EVALUATION OF SURFACE TRANSPORTATION FUNDING ALTERNATIVES USING CRITERIA SYSTEM ESTABLISHED THROUGH A DELPHI SURVEY OF TEXAS TRANSPORTATION EXPERTS

by

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“Janani Janmabhoomischa Swargadapi Gariyasi”

(Mother and the Land of Birth are Superior to Heaven)

– Valmiki Rishi (Sage) in *Ramayana*

Dedicated to:

My parents Smt. Lakshmi Devi and Sri. Markandeya

My wife Sreelatha

My brother and sister Sravana Kumar and Naga Lakshmi

and my country India

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Abstract

EVALUATION OF SURFACE TRANSPORTATION FUNDING ALTERNATIVES USING CRITERIA SYSTEM ESTABLISHED THROUGH A DELPHI SURVEY OF TEXAS TRANSPORTATION EXPERTS

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For more than a decade, transportation officials have been concerned that, at current levels, the fuel tax, the primary funding source of surface transportation in the United States, would not provide enough revenue to satisfy the ever rising transportation needs. Recent studies have evaluated alternative funding strategies at the national and state levels. In this dissertation, the author improves this evaluation procedure by developing a multi-criteria evaluation of different funding options for implementation in Texas using a technique called PROMETHEE. This evaluation uses a new criteria system established through his Delphi survey of Texas-based experts who are experienced in transportation financing and/or participate in transportation funding policy decisions. With a well-organized survey process, the author tries to develop a consensus among the officials from metropolitan planning organizations in Texas, various districts of the Texas Department of Transportation and the staff of the Texas Legislative Transportation Committee members regarding the criteria and their weights. The resultant criteria weights seem to indicate that the expert panel members recognize the importance of public opinion and its impact on reaching a legislative

solution. They appear to be less concerned about criteria that may be addressed through research and modifications to the funding alternatives. This research shows that the funding policy is not seen as a tool for improving user efficiency; this result differs from the common view in the literature that encourages the fuel tax's replacement with VMT charges, which have high implementation and operating costs. Since the criteria system is based on a Texas based panel opinion, it likely strengthens the credibility of the resultant recommendations among the public.

Based on his evaluation, the author recommends increasing the fuel tax and tolling all new freeway capacity, while gradually moving towards congestion based tolls on all toll roads as the set of future funding options. Through a scenario analysis, he shows that his recommendations are not affected by the differences in opinion regarding the criteria weights or any uncertainties in the scoring. Complex, high-cost methods that require advanced technology such as VMT charges and tolling of all existing urban highways are not preferred.

Previous researchers' attempts to identify new alternatives have mainly concentrated on improving the revenue sustainability and promoting efficient travel behavior. With this research, the author tries to bring back the focus to public acceptance and any factors that influence it. Effort to improve the public awareness of transportation funding needs and to improve the public acceptance of increasing the fuel tax and other user charges appear critical for future success.

The author also analyzes the choice of implementing local funding solutions in place of statewide funding solutions. In the expert survey, the panel members suggest a balance between the two types of funding while the statewide funding should remain primary. Based on the literature review and Delphi survey responses, the author

proposes the integration of both methods such that statewide funding remains primary, local funding is coordinated by regional planning and the user-pay principle continues to govern transportation funding.

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List of Acronyms and Abbreviations

Abbreviation	Description
AET	All-Electronic-Tolling
AHP	Analytic Hierarchy Process
AVI	Automatic Vehicle Identifier
CAFE	Corporate Average Fuel Economy
CBO	Congressional Budget Office
CDA	Comprehensive Development Agreement
CNG	Compressed Natural Gas
CPI	Consumer Price Index
DART	Dallas Area Rapid Transit
DCTA	Denton County Transportation Authority
DFW	Dallas-Fort Worth
DM	Decision-Maker
DOT	Department of Transportation
EI	Ease of Implementation Criterion
EIA	Energy Information Administration
EQ	Equity and Fairness Criterion
ETC	Electronic Toll Collection
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GVW	Gross Vehicle weight
HOT	High-occupancy Toll
HOV	High-occupancy Vehicle
HTF	Highway Trust Fund
IRB	Institutional Review Board
LATTE	Loose Association of Transportation & Tolling Experts
LBB	Legislative Budget Board
LOTT	Local Option Transportation Tax
LUSTTF	Leaking Underground Storage Tank Trust Fund
MAP-21	Moving Ahead for Progress in the 21st Century
MCA	Multi-criteria Analysis
MPO	Metropolitan Planning Organization
MSA	Metropolitan Statistical Area
MTA	Mass Transit Account
MTP	Metropolitan Transportation Plan
NCHRP	National Cooperative Highway Research Program
NCTCOG	North Central Texas Council of Governments

NHCCI	National Highway Construction Cost Index
NSTIFC	National Surface Transportation Infrastructure Financing Commission
NSTPRSC	National Surface Transportation Policy and Revenue Study Commission
NTTA	North Texas Tollway Authority
OBD	Onboard Diagnostic System
OBU	On-Board-Unit
PA&PF	Public Acceptance and Political Feasibility Criterion
PPI	Producer Price Index
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluation
PSB	Potential Secondary Benefits Criterion
RG	Revenue Generation Criterion
RMA	Regional Mobility Authority
SAW	Simple Additive Weighting
SHF	State Highway Fund
SLRTP	Statewide Long-range Transportation Plan
TIFIA	Transportation Infrastructure Finance and Innovation Act
The T	Fort Worth Transportation Authority
TMF	Texas Mobility Fund
TRB	Transportation Research Board
TRE	Trinity Railway Express
TRTP	Texas Rural Transportation Plan
TTC	Texas Transportation Commission
TxDOT	Texas Department of Transportation
U.S.	United States
USDOT	United States Department of Transportation
UTP	Unified Transportation Program
VMT	Vehicle Miles Traveled

Chapter 1

Introduction

According to Mr. Oberstar, Chairman of the House Transportation and Infrastructure Committee, four important transformations in United States (U.S.) transportation shaped the current system. The first transformation happened in 1894 when a group of bicyclists obtained 150,000 signatures and requested Congress to initiate a ten thousand dollar study on the feasibility of providing paved roads for them. The second took place in 1896 when the Bureau of Road Inquiry was established leading to the creation of the Bureau of Public Roads in 1916. The third and the most important transformation occurred in 1956 when the Federal Highway Trust Fund was created and the process of building the Interstate Highway System was initiated. As the fourth transformation, the 1991 Intermodal Surface Transportation Equity Act started the post-interstate era. In 2008, while the National Surface Transportation Policy and Revenue Study Commission (NSTPRC) was presenting its final report to the Committee, Mr. Oberstar observed that the U.S. is in its transition to a new era of transportation policy for the 21st century (C-Span Video Library 2008).

In this new era, the interstate highway system has matured and requires a major portion of the annual highway funding for its maintenance and rehabilitation. U.S. cities suffer from severe congestion and air pollution, and require billions of dollars to retain good living conditions. As there has been no increase in the fuel tax[1], which is the major source of revenue for the highway funding at the national and state levels, for

[1] "Fuel tax" term in this dissertation represents the tax on gasoline, diesel and other carbon fuels that is currently in place in the U.S. Any potential tax on alternative motor fuels such as electricity is not included in this term.

two decades, the transportation authorities have to work with constrained funding. In the last two decades, many researchers have been studying the reasons for this funding deficiency and the potential solutions. With this dissertation, the author takes part in this effort by establishing a means to compare different transportation funding alternatives and recommend a funding strategy for Texas, the second largest and the second most populous state in the U.S.

In this introductory chapter, the author first provides some background on transportation funding in the U.S. Then, he lays out the research objectives and briefly outlines the methodology followed to fulfill these objectives.

1.1. History of Highway Funding

In this section, the author provides some history of transportation funding in the U.S. and discusses the current situation of funding at federal and Texas state level.

1.1.1. Early History

Wachs (2009) wrote about a century of taxes. He provided the following historical background on transportation funding. Before 1920, funds for highways were taken from states' general funds, but as the car and truck traffic grew dramatically, the share from the general funds could not keep pace. Officials decided to charge the users of the roads, as the costs of building and maintaining roadways was roughly in proportion to traffic levels. In their present form, motor fuel taxes were invented in the 1910s. At that time, tolling was considered as an option for charging the users; however, the cost of collecting tolls made this option less attractive. Furthermore, some roadways could not be financed entirely by locally generated toll revenues.

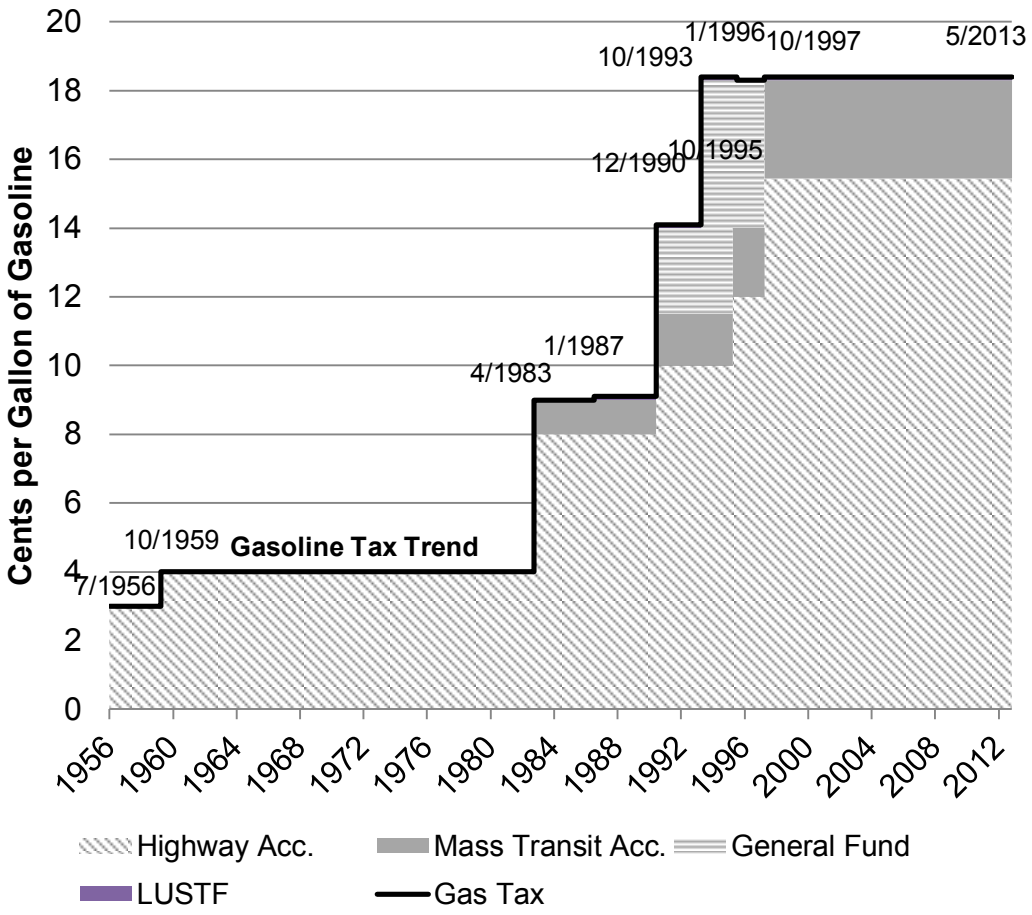
1.1.2. Motor Fuel Taxes and Federal Highway Trust Fund

The solution to this dilemma came when states, starting with Oregon in 1918, adopted an alternative form of user fee: motor fuel taxes. The state charged for road use in rough proportion to motorists' travel, and heavier vehicles paid more money than lighter vehicles because they used more fuel per mile of travel. Still, fuel taxes did not quite match tolls in terms of fairness because they did not levy charges at precisely the time and place of road use. However, fuel taxes cost much less to collect and administer than tolls, and they soon became the nation's principal means of financing its roads. When the federal government decided in 1956 to implement intercity highways on a national scale, it increased federal fuel taxes and created the Federal Highway Trust Fund (HTF), emulating the user-pays principle that had been successful in the states (Weingroff 1996).

Since 1956, the U.S. federal government increased the taxes on fuels many times (Federal Highway Administration (FHWA) 2011a). Figure 1-1 shows the growth of federal fuel tax rate from 1956 to 2013. It also shows how the resultant tax revenue is distributed among the Highway and Mass Transit accounts of the HTF, the General Fund and the Leaking Underground Storage Tank Trust Fund (LUSTTF). After a rise in 1956 and in 1959, the fuel tax was constant for the next 24 years. Then, from 1983 to 1993, it was raised sharply. In 1983, it was raised to nine cents per gallon. Due to the Highway Revenue Act of 1982, a special Mass Transit account was established, and one cent of the fuel tax was transferred from the HTF into it for mass transit development (The Library of Congress Thomas 1982). Since the Omnibus Budget Reconciliation Act of 1990, a part of the taxes on fuels has been allocated towards the General Fund for deficit reduction. In 1993, the Omnibus Budget Reconciliation Act of

1993 increased the gasoline tax to 18.4 cents/gallon while placing 10 cents in the Highway account, 1.5 cents in the Mass Transit account and 6.8 cents in the General Fund (Wheeler 1996). While the allocation towards the General Fund decreased to 4.5 cents in 1995, the Taxpayer Relief Act of 1997 redirected this remaining 4.5 cents to the HTF[2] (FHWA 2011b); however, 0.1 cents of the fuel tax continued to be deposited into the LUSTTF. Since then, the fuel tax that contributes to the HTF has been constant. Table 1-1 shows the federal fuel taxes and the distribution of tax revenue among the HTF and other recipients as of 2011 (Federal Highway Administration (FHWA) 2011a).

[2] Even though the last increase in fuel tax took place in 1993, the last increase to the actual tax contribution to the HTF was in 1997, when the Taxpayer Relief Act of 1997 stopped the redirection of fuel tax to the General Fund. So, any discussion on the stagnation of the fuel tax should use 1997 instead of 1993.



Data Source: (Federal Highway Administration (FHWA) 2011a).

Figure 1-1. Historical Growth of Federal Gasoline Tax and Its Allocation to Different Accounts

Besides the fuel tax, there are other taxes that contribute to the Highway Trust Fund. These are related to the sale of heavy vehicles and their tires, and heavy vehicle use. They are listed in Table 1-2.

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Table 1-1. List of Federal Fuel Taxes as of 2011

Fuel	Tax Rate (cents/ gallon)	Distribution of Tax (cents)			
		Highway Trust Fund		Leaking Underground Storage Tank Trust Fund	General Fund
		Highway	Mass Transit		
Gasoline	18.4	15.44	2.86	0.1	
Diesel Fuel	24.4	21.44	2.86	0.1	
Gasohol (10% Ethanol)	13	6.94	2.86	0.1	2.5
Other Gasohol Fuels	12.4 to 15.322	6.94 to 9.862	2.86	0.1	2.5
Special Fuels (LNG, LPG)	18.3 to 24.3	15.44 to 22.44	1.86 to 2.86	0 to 0.1	
Other Special Fuels	9.25	7.72	1.43	0.1	
Compressed Natural Gas	144.47*	134.76	9.71		

* Cents per Cubic Feet

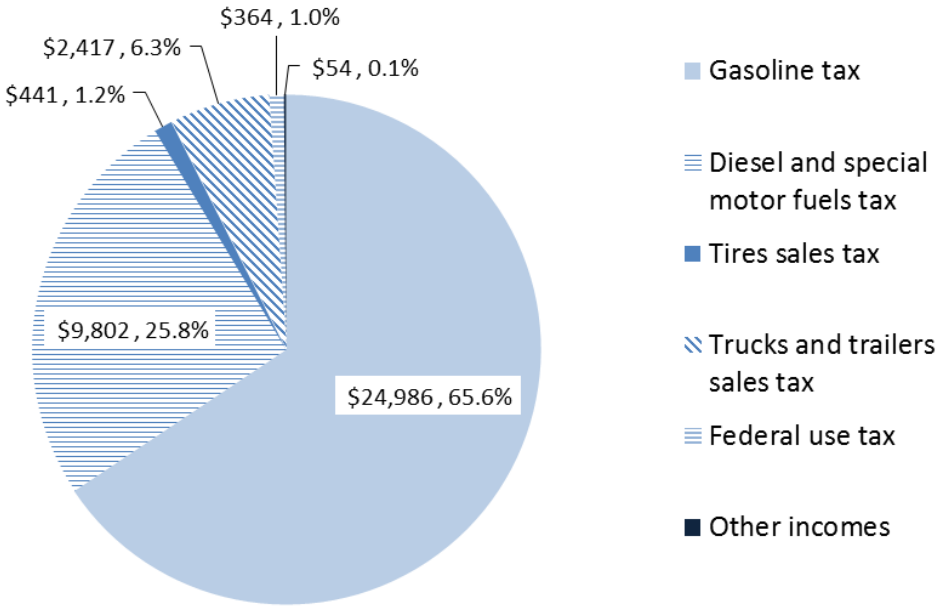
Data Source: (Federal Highway Administration (FHWA) 2011a)

Table 1-2. Truck Related Taxes Contributing to Highway Account of HTF

Tax Type	Tax Rate
Sale of tires with maximum rated load capacity over 3,500 pounds	9.45 cents per each 10 pounds in excess of 3,500
Sale of Trucks over 33,000 gross vehicle weight (GVW) and Trailers over 26,000 lb. GVW	12 percent of retailer's sales price
Annual tax on heavy vehicle use	Up to GVW of 55,000 lb.: $100 GVW over 55,000 lb.: $100+$22 for each 1,000 lb. in excess of 55,000 lb. (or fraction thereof) (maximum tax of $550)

Data Source: (Office of Legislative and Governmental Affairs 2007; FHWA 2012a)

In the fiscal year 2011, from October 1, 2010 to September 30, 2011, the HTF received $36.9 billion from excise taxes and other sources, after subtracting the amount transferred to other Funds. Figure 1-2 shows the contributions from different taxes to the HTF in 2011. Gasoline tax and diesel tax contribute about 90% of revenue in the HTF.



Data Source: (Office of Highway Policy Information (OHPI) 2012a)

Notes:

Tax revenue shown here is before subtracting any transfers to other Funds.

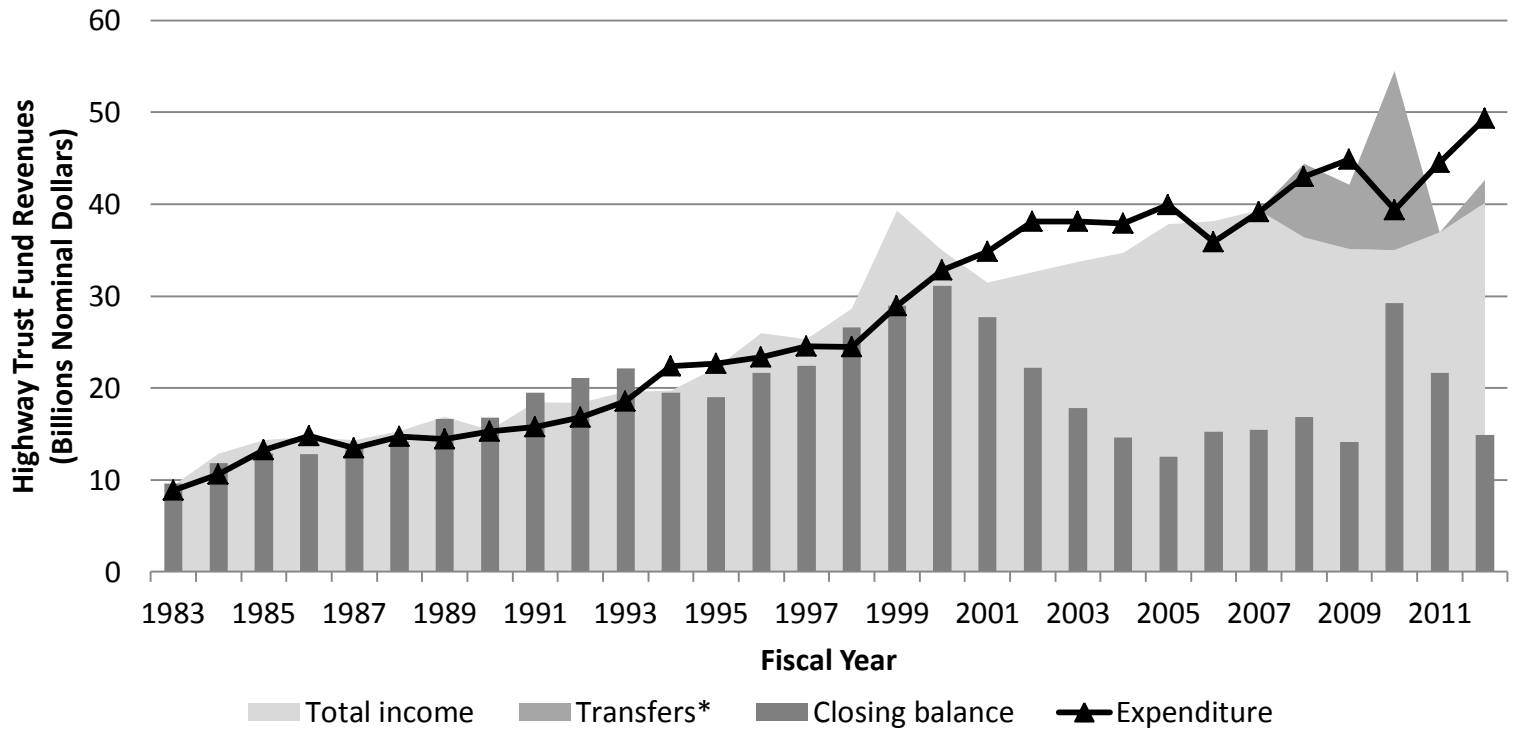
Other incomes include interest income, fines and penalties, and the Transportation Infrastructure Finance and Innovation Act (TIFIA) downward adjustments.

Figure 1-2. Revenue Contributions of Different Sources to HTF in 2011

Spending from the HTF is partly determined by authorization acts by the U.S. Congress. The Moving Ahead for Progress in the 21st Century (MAP-21) is the most current authorization act that has been passed in 2012 and expires in 2014 (FHWA 2012b). For the fiscal year 2013, this act allows obligations up to $50 billion dollars

(Sarah Puro 2013) for spending on highway programs. MAP-21 extends the fuel tax at the current rate up to September 2016 (FHWA 2012a).

The FHWA's Office of Highway Policy Information (2013a) provides historical data regarding the annual deposits and spending for the HTF. The author compares the total money deposited into the HTF and expenditure (also called outlays) from the HTF since 1983 in Figure 1-3. The figure shows the variation in the HTF's closing balance, which rises when the total income of the HTF is more than the expenditure and drops when the expenditure is more than the income. As shown in Figure 1-3, funds have been transferred from the General Fund into the HTF since 2008 to reduce its deficit.



Data Source: (OHPI 2013a; FHWA 2013)

Note: * Funds have been transferred from the General Fund since 2008 to reduce the deficit in the HTF. In 2012, $2.5 billion has been transferred from the LUSTTF.

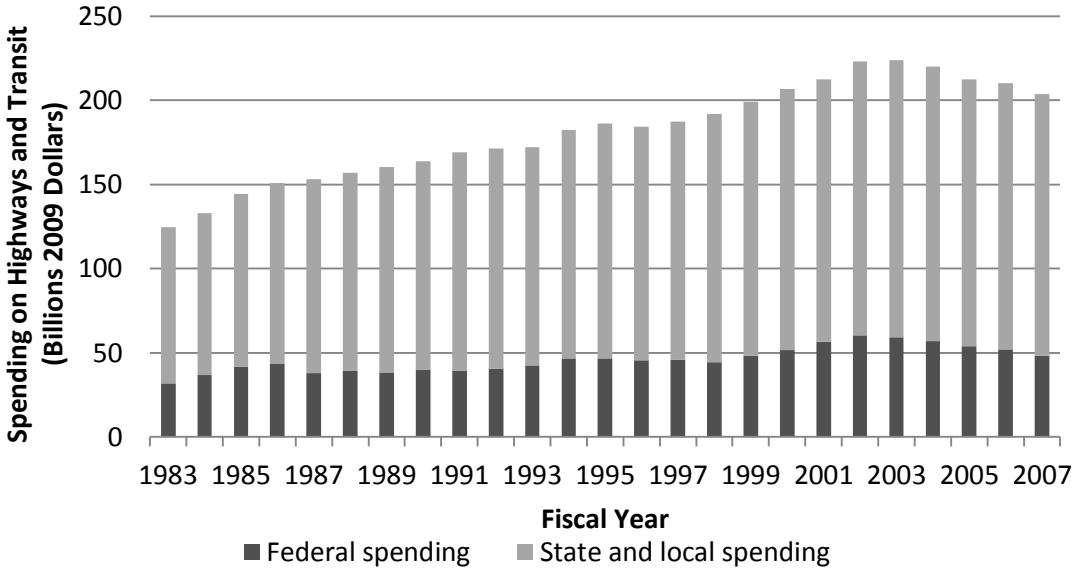
Figure 1-3. Historical Income and Expenditures of Federal Highway Trust Fund

The HTF income has been on an increasing trend for the most part since 1983. The income has increased more than normally for a brief period after 1995 when 2.5 cents of the fuel tax that had been deposited into the General Fund has been diverted back to the HTF. In 1999, the income has experienced a sharp growth, a 37% growth, because the HTF received all 18.4 cents of the gasoline tax. Until 1998, the expenditure has closely followed the income trend and typically has remained lower than the income, which has kept the HTF's closing balance on an upward trend. The expenditure has increased sharply between 1999 and 2002; probably due to an expectation of increased income after 6.8 cents of gasoline tax has been redirected to the HTF from the General Fund. However, the income has dropped sharply in 2000 and 2001. This period can be marked as the start of the HTF's retreat from sustainability. From 2001 to 2005, the expenditure has been higher than the income and so the closing balance has steadily dropped. After two years of expenditures lower than incomes, the income has dropped for three consecutive years from 2008 to 2010. In this period, the deficit in the HTF has been reduced by transferring money into it from the General Fund. After a drop in expenditure in 2010, its high growth has continued. Since 2010, the expenditure has been more than the income and the HTF's closing balance has been dropping significantly.

In this sub-section, the main source of transportation funding at the federal level and the status of the HTF are discussed. The next sub-section reviews how the funds for transportation improvements are generated at the state level and how they are allocated.

1.1.3. Transportation Funding at State Level

Funds authorized from the HTF primarily fund highways, highway safety and transit. Federally funded highways are called Federal-aid Highways. These cover only a portion of all roadways in the U.S. Historically, about 25% of all expenditure on highways and transit in the U.S. is funded by federal money. Figure 1-4 shows the share of federal funding in total spending on highways and transit for the period 1983 to 2007. The remaining funds are generated at the state and local levels. Traditionally, state governments have primarily employed taxes on motor fuels and vehicle registration fees while local governments have used revenues from property taxes and sales taxes to fund roadway and transit projects. The following paragraphs briefly discuss the transportation funding process in Texas at the state level and the local level.



Data Source: U.S. Congressional Budget Office (2010)

Figure 1-4. Federal Share in Total Spending on Highways and Transit in the U.S.

In Texas, the Texas Department of Transportation (TxDOT) maintains about 80,000 centerline miles of road, which comprises about 26% of roads in the state. These state maintained roads carry almost 74% of the total annual vehicle miles traveled in Texas (Legislative Budget Board Staff 2013). The state highway system consists of Interstates, U.S. highways, state highways, farm-to-market roads and other state system highways.

Funding for the construction and maintenance of the state highway system in Texas is generated mainly through vehicle registration fees, taxes on motor fuels and lubricants, and federal funding. Traditionally, the projects are financed through a pay-as-you-go system where roads are built as funding becomes available. However, in the last decade, due to the shortage of funds, borrowing funds through bonds and private investments has occurred. All the revenues generated through taxes and fees, and through borrowing are deposited in two Funds called the State Highway Fund (SHF) and the Texas Mobility Fund (TMF) (Legislative Budget Board Staff 2013). The composition of these Funds and their historical growth are explained below.

State Highway Fund

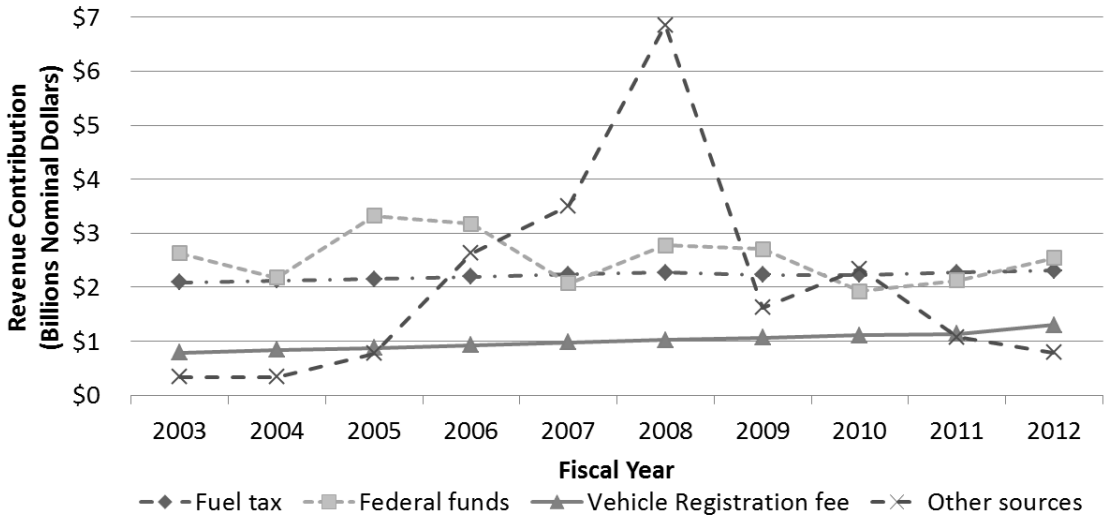
The State Highway Fund is filled by three main sources: federal funds, a tax on motor fuels and vehicle registration fee. In the ten fiscal years from 2003 to 2012, these three sources have, on average, contributed about 75% of the total revenue deposited to the SHF. The state fuel tax (same for gasoline and diesel) is 20 cents per gallon. This is very close to the average of the fuel tax rates imposed by all U.S. states, which is about 21 cents per gallon in 2011 (OHPI 2012b). The Texas fuel tax was increased to 10 cents per gallon in 1984 after being constant at 5 cents per gallon for nearly 30 years. It was increased to 15 cents per gallon in 1986 and further to 20 cents per gallon

in 1991 (Legislative Budget Board Staff 2013). This increase is similar to the sharp increase in federal fuel tax. The government's effort to decrease fuel usage is a probable reason for this increase. Since 1991, it has been unchanged (Legislative Budget Board Staff 2013). Three quarters of the Texas state fuel tax is used for transportation funding while the rest goes to fund education. When federal and state gas taxes are combined, a person who drives 12,000 miles a year with a mileage of 21 miles per gallon pays about 16 dollars per month on gas tax for transportation funding.

The Texas vehicle registration fee schedule was simplified in 2011. Currently, passenger cars pay a vehicle registration fee of $50.75 annually. Heavy vehicles pay higher fees based on their weight. The federal funds deposited into the SHF are reimbursements for the work already performed by TxDOT. Other revenue sources of the SHF include bond proceeds, concession fees from Comprehensive Development Agreements (CDAs), sales tax on lubricants, special vehicle registration fees, commercial vehicle transportation fees, vehicle certificate fees and transfers from other State Funds.

Figure 1-5 shows the trends of different revenue sources of the SHF from 2003 to 2012. It shows that the revenues from the fuel tax and the vehicle registration fee follow a stable growth. In this period, the federal funds have followed a wave-like trend with jumps every three years and are on a slightly declining trend overall. Due to the transfers from other Funds, increased use of bonds and toll concession agreements, revenue from other sources has increased since 2005, especially in 2008, when TxDOT gained about $3.2 billion in 2008 when it entered into a CDA with the North Texas Tollway Authority (NTTA) regarding SH 121 in Denton and Collin Counties in Texas. The reader may note here that this $3.2 billon has later been put in a Regional

Toll Revenue Fund and has been used only in the Dallas-Fort Worth (DFW) area where SH 121 is located (NCTCOG 2013). Figure 1-6 shows how the shares of different revenue sources have varied from 2003 to 2012.



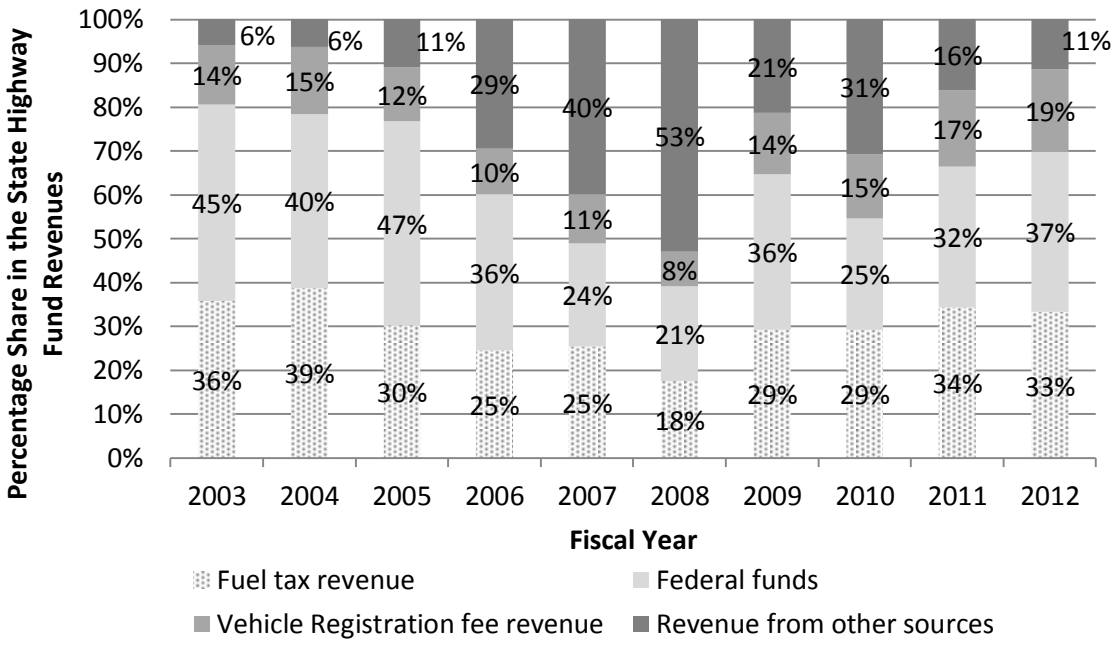
Data Source: Texas Legislative Budget Board (Legislative Budget Board Staff 2013).

Notes:

1. Other sources include transfers from other State Funds, bond proceeds, fees from toll concession agreements and other minor taxes and fees.

2. Sudden increase in the revenue from other sources in 2008 is due to inclusion of $3.2 billion gained by TxDOT from the SH 121 CDA (See more discussion in the text above).

Figure 1-5. Texas State Highway Fund Major Revenue Trends



Data Source: Texas Legislative Budget Board (Legislative Budget Board Staff 2013).

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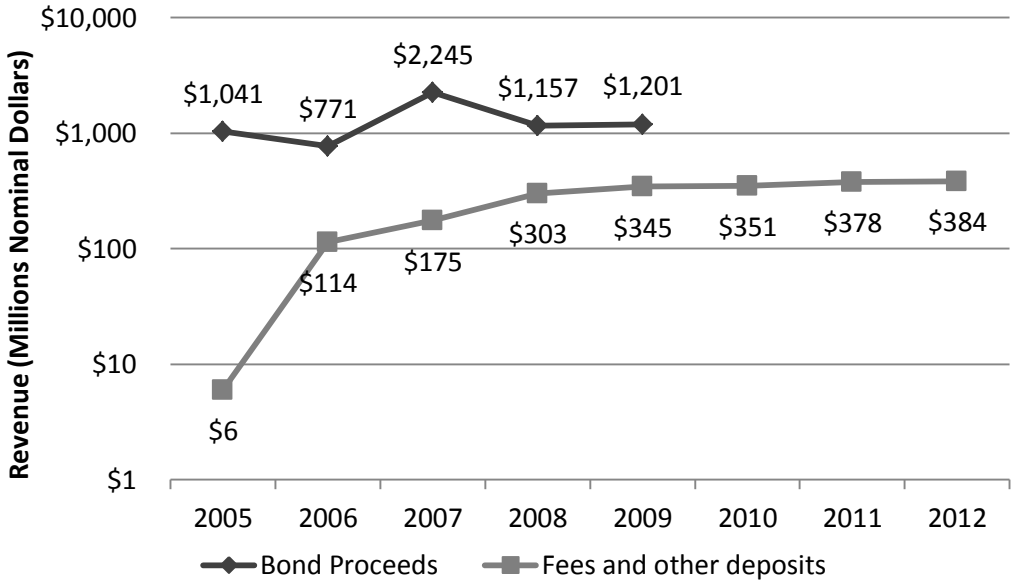
2. Sudden increase in the revenue from other sources in 2008 is due to inclusion of $3.2 billion gained by TxDOT from the SH 121 CDA (See more discussion in the text above).

Figure 1-6. Change in Shares of Revenue Sources in the State Highway Fund

Texas Mobility Fund

The Texas Mobility Fund was established in 2001. This establishment has allowed the Texas Transportation Commission (TTC) to borrow money for construction and maintenance of the highway system for the first time. Bonds are issued and the proceeds are deposited in the TMF. Revenue sources that contribute to the TMF include certain fees charged by the Department of Public Safety such as motor vehicle inspection fees, motor carrier act penalties, drivers license fees and driver record information fees, vehicle title certificate fees, and interest earned on the state deposits

and treasury investments. Revenue from these sources is used to pay off the bonds. Figure 1-7 shows the trends of the revenue from bond proceeds and other revenue sources of the TMF.



Data Source: Texas Legislative Budget Board (Legislative Budget Board Staff 2013).

Figure 1-7. Trends of Revenue Sources in the Texas Mobility Fund

Apart from the SHF and the TMF discussed above, TxDOT receives money from the issuance of the General Obligation Bonds (GO Bonds) which are backed by the Texas General Revenue Fund.

All the funding discussed so far is for TxDOT to use for construction and maintenance of the state highway system. For developing and maintaining the remaining roadways and transit, local governments and certain regional transportation authorities generate their own funds. The following paragraphs provide a glance over the local funding in Texas.

Local Funding in Texas

Some portion of the revenue from the vehicle registration fees is put aside in the County Road and Bridge Fund so that counties can use the money for developing and maintaining county roads (Legislative Budget Board Staff 2013). Texas cities and counties primarily use property tax revenue to build and maintain local arterials and streets, and to develop and operate transit systems. In addition, 242 out of 254 counties impose an optional county fee for 'road and bridge fund' of up to ten dollars along with the state vehicle registration fee (Texas Constitution and Statutes 2011; Texas Department of Motor Vehicles 2011). Two counties along the Texas-Mexico border charge another ten dollars for transportation project mobility fund, which is used by the corresponding county Regional Mobility Authority (RMA) for transportation projects (Texas Department of Motor Vehicles 2011). These local revenues also contribute to complement the state and federal funds in constructing and maintaining state highway system roads. Texas allows local governments to impose a local sales tax, summing up to 2% (Texas Comptroller of Public Accounts (TCPA) 2013a). Ten transit districts covering many counties in Texas charge up to one percent local sales tax, which is part of the aforementioned sales tax (TCPA 2013b). Transit authorities in DFW and Houston areas have been developing light rail projects using these funds.

In addition to the above mentioned major funding methods, there are some minor options. The Pass-through financing program provides the local communities with an option to bear the upfront construction costs of a project and get reimbursed by TxDOT for the amount of traffic using the project (Texas Department of Transportation (TxDOT) 2013a). In another program available, the local governments can finance a transportation project in an underdeveloped area by setting up a Transportation

Reinvestment Zone (TRZ) and using the additional revenue gained due to increase in property taxes from the promotion of the project (TxDOT 2013b).

1.1.4. Funding Allocation Process

As mentioned earlier, funds from the HTF are spent through certain surface transportation authorization acts. While distributing the funds in the HTF among the states, all states do not receive the revenue that is collected in the respective states. Some states, especially those located in the south and mid-west become donor states, which receive less money for their highways than the revenue they contribute to the highway account of the HTF. Some part of their share is used to fund nationally important transportation projects in some states (called donee states) where the tax revenue generated is not sufficient. Money from the HTF is apportioned to different programs by fiscal year, and states obtain obligations from the FHWA to pay for the projects. As the work is finished, the contractors send the invoice to the state department of transportation (DOT) for payment. The state DOT pays the invoice and submits the same to the FHWA, who reimburses the amount. In Texas, such reimbursements are deposited into the SHF.

In Texas, the project construction undergoes a multi-level planning and programming process. First, the statewide goals and priorities are established. In line with these priorities, TxDOT, in collaboration with statewide, regional and local stakeholders that are accountable to users, identifies long range, system-wide transportation needs. TxDOT develops a statewide long-range transportation plan (SLRTP), which is the 24-year blueprint for the transportation planning process and addresses all transportation modes. In conjunction with the SLRTP, the metropolitan planning organizations (MPOs) prepare metropolitan transportation plans (MTPs)

which are comprehensive, multimodal plans of transportation systems and services aimed at meeting the mobility needs of the MPO regions through the next twenty or more years. For the rural regions, the Texas Rural Transportation Plan (TRTP), which is a component of the SLRTP, addresses the enhancement of rural transportation system connectivity, promotion of rural mobility/congestion relief and enhancement of rural transportation. Then, TxDOT prepares a Unified Transportation Program (UTP) which is a 10-year program that guides transportation project development; it covers the projects planned for the first 10 years of the SLRTP. The UTP authorizes projects for construction, development and planning activities and includes projects involving highways, aviation, public transportation, and state and coastal waterways. In this UTP, TxDOT forecasts its yearly cash availability and allocates the money to different TxDOT districts and MPOs for each category of projects. It specifically identifies the account from which the money comes for each allocation. The 2013 UTP allocates about $36.45 billion for twelve categories of projects. Some of these projects add capacity to the transportation system. Others are maintenance and rehabilitation projects (TxDOT 2013c).

The MTPs developed by MPOs are updated every five years or sooner as required by federal regulations. MPOs plan and identify funds for all transportation projects, especially major highways and public transportation projects that are funded by federal and state funds. The list of projects included in the MTPs may also include projects related to city streets and arterials which are funded by local authorities. Sources of funds include the federal and state funds programmed in the UTP, the transit funds from the Federal Transit Administration (FTA), the local funds from cities, counties and other transportation authorities, tolls and other private funds. Different

financing mechanisms such as bonds and public-private partnerships also are used to finance certain planned projects.

1.2. Transportation Funding in the Future

In the previous section, the author provides a brief discussion on the transportation funding process and supplies some historical data. In this section, he discusses the future needs for transportation funding and the challenges that the state is facing to satisfy them.

1.2.1. Needs

Funding need is a subjective term. It changes with the region's transportation and environment goals and also with the expectation of the availability of funds. Depending on the target levels of service for different types of facilities, the list of projects changes and so does the cost of the MTP. The projects planned in the MTPs may not represent a region's transportation needs because the MTPs should be reasonably financially constrained, which means the funds should be reasonably identified for all the projects planned.

The 2030 Committee established by the Texas Transportation Commission produced a report on the funding needs for the period of 2009 to 2030 called "2030 Committee Texas Transportation Needs Report" (2030 Committee 2009). The Committee updated it in 2011 with an enhanced analysis and forecasts for four alternative levels of service for different elements of the Texas transportation system. Some of the reasons mentioned by the Committee for increased funding need included:

- As the population grows and the amount of travel increases, the transportation facilities need to improve. Increasing congestion and air

pollution, and reduced safety increase the cost to each person in terms of the time wasted, costs incurred on health problems and road accidents.

- The nation's highways and bridges need proper maintenance and rehabilitation. Paying now for these repairs reduces the future cost of rebuilding.
- The cost of construction and maintenance has been increasing significantly in the recent past and is expected to do so in the future.

The Committee has considered transportation investments for pavements, bridges, mobility and rural transportation. Total cost of investment for the four scenarios has ranged from $100 billion to $270 billion in 2010 dollars as shown in Table 1-3 (2030 Committee 2011).

Table 1-3. Statewide Total Implementation Costs for Scenarios

Scenario	Cost of Investment (2010 dollars)
Unacceptable Conditions Scenario (Current Trend)	$100 billion
Worst Acceptable Conditions Scenario	$174 billion
Minimum Competitive Conditions Scenario	$217 billion
Continue 2010 Conditions Scenario	$270 billion

Data Source: (2030 Committee 2011)

The 2030 Committee report does not clarify if this investment is from only state and federal governments or from local governments also, and the report does not clarify if it includes funding the construction and maintenance of local streets. In comparison to the above forecast, the Texas SLRTP 2035 prepared by TxDOT, mentions that the funding need for highways, in the context of the state system highways, through 2035 is $370 billion in 2010 dollars. It is based on highway capacity

costs, pavement rehabilitation, and bridge maintenance, inspection and replacement costs. For public transportation, it forecasts another $43 billion[3] (TxDOT 2010).

As discussed earlier, each MPO prepares an MTP that consists of projects planned for a 25 year horizon. In addition to the highway projects that are on the state highway system, this plan includes local and regional projects. The 2035 MTPs from the four major metropolitan areas in Texas – Austin, Dallas, Houston and San Antonio – have a total cost of about $227 billion in nominal dollars[4]. Federal and state funds are expected to provide for about 24% of this cost. Local funds account for about 43%, while the remaining cost is expected to be paid through tolls, private investment and other sources (Capital Area Metropolitan Planning Organization 2010; North Central Texas Council of Governments (NCTCOG) 2011; Houston-Galveston Area Council 2011; San Antonio - Bexar County Metropolitan Planning Organization et al. 2009).

The next sub-section discusses the availability of funds and the challenges involved in meeting the funding needs.

1.2.2. Funding Availability or Unavailability

While the funding needs are rising, the availability of funds is not growing at the same pace. In the Texas SLRTP 2035, TxDOT estimates only $58 billion in available funds for highways for the period from 2010 to 2035 in comparison to the above mentioned $370 billion funding need. This amount includes federal and state funds,

[3] The report does not mention whether the amount is stated in real dollars or nominal dollars. The author assumes that it is a sum of amounts in nominal dollars from different years.

[4] The costs are stated in nominal dollars for different fiscal years and are added. Based on the author's experience, this is not a reasonable method to add the costs. Before summing, all the dollar amounts should be converted into one year dollars, normally either base year or future year. Since the MTPs present the costs summed up without this conversion, and the author does not have any means to convert them, he decides to present them as they are.

and bond proceeds (TxDOT 2010). The extent of the funding crisis faced by the state and the nation and some of the reasons for the crisis are discussed below.

In recent years, a shortage of money in the HTF has existed. The Congressional Budget Office forecasts that, if no steps are taken to increase the balance in the HTF, starting from 2015, the HTF balances will not be sufficient to meet all of its obligations, resulting in steadily accumulating shortfalls (Sarah Puro 2013). From 2008 to 2012, the Congress has transferred $41 billion from the general fund to the HTF to keep it solvent. Another $12.6 billion is authorized for transfer in 2014 (Sarah Puro 2013). The state of Texas has also experienced similar problems. Since 2006, the state has allowed borrowing money for highway construction and currently has about $9 billion in debt including SHF bonds, TMF bonds and GO bonds[5] (Legislative Budget Board Staff 2013).

The following are the main reasons identified for the short fall of the revenue from the fuel tax which is the primary user charge and main source of federal and state surface transportation funding:

- No increase in the fuel tax: At the national level, since 1997, there has been no increase in the fuel tax per gallon that is deposited into the HTF. Since 1991, the state motor fuel tax has not increased. The lack of support from the public and elected leaders can be seen as the main reason for this situation. Williams (2007) mentions that the public distrust caused by the

[5] The SHF bonds for $4.6 billion have been issued and about $1.3 billion has been repaid. The TMF bonds for $6.4 billion have been issued and about $1.6 billion has been repaid. The GO bonds for about $1 billion have been issued (Legislative Budget Board Staff 2013).

increased amount of diversions of revenue from the HTF to non-highway uses as earmarks is one of the main reasons for this lack of support.

- Increase in vehicle fleet fuel efficiency: With increased concerns for dependency on oil and environmental pollution, the overall fuel economy of vehicles has been increasing. The Obama administration has increased the vehicle fleet fuel economy standards called the Corporate Average Fuel Economy (CAFE) standards in 2012. By Model Year 2025, cars and light-duty trucks rolled out by a manufacturer should have an average fuel economy equivalent to 54.5 mpg (Office of the Press Secretary 2012). The Energy Information Administration (EIA) forecasts that the average fuel efficiency for all cars and trucks on the road will increase from 17.8 mpg in 2013 to 25.7 mpg in 2035 if the new CAFE standards are implemented (U.S. Energy Information Administration 2013). With this increase, although the amount of vehicle travel grows every year, the amount of gas or diesel consumption and the revenue from the fuel tax may not grow as much or may even decrease.
- The fuel tax has not been indexed to inflation: So, the purchasing power from the gas tax revenues has shrunk. In the period from 1997 to 2013, the value of the dollar has decreased by about 31% (Bureau of Labor Statistics 2013). That means 18.4 cents tax in 1997 is equivalent to 12.6 cents in 2013.
- Increase in construction and maintenance costs: The unit costs of construction and maintenance activities outpaced the increase in fuel tax revenue.

In the last two decades, many studies have been performed and many articles have been written regarding the solutions for the current and the future funding deficiencies. Some of the solutions proposed in this literature are discussed in the next sub-section.

1.2.3. Funding Strategies

The funding solutions proposed include expanding traditional taxes and fees, increased use of tolling of facilities in many variations, implementing a new tax[6] based on vehicle miles traveled (VMT charges) and other creative ways of generating funds. Currently, employing innovative methods of using funds from different sources to make a project feasible, called innovative financing, is more common.

Traditional Taxes and Fees

Since the funding deficiency has been primarily caused by not increasing the federal and state fuel tax, increasing the fuel tax, either by a fixed amount or periodically with one of the inflation measures, or both, is proposed by most of the related studies and articles (Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance 2006; National Surface Transportation Policy and

[6] A tax on VMT is commonly referred to as a "Mileage-Based User Fee" or a "VMT fee". By definition, taxes are imposed for the primary purpose of raising revenue, with the resultant funds spent on general government services; fees are imposed for the primary purpose of covering the cost of providing a service, with the funds raised directly from those benefitting from a particular service provided (Henchman 2013). In the author's view, since the revenue from the VMT charges is going to be used for transportation investments in general, similar to the revenue from the fuel tax, a VMT charge is a tax even if it is called a VMT fee. In the political arena, sometimes fees may be easier than taxes to create or increase. As Weatherford (2012) mentions in his dissertation, the word "fee" in "VMT fee" may be chosen intentionally by those who promote the adoption of VMT fees. In this dissertation, the author refers VMT fees as VMT charges. Since such charges may vary by a number of user classes, the plural form is often used. Singular form is also used sometimes in this dissertation.

Revenue Study Commission 2007; Institute of Taxation and Economic Policy 2011). Increasing other types of user fees that currently contribute to transportation funding comes next. For example, the study by the National Surface Transportation Infrastructure Financing Commission (NSTIFC) (2009) considers increasing user charges such as vehicle registration fees and taxes on the sales and use of heavy vehicles and their parts.

Increase in other broad-based taxes such as sales tax is considered because such an increase provides significant revenue with as small an increase as 0.25 percentage points. An increase in tax on the sale of vehicles, tires and parts is also considered (National Surface Transportation Infrastructure Financing Commission 2009; Dye Management Group 2009). Revenue from these statewide taxes should be newly allocated to transportation because it currently does not contribute to transportation funding.

Facility Tolling

Tolling has become more attractive at present because of the use of all-electronic-tolling (AET) where tolls are collected electronically, without a need for vehicles to stop or slow down. Cost of toll collection has reduced significantly due to the use of AET (Fleming 2012). There are many variations of tolling such as:

- Tolls on highways and bridges (traditional toll facilities)
- Tolls on exclusive lanes within corridors (express toll lanes)
- Tolls on exclusive high-occupancy vehicle (HOV) lanes (High-occupancy Toll (HOT) lanes)
- Tolls for entering a specific geographic area (cordon pricing)

- Variable tolls based on congestion level, either with a fixed schedule or changing dynamically with congestion level

Revenue from tolls on a new highway or new lanes added to a highway may be used to cover the construction and maintenance costs on that highway corridor. There have been proposals in some states for tolling an existing highway (existing lanes) and using the revenue to maintain or rehabilitate that highway, for example in North Carolina[7] (Samuel and Tollroadsnews 2012).

Currently, tolling is efficient when it is done on limited access highways because the tolls can be captured from all travelers with a reasonable number of collection points. Consequently, as the users of the entire transportation system are not subjected to tolls, the tolling currently supplements other user charges such as the fuel tax rather than replacing them.

Vehicle Miles Traveled Charges

The concept of VMT charges has been under investigation for at least two decades. Report 377 by the National Cooperative Highway Research Program (NCHRP) (Reno and Stowers 1995) has compared the advantages and disadvantages of implementing VMT charges over increasing the fuel tax. Proponents of VMT charges state that replacing fuel tax with VMT charges is advantageous because the increasing vehicle fleet fuel efficiency and increase in alternative fuel vehicles do not affect the revenue or the fairness of the system when the charges are based on mileage (Sorensen et al. 2012). They say that VMT charges may be used to achieve additional policy goals such as reducing traffic congestion by varying charges by vehicle type,

[7] This proposal has not obtained the approval of the North Carolina State Legislature (Tollroadsnews 2013).

time of travel and level of emissions (Sorensen et al. 2012). Variations in VMT charges include weight-mile taxes for trucks (Oregon Legislative Committee Services 2000) and pay-as-you-drive insurance (Wikipedia 2013).

Many researchers have been studying strategies for its implementation (Sorensen et al. 2009). A number of pilot studies have been performed (Rufolo and Kimpel 2008). The cost of collection of VMT charges has been estimated based on a pilot study (Rufolo 2011). Transportation professionals and researchers commonly agree that, due to the technological challenges involved, implementation issues and the high cost of collecting VMT charges, implementation of VMT charges is not feasible in the near future. The exact timeline for that depends on how soon the aforementioned problems are solved. Almost all the related studies consider VMT charges as an alternative, and most studies suggest a transformation to VMT charges in the long-term.

Local Area Funding Solutions

The transportation needs of urban areas with dense population and heavy congestion are usually higher than the needs of the state as a whole. This imbalance in funding is seen between the four major urban areas and the remaining small-urban and rural areas. In such a situation, an increase of the fuel tax in the entire state may raise concerns such as Gov. Perry's that the rural residents pay taxes to subsidize the cost of the urban residents (Lindenberger and Dallasnews 2009). This argument gives rise to local area taxes. In 2009 and 2011, there were proposals in the Texas Legislature for allowing counties to implement a local option transportation tax (Truitt 2009). Currently, county vehicle registration fees (Texas Department of Motor Vehicles 2011)

and local area sales taxes (Texas Comptroller of Public Accounts (TCPA) 2013a) are commonly employed in Texas.

Other Creative Solutions

Taxes on luxury vehicles, which use more fuel than regular cars, can generate some revenue while promoting better fuel efficiency. The author views that donations and sponsorships may prove to be minor revenue sources for transportation funding. Naming rights for certain transportation facilities may be provided in return for the donations.

In this section, the author discusses the deficiencies in transportation funding and the options available to generate more funding. While there are many alternatives, the transportation policy makers need to choose the best strategy that is acceptable to most stakeholders. In the next section, the author discusses the on-going efforts on evaluating different funding options and his intent to participate in them.

1.3. Research on Evaluation of Funding Alternatives and Evolution of the Author's Research

In the last two decades, many studies have been performed at the national level and the state level for evaluating different funding strategies. NCHRP Report 377 contains recommendations to all levels of government regarding evaluating alternatives to the motor fuel tax (Reno and Stowers 1995). The NSTIFC (2009) evaluates various funding alternatives after establishing a criteria system. In this study, the NSTIFC focuses on national level funding solutions while considering their applicability to state and local levels. The NSTIFC evaluates different groups of alternatives over a number of criteria grouped into five main considerations and recommends a future funding strategy to the United States Congress for the short and long terms.

Using the methodologies suggested in NCHRP Report 377 and the NSTIFC Report, numerous state level studies evaluated funding alternatives for a particular state (e.g. (Weinstein et al. 2006; Cedar River Group 2010; Schultz, Louis C. Jr. et al. 2010)). In 2009, the Dye Management Group, Inc. (2009) evaluated various funding alternatives to be implemented in Texas. In another pool of research, researchers evaluated individual attributes of certain alternatives in more detail. For example, NCHRP Report 689 compared the costs of different pricing mechanisms (Balducci et al. 2011).

The current and the expected future deficiency in transportation funding, and the opportunity to contribute to the research on finding a solution for this problem motivate the author's research. He sees that the states take on a higher burden to raise their own funds as the federal funds decrease. So, he concentrates on finding a funding solution for Texas and hopes that his research can be used for other states as well, after some customization to their particular case.

1.4. Research Description

This section conveys the main aim of the author's research. It presents this dissertation's research statement and lists its primary and secondary objectives.

1.4.1. Research Statement

The author wants the evaluation of funding alternatives to capture different perspectives. A funding solution has a greater likelihood of adoption and success when it considers the priorities of both transportation officials and politicians. Due to the differences in their backgrounds as well as their objectives, transportation officials and policy makers may have different priorities. With this in mind, the author establishes an expert panel that includes many transportation officials situated across Texas and the

staff of the Texas Legislative Committees on Transportation. He establishes a set of criteria and their weights, which represent the criteria's relative importance, for evaluating transportation funding alternatives based on the opinions of this expert panel. The author uses the Delphi method (Linstone et al. 1975) to collect the panel's opinions and to build a group consensus. The consensus is developed through an iterative process, where the individual responses are filtered, aggregated and returned to panel participants.

The author evaluates a number of well-defined funding alternatives to find a set of preferable funding strategies for Texas. Proper evaluation of funding alternatives is expected to allow the policy makers and transportation authorities to support their preferred funding strategy among the public with increased credibility. Specific objectives of the research are listed in the following sub-section.

1.4.2. Research Objectives

1. Through a review of existing literature, identify the types of transportation funding that have been implemented, tested or currently studied. Understand their basic advantages and disadvantages.
2. Through a review of available studies on evaluation of funding alternatives, identify the criteria used by the previous studies in evaluating the funding alternatives. Understand how the different funding alternatives perform on different criteria.
3. Establish the criteria and their weights to evaluate transportation funding alternatives in Texas by performing an expert opinion survey.

4. Identify the differences in opinion among the panel members and the groups of members regarding the criteria weights; the members are grouped by their affiliation and their region type (urban or non-urban).
5. Prepare a list of funding alternatives for implementation in Texas to partially fulfill the funding needs in the period from 2013 to 2035. Include alternatives for both statewide and local implementation.
6. Evaluate the funding alternatives using the criteria system developed in this research and develop a set of preferred funding strategies.
7. Perform a sensitivity analysis and present how changes in criteria weights or the alternatives' scores affect the preference of the funding strategies.
8. Study the advantages and disadvantages of locally implemented funding solutions compared to statewide solutions. Obtain the preference of the expert panel regarding this choice of implementing local or statewide funding solution and recommend a strategy for Texas.

1.5. Significance of the Research

The study performed by the NSTIFC mainly evaluates the alternatives for nationwide implementation. The NSTIFC assigns weights a set of criteria and scores the funding alternatives over these criteria based on their performance levels. It suggests that the state and local policy makers may use this methodology as a model and conduct their own evaluation with weights and scores that are specific to their own situations. Most of the studies at the state level do not determine the weights for the criteria but instead they leave the judgment regarding the relative importance of the criteria to the future decision makers. These studies usually define a set of alternatives and discuss their advantages and disadvantages, or assign qualitative scores to the

alternatives on a set of criteria. Although these studies recommend a list of funding alternatives for short term and long term implementation, they do not show a complete analysis.

In this research, the author establishes a criteria system through a Delphi survey of Texas based transportation officials and Legislative staff, who are experienced in transportation planning and financing and/or participate in future funding policy decisions. Use of this criteria system likely strengthens the credibility of the resultant policy recommendations for Texas among the public because the system includes a panel opinion and it is Texas based.

The author evaluates twenty-two well-defined alternatives for implementation in Texas, either statewide or locally. He assigns scores to all the alternatives representing their performance over the criteria based on the NSTIFC's scoring and other studies. This list of alternatives and scoring may be used as a model for future studies at the state or national level.

The author examines the panel members' preference regarding implementation of a future funding solution statewide or locally. The results of this examination can be used by the policy makers to develop a funding policy that is good for the state as well as major urban regions in the state.

Finally, the criteria system established and the evaluation results in this study are useful for the researchers, transportation officials from metropolitan planning organizations, state departments of transportation, transit authorities, the State Legislature and other local or statewide transportation authorities in building a successful surface transportation funding policy for the future.

1.6. Research Methodology – An Overview

This section provides an overview of the methodology followed in this research and lists some basic assumptions.

1.6.1. Methodology

The author first reviews existing literature to identify the types of transportation funding that have been implemented or proposed. He examines their basic advantages and disadvantages. He reviews various studies on the evaluation of funding alternatives; this review focuses on the basic criteria systems used and the evaluation methodology.

He conducts an expert opinion survey using the Delphi method and develops a list of criteria and their weights. He prepares a list of funding alternatives suitable for implementation in Texas and develops a table of scores of the alternatives (scoring table) table using qualitative scores for each of the criteria, which are primarily based on earlier studies. He chooses the suitable evaluation technique and performs the evaluation. Based on the evaluation results, he recommends a future funding strategy for Texas. Finally, he performs a sensitivity analysis to show how a change in the weights or scores may affect the final recommendation.

1.6.2. Assumptions

The following are some basic assumptions made in this study:

- This research addresses the surface transportation funding for Texas from 2013 to 2035. Surface transportation includes streets, highways, transit services and facilities, infrastructure for non-motorized modes. It does not include maritime transportation or aviation modes.

- The funding alternatives are not defined to fund a specific project or project type but to satisfy the surface transportation needs in general.
- All the expert panel members understand the questions and they answer them using sound judgment after thinking about their choices.

1.7. Limitations of the Research

The limitations of the research are those that may affect the study's validity or findings (Rubin and Babbie 2001). In the authors' view, the following limitations may have affected the results of this study.

- This study evaluates only those funding alternatives which generate revenue. The funding deficiency can be reduced by other strategies such as reducing the funding need by managing the demand for travel. Such strategies are not considered here.
- The expert survey spans from January to May 2013. The 83rd Texas Legislative session has taken place exactly during this period. So, both the participation in the survey and the timeline of the survey have been affected by the session. Although the author has tried to obtain the legislative staff's response by following up, the staff's response rate has been low and delayed. The delay of some members' response extended the time between two survey rounds. This excessive time between the rounds may have caused some panel members to forget their original thoughts and thus have made them unable to respond to the survey with their full knowledge.
- Only six officials from the Texas Department of Transportation have participated in the survey. They have withdrawn their participation in the third round due to an internal directive. So, the author has included their

second round responses in the summary of the second round survey but removed them from the summary of the third round survey.

- To increase the participation and reduce the response time, the survey has been performed by email. As a result, the author does not have an opportunity to explain the survey to the panel members.
- This research does not aim to perform a complete and detailed analysis on determining scores for the funding alternatives. The author uses the scores provided by the NSTIFC wherever possible and modifies them to Texas conditions when appropriate, based on existing related literature and his knowledge and experience.
- The performance scores assigned here correspond to the alternative definitions used in this study. They are specific to the Texas conditions for the specified analysis time period. For a different geographic location, or a different time, the scores may change.
- Since the criteria system is established based on the opinion of Texas based experts, this system is applicable to Texas. It can be used in other states or countries with some adjustments depending on their conditions. The criteria system may be used after getting an approval from the transportation officials and other decision makers.

1.8. Delimitations of the Research

The author decides to restrict the scope of this research so that the study overall is more effective. Some of these restrictions are listed below:

- The expert survey includes Texas officials only. Expanding to other states or other organizations would be tedious and may not be manageable. The

survey includes officials from MPOs, TxDOT districts and the Legislative Committees. Other smaller and more local organizations are not included because the author believes that officials from such organizations may not have an overview of the state's funding situation.

- Only personnel who are currently working are included in the survey. Persons who worked before in an organization are not included because they may no longer represent the organization in their responses.

1.9. Organization of the Dissertation

This dissertation is organized as six chapters. This chapter introduces the dissertation and describes the research objectives, methodology and some limitations. In the second chapter, the author reviews the available literature on evaluation of transportation funding alternatives and discusses the role of his dissertation. The third chapter discusses the expert survey and the establishment of the criteria weights. It describes each step of the survey in detail and concludes with the final criteria weights obtained and some of their policy implications. The evaluation of funding alternatives for Texas is explained in the fourth chapter. It discusses the methodology, defines the funding alternatives and presents the results of the evaluation. It recommends a funding strategy for the future and discusses how sensitive these recommendations are with a scenario analysis. Chapter five reviews the advantages and disadvantages of local funding compared to statewide funding and adds the decision makers' perspective to this discussion. This dissertation concludes in the sixth chapter where the author presents major findings from this research, elaborates on the contributions of this research and recommends some avenues for future research.

Chapter 2

Literature Review

In this chapter, the author provides a summary of previous research on the evaluation of transportation funding alternatives and presents a strategy for his research. First, he discusses some of the major alternatives that previous studies have included in their evaluations. Then, he presents some earlier evaluations of transportation funding alternatives. These are divided into two parts. The first part, discussed in the second section, includes national and state level studies performed by both public and private organizations. These studies are similar because they all aim to recommend to the government or the legislature some actions or guidelines regarding future transportation funding policy. The second part is previous research performed by independent organizations or researchers who typically look into a set of alternatives or a set of evaluation criteria in more detail and provide information on how certain alternatives are better or worse than the others in certain circumstances. The author's contribution to research and practice is discussed at the end of the second section. As mentioned in Chapter 1, this research uses a survey technique called the "Delphi method." The last section introduces this method and discusses some important features related to its design.

