad	57,610	0	0	0	0	0	0	0	0	0	57,610
State Waterways & Coastal Waters	700	650	700	650	700	650	700	650	700	650	6,750
Transit	158,350				-	-	-	-	-	-	158,350

Source: Texas Department of Transportation (2012a)

3.4 Funding Classification

In this section, the future funding estimates (see Table 6) are reclassified into the following six funding categories:

- Urban maintenance,
- Rural maintenance,
- Urban construction,
- Rural construction,
- Urban environmental, and
- Rural environmental.

To accomplish this goal, each category/program of the UTP was split into three categories:

- Maintenance,
- Construction, and
- Environmental.

These funding estimates were then divided into rural and urban funding. If possible the split of urban versus rural funding was obtained through the total amount of project expenditures planned for urban and rural areas from a project list of each category/program of the UTP. If that was unavailable, then reliable data sources, such as the District and County Statistics (Texas Department of Transportation 2012b) that include the amount of the current construction and maintenance funding, were used instead. All assumptions regarding funding estimates are provided in this section. Since MBUFs will be collected from surface transportation modes, Aviation and State Waterways and Coastal Waters Programs are excluded in the analysis. As mentioned in the previous section, all counties within Texas were classified as either rural or urban using both the criteria of 50,000 population and MPO boundary for this analysis. As noted in Appendix A, the counties included in MPO boundaries are considered urban areas, and the counties not included in the MPO boundary and the counties with populations less than 50,000 are considered rural areas.

3.4.1 Category 1: Preventive Maintenance and Rehabilitation

Category 1 funding is used for preventive maintenance and rehabilitation of the existing state highway system (Texas Department of Transportation 2012a) and is classified as either urban maintenance or rural maintenance funding. A category 1 project list containing information about project areas is not provided in the UTP, so for the purposes of this analysis, the proportions of the contracted maintenance costs for rural and urban areas in the FY2010 District and County Statistics (DISCOS) (Texas Department of Transportation 2012b) are used to estimate the future proportions of category 1 funds spent in rural and urban areas. The proportions are shown in Table 7, and the results of category 1 funds are shown in Table 8.

TABLE 7 Contracted Maintenance Costs and Proportions

Maintenance FY2010	Urban	Rural	Total
Amount of funding	$1,130,841,895	$648,043,685	$1,778,885,581
Proportions	63.57%	36.43%	100%

Source: Texas Department of Transportation (2012b)

TABLE 8 Classification of Category 1 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban maintenance	583,543,050	663,641,557	622,708,677	640,495,631	710,918,747	766,224,859
Rural maintenance	334,406,950	380,308,443	356,851,323	367,044,369	407,401,253	439,095,141
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban maintenance	688,376,739	663,654,271	812,942,631	812,942,631	6,965,448,794 (63.57%)	
Rural maintenance	394,483,261	380,315,729	465,867,369	465,867,369	3,991,641,206 (36.43%)	

3.4.2 Category 2: Metropolitan and Urban Corridor Projects

Category 2 funding is allocated in order to enhance mobility in all metropolitan areas with populations of 50,000 or more (Texas Department of Transportation 2012a). Most projects in this category are related to construction projects such as the construction of a new six-lane road near Dallas and the expansion of a non-toll expressway near San Antonio to six lanes. Category 2 funding is classified as urban construction funding because category 2 funds are only used for metropolitan areas. See Table 9 for the resulting category 2 funding allocations.

TABLE 9 Classification of Category 2 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban construction	59,980,000	120,820,000	196,470,000	263,960,000	267,790,000	225,190,000
Rural construction	0	0	0	0	0	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban construction	315,910,000	382,630,000	153,560,000	0	1,986,310,000	
Rural construction	0	0	0	0	0	

3.4.3 Category 3: Non-traditional Funded Transportation Projects

Category 3 funding is used to enhance mobility through the use of funding sources not traditionally allocated for the state highway system because projects in this category do not qualify for traditional state highway funding. Category 3 funds include state bond financing under programs such as Proposition 12 (general obligation bonds), pass-through toll financing, unique federal funding, regional toll revenue, and local participation funding (Texas Department of Transportation 2012a). The construction of toll lanes and frontage roads near Austin and the reconstruction of six to eight main lanes and four concurrent managed/high-occupancy vehicle lanes near Dallas are example projects included in this category. Most projects in this category are related to construction projects. Category 3 funding is classified as construction funding and is designated as both urban and rural funding using the proportions based on the category 3

project list, which contains project area information and its funding estimates in the UTP (see Table 10 for the proportions). Note that there are no planned projects in this category in FY2019 and FY2021. Table 11 summarizes the category 3 funding.

TABLE 10 Rural and Urban Proportions of Category 3 Funding

Category 3	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Urban	86.4%	99.4%	100%	100%	100%	100%	100%	-	100%	-
Rural	13.6%	0.6%	0%	0%	0%	0%	0%	-	0%	-

TABLE 11 Classification of Category 3 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban construction	1,208,787,332	1,581,719,441	216,200,000	995,060,000	23,510,000	5,000,000
Rural construction	190,572,668	10,170,559	0	0	0	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban construction	2,000,000	0	174,000,000	0	4,206,276,773	
Rural construction	0	0	0	0	200,743,227	

3.4.4 Category 4: Statewide Connectivity Corridor Projects

Category 4 funding is allocated for mobility and added-capacity project needs on major state highway system corridors that provide statewide connectivity (Texas Department of Transportation 2012a). Category 4 funding is classified as construction funding. There is just one planned project from FY2012 to FY2021 in this category: the expansion of a rural divided rural highway from two to four lanes near San Antonio in FY2012 (see Table 12).

TABLE 12 Classification of Category 4 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban construction	19,000,000	0	0	0	0	0
Rural construction	0	0	0	0	0	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban construction	0	0	0	0	19,000,000	
Rural construction	0	0	0	0	0	

3.4.5 Category 5: Congestion Mitigation and Air Quality Improvement

Category 5 funding is allocated to attain national ambient air quality standards in cities that are currently in non-attainment status, including Dallas, Fort Worth, Houston, Beaumont, and El Paso. Projects in this category are related to congestion mitigation and air quality improvement (Texas Department of Transportation 2012a). Category 5 funding is classified as environmental funding. Since this funding category is only used for urban areas, all funds in this category are classified as urban environmental funding (see Table 13).

TABLE 13 Classification of Category 5 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban environmental	80,830,000	106,000,000	110,610,000	113,800,000	115,040,000	116,310,000
Rural environmental	0	0	0	0	0	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban environmental	117,600,000	118,930,000	120,270,000	121,650,000	1,121,040,000	
Rural environmental	0	0	0	0	0	

3.4.6 Category 6: Structures Replacement and Rehabilitation

Category 6 funding is allocated for replacement or rehabilitation of existing deficient bridges such as the rehabilitation project of an existing bridge and approaches near Beaumont. This funding is also used for construction of grade separation of existing highway-railroad grade crossings and rehabilitation of deficient railroad underpasses on the state highway system (Texas Department of Transportation 2012a). Category 6 funding is classified as maintenance funding. The proportions of rural and urban funding are estimated based on the category 6 project list in the UTP (see Table 14). Since the UTP does not provide a project list for FY2016 to FY2021, the average proportions from FY2012 to FY2015 are used for that period (see Table 15).

TABLE 14 Rural and Urban Proportions of Category 6 Funding

Category 6	2012	2013	2014	2015	Average
Urban	62.51%	50.72%	67.92%	62.66%	60.79%
Rural	37.49%	49.28%	32.08%	37.34%	39.21%

TABLE 15 Classification of Category 6 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban maintenance	156,273,863	126,791,434	169,800,960	156,653,315	151,966,427	151,966,427
Rural maintenance	93,726,137	123,208,566	80,199,040	93,346,685	98,033,573	98,033,573
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban maintenance	151,966,427	151,966,427	151,966,427	151,966,427	1,521,318,133	
Rural maintenance	98,033,573	98,033,573	98,033,573	98,033,573	978,681,867	

3.4.7 Category 7: Metropolitan Mobility/Rehabilitation

Category 7 funding is allocated for transportation needs within the metropolitan area boundaries of MPOs with an urbanized area population of 200,000 or more (Texas Department of Transportation 2012a). Category 7 funding is classified as urban construction funding. The classification result of category 7 funding is provided in Table 16.

TABLE 16 Classification of Category 7 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban construction	178,650,000	202,720,000	224,790,000	196,780,000	198,950,000	201,130,000
Rural construction	0	0	0	0	0	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban construction	203,370,000	205,650,000	207,990,000	210,370,000	2,030,400,000	
Rural construction	0	0	0	0	0	

3.4.8 Category 8: Safety

Category 8 funding is allocated for three federal-aid safety improvement programs: the Highway Safety Improvement Program (HSIP), Safe Routes to School Program, and Federal Railway-Highway Safety Program (Texas Department of Transportation 2012a). Since there was no detailed project list for this category, it is unclear how to appropriately categorize this funding. Since safety projects generally improve safety of an existing transportation system instead of improving safety by construction of a new system, category 8 funding is classified as maintenance funding for the purposes of this analysis. Since there is no project list for this category, the rural and urban funding proportions cannot be directly estimated. As an alternative approach, the average proportions from the Category 8: Proposition 14 Safety Bond program related to construction projects for safety will be used. Since both categories have the same objective of safety improvements, it is assumed that a similar ratio of urban versus rural spending will occur in each category. The proportions used to classify the funding into rural and urban areas, and the classification results, are provided in Table 17 and Table 18, respectively.

TABLE 17 Rural and Urban Proportions of Category 8: Proposition 14 Safety Bond Funding

Category 8	Average from FY2012 to FY2021
Urban	40.96%
Rural	59.04%

TABLE 18 Classification of Category 8 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban maintenance	49,153,417	50,791,864	50,791,864	50,791,864	50,791,864	50,791,864
Rural maintenance	70,846,583	73,208,136	73,208,136	73,208,136	73,208,136	73,208,136
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban maintenance	50,791,864	50,791,864	50,791,864	50,791,864	506,280,198	
Rural maintenance	73,208,136	73,208,136	73,208,136	73,208,136	729,719,802	

3.4.9 Category 9: Transportation Enhancement

Category 9 funding is allocated for projects that are above and beyond what could normally be expected in the way of enhancements to the transportation system. The projects in this category include development of bicycle and pedestrian facilities, safety and educational activities for pedestrians and bicyclists, development of scenic or historic highway programs, landscaping and

other scenic beautification, historic preservation, rehabilitation and operation of historic transportation buildings and facilities, preservation of abandoned railway corridors, archaeological planning and research, environmental mitigation to address water pollution due to highways, reduction in vehicle-caused wildlife mortality, etc. (Texas Department of Transportation 2012a). Because these projects are intended to enhance environmental sustainability, category 9 funding is classified as environmental funding. Since there is no project list for this category, rural and urban funding proportions cannot be directly estimated. As an alternative, the rural and urban proportions from category 10 (supplemental transportation projects) are used to estimate the rural and urban transportation funding because the characteristics of category 9 projects are very similar to the characteristics of category 10 projects. Table 19 provides the classification result.

TABLE 19 Classification of Category 9 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban environmental	54,225,223	61,113,473	62,960,000	61,993,443	43,531,156	65,040,000
Rural environmental	7,414,777	1,186,527	0	1,646,557	20,798,844	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban environmental	65,770,000	66,510,000	67,260,000	68,030,000	616,433,295	
Rural environmental	0	0	0	0	31,046,705	

3.4.10 Category 10: Supplemental Transportation Projects

Category 10 funding is allocated for projects that do not qualify for funding under other categories such as Peach Street area access improvements at a railroad crossing near Fort Worth. These projects include state park roads, the Railroad Rehabilitation and Improvement Program, the Landscape Incentives Awards Program, the Curb Ramp Program, the Green Ribbon Landscape Improvement Program, the Forest Highways—Federal Program, etc. (Texas Department of Transportation 2012a). Category 10 funding is classified as environmental funding. The urban and rural proportions of this category of funding are estimated using the project list in the UTP. Table 20 provides the proportions for rural and urban transportation funding. Table 21 provides the classification result.

TABLE 20 Rural and Urban Proportions of Category 10 Funding

Category 10	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Urban	88.0%	98.1%	100%	97.4%	67.7%	100%	100%	100%	100%	100%
Rural	12.0%	1.9%	0%	2.6%	32.3%	0%	0%	0%	0%	0%

TABLE 21 Classification of Category 10 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban environmental	86,607,287	84,283,621	54,610,000	52,135,278	41,717,640	57,900,000
Rural environmental	11,842,713	1,636,379	0	1,384,722	19,932,360	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban environmental	57,910,000	57,850,000	59,920,000	42,990,000	595,923,826	
Rural environmental	0	0	0	0	34,796,174	

3.4.11 Category 11: District Discretionary

Category 11 funding is allocated for projects selected at the TxDOT district's discretion. Funding from this category can be used for many kinds of projects, but most funds are used for non-capacity improvement projects. Only some projects may be selected for construction on the state highway system. Historically, category 11 funding has been used for overlay, roadway reconstruction, underpasses, and resurfacing projects (Bucher Willis and Ratliff Corporation 2009). Because this category of funding is generally related to non-capacity improvement projects, category 11 funding is classified as maintenance funding. Since there is no planned project list in the UTP, the rural and urban proportions of category 1 (maintenance funding) were used (see Table 22).

TABLE 22 Classification of Category 11 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban maintenance	59,780,288	60,235,552	51,734,533	51,734,533	51,734,533	51,734,533
Rural maintenance	12,439,712	12,534,448	10,765,467	10,765,467	10,765,467	10,765,467
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban maintenance	51,734,533	51,734,533	51,734,533	51,734,533	533,892,105	
Rural maintenance	10,765,467	10,765,467	10,765,467	10,765,467	111,097,895	

3.4.12 Category 12: Strategic Priority

Category 12 funding is used for projects selected by the Texas Transportation Commission that generally promote economic development, increase efficiency of military deployment routes, and maintain the ability to respond to both man-made and natural emergencies (Texas Department of Transportation 2012a). Most projects in this category are related to construction projects such as the reconstruction and widening of an expressway from four to six lanes near Waco. Category 12 funding is classified as construction funding. A project list for this category is only provided in the UTP for the year 2012. It is assumed that the rural and urban proportions in FY2012 may be used for the future years. Table 23 provides the proportions, and Table 24 provides the classification result.