2.1. Transportation Funding Alternatives

The federal fuel tax rate, after being increased in 1956 and then again in 1959, was stagnant at four cents per gallon for twenty-four years up to 1983 (Federal Highway Administration (FHWA) 2011a). The main reasons for this could be: the initial increase was high (100% increase from two cents before 1956 to four cents in 1959); and the increase in travel boosted by the then new interstate highway system caused

the Highway Fund revenue to grow as much as needed to fund the planned projects. Between 1983 and 1993, the federal fuel tax was periodically increased so that the highway and transit funding needs were fulfilled (Federal Highway Administration (FHWA) 2011a). Concurrently, the Texas fuel tax was raised multiple times from 5 cents per gallon in 1980. The last increase occurred in 1991 when the Texas fuel tax was raised from 15 cents to 20 cents per gallon (Legislative Budget Board Staff 2013).

As the fuel tax does not automatically grow with inflation or highway costs, the state legislatures must periodically review the funding needs and revenue stream and raise the fuel tax by an appropriate amount. But, since 1991, the Legislature has not increased the Texas fuel tax. This is one of the main reasons for the current and intensifying transportation funding crisis in Texas. So, an increase in the fuel tax is considered in most of the studies as the first option for the future policy. NCHRP Report 377 evaluates the alternative funding strategies against the fuel tax increase (Reno and Stowers 1995). Many studies do not specify an exact amount of increase to the fuel tax. The Dye Management Group and the NSTIFC both consider a fuel tax increase as an alternative and estimate how much revenue it would be able to generate with a one cent increase in tax at the state and national levels (Dye Management Group 2009; National Surface Transportation Infrastructure Financing Commission 2009).

Having seen the inability of the legislature to increase the fuel tax periodically, many transportation officials and researchers have asked to link the fuel tax rate with some inflation indicator so that the fuel tax grows automatically without a need for legislative action. This is considered as the second option by many studies. The Dye Management Group (2009) uses the Consumer Price Index (CPI) to indicate inflation.

Another such index is the National Highway Construction Cost Index (NHCCI or HCCI) provided by the FHWA's Office of Highway Policy Information; it is used to track price changes associated with highway construction costs, and to convert the highway construction expenditures from nominal dollars to real dollars (OHPI 2013b). In 2013, the 83rd Texas Legislature has a Bill that proposes an increase of Texas fuel tax to 30 cents in two five cent increases in two consecutive years. Then, this Bill proposes annual increases in the fuel tax based on increases in the highway cost index, which is calculated based on the moving monthly average price of highway materials and labor (Harless 2013).

In addition to increasing the fuel tax, studies have also considered increasing other user taxes that contribute to the highway funds at the national and state levels. The NSTIFC studies increases in truck and trailer sales tax, truck tire tax and heavy vehicle use tax, which contribute to the Highway Trust Fund (National Surface Transportation Infrastructure Financing Commission 2009). Similarly, at the Texas state level, an increase of the vehicle registration fee is studied, but no specific dollar amount is specified. The Dye Management Group investigates an increase in registration fee statewide or locally as two separate alternatives (Dye Management Group 2009). House Bill 3664 in the 83rd Texas Legislature proposes a $30 increase to the existing automobile vehicle registration fee of $50.75 and corresponding increases to truck registration fees (Darby 2013). The NSTIFC also includes charging an additional vehicle registration fee for all vehicles nationwide and discusses charging the vehicle registration fee based on the value of the vehicle, which may allow the fee to change with inflation (National Surface Transportation Infrastructure Financing Commission 2009). The author realizes that because of the difficulties in correctly

auditing the value of the vehicles, charging the vehicle registration fee with respect to the value of the vehicle becomes very complex. Prior to 2011, the Texas vehicle registration fee had many classes based on the age and weight of the vehicle, but the 81st Texas Legislature simplified this system and since 2011, all automobiles with a weight less than 6000 lb. pay an equal registration fee (Dickson 2011).

The fuel tax revenue depends on fuel usage. As the nation moves towards vehicles with higher fuel efficiency and low carbon fuels to curb environmental pollution, one can expect that fuel tax revenue will decrease even as the highway usage and the highway costs may not. With this expectation, transportation officials and researchers are calling for a move from the fuel tax towards a more direct user fee based on the actual mileage traveled. Technological improvements such as GPS and on-board devices that track travel location and mileage encourage this thought. The transportation officials see a mileage based charge as a way to encourage travelers to make more efficient travel choices. Most of the studies that evaluate transportation funding strategies include a VMT charge as one of the alternatives. The NSTIFC at the national level and the Dye Management Group at the Texas level consider replacing the fuel tax with a VMT charge as an option. The Dye Management Group indicates that a $0.0135 per mile tax raises revenue equivalent to what the current fuel tax does and estimates the additional revenue raised by a specified additional VMT charge. The VMT charge can be as simple as a fixed per-mile charge for all travelers and paid along with the annual vehicle registration fee or very complex where GPS technology is used to charge differently based on the location, time of travel and vehicle characteristics such as weight and emission level. The NSTIFC and the Dye Management Group both talk about the two ways that a VMT charge system can be

implemented but do not define one or the other in their evaluations (National Surface Transportation Infrastructure Financing Commission 2009; Dye Management Group 2009).

The other major alternative that is prominent because of technological improvements is tolling. The Dye Management Group evaluates an increase of tolls on the existing toll roads in Texas as one option (Dye Management Group 2009). The NSTIFC includes facility tolling and pricing mechanisms as one alternative. It assumes that tolling is not a broad-based federal funding mechanism but rather a state level or local option to fund a specific investment. The NSTIFC also includes cordon pricing as a local funding method, which can be used to relieve congestion in an urban center (National Surface Transportation Infrastructure Financing Commission 2009).

A general sales tax is considered in the studies as a broad-based tax that can generate a significant amount of revenue with small increases in its tax level. The NSTIFC considers a nationwide general sales tax and a dedicated increase to the income tax as well as transferring funds from the General Fund into the Highway Fund as alternatives (National Surface Transportation Infrastructure Financing Commission 2009). The actual tax rates are not specified. The Dye Management Group (2009) includes sales tax increase statewide and locally as two options. As of 2013, revenue from the state sales tax in Texas, except that from the sales of lubricants, does not contribute to the state Highway Fund (Legislative Budget Board Staff 2013). In many counties in Texas, especially in urban areas, 0.25% to 1% local sales tax is charged and the resulting revenue is used to fund the local transit authorities (TCPA 2013b).

The NSTIFC considers a sales tax on certain goods related to transportation – vehicles, vehicle parts and services, automobile tires and bicycle tires – as separate

funding alternatives. It assumes that a national sales tax on these goods will be charged similar to the truck and trailer sales tax that is assessed currently (National Surface Transportation Infrastructure Financing Commission 2009).

Both the NSTIFC and the Dye Management Group evaluate a carbon tax as a new tax on motor fuels. These studies mention that carbon taxes can generate as much as the current fuel tax but agree that carbon taxes are typically part of environmental reform packages and allocating the resulting revenue to general surface transportation funding is difficult. The NSTIFC estimates that based on the European spot price for carbon dioxide credits, the carbon tax will be between 25 and 50 cents per gallon of gasoline (National Surface Transportation Infrastructure Financing Commission 2009; Dye Management Group 2009).

Heavy trucks cause significantly more damage to the roadways than automobiles. To account for the additional cost associated with this damage, trucks are charged a higher amount of taxes than automobiles. In addition to the truck related taxes contributing to the HTF, the NSTIFC evaluates other freight related taxes and fees specific to funding certain investment needs. Among those, three are suitable for state level implementation. Two of them are: charging all the trucks traveling in a region, say a state, based on the weight of the truck; or the weight and distance traveled. This weight and distance traveled option is similar to the weight-mile tax administered in the state of Oregon since 1925 (Oregon Legislative Committee Services 2000). The third strategy is charging a fee for the containers coming in and going out at a port, called a container fee. The revenue from such a fee is used to improve the access roads to the port. The Dye Management Group (2009) also includes a container fee as one of its options.

The Dye Management Group (2009) includes two other funding options that generate local revenue, which are normally used to fund a specific project or to develop a specific area. They are transportation reinvestment zones and land development charges. Examples of land development charges are impact fees and value capture programs.

All the options discussed above generate new net revenue by charging a tax, fee or toll from certain users. There are a few other options, which are normally called financing methods, that are studied by the transportation authorities to complete a project. The Dye Management Group (2009) includes one example, Proposition 12 Bonding Authority, as an option. Under this option, the Texas Transportation Commission (TTC) can borrow money by issuing general obligation bonds to fund highway improvements. General obligation bonds are not new revenues to the State; however, they will be new revenues to TxDOT.

Except the Proposition 12 Bonding Authority, which is a financing method, all the above alternatives generate new revenues through a tax, fee or other kind of charge. Understanding the difference between funding and financing is important. Funding is a primary stream of revenue used to offset cost or to support various leveraging options, while financing is a means by which the primary revenue streams are manipulated to make money available when needed or to reduce the costs of borrowing (Wordreference.com: Language Forums 2011). In this study, the author limits his research to evaluating the funding options. Through certain innovative financing methods, some transportation problems may be relieved or postponed but without new revenue generation, the basic transportation funding problems will not be solved. The NSTIFC recommends that financing approaches can only supplement but

are not a substitute for funding (National Surface Transportation Infrastructure Financing Commission 2009).

2.2. Evaluation of Funding Alternatives

Research on the evaluation of transportation funding alternatives dates back to two decades ago. There have been many studies, both at the federal and state levels, on identifying alternative funding strategies and evaluating them. NCHRP Report 377 contains recommendations, which are applicable to all levels of government, for evaluating alternatives to the motor fuel tax (Reno and Stowers 1995). This report recommends a framework to evaluate alternative revenue sources including their major attributes, the tradeoffs between the sources, and the sensitivity of the choice of revenue sources to different contingencies or scenarios (Reno and Stowers 1995).

NCHRP Report 377 and the studies followed it reveal that the evaluation of transportation funding alternatives is a complex multi-criteria evaluation problem because the selected funding strategy should not only generate enough revenue to satisfy the funding needs of the future but also satisfy other criteria such as public acceptance, fairness among all people and ease of implementation. A typical multi-criteria evaluation consists of the following steps:

- Identify a set of criteria.
- Establish the weightings of the criteria.
- Identify the alternatives to be evaluated.
- Compare all the alternatives against the criteria, one criterion at a time, and assign scores to the alternatives.

- Use an evaluation technique to evaluate the alternatives and identify the best alternative, a group of alternatives or a preference order of the alternatives.
- Perform a sensitivity analysis.

Section 2.1 discusses some of the funding alternatives studied in previous evaluations. In the following sub-sections, the author summarizes the above steps from different evaluation studies. The author reviews a number of studies that evaluate funding alternatives for nationwide, statewide or local implementation. The following is a description of the selected studies but it is not the full list of studies available.

The NSTIFC, established by the United States Congress, evaluated various funding alternatives after establishing a criteria system in its final report submitted in 2009 (National Surface Transportation Infrastructure Financing Commission 2009). In its report submitted to the Texas Department of Transportation in 2009, the Dye Management Group, Inc. (2009) prepared a list of criteria and evaluated various funding alternatives to be implemented in Texas. It also reviewed the feasibility of some alternatives for being implemented locally in certain regions of the state. The Mineta Transportation Institute published a study on transportation funding options for California in 2006. In this study, Weinstein et al. (2006) evaluated various tax and fee based alternatives and facility based alternatives over five criteria. The Pennsylvania State Transportation Advisory Committee conducted a transportation funding study in 2010 (Schultz, Louis C. Jr. et al. 2010). The Cedar River Group (Cedar River Group 2010) conducted a study on implementing alternative transportation funding methods for the Washington State Legislature Joint Transportation Committee in 2010. The Center for Urban Transportation Research at the University of South Florida examined

the state of transportation revenues in Florida for the Florida Metropolitan Planning Organization Advisory Council and assisted in drafting legislation to address the state's transportation funding situation (Center for Urban Transportation Research 2012). A Blue Ribbon Panel, established in 2008, assessed Rhode Island's transportation needs and identified options for potential funding sources (Blue Ribbon Panel 2008). The following sub-sections investigate how these studies execute different components of the evaluation.

2.2.1. Evaluation Criteria

This section describes the criteria used in many previous studies to evaluate transportation funding alternatives. The evaluation criteria stem from the basic reasons for the search for an alternative. The main reasons for the search are:

- The existing fuel tax is not expected to generate enough revenue to satisfy the funding needs of the future.
- Increasing the fuel tax is not favored among the public and politicians.
- The concerns about the fairness of the fuel tax are growing. As congestion increases, people traveling during congested periods impose more costs on society and the environment but they do not fully pay for these impacts. The fuel tax system is unable to charge all the vehicles uniformly based on their road usage as fuel efficiency varies among the vehicles and the number of alternative fuel vehicles increases.
- Some transportation officials and researchers believe that a tax or fee that is a more direct user fee and visible compared to the fuel tax may encourage travelers to use the transportation system more efficiently.

- Another basic consideration in implementing any new tax or fee system is that it should not be difficult to implement.

After investigating many studies on the evaluation of funding alternatives, the author has identified that the criteria used in these studies can be grouped under five main criteria or criteria groups. These are listed below:

1. Revenue generation
2. Equity and Fairness
3. Ease of Implementation
4. Public acceptance and political feasibility
5. Other secondary effects

The following text describes these criteria and shows how the previous studies defined and used them.

Revenue Generation

Primarily, this criterion is concerned about the amount of revenue a funding alternative generates. NCHRP Report 377 defines this criterion as the adequacy of a revenue source and uses it for an initial screening of alternatives (Reno and Stowers 1995). The Report evaluates if a revenue source generates revenues comparable or more than the fuel tax so that it can replace the fuel tax in the future. The Report considers many basic criteria under adequacy. They are listed below (Reno and Stowers 1995):

- Revenue generation potential and tax rate
- Stability and predictability
- Responsiveness (to inflation and to road usage)
- Flexibility
- Appropriateness for dedication
- Potential for needed increases

The Report evaluates if each alternative provides comparable or greater revenues to the government and if the source is relatively stable and predictable. The alternative should be flexible such that the revenue can be invested in any type of surface transportation projects. The “appropriateness for dedication” criterion is based on the user charge rationale and judges if there is a reasonable likelihood that a tax or fee revenue will be dedicated to surface transportation. For example, revenue from income tax or a social security tax will not be accepted by the public for dedication to surface transportation. Hence, such alternatives should be screened early in the evaluation. Once established, it should not be difficult to increase a tax or fee in the future when a need arises (Reno and Stowers 1995).

Equity and Fairness

When evaluating funding alternatives, three types of equity are commonly considered (Rosenbloom 2010). They are:

- User-pay equity
- Ability to pay equity
- Geographic equity

According to the user-pay concept, those who use a transportation system should pay for that system. The higher the cost imposed on the transportation system and environment by a certain group of users, the more that group should pay for the system. For example, trucks impose more damage to the roads than cars do and so trucks should pay more in fees or taxes than cars. NCHRP Report 377 considers the user-pay equity criterion in terms of allocating the cost responsibility among user groups, particularly vehicle classes (Reno and Stowers 1995). The NSTIFC considers this as the ability of a funding mechanism to distribute the cost of investment among individuals based on their direct use and the benefit gained (National Surface Transportation Infrastructure Financing Commission 2009).

Low-income drivers cannot afford to pay much; therefore, the ability to pay concept indicates that they should pay less percentage share of their income than wealthier drivers for transportation. NCHRP Report 377 considers this criterion as equity among persons of different income levels. The Report realizes that less attention is paid to this criterion with respect to transportation finance, mainly because transportation taxes are generally user charges and also are a small percent of costs (Reno and Stowers 1995). The NSTIFC states that the funding alternative should be less regressive, that is, it should avoid placing a disproportionate burden on low-income groups (National Surface Transportation Infrastructure Financing Commission 2009).

Geographic equity examines whether the transportation funds are fairly distributed among the states, regions inside the states and communities inside the regions (Rosenbloom 2010). The NSTIFC defines this equity as the extent to which the charges can be allocated among individuals based on the geographic distribution of the

benefit of the funded investments; however, it realizes that in some instances, some cross-subsidization for the geographically disadvantaged areas may be needed to make sure necessary transportation system improvements are provided (National Surface Transportation Infrastructure Financing Commission 2009). The transportation improvements for rural areas or low population density areas should not be ignored even though they are unable to generate enough revenue at the same tax rate or fee level that people in the urban areas pay.

Some studies consider equity by generations in the evaluation. This evaluates if the life-cycle cost of the surface transportation system is distributed across time in proportion to the direct benefits to its users (Rosenbloom 2010). For example, when tax revenues from today are used to fund a new road, the current generation is paying for the future generation's needs. On the other hand, if a road is constructed using borrowed money and the loans are repaid using the toll revenue, the cost burden of the road is being borne by the actual users of the road. This intergenerational equity means a balance between these two types of financing so that no one generation is unfairly burdened.

Ease of Implementation

The funding alternatives are evaluated for the ease of their implementation and administration. NCHRP Report 377 names this as "simplicity and effectiveness" and considers five parts of this criterion as shown below (Reno and Stowers 1995):

- Point of taxation
- Number of taxpayers
- Compliance cost
- Potential for tax evasion
- Administrative costs

Here, administrative costs mean the cost to the agency that is collecting the tax while the compliance cost means the time and cost spent by the users to comply with the system.

Public Acceptance and Political Feasibility

While proposing a funding option, one should evaluate its acceptability among the public and politicians. NCHRP Report 377 considers public acceptance as one of the other issues rather than the criteria itself (Reno and Stowers 1995). Mainly, the Report stresses the public's perception of fairness.

Other Secondary Effects

Besides generating revenue, a tax or fee system may have some secondary effects; it may be used to encourage people to make better travel decisions. For example, imposing an emissions fee may encourage drivers to use vehicles with better fuel efficiency. A tax or fee may affect economic growth if there is an imbalance in the tax rates paid by different kinds of users. For example, when a tax or fee is increased more than a tolerable value, it may negatively affect the businesses in that region and cause them to move away to a new location (Reno and Stowers 1995).

NCHRP Report 377 suggests that the relationship of the funding alternative to economic efficiency should be considered. Under this criterion, the evaluator should check if the alternative is likely to charge according to the marginal cost of travel.

Marginal cost includes the cost of the trip to society including the impact of congestion on other users, not only on the trip maker (Reno and Stowers 1995).

The NSTIFC includes three effects. The first two are: promotion of efficient system use by the users and promotion of efficient investment by the authorities. The NSTIFC considers that the first one gives rise to the second one. The third one has two dimensions. On one hand, the alternative should be able to charge the users for any external costs produced (similar to the one suggested by NCHRP Report 377). On the other hand, the alternative should not encourage any unwanted user behavior such as avoiding vehicle registration to escape paying the fees (National Surface Transportation Infrastructure Financing Commission 2009).

Studies evaluating the funding alternatives use the above criteria in many variations. In Table 2-1, the author lists different studies and shows key differences in the criteria they use. The choice of criteria also depends on the availability of data and methods to score the alternatives over the criteria. NCHRP Report 377 discusses the basis for each criteria comprehensively both from a practical as well as an academic perspective. In the last decade, studies have been conducted in many states to recommend future transportation funding strategies.

Table 2-1 shows the initial screening criteria separately. Similar to NCHRP Report 377, the Washington study includes two criteria as threshold criteria – whether it is an appropriate state level tax or fee and whether it has a nexus (connection) with transportation. If a funding alternative does not satisfy these two criteria, it is not considered in the evaluation (Cedar River Group 2010).

Table 2-1. List of Criteria Used in Various Transportation Funding Evaluation Studies

Criterion	NCHRP Report 377[1]	NSTIFC[2]	Texas[3]	California[4]	Pennsylvania[5]	Washington[6]
Year of study	1995	2009	2009	2006	2010	2010
Initial screening or Threshold criterion	Adequacy					Nexus with transportation
Revenue Generation						
Revenue potential	Yes	Yes	Yes	Yes	Yes	Yes
Stability	Yes	Yes	Yes	Yes	Yes	Yes
Predictability		Yes	Yes (as ability to use as debt security)	Yes		Yes
Flexibility		Yes	Yes		Yes	Yes (to support local systems)
Responsiveness to inflation	Yes	Yes				
Justification for dedication of revenues to surface transportation	Yes	Yes				
Other types	Potential for needed increases		Viability as local option			Viability as local option

Notes:

1. (Reno and Stowers 1995) 2. (National Surface Transportation Infrastructure Financing Commission 2009)

3. (Dye Management Group 2009) 4.(Weinstein et al. 2006)

5. (Schultz, Louis C. Jr. et al. 2010) 6. (Cedar River Group 2010)

Table 2-1—*Continued*

Criterion	NCHRP 377	NSTIFC	Texas	California	Pennsylvania	Washington
Equity and Fairness						
Equity by benefit gained by use or cost imposed	Yes (by vehicle class)	Yes	Yes	Yes (benefit and cost separated)	Yes	Yes (benefit and cost separated)
Equity among income groups	Yes	Yes	Yes	Yes	Yes	Yes
Geographic equity	Yes	Yes	Yes		Yes	Yes
Other types			Equity across generations; Non-transportation uses;			
Ease of Implementation						
Ease/Cost of administration and implementation	Yes	Yes	Yes	Yes	Yes	Yes
Cost of compliance (Cost on payer's side)	Yes		Yes	Yes	Yes	Yes
Evasion potential	Yes	Yes (called Ease/cost of compliance)	Yes	Yes	Yes	
Technology needed			Yes	Yes		
Other types		Appropriate-ness for federal use		Change in state laws		

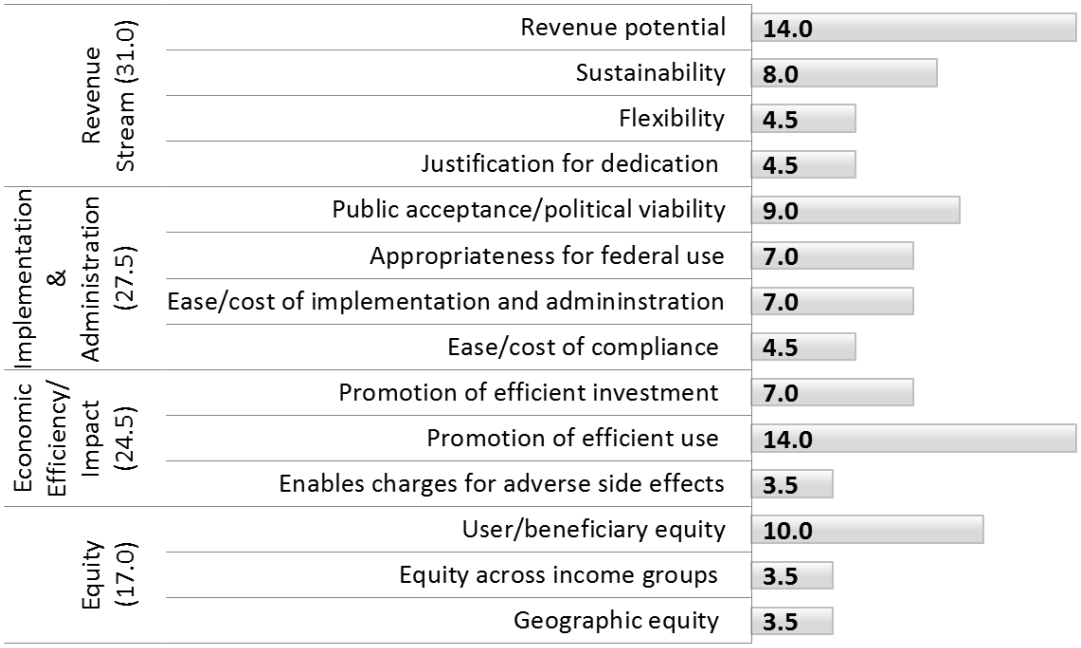
Table 2-1—*Continued*

Criterion	NCHRP 377	NSTIFC	Texas	California	Pennsylvania	Washington
Public acceptance and political feasibility						
Public understanding			Yes			
Public acceptability		Yes		Yes		
Political acceptability	Yes (as an issue)	Yes		Yes	Yes	
Need for changes in laws		Yes	Yes			
Secondary effects						
Promoting economic efficiency	Yes		Yes			Yes (by costs reflecting use)
Promoting efficient use		Yes		Yes	Yes	Yes
Promoting efficient investment		Yes				
Creating less unwanted behavior/ mitigating adverse side effects		Yes		Yes	Yes	
Other types						Ability to create and grow system connections

2.2.2. Weighting the Criteria

This section reviews how the criteria discussed in the previous section are weighted in different studies. As explained at the beginning of Section 2.2, weights are commonly assigned to the criteria, which means they are assigned a fractional score based on the relative importance of each criterion over the other criteria (Rogers 2001). Weights are normalized such that the total of all weights is equal to one. In this report, the author presents them on a scale of one hundred after multiplying all the weights by 100. If all criteria are equally important, all of them are assigned equal weights.

Among all the studies described in the previous section, only the study by the NSTIFC assigns quantitative weights to the criteria. The NSTIFC establishes weights based on its opinion about the relative importance of individual criteria (National Surface Transportation Infrastructure Financing Commission 2009). The NSTIFC Report does not report the weighting method used or the type of group consensus method used in developing these weights. The NSTIFC is composed of fourteen members, half of which are business leaders. Three members are elected members – one state legislative member, one county commissioner and one city council member. Two transportation officers, both related to transit, are included. Figure 2-1 presents these weights. The total of all weights shown is 100, and the total of weights for the criteria under each consideration is shown on the left side in parenthesis.



Data Source: (National Surface Transportation Infrastructure Financing Commission 2009)
Note: Criteria weights are on a 100-point scale

Figure 2-1. Criteria weights established by the NSTIFC

One can see that the NSTIFC gives the highest importance to the revenue potential criterion and the promotion of efficient use criterion. Among equity considerations, user or beneficiary equity is rated significantly more important than equity by income groups and geographic equity. Public acceptance and political viability is given less weight compared to user equity. When the total weights in each consideration are compared, criteria under revenue consideration are given more than 30% weight. The three economic efficiency related criteria represent more than 24% weight. Equity considerations are given the least weight (National Surface Transportation Infrastructure Financing Commission 2009). The NSTIFC seems to give high importance to the ability of an alternative to improve the efficiency in

transportation use and investments. To understand the effect a user charge may produce on the efficiency in use, the author discusses some examples where user charges are used for this purpose in Section 2.3. The NSTIFC states that the efficient use of the system may in turn promote efficient investment. So, these two criteria – promotion of efficient use and promotion of efficient investment – seem to be inter-related and possibly highly correlated.

The criteria weights established by the NSTIFC are not intended to be universal. The NSTIFC focuses on evaluating options at the federal level. It suggests that the evaluation criteria are generally applicable at state and local levels and so the evaluation approach followed by the NSTIFC can be used as a model by state and local policy makers who wish to conduct their own evaluation. The NSTIFC suggests that the users of the evaluation framework may revise the criteria weights depending on their own situations (National Surface Transportation Infrastructure Financing Commission 2009).

The other studies discussed in the previous section do not assign weights to each criterion but keep the weighting process open for the decision makers. NCHRP Report 377 suggests that the decision maker should assign his own weights for the criteria and perform a tradeoff analysis of the alternatives (Reno and Stowers 1995). As mentioned earlier in this section, NCHRP Report 377 and the Washington State funding study consider a set of criteria for initial screening (Reno and Stowers 1995; Cedar River Group 2010). The NSTIFC Report also performs initial screening of the alternatives. It considers some alternatives unviable because they are more suitable at the local level and not at the national level; they are more indirect charges or they are

not suitable for dedication to surface transportation (National Surface Transportation Infrastructure Financing Commission 2009).

In the current research, the author focuses on the evaluation of funding alternatives for the state level. He improves the methodology for establishing criteria weights by involving statewide transportation officials. Section 2.2.5 provides more explanation about the current research and how it extends the available research.

2.2.3. Scoring of Alternatives and Evaluation Techniques

In this sub-section, the author summarizes how the previous studies evaluated various funding alternatives and the methods used in scoring the alternatives for the evaluation criteria. As explained at the beginning of Section 2.2, scoring of alternatives is an essential step in multi-criteria evaluation. In this step, the evaluator develops a rating scale that is qualitative or quantitative. Then, each alternative is assigned a score on that scale.

Among the studies listed in Section 2.2, the study by the NSTIFC performs a more complete evaluation than any other study. The NSTIFC uses the qualitative scoring scale shown in Table 2-2 to score the alternatives.

Table 2-2. Scoring Scales used by the NSTIFC

Scoring Scale				
1	2	3	4	5
Poor	Fair	Good	Very good	Excellent

Scoring scale for "Enables charges for adverse side effects" criterion				
1	2	3	4	5
Encourages unwanted behavior		Neutral	Discourages unwanted behavior	

Source: (National Surface Transportation Infrastructure Financing Commission 2009)

For all the criteria except one, the NSTIFC uses a five-point scale where a score of five means the alternative is excellently consistent with the criterion and a score of one means the alternative is poorly consistent or very inconsistent with the criterion. For the criterion regarding “Creating less unwanted behavior/ mitigating adverse side effects”, the scoring scale represents two different directions as shown in Table 2-2 with a score of three being neutral.

The NSTIFC uses a Simple Additive Weighting (SAW) method to evaluate the funding alternatives (National Surface Transportation Infrastructure Financing Commission 2009). In this method, a weighted total score or overall score is calculated for each alternative by multiplying the scores of an alternative against each criterion with the weight of the corresponding criterion (Rogers 2001). An alternative that scores excellent, a score of five, on all the criteria gets the maximum overall score of five. The lowest possible score is obtained when an alternative performs poorly, getting a score of one, on all the criteria. The NSTIFC identifies that there is no single alternative that scores well on all the criteria and so groups all the funding alternatives into three groups – strong, moderate and weak options based on their overall scores. They are described as below (National Surface Transportation Infrastructure Financing Commission 2009):

- Strong options, those with a weighted total score of 3.24 to 4.21, are viewed as the most likely ones for raising future transportation revenues or for federal actions to help enable states to raise state-level revenues.
- Moderate options, those with a weighted total score of 3.0 to 3.23, are considered potential sources, but they present major concerns in one or more areas.

- Weak options, those with a weighted total score below 3.0, are considered to have low potential or present major concerns in multiple areas.

Other studies discussed in Section 2.2 discuss how well an alternative satisfies a criterion. Some of these studies assign qualitative scoring to the alternatives for all or some of the criteria. For example, the Texas study groups the criteria into three types - Efficiency, Equity and Simplicity and, on each criteria type, it rates the alternatives using qualitative terms. The alternatives are rated as very efficient, efficient, somewhat efficient or not efficient; very equitable, equitable, somewhat equitable or not equitable; and very simple, simple, complex or very complex on each of these three criteria types, respectively (Dye Management Group 2009). NCHRP Report 377 does not use a uniform scoring method for all the criteria. For some criteria, it has two levels – satisfied the criterion or not satisfied the criterion. For the cost of administration and cost of compliance criteria, it lists the estimated cost in the case of the alternatives compared (Reno and Stowers 1995).

After discussing the characteristics of each alternative, some studies present tables with qualitative scores. For example, the Dye Management Group's study for Texas shows one table for each alternative. Some studies, such as the study for California by the Mineta Transportation Institute, list the advantages and disadvantages of several alternatives in a table. NCHRP Report 377 suggests a comparative analysis of two alternatives at a time where the performance of two alternatives on all the criteria is compared and the differences in performances are determined. This is similar to the pairwise comparison that is part of the outranking method the author's research uses. These differences help the decision maker to decide the overall merit of an alternative over the other.

2.2.4. Recommendations Given by the Earlier Studies

This sub-section reviews the funding strategies recommended by earlier federal level and state level studies. Most studies recommend a pool of funding methods to choose from.

NCHRP Report 377 primarily recommends an evaluation procedure for the states and local authorities. It proposes a contract type funding policy, where the government enters into a contract with the citizens; the government agrees to improve the transportation to certain level while the citizens agree to pay certain level of fees to fulfill this objective.

Most studies that evaluate different funding alternatives at national level or state level recommend that the existing transportation taxes or fees should be increased to cater the short term funding need. They also recommend increased use of tolling. Common thought is to move towards VMT charges in the long term, although the studies suggest that studies should be conducted to reduce the challenges in implementing this system. Some specific recommendations are provided below.

The Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance concludes that the reduction in fuel tax revenue due to increase in vehicle fleet fuel efficiency can be offset without any unprecedented increases in fuel tax rates. However, it recommends that a transition to a direct fee system which charges road users for their actual use of roads will benefit the travelers and the public greatly. It suggests two such alternatives: toll roads and toll lanes, and VMT charges.

The NSTPRSC estimates the funding gap but does not evaluate the alternatives. It recommends that the federal fuel tax should be raised by 25 to 40 cents

in the following five years. It also recommends increase of other federal, state and local transportation taxes and fees accordingly. It suggests that state and local governments should be provided more avenues for tolling and congestion pricing. In the post-2025 era, it recognizes VMT charges as the “most promising alternative” and suggests major study regarding the strategies for transitioning to VMT charges from the current fuel tax system.

The NSTIFC recommends to the United States Congress a short and long term future funding strategy using many options from the pool of the strong options. The main recommendations are summarized below:

- Expand the Highway Trust Fund revenues by increasing fuel tax and other related sources. Index the federal fuel tax to inflation to meet future needs.
- Initiate a transition to a broad mileage-based direct user fee system such that a comprehensive VMT charge system is in place by 2020.
- Improve federal policies or programs that can increase the options available to states and localities for funding their non-federal share.
- Improve research and development to support the transition from the current funding system to a VMT charge system

Among the state level studies, the Texas and Pennsylvania studies compare the alternatives but do not recommend any particular alternatives. The Pennsylvania study provides some elements that should be part of a long term solution. They are: VMT charges, tolling existing and new highways, public-private partnerships, borrowing, and local option taxes. Some other state level studies reviewed by the author recommend specific pool of solutions. They are listed in Table 2-3.

Table 2-3. Recommendations from Some State Level Studies

Funding Method	State Level Study*			
	California (2006)[1]	Rhode Island (2008)[2,#]	Washington (2010)[3]	Florida (2012)[4]
Fuel tax increase/ indexing to inflation	Short term solution; 1 cent every year for 10 years	Five or ten cents increase two times in the period	Increase annually or add transportation assessment fee to the fuel price	Increase and index
Increase of vehicle registration fee/ license fee	Mid-term to long term; increase license fee	$20 or $40 increase two times in the period	Index license fees to CPI	
Vehicle related fees			Long term: Increase vehicle sales tax; weight fee and tire fee	
Local taxes				Sales tax, diesel tax
Expanding tolling	Short term to mid-term; PPPs	Tolling on I-95 at state border	Recommended	
Borrowing	Short term; GOBs			
VMT charges	Long term; review its possibility	Flat rate VMT charge from 2014 (in high revenue scenario)		A study on VMT charges
Other		New petroleum products gross receipts tax, redirections of revenue	Annual fees for electric vehicles or vehicles with high fuel efficiency; surcharges on ferry or rail fares	Redirect revenue from vehicle license fee

Sources: 1. (Weinstein et al. 2006) 2. (Blue Ribbon Panel 2008)
3. (Cedar River Group 2010) 4. (Center for Urban Transportation Research 2012)

Notes: * Texas and Pennsylvania studies do not recommend a particular strategy. See the accompanying text for more detail.

Rhode Island study recommends the funding strategy for the period 2009-2018

2.2.5. Sensitivity Analysis

As discussed at the beginning of Section 2.2, performing a sensitivity analysis is important to see how the decisions change when some of the criteria weights or the scores change. NCHRP Report 377 performs a sensitivity analysis considering the external effects on transportation funding such as a national policy on fuel efficiency as well as technological developments. It analyzes the changes in the evaluation results in five different future scenarios as shown below:

1. Increased use of methanol as motor vehicle fuel
2. Increased use of compressed natural gas as motor vehicle fuel
3. High fuel economy
4. Subsidies for alternative fuels
5. Full VMT measurement capability scenario

The NSTIFC study and the other studies related to state level transportation funding discussed in previous sections do not include any sensitivity analysis. Most of the studies recommend a pool or a package of alternatives rather than one alternative. Even though the uncertainty in the inputs to the evaluation resulting in a complete revision of the recommended pool is unlikely, a sensitivity analysis is necessary to find if any preferred alternatives are added or removed from the pool.

2.2.6. Role of Current Research

In the current research, the author approaches the evaluation of transportation funding alternatives from a different perspective. While in most cases, an action by the state legislature is needed to implement a new funding option, transportation officials at various levels in a state may be involved in the decision making process. When given a task of choosing the best strategy for the state, each official may choose a strategy

based on his or her understanding of the transportation funding needs and funding options available, and a set of priorities or a set of criteria. One can expect significant differences in opinions among different officials regarding the best funding strategy. As part of building a funding strategy that has a higher chance of being successful among the public and satisfy all the stakeholders, developing a consensus among these transportation officials and the legislative members appears important. In this research, the author tries to find out the priorities of transportation officials and legislative members located across Texas while selecting the future transportation funding strategy for Texas. With this, he tries to bridge the gap between the legislature and the transportation officials as well as among the individual decision makers.

The author conducts an expert opinion survey using a group communication method called the Delphi method. He includes officials from different metropolitan planning organizations in Texas, various districts of the Texas Department of Transportation as well as the staff of some members of the Texas Senate and House transportation committees in this expert panel. These officials have experience in transportation planning and financing and participate in decision making regarding the future transportation funding policy for Texas. In a three round survey with intermediate feedback, the author tries to build a consensus among the panel members about the decision criteria and their weights, which results in a list of criteria and sub-criteria, and their weights.

This research prioritizes the factors that influence the decision on the choice of future transportation funding strategy. The author hopes that this knowledge will be helpful in selecting one funding method or a package of methods that reasonably satisfy all groups of people in Texas that are affected by this policy. When carefully

modified according to the situations, this study methodology can be extended to other states in the U.S. as well as other nations.

This research extends the work done by the NSTIFC, which primarily evaluates the alternatives for a nationwide implementation. Mainly, this research evaluates a set of funding alternatives suitably defined for Texas and recommends a funding strategy for the state. This set of alternatives includes alternatives that are implementable statewide as well as limited to certain regions of the state. The author scores all these alternatives against the criteria by updating the scores from the NSTIFC Report to the Texas situation. The author uses a concordance approach for evaluation rather than the simple additive weighting method. This approach is less strict and considers the uncertainties and inaccuracies in developing the criteria weights and the scores. The author also performs a sensitivity analysis to examine if the decision on the preferred strategy changes with any changes in the criteria weights or the scores used. This analysis is helpful for the decision makers, especially because of the differences in opinions identified in this research, to understand how big a role these differences may play.

This research studies the choice of implementing statewide or local funding solutions by reviewing the pros and cons of each choice. It collects the decision makers' preference in this regard. After a review of the literature, the expert panels' suggestions and an evaluation of statewide and local funding alternatives, the author presents a method to integrate the local funding with statewide funding.

2.3. Research on Scoring the Alternatives

In this section, the author reviews some of the research that informs how various funding alternatives perform over different evaluation criteria. Under each subsection, research pertaining to one criterion is summarized.

2.3.1. Revenue Generation

The NSTIFC Report estimates the revenue that each revenue source can generate with a unit rate of tax or fee. In turn, it shows the tax or fee rate to be charged nationwide such that one billion per annum revenue can be generated. The NSTIFC uses these estimations to qualitatively assess where a funding alternative lies on a scale of excellent to poor in terms of its ability to generate revenue (National Surface Transportation Infrastructure Financing Commission 2009). Similarly, the Dye Management Group estimates the revenue that a funding alternative generates at a unit rate when implemented statewide in Texas. Here, the unit rate for the fuel tax is a one cent increase, and for a toll road, it is a 10% increase in toll. In the case of a VMT charge system, which is assumed to replace the fuel tax, the unit rate is a 0.1 cents per mile traveled in excess of the rate at which the system generates as much revenue as the current fuel tax does (Dye Management Group 2009).

Vasudevan (2008), in his dissertation, forecasts the revenue generated by a number of funding alternatives implemented nationwide and compares the revenue between 2009 and 2025 with the funds required to maintain the system and the funds required to improve the system nationwide during that period. Since the funding alternative is assumed to take the place of gasoline tax in revenue generation, and since the gasoline tax covers about 65% of the HTF revenue, Vasudevan (2008) uses 65% of the needed revenue as the target for his analysis.

He compares the following six alternatives with some variations under each alternative:

- Gasoline tax as a fixed amount per gallon
- Gasoline tax as a percentage of gas price
- Toll based options
- User fee based on VMT
- User fee based on VMT - varying by VMT ranges
- User fees based on axle load and VMT

He considers future changes expected in gasoline usage because of increased fuel efficiency and growth in the usage of alternative fuel vehicles. He concludes that increasing the existing gasoline tax by 10 cents per gallon will not generate enough revenue to maintain the transportation infrastructure over time, unless the gasoline tax is indexed to the Producer Price Index (PPI). Tolling, when implemented for urban interstates at a rate of 10 cents per vehicle mile and indexed to the PPI, generates enough revenue to maintain the system. A VMT charge, when implemented using the 1993 gasoline tax rate adjusted by the Consumer Price Index (CPI) generates enough revenues to maintain the system. A tiered method where a user fee varies based on VMT, or a combination of axle load and VMT generates enough funds to maintain the system over the years, provided the 2009 rate required to maintain the system is indexed to the CPI. Based on these results, he concludes that the VMT charge when indexed to CPI or PPI is the best alternative. He points out various challenges such as political, behavioral, social, equity, economic and technological considerations involved in implementing the new user fee system and so recommends for a short term increase in gasoline tax until these challenges are overcome (Vasudevan 2008).

In the above study, if the challenges mentioned by Vasudevan are considered in addition to the revenue generation, the VMT charge when indexed to CPI or PPI would not become the best alternative. Vasudevan does not include the cost of collecting VMT charges or tolls. The cost of collecting a VMT charge per 1000 vehicle miles traveled is roughly estimated as being $1.79 for a simple pay-at-the-pump system and $6.26 for a comprehensive VMT charge system (Rufolo 2011). When a VMT charge is used to collect revenue equivalent to what is collected by fuel tax, even the simple system costs about 17% of the revenue collected. The cost of collection of tolling with all electronic tolling (AET) ranges from 12% to15% of the revenue collected (Manuel Fustes, personal communication, May 28, 2013). In the case of tolling, a toll rate of 10 cents per mile is expected to divert traffic from the freeways to the competing minor roads increasing congestion and reducing safety on those roads. Vasudevan does not consider this diversion of traffic. One can expect that the rate of VMT charge at the beginning of its implementation will be such that the revenue it generates will be equivalent to what the gasoline tax will be generating at that time. The author opines that gasoline tax and VMT charge should not be compared just based on revenue because they do not occur at the same time period. When both tax rates are adjusted with CPI or PPI, the main difference between them is the increase in fuel efficiency. By the time the VMT charge is ready for implementation, the vehicle fleet fuel efficiency may no longer be on an increasing trend and may be stabilized. If it is stable, the advantage of the VMT charge will no longer exist because the fuel tax is much cheaper to collect.

DeCorla-Souza (2008) discusses congestion pricing as a new road financing system for U.S. metropolitan areas. He summarizes the revenues from congestion

pricing estimated for five major metropolitan areas in the U.S. He shows that a multi-modal pricing package results in surplus revenue, after covering any implementation costs imposed by the program. He suggests that this surplus revenue is enough to provide the total amount of transportation funding available at the time of his research even if the fuel tax is removed. In a later paper, DeCorla-Souza and Luskin (2009) use TRUCE-ST, a quick response, low budget tool and estimate the revenues from a congestion pricing of urban freeways in one case study state. In their study, each section on a freeway has different toll in the congested time of the peak period based on the congestion on that section; average congestion charge is calculated by averaging tolls across all sections. They consider two alternative pricing schemes, with average congestion tolls of $0.13 per mile and $0.25 per mile. Though it is a preliminary estimation, he concludes that the pricing scenarios generate net revenue sufficient to fund a major expansion of capital spending on highways in the case study state.

The Transportation Research Board (TRB) Special Report 285 prepared by the Committee for the Study of the Long-term Viability of Fuel Taxes for Transportation Finance examines the sustainability of fuel tax revenues in the light of the expected increase in fuel economy standards and increase in fuel prices in the future (Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance 2006). This report concludes that

> the risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years; that is, it should be able to fund growth in capacity and some service improvements, although not at a rate that will reduce overall congestion (Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance 2006).

The TRB Special Report 285 informs that a reduction of 20 percent in average fuel consumption per vehicle mile is possible by 2025 if fuel economy improvement is driven by regulation or sustained fuel price increases. The reduction in revenue due to the reduction in fuel consumption can be offset by an increase of fuel tax, which is not unprecedented (Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance 2006). A 20% increase in statewide fuel tax is four cents per gallon. So, the existing revenue sources are expected to retain the capacity to fund transportation programs at historical levels (Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance 2006).

2.3.2. Equity and Fairness

As discussed in Section 2.2, equity of transportation funding alternatives is measured in terms of three main methods – user-pay equity, ability to pay equity and geographic equity.

Rosenbloom (2010) calls the above three equity concepts as traditional equity concepts and explains them. She discusses how the existing transportation funding methods and some new and evolving revenue sources perform on equity criterion. She first discusses the equity among all population and then evaluates it with reference to older and retired people. She includes the fuel tax, vehicle registration fee, driver's license fee, sales tax and other direct user fees and tolls as existing funding sources and cordon pricing and a VMT charge as new and evolving funding sources (Rosenbloom 2010). As part of similar research, Rosenbloom and Lynott present a more detailed equity evaluation of different funding strategies on the two payment related equity concepts – user-pay and ability to pay (Rosenbloom and Lynott 2011). In this report, Rosenbloom reminds that the equity evaluations are relative. The current or

future funding alternatives cannot be evaluated by comparing to a “perfect” funding source with no negative equity implications. Most transportation taxes are regressive, but some are more regressive than others. Similarly, all taxes used for transportation may have some connection to system use but some have more and some less (Rosenbloom and Lynott 2011). They present a qualitative scoring of all the alternatives considered over user-pay and ability to pay equity criteria. The scores show the relative performance of the funding strategies and are provided on a graphical scale with seven levels. The ability to pay equity evaluation shows the performances before implementing any remedies to reduce the inequities. They write about two expenditure related equity concepts – compensatory and needs-based. Compensatory equity is measured based on how the people who suffered inequities in paying a tax or fee are compensated. When a transportation system responds to travelers with special needs, such a system is referred to be better on the needs-based equity (Rosenbloom and Lynott 2011).

The Special Report 303 from the TRB Committee on Equity Implications of Evolving Transportation Finance Mechanisms recommends that public policy makers should evaluate the equity implications of different new and evolving funding mechanisms such as HOT lanes, mileage based charges before proposing them. This report discusses different concepts of equity and suggests that these concepts should be evaluated for different groups of individuals based on geographical location, economic status, generation, demographic characteristics and the transportation system they use. This report reminds the readers of the complexity in equity evaluation and asks them to take into consideration how the tax burden distributes from the direct

payers to their customers and to the common public (Committee on Equity Implications of Evolving Transportation Finance Mechanisms 2011).

Two studies, one by Robitaille et al. and another by Weatherford, analyze the ability to pay equity of two alternatives – increasing the fuel tax and converting it to a VMT charge. Robitaille et al. (2011) conclude that an increase in fuel tax is slightly less regressive. Weatherford (2011) analyzes the implications of replacing the fuel tax with a VMT charge on different income levels and on rural and urban people. Under this system, the VMT charge appears slightly less regressive.

The NSTIFC Report scores all the funding alternatives considered on user-pay, ability to pay and geographic equity concepts on a scale of 1 to 5. The author uses these scores as a starting point and modifies them as needed depending on the differences in the definition of alternatives considered in this research. The author uses the guidance from the above discussed research to update the scores.

2.3.3. Implementation Issues

The author examines some of the issues related to implementation of transportation funding alternatives that are considered for evaluation. The fuel tax, vehicle registration fees and sales tax on different commodities and other truck related taxes have been in operation for a long time. The vehicle registration fee and sales tax are assessed at the state level and some truck related taxes are assessed by the federal government. Many states including Texas allow their counties to assess local taxes or fees. Tolling is an evolving method and the VMT charge has not been implemented yet anywhere in the U.S. except for testing purposes. Weight-mile taxes for trucks have not been implemented in Texas, but they have been in place in other parts of the country, for example, in Oregon since 1919. Before proposing a new

funding method, the challenges involved in implementing it require review. The cost of implementation, technology needs and any difficulties in enforcement are some of the challenges. The following paragraphs discuss the implementation issues related to the fuel tax and other funding alternatives proposed.

Fuel Tax

A brief description of implementation issues of the current fuel tax system is provided below. Since this research is concerned about funding options for Texas, this paragraph deals with the Texas state fuel tax. This fuel tax is assessed by the Texas Comptroller of Public Accounts on the fuel that is removed from the terminal rack, or imported into the state. It is collected from the fuel suppliers and distributors monthly (TCPA 2011a). Then, the tax is transferred to the retailers and in turn to the consumers as a part of the price of the fuel at the pump. Interstate truckers may buy fuel in one state and use the roadways in another state. In that case, the tax is being paid unfairly to one state but costs are imposed in another state. The International Fuel Tax Agreement improves the fairness of the system. This agreement includes 48 states in the U.S. and Canadian provinces. This agreement tries to redistribute the tax revenue such that the truckers pay according to their use of roadways in each state (International Fuel Tax Association, Inc. 2013).

Since the fuel tax is collected from distributors, the number of payers is very low. This makes the fuel tax collection system very low cost and simple. NCHRP Report 689 identifies the cost of collecting federal motor fuel taxes to be 1% of the revenue collected, including all deductions by state collection agencies, expenses of collecting and administering motor fuel taxes, expenses of inspecting motor fuel and other costs or deductions by the collecting agencies (Balducci et al. 2011). Since the

fuel tax at state and federal level are collected similarly, collection cost for the state fuel tax can be assumed to be one percent of revenue collected.

The violation rate in the case of the fuel tax is reported as about 1%, which can be considered very low (Balducci et al. 2011). Significant enforcement measures performed by the FHWA and the states in early 1990s reduced the evasion in fuel tax significantly (Baluch 1996; FHWA 2012c).

VMT Charges

By definition, a VMT charge means a fee charged per mile of travel. A VMT charge has been in discussion for about two decades. NCHRP Report 377 concludes that a VMT charge should be tested and that some form of mileage based charges is the best alternative to fuel taxes (Reno and Stowers 1995). Since then, the technology needed to implement VMT charges has seen much advancement. A number of studies have been performed to evaluate how a VMT charge system can be successfully implemented. A document released by NCHRP in 2009 presents an analysis of ways that a VMT charge could be implemented within approximately the following five years (Sorensen et al. 2009).

Trials were conducted by the Oregon Department of Transportation, the Puget Sound Council and the University of Iowa on implementing distance based road use charges for passenger cars. The University of Iowa conducted a nationwide test to evaluate technical feasibility and user acceptance of mileage based user charges. The study ran for two years ending in June 2010. It included 2,650 volunteers from 12 areas throughout the country. Approximately 92.5% of all the miles driven were successfully measured by both GPS and the onboard diagnostic system (OBD-II).

Based on the driving location noted by the GPS, charges were totaled and apportioned to the federal, state and local jurisdictions (Hanley and Kuhl 2011).

Heavy vehicle truck tolls based on distance traveled and some measure of their weight have been implemented in Switzerland, Austria and Germany. In Germany, the tolls are only on the network of freeways called Autobahns. Some insurance companies, Progressive Insurance for example, offer pay-as-you-drive insurance in which insurance rates vary based on the number of miles traveled (Sorensen et al. 2009).

The previously mentioned NCHRP document identifies that there are three most promising options for implementing a national system of VMT charges (Sorensen et al. 2009). They are:

- Mileage metering based on fuel consumption:

  Under this approach, all vehicles charged by this system will be equipped with an automatic vehicle identifier (AVI) that stores information about vehicle characteristics such as fuel efficiency, emissions class and weight. The charge is collected at the pump while filling the fuel. When a vehicle comes to a fueling station, the station automatically detects the vehicle and identifies the expected mileage and the corresponding charges based on the expected fuel efficiency and other characteristics. These charges are included in the fuel price. The fuel tax amount is subtracted. Vehicles not yet equipped with an AVI device continue to pay the existing fuel taxes rather than mileage charges. The administration for this option involves a significant expansion of the existing fuel tax system to include retail fuel stations along with wholesalers. Because fuel

taxes are paid at the wholesale level while the VMT charges are paid at the retail level.

- OBD II / cellular-based metering:

Under this method, mileage is metered using an On-Board-Unit (OBU) connected to the OBD-II port. The OBU is equipped with cellular communications, which enables the OBU to determine, with rough accuracy, the location of travel. Hence, it is possible to vary rates by vehicle characteristics, by state or regional jurisdiction, or by smaller geographic area (e.g., area-based congestion tolls in a dense urban district). The location data can be used to distribute the revenues from mileage charges among multiple jurisdictions. Charges can be collected by the pay-at-the-pump model, through a central billing agency or by a debit card system under which charges are deducted from pre-paid debit cards inserted into the OBU. The last option, paying in the car may reduce privacy concerns because the detailed billing information is not transmitted.

- Coarse-resolution GPS-based metering

This is the option employed in the Oregon trials. It has the same metering capability as the OBD II / cellular-based method. Rather than cellular-based location, the OBU here relies on a coarse-resolution GPS receiver to determine the general location of travel, not the specific route. GPS can also be used to measure travel distance – by interpolating between subsequent location points – or the OBU could include a connection to the OBD II port for this purpose. This configuration also enables similar payment mechanisms, including the

pay-at-the-pump model, cellular transmission of mileage data to a central billing agency, and pre-paid debit cards inserted into the OBU.

The above NCHRP document evaluates the methodologies with an aim of implementing the VMT charges in 2015. It notes that from a technical perspective, a simple VMT charge system, with a flat rate cents-per-mile for all automobiles, can be implemented within a few years. The full-fledged system that charges the fees by location and time of travel and based on the vehicle characteristics requires a phase-in process. The report notes that once initiated, the transition to a VMT charge system may occur more rapidly than expected (Sorensen et al. 2009). The researchers continue to perform field tests to understand the issues in implementing the VMT charges.

Since the author is evaluating the funding alternatives for a state level implementation, a review of some important state perspectives on the implementation of VMT charges presented in the NCHRP report is worthwhile (Sorensen et al. 2009). The document identifies that:

- States like the federal government to take the lead.
- Odometer-based systems are not viewed favorably because it requires major changes to DMV operations and databases.
- Privacy issues constitute a significant barrier to public acceptance.
- States are worried about the potential for fraud and evasion.

NCHRP Report 689 describes the cost of alternative revenue-generation systems. It examines the cost for a VMT charge system proposed in the Netherlands. The annual operating cost of a VMT charge system may reach $75 per vehicle. In other terms, it is about $6.26 per 1000 VMT. This cost does not include the full capital

cost (Balducci et al. 2011). Since the VMT charge method is expected to be used in lieu of fuel tax, the revenue collected should be similar to what is collected currently by the fuel tax system. So, the author compares the cost mentioned above with the current fuel tax revenue collected in the U.S. For a vehicle with an average fuel efficiency of 20 mpg (close to the national average), the tax paid for 1000 miles traveled is

1000 miles x 1/20 mpg x $0.184 = $9.20.

Cost = $6.26 per 1000 VMT means about 68% of the revenue collected. Compared to the cost of collection of the fuel tax system, about 1% of revenue, the cost of collection of a VMT charge is very high. One reason for this high cost can be that the amount of VMT charged in the Netherlands may be low; cost may be reduced when a system is implemented across the U.S.

In an offshoot of the above research, Rufolo (2011) compares the rough estimates for the cost of collection of three VMT charge systems – pay-at-the-pump charge fee tested in Oregon, the proposed system in the Netherlands and the German Truck toll system. The estimated cost for the pay-at-the-pump VMT charge is about $1.79 per 1000 VMT. The Oregon pay-at-the-pump is not a full-fledged system. Moreover, it does not have a full enforcement program. So, this cost does not include the cost of enforcement. The cost of collection for the proposed system in the Netherlands is shown already. The German Truck toll system cost is given as $65 per 1000 VMT. The very high cost of the German system may be because it is used only for heavy vehicles on specific roads and seems to include annualized capital cost of the on-board units (Rufolo 2011).

Tolling

In Texas, about 362 miles of tolled facilities including roadways and bridges are operating, being constructed or financed as of 2011. About 77 miles of those are in rural areas (FHWA 2011c). More highways are in the planning stages.

Traditionally, tolls are collected manually at the toll booths. All vehicles stop or slow down at the booth and pay by cash to the person collecting the toll or by dropping the amount in the bucket. In the last two decades, electronic tolling has become more common. Toll gantries placed above the road read the toll tag inside the vehicle passing below and charge the toll at that gantry location. Some toll roads operate with both electronic and cash tolling. For example, the Dallas North Tollway in Dallas, operated by the North Texas Tollway Authority, collected tolls by electronic as well as cash tolling methods before 2009 (North Texas Tollway Authority (NTTA) 2010). Currently, the toll road authorities are moving towards eliminating cash tolls and collecting all tolls through electronic tolling. This method is called All-Electronic-Tolling (AET) method. There are many toll roads in Texas and elsewhere that currently operate in this method. Sam Rayburn Tollway in Collin and Denton Counties is one of the first in Texas to collect tolls in this method (NTTA 2012). For those vehicles that do not own a toll tag, the toll gantries read the license plate information through video detection and mail a bill with all the transactions in a particular period. These can be called video tolls. Video toll users are charged a higher toll than a regular toll tag user, usually in the range of 50% more. An administrative charge is also added for each bill (North Texas Tollway Authority (NTTA) 2010).

NCHRP Report 689 lists the advantages and disadvantages of different types of toll collection. There are many disadvantages in manual toll collection including the

right of way needed and the cost for tollbooths and attendants, the forming of bottlenecks at the tollbooths, employee theft and an increased potential for accidents at the toll booths (Balducci et al. 2011). Bottlenecks at the toll booths cause lower throughput and reduced revenue. Emissions are also increased due to idling vehicles. These are the main reasons for the move towards AET. Unfortunately, the electronic tolling method has some other problems. Video tolling may require special systems and administration staff and coordination with other agencies. This increases costs. With electronic tolling, users may have concerns relating to the privacy of their credit/debit card information, vehicle information and home address information. Automatic billing involves many errors, which increase the compliance costs of the users. To reduce the billing errors, toll authorities may spend more on upgrading their information technology (Balducci et al. 2011).

NCHRP Report 689 analyzed the finance reports from various toll road authorities in the U.S. for the period from 2003 to 2007 and estimated an average operating cost. It calculated the total cost for toll collection, administration and enforcement activities as 33.5% of the revenue based on an average of costs provided by the toll authorities selected for this study. Among the detailed cost components, tolling agencies spent more on the collection cost than other components. On average nearly 26% of revenues were needed just for collecting tolls in 2007. This involved the implementation of toll gantries, ITS, a customer service center, hardware and software, customer account management, and other expenditures (Balducci et al. 2011).

The Reason Foundation studied the cost of collection for tolling with the AET method and informed the authorities that the cost of collection can be reduced if it is done based on a business model they suggested. This study estimated that the

collection cost can be as low as 5% of the revenue for an average toll collected of $5.00 and 8% of the revenue for an average toll collected of $2.00. If some costs associated with enforcement are not retrieved as service charges, the cost can be about 12% of revenue for a $2.00 toll and 9% of revenue for a $5.00 toll (Fleming 2012). The cost of collection depends on the number of transactions because some costs are 'per transaction' rates. So, the average toll collected plays a big role. For a road with a toll rate of $0.15 per mile, which is typical for an urban toll road, a $2.00 toll is equivalent to more than 13 miles. Based on the author's experience on the travel demand modeling for toll roads, this average travel distance is on the higher side. But, bundling two or more trips into one transaction may reduce the number of transactions and the cost associated with it. When tolling is used to collect usage charges on all roadways, in a way to partially or fully replace the fuel tax, the toll rate per mile will be in the range of 2 cents to 5 cents. In that case, the author expects that the collection costs will be higher.

The author consults Mr. Manuel Fustes, who is experienced in toll system design and has worked on many projects worldwide, about the current costs of toll collection. Mr. Fustes informs that, based on his experience, the cost of collection can be about 12% to 15% of the revenue for the AET system even when the depreciation of the toll collection equipment is not considered. This figure assumes that toll tag users contribute to 70-75% of transactions and it does not consider the revenue that is not able to be collected as cost (Manuel, Fustes, personal communication, May 28, 2013). This figure may slightly vary depending on whether the operating agency is a public or private agency.

Weight-mile Tax

Weight-mile tax is currently collected by some states in addition to or in lieu of the fuel tax. Oregon has been collecting some form of this tax since 1919. The per-mile tax rates in Oregon vary by truck weight class for trucks with 80,000lb or less gross weight. They vary by truck weight and number of axles for trucks with more than 80,000lb gross weight.

NCHRP Report 416 evaluates weight-mile tax as an alternative to fuel tax (Weinblatt et al. 1998). It considers two variations: mileage tax varying by weight only and mileage tax varying by weight and number of axles. On the implementation side, the report evaluates the alternatives for administrative efficiency and evasion. The administrative efficiency is measured by comparing the public-sector administrative and enforcement costs to total revenue collected. The report assigns scores for all the alternatives on a scale of one to five, representing poor to excellent performance on each criterion. For administrative efficiency, the weight-mile tax including the axle configuration is given a score of three compared to a score of four for existing fuel tax. For evasion and avoidance, the report estimates that the weight-mile tax varying with only weight will have similar evasion as the fuel tax system for heavy vehicles in 1998, when the study was conducted. If the weight-mile tax varies with axle configuration, the evasion may be higher (Weinblatt et al. 1998). The author notes that the evaluation provides a good insight on the comparison of weight-mile tax system with the fuel tax system even though the actual quantities may be different in 2013 compared to the ones in 1998.

2.3.4. Public Acceptance

This section presents a review of studies that examine the feasibility of a funding alternative with respect to its acceptance among the public and political leaders. Public acceptance is measured mainly through opinion surveys and focus group meetings. In these surveys, typically, the respondents are given a hypothetical scenario and are asked to give their level of agreement. This kind of survey is considered as a 'stated preference survey' because the respondent is stating his or her preference in a hypothetical situation. Public acceptance can also be identified through 'revealed preference' when there is data showing the public acceptance when an actual system is implemented. For example, the public using a toll road shows their willingness to pay a toll and use the road.

Agrawal et al. (2012) present results from nationwide surveys conducted in 2010, 2011 and 2012 regarding the public opinion on different fuel tax and VMT tax alternatives for nationwide transportation funding. This research suggests that a national sales tax of 0.5% is favored about twice more than a 10 cent fuel tax increase or a 1 cent per mile VMT tax nationwide. Favorability for the fuel tax increases when the public is aware of how the revenue is utilized. The public favors a 10 cent increase in fuel tax more when it is phased in as 2 cents increase per year for five years. The public acceptance rates in three surveys in three consecutive years appear similar (Agrawal et al. 2012).

In their study of transportation funding options for California in 2006, Weinstein et al. (2006) perform a public opinion survey to identify the acceptance levels of different funding options for implementation in California including a fuel tax increase, mileage based fee, increase in vehicle registration fee, increase in statewide sales tax,

different tolling options and other financing options. They find that none of the tax and fee based alternatives gained an acceptance of 50% or more. A fuel tax increase with one cent per year for ten years, an increase of the personal vehicle registration fee varying by fuel economy or emissions and an increase of the statewide sales tax by 0.5% gain a similar acceptance level of about 41 to 45%. Replacing the fuel tax with a one cent per mile VMT tax is the least acceptable with only 23% accepting it. Indexing the fuel tax to inflation is less acceptable than pre-set increases in fuel tax. Based on this survey, California people support the green initiative of increasing the registration fee such that it varies by vehicle emission level compared to the same increase for all vehicles. New toll roads and express toll lanes alongside existing highways are supported more than tolling some lanes on a new highway. Converting existing carpool lanes to HOT lanes and developing truck-only toll lanes that trucks must use are supported by more than 50% respondents (Weinstein et al. 2006). Table 2-4 shows the acceptance rates for the relevant funding options taken from the above research.

Table 2-4. Comparison of Likely Voter Support for Funding Options in California

Revenue Option	Percentage of Responses		
	For	Against	Don't Know
Add 1¢/gallon fuel tax each year for ten years	43	54	3
Index existing fuel tax for inflation	28	66	6
Replace 18¢/gallon fuel tax with 1¢/mile mileage fee	23	72	5
Additional $31/year personal vehicle registration fee	34	63	4
Additional $31/year personal vehicle registration fee, varying by fuel economy or emissions	45	51	4
Additional 1/2¢ sales tax	41	57	3
Tolls on new highway lanes	36	59	5
Converting carpool lanes to HOT lanes	56	41	3
New toll roads	44	51	5
Express toll lanes alongside existing highways	47	48	6
Truck-only toll lanes that trucks must use	62	33	5

Source: (Weinstein et al. 2006)

Note: Sum of percentages may not add up to 100 due to rounding.

The NCHRP Synthesis 377 compiles public opinion data on tolls and road pricing from about a hundred studies performed around the U.S. as well as some other countries (Zmud and Arce 2008). This report summarizes public acceptance statistics on constructing new toll roads, adding a toll lane on an existing roadway, converting an existing road into a toll road, congestion pricing or time of day variable pricing, managed lanes and comparison of funding transportation projects through tolls and taxes. This report identifies eight general themes in public opinion results which are important to note while scoring the alternatives for the public acceptance criterion (Zmud and Arce 2008). They are listed below:

1. The public wants to see the value.
2. The public wants to react to tangible and specific examples.
3. The public cares about the use of the revenues.
4. The public learns from experience.
5. The public uses knowledge and information available.
6. The public believes in equity but wants fairness.
7. The public wants simplicity.
8. The public favors tolls over taxes.