TABLE 23 Rural and Urban Proportions of Category 12 Funding

Category 12	FY2012
Urban	88.25%
Rural	11.75%

TABLE 24 Classification of Category 12 Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban construction	636,510,167	144,329,649	126,131,793	377,000,975	96,540,420	83,117,074
Rural construction	84,719,833	19,210,351	16,788,207	50,179,025	12,849,580	11,062,926
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban construction	133,130,290	129,626,629	145,273,961	306,742,424	2,178,403,382	
Rural construction	17,719,710	17,253,371	19,336,039	40,827,576	289,946,618	

3.4.13 Category 8: Proposition 14 Safety Bond

This category of funding is allocated for the safety bond program approved by the Texas Transportation Commission throughout the state (Texas Department of Transportation 2012a). Based on the project list in the UTP, the majority of projects listed in this category are related to construction projects such as the construction of grade separation for safety near San Antonio. Based on the project list, this category is classified as construction funding. Rural and urban proportions of funding were estimated based on the project list. Note that there are only planned projects for FY2012, FY2013, and FY2015 in this category. The proportions are provided in Table 25, and the classification results are provided in Table 26.

TABLE 25 Rural and Urban Proportions of Category 8: Proposition 14 Safety Bond Funding

Category 8: Safety Bond	FY2012	FY2013	FY2015
Urban	41.55%	41.18%	0.00%
Rural	58.45%	58.82%	100.00%

TABLE 26 Classification of Category 8: Proposition 14 Safety Bond Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban construction	33,142,761	16,831,685	0	0	0	0
Rural construction	46,627,239	24,038,315	0	1,360,000	0	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban construction	0	0	0	0	49,974,445	
Rural construction	0	0	0	0	72,025,555	

3.4.14 Category 10: Earmarks—Federal Share

This category follows the characteristics and the urban and rural proportions of category 10 funding, so this category is classified as environmental funding. The rural and urban funding was estimated using the proportions of category 10 provided in Table 20. Table 27 provides the classification results.

TABLE 27 Classification of Category 10: Earmarks—Federal Share Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban environmental	93,715,331	103,853,665	15,720,000	27,070,990	3,606,732	800,000
Rural environmental	12,814,669	2,016,335	0	719,010	1,723,268	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban environmental	850,000	580,000	8,880,000	1,580,000	256,656,718	
Rural environmental	0	0	0	0	17,273,282	

3.4.15 Railroad

This category of funding is used for railroad-related projects. According to the Texas Rail Plan, the Texas rail system aims to provide cost-effective, energy-efficient, sustainable personal mobility and goods movement that connect Texas communities and link Texas businesses with domestic and international markets while minimizing environmental impacts and improving air quality (Texas Department of Transportation 2010a). Based on this, this category is classified as environmental funding. Examples of these projects include the signal timing improvements on the railroad near Fort Worth and the rehabilitation of South Orient Railroad near San Angelo. The rural and urban funding for this category is estimated using the project list in the UTP. The proportions are provided in Table 28, and the classification result is provided in Table 29. Railroad projects are only scheduled in FY2012.

TABLE 28 Rural and Urban Proportions of Railroad Funding

Railroad (FY2012)	Urban	Rural	Total
Proportion	95.37%	4.63%	100%

TABLE 29 Classification of Railroad Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban environmental	54,945,136	0	0	0	0	0
Rural environmental	2,664,864	0	0	0	0	0
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban environmental	0	0	0	0	54,945,136	
Rural environmental	0	0	0	0	2,664,864	

3.4.16 Transit

This category of funding is mainly used for construction, improvement, and operation of public transit systems. The transit category funding is classified as environmental funding. As provided in Table 6, transit funding is dispersed in a lump sum for four years without providing yearly amounts. Only the transit funding from FY2012 to FY2015 is provided in the UTP, so it is assumed that the current transit funding is the same from FY2016 to FY2021. As a result, $39,587,500 ($158,350,000 divided by four years) is used as the one-year statewide transit funding for the period from FY2012 to FY2021. Regarding the rural and urban proportions of transit funding, a transit project list providing project area information is not provided in the UTP, so the rural and urban proportions of transit funding are estimated using the formula in the Texas Transit Programs. The Texas Transit Programs include:

- Section 5303 Planning Program,
- Section 5304 Planning Program,
- Section 5307 Urbanized Formula Program,
- Section 5310 Elderly Individuals with Individuals with Disabilities Program,
- Section 5311 Non-urbanized Program,
- Section 5316 Job Access and Reverse Commute Program, and
- Section 5317 New Freedom Program.

The rural and urban proportions of each program are provided in Table 30. Since there is no formula for the rural and urban proportion of the Section 5310 program in the UTP, the proportions estimated in previous research (Seekins et al. 2007) are used. Table 31 provides the classification results.

TABLE 30 Rural and Urban Proportions of Each Program of Transit Funding

Texas Transit Program	Urban	Rural
Section 5303-5304 Programs	100.00%	0.00%
Section 5307 Program	100.00%	0.00%
Section 5310 Program	57.13%	42.87%
Section 5311 Program	100.00%	0.00%
Section 5316 Program	80.00%	20.00%
Section 5317 Program	80.00%	20.00%
Weighted average (based on the allocated funding of each program)	94.76%	5.24%

TABLE 31 Classification of Transit Funding ($)

Category	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Urban environmental	37,514,667	37,514,667	37,514,667	37,514,667	37,514,667	37,514,667
Rural environmental	2,072,833	2,072,833	2,072,833	2,072,833	2,072,833	2,072,833
Category	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**FY2012-FY2021 Total**	
Urban environmental	37,514,667	37,514,667	37,514,667	37,514,667	375,146,666	
Rural environmental	2,072,833	2,072,833	2,072,833	2,072,833	20,728,334	

3.5 Future Funding Estimates by Classification

Based on the classification results in the previous section, the future funding estimates in the UTP of the six categories are summarized in Table 32 and Figure 2.

TABLE 32 Funding Estimates of the Six Categories in Each Year ($)

Category	2012		2013		2014		2015		2016	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Maintenance	525,289,239 12.3%	834,880,761 19.6%	603,235,079 15.1%	887,484,921 22.1%	533,027,096 21.5%	883,032,904 35.6%	556,367,787 15.3%	887,672,213 24.5%	601,411,559 24.7%	953,408,441 39.1%
Construction	321,919,740 7.5%	2,136,070,260 50.1%	53,419,226 1.3%	2,066,420,774 51.5%	16,788,207 0.7%	763,591,793 30.8%	51,539,025 1.4%	1,832,800,975 50.5%	12,849,580 0.5%	586,790,420 24.0%
Environmental	36,809,857 0.9%	407,837,643 9.6%	6,912,075 0.2%	392,765,425 9.8%	2,072,833 0.1%	281,414,667 11.3%	5,823,122 0.2%	292,514,378 8.1%	44,527,306 1.8%	241,410,194 9.9%
Total	4,262,807,500		4,010,237,500		2,479,927,500		3,626,717,500		2,440,397,500	

Category	2017		2018		2019		2020		2021	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Maintenance	633,105,447 25.9%	1,008,714,553 41.2%	588,493,568 23.8%	930,866,432 37.6%	574,326,035 23.0%	906,143,965 36.3%	659,877,676 24.4%	1,055,432,324 38.9%	659,877,676 25.9%	1,055,432,324 41.4%
Construction	11,062,926 0.5%	514,437,074 21.0%	17,719,710 0.7%	654,410,290 26.5%	17,253,371 0.7%	717,906,629 28.7%	19,336,039 0.7%	680,823,961 25.1%	40,827,576 1.6%	517,112,424 20.3%
Environmental	2,072,833 0.1%	277,564,667 11.3%	2,072,833 0.1%	279,644,667 11.3%	2,072,833 0.1%	281,384,667 11.2%	2,072,833 0.1%	293,844,667 10.8%	2,072,833 0.1%	271,764,667 10.7%
Total	2,446,957,500		2,473,207,500		2,499,087,500		2,711,387,500		2,547,087,500	

Urban Construction	Urban Maintenance	Urban Environmental
• Category 2: Metropolitan and Urban Corridor Projects • Category 3: Non-traditional Funded Transportation Projects • Category 4: Statewide Connectivity Corridor Projects • Category 7: Metropolitan Mobility/Rehabilitation • Category 12: Strategic Priority • Category 8: Prop. 14 Safety Bond	• Category 1: Preventive Maintenance and Rehabilitation • Category 6: Structures Replacement and Rehabilitation • Category 8: Safety • Category 11: District Discretionary	• Category 5: Congestion Mitigation and Air Quality Improvement • Category 9: Transportation Enhancement • Category 10: Supplemental Transportation Projects • Category 10: Earmarks—Fed. Share • Railroad • Transit

Rural Construction	Rural Maintenance	Rural Environmental
• Category 3: Non-traditional Funded Transportation Projects • Category 12: Strategic Priority • Category 8: Prop. 14 Safety Bond	• Category 1: Preventive Maintenance and Rehabilitation • Category 6: Structures Replacement and Rehabilitation • Category 8: Safety • Category 11: District Discretionary	• Category 9: Transportation Enhancement • Category 10: Supplemental Transportation Projects • Category 10: Earmarks—Fed. Share • Railroad • Transit

FIGURE 2 Classification of the UTP's Categories/Programs into the Six Categories

Based on the results in Table 32, urban construction funding is the largest category in the initial year. However, after FY2015, urban maintenance funding will occupy the largest portion among the six categories. Only a little funding is allocated for rural environmental funding for the next 10 years. Table 33 provides the total amount of funding in each category for the next 10 years. Most transportation funding (77.6 percent) will be used for urban areas. Only a small portion of the funding (10.6 percent) will be used for the transportation projects related to improvement of the environment, whereas 52.0 percent and 37.4 percent of the funding will be used for maintenance and construction, respectively.

TABLE 33 Total Amount of Funding of Each Category for the Next 10 Years

FY2012–FY2021			
Category	**Rural**	**Urban**	**Total**
Maintenance	5,935,011,162 20.1%	9,403,068,838 31.9%	15,338,080,000 52.0%
Construction	562,715,400 1.9%	10,470,364,600 35.5%	11,033,080,000 37.4%
Environment	106,509,360 0.4%	3,020,145,640 10.2%	3,126,655,000 10.6%
Total	6,604,235,921 22.4%	22,893,579,079 77.6%	29,497,815,000 100.0%

3.6 Distribution of Total Expense Forecast

In the previous sections, the future funding estimates found in the UTP were classified into the six categories of funding disbursement. However, these estimates only include the funds for fully approved future projects (see Table 34 for the difference). Also included in the UTP is a total expense forecast. This provides the total future cash flows based on department operations, financial participation by others, and the dollar value of project commitments (Texas Department of Transportation 2012a). Thus, the UTP future funding estimates do not include expenses and projected costs for project development (such as project engineering, right-of-way, and professional services), maintenance, operations, debt service, etc., and do not take into account all the expenditures and expected payouts from previous projects. However, the total expense forecast does account for these expenditures and is therefore closer to the true future transportation funding estimates. Since a detailed distribution plan for the total expense forecast is not provided, the total expense forecast cannot be directly classified into the six categories used in this research. Therefore, this research allocated research expenditures to the six categories in the proportions found in the future funding estimates derived from the UTP (see Table 35 for the proportions). Next, these proportions were multiplied by the total expenses as outlined in the total expense forecast to determine the total expenditures in each category.

TABLE 34 The Total Expense Forecast and the UTP Estimates

	FY2012	FY2013	FY2014	FY2015	FY2016
Total Expense Forecast	$9,183,382,052	$8,467,137,104	$7,788,873,254	$6,938,795,065	$6,072,209,729
UTP Estimates	$4,262,807,500	$4,010,237,500	$2,479,927,500	$3,626,717,500	$2,440,397,500
	FY2017	**FY2018**	**FY2019**	**FY2020**	**FY2021**
Total Expense Forecast	$5,878,082,948	$5,898,823,399	$5,839,173,405	$5,937,001,928	$6,051,752,927
UTP Estimates	$2,446,957,500	$2,473,207,500	$2,499,087,500	$2,711,387,500	$2,547,087,500

Table 35 provides the results of the classification of the total expense forecast into the six categories. Note that these estimates were used in the analysis as the future transportation funding disbursement of the six categories.

TABLE 35 Classification of the Total Expense Forecast into Six Categories ($)

Category	FY2012		FY2013		FY2014		FY2015	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Maintenance	1,131,632,561 12.32%	1,798,586,729 19.59%	1,273,658,760 15.04%	1,873,818,322 22.13%	1,674,113,655 21.49%	2,773,400,177 35.61%	1,064,467,264 15.34%	1,698,333,430 24.48%
Construction	693,512,893 7.55%	4,601,744,106 50.11%	112,788,310 1.33%	4,363,000,448 51.53%	52,727,838 0.68%	2,398,263,535 30.79%	98,606,724 1.42%	3,506,595,251 50.54%
Environmental	79,299,612 0.86%	878,606,151 9.57%	14,594,020 0.17%	829,277,244 9.79%	6,510,284 0.08%	883,857,763 11.35%	11,141,053 0.16%	559,651,344 8.07%
Total	9,183,382,052		8,467,137,104		7,788,873,254		6,938,795,065	

Category	FY2016		FY2017		FY2018		FY2019	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Maintenance	1,496,435,363 24.64%	2,372,275,833 39.07%	1,520,846,329 25.87%	2,423,134,776 41.22%	1,403,610,344 23.79%	2,220,200,566 37.64%	1,341,925,527 22.98%	2,117,225,484 36.26%
Construction	31,972,392 0.53%	1,460,054,969 24.04%	26,575,368 0.45%	1,235,781,084 21.02%	42,263,110 0.72%	1,560,827,683 26.46%	40,312,884 0.69%	1,677,404,771 28.73%
Environmental	110,793,074 1.82%	600,678,098 9.89%	4,979,361 0.08%	666,766,029 11.34%	4,943,894 0.08%	666,977,803 11.31%	4,843,220 0.08%	657,461,519 11.26%
Total	6,072,209,729		5,878,082,948		5,898,823,399		5,839,173,405	

Category	FY2020		FY2021	
	Rural	Urban	Rural	Urban
Maintenance	1,444,904,144 24.34%	2,311,032,172 38.93%	1,567,836,463 25.91%	2,507,654,588 41.44%
Construction	42,339,245 0.71%	1,490,769,272 25.11%	97,004,285 1.60%	1,228,633,341 20.30%
Environmental	4,538,788 0.08%	643,418,307 10.84%	4,924,948 0.08%	645,699,301 10.67%
Total	5,937,001,928		6,051,752,927	

CHAPTER 4: TRAVEL DATA

The NHTS is a large-scale, nationwide survey that provides planners and researchers with information regarding the travel behavior of Americans, as well as demographic information that may affect travel (U.S. Department of Transportation 2010). The most recent survey is the 2009 NHTS, which was conducted from March 2008 to May 2009 and includes over 150,000 households nationwide. These households were randomly selected to reflect the entire population when the sample is properly weighted. One unique feature of the survey is that the data include VMT and fuel efficiency information by household. This feature can be used to estimate each household's tax burden, either when the current gas tax is implemented or if an MBUF is implemented. Therefore, gas tax revenue collected either in a specific location (rural or urban area) or from a specific household income class can also be estimated. As a result, the geographical equity and vertical equity of the current gas tax and the MBUF can be estimated. Therefore, this research used data from the 2009 NHTS. However, since the geographical boundary (that defines rural and urban households) of the 2009 NHTS data is different from that of the transportation funding data, the 2009 NHTS data had to be adjusted. Researchers also need to consider future travel behavior because this research deals with future transportation funding. However, the 2009 NHTS data set only provides household travel information in 2008. Thus, future estimates of the number of vehicles, their fuel efficiency, and fuel cost were estimated.

4.1 Weighting the 2009 NHTS Data Set

The 2009 NHTS data include a weighting variable that can be used to adjust the new data to better reflect all Texas households. However, the weights cannot be used in this research without modification because the geographic boundary used by NHTS to divide rural and urban households is different from the boundary that was used to classify transportation funding. This may result in inaccurate analysis of geographical equity when considering a change in the tax system. Thus, in this research, the 2009 NHTS data set was weighted to reflect the Texas population based on their household geographic location.

The 2009 NHTS data set includes a household location variable with households classified as either rural or urban. This variable was categorized by the cartographic boundary (see Appendix A and Figure A-1 for a detailed explanation). This boundary was not consistent with the county boundary used to divide the rural and urban area households for funding in Chapter 3. Thus, each data set was analyzed to identify the number of households in rural and urban areas (see Table 36). The 54 urban counties, as defined in Chapter 3, had a 2010 Census population of 7,676,751 households (86 percent), while the 200 rural counties had 1,246,182 households (14 percent). Based on the 2009 NHTS data, there were 1,714,454 rural Texas households (22 percent) and 6,199,869 urban Texas households (78 percent).

TABLE 36 The Number of Households in the 2010 Census and the 2009 NHTS

	(a) 2010 Census Statistics (2010)	(b) 2009 NHTS Data (2008)	Ratio (b/a)
Rural	1,246,182 (14%)	1,714,454 (22%)	1.38
Urban	7,676,751 (86%)	6,199,869 (78%)	0.81
Total	8,922,933 (100%)	7,914,323 (100%)	0.89

Source the for 2010 Census: Texas State Data Center (2013a)

The total number of households in the 2010 Census is also different from the total number of households in the 2009 NHTS data set. The main reason for this difference is that the households in the 2009 NHTS data set modified for this research only represent vehicle-owning households, while the households in the 2010 Census represent all households regardless of vehicle ownership. Furthermore, the two-year difference in when the data were collected may produce additional differences in the total number of households. The 2010 Census data were the most reliable source and matched the funding data set based on county boundaries, and were therefore used as the true total population. However, the difference in the percentage of rural and urban households between both data sets needs to be considered because the difference is caused by the use of the different boundaries in both data sets.

The most ideal method to adjust the difference is to recategorize one data set based on the boundary of the other data set. However, this method could not be applied because the 2009 NHTS data set only mentions whether the household was rural or urban, and not the specific address of a household.

Therefore, this research adjusted the ratios of rural and urban NHTS households to match the 2010 Census. For this, the weight variable included in the 2009 NHTS data was adjusted using Equations 1 and 2:

$$\text{Adjusted Weight of Rural HH} = \text{Weight of Rural HH} \times \frac{Total\ Number\ of\ Households\ \times 14\%}{Number\ of\ Households\ in\ the\ Rural\ Area} \quad (1)$$

$$= \text{Weight of Rural HH} \times \frac{7{,}914{,}323\ \times 14\%}{1{,}714{,}454}$$

$$\text{Adjusted Weight of Urban HH} = \text{Weight of Urban HH} \times \frac{Total\ Number\ of\ Households\ \times 86\%}{Number\ of\ Households\ in\ the\ Urban\ Area} \quad (2)$$

$$= \text{Weight of Urban HH} \times \frac{7{,}914{,}323\ \times 86\%}{6{,}199{,}869}$$

where HH = household.

To better understand this calculation to adjust the weights in the 2009 NHTS data, an example calculation is shown in Example 1:

Example 1: Adjusting weights in the 2009 NHTS data:

- Weight of the Rural Household (Household ID: 20001603): 291
- Adjusted Weight of the Rural Household:

$$= \text{Weight of Rural HH} \times \frac{7{,}914{,}323 \ \times 14\%}{1{,}714{,}454} = 291 \times \frac{7{,}914{,}323 \ \times 14\%}{1{,}714{,}454}$$

$$= 188$$

- Weight of the Urban Household (Household ID: 20000231): 1076
- Adjusted Weight of the Urban Household:

$$= \text{Weight of Urban HH} \times \frac{7{,}914{,}323 \ \times 86\%}{6{,}199{,}869} = 1076 \times \frac{7{,}914{,}323 \ \times 86\%}{6{,}199{,}869}$$

$$= 1181$$

After applying the adjusted weights, the percentages of urban and rural households became the same in the NHTS and in the Census data (see the third and fourth columns in Table 37) compared to the previous ratio in Table 36, which was not consistent. Also note that the ratios between the 2008 NHTS population and 2010 Census population became 0.89 after adjusting the weights (see the fifth column in Table 37).

TABLE 37 Changes in the Number of Households

	2009 NHTS Data (2008)		**(c) 2010 Census Statistics (2010)**	**Ratio (b/c)**
	(a) Before Adjusting the Weights	**(b) After Adjusting the Weights**		
Rural HHs	1,714,454 (22%)	1,105,319 (14%)	1,246,182 (14%)	0.89
Urban HHs	6,199,869 (78%)	6,809,004 (86%)	7,676,751 (86%)	0.89
Total HHs	7,914,323 (100%)	7,914,323 (100%)	8,922,933 (100%)	0.89

The results of the number of households disaggregated by the four criteria (household income level, number of employed household members, household size, and household geographic location) were analyzed. The next two tables (Table 38 and Table 39) represent the results of the number of households after adjusting the weights.

TABLE 38 Number of Vehicle-Owning Urban Households in Texas in 2008 (after Adjustment)

0 Employees	Household Size				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	267,641	142,164	37,584	78,357	525,747
20–40	155,269	117,348	20,035	35,962	328,615
40–60	56,574	68,868	8,634	13,201	147,278
60–100	26,410	56,693	5,923	9,476	98,501
100+	12,788	38,014	7,133	12,364	70,299
Total	518,683	423,087	79,310	149,360	1,170,439
1 Employee	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	186,191	120,821	81,313	186,007	574,332
20–40	373,271	171,557	106,812	188,741	840,381
40–60	267,928	166,160	69,345	85,411	588,843
60–100	244,715	156,736	92,704	110,178	604,333
100+	105,349	146,341	64,742	110,321	426,752
Total	1,177,454	761,613	414,917	680,658	3,034,641
2+ Employees	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	41,220	54,552	149,749	245,520
20–40	NA	100,875	85,688	201,991	388,554
40–60	NA	170,965	104,824	172,725	448,513
60–100	NA	254,232	209,309	262,052	725,593
100+	NA	309,838	203,327	282,580	795,745
Total	NA	877,129	657,699	1,069,097	2,603,925
Total	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	453,832	304,204	173,450	414,113	1,345,599
20–40	528,540	389,780	212,536	426,694	1,557,550
40–60	324,502	405,992	182,803	271,337	1,184,634
60–100	271,125	467,660	307,936	381,706	1,428,427
100+	118,137	494,193	275,202	405,265	1,292,796
Total	1,696,136	2,061,829	1,151,926	1,899,115	6,809,006

TABLE 39 Number of Vehicle-Owning Rural Households in Texas in 2008 (after Adjustment)

0 Employees	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	45,692	30,390	6,437	6,786	89,305
20–40	23,153	34,812	3,174	5,157	66,296
40–60	8,122	19,878	1,433	3,072	32,505
60–100	5,095	16,294	3,048	4,300	28,736
100+	2,260	8,774	1,349	2,454	14,837
Total	84,322	110,148	15,441	21,768	231,679
1 Employee	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	24,240	13,999	15,430	15,398	69,066
20–40	35,721	29,312	13,204	20,650	98,887
40–60	32,391	29,764	10,164	11,354	83,672
60–100	19,220	30,014	16,234	25,135	90,602
100+	8,767	27,261	15,133	21,502	72,662
Total	120,340	130,348	70,165	94,037	414,890
2+ Employees	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	NA	3,637	5,191	15,672	24,501
20–40	NA	17,053	14,208	44,766	76,027
40–60	NA	25,068	13,993	30,515	69,577
60–100	NA	56,661	28,956	54,086	139,703
100+	NA	52,439	37,957	58,547	148,943
Total	NA	154,859	100,305	203,586	458,750
Total	**Household Size**				
Household Income Level ($1,000s)	**1**	**2**	**3**	**4+**	**Total**
<20	69,932	48,026	27,058	37,855	182,872
20–40	58,875	81,177	30,586	70,573	241,210
40–60	40,513	74,709	25,590	44,941	185,753
60–100	24,315	102,969	48,238	83,520	259,042
100+	11,027	88,474	54,439	82,502	236,442
Total	204,661	395,355	185,911	319,391	1,105,319

4.2 Estimating Future Travel Data from 2012 To 2021

The 2009 NHTS data only provide 2008 travel information for households. However, this research requires future travel data from 2012 to 2021 to estimate tax from either the current gas tax or an MBUF. To estimate the tax revenues from 2012 to 2021, the number of vehicles in the future, future fuel efficiency in miles per gallon (MPG), and future fuel cost are required.

4.2.1 Estimating NHTS Weights from 2012 to 2021

Each weight in Section 4.1 reflects the number of vehicles that may have the same travel characteristics in 2008. Thus, the sum of the weights is the same as the total number of vehicles owned by Texas households. Those weights cannot be used for future estimation because the number of vehicles in Texas will change in the future. Thus, the weights for future travel need to be generated. If there are projections for vehicle increase rates in Texas for the future, the weights in 2008 can be easily adjusted using the rates for the future weights. However, the data needed for this research (projected vehicle increase rates classified by the household location (rural and urban areas)) were not available. .

To estimate the number of vehicles in Texas during 2012 to 2021, this research first estimates past vehicle increases in both rural and urban areas between 2001 and 2007 (see Table 40).

TABLE 40 Registered Vehicles in Texas and Increase Rate

	2001	2007	Increase	Percent Increase	Average Annual Percentage Increase
Registered vehicles in rural areas	2,975,311	3,490,049	514,738	**17.30%**	2.70%
Registered vehicles in urban areas	14,489,524	17,412,592	2,923,068	**20.17%**	3.11%
Total registered vehicles in Texas	17,464,835	20,902,641	3,437,806	**19.68%**	3.04%

Source: Texas Department of Transportation (2013)

This research also considered past population increases in both rural and urban areas between 2001 and 2007 (see Table 41) because the change in population generally affects the number of vehicles.

TABLE 41 Population in Texas and Increase Rate

	2001	2007	Increase	Percent Increase	Average Annual Percentage Increase
Population in rural areas	3,256,561	3,383,463	126,902	**3.90%**	0.64%
Population in urban areas	18,068,457	20,520,917	2,452,460	**13.57%**	2.14%
Population in Texas	21,325,018	23,904,380	2,579,362	**12.10%**	1.92%

Source: Texas State Data Center (2013b)

When the population in rural areas increased by 3.90 percent, the number of registered vehicles in rural areas increased by 17.30 percent. Similarly, when the population in urban areas increased by 13.57 percent, the number of registered vehicles in urban areas increased by 20.17 percent. This relationship between population growth and the increase in the number of vehicles (see Table 42) was applied to estimate the future number of vehicles (see Table 43).

TABLE 42 Relationship between Vehicle Increase and Population Increase

	(a) Vehicle Increase Rate	(b) Population Increase Rate	Ratio (a/b)
Rural areas	17.30%	3.90%	**4.44**
Urban areas	20.17%	13.57%	**1.49**
All of Texas	19.68%	12.10%	1.63

TABLE 43 Population and Vehicle Increases

Year	Increases for Rural Areas		Increases for Urban Areas	
	Population	Registered Vehicles	Population	Registered Vehicles
2008	NA	NA	NA	NA
2009	0.73%	3.23%	2.06%	3.06%
2010	0.61%	2.73%	1.60%	2.38%
2011	0.88%	3.89%	1.54%	2.29%
2012	0.83%	3.70%	1.54%	2.29%
2013	0.83%	3.70%	1.53%	2.27%
2014	0.83%	3.70%	1.52%	2.25%
2015	0.85%	3.75%	1.50%	2.23%
2016	0.85%	3.75%	1.49%	2.21%
2017	0.84%	3.74%	1.48%	2.20%
2018	0.84%	3.72%	1.47%	2.18%
2019	0.84%	3.71%	1.46%	2.16%
2020	0.83%	3.70%	1.44%	2.15%
2021	0.84%	3.74%	1.43%	2.13%

Source: Population from Texas State Data Center (2013c)

The increase in the number of vehicles (Table 43) was applied to the NHTS weighting factors discussed in Section 4.1. This resulted in the increase in the number of vehicles shown in Table 44.

TABLE 44 Estimated Number of Household Vehicles in Texas from 2008 to 2021

Year	Vehicles in Rural Areas	Vehicles in Urban Areas	Total Vehicles in Texas
2008	2,494,374 (16%)	13,227,540 (84%)	15,721,914
2009	2,574,854 (16%)	13,632,063 (84%)	16,206,917
2010	2,645,141 (16%)	13,956,679 (84%)	16,601,820
2011	2,748,081 (16%)	14,276,486 (84%)	17,024,567
2012	2,849,682 (16%)	14,603,155 (84%)	17,452,837
2013	2,955,054 (17%)	14,934,913 (83%)	17,889,967
2014	3,064,516 (17%)	15,271,514 (83%)	18,336,030
2015	3,179,542 (17%)	15,612,476 (83%)	18,792,018
2016	3,298,840 (17%)	15,958,100 (83%)	19,256,940
2017	3,422,377 (17%)	16,308,715 (83%)	19,731,092
2018	3,549,801 (18%)	16,664,408 (82%)	20,214,209
2019	3,681,667 (18%)	17,024,987 (82%)	20,706,654
2020	3,817,942 (18%)	17,390,388 (82%)	21,208,330
2021	3,960,543 (18%)	17,760,354 (82%)	21,720,897

4.2.2 Estimating Fuel Efficiency Improvements

The current gas tax is charged in proportion to the amount of fuel consumed. The amount of fuel consumed in each household can be calculated by dividing the VMT of each household vehicle by the fuel efficiency (in MPG) of the vehicle. The 2009 NHTS data include these VMT and MPG estimates (included in the ANNMILES and the EIADMPG variables, respectively, in the 2009 NHTS data) of each household vehicle in 2008. However, the average fuel efficiency is expected to increase in the future (Castiglione et al. 2011). This will reduce the gas tax burden of each household and Texas gas tax revenue because the amount of fuel consumed will decrease. Table 45 provides the projections of average MPG for all vehicles in Texas that were used in the Transportation Revenue Estimator and Needs Determination System (TRENDS) model (Castiglione et al. 2011). Each vehicle in the NHTS data set had its fuel efficiency increased by the values in Table 45 for each year.