From this report, based on the surveys performed during 2003 to 2006 in Texas, the following results are understood (Zmud and Arce 2008):

- The public favors tolls over fuel tax increases.
- Tolling is a good idea for new construction but not for existing roads.
- Converting existing roads into toll roads is worse than adding toll lanes for existing roads which is worse than constructing new toll roads.
- Time of day tolling or congestion pricing is not favored over fixed tolling. Dynamic tolling is strongly opposed.
- The public supported charging higher tolls for trucks.
- Favorability towards toll alternatives increased when more information was given.

Kockelman et al. (2009) conduct surveys and focus group meetings in Texas to understand the public perception of tolling existing facilities and other transportation policies. This study identifies that tolls are preferred to gas taxes, as is the improvement of existing roads before building new ones. Support for toll policies may be increased by educating Texans about the costs of roadway construction and

maintenance, current revenue sources and the benefits of tolling. The survey shows that congestion pricing is not favored by the respondents. In the case of congestion pricing tolls, 41% of the respondents indicate that they would change their route to avoid tolls while 34% favor doing nothing. The focus group discussion identifies that a lack of information about the transportation funding and the logistics of toll roads within the general public may be one source of the opposition to tolls. It shows that the public was not knowledgeable about the reasons for traffic congestion and the inadequacy of gas tax revenues. Toll road technology also prompts confusion (Kockelman et al. 2009). Many new toll roads have been developed in Texas since 2006 in which period this study was conducted. The public opinion may have changed by 2013 because the public is now using more toll roads than before the survey.

King et al. (2007) argues that the political feasibility of congestion toll systems will be improved if the revenue from these systems is allocated to the cities, and particularly to the cities that the freeways pass through.

Schaller (2010) analyzes how Mayor Michael Bloomberg's 2007 congestion pricing proposal for New York gained widespread public support but was ultimately blocked in the State Legislature. He concludes that gaining the approval for pricing requires changing how motorists view the effect of pricing on themselves.

The national evaluation of mileage based charges conducted by the University of Iowa includes a question to know how the participants feel about the idea of replacing the gas tax with a mileage-based road user fee. At the beginning of the study, 41% of the participants favor the idea. By the end of the study about 26% who have been neutral at the beginning move towards positive. At the end, 70% favor the idea and 17% have negative opinion about it. This shift shows that as the participants

became familiar with the mileage-based fee system their attitude became more positive towards it (Hanley and Kuhl 2011). There may be a possible bias in this result because when a person volunteers for the study, he may already be somewhat inclined towards the mileage-based charges.

One major concern about the VMT charge system is travelers' privacy. The public is concerned that a VMT charge system invades their privacy by tracking the location and time of their travel. The Iowa study also tests how the participants care about privacy by varying the detail in their invoice and asking them how much detail they want to have in their invoice. The preference of the participants moves towards an invoice configuration showing miles traveled in each jurisdiction (increased auditability) from a maximum privacy configuration where just cumulative mileage and total amount is shown (Hanley and Kuhl 2011). Although Hanley and Kuhl call it the maximum privacy configuration, the author is uncertain whether the participants feel that an invoice containing more detail causes any harm to their privacy. If they do not feel so, the movement of the participants towards seeing more detail on the invoice may not be due to the privacy concerns but due to some other reason. Nevertheless, researchers are making efforts to reduce the privacy concerns by transmitting the lowest amount of traveler or trip information possible to the central billing location.

There have been some surveys in California to understand how people support policies that are intended to improve the environment. Martin et al. study the support of the people of California for the feebate policy through a telephonic survey and focus group process. Feebates are designed to offer private vehicle buyers a rebate for the purchase of a low-emission vehicle and a fee for those that produce higher emissions. It is an example of policies that are aimed to improve the environment. They identify

that 76% of the respondents support the policy (Martin et al. 2011). Agrawal et al. investigate the public preference of a green vehicle registration fee increase – varying the vehicle registration fees based on emission level, feebate and green mileage fee – varying mileage fee based on emission level. They find that all three proposals are supported by more than 50 % of the respondents. In addition, the increase in support between a flat rate tax and a green tax is 20 or more percentage points in both the cases of vehicle registration fee and mileage fee (Agrawal et al. 2010).

The author understands that the results of these public opinion surveys should be used with caution. The public opinion may differ with the level of understanding the public has on the choices, the need for funding and the consequences of not increasing the user charges. Their opinion may change when they are informed how the tax revenue is used. For example, the public favors a fuel tax increase when they are informed that the resulting revenue is used for maintaining roadways or to improve safety (Agrawal et al. 2012). So, while the public acceptance may be one of the important factors in selecting a funding strategy, any analysis should consider the uncertainty in the public opinion data.

In this and the next paragraphs, some examples of public or political acceptance of actual implementation of new charges or expansion of existing charges are presented. Although the general sales tax is understood to be less equitable compared to the fuel tax and other transportation funding alternatives; and the sales tax is not well connected with transportation use, some public surveys show that the public supports the sales tax more than it supports the fuel tax, tolling and other alternatives (Agrawal et al. 2012; Kockelman et al. 2009). The Commonwealth of Virginia passed a new transportation bill in 2013 that increases the state sales tax from

5.0% to 5.3% (Washington Post 2013). Goldman and Wachs (2003) provide justification for this public opinion in their paper on local option transportation taxes. Some reasons are:

- The sales tax has better horizontal equity: individuals of comparable money pay roughly the same amount of tax. So, people feel a sense of “fairness”, particularly where sales taxes are used to finance transportation plans that include multiple modes.
- If fuel tax money is used to fund transit facilities, motor vehicle users feel this is unfair because transit users do not pay fuel tax. All users of the transportation system contribute some amount when they pay sales tax.
- Some groups of people perceive that sales taxes are equitable because expenditure is more indicative of ability to pay than income.
- In tourist areas, visitors of the area contribute a larger share of sales tax revenue.

Many states in the U.S. have local option taxes for transportation. Such charges that are commonly collected are fuel taxes, vehicle registration fee or sales taxes. Often, local option taxes require voter approval so they tend to indicate public acceptance. Goldman and Wachs (2003) list the states where local option taxes are in place and where the revenue is used for transportation projects. Local option sales tax is more widespread with 33 states having it. Local option fuel tax is less popular with only nine states having it. Ten transit districts in Texas have established a local option sales tax for transit projects after voter approval. Voters in Dallas and Houston have approved sales taxes for new rail projects while voters in Austin and San Antonio did not approve light rail projects financed with sales tax (Goldman and Wachs 2003). In

2009 and 2011, the Texas Legislature has proposed two bills that provide allowance for congested metropolitan areas to collect a local option fuel tax to fund specific transportation projects with voter approval, but both bills failed to pass (Truitt 2009; Rodriguez 2011).

2.3.5. Promotion of changes in user behavior

The primary role of a funding alternative is to generate revenue. Traditionally, the money paid by a user towards transportation funding compared to the total out of pocket cost paid by him for transportation has been insignificant. The increased congestion and insufficient funding has given rise to the thought that transportation user charges should be used to encourage the travelers to use the transportation resources more efficiently and improve their fuel efficiency. Examples for efficient uses of transportation system are reducing travel, traveling in uncongested times or using public transportation. Such proposals of user charges usually require directly charging the travel and/or increasing the charges significantly. In this regard, a review of the effect that a user charge may have on the travel and the fuel efficiency is useful.

The effect of fuel tax may be inferred from the effect of increase in fuel prices. Brand (2009) reports the estimated reduction in VMT and fuel consumption due to a sharp increase in fuel price in 2008. Although this represents a short term effect and is based on only one event, it informs about the range of increase in fuel price that is needed to change the travel behavior. He estimates that the effect depends not only on the increase in fuel price but also the actual fuel price before and after increase. The effect increases with the actual price. In 2008, an increase of about 30% in fuel price from about $3.00 to $3.90 per gallon resulted in about 6% reduction in national VMT, after accounting to baseline annual increase (Brand 2009). Literature shows that when

the fuel price increase is sustained for a long time, the VMT reduction will be about twice the effect seen in the short term (Graham and Glaister 2002). This shows that an increase of 30 to 50 cents in the fuel tax is necessary to be effectively seen in the fuel price and cause some reduction in travel. However, this increase, a minimum of 150% increase over the Texas fuel tax and about 75% increase over the total of federal and Texas fuel taxes, is very large and may not gain public support. Brand (2009) recognizes that higher fuel prices may also cause drivers to use fuel efficient vehicles. He also mentions that the change in fuel efficiency is caused more by a change in fuel economy standards than an increase in fuel price. When fuel efficiency increases, the effect of fuel price on VMT will decrease.

In the last decade, tolls are used in many forms to raise money and reduce congestion in the U.S. and other countries. In the case of a toll road, when a non-toll alternative path is available, some travelers divert from toll road thereby reducing congestion on it. As an example of the range of tolls, the toll roads operated by North Texas Tollway Authority in Dallas-Fort Worth area have a toll rate of about 16 cents per mile (NTTA 2013). In comparison, the total of federal and state fuel taxes in Texas represent about two cents per mile.

Congestion pricing tolls, managed lanes or cordon pricing are some other forms of tolls. Timilsina and Dulal (2008) review that the London's cordon tolls system has reduced the city-center traffic by 12% and the Copenhagen system has reduced annual car mileage by 7%, 6.5% and 3% in three years, respectively. Zupan and Perrotta (2003) estimate that a London-type congestion charge is implemented in New York City, total daily traffic volume in the city may be reduced by 9%. The cordon pricing system in London charges eight pounds to enter the central business area

(Schmöcker et al. 2006). As another example of congestion tolls, the SR 91 express lanes in California charge more than nine dollars in the peak period for a one way trip (91 Express Lanes 2013).

VMT charges are proposed as a replacement of the fuel tax in the long term. In Oregon, an experiment has been conducted to find if a higher mileage charge in the peak period would reduce the VMT in peak period and shift the trips to the off-peak period. As a result, Rufolo and Kimpel (2008) report that a 10 cent per mile VMT charge in the peak period, compared to a 0.43 cent per mile in the off-peak period, has showed a reduction in VMT in the peak period; however due to a low sample size and some external factors, the results are uncertain.

As shown above, very high charges are required to affect user behavior. Many a time, congestion related charges are restricted to one facility or local area where the congestion reduction is intended. The author observes that the decision on implementing a congestion charge system is different from selecting a future statewide funding strategy.

2.4. The Delphi Method – Methodology and Applications

The Delphi method has been first used by the researchers at the RAND Corporation in the early 1950s for a defense related research (Dalkey and Helmer 1963). Since its introduction, it has been used by many researchers in hundreds of applications (Gupta and Clarke 1996; Linstone et al. 1975; Skulmoski et al. 2007). It is a method of facilitating group decision making. In this research, this method is used to obtain the combined opinion of transportation officials on the criteria and their weights for evaluating transportation funding alternatives. In this section, the author first presents the basic procedure followed in the Delphi method. Then, he provides

examples of some problems similar to the one in the current study where the Delphi method has been previously applied. Then, he reviews various specific aspects of the method such as the sample size, number of iterations, communication method and use of the feedback.

2.4.1. Basic Methodology of the Delphi Method

Though many variations of this method have been used by researchers, Linstone and Turoff (1975) present an acceptable definition of the Delphi technique.

> Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. To accomplish this "structured communication", there is provided: some feedback of individual contributions of information and knowledge; some assessment of the group judgment or view; some opportunity for individuals to revise views; and some degree of anonymity for the individual responses (Linstone et al. 1975).

From the above definition, the key ingredients of the structured communication involved in the Delphi method are anonymity, feedback of group response and multiple rounds of communication to facilitate a consensus. The following bullets describe the typical Delphi process (Linstone et al. 1975; Elliot et al. 2005):

- Define the question to be answered.
- Identify a group of individuals who have the relevant knowledge and experience and can provide their opinion to solve the question. These are called "experts".
- Recruit the experts into the panel. Explain the Delphi process to them. Do not reveal individuals among each other.
- Prepare and distribute a questionnaire. Obtain the panel members' responses including some justifications and comments.

- Summarize and analyze the responses. Prepare statistics such as median, mode and variation to represent the group response.
- Test if a consensus is reached. If so, conclude the survey and report the findings. If a consensus is not reached, send a summary of group responses and ask the panel members to consider revising their responses in the light of the group response and any new information they have.
- Summarize the revised responses and test if a consensus is reached. Continue sending further questionnaires until a consensus is reached or until the revisions are not expected to be significant.

The success of application of the Delphi method depends on how well the expert panel is chosen, how the moderator[8] organizes the communication and how the summaries are prepared and presented during a feedback. The design of a Delphi survey, which consists of many parts, should be well adapted to the particular study situation.

2.4.2. Types of Delphi

Turoff (2013) states that four types of Delphi studies are done very often. They are the following:

- Trend Delphi: This is used for producing a forecast of a trend along with the mental model of the group making the extrapolation of the trend curve into the future.
- Problem Solving Delphi: This type of Delphi is used for collecting solutions to the problem which are rescaled to a group interval scale based upon

[8] In the Delphi survey, a moderator is a person or a team that interacts with the panel members to transfer the ideas among them.

individuals ranking or paired comparisons. Use voting to focus discussion on items that need it.

- Policy Delphi: This type of Delphi seeks policy resolutions and the strongest supporting and opposing justifications and arguments to advocate each policy resolution. Unlike the original Delphi method, a policy Delphi does not seek a consensus over a decision (Turoff 1975).
- Cross Impact Modeling: This type of Delphi is performed after establishing a set of unique events through trend Delphi studies. Then, in this step, a model of the future possible outcomes is built through a collaborative analysis.

Skutsch (1972) introduces another type of Delphi called “Goals Delphi”. In her research, Skutsch asks the participants to generate a list of well-defined objectives, and then try to narrow them and aggregate them into groups. Later, the participants provide weights to represent the relative importance of the objectives. Feedback consists of a summary of weights including the average weights and frequency diagrams (Skutsch 1972).

The author’s current research, where a set of criteria are weighted by the transportation officials, can be considered as another problem solving Delphi. In this case, a scaling method is utilized to obtain the participants’ opinion regarding the relative importance of the evaluation criteria. The problem being solved is the establishment of the criteria and weights.

2.4.3. Applications of the Delphi Method

In the 1960s and 1970s, the Delphi method was used mainly for technological forecasting. For example, a study conducted by Gordon and Helmer (1964) aims at

assessing the direction of long-range trends, with a special emphasis on science and technology, and their probable effects on the society and the world. By 1975, it started being applied in the fields of management science and operations research to solve more complex problems in areas such as environment, health and transportation. The Delphi, though started in a non-profit organization, has been used by government and industry as well as academic researchers (Linstone et al. 1975). Gupta and Clarke compile a list of papers on the Delphi methodology and applications in forecasting published in the period from 1975 to 1994. They find that the three most popular areas for Delphi applications are noted as education, business and healthcare (Gupta and Clarke 1996).

Skulmoski et al. (2007) review the Delphi method's applications in graduate research and find that it has been used in many dissertations and theses by students, both in qualitative and quantitative researches. Majority of applications have been in the fields of education and healthcare. In these studies, the researchers customize the method to suit to the corresponding research problem.

The author reviews some studies where the Delphi method is used for criteria establishment in the past. The author mainly reviews how these studies differ in the study parameters such as objective, type of participants, number of iterations, scaling method and feedback types. A brief summary of these example studies is provided below:

- Curren et al. use a two round Delphi survey in developing a set of inter-professional collaborator competencies and an associated competency-based assessment rubric. Participants from across multiple health profession education programs rate different competency statements for

importance and clarity with a Likert scale of one to five. The terminology of the competency statements is revised after the first round based on the respondent comments. A focus group study with the faculty and the students is later performed to validate and refine the statements (Curran et al. 2011).

- Xia and Chan perform a three-round Delphi study to develop criteria for evaluating different operational variations of a design-build system. Officials with sufficient design-build experience and knowledge from relevant organizations participate in this survey. The respondents are not given any initial list of criteria; each of them provides a set of criteria to start with. In the second round, they weight all these criteria choosing one of five levels of importance. The authors test the level of consensus achieved through a statistical analysis. The average importance levels are presented as a feedback. In the third round, only the criteria that are rated on average at least as “important” are re-weighted. At the end, a group of higher officials are asked to validate the resultant criteria weights (Xia and Chan 2012).
- Pirdavani et al. use the Delphi method to develop the criteria and their weights for evaluating accident hotspots. The expert panel consists of 40 experts having several years of relevant experience in the field of traffic safety and working in in the field of traffic safety or teaching as a university professor. In the first round, the experts are given a set of seven criteria and are asked to choose the important ones and add any new criteria. The criteria and sub-criteria are shortlisted based on voting in the second round. Then, they are weighted using the pairwise comparison method, where two

criteria are compared at a time, in the third round. The authors find the final weights after the third round. These weights are not fed back to the participants to obtain further consensus (Pirdavani et al. 2010).

As seen in these studies, the design parameters of the Delphi method vary with the study situation. The next sub-section discusses various aspects related to the Delphi survey, especially its design.

2.4.4. Various Aspects of the Delphi Method

The author reviews different aspects of the Delphi method in this sub-section, which are later used in shaping the expert survey in this research.

Objective of a Delphi Study

A Delphi study should be used to analyze a potential decision or action and provide that to a single individual or role that is accountable for the decision to be made. Its objective is not to make a decision (Turoff 2013).

Expert Panel

Usually, the expert panel members are experts of the topic to be investigated. The knowledge and experience that the participants are expected to have depends on the specific topic and questions being addressed. The participants should be well informed about the topic (Elliot et al. 2005). Adler and Ziglio (1996) suggest that in addition to the expertise, the participants should be willing to participate, have sufficient time to participate in the Delphi and have effective communication skills.

Historically, Delphi surveys have used sample sizes from four to more than 100 depending on the research question and specific circumstances. So, there is no typical sample size for a Delphi study (Skulmoski et al. 2007). This sample size is usually higher when the sample is heterogeneous, that is, the participants differ in their

experience or roles such that they can form a few groups and the study seeks to identify the group opinions separately and compare them. Four to five members in each group is necessary for a reasonable outcome (Martin Wachs, personal communication, January 15, 2013) (Elliot et al. 2005).

The study organizers should provide enough motivation for the participants. A Delphi survey gives an opportunity to exchange useful information and knowledge with other participants. The panel members should be informed that they are communicating with their peers who have some important knowledge and experience to share. The moderator should gather all the obvious material and ask the participants questions that are not answered already. To gain the participants' interest, the problem should be important and should not have an obvious solution; the results should be taken seriously and should be useful to a broader audience (Turoff 2013).

Number of Iterations and Termination of the Delphi

Based on a review of many studies that use the Delphi method, Skulmoski et al. (2007) suggest that a three round Delphi is typical. Some studies also have had one or two rounds. The first round usually contains a broad question allowing the participants to provide an open-ended answer. The questionnaire becomes more focused and seeks objective answers in the second and third rounds, as seen in the example studies discussed earlier.

Skutsch (1972) suggests that one should estimate if the marginal return of information warrants the additional participant patience needed for a new round of survey. The moderator may identify when to terminate the Delphi by close observation and communication with the participants.

Feedback

The feedback of the group response and the opportunity given to the participants to revise their responses based on the collective response makes the Delphi different from an ordinary polling procedure. Partial or complete anonymity is utilized so that the responses do not create any unwanted psychological effects (Mitroff and Turoff 1975).

Feedback of the first round survey usually consists of a compilation of the ideas gathered. As observed in the example studies discussed earlier, it may have a shortlist of items that are taken into the second round. The summary and analysis of the responses depends on the nature of the responses. For example, when a scaling method is used in the survey, a summary showing frequency histograms, median with upper and lower quartiles and/or mode is commonly presented in a feedback (Skulmoski et al. 2007; Skutsch 1972). Skutsch (1972) finds that a hard feedback with no justifications may result in a forced consensus, which may be temporary. So, the feedback should also include different arguments used by the respondents to justify their responses so that the participants can decide their revisions with more thorough reasoning than just having to adapt to the majority opinion.

Scaling Methods

The Delphi method is commonly used not only to identify the most important policy or entity but also to know the degree with which it is preferred. So, the scaling method used should be an interval scaling method[9] (Scheibe et al. 1975). Interval scale is also called ratio scale.

[9] Skutsch (1972) mentions that there are three types of social judgments: the choice of one entity out of many, the rank ordering according to preference and the development of weighted

Simple ranking and a Likert-type rating scale are the two most common methods used (Scheibe et al. 1975). In simple ranking, the participant arranges all entities in an order of importance. When the number of entities increase, this process becomes difficult because one should consider all the entities in one's mind. When a Likert scale is used, the participant assigns one of the levels on the scale to each option. Rating method and pairwise comparison method are also used in Delphi surveys. In a rating method, the participant takes one entity and assigns a score to it. Usually, a range of scores is specified. In a pairwise comparison method, the participant compares two entities at a time and selects one of them.

Based on an experiment on different scaling methods, Scheibe et al. (1975) suggest that a rating scheme and pairwise comparison produce interval scales. They suggest that the participant's difficulty in answering should be considered while choosing an appropriate scaling method.

Various design parameters are discussed above. These provide guidance to the author when he designs the Delphi survey in this research. Chapter 3 discusses more detail on the Delphi survey process and parameters used in this research.

2.5. Chapter Summary

In this chapter, the author presents a review of available literature on transportation funding alternatives and their evaluation. He shows how his research fits in the overall research realm. After a review of the formation of various funding alternatives studied by previous studies, he reviews how these studies consider

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priorities between entities. These correspond to nominal, ordinal and interval scaling, respectively. Nominal decisions may be relatively simple while interval decision making is difficult.

different steps of evaluation. He learns what criteria system is used and how it is defined. Then, he reviews the scoring processes and the evaluation techniques used. He studies the funding strategies recommended by these studies. This information is used in various steps in this research. This chapter also includes a discussion on the Delphi method which is used in this research as a survey method. In the next chapter, a criteria system is established to evaluate the funding alternatives for Texas. The evaluation part is discussed in Chapter four.

Chapter 3

Establishing the Criteria System Using an Expert Opinion Survey

As mentioned in the previous chapter, the author conducts an expert survey to establish the evaluation criteria and their weights. In this chapter, the author describes the methodology for this survey and presents its results. The first section explains the survey methodology. The second section describes the initial steps of the survey. The following three sections explain how each round of the survey is performed and presents a summary of the analysis of the surveyed data. The last section presents the final survey results, and some discussion and recommendations.

3.1. Survey Methodology

The objective of the survey is to establish the criteria and their weights based on the opinions of various transportation officials who are experienced in transportation planning and financing and/or participate in making future transportation funding policy decisions. The author evaluates different methods to achieve this objective. The first sub-section below explains why the Delphi method is chosen for this survey. The following sub-section presents the survey methodology.

3.1.1. Choosing the Delphi Method

The survey method depends on many parameters. Some important decision parameters considered are listed below:

- Potentially, about twenty to twenty-five experts participate in the survey.
- The experts are high level management officials from various metropolitan planning organizations, Texas Department of Transportation or the staff of the Texas Legislative Committee members.
- The experts have busy schedules with jobs more important than this survey.

- The experts' opinions on the criteria and their weights may differ significantly.
- The experts' education and professional backgrounds, type of experience and ways of expressing their opinions may be diverse.
- All the experts are able to communicate through electronic mail (e-mail).
- Most of the experts have sufficient basic knowledge on transportation funding and issues related to it; therefore, they are able to read and comprehend the survey questionnaire.

With the above considerations in mind, the author evaluates the suitability of different group decision methods for this survey.

Face-to-face Group Discussion

In this group decision method, all the participants of the survey assemble at one place and time and they are presented with the list of initial criteria. They have two tasks: decide which criteria should be used and assign weights to each criterion depending on the relative importance of each criterion.

The main advantage of this method is that the group is able to meet and directly communicate about the problem. Acacio (2012) writes about the advantages of face-to-face communication. Face-to-face meetings usually are more effective than other kinds of meetings, that is, a consensus may be reached sooner. When there are many participants, there is more opportunity for creative ideas and contribution. The participants gain from the non-verbal communication as well as the personal touch that is feasible in these communications.

The main challenge in this method is to bring all the group members to assemble at a time and place. The cost associated with this meeting is very high. Since

they are all very busy officials and, the survey is not one of their priorities, having all of them to meet at the same time is not practical. Assuming that obtaining participation is possible, there are other problems associated with the discussion. In such a group discussion environment, a few members may dominate the discussion and prevent all the members from presenting their ideas. Because of the limited time available, all the members may not be able to understand the problem and think well before providing their opinions. Since the group is large and the members have diverse backgrounds, there may be significant differences in opinion. This may cause the group to not arrive at a decision or to arrive at a decision with many group members left without satisfaction. For these reasons, the author does not choose the face-to-face discussion method for this research.

Group Discussion through Teleconference

A teleconference means a group discussion over a phone call having the group members located at their convenient place with or without using a video camera to see one another. This method allows for a discussion with a low cost but it has all the other challenges as face-to-face communication. The communication is not as effective as face-to-face communication. Since the size of the group is large, a teleconference may result in group members being misunderstood or misinterpreted. For these reasons, this is not a good alternative.

Single Round Survey

In this method, the author sends a survey questionnaire requesting all the panel members to choose the evaluation criteria and provide weights for them. The final weights are calculated by averaging the weights given by the panel members. Since all the panel members use electronic mail, this survey is performed by electronic mail. As

all the questions are included in one survey, the survey may become too long and tedious for the panel members to answer with their full attention. The author may not be certain if the panel members understand the questionnaire. The panel members' opinions on the criteria or the criteria weights may differ significantly and so, the resultant list of criteria and the average weights obtained from the survey may not be reliable. With a single round survey, the author does not have an opportunity to reduce the differences among the panel members' opinions and improve the reliability of the criteria and weights.

Delphi Survey through Electronic Mail

The Delphi method is introduced in Chapter 2. In this method, the author plays the role of a moderator and facilitates a structured communication among the panel members. He seeks responses of the panel members separately on multiple rounds of questionnaires. The panel members get sufficient amount of time to think about the survey and provide their response at their convenience. Since there is no direct confrontation among the panel members, there is a bigger opportunity for the members to express their independent views on the subject. After each round, the author provides the summary of the responses as feedback to the members. The panel members have an opportunity to study the group response and revise their own response in the light of this and any other new information available to them. In this process, a reduction in the differences in opinion is possible, because some of the panel members may revise their opinion towards the consensus opinion after realizing the deficiencies in their thought process; or simply agreeing to compromise to allow a consensus. Throughout the survey, the author maintains anonymity of the panel members, that is, he does not reveal identification details such as name and

occupation of the panel members to one another. This allows the panel members to provide the most opposing views without any hesitation.

3.1.2. Methodology

The author first writes down the research question and identifies the suitable experts who can provide an answer. The main aim of the survey is to establish criteria and their weights for evaluating transportation funding alternatives. The author defines the 'experts' as those who are experienced in transportation planning and financing and/or participate in making future transportation funding policy decisions. Then, the author prepares a list of potential panel members. This list consists of high level officials from the twenty five metropolitan planning organizations (MPOs) in Texas, various districts of the Texas Department of Transportation and the staff of the members of the House and Senate Transportation Committees of the Texas Legislature (Leg. Comm.).

After obtaining an approval from the Institutional Review Board[10] (IRB), the author recruits the panel members through a request for participation. He explains to them the survey process and informs them that the identity of the members is not revealed to the participants or in any reports related to the study.

The survey includes three rounds of questionnaires. Skulmoski et al. (2007) identifies that this is typical for a Delphi survey. In the first round, the author provides the panel members with an initial list of criteria and asks them to choose the criteria that are important to include in the evaluation. After the first round, the author summarizes and analyzes the panel members' responses and comments, and uses this analysis to finalize the list of main criteria and sub-criteria.

[10] See Section 3.1.3.

In the second round, the author provides the panel members with the list of criteria and asks them to weight the criteria, that is, to provide their opinion on the relative importance of the criteria against one another. Main criteria are weighted using the pairwise comparison method and sub-criteria are weighted using the 100-point scale method. These weighting methods are elaborated later in this chapter. After the second round survey, the author prepares a summary of criteria weights along with the comments and justifications provided by the panel members. He distributes this summary to the panel members for their review.

In the third round, the author presents the panel members with a comparison of their original responses with the average group response and asks them if they are willing to revise their responses in the light of the group response. After the third round, the author summarizes the revised responses and presents a final summary of the criteria weights. He also includes any remaining differences in the opinions on the criteria weights in the summary so that a future dialogue can refer to them. The activities in the survey are shown as a flow chart in Figure 3-1.

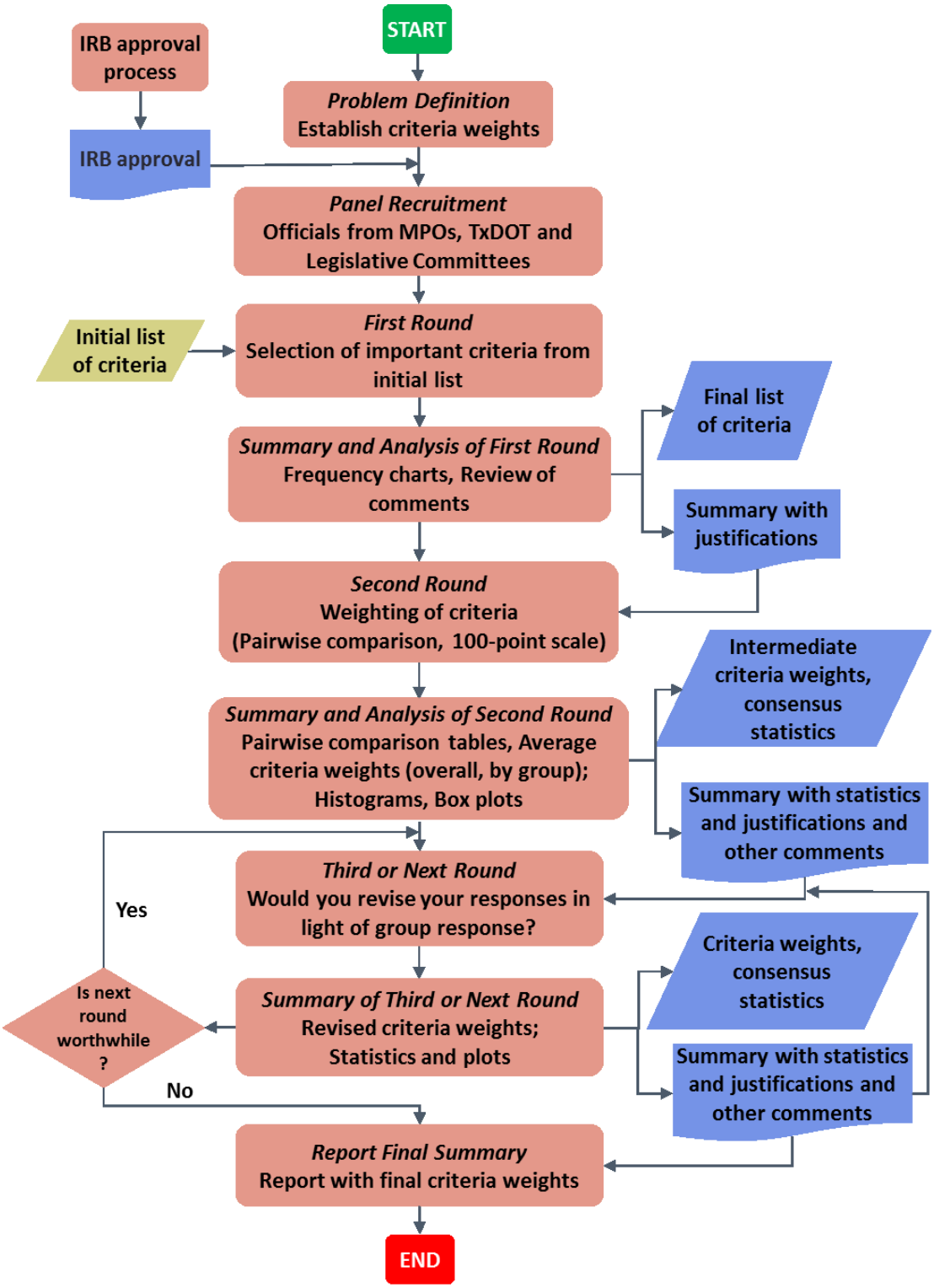


Figure 3-1. Survey Activity Flow Chart

Expert Panel Composition and Size

In this survey, a total of 28 members participate in different rounds. Historically, Delphi surveys have used sample sizes from four to more than 100 depending on the research question and specific circumstances (Skulmoski et al. 2007). So, there is no typical sample size for a Delphi study. This sample size is usually higher when the sample is heterogeneous, that is, the participants differ in their experience or roles such that they can form a few groups and the study seeks to identify the group opinions separately and compare them. The author aims to have at least five members in each of the three groups, namely, MPOs, TxDOT and Legislative Committees. These three groups differ in their basic functionality. MPOs plan future transportation projects and allocate the funds available. TxDOT implements the projects and provides funds from the state and federal highway funds to different regions of the state. The Legislative Committees work on making new transportation policies by introducing new bills in the Legislature.

The author requests participation of 25 officials from 23 different MPOs. Fifteen of them participate. Similarly, thirteen officials from different TxDOT districts and nineteen members from the House and Senate Transportation Committees are invited. Six members from TxDOT and seven members from the Legislative Committees participate. Since the second round is the main round where criteria weights are obtained, the author allows some members to participate starting from this round. He adds four new members from the Legislative Committees in the second round by visiting the Committee members' offices personally. Table 3-1 shows the number of panel members that participated in each round of the survey. The list separates the

panel members by their organization and by their region type – urban or non-urban[11]. In total, 22 members participate in the first round survey and 26 members participate in the second round. Sixteen members respond to the third round. After the second round, TxDOT officials have formally withdrawn from the survey due to an administrative directive.

Table 3-1. Number of Survey Participants in Each of the Three Rounds

Organization/Area type	Requests for Participation	Participants		
		First Round	Second Round	Third Round
MPO	**25**	**15**	**14**	**13**
Urban		5	5	4
Non-urban		10	9	9
TxDOT	**13**	**5**	**5***	**None#**
Urban		2	3	
Non-urban		3	2	
Legislative Committees	**19**	**2**	**7**	**3**
Urban		1	5	3
Non-urban		1	2	0
Total		**22**	**26**	**16**

* One of the five responded to the first round did not respond to the second round. One new member responded to the second round.

TxDOT personnel formally declined to participate in the survey at the end of the second round.

[11] Regions are classified as urban or rural based on the population as well as the nature of urban development and traffic conditions. Metropolitan areas of Dallas - Fort Worth, Houston, Austin and San Antonio are included in urban group because all these areas have more than a million people, have major urban centers and congested traffic conditions. All the remaining areas except El Paso are included in non-urban group because they have low population and have relatively less dense urban area. El Paso is included in the urban group because it has more than 800,000 people and has a reasonable dense urban area with many major roadways. El Paso urban area is closely knit with Juarez urban area located across the U.S.-Mexico Border. Total population of this combined urban area is more than 2 million (City of El Paso 2010).

Overall, the author aims to have the panel members distributed reasonably across Texas, among MPOs, TxDOT and Leg. Comm., and between urban and non-urban areas. This approach means that no single group of panel members dominates the overall opinion. The number of members from MPOs is significantly higher than the other two affiliations. To prevent any domination from this group, while aggregating the responses, the author first aggregates the responses by affiliation and then combines the three resulting group responses. This process is explained in Section 3.1.5.

Medium of Communication

For the most part, the survey is conducted by e-mail. The questionnaire is sent as a Microsoft Word™ file by e-mail. The members complete it and return it by e-mail. In the second round, to reduce the panel members' burden of reading and understanding the survey and to increase participation, the author obtains two responses by telephone interviews and five responses through personal interviews.

Survey Timeline

Figure 3-2 presents the start and end dates of the important events in the survey. The preparation for the survey, which includes the preparation of draft survey questionnaires, IRB review and pilot surveys, starts in early December 2012 and finishes by the end of the month. The recruitment process starts after the IRB review. Although about 75% of the recruitment is completed in the first two weeks, the recruitment process continues until the middle of March 2013 when some of the Legislative Committee member staff joins the expert panel. One main reason for the prolonged recruitment process is the commencement of the 83rd Texas Legislative session in January 2013; the Regular session lasts five months to the end of May 2013. The recruitment of the House and Senate Transportation Committee member

staff is delayed because the Committees are formed in January and February, following the beginning of the session.

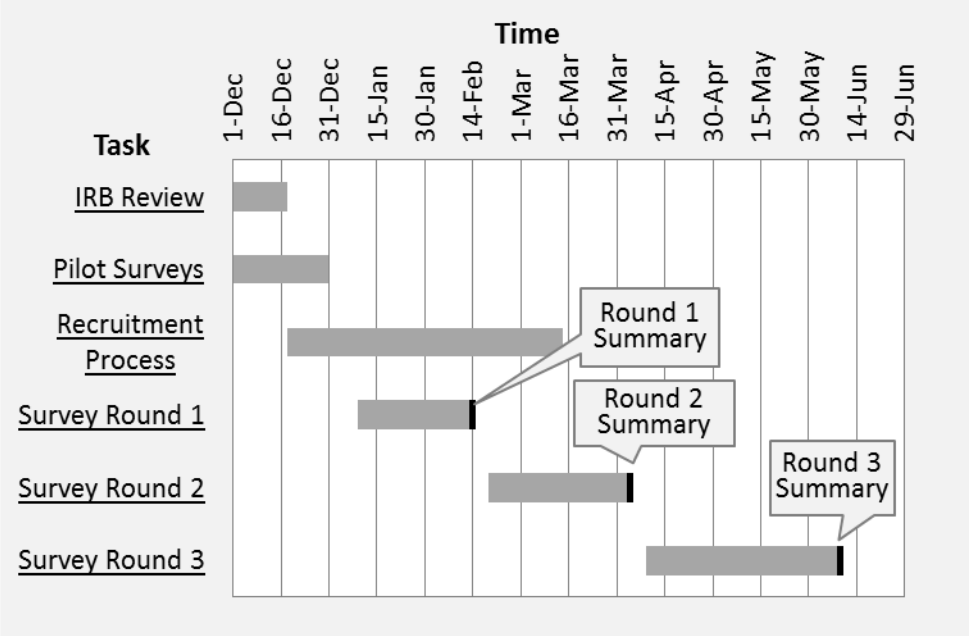


Figure 3-2. Survey Time Line

The survey duration in Figure 3-2 is the time from the date when the survey questionnaire is sent to the date when the summary of corresponding survey data is sent out to the panel members. The majority of the responses are received in the first week after the questionnaire is sent. For each round, preparation of the summary takes about one week to ten days. The author extends the third round until after the Legislature's Regular Session ends when the schedules of the Committee member staff become less congested.

This sub-section discusses the methodology in brief and informs the reader about the number of panel members participating in the survey. The following sub-sections discuss each step of the survey in more detail.

3.1.3. Initial Steps

Before contacting the potential respondents, the author obtains an "Exempt" approval from the Institutional Review Board (IRB). The IRB reviews the research in order to determine that the rights and welfare of the human subjects are adequately protected (University of Texas at Arlington Regulatory Services 2013). It reviews the survey process, how the subjects are contacted, how their information is stored and used, and the draft versions of the questionnaires for all the rounds of the survey. The survey is "Exempt" because the study does not reveal the information of the individual respondents. The IRB approval letter is attached in Appendix A.

The author sends a formal e-mail to each official requesting his or her participation. This request for participation includes the study description, the survey methodology, the official's expected response time and the fact that their information is not revealed during or after the study. The officials are asked to send a brief description of their experience in transportation financing and their current role. The author follows up with telephone calls to answer any questions that the officials may have. Many MPO personnel accept the request. A few officials forward the request to an officer who is more relevant to this study. Some more officials accept the request after a follow-up e-mail or phone call. As mentioned earlier, the recruitment of the Senate and House Transportation Committee members is done while the first round and second round surveys are on-going.

The author prepares the draft questionnaires for all the three rounds and performs pilot surveys. The surveys are reviewed by one professor in transportation engineering, four doctoral students in transportation engineering, one professional from a field other than transportation, one of the potential survey respondents and a few

friends who are educated but are not familiar with the subject. The comments obtained from the pilot surveys are used to refine the survey questionnaires. The author's aim is to make the questionnaires concise, easy to understand and requiring less time and effort to answer.

3.1.4. First Round Survey

The objective of the first round survey is to finalize the list of criteria. The author performs a literature review and compiles an initial list of criteria used in the evaluation of funding alternatives. A summary of this review is provided in Chapter 2. The initial list consists of five main criteria with descriptions. The criteria includes revenue generation potential, equity and fairness, ease of implementation, political feasibility, and improvement in transportation system performance and environment. The descriptions are shown in the sample first round survey questionnaire in Appendix B. Each main criterion has a set of sub-criteria. The author has considered a Yes/No type question where the panel members choose whether to include a criterion in the evaluation or not. Based on the available studies, most of the criteria in the initial list are used in the evaluation. So, all the panel members except a few may choose a Yes; however, some members may think that a criterion is more important or less important. So, instead of a Yes/No question, the author asks the members to specify how important it is to include a criterion or a sub-criterion in the list. This allows the author to decide whether or not to include a criterion after analyzing the responses. A Likert scale (Likert 1932) of five importance levels is used. This scale, as discussed by

McLeod (2008), ranges from very important to not important[12]. Figure 3-3 shows the format of the table used in the survey for the main criterion. The panel members are asked to write down any additional criteria they may think of and any comments they have. The comments of the panel members are helpful to understand the members' basis for arriving at their opinion. They are also useful to refine the definitions of the criteria.

Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Revenue Generation Potential					
Comments:					
Political Feasibility					
Comments:					

Notes:

The respondents fill the appropriate cell with 'X'.

Throughout the surveys, the space provided for respondent's input is shaded in green color.

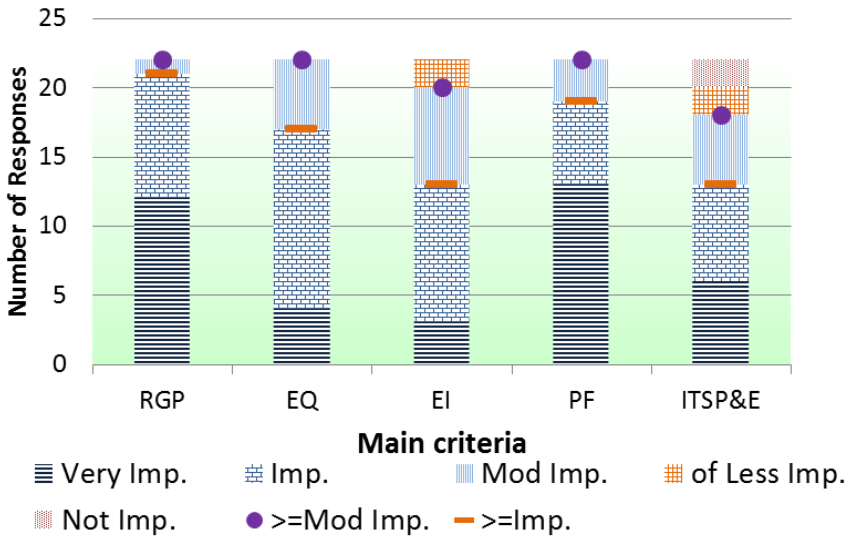
Figure 3-3. Format of the Table Used in the First Round Survey for Obtaining Importance Level Given to a Criterion or a Sub-criterion

Analysis

The importance levels assigned to each criterion by the panel members as well as their comments are summarized and analyzed. Since the scale used is an ordinal scale, a bar chart shown in Figure 3-4 is used to convey the importance given to each criterion. This chart shows the distribution of different levels of importance given to

[12] Another five level scale considered is: Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. The author has suspected that most of the panel members may vote for one of the first two. So, the author chooses the 'importance' scale which contains more room for judgment.

each main criterion out of 22 responses. For each criterion, the number of panel members choosing an importance level of moderately important (Mod Imp.) or higher is shown using a dot and the number of those choosing important (Imp.) or higher is shown using a horizontal bar. Similar graphs are prepared for the sub-criteria under each main criterion. The author includes a criterion in the evaluation if it receives more than half of the responses with moderately important or above. He also reviews if a criterion gets very few votes for the 'very important' and 'important' levels. All the main criteria and most of the sub-criteria are retained in the list.



Abbreviations:

RGP: Revenue generation potential EQ: Equity and fairness

EI: Ease of implementation PF: Political feasibility

ITSP&E: Improvement in transportation system performance and environment.

Imp.: Important Mod Imp.: Moderately important.

Figure 3-4. Distribution of Important Levels Given to Different Main Criteria

After reviewing the panel members' comments and more literature, the author re-organizes and re-defines the criteria. Table 3-2 shows the final list of criteria and

sub-criteria along with their short-forms. Each criterion is assigned a code which is used in the surveys and later discussion.

Table 3-2. Final List of Criteria and Sub-criteria for Evaluating Transportation Funding Alternatives

Code	Criteria and Sub-criteria
RG	**Revenue Generation (Rev. Gen.)**
RG1	Revenue generation potential (Rev. gen. pot.)
RG2	Revenue sustainability (Rev. sust.)
RG3	Revenue predictability (Rev. pred.)
RG4	Flexibility in investment (Flex. in inv.)
RG5	Ease of tax or fee increases when needed (Ease of incr.)
EQ	**Equity and Fairness (Equity)**
EQ1	Equity in paying by benefit gained and cost imposed (user-pay) (User-pay eq.)
EQ2	Ability to pay equity (Ability to pay eq.)
EQ3	Geographic equity (Geo. eq.)
EI	**Ease of Implementation (Ease of Impl.)**
EI1	Cost of implementation (Cost of impl.)
EI2	Simplicity of payment structure (Simplicity of pay.)
EI3	Ability to prevent evasion (Abil. prev. evas.)
EI4	Ability to use existing payment infrastructure (Use exist. infra.)
EI5	Ease of co-ordination with bordering regions (Co-ord. borders)
PA&PF	**Public Acceptance and Political Feasibility (Pub. Acc. & Pol. Feas.)**
PA&PF1	Ease of explaining to the public (Expl. public)
PA&PF2	Acceptability to the public (Accept. public)
PA&PF3	Less need for legislative action (addition, deletion or amendment of laws) (Less leg. action)
PSB	**Potential Secondary Benefits (Pot. Sec. Ben.)**
PSB1	Promotion of efficient use of system by changing travel behavior (Prom eff. trav.)
PSB2	Promotion of fuel efficiency and use of low emission fuels (Prom. fuel eff.)

These criteria are defined in the next few paragraphs. This final list of criteria and descriptions are presented to the panel members as a summary after the first

round survey. This summary shows the key observations and how they are used to refine the criteria.

Revenue Generation Criterion

This criterion includes five sub-criteria as described below.

Revenue generation potential: This measures the ability of a funding alternative to generate significant revenue using politically and economically viable rates to serve the investment needs[13] over the target time frame.

Revenue sustainability: This evaluates the extent to which the funding mechanism provides stable (or increasing) revenue over the years while responding to external factors such as changes in travel behavior and fuel efficiency. The funding alternative should provide increased revenue when transportation system usage increases. If the rate of tax or fee is indexed to inflation or a transportation cost index, the alternative gets a better score for this sub-criterion.

Revenue predictability: The accuracy with which the revenue from a funding mechanism can be predicted indicates revenue predictability. Better prediction allows the officials to respond to any adverse situations.

Flexibility in investment: The extent to which the mechanism is appropriate for a wide (and potentially changing) range of investments and can be redirected to meet changing objectives, market dynamics, technology options, etc. For example, broad-based alternatives such as the gas tax or general taxes tend to have considerable flexibility, while narrowly focused mechanisms, such as facility-specific tolls, generally are inherently less flexible.

[13] As discussed in Chapter 1, the investment needs here are the funding needs for Texas for a period from 2013 to 2035.

Ease of tax or fee increases when needed: The extent to which it is easy to adjust the tax or fee when needed by an action by the operators or local or regional policy makers. For example, increasing a countywide vehicle registration fee may be easier than increasing a statewide fuel tax. This pertains to the tax in concept rather than the actual tax rate or the pre-decided increase mechanism. That is, once a tax policy is chosen and its specifics are decided, this sub-criterion evaluates how difficult a future change of policy is to facilitate an increase of the tax or fee rate. Suppose that a tax policy is set up such that the fuel tax is increased yearly with inflation. This sub-criterion tests how difficult a change in this policy is for increasing the fuel tax more than its increase with inflation.

Equity and Fairness Criterion

This criterion evaluates the fairness of the tax or fee system. Transportation funding options are traditionally evaluated for three concepts of equity, namely, user-pay, that is, pay by benefits received and cost imposed, ability to pay and geographic equity (Rosenbloom 2010).

Equity in paying by benefit gained and cost imposed (User-pay equity): As per the user pay concept, those who benefit from a transportation system by using it should pay for that system. The higher the cost imposed on the transportation system and environment by a certain group of users, the more that group should pay for the cost. For example, cars and trucks should pay for the roads as they benefit from using them. Trucks impose more damage to the roads than cars do and so trucks should pay more fee or tax than what cars pay.

Ability to pay equity: Low-income drivers cannot afford to pay much; therefore, they should pay a lower share of their income than wealthier drivers for transportation. This is called the ability to pay concept.

Geographic equity[14]: This evaluates the extent to which the cost allocation/impact of the mechanism can be structured to match the geographic distribution of the benefit of the funded investments. There are instances where some amount of cross-subsidization may be required to ensure important and necessary system improvements in places that are geographically disadvantaged in terms of population density, for instance (National Surface Transportation Infrastructure Financing Commission 2009). For example, money generated in urban areas such as Dallas-Fort Worth[15] may be used to improve rural sections of I-35, which is a major north-south interstate highway passing through Texas, which also serves the Dallas-Fort Worth region. The amount of user charges generated in some rural areas may not be sufficient to fund I-35's improvements in those regions.

Ease of Implementation Criterion

This criterion includes five sub-criteria as described below.

Cost of implementation: This includes the cost of initial implementation, on-going administration and cost of compliance relative to the revenue generated. Under this criterion, when two alternatives generate similar revenues, the alternative with less cost gets a better ranking.

[14] The survey and the accompanying documents erroneously referred this as geographic equity. The author corrects this error in this document.

[15] A major urban area located in the North Texas region.

Simplicity of payment structure: The tax rate and payment structure should be simple for the payers to understand and to keep their records.

Ability to prevent evasion: The system should be such that evasion of charges can be prevented or reduced easily and with less cost.

Ability to use existing payment infrastructure: Using existing administrative and physical payment infrastructure is considered an advantage in this criterion. Any new payment infrastructure will take time to develop and includes costs related to transformation from the old system to the new system. Other issues such as training employees for operating the new system and resistance from the operators to change to the new system also exist.

Ease of co-ordination with bordering regions: A system should not be difficult for the geographically connected regions to coordinate in collecting fees and preventing evasion of taxes or fees at the borders of the regions. This kind of coordination may be needed at a place where enforcement changes such as the borders of a state, metropolitan area or a county where a tax rate or a funding policy differs between the regions.

Public Acceptance and Political Feasibility Criterion

This criterion includes three sub-criteria as described below.

Ease of explaining to the public: The funding alternative should be easy to explain to the public. Only then, it will stand a chance of being accepted among the public. The ease of explaining depends on factors such as how similar a new system is compared to the existing system, how the tax or fee is calculated, how it is connected with transportation and whether or not it is termed as a tax. Ease of explaining to the public mainly affects the public information/awareness campaign efforts. While the simplicity

of payment structure under the ease of implementation criterion directly considers the actual pricing/billing and the method of payment, the details regarding the tax rate such as how it differs by user and by usage are of concern in this sub-criterion.

Acceptability to the public: This pertains to how well a funding alternative is accepted by the public. Public acceptance is the key for a funding alternative being accepted by the elected officials.

Less need for legislative action: The feasibility of a funding alternative is increased when there is less need for legislative action by the elected officials (at local or state level). This may include passing new laws, removing outdated laws or amending existing laws.

Potential Secondary Benefits Criterion

This criterion includes two sub-criteria as described below.

Promotion of efficient use of system by changing travel behavior: This evaluates the extent to which the funding mechanism can promote efficient use of the transportation system by encouraging travelers to make changes in their travel behavior. Such changes include but are not limited to reducing the frequency and distance of travel, traveling in off-peak periods and using alternative modes such as carpooling, public transit and non-motorized modes. Any tool included in the funding mechanism that penalizes inefficient use helps the funding mechanism to obtain a higher rating. For example, congestion pricing is seen as an alternative that discourages travel in congested time periods on certain roadways.

Promotion of fuel efficiency and use of low emission fuels: This evaluates the extent to which the funding mechanism encourages use of low emission fuels and an increase of fuel efficiency by users.

Refinements to the Initial List of Criteria

The author performs the following main refinements to the list of criteria as a result of the responses from the first round survey:

- The definition of the revenue generation criterion is changed from a quantitative comparison of revenue to a qualitative assessment. Under the revenue generation criterion, the short term revenue potential sub-criterion is removed. Two sub-criteria – revenue generation potential and flexibility in investment are added.
- Under the ease of implementation criterion, the less need for new technology sub-criterion is removed because it is given less importance by the panel members.
- Under the equity and fairness criterion, the connection with transportation sub-criterion is removed because this factor is included inside the ease of explaining to the public sub-criterion under the public acceptance and political feasibility criterion.
- One can expect the politicians to represent the public opinion from their constituencies. But the public acceptance part is masked by the "political" word in the political feasibility criterion. For this reason, the panel members seem to misunderstand this criterion. Moreover, due to a bias because of the word "political", this criterion may get a higher weight. So, the name is changed to "public acceptance and political feasibility".
- The criterion called improvement in transportation system performance and environment is renamed as potential secondary benefits. In the first round, some members have misinterpreted the "improvement" as the improvement

gained after spending the revenue generated on transportation improvements. Furthermore, the improvement in user behavior due to a new funding tax or fee is very low.

A complete summary of the first round survey is provided in Appendix E.

3.1.5. Second Round Survey – Weighting the Criteria

The objective of the second round survey is to obtain weights for the criteria from the panel members. The weights represent the importance of each decision criterion relative to all others. Some methods of calculating criterion weights are discussed next.

Weighting Methods

Rogers (2001) explains different basic techniques for calculating criterion weights based on the judgment of the decision maker (DM). They are: ranking, ratio method, pairwise comparison and resistance-to-change grid method. When the DM is not able to decide the weights, all criteria can be assumed to be equally important, and can be assigned equal weights.

In the ranking method, all the criteria are assigned ranks based on their importance. Then, each criterion is assigned a score obtained by subtracting its rank from the total number of criteria plus one. The relative weights of each criterion are calculated by normalizing these scores (Rogers 2001).

In the case of the ratio method, the DM first assigns a score of 1.0 to the least important criterion. Then, the DM assigns a score of more than one to each of the remaining criteria indicating its relative importance over the least important criterion. Normalized weights are calculated using these ratio scores (Rogers 2001).

In another method called the 100-point scale method or constant scale method (Wikipedia 2013), the DM compares all the criteria as a group and distributes a total score of 100 among them.

In all the above methods, the DM considers all the criteria together while scoring or ranking them, which becomes difficult when the number of criteria increases. In the ratio method, this is relieved in the second step because each criterion is compared with the least important criterion. The 100-point scale method is sometimes preferred because the DMs are able to feel the actual weights.

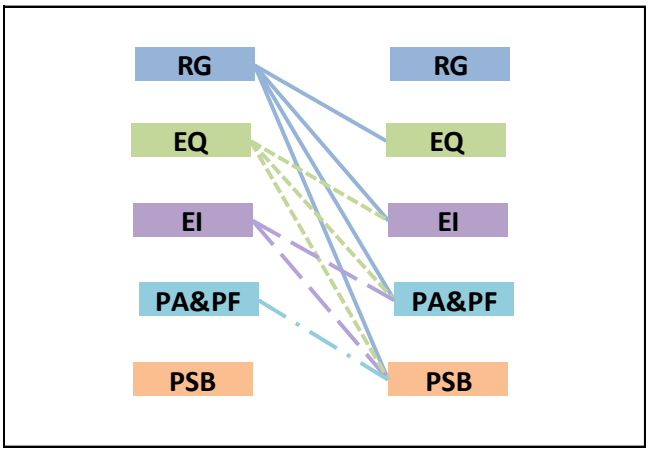
In the case of the pairwise comparison method, a DM compares all the criteria in pairs and assigns a score to each pair, forming a pairwise comparison matrix. In each comparison, a score of “0”, “1” or “2” is assigned depending on whether the first criterion is less, equally or more important than the second criterion, respectively. In a pairwise comparison matrix, each row corresponds to one criterion. The relative weight for each criterion is obtained by adding the scores it obtains against the remaining criteria. The sum of all scores in a row in a pairwise comparison table represents the relative weight for the criterion corresponding to the row. The relative weights are normalized to give the final weights.

The resistance-to-change grid method is another pairwise comparison method where the scores are assigned in a different way. Here, instead of just giving two criteria names to the DM, each of the two is written as most desirable and least desirable attribute of an alternative. For example, the ease of implementation criterion is shown as “very easy to implement/very difficult to implement” and the revenue generation criterion is shown as “very good revenue generator/very bad revenue generator.” The DM chooses which one in the pair he is least willing to change from

most desirable to least desirable state. The chosen criterion is assigned a score of "1" and the other is given a score of "0". If the DM's willingness to change is equal in both criteria, they both receive a score of "0.5" (Rogers 2001).

Weighting Methods Used in the Survey

The author has two tasks: choosing the weighting methods for the main criteria and sub-criteria and identifying the best way to present them in the survey so that the panel members can easily comprehend and answer. The author chooses to use the pairwise comparison method for the main criteria because it is simple to understand and reduces the burden on the panel members by asking them to compare two criteria at a time. The author assumes that a symmetric relation is satisfied in pairwise comparisons, that is, if criterion A is more important than criterion B, criterion B is less important than criterion A. Pairwise comparisons can be performed directly in a matrix format, where a criterion corresponding to a matrix row is compared to each criterion that is corresponding to a matrix column. In that case, either the upper triangular matrix or the lower triangular matrix is filled. The author realizes through the pilot surveys that this method needs more explanation and is confusing to the panel members. Eckenrode (1965) finds that the matrix based pairwise comparison requires more time and is difficult to answer than other weighting methods. In his study, asking the participants to compare two criteria at a time in separate questions is found to be easier to answer. The author follows this method. Since there are five main criteria, there are ${}_5C_2$, that is, ten pairwise comparison questions. To simplify the structure further, the author presents these questions in four groups containing four comparisons for RG, three comparisons for EQ, two for EI and one for PA&PF. The actual comparisons are shown in Figure 3-5.



Note: Each line indicates a pair that is formed by the two criteria at its edges. There are ten pairs in total, divided into four groups (indicated by four different line patterns).

Figure 3-5. Pairwise Comparisons of Main Criteria

After each group of comparisons, the panel members are asked to provide any comments or justifications for their opinion. The table cells are shaded with different colors so that a specific criterion is located easily. As an example, Figure 3-6 shows the pairwise comparison question for the Equity and Fairness criterion.

Question: Please fill in the green box with the criterion (short form) you think is more important between the two. If you think both criteria have the same importance, please fill the green box with "SAME". Please write any comments or justifications for your decision in the space provided below the table.

	Criterion A		Preference	Criterion B	
ROW 5	Equity and Fairness	EQ		EI	Ease of Implementation
ROW 6	Equity and Fairness	EQ		PA&PF	Public Acceptance and Political Feasibility
ROW 7	Equity and Fairness	EQ		PSB	Potential Secondary Benefits

Comments:

Note: For better visualization, each criterion is indicated with a color. A criterion is accompanied by the corresponding color wherever it is shown in the pairwise comparison questions.

Figure 3-6. Format of the Pairwise Comparison Question

Using the pairwise comparison method for the sub-criteria increases the number of questions and the effort of the panel members significantly. So instead, the author uses the 100-point scale method, which is more direct and easy to understand and translate when compared to most other techniques. Although this method requires the panel members to compare all the sub-criteria at one time instead of two at a time, this problem is reduced because three of the five criteria have only three or fewer sub-criteria. The fact that the panel members have a chance to revisit their criteria weights in the following round is also an advantage in this regard. The author considers the ratio method for weighting the sub-criteria but does not choose it because of its

complexity. Suppose that there are three criteria – A, B and C and that the DM identifies B as the least important. In the ratio method, the DM needs to not only qualitatively identify that A's importance over B is more than C's importance over B, but also quantify how much more it is. The Delphi method's structure makes determining if all the panel members have comprehended these comparisons while deciding the scores difficult. Moreover, when many individuals assign their weights in this method, combining the weights is very difficult. Consider two criteria A and B. Assume that A is given a score of 1.0. Suppose that both member 1 and member 2 think that B is 'very much more important' than A. But member 1 may translate this statement as twice more important (giving a score of 2.0 to B) while member 2 translates the same as five times more important (giving a score of 5.0 to B). These scores translate into a very different set of weights for A and B – 0.33 and 0.67 from member 1; and 0.17 and 0.83 from member 2. The accuracy of the weighting method is reduced by this inconsistency in translation of words into scores and into weights eventually. For these reasons, the author does not choose the ratio method. Instead, he uses the 100-point scale method, which is more direct and easy to understand. Figure 3-7 shows the format of the sub-criteria weighting questions. Five questions, each containing a weighting table for the sub-criteria under one main criterion are included. A sample of the second round survey is shown in Appendix C.

Question: Table below shows the sub-criteria for the Equity and Fairness criterion. Please fill the column "Score" as illustrated in the example above with the scores for each sub-criterion such that the total score is 100. Please provide your comments/justifications below the table.

Main Criterion	Sub-criteria	Score
Equity and Fairness (EQ)	Equity in paying by benefit gained and cost imposed (user-pay)	
	Ability to pay equity	
	Geographic equity	
	Total	**100**

Comments:

Figure 3-7. Format of the Sub-criteria Weighting Question

Summary and Analysis

The author summarizes all the responses obtained and calculates the criteria weights. For the main criteria, one pairwise comparison table is prepared for each panel member. Suppose that rows of the table are represented by I and columns are represented by J. As suggested by Rogers (2001), cells of the pairwise table are filled with "0", "1" or "2" depending on whether criterion I is less, equally or more important than criterion J, respectively. The weights are calculated by normalizing the row totals[16] of this pairwise comparison matrix (Rogers 2001). Figure 3-8 illustrates this calculation.

[16] Sum of all values in a row.

Pairwise Comparison Responses:

ROW	Criterion A	Preference	Criterion B
ROW 1	**RG**	RG	EQ
ROW 2	**RG**	RG	EI
ROW 3	**RG**	PA&PF	PA&PF
ROW 4	**RG**	RG	PSB
ROW 5	EQ	EQ	EI
ROW 6	EQ	PA&PF	PA&PF
ROW 7	EQ	EQ	PSB
ROW 8	EI	SAME	PA&PF
ROW 9	EI	EI	PSB
ROW 10	PA&PF	PA&PF	PSB

Pairwise Comparison Table:

Criterion	RG	EQ	EI	PA&PF	PSB
RG		RG	RG	PA&PF	RG
EQ			EQ	PA&PF	EQ
EI				SAME	EI
PA&PF					PA&PF
PSB					

Calculation of Weights:

Criterion	RG	EQ	EI	PA&PF	PSB	Row Sum	Row Sum+1	Weights
RG		2	2	0	2	6	7	28
EQ	0		2	0	2	4	5	20
EI	0	0		1	2	3	4	16
PA&PF	2	2	1		2	7	8	32
PSB	0	0	0	0		0	1	4

Column Sum	25	100

Figure 3-8. Illustration of Calculation of Weights from Pairwise Comparison Responses

In this method, when any one criterion is less important than every other criterion, its corresponding row total becomes zero and that criterion receives a weight of zero. Rogers (2001) suggests that, in such a case, all row sums should be increased by one. Many responses in the current survey data have one criterion with zero weight. So, to maintain consistency, the author decides to increase the row sums by one in all responses. In each response, the weights are calculated by normalizing the row sums such that the sum is one. For simplicity, the weights here are presented after being multiplied by 100, that is, on a 100-point scale.

In this translation of pairwise comparison into criteria weights, the maximum and minimum weights possible are 36 and four (on a scale of zero to 100), respectively. If a criterion is given higher importance over all other criteria, it gets a weight of 36. If a criterion is given lower importance over all other criteria, it gets a weight of 4. If the pairwise comparison responses result in a perfect rank order, that is no two criteria are equally important, the weights (on a 100-point scale) of the criteria ranked in the order of importance as one, two, three, four and five are: 36, 28, 20, twelve and four, respectively. If any two criteria are equally important, they have the same weight and it is equal to the average of the two weights. For example, if the two criteria below the top ranked criterion are equally important, their combined rank is 2.5 and their weights are equal at 24.

The scores on a 100-point scale assigned by the panel members to the sub-criteria under each criterion are directly translated into weights for the sub-criteria.

The next task is to aggregate the responses into one criteria weight vector. While there are many methods for aggregating all the pairwise comparison data into

a set of criteria weights, they differ in two basic ways. In one way, all the pairwise comparison tables are aggregated cell-by-cell into one resultant table and then, the weights are calculated from the resultant aggregated table. In another way, one set of weights are calculated from each individual pairwise comparison table and then all the weight vectors are aggregated element-by-element (Zhou 1996). The author uses the second method; he first calculates weight vectors from each pairwise comparison table and aggregates them. The geometric mean and arithmetic mean are two simple methods commonly used to aggregate (Zhou 1996). After considering both methods and finding that they result in similar average weights, the author selects the geometric mean method for this study.

The pairwise comparison method allows for some inconsistencies in the responses. As mentioned before, the author assumes that the symmetric relation is satisfied, but he does not presume that the transitive relation is satisfied. Suppose that there are three criteria A, B and C and that 'A>B' indicates 'A is more important than B' and 'A<B' indicates 'A is less important than B'. Then, if A>B, the author assumes that B<A; but if A>B and B>C, he does not assume that A>C. So, the author monitors if there are many such inconsistencies in a panel member's response. To account for this, the author assigns a weight called "reliability rating" to each pairwise comparison response and uses a weighted geometric mean method to aggregate the main criteria weights as described by Zhou (1996). A reliability rating is used to represent the confidence level in the responses. In this case, a large number of inconsistencies is assumed to indicate the panel member's indecisiveness or simply his or her lack of understanding of the method. Hence,

such responses are given lower importance rating. In this process, the author assigns a reliability rating of “2” to five responses that have shown many inconsistencies and “3” for the remaining responses.