Table 46 provides average MPGs of Texas household vehicles from 2008 to 2021. Note that average MPG estimates in Table 45 include other vehicles along with household vehicles, while average MPG estimates in Table 46 include only household vehicles in Texas.

TABLE 45 Projections of Average MPG in Texas (All Vehicles)

Year	Average MPG Estimates in Texas	Percent Increase
2008	19.8215	NA
2009	20.5981	3.92%
2010	21.4313	4.05%
2011	22.3021	4.06%
2012	22.7782	2.13%
2013	23.2662	2.14%
2014	23.7874	2.24%
2015	24.3469	2.35%
2016	24.9510	2.48%
2017	25.6076	2.63%
2018	26.3263	2.81%
2019	27.1195	3.01%
2020	28.0031	3.26%
2021	28.9977	3.55%

Source: Castiglione et al. (2011)

TABLE 46 Average MPG Estimates of Texas Household Vehicles from 2008 to 2021

Year	Average MPG of Rural Household Vehicles	Average MPG of Urban Household Vehicles	Average MPG of All Texas Household Vehicles
2008	20.7675	21.0981	21.0456
2009	21.5812	21.9247	21.8701
2010	22.4542	22.8116	22.7546
2011	23.3665	23.7385	23.6784
2012	23.8654	24.2452	24.1832
2013	24.3766	24.7646	24.7006
2014	24.9227	25.3194	25.2531
2015	25.5089	25.9149	25.8463
2016	26.1419	26.5580	26.4867
2017	26.8298	27.2568	27.1828
2018	27.5828	28.0218	27.9447
2019	28.4139	28.8661	28.7857
2020	29.3396	29.8066	29.7226
2021	30.3817	30.8653	30.7771

4.2.3 Estimating Fuel Costs

The 2009 NHTS data include the cost of fuel (dollars per gallon) (the variable name in the data is GCOST) that each household paid for 1 gallon of gasoline in 2008. The values of the variable

may be different depending on household because their locations are different, and gas prices are also different depending on where gasoline is purchased.

These fuel costs are not directly involved in the calculation of the tax burden. However, a shift to the MBUF will cause a change in fuel prices because the tax is a significant component of the total fuel price. This change may also affect the VMT of households—as fuel price increases, VMT is generally reduced. This effect of fuel price change on VMT due to the shift to MBUFs will be considered in this research (a more detailed explanation is in Chapter 5). Thus, estimates of fuel cost for each household from 2012 to 2021 are also required.

For future fuel price estimates, this research assumes that the cost of fuel for each household will change at the same rate as nationwide gasoline prices. For the fuel cost estimates in 2012, historical data of average gasoline prices in Texas between 2008 and 2012 were used to estimate the increase (see Table 47) (U.S. Energy Information Administration 2013).

TABLE 47 Average Gasoline Prices and an Increase Rate in Texas between 2008 and 2012

Year	Price ($/Gallon)	Increase Rate (%)
2008	3.169	NA
2012	3.486	10.00

Note that the prices include the current federal and state gas taxes (38.4 cents).

For the fuel cost estimates from 2013 to 2021, projected U.S gasoline price changes from 2013 to 2021 were used (see Table 48) (U.S. Department of Transportation 2009).

TABLE 48 Projected Average Gasoline Prices and Increase Rates in U.S. from 2012 to 2021

Year	Price ($/Gallon)	Taxes ($/Gallon)	Retail Price ($/Gallon)	Increase Rate (%)
2012	3.112	0.384	3.496	NA
2013	3.304	0.384	3.688	5.48
2014	3.511	0.384	3.895	5.62
2015	3.679	0.384	4.063	4.31
2016	3.894	0.384	4.278	5.30
2017	4.146	0.384	4.530	5.89
2018	4.381	0.384	4.765	5.19
2019	4.657	0.384	5.041	5.79
2020	4.954	0.384	5.338	5.88
2021	5.309	0.384	5.693	6.66

Note that prices in the second column do not include the current federal and state gas taxes. Increase rates are calculated based on the retail prices in the fourth column.

The increase rates in Tables 47 and 48 are applied to each household's fuel cost estimates for each future year.

This same procedure was applied to all the fuel cost estimates in 2008 to estimate the future fuel costs. Table 49 provides average fuel cost estimates of Texas households in 2008 and from 2012 to 2021 for purchase of 1 gallon of gasoline.

TABLE 49 Average Fuel Cost Estimates of Texas Households in 2008 and from 2012 to 2021

Year	Average Fuel Cost of Rural Households ($/Gallon)	Average Fuel Cost of Urban Households ($/Gallon)	Average Fuel Cost of Entire Texas Households ($/Gallon)
2008	2.9012	2.9008	2.9009
2012	3.1914	3.1910	3.1911
2013	3.3662	3.3658	3.3659
2014	3.5553	3.5549	3.5550
2015	3.7085	3.7080	3.7082
2016	3.9052	3.9047	3.9048
2017	4.1352	4.1347	4.1348
2018	4.3498	4.3493	4.3494
2019	4.6019	4.6013	4.6015
2020	4.8722	4.8716	4.8718
2021	5.1969	5.1963	5.1965

CHAPTER 5: MBUF AND FUNDING DISBURSEMENT SCENARIOS

The development of estimates of spending on transportation for 2012 to 2021 was described in Chapter 3. In Chapter 4, weighted NHTS data were examined and used to predict future travel. From this estimate of travel, it is possible to predict revenues from either an MBUF or a gas tax. Thus, to evaluate the equity of an MBUF, this research considers a change in revenue collection as well as disbursement of funds. A shift from the current gas tax to an MBUF is considered in Scenarios 1, 2, 3, and 4. Then, in addition to using an MBUF, changes in the disbursement of funds are considered in Scenarios 2, 3, and 4. The scenarios were analyzed twice, once using revenue generated from a static model and once using revenue generated from a dynamic model. Table 50 provides a brief description of the scenarios, while more detailed scenario structures are explained in Section 5.2. Lastly, all monetary estimates in this chapter are expressed in year 2012 dollars and apply a 4 percent inflation rate. This rate is the same as the inflation rate used in the UTP (Texas Department of Transportation 2012a).

TABLE 50 Brief Description of the Scenarios

Scenarios	Gas Tax System	Funding Disbursement
Scenario 1	Current state and fed. gas tax	Same as the current disbursement
Scenario 2 (static and dynamic)	Flat MBUF and fed. gas tax	Same as the current disbursement and increased revenue by the MBUF
Scenario 3 (static and dynamic)	Flat MBUF and fed. gas tax	More disbursement to maintenance funding
Scenario 4 (static and dynamic)	Flat MBUF and fed. gas tax	More disbursement to environmental funding

5.1 Static versus Dynamic Scenarios

Revenue that will be collected from the MBUF in the future is estimated assuming no change in driver behavior due to the MBUF (static) and a change in VMT due to the MBUF (dynamic). To estimate the change in VMT due to the MBUF for the dynamic scenario, reasonable values of elasticity of demand are required. 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 2010b). Similarly, elasticity in terms of VMT and the associated price of gas/MBUF can be defined mathematically as Equation 3:

$$\text{Elasticity} = \frac{\%\ Change\ in\ VMT}{\%\ Change\ in\ Total\ Cost\ of\ Gas\ and\ MBUF} = \frac{\frac{VMT_2 - VMT_1}{VMT_1}}{\frac{P_2 - P_1}{P_1}} \qquad (3)$$

where VMT1 = original VMT,
VMT2 = new VMT,
P1 = original price of gas, and
P2 = new price of gas (no state tax) plus an MBUF.

However, since MBUF research is still in the theoretical stage, empirical elasticity in terms of VMT and the associated price of gas/MBUF cannot be directly estimated. Thus, this research adopted the values of elasticity used in previous MUBF research (Burris and Larsen 2012) (see Table 51). The values in Table 51 are the indirectly estimated values for the purpose of Burris and Larsen's research (2012) from the gasoline price elasticities in the Wadud et al. research (2009).

TABLE 51 Price Elasticities by Household Income Level and Geographic Location

Household Income Level ($1,000s)	Urban Households	Rural Households
<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

Source: Burris and Larsen (2012)

These elasticities were used to calculate the anticipated change in annual VMT for households within each subcategory disaggregated by household income level and geographic location. 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. An example calculation to determine the new annual VMT due to the MBUF using the elasticities for a single urban household whose household income level is between $20,000 and $40,000 is shown in Example 2:

Example 2: Example of Estimating VMT under a Dynamic Scenario:
Determining the new annual VMT due to the MBUF, applying the elasticities for the urban household whose household income level is between $20,000 and $40,000:

- Initial VMT: 10,000 miles
- Weight Associated with That Vehicle (Estimated in Section 4.2.1): 1304.08
- Initial Weighted VMT:
  = (Initial VMT) · (Household Vehicle's Weight) = 10,000 miles · 1304.08
  = 13,040,813 miles
- EIADMPG in 2012 (Estimated in Section 4.2.2): 26.20 MPG
- Texas State Gas Tax: $0.20 per gallon
- Price of Gas in 2012 (Estimated in Section 4.2.3): $3.21 per gallon
- Initial Revenue from State Gas Tax:
  $$= \frac{(Texas\ State\ Gas\ Tax)}{(EIADMPG)} \cdot (Initial\ Weighted\ VMT)$$
  $$= \frac{(\$0.20)}{(26.20\ MPG)} \cdot (13.040.813\ Miles) = \$99{,}544$$
- Initial Cost from the Rest of the Price of Gas:
  $$= \frac{(Price\ of\ Gas - Texas\ State\ Gas\ Tax)}{(EIADMPG)}$$

$\cdot (Initial\ Weighted\ VMT\ for\ This\ HH\ Type)$

$= \frac{(\$3.21 - \$0.20)}{(26.20\ MPG)} \cdot (13{,}040{,}813\ Miles) = \$1{,}499{,}185$

- Initial Cost of Gas:
  $=$ (Initial Revenue from State Gas Tax)
  $+$(Initial Cost from the Rest of the Price of Gas)
  $= \$99{,}544 + \$1{,}499{,}185 = \$1{,}598{,}729$

Iteration 1:

- Determining Rate of the MBUF:
  $= \frac{(Collected\ Amount\ to\ Equal\ the\ Same\ 2012\ Net\ Revenue\ as\ the\ State\ Gas\ Tax)}{(Total\ VMT\ under\ the\ State\ Gas\ Tax)}$
  $= \frac{(\$1{,}662{,}386{,}960)}{(190{,}854{,}877{,}961\ Miles\ )} = \$0.008710\ per\ Mile$
- Revenue from the MBUF:
  $=$ (Initial Weighted VMT) $\cdot$ (Flat MBUF) $=$ (13,040,813 Miles) $\cdot$ ($0.008710)
  $= \$113{,}588$
- Revenue from the MBUF plus the Cost of Gas:
  $=$ (Revenue from the MBUF) $+$ (Initial Cost of the Rest of the Price of Gas)
  $= \$113{,}588 + \$1{,}499{,}185 = \$1{,}612{,}773$
- Percent Change in Overall Price of Gas When Switching from the State Gas Tax System to the MBUF System:

$$= 100 \cdot \frac{(Revenue\ from\ the\ MBUF\ Plus\ the\ Cost\ of\ Gas) - (Inital\ Cost\ of\ Gas)}{(Initial\ Cost\ \ of\ Gas)}$$

$$= 100 \cdot \frac{(\$1{,}612{,}773) - (\$1{,}598{,}729\ )}{(\$1{,}598{,}729\ )} = 0.88\%$$

- Elasticity for the Household: −0.280
- Percent Change in VMT:
  = (Percent Change in Overall Price of Gas When Switching from State Gas Tax System to the MBUF System) · (Elasticity for the Household)
  =0.88% · −0.280= −0.25%
- New Weighted VMT due to the MBUF
  = (Initial Weighted VMT) + (Initial Weighted VMT) · (Percent Change in VMT)
  = 13,040,812.53 Miles + 13,040,812.53 Miles · −0.25% = 13,008,736.98 Miles

Iteration 2:

- Determining Rate of the New MBUF:
  $= \frac{(Collected\ Amount\ to\ Equal\ the\ Same\ 2012\ Net\ Revenue\ as\ the\ State\ Gas\ Tax)}{(Total\ New\ VMT\ under\ the\ MBUF\ in\ Iteration\ 1)}$
  $= \frac{(\$1{,}662{,}386{,}960)}{(190{,}574{,}095{,}782\ Miles\ )} = \$0.008723\ per\ Mile$
- Revenue from the New MBUF:
  $=$ (New Weighted VMT) $\cdot$ (Flat MBUF) $=$ (13,008,736.98 Miles) $\cdot$ ($0.008723)

$= \$113{,}475$

- Revenue from the New MBUF plus the Cost of Gas:
  $= (\text{Revenue from the New MBUF}) + (\text{Initial Cost of the Rest of the Price of Gas})$
  $= \$113{,}475 + \$1{,}499{,}185 = \ \$1{,}612{,}660$
- Percent Change in Overall Price of Gas When Switching from the MBUF in Iteration 1 to the New MBUF in Iteration 2:
  $= 100 \cdot$
  $$\frac{(Revenue\ from\ the\ New\ MBUF\ plus\ the\ Cost\ of\ Gas) - (Revenue\ from\ the\ MBUF\ plus\ the\ Cost\ of\ Gas)}{(Revenue\ from\ the\ MBUF\ plus\ the\ Cost\ of\ Gas)}$$
  $$= 100 \cdot \frac{(\$1{,}612{,}660) - (\$1{,}612{,}773\ )}{(\$1{,}612{,}773)} = -0.00701\%$$
- Elasticity for the Household: −0.280
- Percent Change in VMT:
  = (Percent Change in Overall Price of Gas When Switching from the MBUF in Iteration 1 to the New MBUF in Iteration 2) · (Elasticity for the Household)
  = −0.00701% · −0.280 = 0.00196%
- New Weighted VMT due to the New MBUF
  = (New Weighted VMT in Iteration 1) + (New Weighted VMT in Iteration 1) · (Percent Change in VMT)
  = 13,008,736.98 Miles + 13,008,736.98 Miles · 0.00196% = 13,008,992.19 Miles

The change in costs and therefore VMT due to the dynamic MBUF is extremely small, as shown in Iteration 2. Therefore, calculations in this research only use one iteration. This procedure was applied to all the households for each year from 2012 to 2021 to determine each new annual VMT in the dynamic scenarios.