The author aggregates the sub-criteria weights using a simple geometric mean method considering all responses to have the same reliability rating.

In this research, the author tries to understand if there are differences in opinions among different groups of panel members. Rogers (2001) suggests the need for generating separate sets of weights when necessary. In this research, panel members are grouped based on the organization or the region type as explained earlier. The criteria weights are first averaged by the organization – MPO, TxDOT or Leg. Comm. Then, the overall average weight for each criterion is calculated by geometric mean of the group average weights. Equations (1) through (4) describe the calculation of group average weights and overall average weights.

Average relative weight by group: $$w_{ig}' = \left[\prod (w_{ij})^{R_j}\right]^{\frac{1}{\sum R_j}}; j = 1,2,3,...n_g \quad (1)$$

where,

w_{ig}' = raw average weight of criterion i for group g,

n_g = number of respondents in respondent group g,

w_{ij} = weight of criterion i given by respondent j in group g and

R_j = reliability rating of respondent j from group g.

Overall average relative weight: $$w_i' = \left(\prod w_{ig}'\right)^{\frac{1}{G}}; g = 1,2,...G \quad (2)$$

where,

w_i' = overall average relative weight of criterion i,

G = number of groups and

g = group identification.

Overall average weight: $$w_i = \frac{w_i'}{\sum w_i'}; i = 1,2,...m \quad (3)$$

Group average weight: $$w_{ig} = \frac{w_{ig}'}{\sum w_{ig}'}; i = 1,2,...m \quad (4)$$

where,

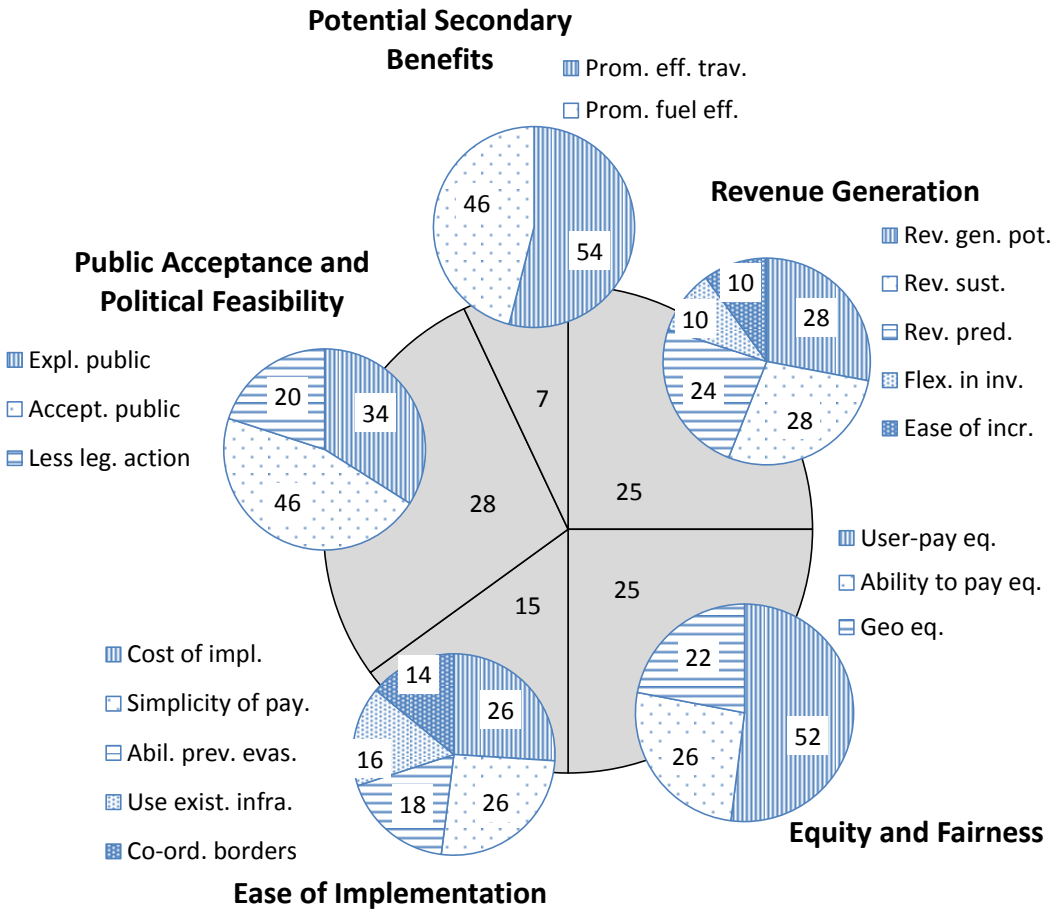
w_i = normalized overall average weight of criterion i,

w_{ig} = normalized group average weight of criterion i and

m = number of criteria.

Resultant Criteria Weights and Variation

The resultant weights for the main criteria and sub-criteria from the second round survey are presented in Figure 3-9 in the form of separate pie charts. The central pie chart shows the main criteria weights. Each pie chart at the perimeter shows how the total weight of a main criterion is distributed among different sub-criteria under that main criterion. Sub-criteria weights are shown in the form of local weights, which add up to 100 inside one main criterion. The main criteria weights and the sub-criteria local weights are rounded to integers.



Note: Pie diagrams show the weights on a 100-point scale as labels. These weights are local weights. Weights of all the sub-criteria under one main criterion add up to 100.

Figure 3-9. Overall Average Criteria Weights Resulted from the Second Round Survey

The final weights of all the sub-criteria, also called global weights, are calculated by multiplying the sub-criteria weights by the corresponding main criterion weight. Figure 3-10 shows the sub-criteria global weights as a bar chart. The global weights are rounded to one decimal digit.

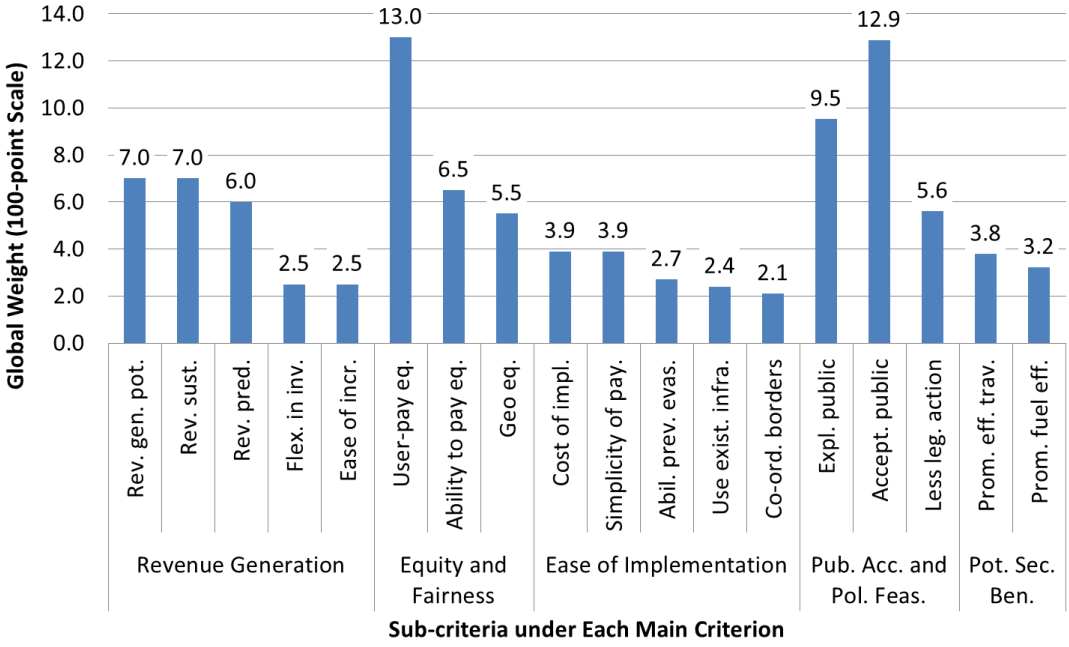


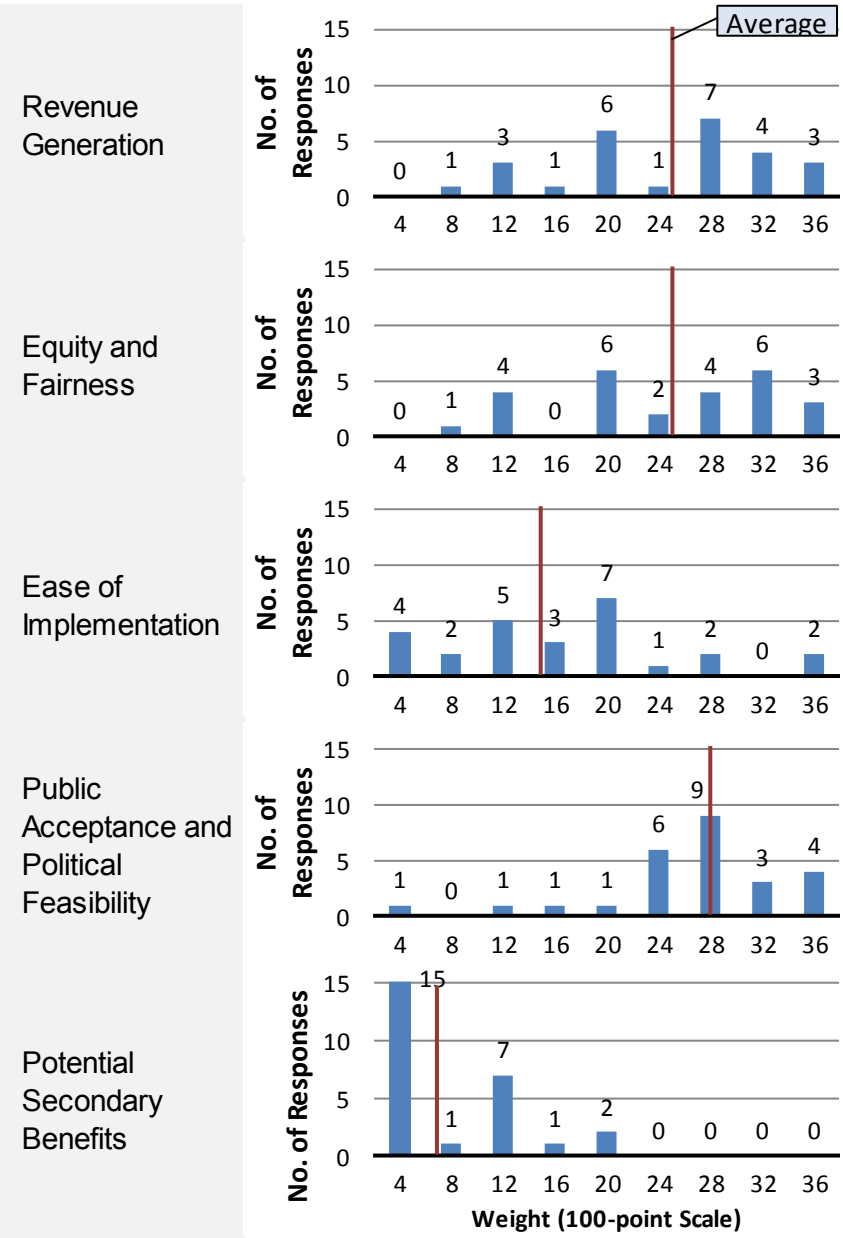
Figure 3-10. Global Weights of all the Sub-criteria from the Second Round Survey

Some notable points from these results are:

- The public acceptance and political feasibility criterion has the highest weight. The revenue generation and equity criteria are right below. These three together cover about 78% of the total weight.
- The revenue generation potential, revenue sustainability and revenue predictability criteria cover 80% of the revenue generation criterion.
- The user-pay equity criterion covers more than 50% of the equity criterion.
- The acceptability to the public sub-criterion covers close to 50% of the public acceptance and political feasibility criterion. Adding the ease of explaining to public sub-criterion to this brings the total weight to 80%.

- Overall, the user-pay equity, ease of explaining to the public and acceptability to the public criteria are the three criteria that stand out. Together, they account for about 36% of the overall weight.

More discussion about these results and their implications are discussed along with the results of the third round survey in Section 3.2. As mentioned earlier, these weights are averages of the panel member responses. This set of weights can be considered as the potential consensus opinion. But, the author needs to understand the differences among the panel members' opinions to be able to assess how far the responses are from the consensus opinion. The author prepares frequency histograms and box-and-whisker plots to understand the variation in the responses. The box-and-whisker plots are discussed later along with the results of the third round survey. The frequency histograms, which indicate the distribution of the responses among different weights, are presented here. Figure 3-11 shows the histograms for the five main criteria. They are stacked on one another so that the distributions can be compared one to one. As a reference, the location of the overall average weight is shown with a vertical line. The reader may note that these weights are not directly given by the panel members but are derived from the pairwise comparison tables as discussed earlier. Since there are five criteria, the pairwise comparison method used in this research restricts the main criteria weights to be one of the multiples of four between four and 36. Furthermore, the set of all weights contains more instances of four, twelve, 20, 28 and 36 than the intermediate values because the number of pairwise comparisons marked as equally important is smaller than that marked otherwise.



Note: These weights are calculated from the pairwise comparison responses provided by the panel members.

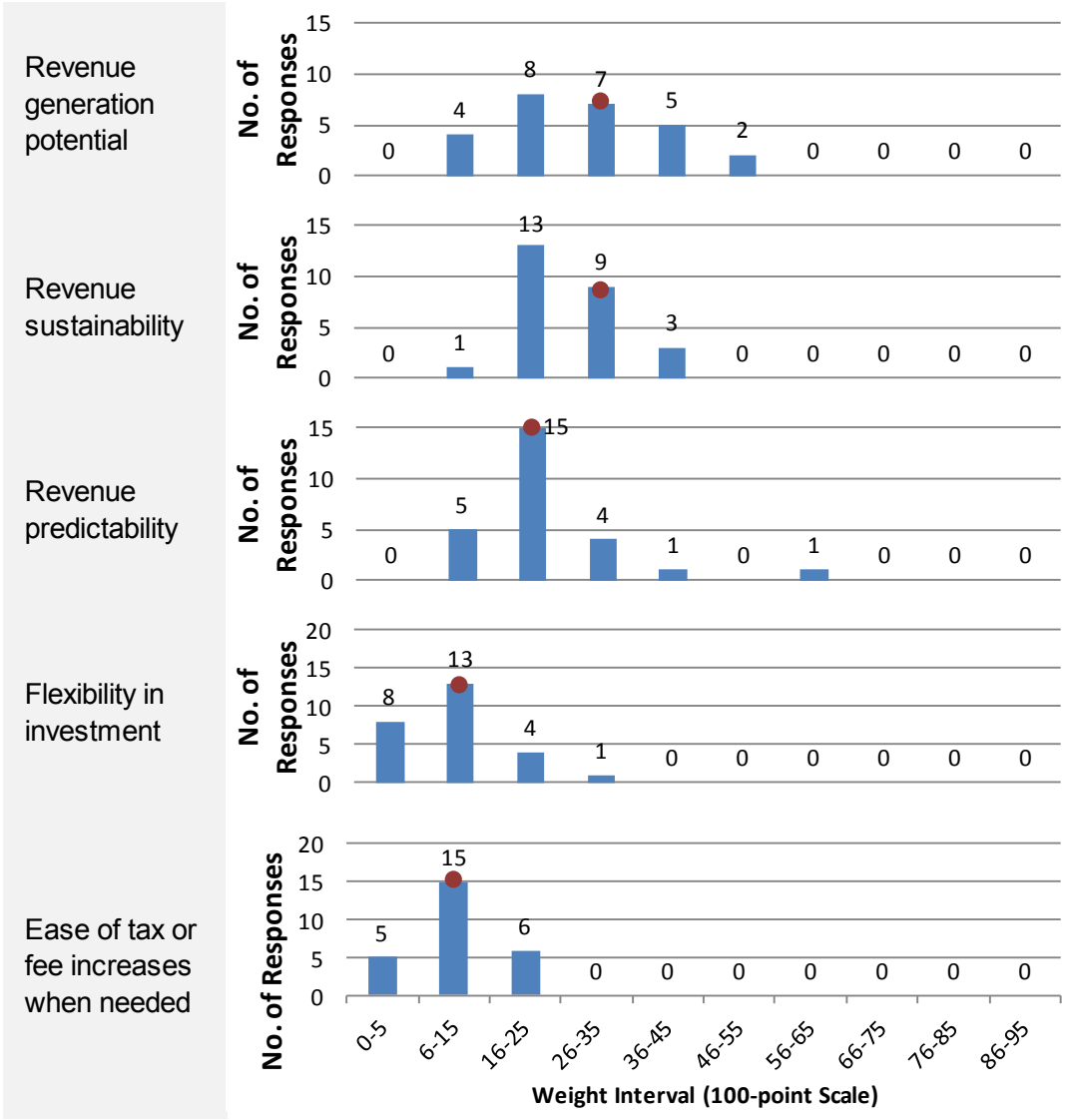
Figure 3-11. Distribution of Panel Member Responses: Weights of the Main Criteria

These graphs show that the weights of the RG, EQ and EI criteria are spread over about 24 weight points (ignoring a frequency of one). The weights of

the PA&PF and PSB criteria are relatively narrowly spread out. When the criteria are compared based on their weights, the PA&PF criterion is consistently among the top two criteria and the PSB criterion is consistently the least important one. None of the plots clearly indicate a bimodal distribution.

Figure 3-12 through Figure 3-16 contain frequency histograms for the sub-criteria weights grouped by the corresponding main criterion. In each histogram, the location of the overall average sub-criterion weight is marked by a dot. The panel members are free to assign any value to each sub-criterion under the 100-point scale method. However, about 75% of the weights are multiples of ten and almost all are multiples of five. The author chooses the intervals with multiples of five so that the values at the ends of the intervals are lower and thus the definition of the intervals has less effect on the shape of the graph.

Figure 3-12 shows the distribution of weights of the sub-criteria under the RG criterion. It shows that the weights for the revenue generation potential sub-criterion are more spread out than the remaining sub-criteria. It seems that this sub-criterion competes with the revenue sustainability sub-criterion to be the most important among these five. The revenue predictability sub-criterion gets one value of 60, which may be an outlier. The flexibility in investment and the ease of tax or fee increases when needed sub-criteria are spread from zero to 25 with modes between six and fifteen.



Notes:

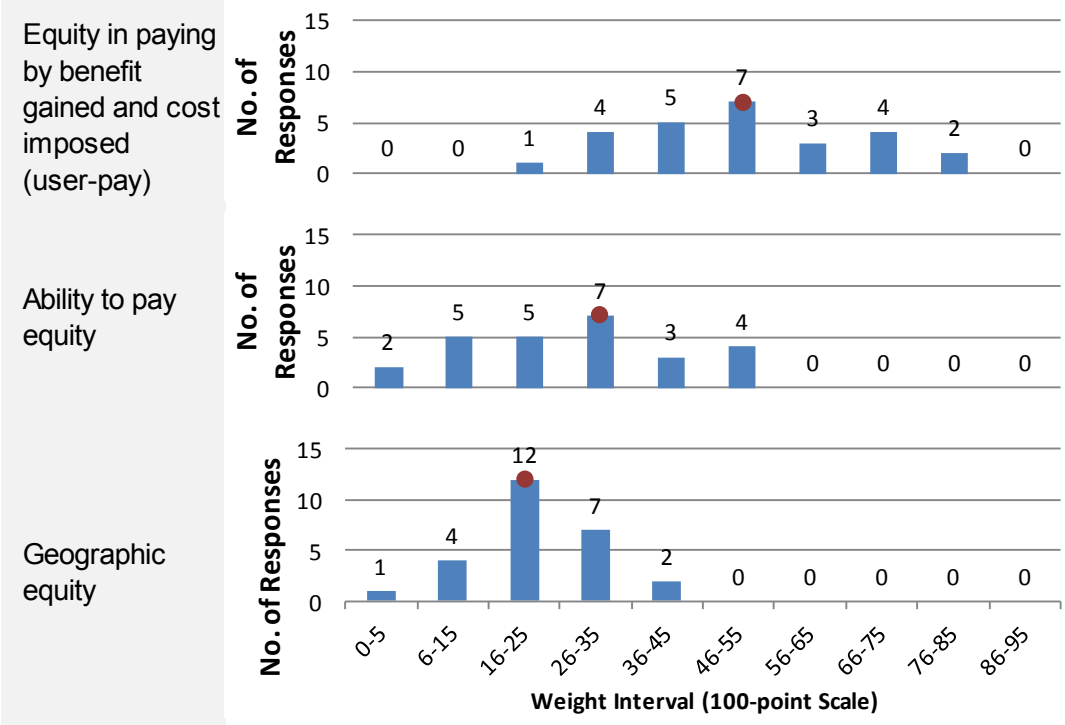
More than 90% of the weights are divisible by five.

The dot indicates the interval where the overall average weight falls.

Figure 3-12. Distribution of Panel Member Responses: Weights of Sub-criteria under the Revenue Generation Criterion

As shown in Figure 3-13, the responses for the user-pay equity and the ability to pay equity sub-criteria are widely spread. This shows the difficulty in

reaching a consensus on the weights of these criteria. The geographic equity sub-criterion has a better consensus. Its weights are spread between zero and 45 and have their mode in the 16 to 25 interval.



Notes:

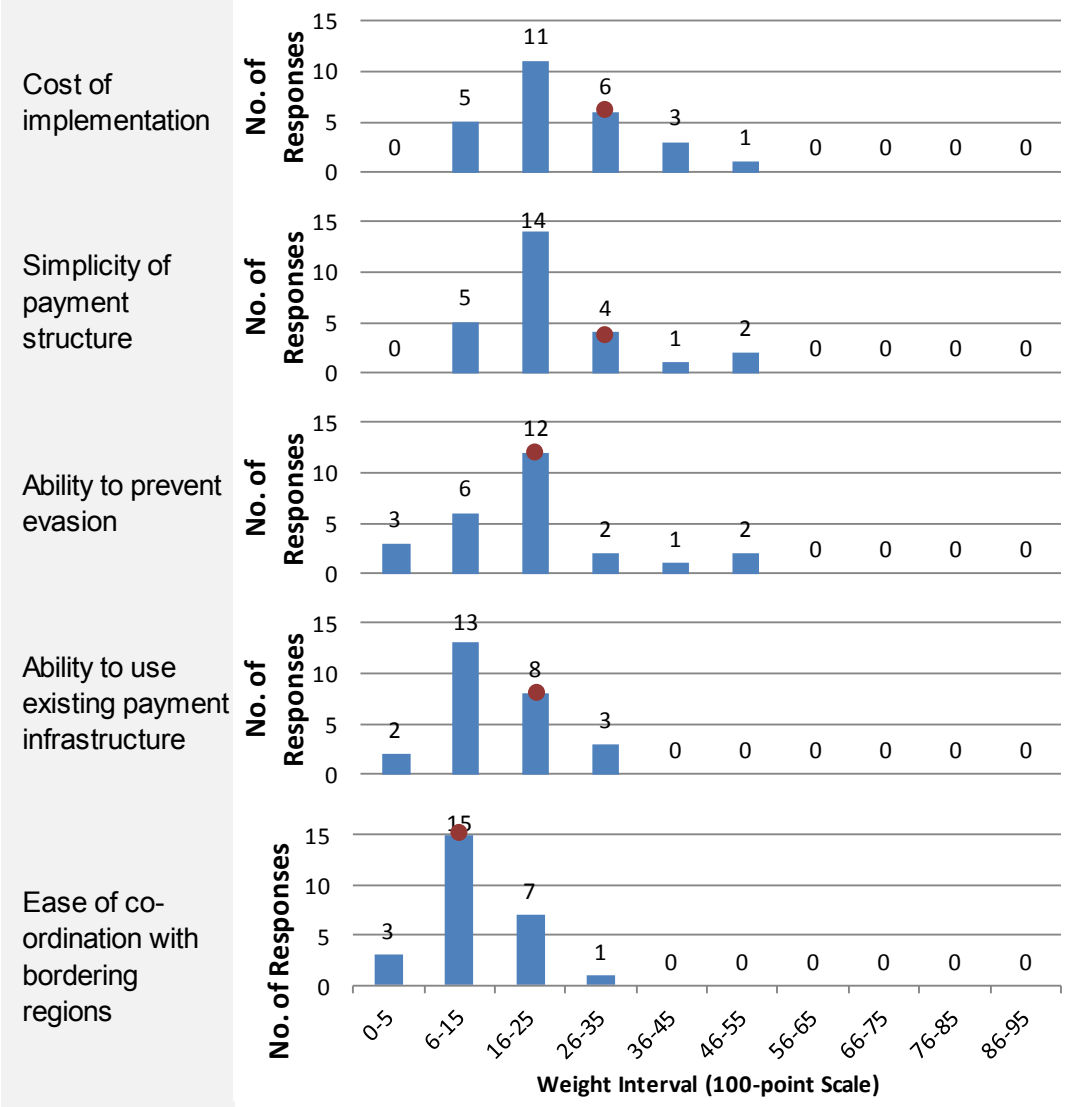
All except two weights are divisible by five.

The dot indicates the interval where the overall average weight falls.

Figure 3-13. Distribution of Panel Member Responses: Weights of Sub-criteria under the Equity and Fairness Criterion

As shown in Figure 3-14, the majority of the weights given to the sub-criteria under the ease of implementation criterion are concentrated between six and 25. This means that the panel members do not give a high importance level to any one sub-criterion. The distributions of weights of the first three sub-criteria are similar,

while the other two have almost equal distributions. With some revisions in the weights in the third round, a good consensus is likely.



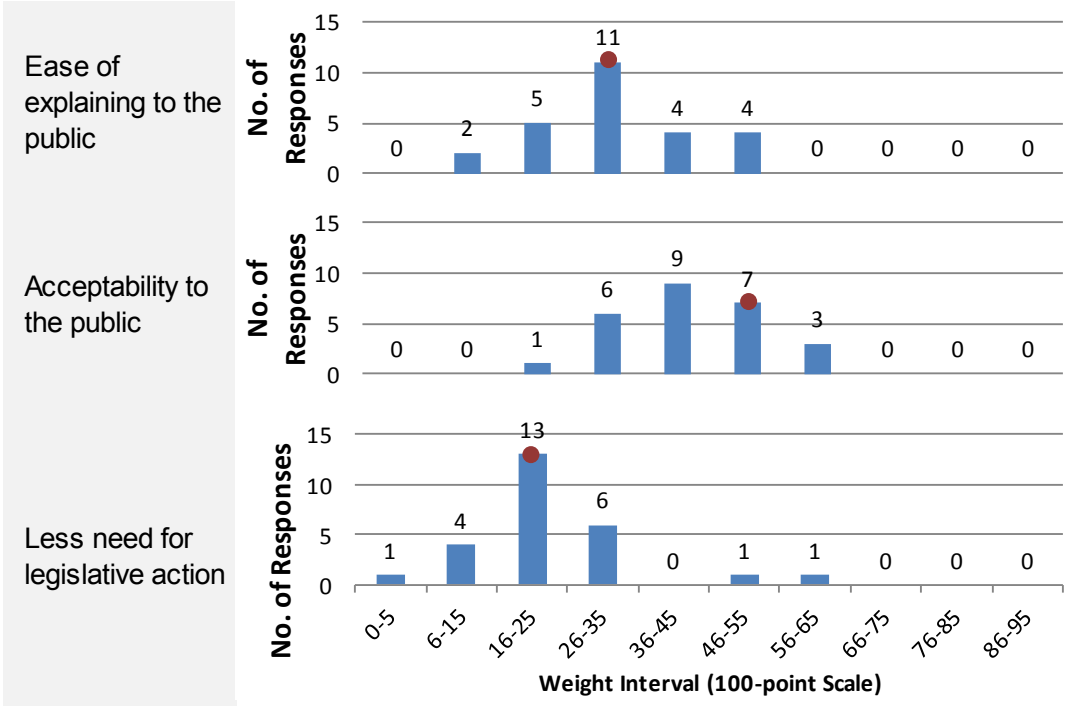
Notes:

All except two weights are divisible by five.

The dot indicates the interval where the overall average weight falls.

Figure 3-14. Distribution of Panel Member Responses: Weights of Sub-criteria under the Ease of Implementation Criterion

Distributions of weights of all the sub-criteria under the PA&PF criterion have values spread on both sides of a peak, while the acceptability sub-criterion has more variation than the other two sub-criteria have. In Figure 3-14, the acceptability to the public sub-criterion has more variation, which is a sign of having low consensus; however, in this case, a majority of the panel members seem to agree that the acceptability to the public is more important than the other two, they seem to differ on how much more important it is.



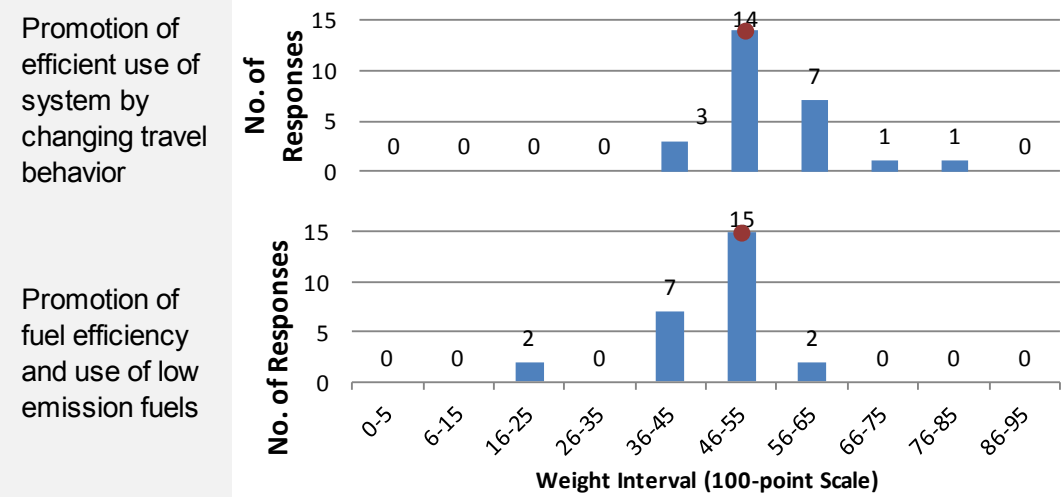
Notes:

All except three weights are divisible by five.

The dot indicates the interval where the overall average weight falls.

Figure 3-15. Distribution of Panel Member Responses: Weights of Sub-criteria under the Public Acceptance and Political Feasibility Criterion

As shown in Figure 3-16, the majority of the panel members indicate that promotion of efficient travel behavior and promotion of fuel efficiency are equally important, showing a potential consensus. There are two panel members who do not agree with this opinion and give the promotion of efficient travel behavior significantly more importance than the promotion of fuel efficiency.



Notes:
All weights are divisible by five.
The dot indicates the interval where the overall average weight falls.

Figure 3-16. Distribution of Panel Member Responses: Weights of Sub-criteria under the Potential Secondary Benefits Criterion

The author summarizes the justifications presented along with the responses and analyzes them. He separates the comments that support the potential consensus opinion from the remaining comments. The author prepares a concise summary of the conclusions from the second round survey and presents it to the panel members. This summary is shown in Appendix F. This summary includes the following elements:

- Resultant weights for main criteria and sub-criteria and key inferences from them
- Graphical presentation of main criteria weights and sub-criteria global weights
- The response for the pairwise comparison question that would have represented the average main criteria weights
- Important judgments and justifications inferred from the panel members' comments, supporting the potential consensus opinion and alternate opinions
- Box-and-whisker plots for main criteria and sub-criteria showing the geometric mean, interquartile range, and minimum and maximum weights with explanation of the variation and how reaching a consensus is indicated by this plot.

3.1.6. Third Round Survey – Efforts towards Consensus

The aim of the third round survey is to reduce the differences among the panel members' opinions on the criteria weights and facilitate a consensus. This step is one of the main strengths of the Delphi method. The panel members are shown the overall average weights for main criteria and sub-criteria and how different their own original response is to this average. The survey asks the members if they are willing to revise their response in the light of the panel's combined response. They are asked to review the summary discussed in the previous section.

Need for a Good Feedback

The revision of the opinion should not be based merely on the statistics of the criteria weights but also based on the related justification. Scheibe et al. (1975) perform a Delphi experiment and find that those respondents who revise their responses significantly to conform to the group consensus opinion have had difficulty in giving and taking ideas from the feedback. In their experiment, they find that the respondents who strongly conform with the consensus opinion have not been happy with the Delphi process. As a reason, Scheibe et al. speculate that the group pressure from some forms of feedback may force the participants to take positions they find uncomfortable. Although the participants compromise on paper, they may still hold their original views. When certain decisions taken in the Delphi process are implemented, the participants may be dissatisfied with the results. Skutsch (1972) finds that hard feedback including just the statistics such as means and variation may cause this irrational consensus. With this in mind, the author carefully designs the third round survey questionnaire to precisely show the differences in opinions and show the justifications in a concise manner such that the panel members can think about the other members' opinions and justifications and make a more informed decision whether or not and how much to revise their original opinion.

Questionnaire

The third round survey is ten pages long with six questions, one for the main criteria and one for each set of sub-criteria. The main characteristics of the questionnaire are described below:

- The survey is customized to each individual panel member. Each member receives a different survey.
- The introduction of the survey describes the aim of the third round questionnaire. To generate a sense of trust and importance, the survey states that the averages calculated include all of the panel members' responses.
- The survey informs the panel members that the pairwise comparison responses assigned by them are transformed into weights and are averaged. The preferences originally given by the panel member in the main criteria pairwise comparison are shown side by side with the preferences that represent the overall average weights. All the responses that do not match the average response are shown in RED color. A sample of the comparison table used in the survey is shown in Figure 3-17. The survey informs the panel members the possible range of weights that the criteria may have when the pairwise comparison responses are translated into weights. It tells that a criterion that is preferred to all other criteria gets thirty-six percent weight while a criterion gets the minimum possible weight of four percent when every other criterion is preferred to it.
- In the first question, the survey has a table containing the weights for each main criteria calculated based on the panel member's responses and the average weights. It provides an adjacent blank column to be filled with the revised weights. All weights are shown on a 100-point

scale. Below the table, an option is given to the panel members to adopt the average response as their own revised response. Then, the survey asks the panel members to identify the reasons for their revision. It asks them to select one of two reasons: whether the member agrees to the justification provided or he or she does not agree to the justifications completely but is willing to compromise to help reach consensus. A sample question is shown in Figure 3-18. The response to this question helps the author to analyze the effectiveness of the feedback. Space is provided for any additional comments.

- Below the question, a discussion is provided showing the major conclusions in the average response and the justifications identified from the responses and comments.
- The following five questions follow the same pattern as the first question. In each question, the survey asks the panel members to provide revisions to the weights of the sub-criteria under one main criterion.

The complete third round survey questionnaire for one participant is included in Appendix D.

	Criterion A	vs.	Criterion B	Preference	
				Yours	Overall Average
ROW 1	RG	vs.	EQ	SAME	SAME
ROW 2	RG	vs.	EI	RG	RG
ROW 3	RG	vs.	PA&PF	SAME	PA&PF/SAME
ROW 4	RG	vs.	PSB	RG	RG
ROW 5	EQ	vs.	EI	EQ	EQ
ROW 6	EQ	vs.	PA&PF	SAME	PA&PF/SAME
ROW 7	EQ	vs.	PSB	EQ	EQ
ROW 8	EI	vs.	PA&PF	*SAME*	PA&PF
ROW 9	EI	vs.	PSB	*PSB*	EI
ROW 10	PA&PF	vs.	PSB	PA&PF	PA&PF

Note: In the "Yours" column, any preference that does not match the corresponding overall average preference is shown in RED italics format.

Figure 3-17. Sample of Pairwise Comparison Table Used in the Third Round Survey

Showing Individual Member's Preferences with Overall Average Preferences

Question: After learning about this group response, would you like to revise your opinion and update your weights to come closer to the average weights?

If so, please fill the last column with your revised weights on 100-point scale

Main criteria	Your Weights	Overall Average	Your Revision
Revenue Generation (RG)	28	25	
Equity and Fairness (EQ)	28	25	
Ease of Implementation (EI)	8	15	
Public Acceptance and Political Feasibility (PA&PF)	24	28	
Potential Secondary Benefits (PSB)	12	7	
Total	**100**	**100**	**100**

OR, if you want to adopt the overall average weights as your revised weights, please fill this box with YES	

Comments:

Below, please accept a reason for revising your response by marking 'X'; OR Provide any other comments or reasons for revising or not revising your response.

a. I agree with the justifications and so, I revised.	
b. I do not completely agree with the reasons but I am willing to compromise to help reach consensus. So, I revised.	
Other:	

Figure 3-18. Sample Question to Obtain Revised Criteria Weights

Summary and Analysis

In the third round survey, the panel members provide their revised criteria weights using the 100-point scale method. So, the author translates all the responses directly into weights. For those panel members who do not respond to the third round survey, the author assumes that their second round responses are maintained unrevised. Overall average weights are calculated using the geometric mean. The author reviews the interquartile range and the range of weights, which indicate the variation remaining in the criteria weights after the third round. The author assesses the success of the third round survey in reducing the differences in opinions by comparing the new box-and-whisker plots with those prepared using the criteria weights obtained after the second round survey. The author also analyzes the reasons for the revisions. The results are presented with some discussion and policy implications in the next section. The results show that many panel members revise their weights such that the weights are close to the average weights.

The author concludes the survey with the third round survey. At the end, the author prepares a summary of the final criteria weights and the differences in opinions that still remain. He presents this summary to the panel members. Appendix G contains this summary. The whole communication, starting from the requests to participation to the presentation of the final summary, has spanned a period of about six months. The three rounds of the survey, starting from the launch of the first round survey to the time when most of the responses for the third round survey are received, spanned about three and a half months. That is about one and a half months more than the initially estimated time. Since the 83rd Texas Legislative

regular session has been happening and the legislative committee members and their staff have been busy, the author extends the third round survey until its end so that the participation increases. Due to the extended time of the survey, gaining the attention of the panel members to respond to another round of survey is less likely. Moreover, the interquartile range of the criteria weights reduces for most criteria. Skutsch (1972) suggests that the analyst should estimate if the marginal return of information warrants the additional participator patience required. After the third round, the author estimates that a fourth round is not warranted. So, the author decides to end the survey after the third round.

3.2. Results and Discussion

The primary result from the Delphi process is a criteria system and their associated weights to be used in the evaluation of transportation funding alternatives. This section first presents the final criteria weights calculated after the third round survey and discusses their implications. The variation in criteria weights and any specific deviations from the average weights are presented next.

3.2.1. Summary of Criteria Weights

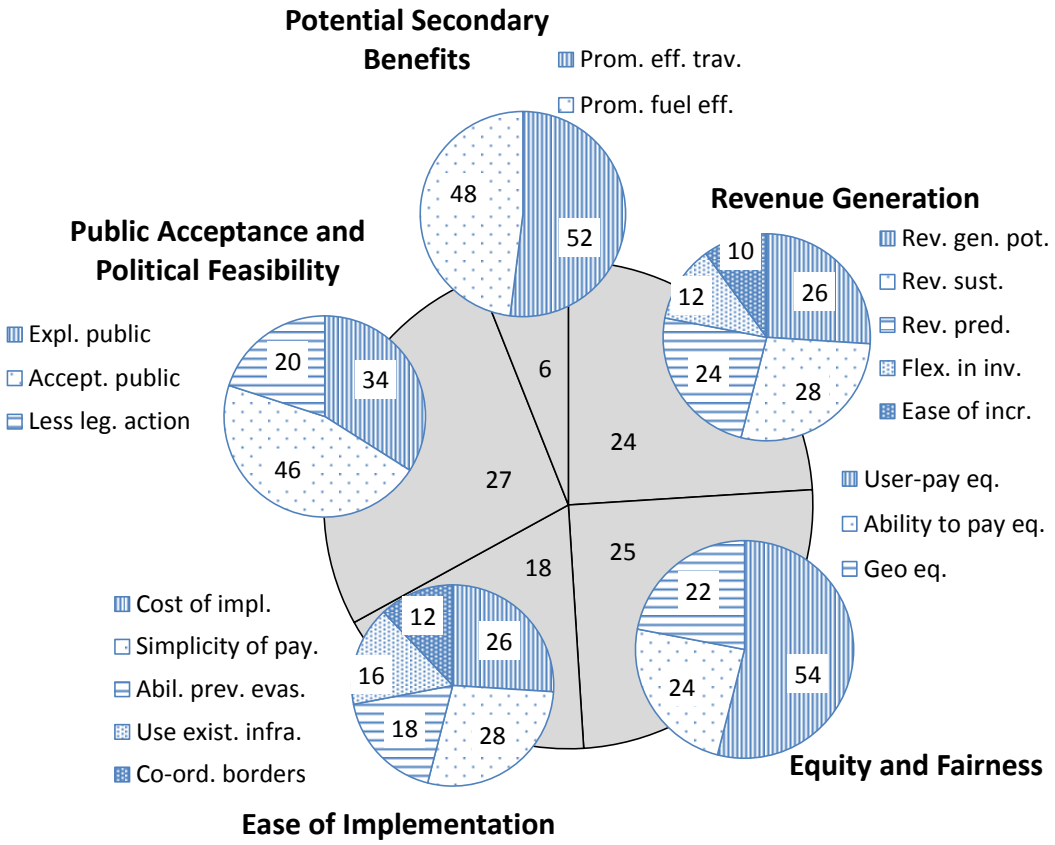
Figure 3-19 shows the overall average weights for the main criteria and sub-criteria in the form of separate pie diagrams. The sub-criteria weights are shown in the form of local weights, which add up to 100 inside one main criterion. Figure 3-20 shows the sub-criteria global weights as a bar chart. Some notable points from these results are listed below:

- The public acceptance and political feasibility (PA&PF), revenue generation (RG) and equity (EQ) criteria have similar weights and are

significantly higher than the other two criteria. The PA&PF criterion has a slightly higher weight (27%) than the RG and EQ criteria (24% and 25%, respectively). These three together cover about 75% of the total importance. The ease of implementation criterion is given a lower importance (18%). Since all the panel members are high-level decision makers in their organizations, they may be thinking about the initial success of a funding policy until it gets accepted for implementation. In their view, any implementation issues may not pose significant long term challenges and they may be mitigated through innovation, and restructuring of the alternatives.

This result implies that the policy makers should concentrate those funding alternatives which are acceptable to the public. They should choose the alternatives that are good in different aspects of revenue generation while being fair to different user groups. Although less important, the cost and difficulties involved in the implementation of the funding mechanism should be evaluated.

Another important observation relates to the PA&PF criterion; not only does it have the largest average weight, but it also consistently appears as one of the top two criteria. While the average weights show that the PA&PF, RG and EQ criteria are equally important, a closer look at the responses and further investigation may point that the real consensus opinion indicates that the PA&PF criterion is the most important.



Note: Pie diagrams show the weights in 100-point scale as labels. These weights are local weights. Weights of all the sub-criteria under one main criterion add up to 100.

Figure 3-19. Overall Average Weights of Main Criteria and Sub-criteria after Third Round Survey

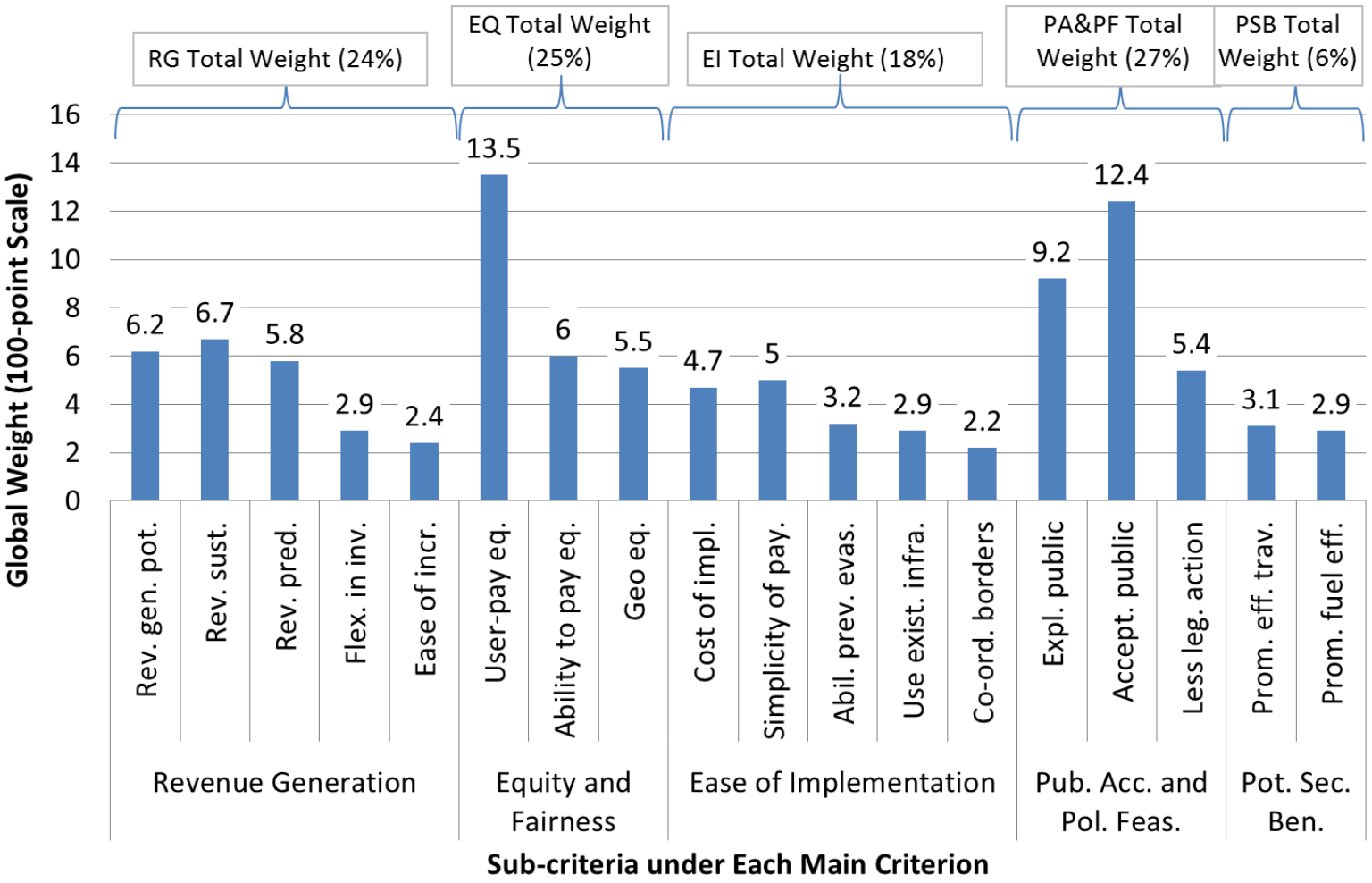


Figure 3-20. Sub-criteria Global Weights after Third Round Survey

- The potential secondary benefits criterion, which contains promotion of efficient travel behavior and promotion of fuel efficiency as sub-criteria, receives only about 6% of the overall weight. Based on their comments, the panel members believe that transportation user charges, at the level of current tax/fee/toll rates, are unlikely to significantly affect public behavior. If these charges are increased, they likely fear a decrease in public acceptance. According to this result, the policy makers need not pay significant attention to its ability to promote efficient system use while selecting a funding alternative.

  This result opposes the opinion of many researchers who suggest the implementation of fees that are more directly related to the transportation system use. Once such fees are established, one may adjust them to discourage higher travel mileage or travel in the peak periods, for instance. The study from the NSTIFC assigns a total weight of 24.5% to the economic efficiency and impact considerations[17] (National Surface Transportation Infrastructure Financing Commission 2009). As the traffic congestion increases and environmental pollution worsens, and the resources become scarcer, the funding policy may be used, along with other measures, to improve efficiency in system use for long term sustainability.

[17] Three sub-criteria are included under this criterion. They are: the promotion of efficient use, the promotion of efficient investment and the ability to charge for adverse side effects of the funding mechanism or the transportation investment made (National Surface Transportation Infrastructure Financing Commission 2009).

One may attribute the low weight given to the potential secondary benefits criterion to its location in the list of criteria in the questionnaire and to the word “secondary” in its name. However, the author believes that these factors do not play a significant role. The first round survey has the improvement to transportation and environment explicitly as a main criterion and the summary of the first round clearly mentions why the name of the criteria is changed. In addition, the comments accompanying the responses indicate the panel members understand this criterion.

- The revenue generation potential, revenue sustainability and revenue predictability sub-criteria cover about 80% of the revenue generation criterion. Based on their comments, the panel members believe that the flexibility of investment and the ease of increasing the tax rate sub-criteria are minor challenges and do not merit the same importance as the other sub-criteria. The officials may be concentrating on those issues which are immediate problems and are more visible to the public.
- The user-pay equity sub-criterion covers more than 50% of the equity criterion’s weight. The panel members may believe in charging the travelers by their use. The user-pay concept seems to be understood easily by the public and is universally popular because this concept expands to many public utilities and virtually all free markets. This may have caused the panel members to give great importance to this concept compared to the ability to pay and geographic equity concepts. The

traditional fuel tax system is more based on the user-pay equity than on the other two. This result reiterates the need for continuing this method in the future.

While the transportation experts choose to give great importance to user-pay equity in this survey, the public may or may not feel the same way. They may give more importance to the ability to pay equity criterion because it is related to their income, which translates into higher weight to the ability to pay equity sub-criterion. A survey may be conducted to obtain the public opinion on this issue.

Insistence on strong performance over these less important criteria, ability to pay equity and geographic equity, appears likely to pose political challenges and work against forming a consensus. Regarding the ability to pay equity, the literature (Rosenbloom and Lynott 2011) indicates that most of the existing and planned funding alternatives do not satisfy this concept well. Poor performance with respect to the ability to pay equity sub-criterion may be remediated by providing better mass transit and other programs for those who are negatively affected by the funding policy. Regarding geographic equity, within Texas, the allocation of funds and does not appear to pose identical challenges to those readily observed at the federal level; at the time of the distribution of revenue collected from a nationwide tax, states ask for a return of the money collected from their own citizens.

- Overall, user-pay equity, ease of explaining to the public and acceptability to the public are the three sub-criteria that stand out. Together, they account for about 35% of the overall weight. These criteria combine to provide an effective measure of public support. When a funding alternative strongly satisfies these, it appears likely to gain support from both transportation officials and politicians. Support from the citizens translates into support from politicians. Before evaluating the alternatives over all the criteria, an initial screening may be done by comparing the alternatives' performance over these three criteria.
- Although the ease of implementation criterion has a weight of 18% and the potential secondary benefits criterion has a weight of 6%, the former has five sub-criteria while the latter has only two. For this reason, some of the sub-criteria under the ease of implementation criterion have similar global weights as those of the sub-criteria under the potential secondary benefits criterion.
- Based on the results of the second round survey, when the panel members are grouped based on their organization affiliation, the Leg. Comm. staff seems to give less importance to the revenue generation criterion than the members from the MPOs and TxDOT do. This pattern exists even after the third round between the Leg. Comm. staff and the members from the MPOs. However, the author is not able to conclude this with confidence because only three members from the Leg. Comm. group respond to the third round.

- When the panel members are grouped based on whether they represent an urban or non-urban area, the urban group seems to give lower importance to revenue generation than equity while the non-urban group seems to do otherwise. Figure 3-21 demonstrates this result. The probable reason is that due to the diverse users in urban areas, implementing equity is more necessary. On the other hand, non-urban areas, due to their low population, may not generate enough local revenue and depend more on a statewide initiative to generate enough revenue. Hence, the new funding strategy should be able to provide enough revenue for the rural areas while at the same time be equitable to the urban population, which is diverse in nature.

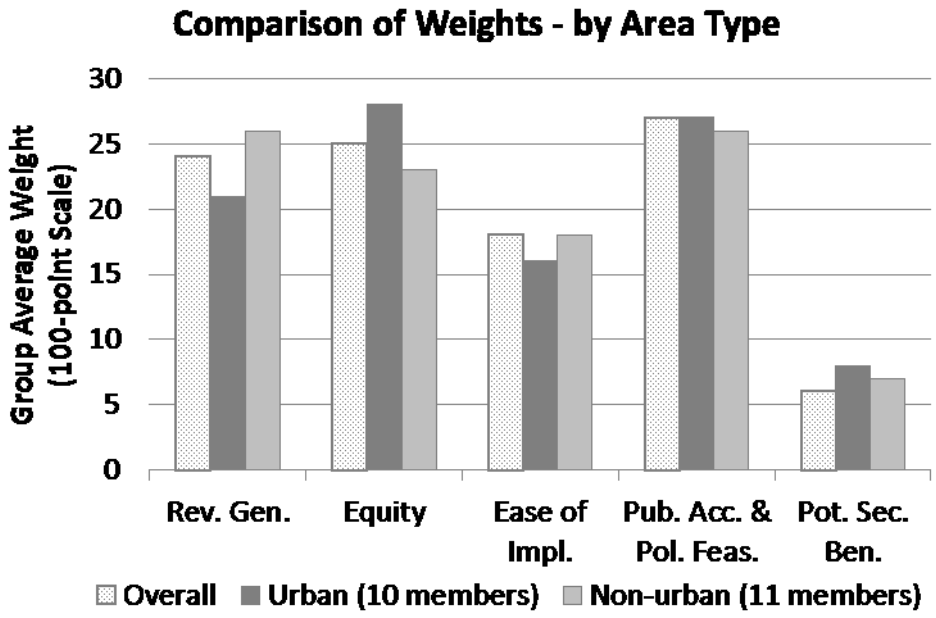


Figure 3-21. Comparison of Main Criteria Weights by Area Type

3.2.2. Comparison of Criteria Weights - Current Study versus the NSTIFC Study

The NSTIFC study uses a comprehensive criteria system similar to the one used in the current study. The criteria and weights used by the NSTIFC study are presented earlier in Chapter 2. The author compares the weights established in his study with those assigned by the NSTIFC. Table 3-3 presents this comparison. To make a one-to-one comparison possible, the author regroups the criteria from the NSTIFC study.

The NSTIFC study uses one sub-criterion pertaining to appropriateness of the funding mechanism for implementation at the federal level. This sub-criterion is not included in this comparison because the current study does not consider alternatives for nationwide implementation. Similarly, the ease of co-ordination with bordering regions sub-criterion used in the current study is not included because it relates to statewide or local implementation.

Table 3-3. Comparison of Criteria Weights: Current Study versus NSTIFC Study

Criterion		Weight		
NSTIFC Study	**Current Study**	**NSTIFC Study**	**Current Study**	**Percent Difference**
Revenue generation	**Revenue generation**	27	22	-18%
Revenue potential	Revenue potential			
Sustainability	Revenue sustainability			
	Revenue predictability			
Flexibility	Flexibility in investment			
Equity	**Equity**	17	25	47%
User-pay equity	User-pay equity			
Ability to pay equity	Ability to pay equity			
Geographic equity	Geographic equity			
Implementation	**Ease of implementation**	12	16	37%
Ease/cost of implementation & administration	Cost of implementation			
	Simpl. of pay. Structure			
	Ability to use existing payment infrastructure			
Ease/cost of compliance	Prevent evasion			
Public acceptance and political viability	**Public acceptance and political feasibility**	14	27	100%
Justification for dedication	Ease of explaining to the public			
Public acceptance/ political viability	Acc. to the public			
	Less need for leg. action			
Economic efficiency	**Potential secondary benefits**	25	6	-76%
Promotion of efficient investment	Promotion of efficient travel behavior			
Promotion of efficient use	Promotion of fuel efficiency			
Enables charges for adverse side effects				

Source of NSTIFC Study data: (National Surface Transportation Infrastructure Financing Commission 2009)

The main differences between these two criteria weight systems are listed below:

- The NSTIFC study gives the promotion of economic efficiency about one quarter of the total weight. In comparison, the potential secondary benefits criterion, which includes the sub-criteria related to promotion of efficient system use, is only given six percent of the total weight. The economic efficiency considerations have three parts. The NSTIFC study states that efficient investments may result from efficient system use and includes it as a separate sub-criterion. The third part of this criterion pertains to the ability of a funding mechanism to internalize any adverse effects caused by the funding mechanism or the investment by charging appropriately. Since all these factors are inter-related and are secondary benefits of the funding alternative, their total weight is compared with the weight of the PSB criterion. This implies that the NSTIFC study's criteria system favors the alternatives that are proposed to encourage efficient travel behavior more than the current study does. Especially the higher weight for this criterion favors implementation of comprehensive tolling and VMT charge systems.
- Secondly, the expert panel in the current study gives significantly more importance to the equity and public acceptance and political feasibility criteria than the NSTIFC does. Both these criteria either directly or indirectly relate to public perception. The NSTIFC gives significantly more importance to revenue generation and promotion of economic

efficiency than meeting the public perception whereas the Texas-based officials in this study think otherwise.

- Both studies agree that the user-pay equity sub-criterion should have more than 50% weight of the equity criterion. The other two sub-criteria have relatively similar weights in both studies.
- One important point to be noted here is that the user-pay equity and the promotion of economic efficiency criteria are somewhat inter-related because when a funding mechanism charges based on the usage, it has more opportunity to discourage inefficient usage. However, the NSTIFC gives lower importance to the user-pay equity while giving one of its secondary effects higher importance.
- The implementation considerations are given low importance by both the studies although the current study gives about 37% more weight than the NSTIFC's weight. So, both studies agree that the implementation issues may be solved with time due to technology improvement and better policies. In addition, the NSTIFC, as it considers the implementation issues as the least important, does not discourage selection of high-cost, technologically challenging comprehensive tolling and VMT charge systems.
- Both studies consider the revenue generation criterion to be of high importance while the NSTIFC study considers it to be the most important.

Due to the significant differences between the two criteria weight systems, the evaluation results based on these two systems are likely to be different. A future study may conduct expert surveys in other states to find if the state transportation officials truly have different opinions than the NSTIFC. The author tests how the results of the NSTIFC's evaluation changes when the criteria weights from the current study are used. This analysis is discussed in Chapter 4.

3.2.3. Variation in Criteria Weights

The author analyzes the variation in criteria weights using box-and-whisker plots. In these plots, the average weight, the interquartile range, which implies the range from the 25^{th} percentile to 75^{th} percentile value, and the minimum and maximum values are plotted. The interquartile range is shown as a box and the upper 25% and lower 25% of the weights are shown as lines (or whiskers) extending from the box. Figure 3-22 shows a box-and-whisker plot for the main criteria weights. This plot compares the variation in the weights for each criterion from the third round survey with the same from the second round survey. The author has aimed to reduce the size of the box as well as the total range between the second and third round surveys. One can see from Figure 3-22 that the interquartile ranges of all the criteria weights decrease indicating that the responses are closer to the consensus in the third round. But, often, the range indicated by the lowest and highest weights given to a criterion remains large. The reduction in interquartile range is greater in the case of the public acceptance and political feasibility criterion and the equity and fairness criterion compared to the others. The variation in the weights means that the averages shown tend to be less certain and call for a

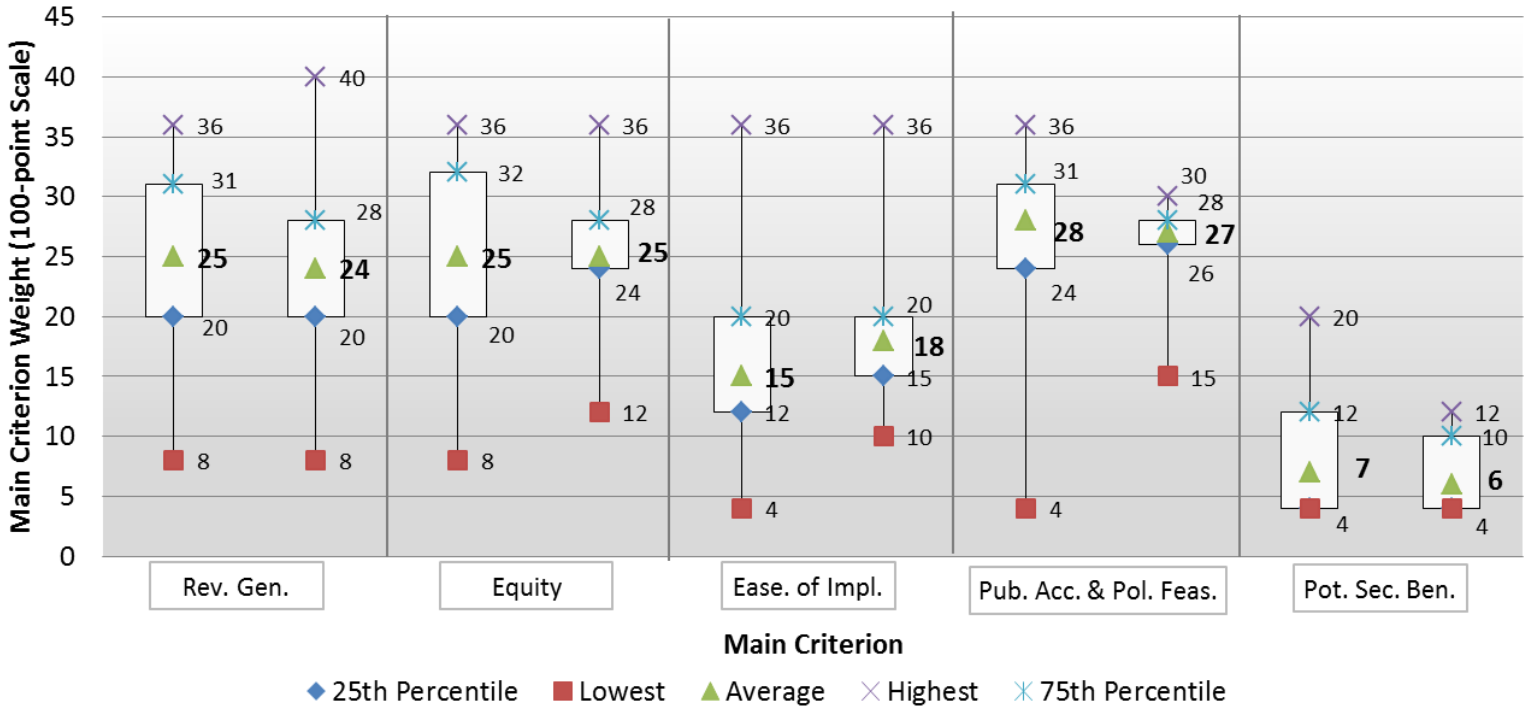
sensitivity analysis to understand if the best funding approach decision changes when the weights are different. In such an analysis, studying the effect of varying the weights by 50% on both directions, increasing and decreasing, seems appropriate. As an exception, the weight of the PA&PF criterion does not vary much on the higher side and so a reduced weight scenario seems sufficient.

Figure 3-23 to Figure 3-27 show the variation in the weights of the sub-criteria under each main criterion. These plots show that the sub-criteria weights also follow similar pattern as the main criteria except that the interquartile ranges become significantly small after the third round. All sub-criteria except three have their interquartile ranges as five or less. One probable reason for this may be that the panel members give lower importance to weighting the sub-criteria than the main criteria, and are able to compromise where possible so that the weights are closer to consensus.

One difference between the range and the interquartile range is that the interquartile range is affected by the group response, while the range changes only when the member who gave the minimum or maximum weight changes his response, or when any other member changes his weight to outside of the range. In the third round survey, since many panel members change their responses towards the consensus weight, the interquartile range decreases. Many responses that have been in the upper or lower quartile (along the whisker) in the second round are closer to the box in the third round, but as long as the maximum or minimum response does not move, the range remains large. Furthermore, as mentioned earlier, some panel members have not responded to the third round survey. Since

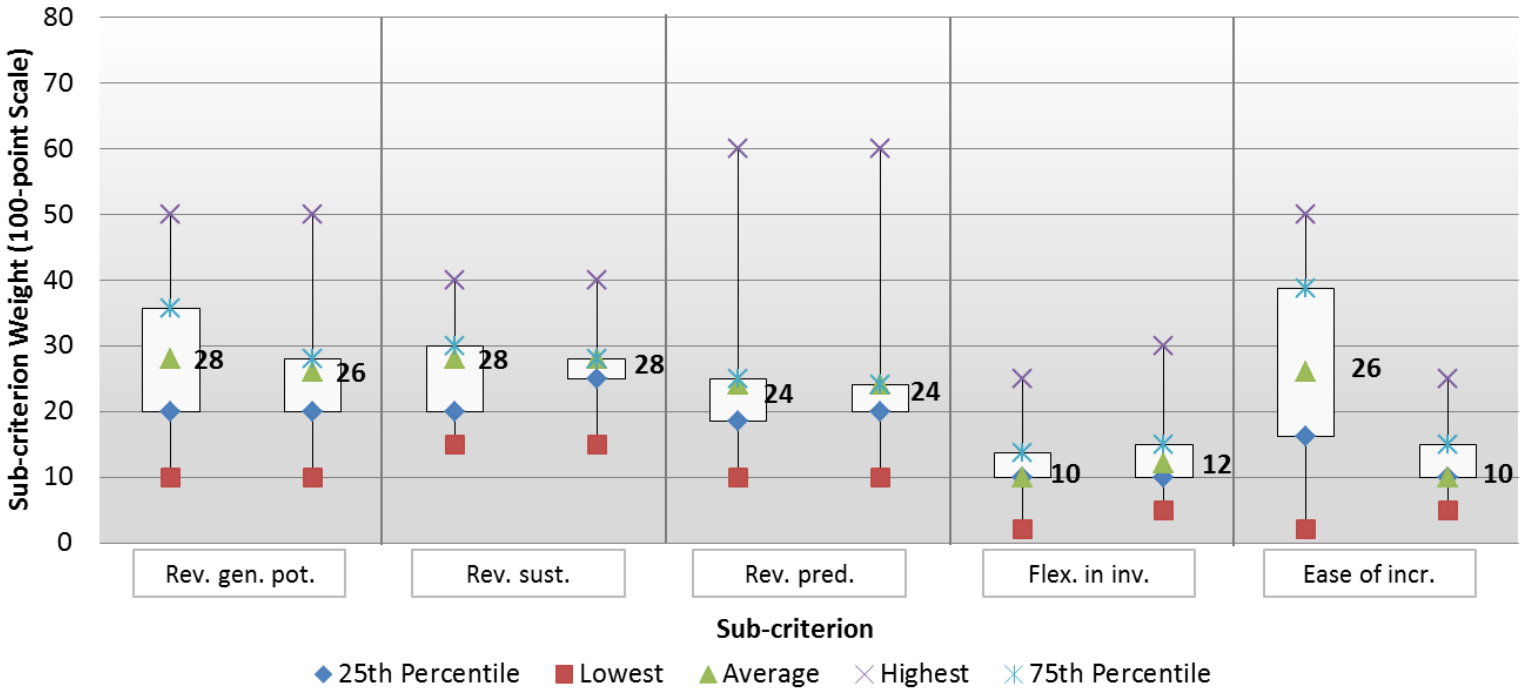
the author assumes that their second round response remains unchanged, some of the responses which correspond to maximum or minimum weight remain. This is another reason for the range to remain large.

Sensitivity analysis may also be performed to examine the effect of changing one or more sub-criteria weights although the effect is not expected to be as much as that from a variation in main criteria weights.



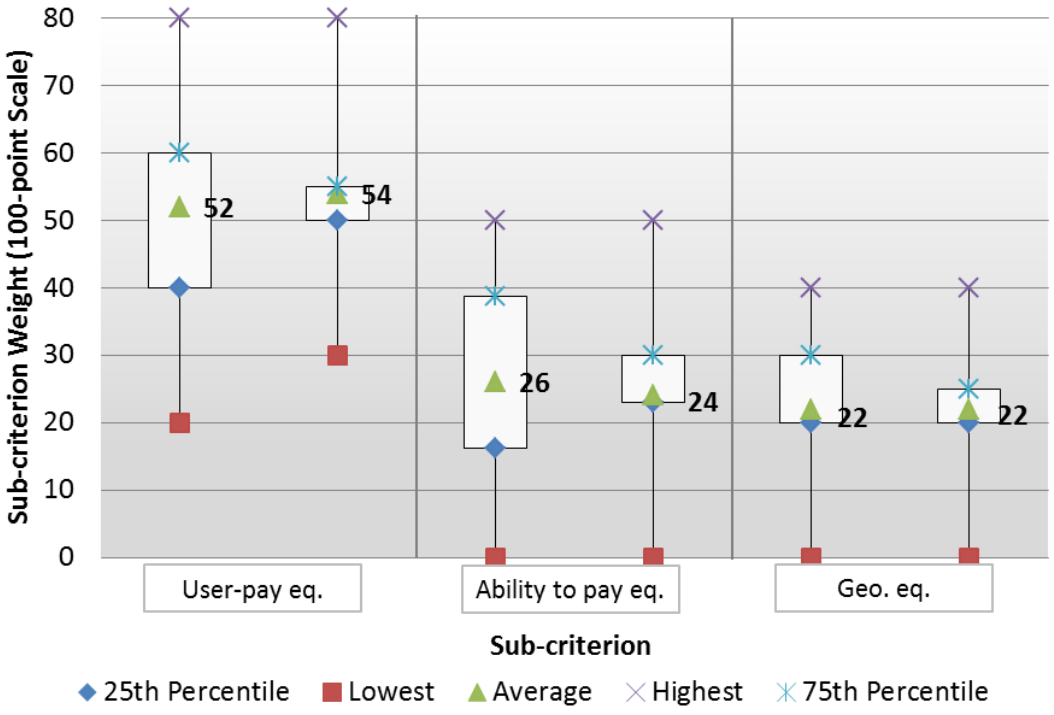
Note: For each main criterion, box-and-whisker plots for Second Round and Third Round responses are shown from left to right.

Figure 3-22. Variation in Main Criteria Weights



Note: For each sub-criterion, box-and-whisker plots for Second Round and Third Round responses are shown from left to right.

Figure 3-23. Variation in Sub-criteria Weights – Revenue Generation Criterion

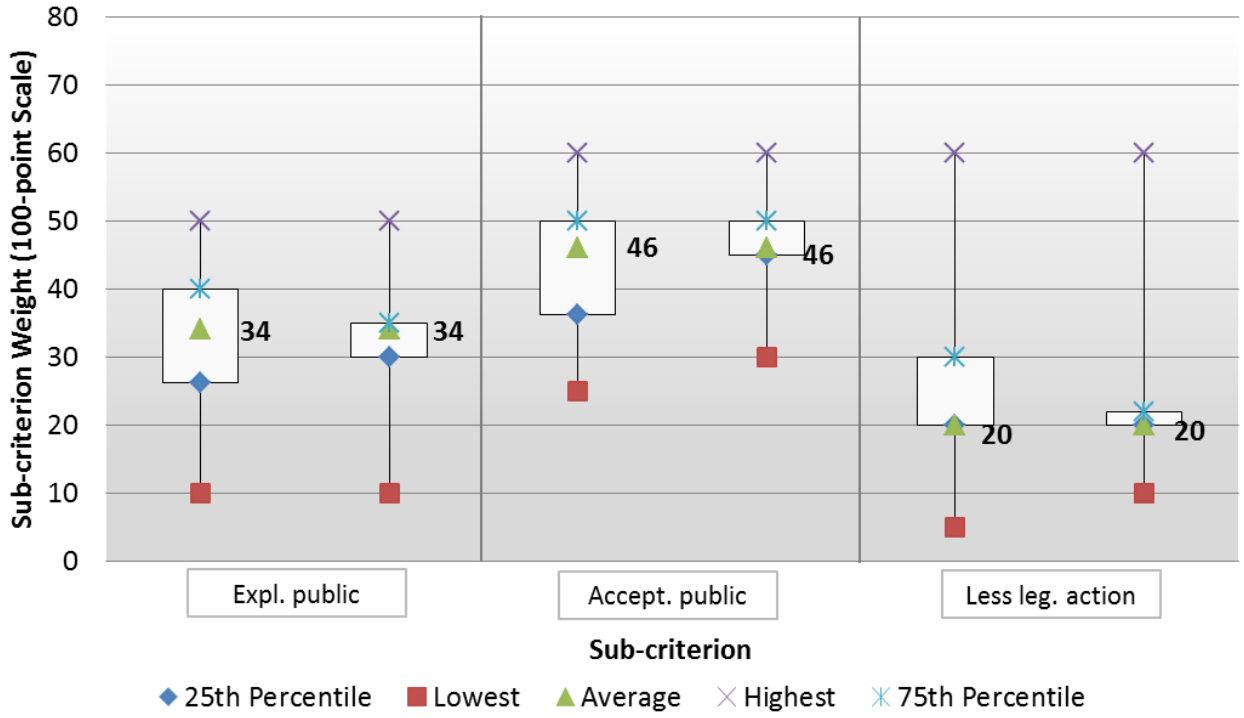


Note: For each sub-criterion, box-and-whisker plots for Second Round and Third Round responses are shown from left to right.

Figure 3-24. Variation in Sub-criteria Weights – Equity and Fairness Criterion

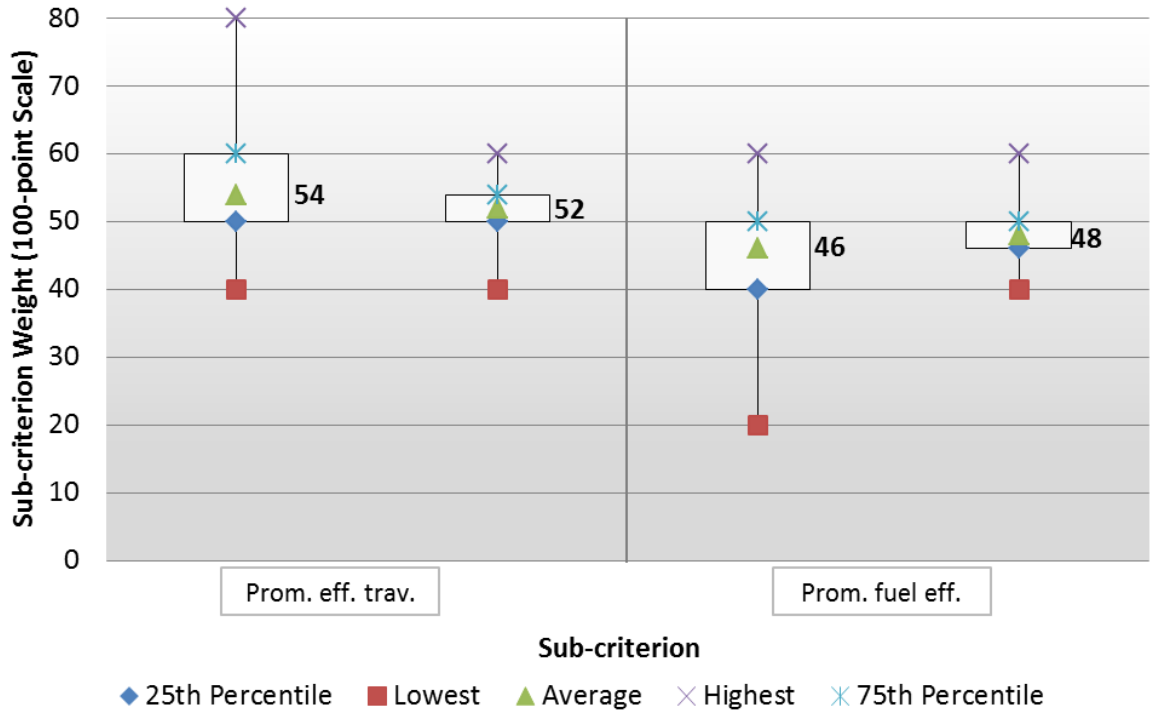
Note: For each sub-criterion, box-and-whisker plots for Second Round and Third Round responses are shown from left to right.

Figure 3-25. Variation in Sub-criteria Weights – Ease of Implementation Criterion



Note: For each sub-criterion, box-and-whisker plots for Second Round and Third Round responses are shown from left to right.

Figure 3-26. Variation in Sub-criteria Weights – Public Acceptance and Political Feasibility Criterion



Note: For each sub-criterion, box-and-whisker plots for Second Round and Third Round responses are shown from left to right.

Figure 3-27. Variation in Sub-criteria Weights – Potential Secondary Benefits Criterion

Based on the comments obtained from the panel members in the third round survey, the author identifies the following main conflicts in opinions that need to be addressed in future discussions to achieve a better consensus:

- *The revenue generation criterion is the most important because it is the only reason a new funding mechanism is being developed*. There are many alternatives that provide enough revenue. This particular conflict can be reduced by using revenue generation as a threshold criterion wherein a number of candidate alternatives are added to the evaluation list only if they all have a pre-specified revenue generation potential in the long term.
- *The equity criterion is less important.* One member thought that others are overemphasizing equity and fairness. None of the current funding mechanisms are fair and equitable. The member thinks that, as long as an alternative is accepted by the public and politically feasible (performs well on the PA&PF criterion), its performance on equity may not prevent it from being implemented. A review of the positive and negative effects of an equitable mechanism may provide an opportunity to reduce this difference.
- *The potential secondary benefits criterion should not be included in the evaluation.* This conflict can be reduced by discussing the funding alternatives that can indeed have an effect on travel behavior and fuel efficiency. The positive effect that altering public behavior may have on accessing future federal funds can be discussed.
- *The potential secondary benefits should not be of very low importance.* One member feels that other members failed to recognize the significant ways a specific funding source could affect the travel behavior. Identifying the

funding mechanisms that can produce such effect and the specific conditions when they are suitable may help reducing this conflict.

- *Under the revenue generation criterion, the flexibility in investment should not be very less important*. This difference may stem from the fact that urban areas may need more varieties of investment than rural areas. This can be addressed by structuring a tax or fee to allow enough flexibility in investment when required.
- *Under the equity and fairness criterion, ability to pay equity is not important.* The cost of transportation is not just a factor of taxes/fees; there is also the issue of time, purpose for the trip, etc. Private companies do not charge different prices to customers based on their ability to pay. The consumer decides what quantity/quality of product/service to buy based on their own ability to pay. By identifying ways to invest in transportation improvements that compensate for any inequities caused by a funding mechanism, this conflict may be resolved.

3.2.4. Reason for Revision of Opinion – Feedback's Role in Consensus

The author examines how the feedback provided to the panel members in the third round survey has affected their choice to revise their decisions. Many panel members revise their responses and assign weights that are closer to the average weights. Some agree to adopt the average response as their own, at least for some groups of sub-criteria. Some members reiterate their stand and do not revise. One member is not satisfied how his pairwise comparison responses are translated into weights and revises his response away from the average response. The author examines the revision characteristics of the panel members including 105 decisions,

one decision per one question (21 panel members, five questions each). The decisions corresponding to the sub-criteria under the PSB criterion are not included because many panel members already have their weights closer to the consensus weights in the second round and hence do not change them. Figure 3-28 shows that about half of the 60% panel members who changed their responses closer to the consensus agree to the justifications shown in the survey.

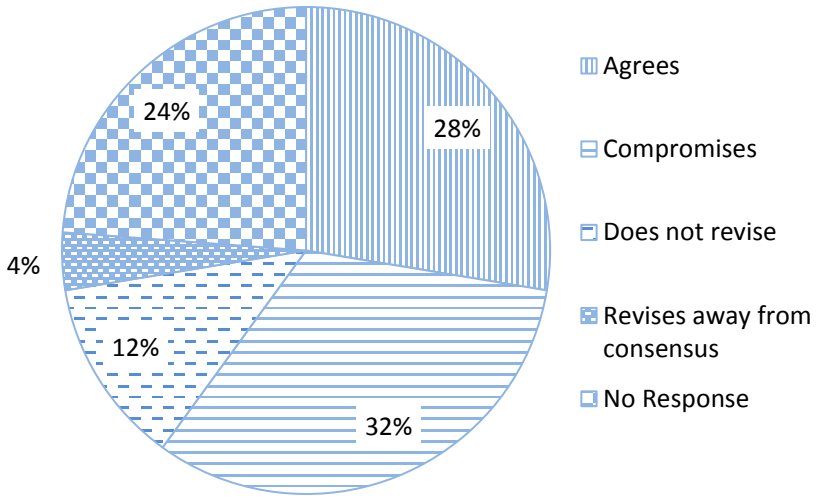


Figure 3-28. Distribution of Panel Members by Their Revision Characteristics

3.2.5. Limitations of the Survey

Although the author organizes the survey well, there are some limitations for this survey that are important to point out. Future surveys may address these issues. These limitations are given below:

- Since the survey is overlapped with the Legislative session, both the survey participation and its timeline have been affected by the session. Although the author has tried to obtain the legislative staff's response by following up, the staff's response rate has been low and delayed. The delay of some

members' response extended the time between two survey rounds. This excessive time between the rounds may have caused some panel members to forget their original thoughts and thus have made them unable to respond to the survey with their full knowledge.

- The participation of the members from TxDOT and Leg. Comm. has been low. The members from TxDOT have not participated in the third round.
- As the survey is conducted through e-mail, the author does not have an opportunity to explain the survey to the panel members. This may affect the understanding of the criteria and the weighting process. The author tries to remedy this issue by providing clear and concise explanation and choosing the weighting methods that are suitable for this kind of survey.

3.3. Chapter Summary

In this chapter, the author discusses the expert survey performed in this research to establish the criteria and their weights to evaluate the transportation funding alternatives. He briefly outlines the methodology and describes each step of the survey. He presents the average criteria weights and their variation, and discusses some of their policy implications. Among the five main criteria, the public acceptance and political feasibility, equity and fairness, and revenue generation criteria are approximately equally important and are more important than the other two. The PA&PF criterion is consistently weighted as one of the top priorities. By assigning a total average weight of about one third of the total weight to the user-pay equity, ease of explaining to the public and acceptability to the public sub-criteria, the Texas-based transportation experts emphasize on meeting the public perception in selecting a funding alternative. In the next chapter, a well-defined set of funding alternatives are

evaluated over the criteria system established here. The variation in the criteria weights and the opposing opinions discussed in this chapter provide guidance for defining different analysis scenarios in the evaluation.

Chapter 4

Multi-criteria Evaluation of Funding Alternatives

With the aim of recommending a preferred funding strategy for Texas, the author evaluates a set of transportation funding alternatives. The selection of the preferred funding strategy involves comparing multiple attributes of the funding alternatives, many of which cannot be quantified and cannot be converted into monetary terms. A multi-criteria analysis (MCA) is more suitable for this selection, because the evaluation framework allows all the attributes to be presented in a comprehensive and consistent format (Rogers 2001). In MCA, all the alternatives are first evaluated separately on each criterion and then the resultant decisions are aggregated into a final decision using additional information, or by assuming a set of weights for the individual criteria. These weights represent the relative importance of the criteria. The author follows the basic steps of MCA shown in Figure 4-1 (Rogers 2001).

Here, the objective of the evaluation is to find a shortlist of funding alternatives from a large pool of alternatives. The preferred funding strategy can be formed as a combination of these shortlisted alternatives. The criteria and their weights are established in Chapter 3. This criteria system is named the base criteria system. Then, the author identifies a set of funding alternatives and clearly defines them to suit for implementation in Texas. Next, he assigns scores to the alternatives over each criterion according to their relative performance. He assesses the alternatives using an appropriate multiple criteria evaluation method. The specific evaluation technique usually depends on the objective of the evaluation, the type and number of alternatives and how the criteria weights and scores are developed (Rogers 2001). Here, the

author uses an outranking method called PROMETHEE for this purpose. He tests the stability of the results through a sensitivity analysis.

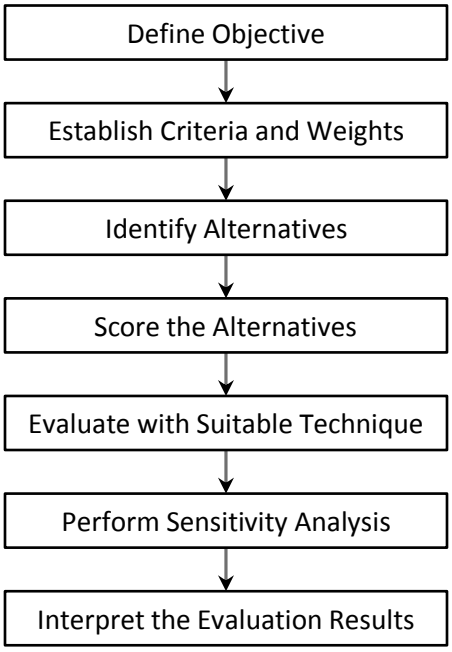


Figure 4-1. Common Steps in Multi-criteria Evaluation

The first section provides the list of alternatives and their definitions. Scoring of the alternatives is discussed in the second section. The third section describes the PROMETHEE method. The fourth section explains different steps in the analysis. Finally, the fifth section presents the results and discusses the preferred funding strategy for the future.

4.1. Transportation Funding Alternatives Studied

The alternatives chosen for evaluation in this study can be classified into three groups – statewide major alternatives, statewide supplementary alternatives and local alternatives. Funding alternatives that are expected to provide a substantial amount of revenue and are implemented statewide are included in the statewide major alternatives. The statewide supplementary alternatives are those that either affect only

a specific user group or do not provide a substantial amount of revenue. Major metropolitan areas in Texas have different funding needs compared to rural areas because of the population density and the higher levels of congestion and environmental pollution. One objective of this research is to examine if implementing a funding alternative locally is better, that is, in the major metropolitan areas alone rather than implementing it across the state. Three such alternatives for local implementation are identified for this study and are grouped as local alternatives. These are evaluated against corresponding statewide alternatives. The alternatives are listed in the three subsections below.

4.1.1. Statewide Major Alternatives

Table 4-1 lists all the statewide major alternatives. Each alternative is identified with an alphanumeric label. This label is used in later sections to refer to the alternative.

The first three alternatives are three variations of an increase in fuel tax. Some form of these three alternatives has been implemented in different states in the U.S. While A1 represents a fixed increase in the fuel tax, A2 represents increasing the fuel tax first and then indexing it to one of the inflation indicators. Earlier research and legislative proposals suggest the use of either the consumer price index (CPI) or the highway construction cost index (HCCI) as the inflation indicator. The HCCI is more volatile than the CPI, although in the long term, they may have similar growths. So, the author recommends using the CPI as an indicator of inflation for indexing the fuel tax. Virginia recently passed a law that repealed the statewide fuel tax and replaced it with a sales tax on motor fuels which is similar to A3 (Washington Post 2013). The carbon tax (B) is a new tax on fuel to account for the carbon emissions produced by motor

vehicles. A vehicle with average fuel efficiency driven for average mileage produces about 4.8 metric tons of carbon dioxide in a year (U.S. Environmental Protection Agency 2013). Increase of vehicle registration fee (C) and increase of general sales tax (D) are included as two separate alternatives. There are four variations of tolling (E1-E4) depending on tolling only new capacity or existing capacity also, and tolling with a fixed toll or a variable, time of day tolling method. Two variations of VMT charge (F1, F2) are included – a simple flat rate and a comprehensive VMT charge. The last alternative, G, does not increase any existing tax[18] or impose any new tax but reallocates some of the existing sales tax revenue towards transportation funding. In this study, the analysis assumes the transportation related investment to be an independent government sector. Re-allocation of money from some types of sales tax to transportation may cause shortfalls in the funding for other government sectors such as education and healthcare. Such shortfalls are not considered in this analysis directly; however these are discussed while providing policy recommendations.

[18] Here, the word "tax" represents a generic transportation charge and may be in any form such as a tax, fee or toll. Similarly, throughout this chapter, when "tax" is used without specifying the type, it represents any transportation charge.

Table 4-1. List of Statewide Major Alternatives

Label	Alternative
Description	
A1	Fuel tax - fixed increase
Increase fuel tax by a fixed amount. For example, increase by 10 cents/gallon. Statewide gas tax becomes 30 cents/gallon; diesel tax becomes 30 cents/gallon.	
A2	Fuel tax - increase and index to inflation
Increase fuel tax by a fixed amount (e.g. by 10 cents/gallon). Then, increase fuel tax every year afterward by inflation (using the growth in consumer price index or highway construction cost index). On the first day of every year, the amount of tax will be reset.	
A3	Sales tax on motor fuels - New
Increase fuel tax by a fixed amount (e.g. by 5 cents/gallon). Then, convert the fuel tax into a sales tax on fuel. Remove the state fuel tax and replace it with an equivalent amount of sales tax on the wholesale price of fuel at the rack.	
B	Carbon tax - New
Carbon tax is collected as cents per gallon of fuel on top of the fuel tax. For example, 20 cents per gallon. It depends on fuel type and is based on the amount of CO_2 emitted by unit of fuel volume.	
C	Vehicle registration fee - fixed increase statewide
Increase vehicle registration fee by a fixed amount. For example, increase it by $25 for light vehicles and by $50 for heavy vehicles.	
D	General sales tax - fixed percent point increase statewide
Increase statewide general sales and use tax by a small fixed percentage point (e.g. 0.25%) and assign any revenue generated by this additional tax to the State Highway Fund.	
E1	Tolling all new freeway capacity with fixed tolls
Any new capacity on freeways, general purpose lanes or managed lanes, will be tolled with an appropriate toll rate. Toll rates will be set for demand management and revenue maximization. Tolls are high because toll revenue should be used to cover the construction and maintenance cost of the additional capacity, or even the full facility itself. Tolls vary by gantry but are fixed for all times of a day.	
E2	Tolling all new freeway capacity with variable tolls
Any new capacity on freeways, general purpose lanes or managed lanes will be tolled with an appropriate toll rate. Toll rates will be set for demand management and revenue maximization. Tolls are high because toll revenue should be used to cover the construction and maintenance cost of the additional capacity, or even the full facility itself. Tolls vary by gantry location and during different time periods of the day depending on the historical congestion.	

Table 4-1—*Continued*

Label	Alternative
Description	
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)
In addition to tolling all new capacity, all existing freeway capacity in urban areas will be tolled with a small toll rate, between 2 cents and 5 cents per mile. The objective is to collect tolls without diverting significant traffic from the highway. Tolls vary by gantry but are fixed for all times of a day.	
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)
In addition to tolling all new capacity, all existing freeway capacity in urban areas will be tolled with a small toll rate, between 2 cents and 5 cents per mile. The objective is to collect tolls without diverting significant traffic from the highway. Tolls vary by gantry location and during different time periods of the day.	
F1	VMT charges - Flat rate (Phased in from 2020 to 2025)
Start with increased fuel tax in 2013. Phase in from 2020 to 2025, a flat rate VMT charge per mile for all vehicle miles equivalent to the fuel tax (e.g. 2 cents per mile). This should cover the cost of collection also. Odometer reading or an on-board device will be used. Charge is assessed annually at registration or at pump along with gasoline purchase.	
F2	VMT charges - Comprehensive rates (Phased in from 2020 to 2035)
Start with increased fuel tax in 2013. Phase in from 2020 to 2035, a VMT charge equivalent to the fuel tax. By 2035, the VMT charge should vary by vehicle type, location and time of travel, and vehicle emission levels.	
G	Re-allocating revenue from the tax on the sale of motor vehicles, tires and parts to transportation improvements.
Re-allocate revenue from the tax on the sale of motor vehicles, tires and parts from the state's general fund to transportation improvements.	

4.1.2. Statewide Supplementary Alternatives

Table 4-2 lists all the statewide supplementary alternatives. The first alternative intends to charge trucks based on their weight and the mileage they travel to account for the extra damage they cause to the highways. This is similar to the weight-mile tax in Oregon (Oregon Legislative Committee Services 2000). The 1994 and 2002 highway cost allocation studies in Texas find that cars and pickup trucks contribute more revenue than the cost they impose on the highway system and cross-subsidize the heavy trucks and buses (Euritt et al. 1994; Luskin et al. 2002). The existing fuel tax system has an inequity because alternative fuel vehicles are not charged a fuel tax. Some states have started to impose a special annual fee on electric vehicles to account for their road use (e.g. Washington State Legislature (2012)). The second and third alternatives (I and J) are to reduce this inequity by charging these vehicles a higher registration fee or a mileage based charge. K1 and K2 intend to raise a small amount of revenue to supplement a major alternative by increasing the sales tax on vehicles and tires, respectively. The last alternative, L, is an increase in drivers license fees.

Table 4-2. List of Statewide Supplementary Alternatives

Label	Alternative
Description	
H	Freight weight-mile charge
Charge the trucks based on their weight and their travel mileage. In addition to federal and state fuel tax and federal heavy vehicle use tax, charge a rate, cents per weight-mile traveled in Texas. This tax should vary by location and time of travel and vehicle axle load. A rate chart showing the tax rates for different weight classes and number of axles will be published based on a highway cost allocation study.	
I	VMT charges on electric and CNG vehicles - flat rate
Charge a flat rate per each mile traveled by electric or CNG vehicles at the time of registration renewal. An example rate is 2 cents/mile. This rate should be equivalent to the fuel tax amount per mile paid by a gasoline vehicle with 85th percentile fuel efficiency.	
J	Vehicle registration fee increase for electric and CNG fuel vehicles
Increase vehicle registration fee for electric and CNG fuel vehicles. This increase should be equivalent to the average amount of fuel tax paid annually by gasoline vehicle with 85th percentile fuel efficiency.	
K1	Sales tax on vehicle sales - fixed percent point increase
Increase vehicle sales tax and use the additional revenue for transportation improvements.	
K2	Sales tax on motor vehicle tires - fixed percent point increase
Increase sales tax on tires and use the additional revenue for transportation improvements.	
L	Drivers license fees - fixed increase statewide
Increase drivers license fee (e.g. by $5) and dedicate this revenue to improve transportation.	

4.1.3. Local Alternatives

Table 4-3 lists all the local alternatives. The three local alternatives include increasing the local vehicle registration fee, increasing the local sales tax and imposing a new local fuel tax. Local registration fee and local sales tax are currently in place in many counties in Texas. The third one is new and has been discussed in the 81st and 82nd Texas legislatures in 2009 and 2011 respectively (Truitt 2009; Rodriguez 2011).

Table 4-3. List of Local Alternatives

Label	Alternative
Description	
M	Vehicle registration fee increase locally
Add the provision for local increase in vehicle registration fee. Actual increase may be between $5 and $50 depending on local needs. This should be implemented in Dallas-Fort Worth, Houston, Austin and San Antonio metropolitan areas as needed.	
N	Increase in allowance for local general sales tax
Increase the cap for the state total sales tax. Allow that each local jurisdiction may vote for increase in sales tax. Voters should be shown how the revenue will be spent at the time of voting.	
O	Local option fuel tax – New addition to the state fuel tax
Allow the local jurisdictions to increase fuel tax locally based on a majority vote. Voters should be shown how the revenue will be spent at the time of voting.	

4.2. Scoring of Alternatives

After defining the funding alternatives, the author assigns scores for these alternatives over each sub-criterion of each main criterion. These scores are qualitative and they represent the relative merit of one alternative compared to the other alternatives. They do not intend to represent any cardinal and independent value.

The scoring presented by the NSTIFC Report is used as the starting point for the scoring (National Surface Transportation Infrastructure Financing Commission 2009). The scoring table from the NSTIFC Report is provided in Appendix I. The following steps describe the scoring process:

- The alternatives studied by the author are similar to the ones studied by the NSTIFC. For each alternative, the author identifies any alternative from the NSTIFC Report that closely matches it.
- The list of criteria and some of the criteria definitions used in this research differ from those used by the NSTIFC. The author re-evaluates the alternatives where necessary according to the criteria used in this research.
- The author prepares scoring tables which contain scores and justifications. He takes each sub-criterion under one main criterion at a time and evaluates all alternatives against it. The author reviews the score given by the NSTIFC for the alternative under consideration or any closely matching alternative. He assigns this score unless he finds a different score that is more justified based on specific alternative definitions and/or differences between federal and state based solutions; in this case, he adjusts the score correspondingly. He refers to other studies that discuss the scoring with respect to one main criterion or one class of alternatives in more detail.

For example, Rosenbloom and Lynott (2011), in their study on the equity considerations of transportation funding alternatives for older Americans, provide a table showing the relative equity performance of various funding options.

- The NSTIFC studies the alternatives for nationwide implementation. So, the author reviews the applicability of the scores to the implementation in Texas and modifies them where needed.
- For supplementary alternatives such as charging a higher registration fee for electric and CNG vehicles, scoring is given considering them as independent alternatives rather than coupling them with major alternatives.

The scores are assigned on a scale of 1 to 5 where the merit increases from 1 to 5. Least interval between the scores is 0.5. Table 4-4 presents the entire scoring table. The subsections below discuss the scoring of alternatives under each criterion. Each subsection contains scoring tables for the corresponding sub-criteria with justifications.

Table 4-4. Scoring Table for All Alternatives over All Criteria

Main criteria	Sub-criteria	Alternative													
		Weight*	A1	A2	A3	B	C	D	E1	E2	E3	E4	F1	F2	G
Revenue Generation	Revenue generation pot.	6.2	5	5	5	5	5	5	3	3	4.5	4.5	4.5	4	5
	Revenue sustainability	6.7	2	4	3.5	2	3	5	4	4	4	4	4	4	5
	Revenue predictability	5.8	4	4	3	4	4	4	2	2	3	3	4	4	3.5
	Flexibility in investment	2.9	5	5	5	2	5	5	2	2	3	3	5	5	5
	Ease of tax or fee increases when needed	2.4	1	1	1	1	2	1	3	3	3	3	1	1	1
Equity and Fairness	User-pay equity	13.5	3.5	3.5	3.5	4	2	1	4	4.5	5	5	3	5	2
	Ability to pay equity	6	2	2	2	2	2	1	3	3	2	2	2	2	2.5
	Geographic equity	5.5	2	2	2	2	3	3	5	5	5	5	2	4	2.5
Ease of Implementation	Cost of implementation	4.7	5	5	4	5	5	4.5	3.5	2.5	2.5	1.5	2	1	5
	Simplicity of payment str.	5	5	5	5	5	4.5	5	3	2	2	1	4	1	5
	Ability to prevent evasion	3.2	4	4	4	4	4	4	1	1	1	1	1	1	4
	Ability to use existing payment infrastructure	2.9	5	5	4	4	5	4	4	3	3	2	2	1	5
	Ease of co-ordination with bordering regions	2.2	5	4.5	4.5	2	5	5	4	4	4	4	2	3	5
Public Acceptance and Political Feasibility	Ease of explaining to the pub.	9.2	5	4.5	4	3	4.5	3	4	2.5	3	1	3	1	4.5
	Acceptability to the public	12.4	2.5	1.5	1.5	2	3	1.5	3	3	1	1	2	1.5	4
	Less need for legislative action	5.4	4	3	2.5	2	4	3	5	5	2	2	2	1	4
Potential Secondary Benefits	Promotion of efficient travel behavior	3.1	2	2.5	2.5	3	1.5	1	4	5	4.5	5	4	5	1
	Promotion of fuel efficiency	2.9	3	3.5	3.5	5	2	2	2	2	2	2	1	2.5	2

Note: * These criteria weights are those established in this research as explained in Chapter 3.

Table 4-4—*Continued*

Main criteria	Sub-criteria	Alternative								
		H	I	J	K1	K2	L	M	N	O
Revenue Generation	Revenue generation pot.	3	1	1	2	2	3	3	3	3
	Revenue sustainability	4	4	3	5	5	4	3	5	2
	Revenue predictability	3	3	3	3.5	3	4	3.5	3.5	3.5
	Flexibility in investment	4	5	5	5	5	3	3	2	2
	Ease of tax or fee increases when needed	2	2	2	1	1	2	3	2	2
Equity and Fairness	User-pay equity	5	3.5	2	2	2.5	2	2.5	2	4
	Ability to pay equity	3	3	3	2.5	1.5	2	2	1	2
	Geographic equity	3	2	3	2.5	2.5	3	5	5	5
Ease of Implementation	Cost of implementation	2	3	4.5	4.5	4.5	4.5	4.5	4	3
	Simplicity of payment structure	2	4	4.5	5	5	5	4.5	5	5
	Ability to prevent evasion	2	4	5	4	4.5	4.5	4	4	3
	Ability to use existing payment infrastructure	1	3	5	4	4	4	5	5	3.5
	Ease of co-ordination with bordering regions	2	2	5	5	5	5	3	4	2.5
Public acceptance and political feasibility	Ease of explaining to the public	3.5	4	4.5	4	4	4	4.5	3.5	4
	Acceptability to the public	2	4	3	2	3	2	4	3.5	3
	Less need for legislative action	2	2	3	3	3	3	2.5	2.5	2.5
Potential secondary benefits	Promotion of efficient travel behavior	5	4	1.5	1.5	1	1	1	1	2
	Promotion of fuel efficiency	2	1	1	2	2	2	2	2	3

4.2.1. Revenue Generation Criterion

The main aim of a funding alternative is to generate revenue. Under this criterion, the funding alternatives are evaluated for their effectiveness in different aspects of revenue generation. These aspects represent different sub-criteria. Scoring under each of the five sub-criteria is described below.

Revenue Generation Potential

This sub-criterion measures the ability of a funding alternative to generate significant revenue using politically and economically viable rates to match the investment needs over the target time frame. The investment need here is the surface transportation funding need in Texas for the period of 2013 to 2035. As discussed in Chapter 1, funding needs in Texas have been indicated by the TxDOT 2035 SLRTP. However, the funding need specified in this document is about six times the funds identified for this horizon. The author believes that none of the alternatives studied here can provide sufficient revenue to meet all of the funding need with viable rates. Hence, this study targets a funding need that is achievable by at least one of the alternatives as they are defined. A politically and economically viable rate implies that the rate does not develop severe public disapproval or it does not severely affect the current economic conditions. The revenue generation potentials of the alternatives are compared qualitatively rather than comparing the exact revenue forecasts, because the amount of revenue each alternative generates depends on the actual tax or fee rate which can have a range of values that are politically and economically viable. Moreover, these revenue forecasts involve uncertainties, which complicate their usage in the analysis. The NSTIFC Report estimates the rate of tax or fee to be implemented

nationwide to generate one billion dollars in a year (National Surface Transportation Infrastructure Financing Commission 2009).

For some alternatives such as tolling and VMT charges, the cost of collection is significant. Based on the rough estimates of cost per 1000 vehicle miles traveled presented by Rufolo (2011), the flat rate VMT charge system using the pay at the pump method is about 18 times more expensive than the fuel tax collection. As a reference, the cost of collecting the fuel tax is about 1% of the revenue, assuming a fuel efficiency of 20 mpg (Rufolo 2011). Similarly, as per the author's communication with Fustes (Personal communication, May 28, 2013), the owner of Loose Association of Transportation & Tolling Experts (LATTE), the collection of tolls costs about twelve to fifteen percent of the revenue collected[19]. Since the cost of collection forces the per-mile rate to be higher, the revenue generation potential is considered as reduced.

Table 4-5 presents the scores for all the alternatives and some justification for them. The scores of the alternatives based on fuel tax, vehicle registration fee and sales tax, and the re-allocation of certain sales tax revenue to transportation match those given by the NSTIFC. The scores for the alternatives related to tolling and VMT charges are different from the NSTIFC scores due to the above mentioned reason and also because they are defined more specifically.

Revenue Sustainability

This criterion evaluates the extent to which the funding mechanism provides stable or increasing revenue in the future while responding to external factors such as changes in travel behavior, fuel efficiency and inflation. The funding alternative should provide increased revenue when transportation system usage increases. Revenue

[19] This assumes that all tolls are collected electronically (See Chapter 2 for more detail).

sustainability has become a concern mainly because the current fuel tax is considered not sustainable. Its revenue generation potential is forecast to decrease due to the expected future increase in vehicle fleet fuel efficiency. Fuel tax revenue has lost its buying power significantly since it has not been increased in the last two decades. For these reasons, the fuel tax increase with fixed amount (A1) is given a sustainability score of "2". The remaining alternatives have been scored with reference to this alternative. The NSTIFC's definition of the revenue sustainability criterion covers the predictability also. It considers indexing user charges to inflation as one separate strategy to increase the sustainability. So, it does not include any one such option in the evaluated list. The sustainability scores given by the author for the alternatives related to sales tax, tolling and VMT charges match with the NSTIFC scores. Table 4-5 shows the scores given to all the alternatives and some justification for them.

Revenue Predictability

The accuracy with which the revenue from a funding mechanism can be predicted or forecast is evaluated under this criterion. As mentioned above, the NSTIFC does not consider the predictability characteristic separately. Forecasting revenue usually involves analysis of historical trends of the revenue stream as well as the socioeconomic data that affects the travel demand. For example, a forecast of gas tax revenue may be developed by extending the historical gas tax revenue trend or estimating and applying a regression model with gas tax revenue as the dependent variable and independent variables such as population, vehicle miles traveled and car ownership. The predictability depends on the availability of data and the amount of variation in the data trends used. Forecasting revenue from toll roads involves modeling future travel demand and travelers' willingness to pay, which can involve

significant uncertainties (Kriger et al. 2006). Hence, forecasting revenue for tolled facilities accurately is difficult. Table 4-6 shows the scores given to all the funding alternatives and some justification for them.

Flexibility in Investment

This criterion evaluates the extent to which the funding mechanism is appropriate for a wide (and potentially changing) range of investments and can be redirected to meet changing objectives. The NSTIFC defines this criterion more broadly than just flexibility in investment. Revenue from most of the broad-based tax or fee systems has been used for a wide range of investments; therefore, they are given good scores for flexibility. They match the NSTIFC scores. The alternatives related to tolling are given a lower score because the revenue from toll roads is usually restricted for investment in the corridor. In some cases, such revenue is used to improve other roads in the region where the corresponding toll road is located. For example, the revenue gained through a recent concession agreement in North Texas is invested region wide (NCTCOG 2013). The scores given to the alternatives and some justification for them are presented in Table 4-6.

Table 4-5. Scoring Table for Revenue Generation Criterion – Revenue Generation Potential and Revenue Sustainability

Revenue Generation Potential		Revenue Sustainability*	
Score	Reason	Score	Reason
A1	Fuel tax - fixed increase		
5	From the NSTIFC Report; Yields significant revenue with a small percentage impact on total motor fuel price.	2	From the NSTIFC Report; Two factors hurt the sustainability - increase in fuel efficiency and inflation; Revenue increases with VMT.
A2	Fuel tax - increase and index to inflation		
5	From the NSTIFC Report; Yields significant revenue with a small percentage impact on total motor fuel price.	4	Ability to grow with inflation is a major positive point; Increase in fuel efficiency still is a major factor that reduces the sustainability.
A3	Sales tax on motor fuels - New		
5	From the NSTIFC Report; Yields significant revenue with a small percentage impact on total motor fuel price.	3.5	Assuming that gas price grows with inflation, revenue keeps growing. Gas price in real dollars grew more than 6% annually in the last decade. Increase in fuel efficiency still is a major factor that reduces the sustainability.
B	Carbon tax – New		
5	From the NSTIFC Report; Additional tax on motor fuel. So very good revenue potential.	2	From the NSTIFC Report; Same problems as fuel tax.
C	Vehicle registration fee - fixed increase statewide		
5	From the NSTIFC Report; high revenue potential with reasonable increase in vehicle registration fee.	3	Grows with the growth in number of vehicles, which in turn is related to the population growth, which is stable; Population growth is slower than growth in road usage; Does not grow with inflation.
D	General sales tax - fixed percent point increase statewide		
5	From the NSTIFC Report; High revenue potential with small increase in tax rate.	5	From the NSTIFC Report; Grows with inflation as well as with sales revenue, which depends on population growth which is stable. It also depends on income.

* The NSTIFC Report defines sustainability as including both stability and predictability of the revenue stream.

Table 4-5—*Continued*

Revenue Generation Potential		Revenue Sustainability	
Score	Reason	Score	Reason
E1	Tolling all new freeway capacity with fixed tolls		
3	A significant amount of revenue is generated but not as high revenue as produced by fuel tax; higher tolls required. Collection cost is about 12-15% of the revenue.	4	From the NSTIFC Report; Grows with inflation if tolls are adjusted with inflation. Some instability since demand depends on time savings and drivers' willingness to pay.
E2	Tolling all new freeway capacity with variable tolls		
3	A significant amount of revenue is generated but not as high revenue as produced by fuel tax; higher tolls required. Collection cost is high.	4	From the NSTIFC Report; Similar to E1
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)		
4.5	Tolling all urban highways raises a significant amount of revenue. Yet, it may not be sufficient to replace fuel tax. Collection cost is high.	4	From the NSTIFC Report; Similar to E1
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)		
4.5	Tolling all urban highways raises a significant amount of revenue. Yet, it may not be sufficient to replace fuel tax. Collection cost is high.	4	From the NSTIFC Report; Similar to E1
F1	VMT Charges - Flat rate (Phased in from 2020-2025)		
4.5	From the NSTIFC Report, adjusted; a small charge will raise money equivalent to fuel tax. Collection cost is high.	4	From the NSTIFC Report; Revenue increases with overall VMT which is related to the cost imposed on roadways; VMT growth is mostly stable; Rate not tied to inflation.
F2	VMT Charges - Comprehensive rates (Phased in 2020-2035)		
4	From the NSTIFC Report, adjusted; a small charge will raise money equivalent to fuel tax. Collection cost is very high.	4	From the NSTIFC Report; Similar to F1
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.		
5	All the sales tax paid on sales of vehicles, tires and parts will be a significant amount.	5	Different from the NSTIFC Report[#]; Revenue is stable because sale of vehicles, parts and tires can be related to the road usage. It grows with inflation also.

[#] The NSTIFC Report defines the alternative as allocation of general funds, regardless of the actual tax source, to transportation.

Table 4-5—*Continued*

Revenue Generation Potential		Revenue Sustainability	
Score	Reason	Score	Reason
H	Freight weight-mile charge		
3	Only trucks included. Not as much as in flat rate VMT charge. This tax can be used in conjunction with another tax related to automobile use.	4	Revenue increases with overall truck VMT and weight movement which is directly related to the cost imposed on roadways; VMT growth is mostly stable; Revenue is less sustainable because the tax rate is not tied to inflation.
I	VMT charges on electric and CNG vehicles - flat rate		
1	Very low revenue. One can make it reasonable by coupling with a fuel tax alternative.	4	Similar to F1.
J	Vehicle registration fee increase for electric and CNG fuel vehicles		
1	Very low revenue. One can make it reasonable by coupling with a fuel tax alternative.	3	Similar to C.
K1	Sales tax on vehicle sales - fixed percent point increase		
2	Tax base and tax rate increase are only a portion of Alternative G. So, a lower amount of revenue is expected to be generated.	5	Similar to G.
K2	Sales tax on motor vehicle tires - fixed percent point increase		
2	Tax base and tax rate increase are only a portion of Alternative G. So, a lower amount of revenue is expected to be generated.	5	Similar to G.
L	Drivers license fees - fixed increase statewide		
3	Increases in drivers license fee is not expected to be significant to raise enough money to solve the funding needs on its own.	4	From the NSTIFC Report; Revenue mainly depends on population; Does not depend on travel; Does not grow with inflation.

Table 4-5—*Continued*

Revenue Generation Potential		Revenue Sustainability	
Score	Reason	Score	Reason
M	Vehicle registration fee increase locally		
3	For local region it is good. If implemented in only one major urban area, it may have to be coupled with a statewide alternative to satisfy statewide funding needs.	3	Similar to C.
N	Increase in allowance for local general sales tax		
3	For local region it is good. If implemented in only one major urban area, it may have to be coupled with a statewide alternative to satisfy statewide funding needs.	5	Similar to D.
O	Local option fuel tax – New addition to the state fuel tax		
3	For local region it is good. If implemented in only one major urban area, it may have to be coupled with a statewide alternative to satisfy statewide funding needs.	2	Similar to A1.

Table 4-6. Scoring Table for Revenue Generation Criterion – Revenue Predictability and Flexibility in Investment

Revenue Predictability		Flexibility in Investment	
Score	Reason	Score	Reason
A1	Fuel tax - fixed increase		
4	Revenue depends on fuel usage; Fuel usage can be predicted with reasonable accuracy. Assume that CAFE standards will be implemented.	5	From the NSTIFC Report; Fuel tax revenue is proven to be flexible for investment.
A2	Fuel tax - increase and index to inflation		
4	Fuel usage can be predicted accurately. For the long run, inflation can also be predicted well. Assume that CAFE standards will be implemented.	5	From the NSTIFC Report; Fuel tax revenue is proven to be flexible for investment.
A3	Sales tax on motor fuels - New		
3	Fuel price is less accurately predicted. Although there are short term fluctuations, yearly growth can be somewhat stable and predictable.	5	From the NSTIFC Report; Fuel tax revenue is proven to be flexible for investment.
B	Carbon tax – New		
4	Fuel usage and carbon usage can be predicted well. Assume that CAFE standards will be implemented.	2	Not flexible. Examples show that the revenue may be restricted to investments improving environment.
C	Vehicle registration fee - fixed increase statewide		
4	Growth of number of registered vehicles can be reasonably well predicted.	5	From the NSTIFC Report; In Texas registration fee is being used for highway funding flexibly.
D	General sales tax - fixed percent point increase statewide		
4	Growth of sales can be predicted reasonably well.	5	From the NSTIFC Report; So far they are not used for transportation. If the additional tax is moved to Highway fund, the investments are flexible.

Table 4-6—*Continued*

Revenue Predictability		Flexibility in Investment	
Score	Reason	Score	Reason
E1	Tolling all new freeway capacity with fixed tolls		
2	Toll revenues for new toll roads can be difficult to predict.	2	Use of revenue is usually restricted to improvement of the toll road corridor.
E2	Tolling all new freeway capacity with variable tolls		
2	Toll revenues for new toll roads can be difficult to predict.	2	Use of revenue is usually restricted to improvement of the toll road corridor.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)		
3	Toll revenues for existing freeways can be predicted reasonably well. Prediction of revenue is difficult for new toll roads.	3	Similar to E1; When existing freeways are tolled, revenue can be spent on a wider range of projects.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)		
3	Toll revenues for existing freeways can be predicted reasonably well. Prediction of revenue is difficult for new toll roads.	3	Similar to E1; When existing freeways are tolled, revenue can be spent on wider range of projects.
F1	VMT charges - Flat rate (Phased in from 2020-2025)		
4	VMT can be predicted well.	5	From the NSTIFC Report; Revenue from VMT charges is very flexible similar to the fuel tax revenue.
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)		
4	VMT can be predicted well.	5	From the NSTIFC Report; Revenue from VMT charges is very flexible similar to the fuel tax revenue.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.		
3.5	The amount of sales of vehicles, parts and tires is somewhat difficult to predict because the prices and number of new and used car purchases may vary.	5	From the NSTIFC Report; Supposed to be very flexible if the money is transferred to highway fund.

Table 4-6—*Continued*

Revenue Predictability		Flexibility in Investment	
Score	Reason	Score	Reason
H	Freight weight-mile charge		
3	This is a new tax. Revenue prediction in the first years of implementation may be difficult because historical data may not be available; There could be some reduction in freight travel due to this tax; Prediction may be more accurate in later years.	4	From the NSTIFC Report; Investments may be restricted to facilities for truck travel.
I	VMT charges on electric and CNG vehicles - flat rate		
3	Somewhat difficult to predict the number of these vehicles and their mileage	5	Revenue may join Fuel tax revenue in the Highway Fund. Uses are very flexible
J	Vehicle registration fee increase for electric and CNG fuel vehicles		
3	Somewhat difficult to predict the number of these vehicles	5	Revenue may join Fuel tax revenue in the Highway Fund. Uses are very flexible.
K1	Sales tax on vehicle sales - fixed percent point increase		
3.5	Number of vehicles sold can be predicted reasonably well. But the revenue of vehicle sales may be somewhat difficult to predict.	5	Similar to general sales tax, expected to be very flexible.
K2	Sales tax on motor vehicle tires - fixed percent point increase		
3	Low quantity, tire purchases may vary by year, so predictability may be low.	5	Similar to general sales tax, expected to be very flexible.
L	Drivers license fees - fixed increase statewide		
4	Number of drivers licenses issued can be reasonably well predicted.	3	Can be restricted to Department of Motor Vehicles (DMV) related spending.

Table 4-6—*Continued*

Revenue Predictability		Flexibility in Investment	
Score	Reason	Score	Reason
M	Vehicle registration fee increase locally		
3.5	Similar to C. At local level, variation in data makes the prediction slightly difficult.	3	Some restrictions may be there. Where to spend and how to spend.
N	Increase in allowance for local general sales tax		
3.5	Similar to D. At local level, variation in data makes the prediction slightly difficult.	2	Some restrictions may be there. Where to spend and how to spend; Currently certain local sales tax is used for funding transit.
O	Local option fuel tax – New addition to the state fuel tax		
3.5	Similar to A1. At local level, variation in data makes the prediction slightly difficult.	2	Some restrictions may be there. Where to spend and how to spend; Currently certain local sales tax is used for funding transit.

Ease of Increase in Tax or Fee

This criterion evaluates the ease of adjusting the tax or fee when needed; this action may be taken by the operators, or local or regional policy makers. Recent evidence has indicated that increasing taxes is very difficult. An increase of fees is considered relatively less difficult. A broad based charge is more difficult to adjust because it affects large population and may create public resistance. Whereas, a narrow based charge such as tolling may be easier to change because it only affects a small group of users. Table 4-7 shows the scores for all the alternatives and some justification for them. The NSTIFC does not include this criterion and so, the scores are assigned by the author.

Table 4-7. Scoring Table for Revenue Generation Criterion – Ease of Increase in Tax or Fee

Ease of Increase in Tax or Fee	
Score	Reason
A1	Fuel tax - fixed increase
1	Very difficult to increase the base rate.
A2	Fuel tax - increase and index to inflation
1	Very difficult to increase the base rate. But the need for its increase is very low.
A3	Sales tax on motor fuels - New
1	Very difficult to increase the base rate. But the need for its increase is low if fuel price keeps increasing.
B	Carbon tax - New
1	Very difficult to increase the base rate.
C	Vehicle registration fee - fixed increase statewide
2	Statewide vehicle registration fee increase is very difficult. But some advantage because it is not termed as a tax.
D	General sales tax - fixed percent point increase statewide
1	Very difficult to increase the base rate.
E1	Tolling all new freeway capacity with fixed tolls
3	Increase of tolls is not as difficult compared to a broad-based tax.
E2	Tolling all new freeway capacity with variable tolls
3	Increase of tolls is not as difficult compared to a broad-based tax.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)
3	Increase of tolls is not as difficult compared to a broad-based tax.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)
3	Increase of tolls is not as difficult compared to a broad-based tax.
F1	VMT charges - Flat rate (Phased in from 2020-2025)
1	Very difficult to increase the base rate.
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)
1	Very difficult to increase the base rate.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.
1	Very difficult to increase the base rate.

Table 4-7—*Continued*

Ease of Increase in Tax or Fee	
Score	Reason
H	Freight weight-mile charge
2	Very difficult to increase the base rate. But number of people affected is lower.
I	VMT charges on electric and CNG vehicles - flat rate
2	Very difficult to increase. But very few are affected.
J	Vehicle registration fee increase for electric and CNG fuel vehicles
2	Very difficult to increase. But very few are affected
K1	Sales tax on vehicle sales - fixed percent point increase
1	Very difficult to increase the base rate.
K2	Sales tax on motor vehicle tires - fixed percent point increase
1	Very difficult to increase the base rate.
L	Drivers license fees - fixed increase statewide
2	Very difficult to increase the base rate. But it is a fee. If dedicated to a use, it may be less difficult.
M	Vehicle registration fee increase locally
3	Local tax increases are relatively less difficult than statewide. Also, there is some advantage because this is termed as a fee.
N	Increase in allowance for local general sales tax
2	Local tax increases are relatively less difficult than statewide.
O	Local option fuel tax – New addition to the state fuel tax
2	Local tax increases are relatively less difficult than statewide.

4.2.2. Equity and Fairness Criterion

Under this criterion, the funding alternatives are scored based on how well they satisfy three different concepts of equity: user-pay equity, ability to pay equity and geographic equity. The NSTIFC considers these three concepts in its evaluation. The author uses the scores given by the NSTIFC as a starting point to score the alternatives. In addition, the author takes guidance from the relative equity performance ratings given to various funding options by Rosenbloom and Lynott (2011). Rosenbloom clarifies that the equity evaluations are relative. The current or future funding alternatives cannot be evaluated by comparing to a "perfect" funding source with no negative equity implications. Most transportation taxes are regressive, but some are more regressive than others. Similarly, all taxes used for transportation may have some connection to system use, but some have more and some other have less (Rosenbloom and Lynott 2011).

Equity in Paying by Benefit Gained and Cost Imposed (User-pay)

As per the user-pay concept, those who benefit from a transportation system by using it should pay for that system. The higher the cost imposed on the transportation system and environment by a certain group of users, the more that group should pay for the costs. For example, cars and trucks should pay for the roads as they benefit from using them. Trucks cause more damage to the roads than cars. They also consume more roadway capacity. So trucks should pay a higher fee or tax than what cars pay.

The reader should note here that the alternatives are studied with respect to their equity based on the amount of use of highway and transit facilities. Any tax or fee is designed to charge the users based on use of a certain facility or commodity.

According to the user-pay concept here, when the revenue from that tax or fee is used for funding transportation, the amount that one is charged should be based on the type and frequency of use of transportation facilities. For example, a comprehensive VMT charge where travelers are charged by mile traveled varying by vehicle type, location and time of travel is considered as one of the most appropriate user charges. Whereas, the general sales tax is not based on whether or not the purchaser uses a transportation facility and so it performs poorly on user-pay equity. However, some alternatives are intended to fund a specific branch of transportation. The equity of those alternatives should be evaluated with respect to that branch. For example, revenue from tolling is usually used to fund improvements to that toll facility corridor rather than a broad transportation need in the region. Similarly, revenue from a carbon tax may be used for specific transportation improvements that improve air quality in the region. Since a carbon tax is charged based on use of carbon, it may score higher on user-pay equity.

Table 4-8 presents the scores of all the alternatives and discusses justifications for them. The relative performance ratings given by Rosenbloom and Lynott (2011) are used to assign the user-pay equity score for most major alternatives. Depending on the specific definition of the alternatives, the author refines or rescales the scores. At the end, the scores for the major alternatives are in the same direction as the scores given by the NSTIFC; however they may differ in distances between the scores of any two alternatives.

Ability to Pay Equity

Low-income drivers cannot afford to pay much; therefore, they should pay a lower share of their income than high income drivers for transportation. This is called

the ability to pay concept. This concept is more difficult to measure because the low-income travelers may reduce their cost by changing their travel behavior including the mode of travel or number of trips and distance of travel. The transportation authority may compensate some inequities in the payment system by providing subsidies to low-income travelers by providing them transit or other facilities. This concept is named compensatory equity (Rosenbloom and Lynott 2011). While scoring the alternatives for ability to pay equity, the performance of the alternatives without the inclusion of compensatory measures is considered.

Table 4-8 shows the scores assigned for all the alternatives on this sub-criterion and some justification for them. The scores of the alternatives are less than or equal to the middle point of the scale and do not vary significantly, similar to the ones given by the NSTIFC. Based on the relative performance scores given by Rosenbloom and Lynott (2011), the scores of the sales tax increase and VMT charges are reduced.

Table 4-8. Scoring Table for Equity and Fairness Criterion – User-Pay Equity and Ability to Pay Equity

User-pay Equity		Ability to Pay Equity	
Score	Reason	Score	Reason
A1	Fuel tax - fixed increase		
3.5	From the NSTIFC Report (rescaled); Fuel tax is an indirect user fee	2	From the NSTIFC Report; Regressive tax; Not based on ability to pay.
A2	Fuel tax - increase and index to inflation		
3.5	From the NSTIFC Report (rescaled); Fuel tax is an indirect user fee	2	From the NSTIFC Report for fuel tax; Regressive tax; Not based on ability to pay.
A3	Sales tax on motor fuels - New		
3.5	From the NSTIFC Report (rescaled); Fuel tax is an indirect user fee	2	From the NSTIFC Report; Regressive tax; Not based on ability to pay.
B	Carbon tax - New		
4	More direct user charge than fuel tax because the aim of a Carbon tax is to charge for the Carbon used. But it does not consider where and in what conditions carbon was used or emissions were produced.	2	From the NSTIFC Report; It is same as fuel tax. Additional tax per gallon of fuel. Independently, same inequity as fuel tax.
C	Vehicle registration fee - fixed increase statewide		
2	Not based on travel. Registration of vehicles has some indication of travel.	2	From the NSTIFC Report; not equitable. People of income levels pay the same rate if they own a vehicle.
D	General sales tax - fixed percent point increase statewide		
1	From the NSTIFC Report; Not based on travel.	1	Very regressive. Even more regressive than fuel tax.

Table 4-8—*Continued*

User-pay Equity		Ability to Pay Equity	
Score	Reason	Score	Reason
E1	Tolling all new freeway capacity with fixed tolls		
4	Direct user charges on some highways. Does not consider use by time of day or congestion level.	3	From the NSTIFC Report.
E2	Tolling all new freeway capacity with variable tolls		
4.5	From the NSTIFC Report (rescaled); Time of day tolls reduce user-pay inequity.	3	From the NSTIFC Report.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)		
5	Flat rate tolling reduces equity but tolling of all existing urban freeways expands the customers served with better user-pay equity.	2	Same situation as E1 except that existing urban freeways are tolled and so, all users pay similar amounts. As there is less choice, more low income drivers may have to pay more often and/or higher percentage of income.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)		
5	Tolls are direct user charges. By adding congestion pricing, they consider congestion and emissions.	2	Same situation as E1 except that existing urban freeways are tolled and so, all users pay similar. As there is less choice, more low income drivers may have to pay more often and/or higher percentage of income.
F1	VMT charges - Flat rate (Phased in from 2020-2025)		
3	Flat rate VMT charge is less equitable than fuel tax because it does not account for congestion and fuel consumption.	2	Performs less well for rural drivers who have longer distances to travel and fewer transportation options.
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)		
5	From the NSTIFC Report; Direct charges based on mileage; With variable charges, it considers congestion and emissions.	2	Performs less well for rural drivers who have longer distances to travel and fewer transportation options.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.		
2	Sales taxes are not based on travel. But tax on sale of vehicles and parts is closer to transportation use.	2.5	Higher income people are expected to buy expensive vehicles and parts and so pay more than lower income people do.

Table 4-8—*Continued*

User-pay Equity		Ability to Pay Equity	
Score	Reason	Score	Reason
H	Freight weight-mile charge		
5	Directly targeting road use and cost imposed by trucks.	3	From the NSTIFC Report. It is freight related. Income does not pay as much role as in auto trips. But some problems are there on individually owned truck movements.
I	VMT charges on electric and CNG vehicles - flat rate		
3.5	Flat rate VMT charge is suitable for these vehicles. But congestion is not taken into consideration. If used as a supplement for fuel tax, it corrects one deficiency of the fuel tax system by charging electric and CNG vehicles based on their use.	3	Number of tax payers is lower. Does not pose too much problem, because alternative fuel vehicles are expensive, and are expected to be used by higher income people.
J	Vehicle registration fee increase for electric and CNG fuel vehicles		
2	Not based on travel. Registration of vehicles has some indication of travel. But if J is used as a supplement for fuel tax, it corrects one deficiency of fuel tax system by charging electric and CNG vehicles.	3	Number of tax payers is lower. Does not pose too much problem, because alternative fuel vehicles are expensive and are expected to be used by higher income people.
K1	Sales tax on vehicle sales - fixed percent point increase		
2	User-pay equity is better than general sales tax because this is related to vehicle sales.	2.5	Similar to sales tax. But one can expect that higher income people buy more expensive vehicles than lower income people do. So the inequity is reduced a little.
K2	Sales tax on motor vehicle tires - fixed percent point increase		
2.5	User-pay equity is better than general sales tax because this is related to tire sales. Tire sales may indicate the increased road use.	1.5	Similar to sales tax. But one can expect that higher income people spend more on tires than lower income people. So the inequity is reduced a little.
L	Drivers license fees - fixed increase statewide		
2	Similar to vehicle registration fee, this fee is not based on travel.	2	From the NSTIFC Report.

Table 4-8—*Continued*

User-pay Equity		Ability to Pay Equity	
Score	Reason	Score	Reason
M	Vehicle registration fee increase locally		
2.5	Similar to C. User-pay equity increases for local taxes because the charges cover the transportation costs imposed locally.	2	Urban areas have diverse population. Incomes may be different. Flat vehicle registration fee increases inequity. But, since the amount of increase is expected to be smaller, the effect may be lower.
N	Increase in allowance for local general sales tax		
2	Similar to D. User-pay equity increases for local taxes because the charges cover the transportation costs imposed locally.	1	Similar to D. This score does not consider that, in Texas, local sales taxes are usually used for transit related improvements, which provide transportation alternatives and access for low income people. This is considered in a separate scenario.
O	Local option fuel tax – New addition to the state fuel tax		
4	Similar to A1. User-pay equity increases for local taxes because the charges cover the transportation costs imposed locally.	2	From the NSTIFC Report; Regressive tax; Not based on ability to pay.

Geographic Equity

The alternatives are evaluated based on whether "the cost allocation/impact of the mechanism can be structured to match the geographic distribution of the benefit of the funded investments" (National Surface Transportation Infrastructure Financing Commission 2009). Geographic equity refers primarily matching the cost burden to the benefits in terms of geography. One should note that in some cases, some places that are disadvantaged geographically, in terms of population density for example, will need some amount of cross-subsidization to ensure important and necessary system improvements (National Surface Transportation Infrastructure Financing Commission 2009).

Under this criterion, the alternatives such as tolling and comprehensive VMT charges score the highest because the charges are based on the actual location of travel. When such information is available, revenue collected in one location may be invested in the same location, although this should be done without creating any major disadvantage to certain regions. Local taxes[20] score well on this criterion because the revenue from these taxes is usually used for funding transportation needs inside the location. Table 4-9 shows the scores assigned to all the alternatives and some justification for them. Most scores match those given by the NSTIFC. Since the comprehensive VMT charges collect information on location of travel, its score should be high. So, for this alternative, the score is increased.

[20] As mentioned in Footnote 1, this term "tax" is generic.

Table 4-9. Scoring Table for Equity and Fairness Criterion – Geographic Equity

Geographic Equity	
Score	Reason
A1	Fuel tax - fixed increase
2	From the NSTIFC Report.
A2	Fuel tax - increase and index to inflation
2	From the NSTIFC Report.
A3	Sales tax on motor fuels - New
2	From the NSTIFC Report.
B	Carbon tax - New
2	From the NSTIFC Report.
C	Vehicle registration fee - fixed increase statewide
3	From the NSTIFC Report. County level revenue is available. Some geographic tracking can be done.
D	General sales tax - fixed percent point increase statewide
3	From the NSTIFC Report. County level revenue is available. Some geographic tracking can be done.
E1	Tolling all new freeway capacity with fixed tolls
5	From the NSTIFC Report. Assuming money spent in the same corridor.
E2	Tolling all new freeway capacity with variable tolls
5	From the NSTIFC Report. Assuming money spent in the same corridor.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)
5	From the NSTIFC Report. Assuming money spent in the same corridor.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)
5	From the NSTIFC Report. Assuming money spent in the same corridor.
F1	VMT charges - Flat rate (Phased in from 2020-2025)
2	Location information is not available. So equity is lower.
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)
4	NSTIFC Report assigns 3.0. Since comprehensive VMT tax system collects the mileage location, more opportunity for geographic equity is available.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.
2.5	Although geographic location of sales can be tracked, vehicles and vehicle parts may be purchased in one location and used in another location. So, providing geographic equity is difficult.

Table 4-9—*Continued*

Geographic Equity	
Score	Reason
H	Freight weight-mile charge
3	From the NSTIFC Report. GPS tracking is available. Potentially can be charged by location. But freight may travel long distance, and county level allocation may be small.
I	VMT charges on electric and CNG vehicles - flat rate
2	Same as flat rate VMT charge
J	Vehicle registration fee increase for electric and CNG fuel vehicles
3	Same as vehicle registration fee increase
K1	Sales tax on vehicle sales - fixed percent point increase
2.5	Although geographic location of sales can be tracked, vehicles and vehicle parts may be purchased in one location and used in another location. So, providing geographic equity is difficult.
K2	Sales tax on motor vehicle tires - fixed percent point increase
2.5	Although geographic location of sales can be tracked, vehicles and vehicle parts may be purchased in one location and used in another location. So, providing geographic equity is difficult.
L	Drivers license fees - fixed increase statewide
3	From the NSTIFC Report.
M	Vehicle registration fee increase locally
5	Local taxes present good geographical equity.
N	Increase in allowance for local general sales tax
5	Local taxes present good geographical equity.
O	Local option fuel tax – New addition to the state fuel tax
5	Local taxes present good geographical equity.