5.2 Scenario Structure

This section provides a detailed description of how each of the scenarios is structured. All scenarios are structured based on two perspectives, revenue collection and transportation funding disbursement. The revenue here implies the total expected Texas revenue from either the current gas tax (both state and federal) or the MBUF with the federal gas tax. The disbursement of transportation funding reflects possible changes in future funding disbursement, including distribution of increased revenue due to the MBUF, additional disbursement to maintenance funding, and additional disbursement to environmental funding.

5.2.1 Scenario 1

Scenario 1 was developed to provide a reference point for the other scenarios. Thus, this scenario evaluates the equity of the revenue that will be collected from the current gas tax together with the current planned transportation funding disbursement from 2012 to 2021 (estimated in Section 3.6).

Revenue

To calculate the revenue estimates from 2012 to 2021, 20.0 cents of the state gas tax and 18.4 cents of the federal gas tax are applied in this scenario. It is assumed that there will be no changes in these taxes from 2012 to 2021. Annual gas tax revenue from both taxes is calculated as shown in Equation 4:

$$\text{Annual Revenue}_{j,l} = \sum_{i=1}^{n} \frac{ANNMILES_{i,j,l} \times WEIGHT_{i,j,l} \times (20.0 + 18.4\ (Cents/Gallon))}{EIADMPG_{i,j,l}} \quad (4)$$

where i = household i = 1,2, ·····,n;
n = total number of households in each location (urban or rural);
j = year = 2012, 2013, ·····, 2021;
l = location = urban or rural;
ANNMILES = VMT (miles/year);
WEIGHT = weighting factor; and
EIADMPG = fuel efficiency (miles/gallon).

For the purpose of determining the percent change in price needed to implement the dynamic model associated with the MBUF scenario, it was also necessary to determine annual household expenditures on gas, both with and without the state gas tax. These two calculations are shown in Equations 5 and 6:

$$Annual\ Household\ Spending\ on\ Gas_{i,j}(Excluding\ the\ State\ Gas\ Tax) = \frac{ANNMILES_{i,j} \times WEIGHT_{i,j} \times (X_{i,j} - \$0.20)}{EIADMPG_{i,j}} \quad (5)$$

where $X_{i,j}$ = price of 1 gallon of gas ($/gal) including taxes (estimated in Section 4.2.3).

$$Annual\ Household\ Spending\ on\ Gas_{i,j}(Including\ the\ State\ Gas\ Tax) = \frac{ANNMILES_{i,j} \times WEIGHT_{i,j} \times (X_{i,j})}{EIADMPG_{i,j}} \quad (6)$$

Funding Disbursement

Scenario 1 uses the current funding disbursement plan from 2012 to 2021 shown in Section 3.6 (see Table 35).

5.2.2 Scenario 2

In Scenario 2, the state gas tax is replaced with a flat MBUF to estimate revenue. In addition, static models (no change in driver behavior due to the MBUF) and dynamic models (a change in VMT due to the MBUF) are considered as illustrated in Section 5.1. A shift from the current

state gas tax to the MBUF will increase projected revenues since fuel efficiencies are increasing while VMT is increasing. Thus, for the funding disbursement in this scenario, increased revenue due to the MBUF was distributed into the six categories.

Revenue

To estimate revenues from 2012 to 2021, this research first determined a flat MBUF that would generate roughly the same gross revenue in 2012 as the current state gas tax. The amount of revenue in 2012 from the current state gas tax was calculated by multiplying the VMT of all Texas vehicles (from the NHTS data set) by 20 cents/gallon and dividing by each vehicle's fuel efficiency (see Example 2). This was $1,662,386,960. The total VMT of the Texas households was 190,854,877,961 miles in 2012. Thus, the rate of flat MBUF in the static model was calculated as follows:

$$\text{Rate of Flat MBUF}_{Static} = \frac{Total\ Revenue\ in\ 2012\ from\ the\ Current\ State\ Gas\ Tax}{\sum Weighted\ ANNMILES\ in\ 2012} \quad (7)$$
$$= \frac{\$1{,}662{,}386{,}960}{190{,}854{,}877{,}961\ \text{Miles}} = \$0.008710/\text{Mile}$$

This rate of $0.008710/mile was applied to estimate the revenue in static Scenario 2. The next step was to determine an MBUF associated with the dynamic model. Thus, changes in VMT due to the MBUF were first estimated as shown in Example 2. Table 52 provides the change in total VMT in 2012 due to the MBUF. Since the rate of $0.008710/mile was determined based on approximately the same revenue as the current state gas tax, the effect of the rate on VMT was small.

TABLE 52 Change in Total VMT due to the MBUF in the Year 2012

a) Initial Total VMT of Texas Households (Miles)	b) New Total VMT of Texas Households (Miles)	Difference (b-a) (Miles)	Percent Change
190,854,877,961	190,574,095,782	−280,782,179	−0.147%

A rate of flat MBUF in the dynamic model was calculated as follows:

$$\text{Rate of Flat MBUF}_{Dynamic} = \frac{Total\ Revenue\ in\ 2012\ from\ the\ Current\ State\ Gas\ Tax}{\sum New\ Weighted\ ANNMILES\ in\ 2012\ due\ to\ the\ MBUF} \quad (8)$$
$$= \frac{\$1{,}662{,}386{,}960}{190{,}574{,}098{,}782\ \text{Miles}} = \$0.008723/\text{Mile}$$

This rate of $0.008723/mile was applied to estimate the revenue in dynamic Scenario 2.

In addition, in dynamic Scenario 2, changes in VMT due to the MBUF ($0.008710/mile) were also considered for every year from 2013 to 2021 (see Table 53) to estimate the revenue from 2013 to 2021 because the weights, fuel costs, and fuel efficiencies were different for each year in Section 4.2.

TABLE 53 Changes in Total VMT due to the MBUF from 2013 to 2021

Year	a) Initial Total VMT of Texas Households (Miles)	b) New Total VMT of Texas Households (Miles)	Difference (b-a) (Miles)	Percent Change
2013	195,698,531,539	195,343,468,139	−355,063,400	−0.181%
2014	200,644,767,365	200,215,120,616	−429,646,749	−0.214%
2015	205,706,898,483	205,195,139,083	−511,759,400	−0.249%
2016	210,871,979,914	210,279,930,570	−592,049,344	−0.281%
2017	216,143,092,836	215,471,421,904	−671,670,932	−0.311%
2018	221,516,760,879	220,757,399,596	−759,361,283	−0.343%
2019	226,997,878,135	226,150,327,863	−847,550,272	−0.373%
2020	232,585,366,615	231,644,564,032	−940,802,583	−0.404%
2021	238,300,419,250	237,266,579,200	−1,033,840,049	−0.434%

This research assumed that the rate of the federal gas tax will be maintained in the future at the current rate. In addition, similar to Burris and Larsen's research (2012), 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. Thus, 80 percent of the MBUF revenue collected from urban households was considered revenue for urban areas, and 20 percent of the MBUF revenue was considered revenue for rural areas. Conversely, 80 percent of rural household travel was assumed to be on rural roadways, and 20 percent of rural household travel was assumed to be on urban roadways. Thus, 80 percent of the MBUF revenue collected from rural households was considered revenue for rural areas, and 20 percent of the MBUF revenue was considered revenue for urban areas. Annual gas tax revenues from both taxes in rural and urban areas are calculated as shown in Equations 9 and 10:

$$\text{Annual Revenue}_{j,URB,m} = 0.80 \cdot \sum_{i=1}^{n} \left(MBUF_m \cdot Weighted\ ANNMILES_{i,j,URB,m} \right) + 0.20 \cdot \sum_{i=1}^{n'} \left(MBUF_m \cdot Weighted\ ANNMILES_{i,j,RUR,m} \right) + \frac{\$0.184 \cdot Weighted\ ANNMILES_{i,j,URB,m}}{EIADMPG_{i,j,URB}} \quad (9)$$

where j = year = 2012, 2013, ·····, 2021;
URB = urban area;
RUR = rural area;
m = model = static or dynamic;
i = household i = 1,2, ·····,n;

n = total number of households in each location (urban or rural); and
MBUF = $0.008710/mile for static scenario or $0.008723 for dynamic scenario.

$$\text{Annual Revenue}_{j,RUR,m} = 0.80 \cdot \sum_{i=1}^{n} \left(MBUF_m \cdot Weighted\ ANNMILES_{i,j,RUR,m} \right) + 0.20 \cdot \sum_{i=1}^{n'} \left(MBUF_m \cdot Weighted\ ANNMILES_{i,j,URB,m} \right) + \frac{\$0.184 \cdot Weighted\ ANNMILES_{i,j,RUR,m}}{EIADMPG_{i,j,RUR}} \quad (10)$$

Funding Disbursement

Planning for future transportation projects, including environmental reviews, public input, and funding allocation, takes many years. Therefore, this research assumes that changes to funding disbursements begin in 2017. Tables 54 and 55 provide the increased revenues from 2017 to 2021 due to the MBUF in the static model and in the dynamic model, respectively.

TABLE 54 Increased Revenues in the Static Model from 2017 to 2021

Year	a) Revenue from the Current Gas Taxes	b) Revenue from the MBUF and Fed. Gas Tax in Static Model	Increased Revenue (b-a)
2017	$2,643,650,158	$2,814,152,354	$170,502,196
2018	$2,534,232,202	$2,739,198,710	$204,966,508
2019	$2,424,199,532	$2,664,105,300	$239,905,768
2020	$2,313,148,440	$2,588,665,879	$275,517,439
2021	$2,200,841,937	$2,512,892,714	$312,050,777

TABLE 55 Increased Revenues in the Dynamic Model from 2017 to 2021

Year	a) Revenue from the Current Gas Taxes	b) Revenue from the MBUF and Fed. Gas Tax in Dynamic Model	Increased Revenue (b-a)
2017	$2,643,650,158	$2,809,263,152	$165,612,994
2018	$2,534,232,202	$2,733,530,290	$199,298,088
2019	$2,424,199,532	$2,657,744,131	$233,544,599
2020	$2,313,148,440	$2,581,651,158	$268,502,718
2021	$2,200,841,937	$2,504,667,836	$303,825,899

The increased revenue each year in Tables 54 and 55 was distributed to the six categories with the same average proportions from 2012 to 2021 estimated in Section 3.6 (see Table 56). Finally, those additional revenues were then added to the annual funding amounts estimated in Section 3.6 (see Table 35 for the annual funding amounts).

TABLE 56 Average Proportions of Six Categories' Funding from 2012 to 2021

Category	Rural	Urban
Maintenance	$ 13,919,430,410	$ 22,095,662,076
	20.45%	32.47%
Construction	$ 1,238,103,051	$ 23,523,074,460
	1.82%	34.56%
Environmental	$ 246,568,254	$ 7,032,393,560
	0.36%	10.33%
Total	$ 68,055,231,811	

5.2.3 Scenario 3

If the current transportation funding shortfalls are not improved, construction funding may be shifted to maintenance funding to maintain the current transportation infrastructure, rather than be used to construct new infrastructure. Scenario 3 was designed to consider this change in funding disbursement focus.

Revenue

The same revenue structure as in Scenario 2 was applied to this scenario. Thus, the revenue estimates are also the same as those of Scenario 2.

Funding Disbursement

This scenario also assumed that the funding disbursement focus can only be changed from 2017 to 2021. For the funding disbursement in this scenario, this research assumed that 50 percent of construction funding for each year from 2017 to 2021 estimated in Scenario 2 would be shifted to maintenance funding in the future. Tables 57 and 58 provide the funding disbursement estimates from 2017 to 2021 in Scenario 2, and Table 59 provides the amount of the shifted construction funding from 2017 to 2021.

TABLE 57 Funding Disbursement in the Static Scenario 2 from 2017 to 2021

	2017		2018		2019	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Maintenance	1,555,719,379	2,478,492,150	1,445,532,426	2,286,747,554	1,390,993,784	2,195,116,289
	25.72%	40.98%	23.68%	37.46%	22.88%	36.11%
Construction	29,677,250	1,294,714,626	45,991,988	1,631,673,704	44,677,399	1,760,327,437
	0.49%	21.41%	0.75%	26.73%	0.73%	28.96%
Environmental	5,597,101	684,384,639	5,686,500	688,157,735	5,712,414	682,251,851
	0.09%	11.31%	0.09%	11.27%	0.09%	11.22%
Total	6,048,585,144		6,103,789,907		6,079,079,173	

	2020		2021	
	Rural	**Urban**	**Rural**	**Urban**
Maintenance	1,501,256,106	2,400,485,107	1,631,660,639	2,608,968,893
	24.17%	38.64%	25.64%	41.00%
Construction	47,351,630	1,586,000,998	102,681,307	1,336,492,700
	0.76%	25.53%	1.61%	21.00%
Environmental	5,537,005	671,888,522	6,055,527	677,944,638
	0.09%	10.82%	0.10%	10.65%
Total	6,212,519,367		6,363,803,704	

TABLE 58 Funding Disbursement in the Dynamic Scenario 2 from 2017 to 2021

	2017		2018		2019	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Maintenance	1,554,719,383	2,476,904,760	1,444,373,057	2,284,907,174	1,389,692,725	2,193,050,992
	25.72%	40.98%	23.69%	37.47%	22.88%	36.11%
Construction	29,588,303	1,293,024,689	45,888,864	1,629,714,433	44,561,673	1,758,128,719
	0.49%	21.39%	0.75%	26.72%	0.73%	28.95%
Environmental	5,579,387	683,879,420	5,665,963	687,571,996	5,689,367	681,594,528
	0.09%	11.32%	0.09%	11.28%	0.09%	11.22%
Total	6,043,695,941		6,098,121,487		6,072,718,004	

	2020		2021	
	Rural	**Urban**	**Rural**	**Urban**
Maintenance	1,499,821,375	2,398,207,620	1,629,978,393	2,606,298,502
	24.17%	38.65%	25.65%	41.01%
Construction	47,224,014	1,583,576,382	102,531,675	1,333,649,797
	0.76%	25.52%	1.61%	20.98%
Environmental	5,511,590	671,163,665	6,025,728	677,094,732
	0.09%	10.82%	0.09%	10.65%
Total	6,205,504,646		6,355,578,826	

TABLE 59 Amount of the Shifted Construction Funding from 2017 to 2021

	2017	2018	2019	2020	2021
The Amount Shifted in Static Scenario 3	$662,195,938	$838,832,846	$902,502,418	$816,676,314	$719,587,004
The Amount Shifted in Dynamic Scenario 3	$661,306,496	$837,801,649	$901,345,196	$815,400,198	$718,090,736

To distribute this shifted construction funding in each year into rural maintenance and urban maintenance funding for each year, the average proportions of rural maintenance and urban

maintenance funding from 2012 to 2021 was used (see Table 60). The environmental funding disbursement is not changed in this scenario.