4.2.3. Ease of Implementation Criterion

Under this criterion, there are five sub-criteria. Under each sub-criterion, the funding alternatives are evaluated for a different aspect of implementation. While assigning scores to the alternatives for each sub-criterion, different groups of characteristics of alternatives are considered. Below is the list of these characteristics.

1. Cost of implementation (each component is represented as a percentage of revenue collected)
    - Initial cost of implementation
    - Cost of on-going administration
    - Cost to the users to comply
2. Simplicity of payment structure
    - Number of tax or fee rate classes
    - How easily can a payer verify how much he pays
    - Number of transactions or number of times a person is charged
3. Ability to prevent evasion
    - Number of payers and number of collection points,
    - Cost of enforcement
    - History of evasion
    - Available methods to curb evasion
4. Ability to use existing payment infrastructure
    - Ability to use existing administrative and physical payment infrastructure
    - Differences in collection mechanism and technology between existing and future systems
    - Need for updating knowledge of existing tax or fee administrators

5. Ease of co-ordination with bordering regions
    - How different the type of tax or fee, and the rates across the borders of the geographical areas in concern
    - Chances of tax or fee evasion due to change of jurisdiction
    - Ability to use any established coordination or enforcement procedures

Table 4-10 presents the scores assigned for the alternatives on the first two sub-criteria. The score for the cost of implementation sub-criterion increases as the cost decreases. The traditional taxes such as the fuel tax and sales tax have costs in the order of one to two percent of revenue (Balducci et al. 2011; Tuerck 2007). Tolling costs about twelve to fifteen percent of the revenue (Manuel Fustes, personal communication, May 28, 2013). Variable tolling costs more than fixed tolling. VMT charges cost even more. One study has estimated the cost of collection of a flat rate VMT charge as about eighteen percent of the revenue (Rufolo 2011). The comprehensive VMT charge is expected to cost significantly higher than the flat rate VMT charge. The fuel tax increase or indexing it to inflation and the re-allocation of revenue have the highest score, similar to the one given by the NSTIFC. The scores for the alternatives related to tolling and VMT charges are adjusted according to their definitions. The NSTIFC considers a nationwide implementation of registration fee and sales tax and hence, assumes a high cost for them. However, since they are existing charges in Texas, any additional cost of increasing and dedicating that additional revenue is expected to be minimal. The NSTIFC does not consider the simplicity of payment structure as a sub-criterion, so the scores on this sub-criterion are judged by the author based on the above mentioned factors. Tolling and VMT charges have lower

scores on this sub-criterion because the charges vary by travel location or corridor, time of travel, and/or vehicle characteristics.

Table 4-10. Scoring Table for Ease of Implementation Criterion – Cost of Implementation and Simplicity of Payment Structure

Cost of Implementation		Simplicity of Payment Structure	
Score	Reason	Score	Reason
A1	Fuel tax - fixed increase		
5	From the NSTIFC Report; No extra cost.	5	Very simple. All fuel buyers pay a fixed amount of tax included in fuel price.
A2	Fuel tax - increase and index to inflation		
5	From the NSTIFC Report; No extra cost.	5	Very simple. All fuel buyers pay a fixed amount of tax included in fuel price.
A3	Sales tax on motor fuels - New		
4	If it is administered as a sales tax at the pump, cost may be high. But if the sales tax is converted to fixed cents per gallon changing every six months, cost is minimal.	5	Very simple. All fuel buyers pay a fixed amount of tax included in fuel price. If collected as a percentage of fuel price, everyone pays a fixed percentage.
B	Carbon tax - New		
5	From the NSTIFC Report; No extra cost if collected along with fuel tax.	5	Very simple. Just in addition to existing tax and it is a fixed tax
C	Vehicle registration fee - fixed increase statewide		
5	No extra cost. All systems are established.	4.5	Very simple. Annually, one fixed amount is charged. But there are a number of vehicle classes and fee is increased differently for cars and trucks.
D	General sales tax - fixed percent point increase statewide		
4.5	No extra cost in implementation. But for dedication, movement of revenue, there will be some cost.	5	Very simple. Collected as a percentage of price.

Table 4-10—*Continued*

Cost of Implementation		Simplicity of Payment Structure	
Score	Reason	Score	Reason
E1	Tolling all new freeway capacity with fixed tolls		
3.5	Cost of collecting tolls consumes about 12-15% of the revenue. Score considers any increase in overall cost due to new toll lanes. Significant compliance cost for users in terms of any toll tag or video tolling costs. As the number of toll roads increases, the cost of integration for authorities and time spent in book keeping by users increases.	3	Tolls are different on each toll gantry on each toll road. Tolls vary by vehicle class. So it can be complex to understand and keep note of transactions and tolls paid. Significant time may be spent by users to verify payments.
E2	Tolling all new freeway capacity with variable tolls		
2.5	Similar to E1. Variable tolling increases toll collection cost because of technology used. For users, significant increase in time spent in book keeping efforts.	2	Significantly more complex than E1 because tolls change by time of day and sometimes due to congestion level.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)		
2.5	Similar to E1; For existing roads, cost increases because the number of users is great. But as the toll rates are low, ratio of cost to revenue increases.	2	Similar to E1; But number of toll roads and road sections increase. Complexity multiplies.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)		
1.5	Significant cost increase compared to E2 because all existing urban freeways are tolled.	1	Significantly more complex than E3 because tolls change by time of day and sometimes due to congestion level.
F1	VMT charges - Flat rate (Phased in from 2020-2025)		
2	Collection cost is more than in tolling because of new technology, new tax collection system and the fact that tax is collected from all drivers in the state.	4	Tax is collected as a fixed rate in cents per mile for all users. It is very simple to understand and pay. Assuming that fuel tax is removed. Phasing in brings complexity.

Table 4-10—*Continued*

Cost of Implementation		Simplicity of Payment Structure	
Score	Reason	Score	Reason
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)		
1	From the NSTIFC Report. A new tax administration system should be implemented, new technology needed, significant initial cost and ongoing cost. Costs for users to comply and make sure they are not charged wrongly.	1	Tax rates vary by location and time of day and vehicle type and level of emissions. Payers must be intelligent to understand and be able to calculate their share of tax to make sure they are not charged wrongly. Phasing in brings more complexity.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.		
5	From the NSTIFC Report; No extra cost.	5	No additional tax. Fixed rate of tax and easy to understand.
H	Freight weight-mile charge		
2	Currently, this tax is not available. A full-fledged weight-mile tax system for trucks costs a significant amount for implementation. Ongoing costs both for the collection authority and for the trucking companies are expected to be significant.	2	Will be complex. Varies by weight, number of axles and mileage. Significant record keeping efforts for truck operators.
I	VMT charges on electric and CNG vehicles - flat rate		
3	Cost of implementation is similar to flat rate VMT charge but lower because payers are only a few. So can be achieved by adding a branch to the current vehicle registration system. Some time is spent by users in verifying the charges and payments.	4	Same as flat rate VMT charge.
J	Vehicle registration fee increase for electric and CNG fuel vehicles		
4.5	An insignificant cost added to the vehicle registration fee system because it needs to track a separate class of vehicles.	4.5	Same as vehicle registration Fee increase.

Table 4-10—*Continued*

Cost of Implementation		Simplicity of Payment Structure	
Score	Reason	Score	Reason
K1	Sales tax on vehicle sales - fixed percent point increase		
4.5	Vehicle sales tax is an established tax at state level. Some cost may be involved in allocation of money.	5	Very simple. Similar to general sales tax.
K2	Sales tax on motor vehicle tires - fixed percent point increase		
4.5	Vehicle tire tax is an established tax at state level. Some cost may be involved in allocation of money.	5	Very simple. Similar to general sales tax.
L	Drivers license fees - fixed increase statewide		
4.5	Drivers license fees is an established system at state level. Some cost may be involved in dedication of money.	5	Very simple. Fixed amount paid after every three to six years.
M	Vehicle registration fee increase locally		
4.5	Currently, most of the counties are collecting a local registration fee. Some additional cost due to addition of any new counties as well as the revenue allocation to transportation.	4.5	Similar to statewide vehicle registration fee. No additional complexity.
N	Increase in allowance for local general sales tax		
4	Some additional cost due to local nature of the tax collection and distribution of revenue. Initial cost due to administration of voting.	5	Although it is a local increase, the tax is a simple percentage over price. Such local variations in sales tax currently exist.
O	Local option fuel tax – New addition to the state fuel tax		
3	Initial cost due to administration of voting; Recording of fuel delivered to the county; County level administration costs; Some additional book keeping by the fuel distributors.	5	The payers just see total fuel tax (federal+state+local). There is not much complexity for them.

Table 4-11 presents the scores of alternatives on the ability to prevent evasion and the ability to use existing payment infrastructure sub-criteria and provides some justification for them. Notably, the author's scores for the ability to prevent evasion sub-criterion disagree with the NSTIFC scores for the alternatives related to tolling and VMT charges because their enforcement is expected to be expensive. Toll evasion is a common problem, especially when all tolls are collected electronically. When the VMT charges are implemented at state level rather than at national level, enforcement becomes more difficult. The NSTIFC assigns poor score to the sales tax, probably because it considers a nationwide sales tax[21], which may incur significant enforcement cost.

On the ability to use existing payment infrastructure sub-criterion, the newly proposed alternatives including VMT charges, freight weight-mile tax and comprehensive tolling are assigned lower scores because they require new infrastructure.

[21] Currently, there is no national sales tax in the U.S.

Table 4-11. Scoring Table for Ease of Implementation Criterion – Ability to Prevent Evasion and Ability to Use Existing Payment Infrastructure

Ability to Prevent Evasion*		Ability to Use Existing Payment Infrastructure	
Score	Reason	Score	Reason
A1	Fuel tax - fixed increase		
4	From the NSTIFC Report; very few tax payers to the government; Currently, evasion is very low.	5	No need for any new payment infrastructure.
A2	Fuel tax - increase and index to inflation		
4	From the NSTIFC Report; very few tax payers to the government; Currently, evasion is very low.	5	No need for any new payment infrastructure.
A3	Sales tax on motor fuels - New		
4	Very few tax payers to the government; Currently, evasion is very low; If tax is collected at pump, more evasion problems may occur.	4	If sales tax is calculated differently for all payers at the pump, some new infrastructure is needed. If collected as a fixed tax in cents per gallon for all users and changed a few times a year, little new infrastructure needed. To account for this uncertainty, a smaller score is given.
B	Carbon tax - New		
4	From the NSTIFC Report; very few tax payers to the government; Currently, evasion of fuel tax is very low.	4	New tax but same payment infrastructure as fuel tax. Some guidelines on sending revenue to certain account. Carbon tax can be a part of a comprehensive program which includes tax on carbon emissions from various sources. If that happens, infrastructure may be significantly different.
C	Vehicle registration fee - fixed increase statewide		
4	From the NSTIFC Report; Very less evasion problems currently.	5	No need for any new payment infrastructure.
D	General sales tax - fixed percent point increase statewide		
4	Although number of payers is a lot, evasion problems are less because already the system is well established.	4	Existing payment infrastructure is used. But some guidelines about the account to which the additional revenue should be dedicated.

* This uses the Cost of Compliance criterion used by the NSTIFC Report which deals with the enforcement costs.

Table 4-11—*Continued*

Ability to Prevent Evasion*		Ability to Use Existing Payment Infrastructure	
Score	Reason	Score	Reason
E1	Tolling all new freeway capacity with fixed tolls		
1	Significant possibility of evasion; cost of enforcement is high.	4	Payment infrastructure is available. Every time a new road is built as toll road, some effort on new infrastructure specific for tolling that road.
E2	Tolling all new freeway capacity with variable tolls		
1	Significant possibility of evasion; cost of enforcement is high.	3	Similar to E1; Variable tolling needs more advanced infrastructure to administer.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)		
1	Number of toll payers and number of toll collection points significantly increase. So there will be significant problems.	3	Payment infrastructure is available. Significant effort needed for developing uniform payment infrastructure in each urban area for existing and new toll roads.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)		
1	Significant possibility of evasion; cost of enforcement is high.	2	Similar to E3; Variable tolling needs more advanced infrastructure to administer.
F1	VMT charges - Flat rate (Phased in from 2020-2025)		
1	Number of payers is great, evasion problems are significant. If odometer reading is used, problems due to false recording, wrong odometers etc.	2	Completely new payment infrastructure. If tied to the vehicle registration system or pay at the pump, some of the existing infrastructure can be used.
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)		
1	More complex; and so, there will be more chances for evasion. But GPS technology may give some advantage. However, cost of enforcement increases significantly.	1	Similar to F1; Significant advanced infrastructure is needed to implement the variable or comprehensive VMT charge.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.		
4	Similar to evasion of sales tax. Possible inaccurate report of vehicle sale price.	5	No new payments. A simple allocation of this tax will do.

Table 4-11—*Continued*

Ability to Prevent Evasion*		Ability to Use Existing Payment Infrastructure	
Score	Reason	Score	Reason
H	Freight weight-mile charge		
2	Number of payers is smaller than a VMT charge system. If odometer reading is used, problems are due to false recording, wrong odometers etc. Evasion due to under-reporting of weights. Enforcement cost may be high because of weights measurement as well as GPS tracking.	1	Completely new payment infrastructure.
I	VMT charges on electric and CNG vehicles - flat rate		
4	Some evasion may be there because of false reporting of mileage. But number of payers is small. Assumed that owners of alternative fuel vehicles are responsible in paying their fees.	3	New system of payments. If coupled with vehicle registration system, some existing infrastructure can be used.
J	Vehicle registration fee increase for electric and CNG fuel vehicles		
5	Very few payers; Assumed that owners of alternative fuel vehicles are responsible in paying their fees.	5	No need for any new payment infrastructure.
K1	Sales tax on vehicle sales - fixed percent point increase		
4	Same as sales tax; But some evasion may occur due to wrong noting of vehicle value.	4	Existing payment infrastructure is used. But some new guidelines about the account to which the additional revenue should be dedicated.
K2	Sales tax on motor vehicle tires - fixed percent point increase		
4.5	Similar to sales tax; Better score because this corresponds to a small and specific portion of sales.	4	Existing payment infrastructure is used. But some new guidelines about the account to which the additional revenue should be dedicated.
L	Drivers license fees - fixed increase statewide		
4.5	Drivers license is used as an identity and is assumed that people would not evade because of a small increase in the fee.	4	Existing payment infrastructure is used. But some new guidelines about the account to which the additional revenue should be dedicated.

Table 4-11—*Continued*

Ability to Prevent Evasion*		Ability to Use Existing Payment Infrastructure	
Score	Reason	Score	Reason
M	Vehicle registration fee increase locally		
4	Similar to statewide vehicle registration fee.	5	Most of the counties already charge local fee in addition to the state vehicle registration fee. So, no new infrastructure needed.
N	Increase in allowance for local general sales tax		
4	Similar to statewide general sales tax.	5	Most of the counties already charge local sales tax in addition to the state sales tax. So, no new infrastructure needed.
O	Local option fuel tax – New addition to the state fuel tax		
3	More chances of evasion because sellers of fuel must report how much is delivered to a county and file such tax separately.	3.5	Most of the existing payment infrastructure is used. Only some extra infrastructure needed to process the taxes at metro or county levels.

Table 4-12 presents the scores of alternatives on the ease of co-ordination at the borders sub-criterion. The NSTIFC does not consider this sub-criterion. The author assigns the scores based on his judgment.

Table 4-12. Scoring Table for Ease of Implementation Criterion – Ease of Co-ordination with Bordering Regions

Ease of Coordination at the Borders	
Score	Reason
A1	Fuel tax - fixed increase
5	Same tax system both sides, rates are comparable, not much coordination needed
A2	Fuel tax - increase and index to inflation
4.5	As the fuel tax increases significantly later, the potential difference in fuel prices at the borders may pose a problem.
A3	Sales tax on motor fuels – New
4.5	Tax calculation method is different between bordering regions. Some coordination issues may arise.
B	Carbon tax – New
2	Bordering regions do not have this tax. Significant difference in fuel price at border. So potential for enforcement issues at the borders.
C	Vehicle registration fee - fixed increase statewide
5	No big problems because of difference in vehicle registration fee. Because vehicles need to be registered in the state of residence.
D	General sales tax - fixed percent point increase statewide
5	Increasing in tax rate is small. No coordination problems are expected.
E1	Tolling all new freeway capacity with fixed tolls
4	Some enforcement issues, especially at the borders with Mexico, because of not being able to locate the travelers for charging tolls.
E2	Tolling all new freeway capacity with variable tolls
4	Some enforcement issues, especially at the borders with Mexico, because of not being able to locate the travelers for charging tolls.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)
4	Some enforcement issues, especially at the borders with Mexico, because of not being able to locate the travelers for charging tolls.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)
4	Some enforcement issues, especially at the borders with Mexico, because of not being able to locate the travelers for charging tolls.
F1	VMT charges - Flat rate (Phased in from 2020-2025)
2	Unless adjacent states also implement this system, there will be problems. When GPS is not used, identifying if vehicle miles traveled were in another state is difficult.

Table 4-12—*Continued*

Ease of Coordination at the Borders	
Score	Reason
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)
3	Unless adjacent states also implement this system, there will be problems, especially for out of state travelers. GPS technology helps in this regard.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.
5	No new problems in coordination at the borders.
H	Freight weight-mile charge
2	Unless adjacent states also implement this system, there will be problems. Border issues arise both in accurately charging for miles traveled inside Texas and in identifying the weight of trucks.
I	VMT charges on electric and CNG vehicles - flat rate
2	When there is no GPS technology, there will be problems; some may claim that they drove in adjacent states.
J	Vehicle registration fee increase for electric and CNG fuel vehicles
5	No significant problem
K1	Sales tax on vehicle sales - fixed percent point increase
5	No new problems in coordination at the borders.
K2	Sales tax on motor vehicle tires - fixed percent point increase
5	No new problems in coordination at the borders.
L	Drivers license fees - fixed increase statewide
5	If one lives inside Texas, one must have drivers license with address. No problem with borders.
M	Vehicle registration fee increase locally
3	There will be some problems between the counties. Registered in one county, driving in another county.
N	Increase in allowance for local general sales tax
4	There may be some problems between counties. May purchase goods from another county where sales tax is lower. But since the additional tax is low, the effect reduces.
O	Local option fuel tax – New addition to the state fuel tax
2.5	If the tax is significantly different, there could be some problems at the border. Drivers may cross a county or region border to buy gas if the tax is less across the border. But the low amount of county or metro level tax may reduce the problems.

4.2.4. Public Acceptance and Political Feasibility Criterion

Under this criterion, the author evaluates the feasibility of implementing a new funding method or expanding an existing method in terms of its acceptability among the public as well as the ease of such policy for being passed by the elected leaders. The NSTIFC considers one criterion called "Public acceptance and political viability" which is close to this criterion (National Surface Transportation Infrastructure Financing Commission 2009).

Ease of Explaining to the Public

Scoring of alternatives under this sub-criterion depends on how easy the funding alternative is to explain to the public. This explanation is assumed to be given as part of a public campaign for obtaining the public acceptance of the funding alternative. In addition to this initial effort, an ongoing explanation, after it is implemented, is necessary. The following factors may facilitate better explanation:

- Similarity of a funding alternative to the existing system
- Simplicity and ease of explaining the calculation of the tax or fee for different types of users
- Good connection with transportation

While scoring the alternatives, the above factors are taken into consideration. For each alternative, the author prepares a reasonable explanation to give to the public. Some questions that may arise from the public are also shown. This information is shown in Appendix H. Table 4-13 shows the scores assigned to the alternatives under this criterion and some justification for them. The NSTIFC does not have a sub-criterion that is comparable to this one. One of its sub-criteria, justification for dedication, is

comparable to the factor, good connection with transportation. The scores are assigned by the author based on his knowledge and judgment.

Acceptability to the Public

The author scores each funding alternative based on how well it may be accepted by the public. Public acceptance is the key for a funding alternative being accepted by the elected officials. One common method to learn public acceptance is to conduct a public opinion survey where survey respondents are asked to rate their preference of each funding option listed in the survey.

Public opinion is very difficult to know; it may vary based on situation, time to time, and location to location based on the public's awareness of the choices they have and the consequences of choosing one or the other choices. When properly informed about the need for a new funding source, how it is implemented and where the revenues are used, the public may accept the new funding source more than otherwise.

In addition to referring to the NSTIFC Report, the author reviews some public opinion surveys performed nationwide as well as in many states. The NCHRP Synthesis 377 compiles public opinion data on tolls and road pricing from about one hundred studies performed around the U.S. as well as some other countries (Zmud and Arce 2008). Some main findings of this report from the surveys performed in Texas and elsewhere are provided in Chapter 2.

Agrawal et al. presents results of nationwide surveys performed in 2010, 2011 and 2012 regarding the public opinion on different fuel tax and VMT tax alternatives (Agrawal et al. 2012). This research suggests that a national sales tax of 0.5% is favored about two times more than a 10 cent fuel tax increase or a one cent per mile

VMT tax nationwide. Favorability for the fuel tax increases when the public is aware of how the revenue is used. The public favors a 10 cent increase in fuel tax more when it is phased in as a two cent increase per year for five years (Agrawal et al. 2012).

In their study of transportation funding options for California in 2006, Weinstein et al. (2006) perform a public opinion survey to identify the acceptance levels of different funding options for implementation in California including fuel tax increase, mileage based fee, increase in vehicle registration fee, increase in statewide sales tax, different tolling options and other financing options. Chapter 2 contains a summary of the public opinion data collected in this survey. The author reviews the results of this survey and examines the applicability of these for Texas in 2013 and the future. Some of the main differences identified are:

- California has a history of a 'green' movement and has implemented a number of policies to bring awareness towards environmental protection. In comparison, the Texas public lags behind in such environmental protection initiatives.
- The vehicle registration fee and other annual fees in California are significantly higher than those in Texas.
- Increase in fee is more favored in Texas than an increase in tax.

Using the findings from the literature discussed above, the author assigns the scores to the alternatives under this criterion. The alternatives are scored for public acceptance relative to each other rather than for absolute acceptance levels. Since this criterion is weighted among the top of other criteria and due to the uncertainties in the scoring of the alternatives, the author identifies the need for a sensitivity analysis to

see if any changes in scores affect the order of preference of the alternatives. Section 4.4.5. discusses the sensitivity analysis.

Table 4-13 presents the scores assigned to the alternatives and some justification for them. These scores are in the similar range as the ones assigned by the NSTIFC on the public acceptance and political viability. The surveys and previous literature show that the public strongly oppose tolling existing highways. So, such alternatives are given the least score. The surveys show that the public accept variable tolling less than fixed tolling; however, recent developments in managed lane projects in Texas show that public acceptance of variable tolling and fixed tolling may not be significantly different.

One should note here that these public acceptance scores represent relative acceptance of one alternative over another. Lack of public and political support for increasing the fuel tax and other user charges seems to be the main reason for the current funding crisis. The surveys mentioned above show that, except a few tolling related alternatives, all the alternatives have less than 50% acceptance. Currently, in Texas, the Legislature seems to oppose any new taxes or increasing existing taxes. The author is not clear if the public in general agrees with this opinion. If the public agrees, this represents a significant barrier for implementing any new funding policy that aims to raise more revenue.

Less Need for Legislative Action

Under this criterion, the author scores the funding alternatives with regard to the amount of legislative action needed to bring a new funding policy into implementation. Legislative action may include creating new laws, and amending or repealing existing laws. The author assumes that as legislative action for a funding alternative increases,

its feasibility of being implemented decreases. Scores are given from 1 to 5 in the order of decreasing amounts of legislative action. Current laws in Texas allow tolling new freeway capacity with fixed or variable tolls; therefore, there is no need for any changes in laws for implementing this option (E1 or E2). So, this alternative is given a score of 5. To implement a comprehensive VMT charge system all over the state after removing the fuel tax, the state legislature needs to change a significant number of laws and write the regulations for a new tax system; hence, this alternative is given a score of 1. Table 4-14 presents the scores assigned to the alternatives under this criterion and some justification for them.

Table 4-13. Scoring Table for Public Acceptance and Political Feasibility Criterion – Ease of Explaining to the Public and Acceptability to the Public

Ease of Explaining to the Public		Acceptability to the Public	
Score	Reason	Score	Reason
A1	Fuel tax - fixed increase		
5	Same as existing system; Simple change of tax to explain; Well connected with transportation.	2.5	From the NSTIFC Report (rescaled); Tax increase is not popular.
A2	Fuel tax - increase and index to inflation		
4.5	Similar to A1; Need to explain about the index and how the tax will change every year.	1.5	Less popular than A1.
A3	Sales tax on motor fuels - New		
4	Fuel tax is existing tax. Need to explain reason for change and the difference between an old and new system. Can be compared to the existing if it is fixed rate for six months. Good connection with transportation.	1.5	It is a tax. Less popular than A1. May be less popular than A2 because if fuel price increases sharply, public will see their taxes increase sharply.
B	Carbon tax - New		
3	New tax; Need to first explain the carbon tax concept; Tax charged similar to fuel tax; Calculation is simple; Well connected to transportation and environment.	2	Not favorable because another tax on fuel; But the environmental concern and the uses of revenue may increase the acceptability.
C	Vehicle registration fee - fixed increase statewide		
4.5	Same as existing registration fee system; Less connected with transportation use - questions may arise; Simple change in fee.	3	NSTIFC Report scores a nationwide increase in vehicle registration fee as 2; Scored higher here because in Texas, fees are more favored than taxes and it is a one-time annual fee.
D	General sales tax - fixed percent point increase statewide		
3	Same as existing tax; Simple change in tax rate; But use of additional revenue should be explained; Not connected to transportation use; So questions will arise.	1.5	National public opinion survey showed sales tax is more popular than fuel tax (Agrawal et al. 2012). However, Texas has high rate of sales tax. It is tied at fifth and sixth for general sales taxes among all states. So, it may be less popular.

Table 4-13—Continued

Ease of Explaining to the Public		Acceptability to the Public	
Score	Reason	Score	Reason
E1	Tolling all new freeway capacity with fixed tolls		
4	Many people in urban areas have seen toll roads; Some urban and some rural people may need basic clarifications; Directly connected to transportation use. Complication in explaining about how toll rates are calculated, how it will be paid and how it will be enforced.	3	From the NSTIFC Report; Tolling is relatively more popular in Texas.
E2	Tolling all new freeway capacity with variable tolls		
2.5	Similar to E1; Need to explain the need for variable tolls and how they will be calculated and when and how users will know what they have to pay. Dynamic tolling concept is very complicated to explain.	3	From the NSTIFC Report; Tolling is relatively more popular in Texas.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)		
3	Similar to E1; Need to define urban freeways, explain how tolls are different on different roads; People should know how the system will be managed such that it is fair and less burdensome for them.	1	Tolling of existing roads is not at all favored at this time.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)		
1	This alternative is very difficult to explain because it is a mix of E2 and E3. Need to explain how tolling of new and existing roads is integrated and how the variable tolling is implemented. Toll rates should be explained.	1	Tolling of existing roads is not at all favored at this time.
F1	VMT charges - Flat rate (Phased in from 2020-2025)		
3	New system. Need to explain the need for this new system and why this shift from the fuel tax to a VMT charge; Well connected to transportation. Need to explain how the VMT charge is phased in and how the tax is calculated and collected.	2	Acceptance is equal to or lower than that of fuel tax increase. Surveys show that public acceptance of fuel tax increase is greater when fuel tax is gradually increased, or when the public is informed of their actual tax burden (Agrawal et al. 2012).

Table 4-13—Continued

Ease of Explaining to the Public		Acceptability to the Public	
Score	Reason	Score	Reason
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)		
1	Similar to F1; Need to explain the need for comprehensive rates, tax rate calculation is complicated to explain, VMT charges are phased in and how the tax is administered; Questions may arise about cost, use of on-board device, privacy and enforcement. Can have higher score because of the benefits it provides over fuel tax.	1.5	Acceptance is lower than for a flat rate VMT charge. Some reasons for this are complexity, change from existing system, GPS on board system, location tracking or privacy issues etc. If public is convinced of the advantages this system has, especially towards reducing congestion and emissions, acceptability may increase.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements.		
4.5	Existing taxes, no increases, Tax rates and calculations are known. Need to explain the need for re-allocation and the revenue that is moved. Revenue from transportation related taxes is moved.	4	From the NSTIFC Report; people do not pay any extra tax. This increases acceptability. Public may be happy to see that the government is utilizing some funds that would have gone for less important uses towards transportation.
H	Freight weight-mile charge		
3.5	New system in Texas but examples from other states are available to show. Need to explain the need for this tax and how it will be implemented. Directly related to transportation. Only trucks are charged. So, regular people do not need to understand the implementation detail.	2	From the NSTIFC Report; New tax system, somewhat complicated, needs phase in time, only truck companies will have problem.
I	VMT charges on electric and CNG vehicles - flat rate		
4	New system. Directly related to transportation use. Need to explain the need for this tax and how is collected. Collection process can be easy. Questions will arise about penalizing environmentally friendly vehicles.	4	This will be more acceptable compared to converting into VMT charges for everyone. This tax aims to remove one of the user inequities in fuel tax. So, this may become more acceptable, but protests from environmental groups may arise.

Table 4-13—Continued

Ease of Explaining to the Public		Acceptability to the Public	
Score	Reason	Score	Reason
J	Vehicle registration fee increase for electric and CNG fuel vehicles		
4.5	An extension of existing fee. Moderately transportation related; fee structure is simple. Questions will arise about penalizing environmentally friendly vehicles.	3	Higher vehicle registration fee for these vehicles regardless of use will be less acceptable than the usage based charge as in 'I'. Protests from environmental groups may arise.
K1	Sales tax on vehicle sales - fixed percent point increase		
4	Existing tax; Simple tax increase. Moderately connected to transportation; Need to explain the need for its increase and dedication.	2	From the NSTIFC Report.
K2	Sales tax on motor vehicle tires - fixed percent point increase		
4	Existing tax; Simple tax increase. Moderately connected to transportation; Need to explain the need for its increase and dedication.	3	From the NSTIFC Report.
L	Drivers license fees - fixed increase statewide		
4	Existing fee; Simple fee increase; Only slightly connected with transportation; Need to justify its increase and dedication now. Until now, DL fees are used to administer the DL system.	2	Many people use the drivers license as ID card. Increase of fee affects more than just drivers. No direct relationship with road usage. Increase in drivers license fee may have lower acceptance.

Table 4-13—Continued

Ease of Explaining to the Public		Acceptability to the Public	
Score	Reason	Score	Reason
M	Vehicle registration fee increase locally		
4.5	Existing system; Moderately related to transportation use; Simple fee structure; Many counties already have an additional fee. Need to explain the need for this increase in local fee in certain regions. In some regions, need to explain how this system is different from statewide fee.	4	Already in place in many counties. More acceptable than statewide increase. If the revenue from registration fee is dedicated to certain investments, the acceptability is even more.
N	Increase in allowance for local general sales tax		
3.5	Existing system; Many counties already implement local sales tax; Potential simple tax increase locally. Need to explain the need of local tax and about the voting process. Not transportation related. If funds are to be dedicated to certain projects, the list of these projects must be explained.	3.5	Already in place in many urban areas. More acceptable than statewide increase. If the revenue from the local sales tax is dedicated to certain investments, the acceptability is even more. Being able to vote on the tax improves the acceptance.
O	Local option fuel tax – New addition to the state fuel tax		
4	Existing system for statewide but local option tax is new. Examples from other states can be shown. Tax is transportation related and simple. Some effort is needed to tell about the local fee system and how it is implemented. Voting process should be discussed. If funds are to be dedicated to certain projects, the list of these projects must be explained.	3	More acceptable than statewide increase. If the revenue from local fuel tax is dedicated to certain investments, the acceptability is even more. Being able to vote on the tax improves the acceptance.

Table 4-14. Scoring Table for Public Acceptance and Political Feasibility Criterion – Less Need for Legislative Action

Less Need for Legislative Action	
Score	Reason
A1	Fuel tax - fixed increase
4	Only one action.
A2	Fuel tax - increase and index to inflation
3	Need to make laws to increase one time as well as to increase every year; Discussion about which index and how it is to be calculated.
A3	Sales tax on motor fuels - New
2.5	Significant action. Repeal of tax as it is, add new definition.
B	Carbon tax - New
2	New tax initiation, dedication of revenue. Need to develop new laws, who to be charged, what tax rate, how to use the revenue. If this is part of a broader carbon tax program, the amount of legislative action is very complicated.
C	Vehicle registration fee - fixed increase statewide
4	Only one action.
D	General sales tax - fixed percent point increase statewide
3	Law to increase the rate, law to transfer and dedicate.
E1	Tolling all new freeway capacity with fixed tolls
5	No new law. Can continue what is going on now.
E2	Tolling all new freeway capacity with variable tolls
5	No new law. Can continue what is going on now.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)
2	New law on allowing tolls on existing roads; Guidelines on items such as which roads can be tolled, toll rates, revenue dedication, spending restrictions.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)
2	Similar to E3.
F1	VMT charges - Flat rate (Phased in from 2020-2025)
2	Very significant action needed. Gradual phase in of new system; New tax system should be written including who is charged, tax rates, how it should be collected, laws of enforcement, how the revenue is allocated.

Table 4-14—Continued

Less Need for Legislative Action	
Score	Reason
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)
1	Similar to F1; Comprehensive VMT charges involve more laws regarding the detailed tax classes. May need laws requiring all vehicles to carry on board devices.
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements
4	Re-allocation of money from General fund. One law.
H	Freight weight-mile charge
2	New tax initiation. Full tax system may be formulated. Similar to flat rate VMT tax.
I	VMT charges on electric and CNG vehicles - flat rate
2	New tax system should be written including who is taxed, how it is calculated and collected, how to enforce it and how the revenue is allocated.
J	Vehicle registration fee increase for electric and CNG fuel vehicles
3	One law to increase vehicle registration fee of certain vehicles. Discussion on creating different vehicle classes.
K1	Sales tax on vehicle sales - fixed percent point increase
3	At least two laws, increasing and dedication
K2	Sales tax on motor vehicle tires - fixed percent point increase
3	At least two laws, increasing and dedication
L	Drivers license fees - fixed increase statewide
3	At least two laws, increasing and dedication
M	Vehicle registration fee increase locally
2.5	Two steps in the process. Legislature needs to make provisions for counties to increase registration fees; Local governments should act on increase.
N	Increase in allowance for local general sales tax
2.5	Two steps in the process. Legislature needs to increase the allowance for local sales tax; Local governments should act on increase. Voting may delay the process.
O	Local option fuel tax – New addition to the state fuel tax
2.5	Two steps in the process. Legislature needs to allow for local fuel tax; Local governments should act on increase. Voting may delay the process.

4.2.5. Potential Secondary Benefits Criterion

As discussed in Chapter 3, this criterion evaluates how well a funding alternative promotes efficient use of transportation system and encourages reduction of use of carbon fuels. The basis for scoring the alternatives under this criterion is provided below.

Promotion of Efficient Use of System by Changing Travel Behavior

This evaluates the extent to which the funding mechanism can promote efficient use of transportation system by encouraging travelers to make changes in their travel behavior. Such changes include but are not limited to reducing the frequency and distance of travel, traveling in off-peak periods and using alternative modes such as public transit and non-motorized modes. Any tool included in the funding mechanism that penalizes inefficient use helps the funding mechanism to get a higher rating. For example, congestion pricing is seen as an alternative that discourages travel in congested time periods on certain roadways. The NSTIFC considers three sub-criteria under the economic efficiency considerations. The promotion of efficient use sub-criterion among them closely matches with the sub-criterion in discussion.

As the author reviews in Chapter 2, user charges should be significantly larger than those currently in place (in the order of about ten times of the current charges) to instigate a change in travel behavior. The main objective of the funding alternatives studied here is to generate revenue to solve the funding deficiency; the alternatives related to fuel tax, VMT charges and other broad-based taxes do not consider such great increases in current user charges. So, these alternatives promoting any significant change in travel behavior is less likely. Tolls are in the range of producing a significant effect but they are only concentrated in certain corridors.

The scores given here represent a relative effect rather than an absolute effect. The alternatives are scored on a scale of 1 to 5, where 1 means that the alternative does not have an effect and 5 means that the alternative provides the highest encouragement for efficient travel behavior among all the alternatives considered. The following are some characteristics of a funding alternative which are expected to promote efficient travel behavior:

- The tax or fee has a direct relation to the extent of travel. For example, a VMT charge is directly related to the miles traveled.
- The amount the user pays is visible as a separate amount rather than being embedded inside a total price. A toll is clearly seen separately compared to a gasoline tax that is embedded inside gasoline price although electronic toll collection somewhat reduces this clarity.
- The alternative produces a statewide effect rather than a local effect. For example, a statewide fuel tax increase produces a statewide effect where as a local option fuel tax produces a local effect.
- The higher the amount paid for a mile traveled, the higher the encouragement.

Table 4-15 shows the scores given to each alternative along with some justification. The NSTIFC assigns the maximum score to tolling and VMT charges and minimum to sales tax and re-allocation of revenue from general fund. Keeping the maximum score for the comprehensive tolling and comprehensive VMT charges and the minimum to the sales tax and re-allocation, the author assigns the remaining scores based on their relative effect.

Promotion of Fuel Efficiency and Use of Low Emission Fuels

This evaluates the extent to which the funding mechanism encourages system users to select low emission fuels and increase their fuel efficiency by users. The alternatives are scored on a scale of 1 to 5. Some funding alternatives may produce a negative effect by removing any encouragement for reducing the use of carbon fuels rather than increasing it. To account for this negative effect, the author considers a two-sided scale. A score of 2 is given for the alternatives that do not affect the existing situation. A score of 1 is given for negatively affecting alternatives. A positive effect is measured on a scale from 2 to 5 where a score of 5 represents the highest positive effect among the alternatives considered. The NSTIFC does not consider this sub-criterion. So, the author assigns these based on his knowledge and judgment. Table 4-15 shows the scores given to each alternative along with some justification for them.

Table 4-15. Scoring Table for Potential Secondary Benefits Criterion

Promotion of Change in Travel Behavior		Promotion of Change in Fuel Efficiency	
Score	Reason	Score	Reason
A1	Fuel tax - fixed increase		
2	Somewhat direct charge on travel; Tax is hidden inside fuel price; Statewide effect; Increase of 10 cents will increase gas price by about 3% and may have positive but insignificant effect.	3	Direct charge on fuel; Tax is hidden inside fuel price; Statewide effect; Increase of 10 cents will increase gas price by about 3% and may have positive but insignificant effect.
A2	Fuel tax - increase and index to inflation		
2.5	Similar to A1; Higher positive effect because users are informed that more travel will increasingly cost more.	3.5	Similar to A1; Higher positive effect because the users are informed that it will increase every year.
A3	Sales tax on motor fuels - New		
2.5	Similar to A1; Higher positive effect because users are informed that more travel will increasingly cost more.	3.5	Similar to A1; Higher positive effect because the users are informed that it will increase every year.
B	Carbon tax - New		
3	From the NSTIFC; Similar to A1; Carbon tax can be about 25 cents per gallon and so fuel price and in turn, travel cost may increase significantly; Relatively higher effect than A2 or A3.	5	Similar to A1; Carbon tax can be about 25 cents per gallon and so fuel price may increase significantly; Relatively, the highest positive effect.
C	Vehicle registration fee - fixed increase statewide		
1.5	Fee relates to vehicle ownership; Not a direct charge on travel; Directly visible as a fee; Statewide effect; Some effect on vehicle ownership and in turn on travel although insignificant.	2	Not a direct charge on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
D	General sales tax - fixed percent point increase statewide		
1	No relation to travel; Does not affect travel behavior.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
E1	Tolling all new freeway capacity with fixed tolls		
4	Direct fee on travel; Directly visible, Not completely a statewide effect but many lanes on freeways across the state will have tolls; Tolls have potential to encourage reduction of travel frequency as well as travel distance.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.

Table 4-15—Continued

Promotion of Change in Travel Behavior		Promotion of Change in Fuel Efficiency	
Score	Reason	Score	Reason
E2	Tolling all new freeway capacity with variable tolls		
5	Similar to E1; Variable price tolling has potential to discourage travel in congested periods; Relatively, one of the highest positive effects.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
E3	Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)		
4.5	Direct fee on travel; Directly visible, Potential for broad effect; Tolls have potential to encourage reduction of travel frequency as well as travel distance. Higher effect than E1 because existing urban freeways are tolled.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
E4	Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)		
5	Directly visible, statewide effect, direct fee on travel, tolls may be high and so there may be effect on congestion on the toll road. People may have to drive less, travel on arterials, travel in off peak periods etc.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
F1	VMT charges - Flat rate (Phased in from 2020-2025)		
4	Direct charge on travel mileage; Directly visible charge; Statewide effect; Although charge may be small in terms of cents per mile, potential for encouragement for reducing overall travel mileage.	1	Not a direct fee on fuel, So, there may not be any effect on fuel use. VMT charge replaces current fuel tax. So, there will not be any encouragement to improve fuel efficiency. This is a negative effect.
F2	VMT charges - Comprehensive rates (Phased in 2020-2035)		
5	Similar to F1; With charges varying by vehicle type, time of travel and location, F2 has potential for encouragement for improvement in travel behavior. Relatively one of the highest positive effects.	2.5	VMT charge is primarily based on mileage. Tax may potentially vary by vehicle emission level. Directly visible charge; Statewide effect; The rate variation will be very low per mile, the effect is not significant. Not as much positive effect as A1.

Table 4-15—Continued

Promotion of Change in Travel Behavior		Promotion of Change in Fuel Efficiency	
Score	Reason	Score	Reason
G	Allocating revenue from sales tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires to transportation improvements		
1	From the NSTIFC Report; No additional tax or fee; No effect on travel behavior.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
H	Freight weight-mile charge		
5	Direct charges on truck load and travel; Directly visible charge; Statewide effect but only for trucks; Potential for significant effect on truck travel and weight; Truck travel and weight damage the highways the most; So, relatively one of the highest positive effects.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
I	VMT charges on electric and CNG vehicles - flat rate		
4	Similar to the effect of VMT tax in F1; Limited to electric and CNG vehicles.	1	Potential negative effect. Charges on alternative fuel vehicles. May discourage use of such vehicles.
J	Vehicle registration fee increase for electric and CNG fuel vehicles		
1.5	Similar to C. Limited to electric and CNG vehicles.	1	Potential negative effect. Charges on alternative fuel vehicles. May discourage use of such vehicles.
K1	Sales tax on vehicle sales - fixed percent point increase		
1.5	Not a direct charge on travel; Mainly affects vehicle ownership. Not directly visible; Statewide effect; Small increases in tax; Potentially insignificant effect on vehicle ownership and in turn on travel.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
K2	Sales tax on motor vehicle tires - fixed percent point increase		
1	Not a direct fee on travel, but direct fee on vehicle maintenance; Minor increase, potentially no effect on travel behavior;	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
L	Drivers license fees - fixed increase statewide		
1	Not a direct charge on travel; Small increase; No effect.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.

Table 4-15—Continued

Promotion of Change in Travel Behavior		Promotion of Change in Fuel Efficiency	
Score	Reason	Score	Reason
M	Vehicle registration fee increase locally		
1	Similar to C. The effect is less because it is locally implemented and the amount of increase is less.	2	Not a direct fee on fuel. So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
N	Increase in allowance for local general sales tax		
1	Similar to D. No effect on travel.	2	Not a direct fee on fuel, So, there may not be any effect on fuel use. Assuming fuel tax remains at current level, existing situation remains.
O	Local option fuel tax – New addition to the state fuel tax		
2	Similar to A1; Limited to the area where fuel tax is increased.	3	Tax is hidden inside fuel price; Statewide effect; Direct charge on fuel; Increase of 10 cents will increase gas price by about 3% and may have positive but insignificant effect.

This section describes the process of scoring the alternatives on the criteria and presents the scoring tables with justifications. The next step in the multi-criteria analysis is the evaluation of alternatives. The next section introduces the evaluation technique used in this analysis.

4.3. Evaluation Technique

Rogers (2001) discusses different multi-criteria evaluation methods including simple non-compensating techniques, models based on multi-attribute utility theory such as the Simple Additive Weighting (SAW) method, Analytic Hierarchy Process (AHP) and partially compensating methods such as concordance techniques.

The author believes that the SAW and AHP methods are not suitable for the evaluation in this research because these methods usually require high quality of

inputs in order to generate the proper rank order (Rogers 2001). However, the criteria weights established from the expert survey and the qualitative scores of the alternatives are subjective and ordinal in nature and include some uncertainty. Moreover, in this research, identification of a short list of alternatives that are better than others, rather than a perfect rank order, is sufficient because the alternatives are not specified in detail. For these reasons, the author chooses a partially compensating outranking method called Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE) presented by Brans and Vincke (1985) to evaluate the funding alternatives.

PROMETHEE Procedure

In this outranking analysis, the alternatives are compared pairwise – two at a time – with respect to each criterion. So, the analysis is usually performed in a matrix format.

The following PROMETHEE procedure is presented by Brans and Vincke (1985). In this method, based on the scores of two alternatives over all the criteria and the criteria weights, a degree of outranking is estimated. When an alternative A is compared with another alternative B on a criterion, in PROMETHEE, three types of outranking relationships are considered: A is not preferred to B, A is weakly preferred to B, and A is preferred to B. This relation is not symmetrical, that is, B is compared with A as a separate pair. When A and B have equal or sufficiently closer scores, neither A nor B is preferred to the other. They are indifferent.

A preference score, $P_j(A, B)$ is assigned to each pair of alternatives (A, B) on each criterion j. Assume that, on criterion j, score of A is $g_j(A)$ and score of B is $g_j(B)$

and that their difference $g_j(A) - g_j(B) = x$. The preference score is defined in six forms in PROMETHEE, depending on the type of criterion (Brans and Vincke 1985). The author follows the fifth form, because it is the more general form. In this form, P_j is defined as:

$$\text{Preference Score: } P_j(A,B) = \begin{cases} 0, & x \le q \\ \dfrac{x-q}{p-q}, & q \le x \le p \\ 1, & x \ge p \end{cases} \quad (5)$$

where, q and p are named the indifference threshold and preference threshold, respectively. These two parameters are specific to each criterion and are typically identified by the decision maker. The above equation means that A and B are completely indifferent as long as the deviation between their scores is lower than q. In that case, $P_j(A, B)$ and $P_j(B, A)$ both are equal to zero. When the difference is above this value, the preference of one alternative over the other grows linearly from zero to one until the deviation becomes equal to p. Also, $P_j(B, A)=0$ when $P_j(A, B)>0;$ and vice versa. In this research, the minimum deviation in scores is 0.5. The author believes that a score difference of two indicates a clear preference. So, the indifference and preference thresholds for all except two sub-criteria are chosen as 0.5 and 2.0, respectively. For user-pay equity and cost of implementation sub-criteria, these parameters are zero and 1.5, because the scores are so varying that a 0.5 increase in score is a meaningful difference. Once the preference scores are calculated for a pair of alternatives over all the k criteria, they are aggregated to calculate one degree of outranking, or Preference Index (PI), for that pair.

Preference Index: $\pi(A,B) = \frac{1}{W} \sum_{j=1}^{k} w_j P_j(A,B)$ (6)

where,

j = 1, 2,…, k are criteria

k = total number of criteria

W = sum of criteria weights $= \sum_{j=1}^{k} w_j$ (7)

A Performance Index matrix (PI matrix) is developed with PIs for every pair of alternatives, where each row and column represents one alternative. The PI matrix is not symmetrical. In this matrix, the sum of all elements in a row (row sum) indicates how the alternative corresponding to the row dominates other alternatives. Similarly, the sum of all elements in a column (column sum) indicates how the alternative corresponding to the column is dominated by other alternatives.

Then, two separate rank orders are developed. The first rank order is obtained by sorting the alternatives based on decreasing order of row sums. The second rank order is obtained by sorting the alternatives based on increasing order of column sums. When two or more sums are equal, all the corresponding alternatives are assigned the same rank, which is the average of the ranks corresponding to their positions. For example, suppose that the row sums for four alternatives A, B, C and D are 2.1, 2.1, 3 and 1.8, respectively. Then the ranks assigned to them are: C=1, A=B=2.5 and D=4. Then, there are two methods to obtain the final rank order.

In the case of PROMETHEE I, the two rank orders are combined. This results in a partial pre-order of the alternatives. This is called partial because some

alternatives may be incomparable. If A outranks B in one order and B outranks A in the second order, A and B are uncomparable. In another case, when A outranks B in one order and A and B have same ranks in the second order, A is considered to outrank B. For A and B to be indifferent in the final pre-order, A and B should have same ranks in both the rank orders (Brans and Vincke 1985).

In the case of PROMETHEE II, to obtain a complete rank order, a combined score is calculated by subtracting a column sum from the corresponding row sum. A complete rank order is found by sorting the combined score calculated above in decreasing order (Brans and Vincke 1985).

The author prepares a short list of alternatives that are not outranked by any other alternatives. An outranking graph is prepared to indicate all the outranking relationships. The notations used in an outranking graph are shown in Figure 4-2.

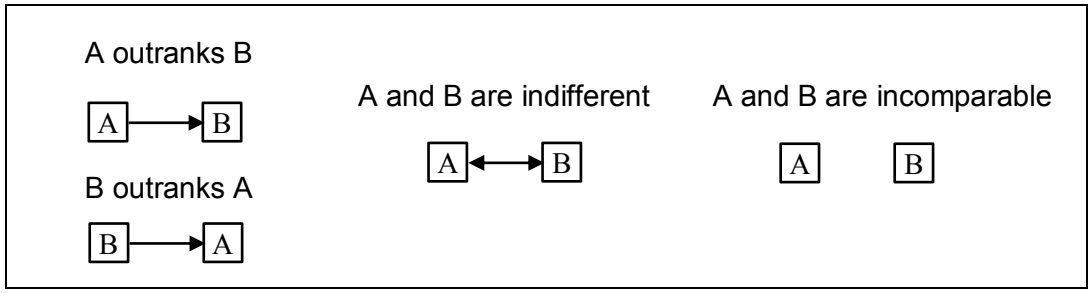


Figure 4-2. Outranking Graph Notations

As explained earlier, a partially compensating evaluation technique such as PROMETHEE is more suitable for this analysis; however, there is one drawback in this method. When a new alternative is added in the future to the list of alternatives, the entire evaluation process should be repeated. Whereas, if a SAW method is used, the analyst calculates the SAW score for the new alternative alone and compares this score with the scores of the remaining alternatives. Nevertheless, since the

PROMETHEE procedure is simple and usually software is used to apply it, the difficulty in analyzing a future alternative may be reduced.

4.4. Analysis Procedure

As shown earlier in this chapter, the author considers 22 funding alternatives, thirteen statewide major, six statewide supplementary and three local alternatives. All the alternatives are scored over eighteen sub-criteria based on their relative performances. The PROMETHEE I method is employed to perform a multi-criteria evaluation. While this mathematical method is quite sophisticated, the analyst cannot apply it straightforwardly to all the alternatives. An analyst should first understand the alternatives and their functions, and perform a systematic analysis. Use of common sense is very important in applying any multi-criteria evaluation method and in interpreting the results. This section presents a few important techniques used in the analysis process while finding a justifiable solution to the evaluation problem.

4.4.1. A Review of Scores

The scoring table shown earlier in this chapter is presented graphically in Figure 4-3 and Figure 4-4. This graphical presentation facilitates the author's comparison of the alternatives' performances over each sub-criterion and over multiple criteria. Through this visual comparison, the author finds the alternative or alternatives that score well on each criterion and those that score low. Similarly, he understands the main strengths and weaknesses of each funding alternative. In the full MCA, if an alternative is outranked with a small margin, this analysis helps in identifying the areas where an alternative can be improved so that it can overcome a marginal difference and become a preferred strategy. This analysis is also used for determining a set of the potential scenarios that may be analyzed for a better understanding of the results.

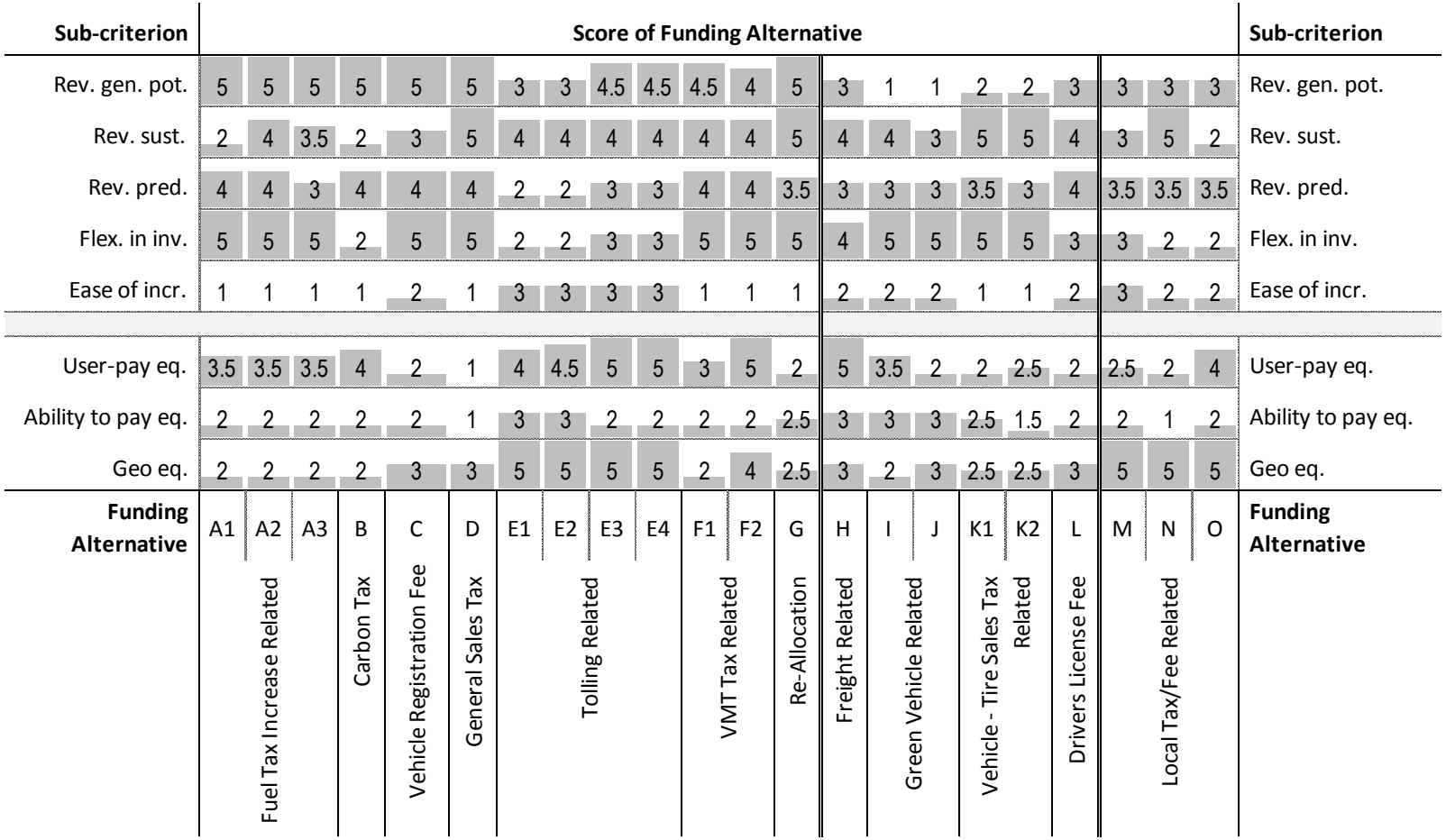


Figure 4-3. Graphical Presentation of Funding Alternative Scores over Each Sub-criterion – RG and EQ Criteria

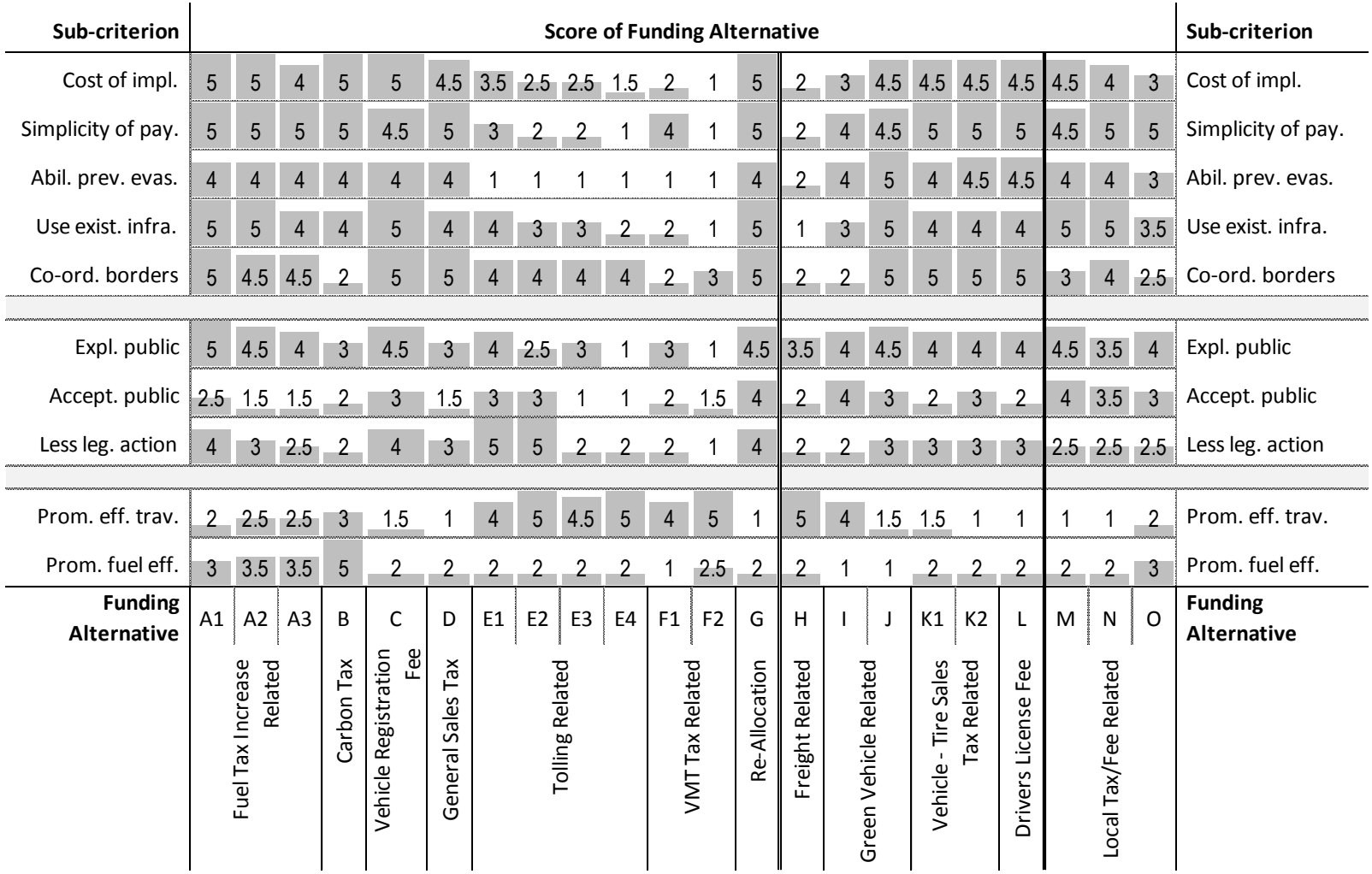


Figure 4-4. Graphical Presentation of Funding Alternative Scores over Each Sub-criterion – EI, PA&PF and PSB Criteria

The fuel tax based alternatives perform well in many criteria, including two of the top three sub-criteria, user-pay equity and ease of explaining to the public. They do not perform as well with respect to public acceptance and ability to pay equity. Alternatives related to tolling and VMT charges are based on direct use and they perform well on user-pay equity and promotion of efficient travel behavior; however, the more complex subset of those (E3, E4, F1 and F2) does not perform well on the public acceptance and ease of implementation criteria. Increase of vehicle registration fee (C), general sales tax (D) and allocation of vehicle, tire and parts sales tax (G) also are based on currently administered taxes; therefore, they all perform well on ease of implementation. But, since they are not directly based on road use, they do not perform well on user-pay equity. G performs very well on public acceptance because the public may prefer using the existing revenue to paying more taxes.

When compared to statewide alternatives, local alternatives have lower revenue generation potential, but have higher user-pay and geographic equity and better public acceptance.

4.4.2. Correlation Analysis

The author performs a correlation analysis of the scoring. Figure 4-5 shows a correlation matrix. Each cell has a correlation coefficient that represents the correlation between the scores assigned to all alternatives over a pair of sub-criteria. Coefficients highlighted are less than -0.68 and more than 0.68 and can be labeled as showing a strong correlation (Weber and Lamb 1970; Mason et al. 1983). Coefficients higher than 0.9 in absolute value can be labeled as showing a very high correlation. For this case, the author reviews the relationship between each pair of criteria where the correlation coefficient is more than 0.85 in absolute value.

Sub-criterion	RG1	RG2	RG3	RG4	RG5	EQ1	EQ2	EQ3	EI1	EI2	EI3	EI4	EI5	PA&PF1	PA&PF2	PA&PF3	PSB1	PSB2
RG1	1.00																	
RG2	-0.16	1.00																
RG3	0.45	-0.18	1.00															
RG4	0.07	0.23	0.37	1.00														
RG5	-0.28	-0.09	-0.63	-0.65	1.00													
EQ1	0.12	-0.29	-0.37	-0.34	0.35	1.00												
EQ2	-0.44	-0.15	-0.57	-0.01	0.33	0.36	1.00											
EQ3	-0.14	0.02	-0.45	**-0.72**	**0.80**	0.32	-0.03	1.00										
EI1	0.09	-0.11	0.31	0.18	-0.35	**-0.72**	-0.22	-0.43	1.00									
EI2	0.00	-0.11	0.43	0.22	-0.52	**-0.77**	-0.34	-0.51	**0.86**	1.00								
EI3	-0.18	-0.08	0.39	0.33	-0.44	**-0.74**	-0.24	-0.52	**0.85**	**0.85**	1.00							
EI4	0.04	-0.13	0.17	0.04	-0.11	**-0.68**	-0.22	-0.16	**0.92**	**0.78**	**0.74**	1.00						
EI5	0.11	0.31	0.01	0.31	-0.13	-0.53	-0.22	-0.09	0.55	0.31	0.40	0.59	1.00					
PA&PF1	-0.17	-0.20	0.09	0.23	-0.17	-0.54	0.13	-0.38	**0.77**	**0.76**	**0.69**	**0.75**	0.32	1.00				
PA&PF2	-0.47	-0.04	-0.21	-0.10	0.17	-0.38	0.25	0.08	0.33	0.36	0.37	0.45	-0.06	0.53	1.00			
PA&PF3	0.01	0.03	-0.39	-0.12	0.19	-0.28	0.28	0.08	0.45	0.22	0.09	0.53	0.55	0.46	0.39	1.00		
PSB1	0.06	-0.05	-0.42	-0.20	0.35	**0.88**	0.46	0.24	**-0.84**	**-0.87**	**-0.85**	**-0.82**	-0.55	-0.66	-0.39	-0.24	1.00	
PSB2	0.53	-0.47	0.29	-0.24	-0.34	0.26	-0.26	-0.18	0.30	0.22	0.15	0.17	-0.08	0.00	-0.32	-0.08	-0.04	1.00

Note: Coefficients that are less than -0.68 or more than 0.68 are shown in bold.

Figure 4-5. Correlation Matrix: Coefficients of Correlation between Alternative Scores on Each Pair of Sub-criteria

Taylor (1990) suggests proper interpretation of correlation coefficients before confirming a correlation. The author applies two of Taylor's suggestions while interpreting these coefficients. First, since the data used for this analysis has only 22 data points, and some of the alternatives are similar to each other, the statistical significance level in this case may be less than needed for a clear decision. Secondly, some of the correlations found here may be coincidental. The author finds that the correlation of the cost of implementation sub-criterion (EI1) with the simplicity of payment structure sub-criterion (EI2) and with the ability to use existing payment infrastructure sub-criterion (EI4) is genuine. As the tax/fee/toll varies by a number of user classes, location of use and other parameters, operating cost may be high. Similarly, when the existing payment systems and personnel are not sufficient and new systems with new and trained personnel are needed to implement a new funding mechanism, costs may rise. Another important correlation is between the user-pay equity sub-criterion (EQ1) and the promotion of efficient travel behavior sub-criterion (PSB1). A funding alternative that is largely based on the user-pay concept has more opportunity to promote a reduction in use. Identification of this relationship between PSB1 and EQ1 is useful to transportation officials. The public and elected leaders may not support the idea of using a funding policy to change user behavior. If higher user-pay equity inherently promotes better user behavior, the transportation officials do not need to introduce a funding mechanism as a tool to promote better travel behavior but rather promote its ability to charge based on use. The author notes these three relationships and evaluates one special scenario where these correlations are removed. Results of this evaluation scenario are shown under Section 4.5. Evaluation Results and Discussion.

The other relationships are not justified well. For example, the correlation between the ability to prevent evasion sub-criterion (EI3) and EI1 is not very strong because the prevention of evasion increases cost of enforcement, which is considered different from the cost of implementation in this analysis. Similarly, the relationship between the ability to prevent evasion (EI3) and the ability to promote efficient travel behavior (PSB1) appears coincidental. For this reason, the author ignores these relationships.

4.4.3. Evaluation by Groups

The author first analyzes all the statewide major alternatives as one group. While this seems to be a straight forward analysis, this analysis has some drawbacks. As the number of alternatives is large, the outranking relationships may become too complicated to be easily understood. Besides, since the group of alternatives includes sub-groups of similar alternatives such as fuel tax related and tolling related, the outranking relations may be affected by interventions. For example, since the A1 and A2 alternatives have similar scores, one may not outrank the other. In a larger group, one may prevent another from being outranked by another alternative. So, the author evaluates the sub-groups separately and finally evaluates the preferred alternatives from these evaluations with the remaining alternatives.

The author evaluates the following groups of alternatives:

0. All statewide major alternatives
1. Fuel tax based: A1, A2 and A3
2. Tolling new capacity: E1 and E2
3. Alternatives related to tolling new and existing capacity, and VMT charges: E3, E4, F1 and F2
4. Local alternatives: M, N and O
5. Shortlisted alternatives from Group 1 to Group 4 above, and B, C, D and G.
6. Non-dominated alternatives from Group 0 and Group 5
7. Charges on green vehicles: I and J
8. Supplementary alternatives: K1, K2 and L
9. Statewide vs. Local alternatives: vehicle registration fee (C vs. M), sales tax (D vs. N) and fuel tax (A1 vs. O)

When existing freeways and new freeway capacity both are tolled, the tolling becomes very broad-based and this alternative becomes closer to a VMT charge. Broad-based tolling has been suggested as a substitute for VMT charges until VMT charges become implementable (Poole 2013). For this reason, the alternatives related to tolling existing and new freeways (E3, E4), and VMT charges (F1, F2) are evaluated as one group.

The result of the evaluation of local funding alternatives (M, N and O) assists the local decision makers in selecting one funding method among the three listed here, if they decide to implement locally. In addition, in Group 9, the author tests whether implementing statewide is preferred to implementing locally, in the case of each of the three alternatives.

Supplementary alternatives K1, K2 and L are combined because all generate a small amount of revenue and cover both auto and truck users. Charges on green vehicles (I or J) can complement a fuel tax increase and increase its user-pay equity and public acceptance. Similarly, the freight weight-mile tax (H) can increase the user-pay equity of the current fuel tax system. The author assumes that alternative H will not be implemented alone but will be used only to complement a fuel tax increase. So, he does not evaluate the alternative H with the other alternatives in this research.

If the evaluations in groups from one to four result in two or more non-dominated alternatives, all of them are included in the fifth evaluation group. The author uses the union of non-dominated alternatives from Group 0 and Group 5, called Group 6, as the basis for recommending a funding strategy. This prevents any alternatives that are not dominated in one group and are dominated in another from being discarded. For the sake of completeness, the author also compares the options in Group 6 and finds the non-dominated alternatives among them.

The scenario where the alternatives are evaluated over the base criteria system with the scoring presented earlier is named the Base Scenario.

4.4.4. Screening Methods

The decision makers may find the task of scoring all the alternatives on eighteen sub-criteria expensive and time-consuming because scoring may involve data collection, surveys and analysis. The author tries to improve the efficiency of the evaluation by first evaluating the alternatives over a sub-set of sub-criteria that contains the most important sub-criteria. This process can be called a screening process. A subset of alternatives that perform well in this screening may be evaluated on all the sub-criteria in the next step.

In the list of sub-criteria, three sub-criteria – the user-pay equity (EQ1), the ease of explaining to the public (PA&PF1) and the acceptability to the public (PA&PF2) – contain more than one-third of the total weight. Good performance on EQ1 provides a sense of fairness while the other two relate to public perception. The author uses these three critical criteria for screening in the first method called Screening Method 1 (SM1). In a second method called Screening Method 2 (SM2), the author adds the revenue generation potential sub-criterion (RG1) to this set of critical criteria so that the alternatives that generate a lower amount of revenue can be filtered. Table 4-16 shows the critical criteria used for screening and their revised weights.

Table 4-16. List of Screening Methods and the Revised Criteria Weights

Screening Method	Description	Original Weight	New Weight
SM1	Only the top three sub-criteria remain in the criteria list	EQ1: 13.5%, PA&PF1: 9.2%, PA&PF2: 12.4%	EQ1: 38.5%, PA&PF1: 26.2%, PA&PF2: 35.4%
SM2	Criteria in SM1 and revenue generation potential (RG1)	RG1: 6.2%, EQ1: 13.5%, PA&PF1: 9.2%, PA&PF2: 12.4%	RG1: 15.1%, EQ1: 32.7%, PA&PF1: 22.2%, PA&PF2: 30.0%

4.4.5. Scenario Analysis

As mentioned earlier, the criteria weights and the alternative scores involve some uncertainty. So, one can expect that the evaluation results contain uncertainty. Therefore, the author performs a sensitivity analysis to examine the effect of any changes in the criteria weights or the alternative scores on the resultant shortlisted alternatives. The author defines two sets of scenarios and tests if the results are different. The paragraphs below describe the scenarios while the results are shown in the next section.

Scenarios with Varying Criteria Weights

Table 4-17 shows the list of scenarios where the base criteria system is changed. There are nine main criteria scenarios (C-1 to C-9), which correspond to changing the main criteria weights. Most of these scenarios are based on the variation in criteria weights obtained by the panel members in the expert survey. The weights of all criteria except the public acceptance and political feasibility (PA&PF) criterion are varied in both directions. The first six scenarios consist of two scenarios for each of the first three criteria, corresponding to increasing or decreasing the weight by 50%. For the potential secondary benefits, the author considers a future scenario where the increasing congestion may change the panel members' views to give more importance to the use of a funding method to promote efficient transportation facility usage. In the last scenario, the PSB criterion is removed from the list of criteria, as suggested by one of the panel members. The expert survey responses show very low variation in the weight of the PA&PF criterion (See Figure 3-22), especially on the higher side of the weights. Moreover, the ease of explaining to the public and acceptability to the public sub-criteria already include more than 20% of the total weight in the base criteria system. So, the author includes only one scenario for the PA&PF criterion, where its weight is reduced to 15%, as suggested by two panel members.

Table 4-17. List of Criteria Weight Scenarios

Scenario	Description	Original Weight	New Weight
Main criteria weight scenarios			
C-1	Increase RG weight by 50%	24%	36%
C-2	Decrease RG weight by 50%	24%	12%
C-3	Increase EQ weight by 50%	25%	38%
C-4	Decrease EQ weight by 50%	25%	13%
C-5	Increase EI weight by 50%	18%	27%
C-6	Decrease EI weight by 50%	18%	9%
C-7	Decrease PA&PF weight to 15%	27%	15%
C-8	Increase PSB weight to 15%	6%	15%
C-9	Decrease PSB weight to 0%	6%	0%
Sub-criteria weight scenarios			
SC-1	Weight of acceptability to the public (PA&PF2) is zero.	PA&PF2: 12.4%	PA&PF2: 0%
SC-2	Revenue predictability (RG3) and flexibility of investment (RG4) have same weights	RG3: 5.8%, RG4: 2.9%	RG3: 4.3%, RG4: 4.3%
SC-3	Weight of ability to pay equity (EQ2) is zero	EQ2: 6%	EQ2: 0%
SC-4	Weight of geographic equity (EQ3) is zero	EQ3: 5.5%	EQ3: 0%
SC-5	Elimination of Simplicity of payment structure, ability to use existing payment infrastructure and Promotion of efficient travel behavior	EI1: 4.7%, EI2: 5.0%, EI4: 2.9% EQ1: 13.5% PSB1: 3.1%	EI1: 12.6%, EI2: 0%, EI3: 0% EQ1: 16.6% PSB1: 0%
SC-6	Weight of revenue generation potential (RG1) is zero	RG1: 6.2%	RG1: 0%
SC-7	Weights of revenue generation potential and revenue sustainability are doubled	RG1: 6.2% RG2: 6.7%	RG1: 12.4% RG2: 13.4%

Scenarios SC-1, SC-2 and SC-3 are based on the suggestion of three different panel members. Scenario SC-4, which tests the effect of not including the acceptability to the public sub-criterion, is included because acceptability of an alternative among the public may be difficult to measure. Furthermore, the public may accept a policy when it is properly explained. In this scenario, the author assumes that the officials can support their explanations when an alternative performs better over the remaining criteria. During a review of scoring, as presented earlier, the author identifies

correlations between a few pairs of sub-criteria. Scenario SC-5 eliminates three sub-criteria to remove these correlations. Scenario SC-6 and Scenario SC-7 are related to the revenue generation. One may view that the need for more revenue is the primary reason for a search for funding alternative. To represent this objective, the weights of the revenue generation potential and revenue sustainability sub-criteria are doubled in Scenario SC-7. On the other hand, the weight of the revenue generation potential is reduced to zero in Scenario SC-6. This scenario gives an opportunity to identify any alternatives that perform well on other criteria but do not generate enough revenue. Such alternatives may be coupled with other compatible alternatives to create a better funding strategy.

Scenarios with Varying Alternative Scores

Table 4-18 presents six scoring scenarios. The author forms these scenarios after the review of the scoring table presented in Section 4.4.1. Here, Scenario S-1 corresponds to the situation when a need arises for funds in a government sector other than transportation and the funds from the vehicle, tire and parts sales tax are re-allocated to that need. To account for this type of situation, revenue sustainability is reduced.

In the Base Scenario, the author assumes that the revenues from tolling are spent in the region where the toll road exists. But when all existing highways are tolled, the revenue may be considered as broad-based revenue and hence it may be deposited into the state highway fund similar to the fuel tax revenue. In this situation, flexibility of investment increases while the geographic equity decreases. Scenario S-2 relates to such a situation.

The cost of implementing tolling and VMT charges is found to be very high at present. The Base Scenario assumes that the costs do not significantly decrease by 2020. Scenario S3 assumes that cost of implementation as well as efforts needed for prevention of evasion significantly decrease before 2020. In that case, scores of alternatives related to tolling and VMT charges will improve for these two criteria.

Table 4-18. List of Scoring Scenarios

Scenario	Description	Criterion	Original Scores	New Scores
S1	Revenue sustainability of G decreases.	RG2	G: 5	G: 3
S2	Revenue from E3 and E4 goes to State Highway Fund. Flexibility increases, Geographic equity decreases.	RG4	E3: 3, E4: 3	E3: 5, E4: 5
		EQ3	E3: 5, E4: 5	E3: 4, E4: 4
S3	Cost of implementation and efforts needed for prevention of evasion of tolling and VMT charges decrease.	RG1	E1: 3, E2: 3, E3: 4.5, E4: 4.5, F1: 4.5, F2: 4	E1: 3.5, E2: 3.5, E3: 5, E4: 5, F1: 5, F2: 5
		EI1	E1: 3.5, E2: 2.5, E3: 2.5, E4: 1.5, F1: 2, F2: 1	E1: 4, E2: 4, E3: 3, E4: 3, F1: 4, F2: 3
		EI3	E1: 1, E2: 1, E3: 1, E4: 1, F1: 1, F2: 1	E1: 3, E2: 3, E3: 3, E4: 2.5, F1: 3, F2: 2.5
S4	Public acceptance of fuel tax increase improves.	PA&PF2	A1:2.5, A2:1.5, A3:1.5	A1:4, A2:3.5, A3:3.5
S5	Public acceptance of tolling of existing freeways improves.	PA&PF2	E3:1, E4: 1	E3: 3, E4: 3
S6	Public acceptance of VMT charges improves.	PA&PF2	F1: 2,F2: 1.5	F1: 4, F2: 3.5
S7	Public acceptance of the re-allocation of vehicle, tire and parts sales tax to transportation decreases	PA&PF2	G: 4	G: 3

The next three scenarios S4, S5 and S6 assume that the public acceptance of one of the three sets of alternatives – related to fuel tax, related to tolling of existing freeways and related to VMT charges – increases.

4.5. Evaluation Results and Discussion

In this section, the author presents the results of the evaluation process. First, the Base Scenario preferred alternatives are presented. Then, the screening process results are compared with the Base Scenario results. The results of the scenario analysis, which shows how the results of the Base Scenario are affected by different variations in the criteria weights and alternative scores, are presented next. Finally, the author discusses these results and provides recommendations about future funding strategy.

4.5.1. Evaluation Results

The primary result of the evaluation is a set of funding alternatives that are not outranked by other alternatives. Evaluation of each group of alternatives results in a set of outranking relationships.

Base Scenario

First, in the Base Scenario, the author evaluates the alternatives in different groups as shown earlier using the base criteria system. Table 4-19 summarizes the results of the Base Scenario evaluation by group. For each group, it shows the set of alternatives that are not outranked by others and thus, “non-dominated”. The “partial pre-order” column contains the outranking relationships. Here, for any alternatives A and B, A-B indicates that A outranks B and A ≈ B indicates that A and B are indifferent. Outranking graphs representing these partial pre-orders for Group 0 and Group 5 are shown in Figure 4-6 and Figure 4-7, respectively. The results of the two screening

methods are placed next to the results of the Base Scenario to facilitate a comparison. The results of the screening methods are discussed under the next sub-heading.

Table 4-19. Evaluation Results – Base Scenario

Group Number	Alternatives	Base	
		Non-Dominated	Partial pre-order
0	All Statewide Major (thirteen alternatives)	A2,G	Graph in Figure 4-6
1	A1,A2,A3	A1,A2	A1-A3, A2-A3
2	E1,E2	E1	E1-E2
3	E3,E4,F1,F2	E3	E3-E4; E3-F1; E3-F2
4	M,N,O	M,O	M-N; O-N
5	A1,A2,B,C,D,E1, E3,G,M,O	A1,E1,G	A1-A2-C-O-B-D; A1-M-O-B-D; G-A2-C-O-B-D; G-E3-D G-M-O-B-D; E1-E3-D
6a	A1,A2,E1,G	A1,E1,G	A1-A2; G; E1
7	I,J	I	I-J
8	K1,K2,O	K2	K2-K1,K2-L
9	C vs. M; D vs. N; A1 vs. O	C,N,A1	C-M; N-D; A1-O

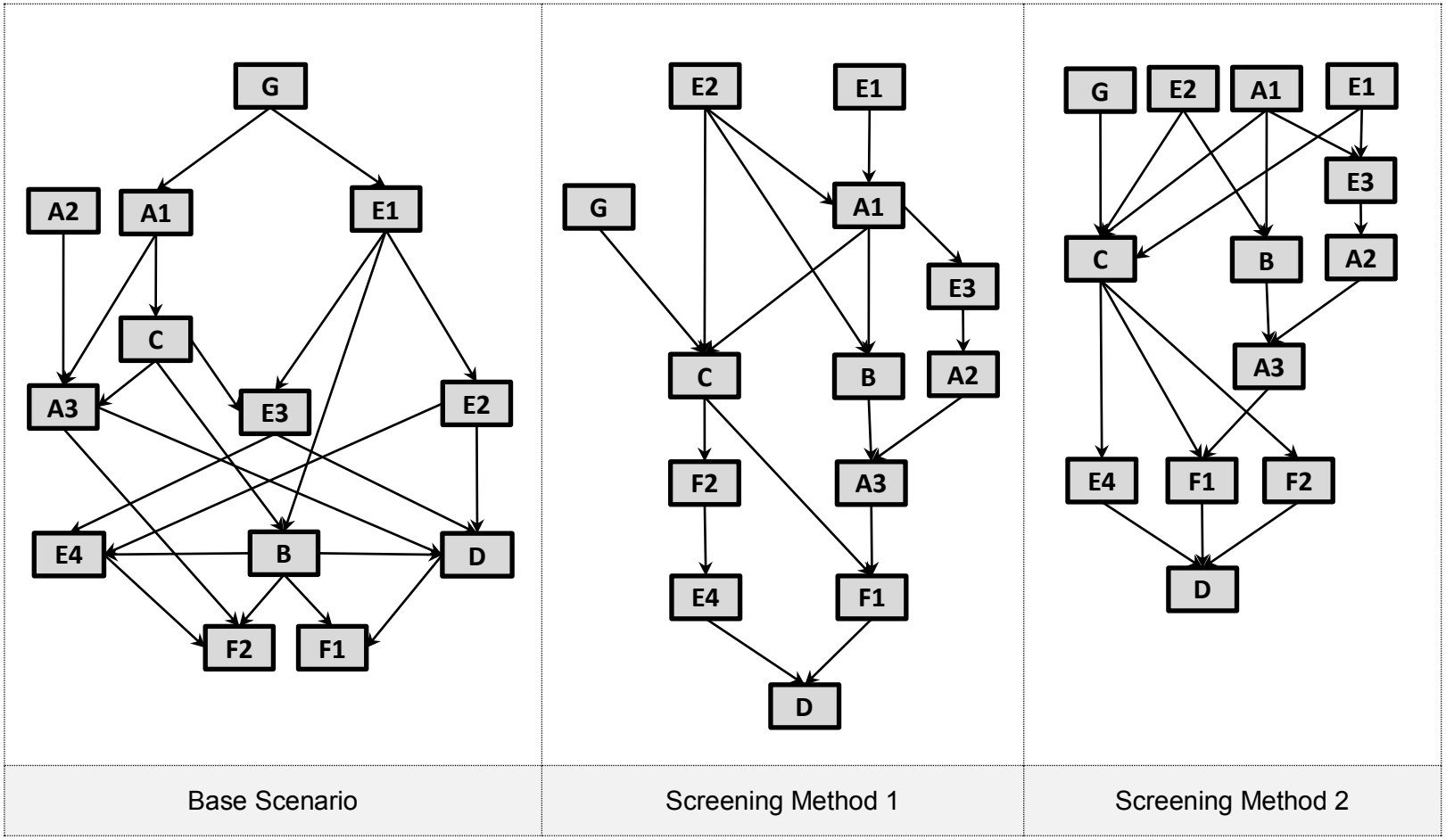
The following are some basic deductions from this analysis:

- In the Base Scenario, when the base criteria system is used, increasing fuel tax with fixed amount (A1), increasing fuel tax and indexing it to inflation (A2), tolling all new freeway capacity with fixed tolls (E1) and re-allocation of vehicle, tire and parts sales tax revenue towards transportation (G) are not dominated by other alternatives, and are on the shortlist. This list is the union of non-dominated alternatives from Group 0 and Group 5 and is called Group 6a. When these alternatives are compared among themselves, A2 is outranked. In the evaluation of Group 5, A1 and G

outrank all the other alternatives except E1. E1 is not comparable to A1 and G; it dominates tolling new capacity and all existing urban freeways with fixed tolls (E3), and increasing statewide sales tax (D). G outranks E3. E1 and E3 are incomparable with the remaining alternatives because they perform better than them on some criteria and worse than them on some other criteria. While E1 and E3 have better user-pay equity, for example, than other alternatives, they perform poorly on the ease of implementation criterion. E3 has poor public acceptance also.

- Indexing fuel tax to fuel price (A3) is outranked by increasing fuel tax by fixed amount (A1) and indexing it to inflation (A2). A1 and A2 are incomparable with each other. Tolling new freeway capacity with fixed tolls (E1) outranks tolling the same with variable tolls (E2), because E1 scores as well as or better than E2 for most criteria. E2 is slightly better than E1 in user-pay equity and promotion of efficient travel behavior. Among alternatives corresponding to tolling existing and new capacity (E3, E4), and VMT charges (F1, F2), tolling with fixed tolls (E3) outranks the other three. Although E3 has poor public acceptance, it outranks F1 in user-pay equity and outranks E4 and F2 in ease of implementation. A1, A2, E1 and E3 are included in the alternatives in Group 5.
- Among the local alternatives, increasing the local vehicle registration fee (M) and imposing a local fuel tax (O) outrank increasing the local sales tax (N). M and O are incomparable, and are included in the alternatives in Group 5.

- When statewide and local alternatives are compared, the general sales tax is preferred for local implementation by a slight margin; local sales tax is currently being implemented in many metropolitan areas in Texas, especially to fund transit development. The vehicle registration fee and fuel tax are preferred for statewide implementation. The main drawback of implementing them locally is due to problems in their implementation.
- The analysis shows that charging the green vehicles by their mileage is preferred to charging them a flat vehicle registration fee. Charging by mileage scores better on the user-pay equity sub-criterion.
- Among the three supplementary alternatives evaluated, increasing tire sales tax (K2) is preferred to increasing vehicle sales tax (K1) and increasing drivers license fee (L). K2 has better user-pay equity than the other two.



Base Scenario	Screening Method 1	Screening Method 2

Figure 4-6. Outranking Relationships for Evaluation of All Statewide Major Alternatives (Group 0)

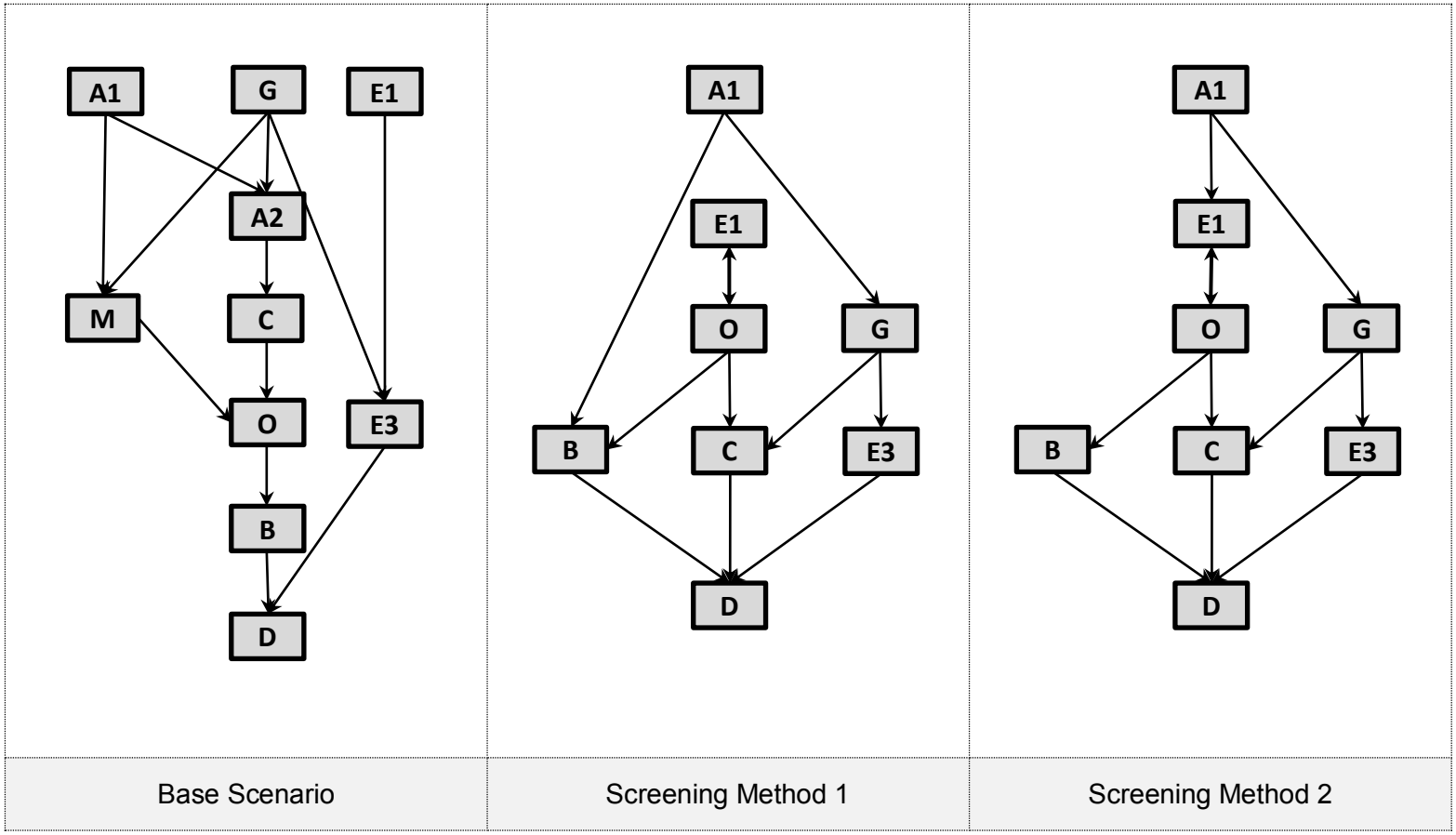


Figure 4-7. Outranking Relationships for Evaluation of Alternatives in Group 5

Interpretation of Outranking Graphs: The outranking graphs in Figure 4-6 and Figure 4-7 use the notations in Figure 4-2. To help the reader interpret these graphs, Figure 4-6 Base Scenario is explained here. In Figure 4-6 Base Scenario, many partial rank orders are seen. G-E1-E2-D-F1, G-E1-E3-E4-F2, A2-A3-F2 are some of them. It also shows that many pairs are not comparable. For example, A1 and E1 are incomparable, even though each of them is outranked by G. Similarly, A1 and A2, E2 and E3, E3 and B, and F1 and F2 are incomparable.

Evaluation by Screening

The author performs the evaluations by group using the two methods of screening as explained in the previous section. The non-dominated alternatives and the partial pre-orders resulting from these two methods are presented in Table 4-20. The outranking graphs are presented in Figure 4-6 and Figure 4-7.

Table 4-20. Evaluation Results – Screening Methods

Group	Alternatives	Screening Method 1		Screening Method 2	
		Non-Dominated	Partial pre-order	Non-Dominated	Partial pre-order
0	All Statewide Major	E1,E2,G	Graph in Figure 4-6	A1,E1,E2,G	Graph in Figure 4-6
1	A1,A2,A3	A1	A1-A2-A3	A1	A1-A2-A3
2	E1,E2	E1	E1-E2	E1	E1-E2
3	E3,E4,F1,F2	E3	E3-F2-E4; E3-F1	E3	E3-F2-E4; E3-F1
4	M,N,O	O	O-M-N	O	O-M-N
5	A1,B,C,D,E1, E3,G,O	A1,E1,O	(E1≈O)-B-D; (E1≈O)-C-D; A1-C-D; A1-G-E3-D; A1-B-D; A1-G-C-D;	A1	A1-(E1≈O)-C-D; A1-(E1≈O)-B-D; A1-G-C-D; A1-G-E3-D

These two screening methods result in similar results. They have the same results for Group 1 through Group 4; however, these results differ from those obtained in the Base Scenario; since only a few sub-criteria are used here, chances of two alternatives inside one group becoming incomparable are lower. Increasing fuel tax with fixed amount (A1) dominates increasing fuel tax and indexing it to inflation (A2) because A2 has lower public acceptance than A1. In these two scenarios, the comprehensive VMT charge system (F2) dominates the tolling of existing freeways with variable tolls (E4) because of its slightly higher public acceptance. In the local alternatives group, the fuel tax (O) becomes the only non-dominated alternative because of its higher performance on the user-pay equity sub-criterion.

When the results of Group 0 and Group 5 are compared between the two methods, the presence of the revenue generation potential sub-criterion in Screening Method 2 gives advantage to A1 because it scores higher on this sub-criterion than the tolling new freeway capacity (E1) and the local fuel tax (O). The unions of the shortlists of Group 0 and Group 5 from the two methods (Group 6b and Group 6c, respectively) are further evaluated using the base criteria system. Table 4-21 presents the results of this evaluation. When alternative O is in the pool (in Group 6b), A1 and the reallocation of vehicle, tire and parts sales tax revenue (G) become the non-dominated alternatives. A1 outranks E1, while A1 and G outrank E2 and O. When O is not in the pool (in Group 6c), G slightly outranks A1 and E1 and becomes the sole non-dominated alternative. As shown earlier in Table 4-19, the shortlist obtained from Group 6a in the Base Scenario includes A1, E1 and G; this list includes all the shortlisted alternatives from Groups 6b and 6c. As an overall test, the author assesses A1, E1 and G and finds that

all three alternatives remain in the non-dominated list with A1 and G becoming indifferent.

Table 4-21. Evaluation Results – Screened Alternatives

Group Number	Alternatives	Non-Dominated	Partial pre-order
6a (shortlist from Base Scenario)	A1,A2,E1,G	A1,E1,G	A1-A2; G; E1
6b (shortlist from SM1)	A1,E1,E2,G,O	A1,G	A1-E1-O; A1-E2; G-O; G-E2
6c (shortlist from SM2)	A1,E1,E2,G	G	G-A1-E1-E2
6d (Overall)	A1,E1,G	A1,E1,G	A1≈G; E1

Policy Recommendations

As mentioned in the previous section, the author bases the recommendations on the alternatives in Group 6 – Group 6a, 6b and 6c. In all these groups, increasing fuel tax, tolling new capacity and reallocation of vehicle, tire and parts sales tax are included in some variation. Hence, these three alternatives should form a surface transportation funding strategy for the future of Texas. Further investigation is necessary to develop the best possible combination of these three and a detailed funding policy. In the evaluation of Group 6 in the Base Scenario, the basic forms of the above alternatives, A1, E1 and G are non-dominated. So, the author forms the recommendations.

As a first measure, the author recommends that the fuel tax should be raised. The exact amount of increase may be determined from more analysis regarding the current and expected funding deficiencies, and the effect of inflation and the expected

increase in vehicle fleet fuel efficiency on the future revenue from the fuel tax. Tolling of new freeway capacity is already being implemented in Texas, at least in urban areas and it does not require any action from the Legislature. Hence, the author recommends that the tolling of new freeway capacity should be continued. Although the re-allocation of vehicle, tire and parts sales tax towards transportation is one of the shortlisted alternatives, the author believes that this option can be implemented only temporarily because when the need occurs for the remaining government sectors, funds may be redirected to those sectors.

The results of the scenario analysis to be discussed under the following sub-headings are helpful in assessing how the uncertainties in the criteria weights or the alternative scores used in the Base Scenario affect the recommendations made above. Under each scenario, the author discusses the results and their implications to the policy recommendations made above.

A Note on the Advantage of Screening Methods

This analysis shows that one of the two screening methods discussed here may be used effectively to make the evaluation process efficient. The sub-criteria included in the screening process are highly important and are clearly visible to the public; the acceptability to the public is the main concern for the policy makers and should be measured first through appropriate surveys. These sub-criteria capture about 35 to 40 percent of the total weight. So, the alternatives that perform well on these sub-criteria are likely to remain in the shortlist even with the inclusion of other sub-criteria, as long as the alternatives do not perform significantly worse than the alternatives immediately below them in the preference order on the other criteria. In addition, the scoring of alternatives on these sub-criteria can be developed even if the

alternatives are not fully structured. For these reasons, the author suggests that one should assign scores to the alternatives on these critical criteria first. Once a set of alternatives that perform well in the screening are identified, that set can be further evaluated on the full criteria system with a more detailed scoring process. In that step, the analyst may study variations of the shortlisted alternatives, which are defined in more detail. On a final cautionary note, the set of screening criteria selected here is specific to the base criteria and the weights established in this research. If the criteria or the weights change, the screening criteria should be modified accordingly.

Scenario Analysis – Scenarios with Varying Criteria Weights

For each scenario, the author evaluates the statewide major alternatives (Group 0) first. Then, he evaluates the alternatives in groups from one to five. He reviews the effect of the variation in the criteria weights on the lists of non-dominated alternatives in Group 0 and Group 5. In addition, he tests the group of non-dominated alternatives (Group 6), which is obtained by combining the non-dominated alternatives from Group 0 and Group 5. This Group 6 evaluation is named as final evaluation. The fourth group he tests is the group of alternatives obtained through screening using the Screening Method 1 – A1, E1, E2, G and O. A summary of non-dominated alternatives obtained in each scenario where the main criteria weights are varied is presented in Table 4-22. Table 4-23 shows the summary of non-dominated alternatives obtained in each scenario where the sub-criteria weights are varied. Each column represents the results of one of the four evaluation groups discussed above. The next paragraphs list some notable findings from each scenario. Under each scenario, the results of the scenario analysis are followed by a discussion on their implications to the recommendations made after the Base Scenario analysis.

Scenario C-1: When the weight of the RG criterion is increased by 50%, the re-allocation of vehicle, tire and parts sales tax to transportation (G) gains because it scores better on many aspects of revenue generation. It outranks the fuel tax increase by fixed amount (A1) in Group 5. The tolling all new freeway capacity with fixed tolls (E1) keeps its place in the non-dominated list of Group 5, mainly due to its performance on sustainability, but eventually in the final evaluation, it is outranked by G.

First, this analysis shows that when the weight of the revenue generation criterion increases, no new option is added to the recommended alternatives set. It recommends that the funds from the vehicle, tire and parts sales tax should be re-allocated to transportation.

Since this alternative has a high risk of withdrawal when other government sectors need funds, the author still recommends the fuel tax increase and indexing to inflation (A2) and the tolling all new freeway capacity with fixed tolls (E1), which are only dominated by the re-allocation of vehicle and tire sales tax to transportation. This analysis shows that if the RG criterion weight increases, the recommendation changes from a one-time increase in the fuel tax to an annual increase with inflation such that the fuel tax is made more sustainable. In another words, suppose that the Base Scenario recommendations are implemented, and in the future, the importance of revenue generation increases; then, the fuel tax should be indexed to inflation. Tolling all new freeway capacity with fixed tolls is still recommended, mainly due to its good revenue sustainability.

Table 4-22. Comparison of Non-dominated Alternatives in Scenarios with Varying Main Criteria Weights

Scenario	Description	List of Non-dominated Alternatives by Group				
		All Statewide Major (Group 0)	Group 5		Group 6[1]	Screened List from SM1 (A1,E1,E2,G,O)
Base	Base criteria system	A2,G	A1,E1,G		A1,E1,G	A1,G
Main criteria weight scenarios						
C-1	Weight of RG is increased by 50%.	A2,G	E1,G		G	G
C-2	Weight of RG is decreased by 50%.	A1,E1,G	A1,E1		A1,E1	A1,E1,G
C-3	Weight of EQ is increased by 50%.	A1, A2, E1, E2	A1,A2,E1,G		A1,E1,E2	A1,E1
C-4	Weight of EQ is decreased by 50%.	G	G		G	G
C-5	Weight of EI is increased by 50%.	A2,G	E1,G[2]		G	A1,G
C-6	Weight of EI is decreased by 50%.	A2, E1,G	A1,E1,G		A1,E1,G	A1,E1,G
C-7	Weight of PA&PF is decreased to 15%.	A1,A2, E1,G	E1,E3,A2		A1,A2,E3,G	A1,G
C-8	Weight of PSB is increased to 15%.	A1,A2, E1,G	A2, E1,G		A2,E1	A1,G
C-9	Weight of PSB is decreased to 0%.	A2,G	G		G	A1,G

Notes:

1. Under Group 6, all non-dominated alternatives from Group 0 and Group 5 are evaluated. For example, under scenario C-2, A1, E1 and G are evaluated and under scenario C-3, A1, A2, E1, E2 and G are evaluated.

2. A1 is eliminated because the local fuel tax (O) is not in the list of alternatives evaluated in Group 5. See more explanation in the following discussion.

Table 4-23. Comparison of Non-dominated Alternatives in Scenarios with Varying Sub-criteria Weights

Scenario	Description	List of Non-dominated Alternatives by Group				
		All Statewide Major (Group 0)	Group 5		Group 6[1]	Screened List from SM1
Base	Base criteria system	A2,G	A1,E1,G		A1,E1,G	A1,G
Sub-criteria weight scenarios						
SC-1	Weight of acceptability to the public (PA&PF2) is zero.	A1,A2,E1	A1,A2,E1		A2,E1	A1
SC-2	Revenue predictability (RG3) and flexibility of investment (RG4) have same weights.	A2,G	A1,E1,G		A1,E1,G	A1,G
SC-3	Weight of ability to pay equity (EQ2) is zero.	A1,A2,G	A1,A2,E1,G		A1,E1,G	A1,G
SC-4	Weight of geographic equity (EQ3) is zero.	A1,A2,G	A1,G		A1,A2,G	A1,G
SC-5	EI2, EQ2 and PSB1 sub-criteria are eliminated.	A2,G	A1,E1,G		A1,E1,G	A1,E1,G
SC-6	Weight of revenue generation potential (RG1) is zero.	A2,G	A1,E1,G		A1,E1,G	A1,E1,G
SC-7	Weights of revenue generation potential and revenue sustainability are doubled.	A2,G	A2,G		G	G

Note: 1. Under Group 6, all non-dominated alternatives from Group 0 and Group 5 are evaluated. For example, under scenario SC-1, A1, A2 and E1 are evaluated and under scenario SC-2, A1, A2, E1 and G are evaluated.

Scenario C-2: When the weight of the RG criterion is decreased by 50%, fuel tax increase by fixed amount (A1) dominates fuel tax increase and indexing to inflation (A2), and fuel tax increase and its conversion to sales tax on fuel (A3) because A1's low score on revenue sustainability has a lower effect on the result. In this scenario, tolling all new freeway capacity with fixed tolls (E1) and tolling all new freeway capacity with variable tolls (E2) gain because their low scores on the revenue generation potential sub-criterion (RG1) and the revenue predictability sub-criterion (RG3) have a lower effect. On the other hand, re-allocation of vehicle, tire and parts sales tax to transportation (G) is outranked in Group 5 and in the final evaluation. When only A1, E1, E2, G and the local fuel tax (O) are compared, G remains in the final list of non-dominated alternatives.

In this scenario, the main recommendations do not change. This shows that the urban decision makers who do not value revenue generation as much arrive at the same recommendation as the Base Scenario. So, the fuel tax increase by fixed amount (A1) and the tolling all new freeway capacity with fixed tolls (E1) remain as the recommended options. The temporary option, the re-allocation of vehicle, tire and parts sales tax to transportation, is not recommended under this scenario.

Scenario C-3: When the weight of the EQ criterion is increased by 50%, the alternatives with better scores for this criterion including the fuel tax related and the tolling related alternatives rise in the rank order. Since the re-allocation of vehicle, tire and parts sales tax to transportation (G) has a lower score for the user-pay equity sub-criterion than the fuel tax and tolling related alternatives, it is outranked in the final evaluation. Tolling all new freeway capacity with variable tolls (E2), which is not in the list of non-dominated alternatives in the Base Scenario, is now non-dominated. Among

the alternatives related to tolling existing freeways and VMT charges (E3, E4, F1 and F2), the simple VMT charge (F1) is dominated by the other three because F1 performs poorly on the EQ criterion. Among the local alternatives, local fuel tax (O) performs the best on the user-pay equity sub-criterion; therefore, it outranks the other two alternatives.

In this scenario, the main recommendations do not change; however, tolling all new freeway capacity with variable tolls (E2) is also recommended because it performs well on the user-pay equity, which represents more than 50% of the equity criterion weight. This indicates that tolling new freeway capacity with variable tolls appears a strong candidate for urban implementation where equity is more valued. Since both tolling options, fixed tolls and variable tolls, are preferred, fixed tolls may be suitable for less congested areas while variable tolls can be implemented on urban freeways which are more congested. The temporary option, the re-allocation of vehicle and tire sales tax to transportation (G) is not recommended because it does not perform well on the equity criterion.

Scenario C-4: When the weight of the EQ criterion is decreased by 50%, the alternatives that do not perform well on this criterion improve in their ranks. The re-allocation of vehicle, tire and parts sales tax to transportation (G) outranks all the other alternatives. The vehicle registration fee increase (C) outranks the fuel tax increase and indexing to inflation (A2) and is incomparable with the fuel tax increase by fixed amount (A1) in this scenario, whereas in the Base Scenario, it is outranked by A1 and A2. The tolling existing urban freeways and all new freeway capacity with variable tolls (E4), and the comprehensive VMT charges (F2) which have better scores for the user-

pay equity sub-criterion, are outranked by the tolling existing urban freeways and all new freeway capacity with fixed tolls (E3) and the simple VMT charge (F1).

To identify the next best alternative in this scenario, the author tests another scenario where G is not included in the evaluated list. In this case, A2 and E1 become the non-dominated alternatives.

Based on the responses from the expert survey conducted in this study, policy makers considering the equity and fairness at such a low importance as in this scenario is very less likely. If such a situation occurs, the re-allocation of vehicle, tire and parts sales tax to transportation (G) is recommended. When equity is less important as the case for rural policy makers, the vehicle registration fee increase gets higher preference, which makes it a potential compromise solution for raising funds statewide. For the reasons mentioned earlier, if G is considered as a temporary alternative, the fuel tax increase and indexing to inflation (A2) and the tolling all new freeway capacity with fixed tolls (E1) are recommended. These do not differ conceptually from the Base Scenario recommendations.

Scenario C-5: When the weight of the EI criterion is increased by 50%, the alternatives such as tolling and VMT charges, which are complex and have a high cost of implementation slide down the rank order. The re-allocation of vehicle, tire and parts sales tax to transportation (G) alone remains in the final evaluation. Among the local alternatives, local registration fee increase (M) outranks the other two, the local sales tax increase (N) and the local fuel tax (O). So, O is not in the evaluated list in Group 5. The fuel tax increase by fixed amount (A1) is outranked by G in Group 5 although A1 has very good scores on the EI criterion. After further analysis, the author realizes that not having O in Group 5 in this scenario decreases the preference score of A1 and

causes this unexpected result. So, he suggests that more investigation of the current method of analysis by groups and the screening is necessary before its full-fledged usage.

This scenario is perceivable given that the EI criterion weights from the survey vary significantly on the upper side. According to one of the panel members, a simple and low cost funding mechanism is favored in smaller regions. In this scenario, no new alternative is added to the recommended set but the tolling is not recommended. The Fuel tax increase by a fixed amount is recommended along with re-allocation of some revenue from vehicle, tire and parts sales tax towards transportation.

Scenario C-6: When the weight of the EI criterion is decreased by 50%, the tolling all new freeway capacity with fixed tolls (E1) climbs up in the ranking. It outranks two more alternatives, the local fuel tax (O) and the carbon tax (B). The list of non-dominated alternatives in the final evaluation remains the same as that in the Base Scenario. E1 is added to the list of non-dominated alternatives when the list of alternatives screened by Screening Method 1 is evaluated.

A notion that the implementation issues can be solved over time by better technology or research may result in this scenario. This scenario does not affect the future funding policy suggested in the Base Scenario. Tolling becomes slightly more favorable as its low performance on some implementation issues has a lower effect.

Scenario C-7: When the weight of the PA&PF criterion is decreased to 15%, the tolling existing urban freeways and all new freeway capacity with fixed tolls (E3) shows the biggest improvement in its rank. The fuel tax increase and indexing to inflation (A2) also shows improvement. E3 and A2 join the list of non-dominated alternatives after the final evaluation. Since the advantage of the tolling all new freeway

capacity with fixed tolls (E1) having good public acceptance is reduced, other alternatives outrank E1.

Based on the variation in the weight of PA&PF criterion from the survey, this scenario represents the lower extreme of the policy makers' individual weights. This scenario increases the scope of the recommendations made in the Base Scenario. The fuel tax increase option is appended by its indexing to inflation. The tolling option is expanded to existing urban freeways also. Suppose that a fuel tax increase or tolling new freeway capacity is implemented; if, in the future, the public acceptance and political feasibility becomes less important than other criteria such as revenue generation or promotion of efficient use of the transportation system, fuel tax may be tied to inflation or tolls may be imposed on existing facilities as well.

Scenario C-8: When the weight of the PSB criterion is increased to 15%, the alternatives that have better potential to promote efficient travel behavior or better fuel efficiency improve their ranks. This increase in the weight of the PSB criterion is not sufficient to remove the re-allocation of vehicle, tire and parts sales tax to transportation (G) from the shortlist of the evaluation of Group 5; however it removes G from the shortlist of the final evaluation. The fuel tax increase and indexing to inflation (A2) replaces the fuel tax increase by a fixed amount (A1) in the final list.

The NSTIFC study gives a weight of about 25% to the economic efficiency related criteria. The author tests a scenario where the PSB criterion weight in Scenario C-8 is doubled, increasing to 30%. In this case, the carbon tax (B) is one of the shortlisted alternatives in Group 5. In the Group 6 evaluation, the tolling of new freeways with fixed and variable tolls, that is, E1 and E2 become the non-dominated alternatives.

As the congestion and air pollution continue to increase and the resources decline, one can perceive that use of a funding policy to promote efficient travel behavior and fuel use will be more important. In this scenario, there is no significant change in the main recommendations conceptually. In addition to a fixed increase in the fuel tax, indexing it to inflation is recommended. Tolling new freeway capacity with fixed tolls remains as a recommendation. The re-allocation of vehicle, tire and parts sales tax is not recommended. If the promotion of efficient transportation system use becomes even more important, the tolling with variable tolls, which can better advance this goal, gradually moves into the recommended list, replacing the fuel tax increase.

Scenario C-9: When the weight of the PSB criterion is decreased to zero, the fuel tax increase by fixed amount (A1) and the tolling all new freeway capacity with fixed tolls (E1), which have better scores on the PSB criterion are outranked by the re-allocation of vehicle, tire and parts sales tax to transportation (G). G is the only alternative remaining after the final evaluation. The carbon tax (B), which outranks the sales tax increase (D) in the Base Scenario, becomes incomparable with D.

To identify the next best alternative in this scenario, the author tests another scenario where G is not included in the evaluated list. In this case, the vehicle registration fee increase (C) joins the fuel tax and tolling related alternatives in the Group 0 shortlist; however, in the final evaluation of Group 6, A1 and E1 become the non-dominated alternatives.

Under this scenario, the future funding strategy does not depend on its ability to promote efficient system use. No new alternatives are added to the recommended list. The re-allocation of vehicle, tire and sales tax towards transportation is recommended; however, since this is considered a temporary alternative, the next best alternatives,

the fuel tax increase with fixed amount and the tolling new freeway capacity with fixed tolls are recommended as in the Base Scenario.

The following paragraphs discuss some notable findings from the analysis of the scenarios where weights of certain sub-criteria are varied.

Scenario SC-1: When the weight of the acceptability to the public sub-criterion (PA&PF2) becomes zero, alternative G loses its advantage over the fuel tax alternatives. It is outranked by the fuel tax related alternatives A1 and A2. The fuel tax increase and indexing to inflation (A2) outranks the fuel tax increase by fixed amount (A1) even though its public acceptance is lower. The tolling existing urban freeways and all new freeway capacity with fixed tolls (E3) is only outranked by A1, A2 and the tolling all new freeway capacity with fixed tolls (E1).

As explained in the previous section, this scenario is based on the thought that if a funding alternative performs better on all the remaining criteria, its public acceptance increases. In this scenario, the recommendations from the Base Scenario, the fuel tax increase and the tolling new freeway capacity remain as the primary options; however, the fuel tax increase with inflation is preferred. The re-allocation of vehicle, tire and parts sales tax towards transportation is no longer recommended.

Scenario SC-2: One of the panel members is concerned that the average weight of the flexibility in investment sub-criterion is very low; he thinks that it should be as much as that of the revenue predictability criterion. This scenario tests the effect of this opinion. When the weight of the sub-criteria revenue predictability (RG3) and flexibility in investment (RG4) are equal, the lists of non-dominated alternatives do not change. The outranking relationships also do not change significantly. The performance of the re-allocation of vehicle, tire and parts sales tax to transportation (G)

over the tolling all new freeway capacity with fixed tolls (E1) increases slightly because the difference between the scores of G and E1 on the flexibility of investment (RG4) sub-criterion is higher than that on the revenue predictability (RG3) sub-criterion.

The policy recommendations from the Base Scenario are not affected by this scenario. The fuel tax increase with fixed amount and the tolling new freeway capacity with fixed tolls remain as primary options with the re-allocation of vehicle, tire and parts sales tax to transportation as a temporary or supplementary option. This indicates that the flexibility being as important as the predictability does not affect the recommendations, especially because the alternatives related to tolling which give lower flexibility in investment also have lower revenue predictability.

Scenario SC-3: When the weight of the ability to pay equity sub-criterion (EQ2) becomes zero, no significant changes in the rank order occur. This is possible because most alternatives do not perform well on this sub-criterion.

The policy recommendations from the Base Scenario are not affected by this scenario; therefore, those policy makers who do not support the ability to pay concept can embrace the Base Scenario recommendations.

Scenario SC-4: When the weight of the geographic equity sub-criterion (EQ3) becomes zero, the tolling all new freeway capacity with fixed tolls (E1) goes out of the final list of non-dominated alternatives and the fuel tax increase and indexing to inflation (A2) joins the list.

In the absence of the geographic equity sub-criterion, the tolling option is not recommended. Both the fuel tax fixed increase and its indexing to inflation are recommended. So, based on the funding needs, the policy makers may decide the extent and frequency of the fuel tax increase. The re-allocation of vehicle, tire and parts

sales tax to transportation can be used temporarily to supplement the fuel tax increase. This analysis also indicates that tolling is most viable in regions that need additional funding and when the toll revenue is returned to that region.

Scenario SC-5: The correlation analysis discussed earlier has shown that alternative scores on some sub-criteria may be correlated. This scenario tests the effect of merging these correlated criteria on the recommendations. When three sub-criteria, simplicity of payment structure (EI2), ability to use existing payment infrastructure (EI4) and promotion of efficient travel behavior (PSB1), are removed, the list of non-dominated alternatives do not change supporting the idea that these three sub-criteria are redundant.

The policy recommendations from the Base Scenario do not change due to this scenario. Since the recommendations are not affected, the analyst may save some time and effort by considering any one of the correlated criteria with a weight equal to the total of their weights. However, the author recommends that both the user-pay equity and the PSB1 criteria are included because the PSB1 sub-criterion measures how visible a user charge is, which is not measured by the EQ1 sub-criterion.

Scenario SC-6: By removing the revenue generation potential sub-criterion (RG1) from consideration, this scenario gives an opportunity to those alternatives which may perform well on many other criteria but do not generate large amount of revenue. Such alternatives may be used as good supplements to the current system. When the weight of the RG1 sub-criterion is zero, the list of non-dominated alternatives does not change. The tolling all new freeway capacity with fixed tolls (E1) and the local alternatives (M and O), which have lower revenue generation potential improve their position in the rank order. E1 outranks the carbon tax (B), M becomes incomparable

with A1 and O becomes incomparable with the vehicle registration fee increase (C). When the alternatives resulting from SM1 are compared in this scenario, E1 joins the shortlist.

The results indicate that the local option taxes, especially the local vehicle registration fee, become prominent options in this scenario. When the implementation of the fuel tax increase is not politically feasible, this analysis points to one of the local options as a promising alternative. Tolling new freeway capacity also becomes more important.

Scenario SC-7: When the weights of the revenue generation potential sub-criterion (RG1) and the revenue sustainability sub-criterion (RG2) are doubled, the fuel tax increase by fixed amount (A1), which has lower revenue sustainability and the tolling all new freeway capacity with fixed tolls (E1), which has lower revenue generation potential, are out of the shortlist. In Group 5, the fuel tax increase and indexing to inflation (A2) outranks A1. In the final evaluation, the re-allocation of vehicle, tire and parts sales tax to transportation (G) marginally outranks A2 and remains in the shortlist as the only alternative.

As the importance of revenue generation potential and revenue sustainability increases, only the re-allocation of vehicle, tire and parts sales tax remains in the recommended list; however, since this option is considered temporary, the fuel tax increase and indexing to inflation, which is only outranked by G and provides sustainable revenue, is recommended as the primary option.

Scenario Analysis – Scenarios with Varying Alternative Scores

A change in scores of a few alternatives on a few criteria is expected to have a significantly smaller effect on the results compared to the variation in criteria weights,

but, an investigation to see if the changes in the scores modify any outranking relationships between any two alternatives remains important. The following paragraphs discuss some notable findings from this analysis.

The results of this analysis are shown in Table 4-24. As discussed earlier, the fuel tax increase by fixed amount (A1), the tolling all new freeway capacity with fixed tolls (E1) and the re-allocation of vehicle, tire and parts sales tax to transportation (G) are not dominated in the Base Scenario.

Scenario S-1: When the score of the re-allocation of vehicle, tire and parts sales tax to transportation (G) on the revenue sustainability sub-criterion (RG2) is reduced to four from five (not shown in Table 4-24), the fuel tax increase by fixed amount (A1) and the tolling all new freeway capacity with fixed tolls (E1) join A2 and G in the list of non-dominated alternatives in Group 0. In the final evaluation of Group 6, A1, E1 and G remain to be the non-dominated alternatives. However, when the score of G on RG2 is decreased to three, G is no longer in the list of non-dominated alternatives in Group 5. Eventually, in the final evaluation, A2 replaces G. In the Base Scenario, G scores five points for the RG2 criterion and so has advantage over other alternatives. If its sustainability is reduced to three, A2, which has a score of four on RG2 outranks G.

This result suggests that if the re-allocation of vehicle, tire and parts sales tax to transportation is not a permanent funding option, then, the fuel tax increase and the tolling of new freeway capacity must be the primary options recommended. Both the fuel tax fixed increase and its indexing to inflation are preferred. So, depending on the revenue needs, the policy makers may decide the extent and frequency of the fuel tax increase.

Table 4-24. Comparison of Non-dominated Alternatives in Scenarios with Varying Alternative Scores

Scenario	Description	List of Non-dominated Alternatives by Group			
		All Statewide Major (Group 0)	Group 5		Group 6*
Base	Base scores	A2,G	A1,E1,G		A1,E1,G
S1	Revenue sustainability of G decreases to three points.	A1,A2,E1,G	A1,E1		A1,A2,E1
S2	Revenue from E3 and E4 goes to State Highway Fund. Flexibility increases, Geographic equity decreases.	A2,G	A1,E1,G		A1,E1,G
S3	Cost of implementation and efforts needed for prevention of evasion of tolling and VMT charges decrease.	A2,G	A1,E1,G		A1,E1,G
S4	Public acceptance of fuel tax increase improves.	A1,A2	A1,A2,E1		A1,A2,E1
S5	Public acceptance of tolling of existing freeways improves.	A2,G	A1,E1,G		A1,E1,G
S6	Public acceptance of VMT tax improves.	G	A1,E1,G		A1,E1,G
S7	Public acceptance of the re-allocation of vehicle, tire and parts sales tax to transportation decreases.	A1,A2,E1,G	A1,E1		A1,E1

Note: * Under Group 6, all non-dominated alternatives from Group 0 and Group 5 are evaluated. For example, under scenario SC-1, A1, A2 and E1 are evaluated and under scenario SC-2, A1, A2, E1 and G are evaluated.

Scenario S-2: When the allocation of revenue from tolling existing freeways (E3 and E4) is statewide, the lists of non-dominated alternatives in the evaluation do not change. The rank order changes slightly. In Group 0, E3 becomes incomparable

with the tolling all new freeway capacity with fixed tolls (E1) with slight margin. E3 outranks the carbon tax (B).

This scenario does not affect the policy recommendations made in the Base Scenario. The fuel tax increase and the tolling new freeway capacity remain the primary options while the re-allocation of vehicle, tire and parts sales tax may be used as a temporary or supplementary option.

Scenario S-3: When the cost of implementing tolling and VMT charges is reduced along with the effort needed for prevention of evasion, all the alternatives related to tolling and VMT charges (E1,E2, E3, E4, F1 and F2) perform slightly better compared to the Base Scenario; however, the lists of non-dominated alternatives in all the groups do not change. When E3, E4, F1 and F2 are compared, F1, which is dominated by E3 in the Base Scenario, becomes incomparable with E3 in this scenario. It joins the list of alternatives evaluated in Group 5. In the rank order of Group 5, E1 outranks the local alternatives M and O and the carbon tax (B) in this scenario, in addition to E3 and D, which it outranks in the Base Scenario. In Group 0, E3 outranks B.

This scenario does not affect the policy recommendations made in the Base Scenario, and it indicates that reductions in implementation costs appear unlikely to make the VMT charges or tolling existing roads suitable alternatives.

Scenario S-4: When the score of the fuel tax alternatives A1, A2 and A3 on the acceptability to the public sub-criterion (PA&PF2) is increased, the re-allocation of vehicle, tire and parts sales tax to transportation (G) moves out of the list of non-dominated alternatives and the fuel tax increase and indexing to inflation (A2) takes its place. A1's score is increased to four while A2's score is increased to 3.5.

In this scenario, since the public acceptance of the fuel tax increase improves, the fuel tax increase and indexing to inflation is added to the recommended list. So, depending on the revenue needs, the policy makers may decide the extent and frequency of the fuel tax increase. This scenario indicates that addressing the public acceptance of the fuel tax alternatives has the potential to eliminate the diversion of other tax revenue from the possible solutions. Tolling new freeway capacity continues to be the other primary option recommended. The re-allocation of vehicle, tire and parts sales tax is not recommended.

Scenario S-5: When the score of the alternatives related to tolling existing freeways, E3 and E4, on the PA&PF2 sub-criterion is increased to three points, E3 is no longer outranked by the re-allocation of vehicle, tire and parts sales tax to transportation (G). It is only outranked by E1. Even with this change in its score, E3 only outranks the sales tax increase (D). The author tests another scenario where E1 is not considered in the evaluated list. In this test, E3 becomes one of the non-dominated alternatives.

This improvement in public acceptance of tolling existing freeways does not change the policy recommendations made in the Base Scenario. This scenario shows that the public acceptance of the tolling of existing freeways is one of the major obstacles in its implementation. This option should first overcome this obstacle for being considered. Then, due to any decision parameter that is not considered in this study, if the policy makers consider the tolling all freeways rather than only new freeway capacity, such an option becomes one of the recommended options.

Scenario S-6: In this scenario, the scores of the alternatives related to VMT charges, F1 and F2, on the acceptability to the public sub-criterion (PA&PF2) are

increased to four points and 3.5 points, respectively. When the alternatives related to tolling existing freeways and VMT charges, E3, E4, F1 and F2, are evaluated as a group, F1 becomes non-dominated. So, F1 joins the evaluated list in Group 5. It outranks the sales tax increase (D) and becomes incomparable with the carbon tax (B) and E3. All the remaining alternatives outrank it. In Group 0, when all statewide major alternatives are assessed, F2 remains outranked by A1, C, E1, E2 and G. It becomes incomparable with A2. When F1's score is increased to five points, it becomes incomparable with the vehicle registration fee increase (C).

The improvement in the public acceptance of the alternatives related to VMT charges does not change the policy recommendations made in the Base Scenario. Just increasing the public acceptance of VMT charges will not move it into the set of recommended alternatives.

Scenario S-7: When the score of the re-allocation of vehicle, tire and parts sales tax to transportation (G) on the acceptability to the public sub-criterion (PA&PF2) decreases to three, G is outranked by fuel tax increase by fixed amount (A1) in Group 5, although it remains incomparable with A1 in Group 0 by a slight margin. In the final evaluation, Group 6, G is outranked by A1 and moves out of the list of non-dominated alternatives.

This scenario shows that when the public acceptance of the re-allocation of vehicle, tire and parts sales tax towards transportation is assumed to be lower, this option is not recommended for implementation. The fuel tax increase with fixed amount and tolling new freeway capacity with fixed tolls remain as the two primary recommended options.

The above scenario analysis shows that the policy recommendations made based on the Base Scenario do not change significantly if individual criteria weights or alternative scores change. The fuel tax increase and tolling new freeway capacity remain as the primary recommendations with two variations. When the fuel tax increase becomes more acceptable to the public or the importance of either the public acceptance criterion or the promotion of efficient travel behavior and fuel efficiency criterion increases, indexing of fuel tax to inflation appends the fuel tax increase with fixed amount. Similarly, use of the variable tolling option is recommended along with the tolling of new freeway capacity when the equity criterion becomes more important or when the promotion of efficient use becomes a very important function of the funding policy. When the public acceptance and political feasibility criterion becomes less important, tolling of existing urban freeways is also recommended. The re-allocation of vehicle, tire and parts sales tax remains to be a very effective but temporary option for supplementing the funding from the fuel tax.

The above results may also be verified through a close review of the alternative scores. The alternatives A1, E1 and G cover each other's deficiencies and together top the scoring table. Figure 4-8 is a radar chart, where the maximum score on each sub-criterion ("Max") and the scores assigned to A1, E1, E2 and G are overlapped. It shows that except on three criteria, the user-pay equity (EQ1), the promotion of efficient travel behavior (PSB1) and the promotion of fuel efficiency (PSB2), the highest score on each sub-criterion belongs to one of the three alternatives, A1, E1 and G. Alternative E2 has the highest score on the PSB1 criterion. Hence, the recommendations formed based on these alternatives are able to remain stable regardless of any changes in criteria weights and alternative scores.

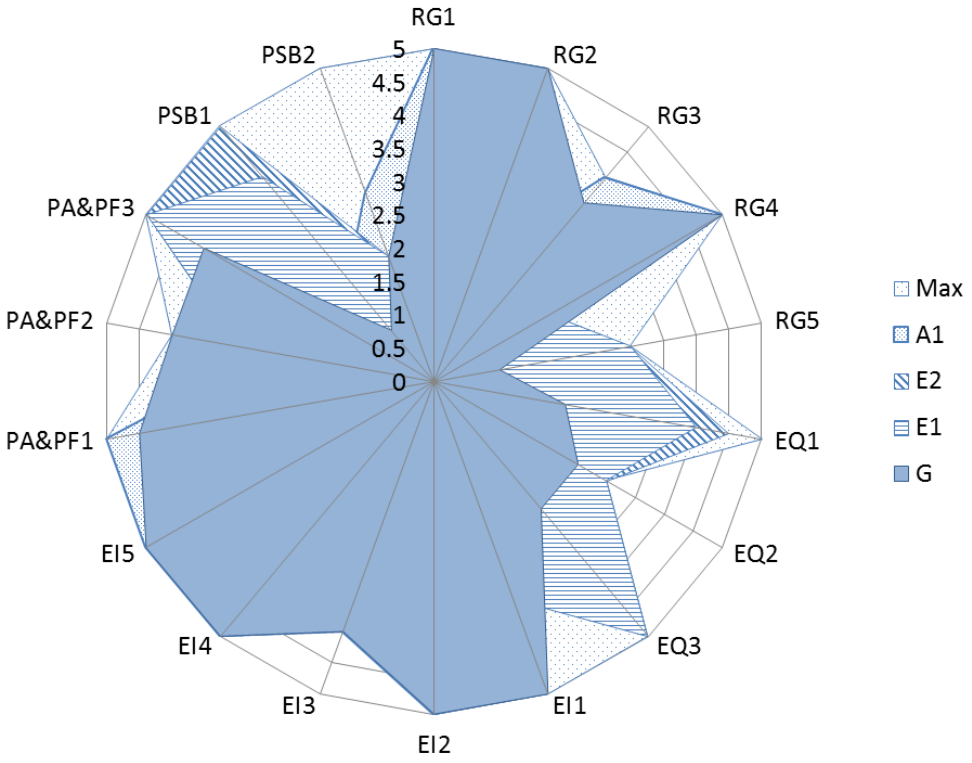


Figure 4-8. Coverage of Scores of Recommended Alternatives

Non-dominance Investigation

In this sub-section, the author tries to build some special scenarios where a particular alternative becomes non-dominated. This analysis informs the decision makers about the circumstances when an alternative becomes one of the preferred alternatives. It also informs them about how an alternative can be improved for becoming a preferred alternative.

Improvements to A1: From the scenario analysis above, one can see that the fuel tax increase by fixed amount (A1) remains to be one of the non-dominated alternatives in most scenarios. It is outranked only by re-allocation of revenue from vehicle, tire and parts sales tax (G) in some evaluations. The analysis also shows that when the public acceptance of A1 is increased, it outranks G. Another concern about

this alternative is its revenue sustainability. When the importance of the revenue sustainability is increased or when the importance of the acceptability to the public is decreased, the fuel tax increase and indexing to inflation (A2), which has better sustainability joins A1 or surpasses it. The author identifies some ways to improve the revenue sustainability and the public acceptance of a fuel tax alternative and lists them below:

- The revenue sustainability of the fuel tax is improved by indexing it inflation, as in alternative A2. However, A2 is expected to have lower public acceptance than A1 does. Moreover, inefficient spending is possible given a possible automatic increase in revenues every year. In another method, the fuel tax may be increased by a fixed, small amount after every two years pending the approval from the state legislature. Then, the legislature may decide, depending on the needs, whether or not to increase the fuel tax in a particular year. In this method, the public acceptance may be higher because the public expects an increase in fuel tax in fixed intervals and is assured that needs and resources are discussed before such an increase.
- Currently, there are concerns among the researchers and the public that the fuel tax is losing its user-pay characteristic because of the on-going increase in usage of fuel efficient or alternative fuel vehicles which use the roadways without paying the current fuel tax. If the fuel tax is supplemented with an annual fee on the electric and other alternative fuel vehicles that do not pay fuel tax, similar to the one charged in Washington (Washington State Legislature 2012), the user-pay equity of the overall road user tax system is expected to increase. In this evaluation, the author shows that a

simple annual fee based on the miles traveled (I) collected along with the vehicle registration fee is better than a flat annual fee for all the alternative fuel vehicles (J).

- Another way to improve the user-pay equity of the fuel tax system is to impose a special tax on the heavy vehicles based on their weight and mileage (H). Appropriate tax rates should be estimated based on the highway cost allocation studies.

Alternative G: The scenario analysis discussed above shows that when the weight of the acceptability to the public sub-criterion (PA&PF2) is zero, when the score of the re-allocation of vehicle, tire and parts sales tax to transportation (G) on PA&PF2 decreases, or when the score of the fuel tax alternatives for PA&PF2 is increased, alternative G moves out of the list of non-dominated alternatives. When G's score on the revenue sustainability (RG2) sub-criterion is decreased, G is no longer preferred. One of the fuel tax alternatives dominates G in the above scenarios. G's revenue sustainability and public acceptance can be lower when the funds from the Texas General Fund are needed for programs other than transportation and the revenue from vehicle, tire and parts sales tax is allocated back to the General Fund. Hence, the author recommends using alternative G only as a temporary supplement to other shortlisted alternatives rather than as a single funding solution.

Alternative C: The scores of the vehicle registration fee increase (C) are very similar to those of the fuel tax related alternatives, A1 and A2. When compared to A1, C has better scores on these sub-criteria: revenue sustainability (RG2), ease of increase in tax or fee (RG5), geographic equity (EQ3) and acceptability to the public (PA&PF2). A1 is better than C on the user-pay equity and four other criteria. When a

group of alternatives including A1,B,C,D, E1, E3 and M are compared, C is outranked by A1 and E1. One strategy to bring C into the shortlist of alternatives is to increase its scores on PA&PF2 and RG2 by 0.5. Then, it is incomparable with A1 and E1 and so it stays in the shortlist along with A1 and E1. On the other hand, when A2 is included in the above evaluation list instead of A1, C is incomparable with A2 by a slight margin and hence stays in the shortlist even without any changes in its scores.

Alternative E2: When compared with the tolling all new freeway capacity with fixed tolls (E1), the tolling all new freeway capacity with variable tolls (E2) performs better only in the case of the user-pay equity sub-criterion (EQ1) and the promotion of efficient travel behavior sub-criterion (PSB1). E2 is preferred to E1 in the situation where

- the score of E2 on the cost of implementation is increased from 2.5 to three, and
- the score of E2 on the ease of explaining to the public sub-criterion (PA&PF1) is increased from 2.5 to 3.5.