TABLE 60 Average Proportions of Rural Maintenance and Urban Maintenance Funding

Category	Rural	Urban	Sum
Maintenance	$13,919,430,410	$22,095,662,076	$36,015,092,486
	38.65%	61.35%	100.00%

5.2.4 Scenario 4

Scenario 4 was designed to be an environmentally friendly transportation funding policy change.

Revenue

The same revenue structure as in Scenario 2 was applied to this scenario. Thus, the revenue estimates are also the same as those of Scenario 2.

Funding Disbursement

If a transportation policy focus moves to an environmentally friendly policy, it stands to reason that transportation funding allocation will reflect this policy. Thus, for the funding disbursement in this scenario, this research assumed that 50 percent of construction funding for each year from 2017 to 2021 estimated in Scenario 2 would be shifted to environmental funding. To distribute the shifted construction funding in each year estimated in Section 5.2.3 (see Table 59) into rural environmental and urban environmental funding for each year, the average proportions of rural environmental and urban environmental funding from 2012 to 2021 were applied (see Table 61). The maintenance funding disbursements in Tables 57 and 58 are not changed in this scenario.

TABLE 61 Average Proportions of Rural Environmental and Urban Environmental Funding

Category	Rural	Urban	Sum
Environmental	$246,568,254	$7,032,393,560	$7,278,961,814
	3.39%	96.61%	100.00%

5.3 Results

The estimated revenue collected from either the current gas tax or the MBUF combined with the federal gas tax were examined first. Then, the funding disbursement estimates for each scenario were shown. The ratio of these estimates (funding disbursement/revenue) for each scenario was also estimated to understand which scenario would be more beneficial for each area. Using these estimates, geographical equity and vertical equity were also evaluated for each scenario. Again, all monetary estimates in this section are expressed in year 2012 dollars using a 4 percent inflation rate.

5.3.1 Revenue

The total revenue estimates from 2012 to 2021 for rural and urban areas is provided in Table 62. As previously mentioned, the rate of the MBUF was set so that it would generate the same revenue in 2012 that will be generated by the current gas tax. However, it was expected that the MBUF would generate more total revenue over all 10 years of analysis (see the fourth column in Table 62). This is primarily related to the fuel efficiency improvement mentioned in Chapter 4. Texas households will consume less fuel due to fuel efficiency improvement, thereby paying less in gas taxes under the current gas tax system. In addition, rural areas would contribute a higher percentage of total revenue under the MBUF system relative to the current tax system. These results were partially caused by the 80/20 assumption illustrated in Scenario 2. Since an MBUF charges based on miles driven, rural areas will generate more revenue, while urban areas will generate less. It is reasonable that the total revenue in the dynamic model is a little less than the revenue in the static model because the total VMT is reduced due to elasticity of demand.

TABLE 62 2012 to 2021 Revenue Estimates for Each Scenario

Scenario	Rural	Urban	Total
a) Current tax (for Scenario 1)	$5,417,437,003 (20%)	$21,557,187,519 (80%)	$26,974,624,522 (100%)
b) MBUF and fed. tax—static (for static Scenarios 2, 3, and 4)	$7,553,595,698 (26%)	$20,965,267,325 (74%)	$28,518,863,023 (100%)
Difference (b-a)	$2,136,158,695	−$591,920,194	$1,544,238,501
c) MBUF and fed. tax—dynamic (for dynamic Scenarios 2, 3, and 4)	$7,546,981,882 (27%)	$20,929,622,877 (73%)	$28,476,604,759 (100%)
Difference (c-a)	$2,129,544,879	−$627,564,642	$1,501,980,237

5.3.2 Disbursement

This research assumed that transportation funding will be distributed into six categories with different amounts allocated to each category based on the scenarios examined. Thus, the total funding disbursements from 2012 to 2021 for each category depend on the scenarios and are compared in Table 63. As expected, the biggest amount of rural maintenance and urban maintenance funding is allocated in both static and dynamic Scenario 3. Rural environmental funding does not largely increase even in Scenario 4 in terms of dollar amount—the environmentally friendly funding disbursement scenario. This is because environmental funding is mainly used for urban areas in the current transportation plan (see Table 61). Since the revenue does not largely increase due to the MBUF (this research allocates the amount of the increased revenue to the six categories in Scenarios 2, 3, and 4), the total amount of funding in Scenario 1 is not much smaller than that in the other scenarios.

TABLE 63 Comparison of Funding Disbursements in Millions of Dollars

Category	R-M	U-M	R-C	U-C	R-E	U-E	Total
Scenarios 1	13,919	22,096	1,238	23,523	247	7,032	68,055
Static Scenario 2	14,165	22,486	**1,260**	**23,939**	251	7,157	69,258
Dynamic Scenario 2	14,159	22,476	**1,259**	**23,928**	251	7,153	69,227
Static Scenario 3	**15,688**	**24,903**	1,125	20,134	251	7,157	69,258
Dynamic Scenario 3	**15,679**	**24,890**	1,125	20,129	251	7,153	69,227
Static Scenario 4	14,165	22,486	1,125	20,134	**384**	**10,963**	69,258
Dynamic Scenario 4	14,159	22,476	1,125	20,129	**384**	**10,954**	69,227

Note: R-M = rural maintenance funding. U-M = urban maintenance funding. R-C = rural construction funding. U-C = urban construction funding. R-E = rural environmental funding. U-E = urban environmental funding. Bold denotes the biggest funding disbursement of each category among the scenarios.

Table 64 provides the total funding disbursement estimates from 2012 to 2021 in urban and rural areas. Based on the estimates of Scenario 3, allocating a greater percentage of funding to maintenance results in an increase in the amount of funding directed to rural areas. However, even if a greater percentage of environmental funding is allocated in Scenario 4, the proportions of the rural and urban disbursements are maintained as the similar proportions of Scenarios 1 and 2.

TABLE 64 Estimates of Funding Disbursement for Each Scenario

Scenario	Rural	Urban	Total
Scenarios 1	$15,404,101,715 (23%)	$52,651,130,096 (77%)	$68,055,231,811 (100%)
Static Scenario 2	$15,676,384,257 (23%)	$53,581,790,241 (77%)	$69,258,174,498 (100%)
Dynamic Scenario 2	$15,669,251,996 (23%)	$53,557,412,215 (77%)	$69,226,664,211 (100%)
Static Scenario 3	$17,063,880,985 (25%)	$52,194,293,513 (75%)	$69,258,174,498 (100%)
Dynamic Scenario 3	$17,054,819,865 (25%)	$52,171,844,346 (75%)	$69,226,664,211 (100%)
Static Scenario 4	$15,674,651,449 (23%)	$53,583,523,049 (77%)	$69,258,174,498 (100%)
Dynamic Scenario 4	$15,667,611,638 (23%)	$53,559,052,573 (77%)	$69,226,664,211 (100%)

5.3.3 Revenue Compared to Disbursement

Next, the ratio of revenue to disbursement was estimated to simultaneously examine both the burden and the benefit for each area (see Table 65). To calculate the ratios in each scenario, the estimates in Tables 62 and 64 were used. A larger ratio means that the area received more funding than its tax burden. This ratio should, in theory, be close to one. However, the revenue includes only the gas tax from household gasoline-run vehicles, while the funding disbursement is based on all kinds of revenue (such as gas tax, registration fee, fare revenue, lubricant tax, etc.). Therefore, the ratio estimates were much greater than one.

TABLE 65 Ratios (Disbursement/Revenue) and Their Rank in Each Scenario

	a) Rural (Rank)	b) Urban (Rank)	Difference (b-a)
Scenario 1	2.84 (1st)	2.44 (7th)	−0.40
Static Scenario 2	2.08 (4th)	2.56 (1st)	0.48
Dynamic Scenario 2	2.08 (4th)	2.56 (1st)	0.48
Static Scenario 3	2.26 (2nd)	2.49 (5th)	0.23
Dynamic Scenario 3	2.26 (2nd)	2.49 (5th)	0.23
Static Scenario 4	2.08 (4th)	2.56 (1st)	0.48
Dynamic Scenario 4	2.08 (4th)	2.56 (1st)	0.48

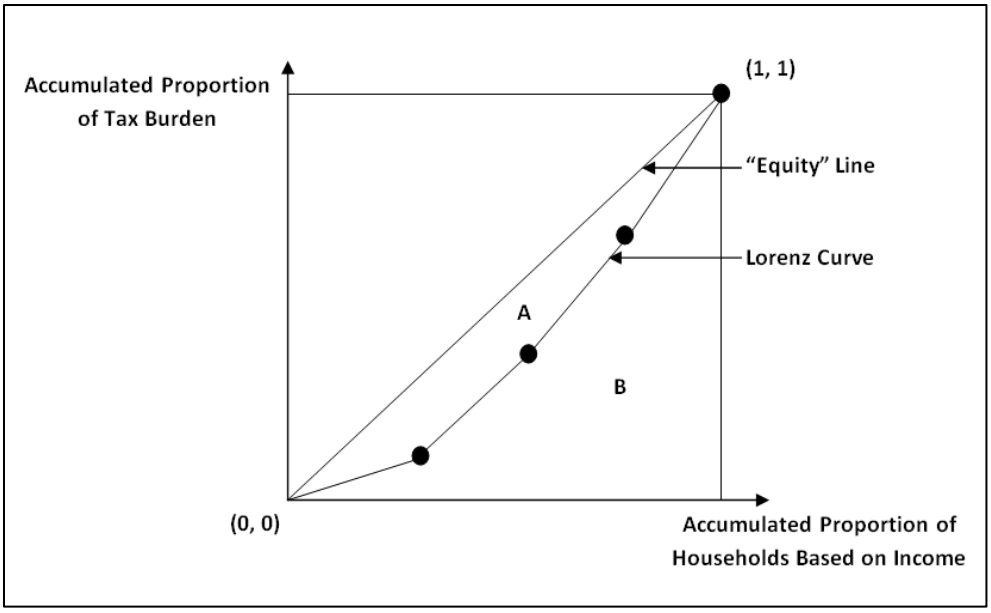
Note: The rank is ordered by the largest ratio across the scenarios.

Comparison of the ratios across the areas gives a rough idea about the geographical equity of the gas tax and funding disbursement. That is, a smaller difference between the ratios in both areas implies more geographical equity. Thus, Scenario 3, where the MBUF combined with the federal tax focuses on maintenance funding disbursement, is the most geographically equitable transportation policy (it has the smallest difference in ratios; see Table 65).

Across the scenarios, Scenario 1 is the most beneficial for rural areas. This is because the current gas tax system collects less revenue from rural areas. However, it is in Scenario 3, where more funds are directed to maintenance, where the ratios of spending divided by taxes are closest for urban and rural areas. By this measure, Scenario 3 is the most geographically equitable.

5.3.4 Gini Coefficients

To quantitatively estimate the equity of revenues and disbursements, Gini coefficients were calculated. Gini coefficients and Lorenz curves (see Figure 3) are common quantitative and visual methods, respectively, used to evaluate equity. To begin, a Lorenz curve is plotted. In Figure 3, the percentage of households in each income class is plotted on the x-axis, and the percentage of tax burden in each household income class is plotted on the y-axis. Thus, the Lorenz curve can be plotted using these x and y coordinates. Because the Lorenz curve is closer to the equity line, the tax in the example is more equitable regardless of household income.



Source: Burris and Larsen (2012)

FIGURE 3 Lorenz Curve Plot for Tax Burden

According to Drezner et al. (2009), "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." The value of a Gini coefficient can range from 0 to 1, with 0 indicating complete equality and 1 indicating complete inequality (Rock 1982). Gini coefficients can be calculated as follows:

$$\mathrm{G} = \frac{A}{A + B} \tag{11}$$

5.3.4.1 Gini Coefficients to Estimate Geographical Equity

Researchers estimated two types of geographical equity (equity between rural and urban areas) for the funding disbursements to reflect two perspectives of the equity. The first one is the equity based on the number of urban and rural households, and the other is the equity based on the percentage of tax burden for each area.

Gini Coefficients of the Disbursements Based on Urban and Rural Households

These coefficients were estimated to evaluate how the funding is geographically disbursed compared to the number of households included in either rural or urban areas. That is, these coefficients are able to evaluate the proposition that "x percent of households in Texas receive y percent of the total funding based on their residence." The x percent and y percent are plotted on the x-axis and y-axis to plot the Lorenz curve of each scenario, as in Figure 4. The estimates in Tables 66 and 64 were used for the x-axis and y-axis, respectively.

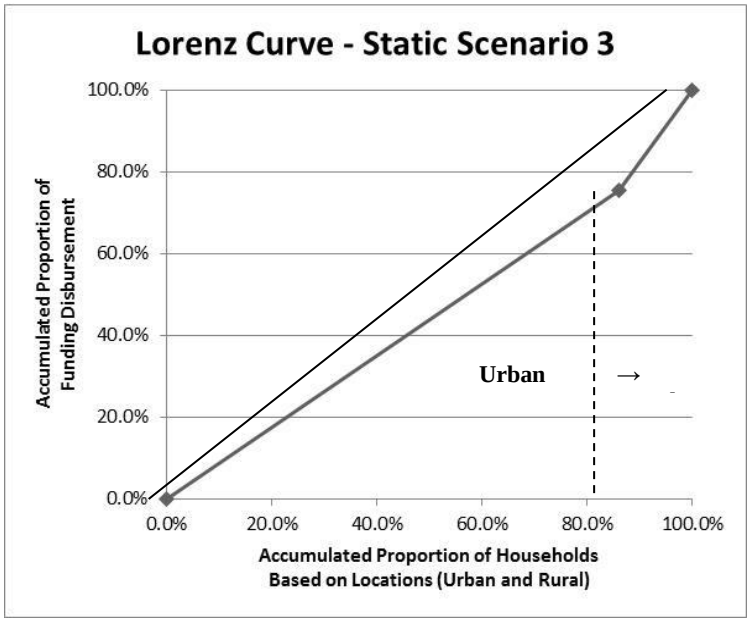


FIGURE 4 Lorenz Curve Plot for Funding Disbursement Based on the Number of Households

TABLE 66 Number of Households in Each Area in Texas

Number of Rural Households	Number of Urban Households	Total
1,105,319 (14.0%)	6,809,004 (86.0%)	7,914,323 (100.0%)

Table 67 provides the Gini coefficient of each scenario. Scenario 3, the focus on the maintenance funding disbursement, is the least equitable based on the number of households that benefit from the funding disbursement. This is because a larger percentage of maintenance funding is used for rural areas compared to the percentage of rural households. Even if more transportation funding is used for environmental improvement in Scenario 4, the geographical equity is maintained at the same level of the current trend in the funding disbursement.

TABLE 67 Gini Coefficients of the Disbursements Based on Rural and Urban Households

Scenario	Gini Coefficients	Rank (1 = Most Equitable, 7 = Least Equitable)
Scenario 1	0.0867	1
Static Scenario 2	0.0867	1
Dynamic Scenario 2	0.0867	1
Static Scenario 3	0.1067	6
Dynamic Scenario 3	0.1067	6
Static Scenario 4	0.0867	1
Dynamic Scenario 4	0.0867	1

Gini Coefficients for Funding Disbursements Compared to the Tax Burden

These Gini coefficients were estimated to evaluate how the funding is geographically distributed compared to each area's contribution to the tax burden. That is, these Gini coefficients are able to evaluate the proposition that "when rural (or urban) areas contribute to x percent of total revenue, rural (or urban) areas receive y percent of the total funding." The x percent and y percent are plotted on the x-axis and y-axis for each scenario (see Figure 5 for an example). The estimates in Tables 62 and 64 were used for the x-axis and y-axis, respectively.

The estimated results are shown in Table 68. When considering the percentage of revenue in each area instead of the percentage of households, the geographic equity of the disbursement was different from the results in Table 67. All scenarios are geographically equitable based on the values of the Gini coefficients (see Table 68)—since the value is close to zero, the disbursement considering the tax burden in each area is geographically equitable. Scenarios 2 and 4 are slightly less equitable than the current gas tax (Scenario 1). Scenario 3 was slightly more equitable than the current gas tax.

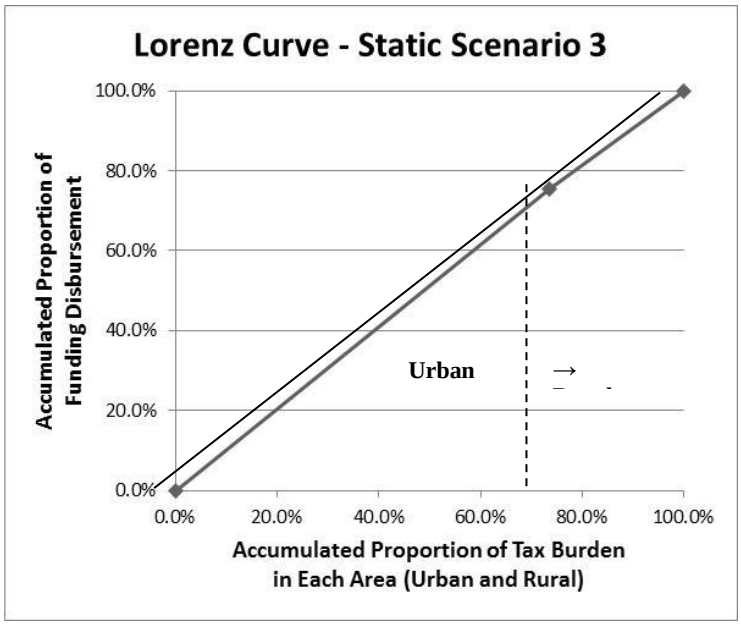


FIGURE 5 Lorenz Curve Plot for Funding Disbursement Based on the Tax Burden of Each Area

TABLE 68 Gini Coefficients of Funding Disbursements Based on the Tax Burden of Each Area

	Gini Coefficients	Rank (1 = Most Equitable, 7 = Least Equitable)
Scenario 1	0.0255	3
Static Scenario 2	0.0385	4
Dynamic Scenario 2	0.0387	6
Static Scenario 3	0.0185	1
Dynamic Scenario 3	0.0187	2
Static Scenario 4	0.0385	4
Dynamic Scenario 4	0.0387	6

5.3.4.2 Gini Coefficients to Estimate Vertical Equity of the Gas Tax

This section provides the vertical equity of the gas taxes, the current gas tax, and the MBUF combined with the federal tax, without consideration of funding disbursement for each income class. Examining the vertical equity of the gas taxes considering the funding disbursement would be more desirable because this measure is able to examine the real equity of the gas taxes. For example, even if one specific income class pays much more gas taxes than other classes, receiving much more funding than other classes would make the taxes equitable. However, this research only looked at revenues because researchers did not have the time or funding to examine how disbursement is varied by each income group.

Gini Coefficients of Tax Burden Based on Household Income

To plot the Lorenz curves for the Gini coefficients in this section, the percentage of households based on income class was plotted on the x-axis, and the percentage of tax burden in each household income class was plotted on the y-axis, as in Figure 3. The estimates in Table 69 were used for the x-axis, and the estimates in Tables 70, 71, and 72 were used for the y-axis. Tables 70, 71, and 72 are the estimated revenues from the current gas tax, the MBUF with the federal tax in the static model, and the MBUF with the federal tax in the dynamic model, respectively.

TABLE 69 Number of Texas Households Based on Income Class

Household Income Level	Number of Households	Percentage
<$20,000	1,528,470	19.3%
$20,000–$40,000	1,798,760	22.7%
$40,000–$60,000	1,370,387	17.3%
$60,000–$100,000	1,687,468	21.3%
$100,000+	1,529,238	19.3%
Total	7,914,323	19.3%

TABLE 70 Revenues from the Current Gas Tax by Income Class (Scenario 1)

Household Income Level	Revenue from 2012 to 2021	Percentage
<$20,000	$2,984,175,900	11.1%
$20,000–$40,000	$4,895,011,806	18.1%
$40,000–$60,000	$4,566,522,797	16.9%
$60,000–$100,000	$7,204,901,985	26.7%
$100,000+	$7,324,012,035	27.2%
Total	$26,974,624,522	100.0%

TABLE 71 Revenues from the MBUF with the Federal Tax in the Static Model by Each Income Class (Scenarios 2, 3, and 4)

Household Income Level	Revenue from 2012 to 2021	Percentage
<$20,000	$3,135,643,032	11.0%
$20,000–$40,000	$5,187,909,453	18.2%
$40,000–$60,000	$4,833,312,904	16.9%
$60,000–$100,000	$7,612,491,568	26.7%
$100,000+	$7,749,506,065	27.2%
Total	$28,518,863,022	100.0%

TABLE 72 Revenues from the MBUF with the Federal Tax in the Dynamic Model by Each Income Class (Scenarios 2, 3, and 4)

Household Income Level	Revenue from 2012 to 2021	Percentage
<$20,000	$3,129,460,900	11.0%
$20,000–$40,000	$5,181,633,134	18.2%
$40,000–$60,000	$4,828,469,243	17.0%
$60,000–$100,000	$7,601,217,934	26.7%
$100,000+	$7,735,823,548	27.2%
Total	$28,476,604,759	100.0%

The results in Table 73 show that the vertical equity of the current gas tax is very similar to that of the MBUF. This is because the rate of the MBUF in this research was determined as a rate that would generate roughly the same net revenue in 2012 as the current gas tax. In addition, all three estimates show that higher income classes pay more. Thus, both the current gas tax and the MBUF can be considered progressive, which is more favorable to a disadvantaged group (the lower income class).

TABLE 73 Gini Coefficients of Tax Burden Based on Household Income

	Gini Coefficients
Current tax (for Scenario 1)	0.1690
MBUF and fed. tax—static (for static Scenarios 2, 3, and 4)	0.1694
MBUF and fed. tax—dynamic (for dynamic Scenarios 2, 3, and 4)	0.1694

CHAPTER 6: CONCLUSIONS AND LIMITATIONS

6.1 Conclusions

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. This is forcing some transportation providers to increase their focus on spending for a more sustainable system (including maintenance), thus shifting how tax revenues are spent. One proposed alternative to the state gas tax is the creation of an MBUF, which would shift how revenues are collected. Through this research, potential equity impacts of these two shifts in funding were examined. To analyze these impacts, this research used the 2009 NHTS Texas data along with detailed spending estimates from TxDOT to consider the equity impacts surrounding both changes in the state gas tax and funding disbursement focus. NHTS data were weighted to reflect results representative of Texas vehicle-owning households in 2008, and using the weighted NHTS data, future travel data from 2012 to 2021 were estimated.

Four different scenarios were implemented to evaluate equity impacts due to these changes during the years 2012 to 2021. The first scenario analyzed was the current state gas tax and the current funding disbursement. This provided a reference point to compare with other scenarios. The other scenarios examined equity impacts of shifting the state gas tax to an MBUF. In the other scenarios, equity impacts of funding disbursement, focusing on either maintenance or environmental funding, were analyzed under a situation where the MBUF is implemented. Each scenario was run both statically and dynamically under the assumption that the MBUF would replace the state gas tax. However, differences between the static and the dynamic estimates were small.

The total revenue estimates from 2012 to 2021 indicated that the MBUF combined with the federal gas tax would generate more revenues than the current gas tax, even if the rate of the MBUF was set so that it would generate the same revenue in 2012 that would be generated by the current gas tax. This is due to the increase in fuel efficiency of future vehicles and thus a decline in gas tax collected per vehicle. In addition, it was found that rural areas will pay an increased share of the revenue if the MBUF is implemented because, based on the modified 2009 NHTS data, rural households have less fuel-efficient vehicles and average mileage traveled is greater than urban households. This research analyzed the planned transportation funding disbursement from 2012 to 2021 based on the UTP and classified the funding into six categories: rural maintenance, urban maintenance, rural construction, urban construction, rural environmental, and urban environmental funding. Most funding (67.4 percent) is planned to be disbursed to urban maintenance and urban construction funding in the UTP. The amounts of the funding disbursement were changed depending on the scenarios examined to simultaneously consider the effect of funding disbursement change on geographic equity with the shift from the gas tax to an MBUF. As a result, it was found that allocating a greater percentage of funding to maintenance would distribute more funding to rural areas, whereas allocating a greater percentage of funding to environmental items would have little impact on the current geographic disbursement.

Using these estimates in each scenario, researchers examined geographic and vertical equity based on the ratio of revenue to disbursement and based on the Gini coefficient. The ratio of revenue to disbursement was used to evaluate geographic equity. A smaller difference between the ratios in rural and urban areas implies more geographical equity because they receive a similar amount of funding compared to their tax burden. Through this measure, the research found that Scenario 3, where the MBUF is combined with the federal tax and focuses more on maintenance funding disbursement, is the most geographically equitable transportation policy (Scenario 3 provides the smallest difference between the ratios). This was because the additional rural maintenance funding is greater than the increased share of the revenue paid by rural areas due to the MBUF.

Gini coefficients were then used to quantitatively examine both geographic and vertical equity. Two types of geographical equity related to funding disbursements were examined. The first one is geographical equity of funding disbursement based on the percentage of urban and rural households. The other is geographical equity of funding disbursement based on the percentage of tax burden for each area. In the first measure, Scenario 3 is the least equitable (the largest Gini coefficient) because rural areas receive a larger percentage of the funding compared to the number of rural households. In the second measure, when considering the tax burden in each area instead of the percentage of households to calculate the Gini coefficient, Scenario 3 is the most equitable (the smallest Gini coefficient). Through the results of these measures, it was found that the equity of a transportation funding disbursement policy can be changed based on how it is measured. The first measure, the geographic equity of the funding disbursement based on the percentage of urban and rural households, can be used to examine a policy that aims to provide equal benefits based on the geographic location of the population. The second measure, the geographic equity of the funding disbursement based on the percentage of tax burden for each area, is useful to examine a policy that aims to distribute funding in relation to how much an area paid in taxes.

Next the vertical equity of the gas taxes was examined using the Gini coefficient. The current gas tax is similar in vertical equity to that of the MBUF combined with the federal tax for all scenarios. This is because the rate of the MBUF was set at a rate that would generate roughly the same net revenue in 2012 as the current gas tax.

Through these analyses, researchers found that considering funding disbursement when examining the effect of a shift to the MBUF may change the equity of different scenarios compared to when funding disbursement is not considered. If the MBUF rate is set at the same level as the current tax, a shift to the MBUF would have little impact on vertical equity. However, geographic equity would be reduced by the MBUF based on the revenue estimates because a shift to the MBUF increases the percentage of tax burden for rural areas. This negative impact can be alleviated by changing the funding disbursement focus; in this research, allocating more funding to maintenance improved geographical equity.

6.2 Research Limitations and Future Research

Due to the inherent difficulties of 10-year predictions for both revenue and funding disbursement estimates, several assumptions were made in performing this analysis. First, a decrease in the

percentage of funds allocated to construction was transferred to either maintenance funding or environmental funding in Scenarios 3 and 4. We assumed the decrease in construction funding to be 50 percent, but this was an arbitrary value and changing this value would affect the results. This is because changes in the funding disbursement inherently included a great deal of uncertainty therefore, future funding changes are difficult to predict. Through obtaining a reliable value, results need to better reflect a possible change in Texas transportation funding.

Additionally, even though this research reviewed diverse Texas transportation plans, the funding disbursement plan for the next 10 years is not perfectly clear because a few transportation plans for some categories/programs are not decided yet. For those plans, this research adopted reliable alternative references. The boundaries to classify rural and urban areas in both the funding disbursement and the NHTS data set were different. Since reclassifying both data sets using only one geographic criterion was impossible, the weights of the NHTS data were merely adjusted to the rural and urban population in the Census data. Clarifying geographic equity change will require a more precise and consistent division of rural and urban areas in future research data sets. Since the NHTS data only provide household travel data in 2008, the number of household vehicles (the weight) for the future was estimated based on historical data and future census estimates. The fuel efficiency improvement and the fuel costs in the future were also estimated based on the estimates of the references. In addition, since this research used the NHTS data set, only household gasoline-run vehicles were included in the analysis under the assumption that vehicles dependent on a different source of energy accounted for only a small portion of all household vehicles. Commercial vehicles registered in each area could not be considered in this research.

In the scenarios where the MBUF is implemented, the breakdown of road-type travel by both urban households and rural households was assumed to be 80/20 based on Burris and Larsen's (2012) research. Even if only one assumption was applied in this research, this assumption greatly affected the results. Thus, a more reliable value obtained from readings from a large sample of vehicles in various locations is required in future research to eliminate the uncertainty of this assumption.

Lastly, the vertical equity of the gas taxes could not be considered together with funding disbursement because this research did not analyze how disbursement varies by income group. For example, how much various income groups use transit, and therefore benefit from increased disbursements to transit, is unknown. Based on the knowledge gained from this research, examining the vertical equity of the gas tax with consideration of funding disbursement to each income class may provide different results and be worth future research.

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APPENDIX A: URBAN AND RURAL COUNTIES IN TEXAS

To estimate future funding allocations to urban and rural areas, it is important to consider how future transportation funding information sources, including the Statewide Long Range Transportation Plan (SLRTP), the Metropolitan Transportation Plan (MTP) of each metropolitan planning organization (MPO) in Texas, and the Texas Rural Transportation Plan (TRTP), divide the state into urban and rural boundaries.

The SLRTP uses six county types to divide the state:

- Urban-metro County is defined as a county with a population greater than 500,000, and the county is a core MPO county;
- Large County is defined as a county with a population greater than 50,000 but less than 500,000, and the county is a core MPO county;
- Suburban County is defined as a county that is contained within an MPO boundary or borders an MPO core boundary with a population greater than 50,000;
- Medium County is defined as a county with a population greater than 50,000, and the county is not an MPO county;
- Small County is defined as a county with a population greater than 20,000 but less than 50,000; and
- Rural County is defined as a county with a population less than 20,000 (Texas Department of Transportation 2010b).

The MTP is the transportation plan for any metropolitan area that is currently considered urbanized or that is expected to become urbanized (Abilene Metropolitan Planning Organization 2010). If the area is contained within the MPO boundary, the area is considered an urban area. Additionally, the TRTP provides boundaries for statewide rural areas that are not included within the MPO boundaries (Texas Department of Transportation 2012c).

Based on a review of these documents—the SLRTP, the MTP, and the TRTP—the county boundary is the best geographical boundary to delineate between a rural and urban area. Furthermore, if an area has a population greater than 50,000 people and is contained within the MPO boundary, this research considers the area to be an urban area. Thus, Urban-metro, Large, and Suburban Counties are considered urban areas among the six county types defined in the SLRTP. Small and Rural Counties are considered rural areas because they are located outside the MPO boundary, and the population is less than 50,000. However, there remains the issue of whether a Medium County should be considered an urban or rural area because its population is greater than 50,000, but it is not included within an MPO boundary. Since it cannot be judged using a similar criterion as above, the population density of these counties was examined. The nine Medium Counties with their corresponding population densities are provided in Table A-1.

TABLE A-1 Counties Classified as Medium and Their Densities in 2009

County	Population Density	County	Population Density
Anderson	53.2/mi^2	Nacogdoches	67.7/mi^2
Angelina	104.4/mi^2	Starr	51.2/mi^2
Cherokee	46.1/mi^2	Val Verde	15.2/mi^2
Lamar	53.4/ mi^2	Walker	81.4/mi^2
Maverick	41.6/mi^2		

Source: RAND Texas (2013)

According to the U.S. Census Bureau, an urban area is defined as core census blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile (U.S. Census Bureau 2012). The population densities of the nine counties are far fewer than 500 people per square mile.

Furthermore, since this research used the 2009 NHTS data set to estimate the statewide gas tax in relation to the implementation of an MBUF, the boundary of rural and urban areas defined in the 2009 NHTS data set was also considered. The shaded area in Figure A-1 indicates an urban area as defined in the NHTS data set.

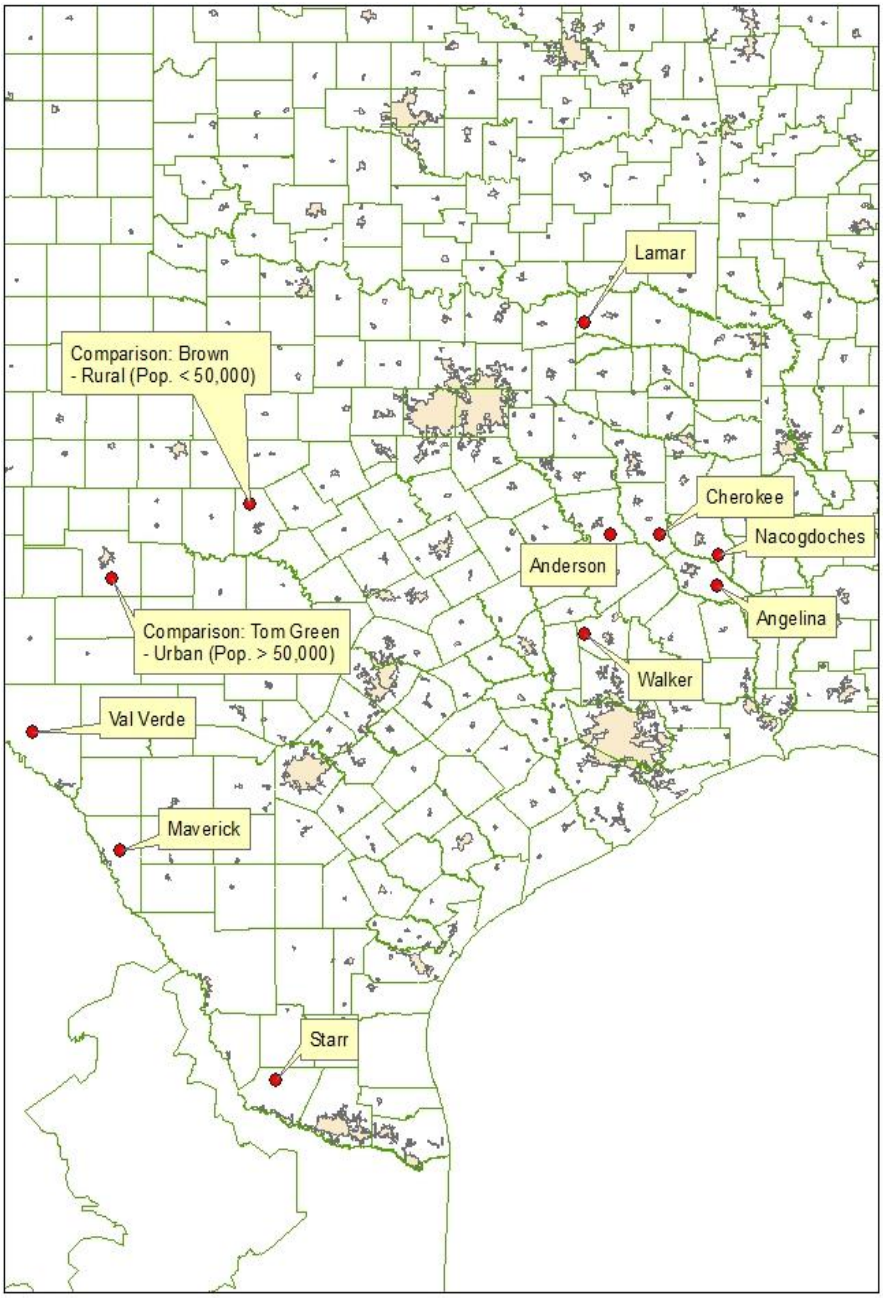

FIGURE A-1 Urbanized Areas of Texas

The nine counties classified as medium have a very small urbanized area within each county. Based on the small urban area and low population density of these nine counties, it is concluded that they should be considered rural areas for this analysis. As a result, 200 of the 254 counties within Texas are considered rural areas, and 54 counties are considered urban areas. A list of counties with their urban or rural designation is provided in Table A-2.

TABLE A-2 List of Counties with Rural or Urban Designation

District	Rural Counties (No. of Counties)	Urban Counties (No. of Counties)
Abilene	Borden, Callahan, Fisher, Haskell, Howard, Jones, Kent, Mitchell, Nolan, Scurry, Shackelford, Stonewall (12)	Taylor (1)
Amarillo	Armstrong, Carson, Dallam, Deaf Smith, Gray, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Roberts, Sherman (15)	Potter, Randall (2)
Atlanta	Camp, Cass, Marion, Morris, Panola, Titus, Upshur (7)	Bowie, Harrison (2)
Austin	Blanco, Burnet, Caldwell, Gillespie, Lee, Llano, Mason (7)	Bastrop, Hays, Travis, Williamson (4)
Beaumont	Chambers, Jasper, Newton, Tyler (4)	Hardin, Jefferson, Liberty, Orange (4)
Brownwood	Brown, Coleman, Comanche, Eastland, Lampasas, McCulloch, Mills, San Saba, Stephens (9)	(0)
Bryan	Burleson, Freestone, Grimes, Leon, Madison, Milam, Robertson, Washington, **Walker** (9)	Brazos (1)
Childress	Briscoe, Childress, Collingsworth, Cottle, Dickens, Donley, Foard, Hall, Hardeman, King, Knox, Motley, Wheeler (13)	(0)
Corpus Christi	Aransas, Bee, Goliad, Jim Wells, Karnes, Kleberg, Live Oak, Refugio (8)	Nueces, San Patricio (2)
Dallas	Navarro (1)	Collin, Dallas, Denton, Ellis, Kaufman, Rockwall (6)
El Paso	Brewster, Culberson, Hudspeth, Jeff Davis, Presidio (5)	El Paso (1)
Fort Worth	Erath, Jack, Palo Pinto, Somervell (4)	Hood, Johnson, Parker, Tarrant, Wise (5)
Houston	Waller (1)	Brazoria, Fort Bend, Galveston, Harris, Montgomery (5)
Laredo	Dimmit, Duval, Kinney, La Salle, Zavala, **Maverick, Val Verde** (7)	Webb (1)
Lubbock	Bailey, Castro, Cochran, Crosby, Dawson, Floyd, Gaines, Garza, Hale, Hockley, Lamb, Lynn, Parmer, Swisher, Terry, Yoakum (16)	Lubbock (1)

TABLE A-2 List of Counties with Rural or Urban Designation (Cont.)

District	Rural Counties (# of Counties)	Urban Counties (# of Counties)
Lufkin	Houston, Polk, Sabine, San Augustine, San Jacinto, Shelby, Trinity, **Angelina**, **Nacogdoches** (9)	(0)
Odessa	Andrews, Crane, Loving, Martin, Pecos, Reeves, Terrell, Upton, Ward, Winkler (10)	Ector, Midland (2)
Paris	Delta, Fannin, Franklin, Hopkins, Rains, Red River, **Lamar** (7)	Grayson, Hunt (2)
Pharr	Brooks, Jim Hogg, Kenedy, Willacy, Zapata, **Starr** (6)	Cameron, Hidalgo (2)
San Angelo	Coke, Concho, Crockett, Edwards, Glasscock, Irion, Kimble, Menard, Reagan, Real, Runnels, Schleicher, Sterling, Sutton (14)	Tom Green (1)
San Antonio	Atascosa, Bandera, Frio, Kendall, Kerr, McMullen, Medina, Uvalde, Wilson (9)	Bexar, Comal, Guadalupe (3)
Tyler	Rusk, Wood, **Anderson, Cherokee** (4)	Gregg, Henderson, Smith, Van Zandt (4)
Waco	Bosque, Falls, Hamilton, Hill, Limestone (5)	Bell, Coryell, McLennan (3)
Wichita Falls	Archer, Baylor, Clay, Cooke, Montague, Throckmorton, Wilbarger, Young (8)	Wichita (1)
Yoakum	Austin, Calhoun, Colorado, Dewitt, Fayette, Gonzales, Jackson, Lavaca, Matagorda, Wharton (10)	Victoria (1)

Note: Bold, underlined counties indicate counties classified as medium. The districts were classified by TxDOT district (http://www.txdot.gov/inside-txdot/district.html).

APPENDIX B: THE FUTURE FUNDING ESTIMATES OF THE SIX CATEGORIES (IN THE CASE THAT THE NINE COUNTIES ARE CONSIDERED URBAN AREAS)

The Funding Estimates of the Six Categories in Each Year ($)

Category	2012		2013		2014		2015		2016	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Maintenance	441,326,369 10.4%	918,843,631 21.6%	529,035,927 13.2%	961,684,073 24.0%	453,470,127 18.3%	962,589,873 38.8%	483,924,254 13.3%	960,115,746 26.5%	519,239,216 21.3%	1,035,580,784 42.4%
Construction	309,388,397 7.3%	2,148,601,603 50.4%	35,244,925 0.9%	2,084,595,075 52.0%	16,788,207 0.7%	763,591,793 30.8%	51,539,025 1.4%	1,832,800,975 50.5%	12,849,580 0.5%	586,790,420 24.0%
Environmental	10,957,548 0.3%	433,689,952 10.2%	3,862,555 0.1%	395,814,945 9.9%	2,072,833 0.1%	281,414,667 11.3%	5,823,122 0.2%	292,514,378 8.1%	2,072,833 0.1%	283,864,667 11.6%
Total	4,262,807,500		4,010,237,500		2,479,927,500		3,626,717,500		2,440,397,500	

Category	2017		2018		2019		2020		2021	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Maintenance	547,599,095 22.4%	1,094,220,905 44.7%	507,680,121 20.5%	1,011,679,879 40.9%	495,002,929 19.8%	985,467,071 39.4%	571,555,043 21.1%	1,143,754,957 42.2%	571,555,043 22.4%	1,143,754,957 44.9%
Construction	11,062,926 0.5%	514,437,074 21.0%	17,719,710 0.7%	654,410,290 26.5%	17,253,371 0.7%	717,906,629 28.7%	19,336,039 0.7%	680,823,961 25.1%	40,827,576 1.6%	517,112,424 20.3%
Environmental	2,072,833 0.1%	277,564,667 11.3%	2,072,833 0.1%	279,644,667 11.3%	2,072,833 0.1%	281,384,667 11.3%	2,072,833 0.1%	293,844,667 10.8%	2,072,833 0.1%	271,764,667 10.7%
Total	2,446,957,500		2,473,207,500		2,499,087,500		2,711,387,500		2,547,087,500	

Comparison to Table 32 (in the Case That the Nine Counties Are Considered Rural Areas) ($)
: Table 32 – Appendix B

Category	2012		2013		2014		2015		2016	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Maintenance	83,962,871 2.0%	−83,962,871 −2.0%	74,199,151 1.9%	−74,199,151 −1.9%	79,556,970 3.2%	−79,556,970 −3.2%	72,443,533 2.0%	−72,443,533 −2.0%	82,172,343 3.4%	−82,172,343 −3.4%
Construction	12,531,343 0.3%	−12,531,343 −0.3%	18,174,300 0.5%	−18,174,300 −0.5%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Environmental	25,852,309 0.6%	−25,852,309 −0.6%	3,049,519 0.1%	−3,049,519 −0.1%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	42,454,473 1.7%	−42,454,473 −1.7%
Total	0		0		0		0		0	

Category	2017		2018		2019		2020		2021	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Maintenance	85,506,353 3.5%	−85,506,353 −3.5%	80,813,447 3.3%	−80,813,447 −3.3%	79,323,107 3.2%	−79,323,107 −3.2%	88,322,632 3.3%	−88,322,632 −3.3%	88,322,632 3.5%	−88,322,632 −3.5%
Construction	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Environmental	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Total	0		0		0		0		0	