When E2 is compared with other alternatives in Group 5 without having E1 in the list of alternatives evaluated, E2 becomes part of the shortlist without any changes to the weights or scores. This means that E2 is only outranked by E1. If tolling with fixed tolls is not a potential alternative, E2 is one of the preferred alternatives. The author recommends that a toll authority may decide to use fixed or variable tolling based on the specific travel characteristics in a toll road corridor.

Alternatives E3 and E4: While these two alternatives perform better than many other alternatives on three criteria – revenue generation, equity and potential secondary benefits – their implementation and public acceptance are the main

challenges. The results of scenario analysis presented in Table 4-22 show that tolling all new freeway capacity and existing urban freeway capacity with fixed tolls (E3) becomes part of the shortlist when the weight of the public acceptance and political feasibility criterion reduces to 15%. The author has tried to change the scores of the tolling related alternatives on the cost of implementation sub-criterion (EI1), the ease of explaining to the public sub-criterion (PA&PF1) and the acceptability to the public sub-criterion (PA&PF2) so that E3 becomes one of the non-dominated alternatives. Table 4-25 shows the modifications that result in E3 being a non-dominated alternative. In addition to these scoring modifications, the importance of the potential secondary benefits is increased by 100% for this result to occur.

Table 4-25. Modification of Scores of Tolling Related Alternatives Applied in Making E3 Non-dominated

Sub-criterion	Alternative Score			
	E1	E2	E3	E4
Cost of implementation (EI1)				
Base	3.5	2.5	2.5	1.5
Modified	4	3.5	3.5	3.5
Ease of explaining to the public (PA&PF1)				
Base	4	2.5	3	1
Modified	4	3.5	3.5	3
Acceptability to the public (PA&PF2)				
Base	3	3	1	1
Modified	4	4	3.5	3.5

After the above changes are made, the score of E3 on the user-pay equity is reduced by 0.5 (changing it from 5 to 4.5). This improves E4's preference score and brings it into the list of non-dominated alternatives.

Alternatives F1 and F2: These two alternatives are often ranked the lowest in the evaluation. One of their main functions is to charge the users more directly by the miles traveled and promote efficient travel behavior. The comprehensive VMT charges (F2) is a very complex system and is rated the lowest on the ease of implementation criterion, but it has the best score on the user-pay equity sub-criterion (EQ1).

To move F1 and F2 into the shortlist, their scores on the ease of implementation criterion (EI) and the public acceptance and political feasibility criterion (PA&PF) are changed. The author assumes that when the cost of implementation for these alternatives decreases, the cost of implementation for the tolling related alternatives also decreases because they all depend on improvement in technology and similar implementation techniques. The score of the re-allocation of vehicle, tire and parts sales tax to transportation (G) on the acceptability to the public is assumed to decrease. In addition to these changes in scores, the weight of the potential secondary benefits criterion (PSB) is increased by 100%, which is foreseeable because of the expected increase in congestion and environmental pollution in the future. When the scores are changed as shown in Table 4-26, F2 becomes one of the non-dominated alternatives.

Table 4-26. Modifications of Scores Applied in Making F2 Non-dominated

Sub-criterion	Alternative Score						
	E1	E2	E3	E4	F1	F2	G
Cost of implementation (EI1)							
Base	3.5	2.5	2.5	1.5	2	1	5
Modified	4	3.5	2.5	2.5	3.5	3	NC*
Ability to prevent evasion (EI3)							
Base	1	1	1	1	1	1	4
Modified	Not changed				4	4	NC
Ease of co-ordination with bordering regions (EI5)							
Base	4	4	4	4	2	3	5
Modified	Not changed				4	4	NC
Ease of explaining to the public (PA&PF1)							
Base	4	2.5	3	1	3	1	4.5
Modified	Not changed				4	3	NC
Acceptability to the public (PA&PF2)							
Base	3	3	1	1	2	1.5	4
Modified	Not changed				4	3	3

Note: * NC means “Not changed”

With the above changes in scores, the simple VMT charge (F1) is outranked by the fuel tax related alternatives, the re-allocation of vehicle, tire and parts sales tax to transportation (G) and F2. During a transition period before implementing a full-scale VMT charge system, F1 may be implemented. Since F1 does not have advantage over the fuel tax system, which is easier to implement and better with respect to user-pay equity and potential secondary benefits, it is not able to surpass the fuel tax based alternatives in the rank order.

NSTIFC’s Evaluation with the Criteria Weights from the Current Study

Chapter 3 includes a comparison of the criteria weights established by the NSTIFC with those obtained from the expert survey. Here, the author examines how the criteria weights from the current study change the results of the NSTIFC’s

evaluation. As explained in Section 4.3, use of the Simple Additive Weighting method is not a suitable technique with the ordinal scores used by the NSTIFC; however, to replicate the same study conditions as of the NSTIFC, the author replaces the NSTIFC's weights with the current study's weights and calculates the overall scores for all the major alternatives using the SAW method.

Figure 4-9 compares the overall scores of each alternative for the two scenarios. As discussed in Chapter 3, the NSTIFC gives high level of importance to promoting economic efficiency, while the current study does not consider it a significant factor in selecting the funding option. Furthermore, the current study gives very high importance to different aspects of public acceptance and political feasibility. As shown in Figure 4-9, the alternatives that have better scores on the public acceptance criterion, improve their overall scores. The VMT mechanism, which has had significant advantage due to its score on the economic efficiency criterion, scores approximately equal to the score of the fuel tax. Tolling, however, is only marginally affected because its performance on the public acceptance and cost of implementation criteria is better than that of the VMT mechanism. This comparison supports the policy recommendations provided in the current study and justifies differing from the NSTIFC in not recommending the implementation of VMT charges in the long term.

The results of the NSTIFC evaluation after replacing the criteria weights from the current study do not completely match with the current study's results. One main reason for this is that the list of criteria used by the NSTIFC does not have as much detail as the current study, for example, the ease of explaining to the public sub-criterion is not included by the NSTIFC. The difference in evaluation techniques used is another major reason.

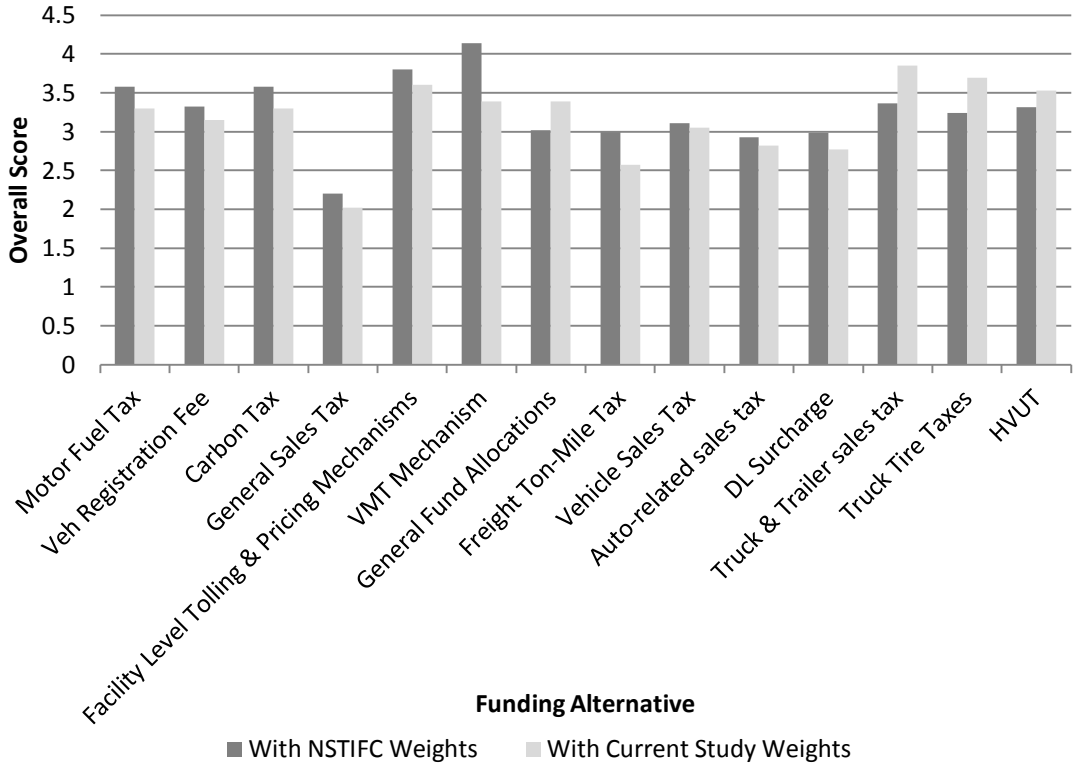


Figure 4-9. Comparison of NSTIFC's Evaluation Results – Application of Weights from NSTIFC and Current Study

4.5.2. Further Discussion

Based on the evaluation discussed above, the author recommends increasing the fuel tax by a fixed amount and tolling all new freeway capacity with fixed tolls as the two primary funding options for the future. He identifies the re-allocation of vehicle, tire and parts sales tax to transportation (G) as a temporary supplement to the current funding system.

One may see that the tolling of new freeway capacity is already being implemented in Texas, at least in urban areas, and does not require any action from the Legislature. Toll roads are usually preferred to taxes because first, they provide the

users with a choice, and secondly, the revenue from toll roads usually is spent to improve the local transportation network, which may directly benefit the local public.

The exact amount of increase in the fuel tax may be decided based on further analysis. The author estimates that if the Texas state fuel tax had been raised with inflation since 1991, it would have increased by about fourteen cents per gallon by 2013. On the other hand, the EPA estimates that, when the 2012 CAFE standards are implemented, the average fuel efficiency for all vehicles, both cars and trucks, in the U.S. will increase by about 45% between 2013 and 2035 (U.S. Energy Information Administration 2013). This implies that the current fuel tax should be increased by nine cents to keep this increase in fuel efficiency from affecting the revenue. Hence, the author believes that an immediate increase of the fuel tax by ten to twelve cents is a reasonable recommendation. The policy makers may review the funding situation after about ten years and evaluate any further increases at that time. The increase of the fuel tax may be spread over four to five years because a step-by-step increase is shown to be more favorable to the public than a one-time increase (Agrawal et al. 2012).

The third preferred option, the re-allocation of existing vehicle, tire and parts sales tax revenue from the general fund may be more acceptable to the public because it does not bring any new tax increase; however, it is not based on user fees as much as fuel tax which funds most of the transportation infrastructure currently. Moreover, when a need arises for other government sectors, funds may have to be re-allocated to those sectors. The author shows that this option has only a marginal advantage over a fuel tax increase, especially in public acceptance. If the weight of the acceptability to the public sub-criterion is reduced or the fuel tax increase becomes more acceptable,

this alternative is outranked by the fuel tax increase. These arguments support the idea that this option is more suitable as a temporary supplement for the fuel tax system.

Many transportation officials and researchers have argued that the existing fuel tax based system should be replaced with a tax based on vehicle miles traveled or congestion pricing tolls. They argue that the existing system does not encourage the public to use the transportation system efficiently; however, the promotion of efficient travel behavior, the main proposed advantage of these systems, is given a very low weight (3%) by the expert panel in this research. As resources continue to become more scarce, the importance of the system efficiency will likely increase. Unfortunately, the complex tolling systems (E3, E4) and VMT charge systems (F1, F2), which are intended to impact user behavior, are outranked by the other funding alternatives. In most cases, their public acceptance and political feasibility is worse than increasing the fuel tax; however, E2, variable pricing based on congestion on all existing and new tolled facilities, has a comparable public acceptance. The analysis shows that when the promotion of efficient use becomes a very important function of the funding policy, variable tolling is recommended. So, the author believes that variable tolling on existing and new toll roads and lanes represents the best and most feasible first step towards encouraging more efficient system use.

In the criteria system established in this research, three sub-criteria – user-pay equity, ease of explaining to the public and acceptability to the public - are related to the public perception and capture one third of the weight. So, the alternatives that perform well on these three criteria are likely to remain in the short list even with the inclusion of other criteria, as long as they do not perform significantly worse than the alternatives immediately below them in the preference order on the other criteria. As

shown in this chapter, these three sub-criteria may be used to screen the alternatives. To add the revenue generation component, the revenue generation potential may be added to these screening criteria. All the alternatives may first be scored and screened using these sub-criteria. Once the screening process is completed, all the criteria may be included for the full evaluation.

The evaluation results show that an increase in fuel tax or vehicle registration fee is preferred for a statewide implementation. In comparison, a sales tax increase is preferred for implementation at the local area level. A local sales tax is currently being implemented in many metropolitan areas in Texas, especially to fund transit development. The readers may note that the local and statewide alternatives have similar scores for many criteria. Moreover, the advantages and disadvantages of implementing a local tax increase are not thoroughly analyzed here. Hence, while the result of this simple evaluation may be used as initial guidance, deciding whether a statewide solution or a local solution is better in general, and whether a particular option is better for statewide implementation or local implementation needs more analysis. In the next chapter, the author provides some insights on this topic.

Finally, for implementing any funding option, the first barrier is to gain the acceptance from the public. Currently in Texas, obtaining the support of the majority of the elected members of the legislature for a fuel tax increase is very difficult. If the public also does not support the increase of fuel tax, the chance of a fuel tax increase is very low. In that case, a public awareness campaign explaining to the public about the transportation funding needs and the actual increase to their monthly or annual tax burden is necessary to improve the acceptance levels among the public. A public

education campaign called “Rethinking our path to mobility” is one such campaign currently happening in Texas (Texas A&M Transportation Institute 2013).

4.6. Chapter Summary

In this chapter, the author describes the evaluation of a number of transportation funding alternatives for implementation in Texas. The criteria system established in the third chapter is used in this evaluation. The author first defines the funding alternatives evaluated and then explains how he scores them over each criterion depending on their performances. He describes different methods of analysis in this evaluation process including a review of scores, an assessment by groups of similar alternatives and a screening process. He explains the multi-criteria analysis technique, PROMETHEE, used in this analysis. He defines many potential scenarios where the weights of the criteria or the scores of the alternatives may change and tests how these changes may affect the results of the analysis. Based on this analysis, he recommends that the policy makers increase the fuel tax and continue tolling new freeway capacity in the state as the primary funding strategy for Texas. He recommends that variable tolling is implemented on all toll roads gradually if the policy makers aim to encourage users to use the transportation system efficiently.

In addition to the funding options that are implemented statewide, some local options are also considered in this evaluation; however, the final recommendations pertain only to statewide implementation. In the next chapter, the author explores the pros and cons of local funding alternatives when compared to statewide alternatives and adds the decision makers’ perspective to this debate.

Chapter 5

Integrating Local Funding with Statewide Funding – The Decision Makers' Perspective

Traditionally, in the United States, the federal and state governments have provided most of the funding for the state-owned highway infrastructure and maintenance. The role of cities and counties has been in developing and maintaining local streets and operating transit facilities. Nevertheless, as urban congestion and population continue to grow, the urban transportation needs increase more rapidly than the state's overall transportation needs. When state and federal funds are insufficient to meet these needs, many state governments have responded by giving local governments more power to generate their own funds through local option taxes and other financing methods. In many states, citywide, countywide or metropolitan area wide taxes such as local option sales tax, local fuel tax and county vehicle registration fee have become popular.

As the local governments raise additional revenue, they often expedite the development of transportation projects that will likely be delayed due to lack of state funding and are considered highly important by the local public or local elected officials; however, researchers and those experienced in transportation policy have raised a number of concerns about this devolution of taxing powers to local governments.

At a time when governments are seeking alternative funding methods to replace or supplement the fuel tax, the debate on implementing a statewide or local funding solution takes on great importance. In this research, the author adds the decision makers' perspective to this discussion by obtaining the choice of a group of transportation officials and legislative staff members. The research supplements this important input with a case study of the use of local transportation funding in the

Dallas-Fort Worth (DFW) area in Texas. Since the phenomenon of local funding is in many states in the U.S., the research and recommendations discussed in this chapter are meant for any state in the U.S.

The next two sections provide some history of local transportation funding in the U.S. and the advantages and disadvantages of local taxes. The third section describes the author's investigation of the decision maker's preference through the expert survey conducted in this research. A summary of the survey results is discussed in the fourth section, while the fifth section consists of the DFW area case study. The sixth section recommends a strategy to integrate the local funding with statewide funding. A summary of this chapter is included in the last section.

5.1. History of Local Funding

Since the rise in automobile use in the 1920s, federal and state governments have been funding most of the highway network in the U.S. through fuel taxes and other user fees. Local governments usually fund local roads and public transit operations and maintenance through property taxes. Since the 1980s, the federal fuel tax has also supported the transit capital improvements. As the nation's highway network has matured, its maintenance requires a larger share of revenue. Moreover, the revenues from fuel taxes and user fees have not grown with the pace of growing construction and maintenance costs. So, in many states, local governments have begun to rely on locally generated funds for new project initiatives (Goldman and Wachs 2003). Local funding is most commonly seen in the form of taxes or fees that are usually charged in addition to the statewide taxes or fees. There are other local initiatives for successfully financing a project such as tax increment financing, tolling and pass-through financing.

5.1.1. Origin and Propagation of Local Transportation Taxes

Goldman and Wachs (2003) discussed the trends in the adoption of local option transportation taxes (LOTTs). They defined LOTT as "a tax that varies within a state, with revenues controlled at the local or regional level, and earmarked for transportation-related purposes" (Goldman and Wachs 2003). They found that the adoption of LOTTs, other than property taxes, started in the late 1960s to support public transit systems, or to embark on major new capital programs (Goldman and Wachs 2003). In the 1970s, the LOTTs became more attractive, because 1) the public opposed a property tax increase, and 2) the reduced demand due to a weak economy, which caused a fuel tax revenue reduction. In the 1980s and 1990s, more states adopted LOTTs; in particular, local option sales taxes became very popular in the 1990s. Local fuel tax and county vehicle registration taxes were also implemented in some states (Goldman and Wachs 2003). Some states restricted the use of LOTT revenues to highway construction, maintenance or transit development, while others permitted a broader range of uses.

Goldman and Wachs (2003) find that, since the 1990s, competition among local governments for economic development and improving quality of life through better transportation systems has been one of the driving factors for the expansion of LOTTs. As an example, two border counties in Texas, Cameron and Hidalgo, seem to compete for economic development by initiating important highway and transit projects that may create new jobs. These counties charge a transportation mobility fee of ten dollars in addition to a road and bridge fee, which is charged by other Texas counties (Hidalgo County Texas 2011). This road and bridge fee is charged along with the state vehicle registration fee. The next sub-section briefly discusses various types of local funding.

5.1.2. Types of Local Funding

For the context of this chapter, the author provides some background regarding the types of local funding and its uses for transportation. Goldman and Wachs (2003) provide a summary of different types of local taxes that exist in the U.S. These taxes may be collected by cities, counties, or other local authorities such as metropolitan transportation authorities.

Property Tax

Traditionally, a property tax represents a major revenue source for most local governments throughout the U.S. Local transportation facilities provide access to the residential and commercial developments, farms and other land uses. Since better accessibility improves the property value, using property taxes to fund local transportation is considered appropriate (Goldman et al. 2001). Property taxes are used to fund local streets in all fifty states; furthermore, in most states, local public transportation is primarily funded through property taxes (Goldman et al. 2001). As the state and federal funds decline, local governments increasingly use property taxes to fund improvements for roads other than local streets.

Motor Fuel Tax

While fifteen states in the U.S. allow local option motor fuel taxes, these taxes are widely implemented in only five states. Most states allowing these taxes require that the revenues be used for transportation, but, the funds are not commonly earmarked to any particular projects. Few states among the fifteen states require voter approval for collecting these taxes (Goldman and Wachs 2003).

Vehicle Registration and License Fee

Thirty-three states allow local governments to collect some type of vehicle license or registration tax/fee for "different purposes, including general revenues, highway construction, public transit operations, air pollution control, and public safety programs" (Goldman and Wachs 2003).

Sales and Use Tax

A local option sales tax has become a very significant and politically feasible alternative to fund new transportation projects. One key advantage of the sales tax is that it can generate significant revenue with a low tax rate because the number of taxpayers is large. Thirty-three states allow local option sales taxes for transportation uses. In many cities around the country, local option sales taxes contribute to various rail transit projects. New York, Ohio and Tennessee have no restrictions on local government use of revenue from local sales taxes (Goldman and Wachs 2003). Some states (including Florida, Iowa, Louisiana, New Mexico and Oklahoma and Texas) require the funds to be earmarked to broad programs, transportation-related or otherwise. Some states (including Arizona, California, South Carolina and Wyoming) require a project-specific expenditure plan before a tax is adopted (Goldman and Wachs 2003).

Income, Payroll or Employer Taxes

While fifteen states allow local governments to collect income, payroll or employer taxes, most of these are used as a general revenue source. Revenue from these taxes is used for transportation only in five states (Goldman and Wachs 2003).

Other Taxes Used for Transportation

Other local taxes used for transportation uses include weight based taxes on mining operations, impact fees on new developments and tourism taxes.

Local Toll Authorities

Regional or local toll authorities can build and operate toll roads. Tolling by these authorities is also considered local funding because regional toll roads are mainly used by local users; furthermore, the revenue is used locally and there may not be a uniform statewide toll policy governing the toll rates and other toll collection policies.

5.1.3. Local Funding in Texas

Texas cities and counties primarily use revenues from property tax and general sales tax to build and maintain city streets and county roads. A small portion of the state vehicle registration fee is allocated for counties to maintain county roads (Legislative Budget Board Staff 2013). In addition, 242 out of 254 counties impose an optional county fee for a “road and bridge fund” of up to ten dollars (Texas Constitution and Statutes 2011; Texas Department of Motor Vehicles 2011). Two counties along the Texas-Mexico border charge another ten dollars for a transportation project mobility fund, which is used by the corresponding county Regional Mobility Authority (RMA) for transportation projects (Hidalgo County Texas 2011). Texas allows local governments to impose local sales taxes that sum up to 2% (Texas Comptroller of Public Accounts (TCPA) 2013a). Ten transit districts covering many counties in Texas account for up to one percent of the aforementioned local sales tax (TCPA 2013b). In the DFW and Houston areas, transit authorities have been developing light rail projects using these funds.

Two bills allowing a local option fuel tax were discussed in the Texas legislative sessions in 2009 and 2011 (Truitt 2009; Rodriguez 2011), but they failed to pass. These bills proposed a countywide transportation tax, mainly a fuel tax, with voter approval.

Through the Pass-through financing program (Texas Department of Transportation (TxDOT) 2013a), the local communities can bear the upfront construction costs of a project and be reimbursed. In another program available, local governments can finance a transportation project in an underdeveloped area by setting up a Transportation Reinvestment Zone. They can finance the project using the additional revenue gained from the increased property tax payments resulting from the project (TxDOT 2013b).

In their latest MTPs, the MPOs of four major metropolitan areas in Texas have allocated more than 50% of the funds necessary for the MTPs' projects from local funds. For the Houston region, 76% of needed funds come from local sales taxes, local fare boxes, local tolling, and city and county taxes. These four regions rely on transit sales tax revenue extensively, which accounts for about 65% of the $83 billion needed for the MTPs' transit projects. On average, transit projects contribute to about 40% of the cost of all planned transportation improvements in these regions (Capital Area Metropolitan Planning Organization 2010; NCTCOG 2011; Houston-Galveston Area Council 2011; San Antonio - Bexar County Metropolitan Planning Organization et al. 2009).

5.2. Pros and Cons of Local Taxes

In this section, the author first presents some benefits and also drawbacks of local taxes identified in the literature. Next, he discusses a special case where local

sales tax is suitable for funding transit projects. Later, he presents an excerpt from the debate that took place in the Texas Legislature regarding a proposal to allow local transportation taxes in Texas.

5.2.1. Advantages and Disadvantages Summarized from Literature

The rise of local option taxes during a time when there is a lack of public support for paying more taxes indicates that the public is willing to pay more taxes if the revenues are used for projects that are directly beneficial to them. The increase in the use of toll roads, especially under a local toll authority, can also be attributed to similar reasons. NCHRP Synthesis 377 finds that the ability to see the toll revenues being spent locally for important projects is one of the main reasons for the public supporting toll roads (Zmud and Arce 2008).

Another important factor supporting local taxes is the significantly large need for funds to improve the congested and polluted major urban areas compared to the lower need in the rural or mid-sized cities, where congestion is a less significant and less frequent problem. People in the rural or small urban areas, where the transportation needs are currently met, appear to be unwilling to pay for spending in metropolitan regions, where the transportation needs are not fully met. This is one of the major reasons stated by the Governor of Texas, Rick Perry, for not supporting the statewide increase in gasoline taxes (Lindenberger and Dallasnews 2009).

Wachs (2003) summarizes four important characteristics of the local sales taxes for transportation, which make them popular. These characteristics are discussed below:

- Most local option taxes are imposed after a local voter approval. Since the tax revenues are shown to be providing necessary projects that directly impact local voters, the voters may lend more support to these taxes.
- Usually, these taxes have a time limit. The public may sense their control of the taxation process because if they find that the funds are not used well or the funds are no longer necessary, they have a chance to revise or end the taxes.
- When the decision of charging local taxes is tied to a specific list of projects, the possibility of spending money inefficiently is reduced.
- The taxpayers are assured that any money raised is spent locally, for local benefit, under the control of a local transportation authority.

The last characteristic above is also true in the case of toll roads which are operated by a local toll road authority, because, in most cases, the toll revenue is spent to repay the debt on the toll road, to maintain the toll road, or to improve the surrounding roadway system both with free and tolled facilities. Toll roads have other important advantages. They provide a choice for the user. One pays only if one uses the toll road. Tolling, especially with congestion pricing tolls, is considered as a tool to promote efficient use of roadways.

As shown above, from a local public perspective, the local taxes seem to be beneficial, but, from a long-term planning perspective and from a statewide or nationwide development perspective, local taxes pose important challenges. Some of these important issues are discussed below:

- Usually, local governments and special transportation authorities, such as the RMAs in Texas, oversee the use of local tax revenues. Goldman and

Wachs (2003) find that LOTTs rarely include a role for MPOs, the agencies that develop the regional transportation plans. They find that only four states have given MPOs either direct or indirect role in controlling the LOTT funds. Bypassing a complex regional planning process may produce more concrete results quickly; however, if the local authority does not coordinate with the regional planning, even though the funded project is locally favored, it may not be the best project with regard to the goals of the region or the state.

- Wachs (2003) sees that the usage of ballot measures for approving LOTT measures may undermine the use of proper benefit-cost analyses.
- The ballot measures usually restrict the use of the revenues to certain specific projects or program areas. Such restrictions prevent the transportation agencies from funding any projects or programs outside the ones mentioned in the ballot when their priorities change in the future (Wachs 2003).
- Sales taxes are more frequently used as LOTTs compared to other taxes for the reasons given earlier. Researchers are concerned about this shift from user fees towards sales taxes, which are paid by the entire general public regardless of their transportation system usage. Sales taxes are also considered regressive, that is, low income people pay a larger percentage of their income compared to high income people. While the fuel tax and the sales tax are both regressive, at least people pay fuel tax only when they use the roadways. Unlike the user fees, sales taxes provide no incentive for the road users to reduce their usage (Wachs 2003).

5.2.2. Use of Local Sales Tax Revenue for Public Transit

As discussed above, a sales tax is regressive and is not a user fee. However, when the sales tax revenue is used to fund public transit projects, these issues are remediated to some extent. First, public transit is used by low income people more than high income people, which partially compensates for the regressive effect (Rosenbloom 2010). Secondly, most of the automobile users perceive the funding of transit facilities through fuel tax revenue unfair because transit riders do not pay any fuel tax. Since all users of the transportation system pay sales taxes, the public perceives the usage of sales tax revenue for public transit and other non-motorized modes as fair (Goldman and Wachs 2003).

5.2.3. Discussion on Local Option Fuel Taxes in the Texas Legislature

As mentioned earlier, the Texas Legislature discussed two separate bills in 2009 and 2011 regarding allowing the counties covered by certain MPOs to charge a local tax and generate revenue for highway and rail improvements (Truitt 2009; Rodriguez 2011). The implementation of this local tax measure required approval by the voters where the ballot initiative included a list of specific projects and their estimated cost. Although the bills did not pass, a review of some major arguments put forward by its supporters and opponents in the legislature appears worthwhile (House Research Organization 2009). Some supporting arguments are:

- One major concern for no political support to raise the fuel tax statewide is that the additional motor fuel tax revenue would be unfairly concentrated for transportation improvements in and around urban areas. This bill would avoid a statewide increase in the motor fuel tax while allowing congested urban areas to propose an increase in local taxes for voter approval. Funds

derived from the local option tax would be dedicated to paying for the listed projects.

- Although, this is not a perfect solution to long-term transportation shortfalls facing the state, it is an emergency measure allowing the most severely congested municipalities and counties to take decisive actions to provide critical infrastructure. Congestion of transportation systems in some metropolitan areas has a demonstrable effect on residents' quality of life, health, and ability to conduct business.
- Depending on the congestion scenario in different counties, local voters have an opportunity to decide on the tax proposal.

Some opposing arguments are:

- This bill could result in an increase of taxes, which is not good during a recession[22].
- Allowing selective increases in municipal areas would be a patchwork approach to transportation funding shortfalls that could have serious long-term implications on statewide connectivity.
- The state needs to address the core issue facing highway funding and increase the motor fuels tax or index it to inflation, preferably both.
- If metropolitan areas are allowed to establish local sources of revenue for transportation projects, it essentially can localize funding for transportation improvements. Without pressure to secure statewide sources of funding, transportation infrastructure outside of metropolitan areas could deteriorate

[22] The U.S. underwent recession in 2008, which continued to have its effects at the time of this debate in the Texas Legislature.

considerably. Furthermore, the author views that when the public is charged a local tax first, they may oppose any increase in the statewide tax because 1) it is an additional burden to them, and 2) they may become comfortable and habituated with the concept of paying for their local needs. So, the long-term implications of the local-option approach for statewide connectivity are troubling, since the state is a major source and destination of freight that depends on quality highways throughout the state.

- The responsibility for expanding and maintaining state highways rests with the state and should not devolve to local entities, which, by nature, are not focused on statewide concerns.
- There are currently other avenues for transportation funding available to the state such as tolling and some special federal funds. These should be pursued instead of local option taxes.

5.3. Investigation of Experts' Perspective on the Choice of Statewide Funding and Local Funding

The sections above discuss the evolution of local transportation funding methods, especially LOTTs, and their advantages and disadvantages. This section describes the author's effort to discover the perspective of transportation officials and legislative staff regarding the choice of implementing a local funding solution in the place of a statewide solution. These officials participate in making decisions regarding the transportation funding policy.

In the first round of the expert survey, the author includes a descriptive question to investigate the panel members' preference regarding the implementation of a new

funding solution statewide or locally. The answers are descriptive and open-ended. The actual text of the question is shown in Figure 5-1.

> Question:
>
> ***Statewide implementation vs. local implementation***:
>
> Local option taxes are considered to be more politically feasible and to produce faster results. When revenue from local taxes is used, the project delivery is usually sped up because of fewer restrictions from federal or state governments.
>
> However, there are concerns that localizing the funding for transportation improvements would eventually undermine the state's role in funding surface transportation projects. With less effort for statewide sources of funding, statewide connectivity as well as the transportation infrastructure outside the metropolitan areas may deteriorate.
>
> The researcher would like to obtain your preference on this topic.
>
> Do you prefer statewide implementation or local implementation of transportation funding solutions? Would a balanced approach be the best? Please provide your justification.

Figure 5-1. Expert Survey Question regarding Statewide Implementation versus Local Implementation

The question provides the main advantages and disadvantages of local funding methods concisely and asks the panel member to give his or her preference and some thoughts justifying their decision. Twenty two panel members respond including fifteen from MPOs, five from TxDOT and two from the legislative committees. The author analyzes the responses and tries to group them into common themes. The next section summarizes the responses and provides some implications to the future funding policy.

5.4. Results of the Survey

After reviewing the responses, the author classifies the panel members' preferences in two broad classes. All the members except two prefer to have the statewide funding as the primary form of funding. The majority prefer a balanced approach with some level of local option funding because of its advantages such as its flexibility and its ability to cater to local needs. The panel members justify their choice. Some members share their ideas on how to structure a new funding system so that it can be the best for both rural and urban regions. Some members suggest how the negative effects of local option funding can be minimized. In the following paragraphs, the two broad classes are discussed.

5.4.1. A Balanced Approach is the Best

Fourteen of the twenty-two panel members suggest that a balanced approach is the best. The opinions vary with regard to the situations where local funding should be implemented and to what extent it should be implemented in association with statewide funding. The following are some of the reasons stated for favoring a balanced approach:

- The state uses a "common sense" approach to gain intra-state connectivity. So, the local funding should not surpass the statewide funding to become the primary option.
- Statewide funding is necessary to provide an efficient and effective statewide system as smaller population areas cannot provide adequate revenues to develop and maintain a comprehensive transportation system. Local options are essential to provide for those projects needed in developing, growing and densely populated areas.

- Locally funded projects tend to focus on the community, which is important, but these projects are less likely to provide adequate connectivity to other areas and regions. While the federal projects have more restrictions, these projects usually are better for the area and they take into account a larger picture. Federal involvement is more coordinated, focuses on longevity, sustainability, and encourages better public input.
- National or statewide sources are not going to disappear even if some areas implement local option taxes.
- The statewide implementation is ideal since there is an oversight of the process and use of funding; however, the local implementation will definitely provide more flexibility for projects.
- The leadership in the state typically recognizes the need for a balanced approach. While statewide funding is needed to maintain a statewide system, local authorities frequently ask for the need to set their own programs.
- Statewide implementation provides more long-term certainty and sustainability and allows industry partners to have more effective business plans. Local implementation does have a place in order to create sound partnerships at the local level for project selection and implementation, including acceptability.

The panel members recognize that a local government should not be able to circumvent state and federal rules simply because they raise enough local funds to do the project unilaterally. They suggest the following methods to effectively combine both statewide and local funding solutions:

- The majority of the funds collected from a local option tax should be used for local projects and the rest should be deposited into a statewide fund to be used on federal or state system infrastructure in the region where the funds are collected.
- Both the state and locals should complement each other's efforts in addressing the regional needs. The local governments should be allowed to raise local revenues. However, to effectively fund the infrastructure that is important for the state, the state needs to reward local governments by leveraging state funds to complement the local funds invested in the state infrastructure. The federal regulatory system should oversee the process and provide guidelines for protecting the environment.
- The state funding solution should provide up to a specific threshold of funding that covers the maintenance and connectivity of the system. The local funding solutions generate additional funding to provide for specific transportation priorities that are not covered by the state threshold and are of importance to the local area for economic development and local citizen needs such as congestion relief in the metro areas.
- Local implementation should be controlled by the state rules. Infrastructure costs should be shared through the state participation. This would cover the need to meet state and federal regulations for on-system[23] improvements.
- A funding system such as sales tax or a vehicle miles traveled charge system can be employed, where it is possible to know the geographic area

[23] "On-system" means facilities that are part of state highway system.

corresponding to revenue generated. Then, some portion of locally collected revenue can be allocated to local government. State and local governments may discuss and decide regarding the funds and responsibilities.

5.4.2. Statewide Implementation is the Best

Five panel members preferred implementing the funding solution only statewide. They supported their view with one of the following reasons:

- Statewide implementation is favored for the best benefit to all and for consistency.
- Local roads are already funded locally. Funding is needed for facilities that are significant regionally and to the state or nation. The funding source for a transportation facility should be at the regional, state or national level depending on at what level it is significant.
- Localizing transportation funding essentially eliminates any significant transportation system improvements outside of the large metropolitan areas.
- The ability to generate local revenue is more limited in the case of small or medium sized regions compared to major metropolitan areas due to fewer people and sometimes lower per capita income.
- A statewide funding solution allows for solving transportation needs statewide, uniformly. Congestion is a statewide issue. Connectivity is also very important.
- Transportation funding is an appropriate and established role for state government.
- Statewide implementation encourages fairness to all areas.

5.4.3. Other Responses

One panel member suggests that the local option solution is better than the state and federal revenue sources that continue to decline, but the member is concerned whether the voters have greater 'trust' in the transportation outcomes from a locally approved revenue source than those funded by statewide funding. The voters need to be assured that their increased support for local funding will not result in a loss of state funding. One member suggests that, while a balanced approach is the best, a local only option should be considered only if statewide initiatives fail.

5.4.4. Summary

Based on these responses, all the panel members understand the importance of the state's role in transportation funding. The state should continue its established role in providing funding for state and national highway system improvements. The members also understand the special needs of local governments and hope the state will permit local funding options. They emphasize the importance of the state's control on generating and using the local funds so that the funds are not spent inefficiently. They give more importance to regional and statewide network connectivity. They propose that the costs of improving the national and state highways, farm-to-market roads and other state roads (state highway system) in a metropolitan area should be shared by local and state governments so that both governments gain from it. Similarly, one can infer from the members' opinions that major roads that are not on the state highway system but are regionally important should be funded by a coordination of different local governments that are benefited by these roads. The panel members mostly concentrate on the roadway funding and do not refer to public transit funding. This may be related to the insignificant transit use in Texas. Furthermore, transit

funding in Texas may not be as deficient as highway funding due to the dedicated local sales tax. In the next section, the author presents a brief case study of the highway and transit funding in the DFW region, which is one of the major metropolitan areas in Texas.

5.5. Dallas-Fort Worth Region Transportation Funding – A Case Study

The Dallas-Fort Worth metropolitan statistical area (MSA) is a twelve-county area located in the North Texas region and includes the three major cities Dallas, Fort Worth and Arlington. It is the fourth most populous MSA in the U.S. with more than 6.5 million people. From the year 2000 to 2010, population in the DFW area has increased by about 1.2 million, a 23.5% increase (Census.gov 2013). As the region is expected to attract similar growth in the future, transportation planners of the area have been working to provide a good transportation system to cater to the increased mobility needs.

The North Central Texas Council of Governments (NCTCOG), which functions as an MPO for this region, has recently updated its MTP, Mobility 2035. In addition to the state and federal transportation related taxes and fees, all the counties in the DFW region charge an additional vehicle registration fee of ten dollars. The DFW region is known for its toll road development. The North Texas Tollway Authority (NTTA) owns and operates most of the toll facilities in this area. A number of tolled and managed lane facilities are being built through public-private partnerships. Furthermore, Dallas Area Rapid Transit (DART), the Fort Worth Transportation Authority (The T) and the Denton County Transportation Authority (DCTA) provide multi-modal transportation facilities in the DFW area. Together, they serve more than 100 million passengers per year on their bus, rail, vanpool and high occupancy lane facilities (Dallas Area Rapid

Transit 2013; Fort Worth Transportation Authority 2010). Each of these authorities collects 0.5% to 1% sales tax in the member cities and uses it for transit improvements. In this case study, the author mainly discusses how the region is successfully moving forward using toll initiatives for highways and local sales tax for public transit.

Until 2006, the NTTA owned and operated two major tollways, one radial toll road connecting Dallas downtown to the northern cities and one partial loop toll road running primarily east-west north of Dallas. During 2007, NTTA obtained a concession for building and operating the SH-121 toll road by paying about $3.2 billion to TxDOT. This money was put in a Regional Toll Revenue fund and was used to fund about 200 projects across the region (NCTCOG 2013). Since 2007, many projects have relied on tolls. If tolling had not been used, these projects would have taken many years to be realized. Two managed lane projects, one in Dallas and the other in the Fort Worth region, were being constructed by different private concessionaires. In the Mobility 2035 plan, NCTCOG estimated that 16% of funds needed for the MTP would be generated from toll revenues (NCTCOG 2011).

DART and the T have been operating a commuter rail called Trinity Railway Express (TRE) between downtown Fort Worth and downtown Dallas since 2001[24] (Trinity Railway Express 2013). The T plans a 27-mile commuter rail from downtown Fort Worth to DFW airport (The T 2013). Since the start of light rail construction in Dallas in 1990, its mileage has steadily grown. Currently, DART operates 85 miles of light rail and is expected to expand it to 93 miles by 2016 (Dallas Area Rapid Transit 2013). DCTA also has opened 21 miles of light rail in 2011. The 1% local transit sales

[24] Some part of TRE started operating in 1996.

tax and the long-term bonds for rail expansion have clearly helped the transportation authorities in this region to build and expand the rail system.

While DART, The T and DCTA are moving forward with their respective systems, the author feels that there is a need for a regional coordination of their efforts. Currently, these authorities do not provide facilities outside their member cities. This may cause discontinuity in service, which may in the long-term result in an inefficient transportation network. The region will benefit from having a single transit authority for this region whose future projects result from a regional planning effort.

5.6. Integration of Local and Statewide Funding

After reviewing the research as well as the survey responses, the author recommends an integrated funding strategy that is governed by the following principles.

- Statewide funding should continue to be primary funding for the state highway system. Local governments in a region should be able to generate some funds for sharing the costs for the benefit of the region.
- Regional transportation planning should govern the uses of local tax revenue.
- The authorities should continue to employ user fees as the major source of revenue for transportation. If charges such as sales tax, which are not tied well with transportation use, are employed as local funding, the resultant revenue should be used to fund transit projects

Based on these principles, the author recommends the funding strategy shown in Figure 5-2. It shows that all projects should be selected through a planning process.

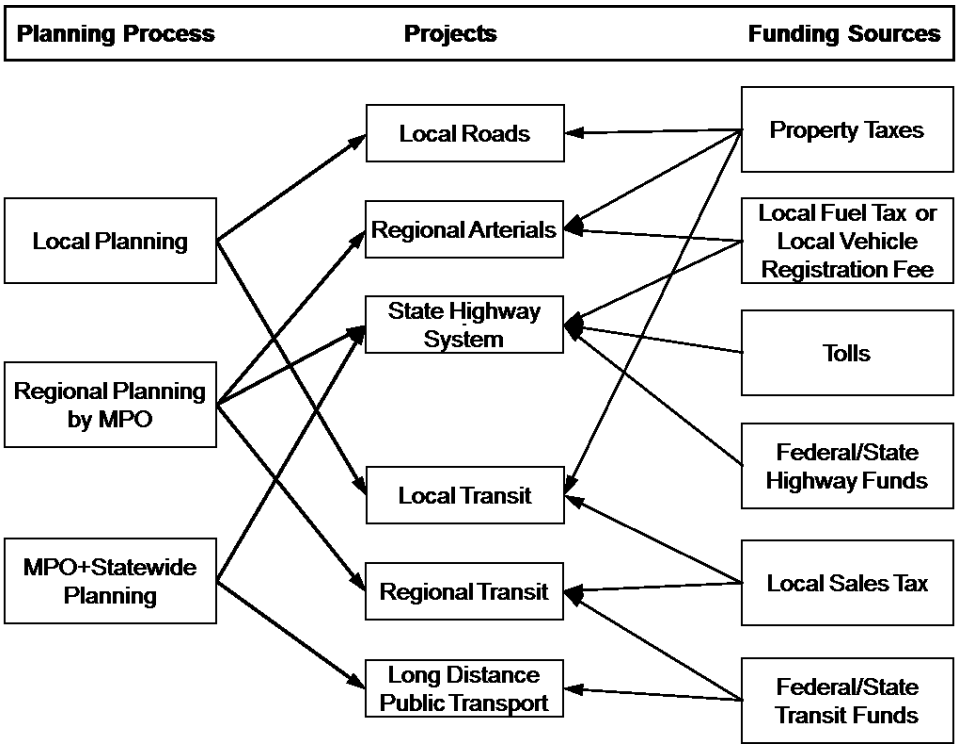


Figure 5-2. Integrated State and Local Funding Strategy

Regionally important arterial projects and the state highway system projects should be selected through regional planning. As the funds become scarce, spending on local roads should also go through local planning. Major capacity improvements to highways should be funded by state and federal funds and local tolls. Some portion of all local taxes should be devoted for regionally important projects, which are coordinated by the MPOs. These funds should be used for improvements to the regional arterial system and to supplement state and federal funding for the maintenance and minor improvements of state highways. Similarly for transit, all transit projects should be selected through a planning process. Property taxes should primarily fund local transit projects while local sales tax revenue should fund the regional transit projects. State and federal transit funds should support funding for regional and long distance transit.

To achieve these goals, the state should implement increases in fuel tax and facilitate tolling of new freeway capacity and/or allocate some of the vehicle, tire and parts sales tax towards transportation. Local governments should implement increases in local fuel tax or local registration fees as much as necessary.

5.7. Chapter Summary

In the previous chapter, the author evaluates many funding alternatives for implementation statewide or locally and recommends a statewide funding strategy. In this chapter, he studies the choice of local funding solution versus statewide funding solution. He first provides a history of local funding and introduces different forms of its existence in the U.S. He reviews the advantages and disadvantages of local funding discussed in the literature. He also presents a set of arguments put forth by both proponents and opponents of a Legislative proposal for implementing local option transportation taxes in Texas. Then, he describes the survey he has performed to obtain the opinions of the expert panel members with regard to choosing a local or statewide funding solution. He presents a summary of the opinions of the members by grouping them into two broad thoughts. The majority suggest that a balanced approach is better where the state continues to be the primary source of funding. The state should provide some avenues for local governments to generate funding when it is not able to fulfill specific local needs. Finally, the author forms a set of guidelines based on the literature and the panel opinions and recommends a method to integrate the local funding with the statewide funding.

Chapter 6

Conclusions and Recommendations for Future Research

When the National Surface Transportation Policy and Revenue Study Commission submitted its final report in 2008, the Chairman of the U.S. House transportation and infrastructure committee saw it as "the first transformational chapter in the transition to a new era of transportation policy for the 21st century" (C-Span Video Library 2008). This Commission estimated that, at current tax/fee/toll levels, the future revenue from the fuel tax and other user fees would be significantly lower than the funds necessary to satisfy the future transportation needs in the U.S. (National Surface Transportation Policy and Revenue Study Commission 2007). It recommended many funding strategies including increasing the federal fuel tax by twenty-five to forty cents in the following five years. In response, the federal government took some measures to improve the funding situation such as transferring funds from the General Fund towards transportation and providing more opportunities for tolling; however, the bigger problem for the long-term has yet to be addressed. The 2030 Committee found similar funding problems for Texas (2030 Committee 2011).

Many studies performed in the last decade have attempted to identify feasible funding alternatives, evaluate those alternatives, and identify a preferable funding strategy for the nation as well as individual states in the U.S. While there are many funding alternatives such as increasing the fuel tax, replacing it with a mileage based tax, increasing sales tax and expanding tolling, officials from transportation agencies and policy makers need to reach a consensus on the best or preferable alternative to be implemented. In this research, the author explores the priorities of Texas-based transportation officials and Legislative Committee member staff in selecting a future

funding strategy for Texas through a three-round Delphi survey. He establishes a criteria system with weights to gauge transportation funding alternatives. He evaluates a list of transportation funding alternatives suitably defined for implementation in Texas using this criteria system and recommends a funding strategy. Since the criteria system used here is established through a Texas-based panel opinion, it likely strengthens the credibility of the evaluation results and the recommendations among the public.

In the next three sections, conclusions from this research, contributions of this study to the exploration of transportation funding options and to other fields, and some recommendations for the future research are presented.

6.1. Conclusions and Recommendations

The criteria system established in this research contains five main criteria including revenue generation, equity and fairness, ease of implementation, public acceptance and political feasibility, and potential secondary benefits. Each of these main criteria has a set of sub-criteria that corresponds to different characteristics of a funding alternative. The ability of a funding alternative to promote efficient travel behavior or to promote fuel efficiency and use of low-emission fuels is included under the potential secondary benefits criterion.

Based on the expert opinion survey, the author prepares a set of weights for the main criteria and sub-criteria. These weights represent the relative importance of the criteria. The author finds that, although the search for new funding methods is due to the existing deficiency in meeting future funding needs, revenue generation is not the most important criterion. Revenue generation, equity and fairness, and public acceptance and political feasibility are approximately equally important. Furthermore,

the criteria weights seem to indicate that the panel members recognize the importance of public opinion and its impact on reaching a legislative solution; in the eighteen sub-criteria, acceptability to the public, ease of explaining to the public and user-pay equity account for more than one-third of the total weight. The panel members appear to be less concerned about criteria such as ease of implementation that may be addressed through modifications to the funding alternatives and research.

A closer look at the analysis of the panel members' responses indicates that not only the public acceptance and political feasibility criterion has the largest average weight but it also consistently appears as one of the top two criteria. This closer look at the responses identifies that the real consensus opinion is that the public acceptance and political feasibility criterion may be the most important.

Many transportation officials and researchers argue that the existing fuel tax based system should be replaced with a tax based on vehicle miles traveled or congestion pricing tolls. Their reason is that the existing system does not encourage the public to use the transportation system more efficiently. The NSTIFC study, which evaluates the funding options at the national level, assigns about one quarter of the total weight to the economic efficiency considerations. They include two main considerations: the promotion of efficient use and the efficient investments that may result from efficient use. However, the transportation officials and the political offices who participated in the survey consider the promotion of better travel behavior and better fuel efficiency through a transportation funding policy relatively unimportant. The author understands from the comments of the panel members that they believe that transportation user charges, at the level of current tax/fee/toll rates, are unlikely to significantly affect public behavior. Based on a summary of effects of congestion

pricing on the travel (Timilsina and Dulal 2008), user charges should be significantly large compared to the ones currently in place in the U.S. to yield even a small reduction in VMT; so, their belief is reasonable. If the charges are increased, the members likely fear a decrease in public acceptance. This result shows that the effect on travel behavior is unlikely to influence future transportation funding decisions in the state of Texas, at least in the near future.

The author evaluates a set of funding alternatives suitably defined for implementation in Texas using the criteria system developed in this research. The list of twenty two potential alternatives includes thirteen statewide major alternatives, six statewide supplementary alternatives and three alternatives for local implementation. The author assigns scores to the alternatives based on their performance on each criterion. He uses a partially compensating method called PROMETHEE for evaluating the alternatives. This method is more suitable for this study than a SAW or AHP method because the criteria weights established from the expert survey and the qualitative scores of the alternatives are subjective in nature and include some uncertainty. Moreover, this study aims at identifying a short list of alternatives that are better than others, rather than a perfect rank order.

The evaluation results suggest that increasing the fuel tax by a fixed amount, tolling all new freeway capacity with fixed tolls and re-allocation of revenue from the current vehicle, tire and parts sales tax towards transportation are the three preferred alternatives.

The expert survey shows that the panel members differ in their opinions regarding the criteria weights. Although they move closer to the consensus opinion in the third round survey, some differences remain. Among the main criteria, the weight of

the public acceptance and political feasibility criterion varies the least. The panel members seem to have opposing views regarding the importance of the revenue generation, and the equity and fairness criteria. On many occasions, a member who assigns a higher-than-average weight to one of the two criteria assigns a lower-than-average weight to the other criterion. In that case, when moving towards consensus, these weights are changed in the opposite directions. The potential secondary benefits criterion also varies from being relatively unimportant to having about twelve percent weight overall. These differences in opinion call for a collective effort to improve the consensus so that a successful future funding strategy can be developed. Through the Delphi process, the author presents a summary of the average group opinion and the major differences in opinion, which can be discussed further. This summary can be used in high level discussions by the legislature or the transportation authorities to achieve a better consensus over the funding strategy. Furthermore, as discussed below, the author finds that these differences do not impede the decision making process because they do not impact the policy recommendations significantly.

The author tests the effect of some of the major differences in the criteria weights identified from the survey and the changes in the scores of the alternatives on the list of preferred alternatives. In this scenario analysis, he finds that the results do not change significantly. In some situations such as when the equity becomes more important or when the promotion of efficient use becomes very important, variations of fuel tax increase and tolling new freeway capacity, which perform well on these criteria join the list of preferred alternatives. This analysis shows that the recommendations remain valid despite some level of differences in the opinions of the expert panel and uncertainties in the scoring process.

Based on the evaluation performed in this study, the author recommends that the policy makers increase the state fuel tax by ten to twelve cents per gallon in regular intervals in the next four to five years. This increase is sufficient to offset the reduction in revenue due to the expected increase in vehicle fleet fuel efficiency in the next twenty five years. He also recommends that the tolling of new freeway capacity, which is currently a common phenomenon in Texas, should be continued to supplement the fuel tax revenue. Furthermore, to improve the revenue sustainability of the fuel tax, the author suggests that a schedule may be set up such that the fuel tax is increased every two or four years with the Legislature's approval. The need for a discussion and approval by the Legislature may provide better public acceptance for this option. In addition, the fuel tax system may be supplemented by an annual fee for electric and other alternative fuel vehicles, which do not pay a fuel tax, based on their annual mileage, and a weight-mile tax on the heavy vehicle use. While generating additional revenue, these measures are expected to improve the user-pay equity of the fuel tax system and provide a supporting argument for increasing the fuel tax.

While re-allocation of vehicle and parts sales tax revenue from the general fund may be more acceptable to the public, it is not based on road use as much as fuel tax which funds most of the transportation infrastructure currently. Moreover, when a need arises for funds from another government sector, funds may have to be re-allocated to that sector. Finally, the scenario analysis shows that this option is outranked by the fuel tax increase option when the latter's public acceptance increases. So, this solution is suggested as a temporary supplement to the current fuel tax system.

As mentioned earlier, the promotion of user efficiency in traveling or use of carbon fuels is given very low importance by the expert panel in this research. As

resources continue to become more scarce, the importance of using a funding mechanism to improve the system efficiency will likely increase. Unfortunately, the complex tolling systems and VMT charge systems, which are intended to significantly impact user behavior, are outranked by the other funding alternatives. Their implementation is costly and difficult; explaining about them to the public is very difficult. In most cases, their public acceptance and political feasibility is lower than that of increasing the fuel tax. In comparison, implementing variable tolls at different time periods based on congestion on all new and existing tolled capacity is relatively less complex. Transferring to such a system from a fixed tolls system can be achieved without major administrative changes. This option also has similar public acceptance and political feasibility level as the fuel tax increase. So, the author believes that variable pricing based on congestion on all new and existing tolled facilities represents the best candidate as the first step towards promoting more efficient system use.

In a large state like Texas, which includes major urban centers and many small urban and rural areas spread across the state, any new funding policy should cater to the specific needs of both urban and rural areas. The author infers from the responses to the expert survey that the panel members from rural areas give more importance to revenue generation while those from urban areas think that equity is more important than revenue generation. Hence, the new funding strategy should be able to provide enough revenue for the rural areas while remaining equitable to the urban population which is diverse in nature.

In response to reduced funding from state and federal governments, local authorities in many states have been raising their own funds through local taxes other than traditional property taxes. Researchers are concerned that the rise in local funding

may undermine the metropolitan planning efforts and also may increase the use of taxes that are not based on usage (Goldman and Wachs 2003). In this regard, the author obtains the preferences and suggestions of the panel members on the choice of implementing future funding solutions statewide or locally. The panel members suggest a balanced approach where the state continues to be the primary funding source for the state highway system while still providing some avenues for local governments to generate their own money because the state is unable to fulfill all the local needs. They suggest that the state should have a control over how the funds are generated at local level and how they are spent. Combining the ideas presented in the literature and the suggestions from the panel members, the author proposes a method to integrate local and statewide funding solutions. In this method, statewide funding remains primary while local governments are allowed to generate some funds and share the costs; local funding is coordinated by regional planning; and the user-pay principle continues to govern transportation funding. In this research, the author compares three local funding alternatives for implementation in major urban areas in Texas. He finds that increasing the fuel tax or vehicle registration fee is preferred to increasing the sales tax.

6.2. Research Contributions

The contributions of the author through this research to the knowledge and practice in the field of transportation funding are summarized as follows:

- The author establishes a criteria system with weights to evaluate transportation funding alternatives based on an expert survey of Texas-based transportation officials and Legislative Committee member staff. Since these officials are directly involved in developing future funding policy and implementing it, and the criteria system is established through a well-

organized group consensus method, a funding strategy recommended based on this criteria system is expected to have higher credibility among the Texas public. So, this criteria system is a significant contribution to the development of future transportation funding policy.

- The criteria system established here is superior to the ones used in earlier studies in the following ways:
    - The NSTIFC also assigns weights to the criteria in its study. The NSTIFC members are appointed by the Secretary of Transportation and various Committees of the U.S. House and Senate and have certain qualifications[25] (National Highway Traffic Safety Administration 2005). The NSTIFC is comprised of mainly business leaders. It has only two transportation executives; both are from public transit related organizations. In contrast, the current study includes the opinion of transportation professionals who are responsible for developing future funding policy for Texas and implementing funding solutions. The panel members are recruited voluntarily through a request for participation. Although the members from TxDOT have withdrawn after the second round, their initial opinion has been captured.
    - The NSTIFC mentions that the weights are based on its opinions about the relative importance of individual criteria but does not provide

[25] Members are appointed from among individuals knowledgeable in the fields of public transportation finance or highway and transit programs, policy, and needs, and may include representatives of interested parties, such as State and local governments or other public transportation authorities or agencies, representatives of the transportation construction industry (including suppliers of technology, machinery, and materials), transportation labor (including construction and providers), transportation providers, the financial community, and users of highway and transit systems (National Highway Traffic Safety Administration 2005).

a clear methodology how it arrived at the weights. In the current study, the panel members' direct opinions regarding the criteria and their weights are collected through a three round Delphi survey. Weighting methods such as the pairwise comparison method and 100-point scale method are utilized for estimating the weights. A consensus among the members is elicited through a well-organized feedback process.

  - Other evaluations regarding funding options for Texas and other states do not use criteria weights. Some studies such as the evaluation of transportation options for California use public opinion surveys as one basis for their recommendations. The current study tries to include the priorities of the transportation experts who are knowledgeable of various aspects regarding transportation funding and are expected to participate in developing a future funding policy and explaining it to the public.

- The criteria weights obtained contribute to shaping the future funding policy for Texas. Some important ways in which this criteria system contributes are given below:
  - Although the search for a new funding system is due to the current and expected deficiencies in revenue generation, the equity and the public acceptance and political feasibility criteria are considered at least as important as the revenue generation. This research identifies which factors should be strong within a funding alternative for it to become successful and remain so for the long term.

- A closer look at the responses shows that the public acceptance and political feasibility is consistently among the top priorities. This closer look identifies that the real consensus opinion of this panel is that the public acceptance and political feasibility criterion may be the most important. This result fits with the current situation where the public and the elected members in Texas have been continuously disapproving any increase in taxes. In comparison, the NSTIFC assigns only about 9% weight to the public acceptance and political viability criterion.
- Based on the opinion of the expert panel members, the ability of a funding alternative to promote efficient travel behavior or fuel efficiency is unlikely to influence future transportation funding decisions in the state of Texas. Their claim that the effect of transportation user charges on the travel behavior is insignificant is reasonable, at least as long as the charges are not increased significantly. This result is very important because many researchers have been promoting VMT charges, which is a complex and expensive tax system, in many states and nationwide stating its benefits in promoting efficient travel behavior. The NSTIFC also assigns about a quarter of the total weight to the economic efficiency considerations.
- The primary reason for the funding deficiency the transportation sector is facing is a lack of public and political support for increasing the fuel tax and other user charges. However, much of the existing literature

concentrates on having good revenue sustainability and the ability to promote efficient system use in the new funding method. This research tries to bring the focus back to gaining the public acceptance. Without an improvement in the public acceptance, any tax increase does not seem feasible.

- The author highlights the need for efforts to develop a consensus among the transportation officials and policy makers regarding their priorities so that a funding strategy that is good for all stakeholders can be selected. He prepares a platform for a high level discussion by summarizing the average criteria weights and the deviations in the opinions of the panel members. This research shows that the officials who have participated in the survey have good agreement on the level of importance given to the public acceptance and political feasibility. They seem to be divided regarding the relative importance of revenue generation and equity. A compromise seems necessary on these two criteria. Although the average weight of the potential secondary benefits criterion is very low compared to the weights of the remaining criteria, some disagreement regarding this criterion remains. Nonetheless, the author shows through a scenario analysis that the final recommendations are not significantly affected by these differences in opinions.
- This research conducts the first formal evaluation of surface transportation funding alternatives for Texas and recommends a funding strategy for the near term and the long term. Major improvements of this study over

previous studies performed at national level and Texas state level are discussed below:

- In its 2009 study, the Dye Management Group assesses a number of alternatives for Texas on many criteria grouped into three major criteria. It does not perform a full-fledged multi-criteria analysis. It rates each alternative qualitatively on the three major criteria and presents the performance of each alternative as a table. It does not recommend a funding strategy. The current study establishes criteria weights, assigns scores to all alternatives on each sub-criteria and performs a full evaluation. It recommends a future funding strategy and shows that the recommendation is less sensitive to any changes in the inputs using a scenario analysis.
- The current study defines the alternatives more specifically to reflect different methods of implementation. Besides major alternatives which are intended to reduce the funding deficiency significantly, some supplementary alternatives, which are intended to improve the existing fuel tax system by generating additional revenue or improving its user-pay equity, are also studied.
- The main improvement over the NSTIFC's national level study is the way the criteria weights are established in this study. The evaluation technique used is also better. The simple additive weighting method used by the NSTIFC is not suitable for the ordinal method of scoring used. The current study uses a more suitable, partially compensating method, PROMETHEE, for the multi-criteria analysis. The scenario

analysis performed in the current study is also an improvement over the NSTIFIC study.

- The criteria weights and the scores assigned to the alternatives include some uncertainty. The author recognizes some of these uncertainties and tests their effect on the recommendations through a scenario analysis. He finds that the primary recommendations are not affected significantly by these changes. He shows that future changes in conditions are easily accommodated by upgrading the funding options recommended for the short term, and a major revision of the funding policy does not become necessary.
- The current study's recommendation for the short term that the fuel tax should be increased agrees with many past studies. However, for the long term, the current study does not recommend replacing fuel tax with VMT charges, as suggested by many other studies. The author tries to list some main justifications to support these recommendations below:
    - Other studies consider the VMT charges as a tool to encourage users to use the transportation system more efficiently. In contrast, the current study shows that the transportation officials in Texas, who have participated in the survey, do not agree. Furthermore, its high initial and operating cost, its complexity and the difficulty in obtaining public acceptance do not warrant shifting from a very simple, inexpensive and well established fuel tax system. This study recommends a variable tolling option as a next step because a transition from fixed tolls is not as expensive. This option partially

achieves the efficiency goals by discouraging travel on certain corridors and certain time periods. This option is also more acceptable by the public.

  - Most studies that recommend the transition towards VMT charges do so for nationwide implementation. This study considers a statewide implementation of VMT charges. Implementation of VMT charges is expensive and includes many challenges, which become very difficult to address at state level.

- Researchers have discussed the advantages and disadvantages of the increased use of local option taxes. While investigating the future funding strategies for a state, examining if a local funding solution is better than a statewide funding solution is important. By obtaining the preferences and suggestions of the transportation experts, the author adds the decision makers' perspective to this discussion. The panel prefers a balanced approach where the state continues to be the primary funding source while allowing the local authorities to generate their own revenue when the state is not able to meet specific local needs. They suggest that the state have some control over the use of locally generated revenue. Based on the literature review and the expert opinion, the author forms a set of guidelines for integrating the local funding with the statewide funding measures.
- In this research, a set of screening criteria is established. This consists of the user-pay equity, ease of explaining to the public and acceptability to the public criteria. As mentioned earlier, these three criteria represent more than one third of the total weight. Revenue generation potential may also be

added to this list. One may first evaluate the alternatives on these critical criteria. The shortlisted alternatives from this screening may be scored on all the criteria and evaluated further. This process is expected to reduce the cost and time needed for the evaluation. Some previous studies have used a threshold criterion such as revenue generation and connection to transportation. These may still be used while forming the pool of the alternatives for evaluation.

In addition to the above, the author has one contribution to the way the Delphi surveys are designed. In the third round survey, the author asks the panel members to provide the reasons for their revision. He includes two options: 1) they agree to the reasons and 2) they do not agree but are able to compromise to help reach consensus. This is a very important question and is not commonly included by the users of the Delphi method. The response to this question indicates how well the feedback of the survey works in building a consensus. This assessment is necessary to examine the reliability of the consensus opinion.

6.3. Recommendations for Future Research

Many of the contributions listed above can also guide future research. Some specific research ideas are listed below:

- The current study is conducted by the author as part of his dissertation. While the author has put forth his best efforts in this study, some improvements may help improve the support for the study's recommendations. For the help of future studies, either in Texas or elsewhere, these improvements are listed below:

- A formal study that is similar to this study should be administered by the state Legislature, TxDOT or similar entity. Such study can encourage participation in the survey and provide additional credibility.
- The participation in the expert survey, especially that of TxDOT officials and Legislative Committee member staff, should be increased. The study, being a formal study, may encourage more officials to participate and to provide their responses with more attention. The participation should still be voluntary and the anonymity of the participants should still be maintained.
- While continuing e-mail as the medium of communication, the surveyors may explain the terminology and questions by telephone to improve the understanding of the panel members.
- The criteria are independent to each other. One should identify if the members are considering any two criteria dependent to one another and clarify any ambiguities through more explanation.
- The schedule of the future surveys should not overlap with the state legislative session. This may increase the participation and expedite the overall survey response. Reducing the time between the questionnaires helps in keeping the attention of the participant and may improve the overall validity of the survey.
- The scoring process can be improved. In the existing literature, researchers concentrate mainly on scoring certain alternatives on individual criteria. A state level study such as this one should define the alternatives precisely for implementation and develop the scores

by integrating these individual studies and comparing various characteristics of the alternatives, as defined. A group of experts who are knowledgeable in different aspects of the funding alternatives may be surveyed to obtain the relative importance of the alternatives. The preference and indifference thresholds should be decided based on new scoring systems.

    - The study may examine how sensitive the results are to the way the alternatives are defined.

- An immediate extension of this study may be to confirm if indeed the consensus opinion is that the public acceptance and political feasibility criterion is the most important. This may be achieved by taking this observation back to the panel members and asking them if they agree with this opinion.
- Usually, funding alternatives are assigned a score depending on how well they satisfy a criterion. This study does not determine if there is an upper limit for satisfaction, that is, after a certain performance threshold, further increases in performance may not improve the chances of selecting an alternative and may even reduce them. Future research may examine if the panel members think of any criterion in this way.
- Future research may investigate if the criteria system developed in this research can be directly used in other states or countries and if the criteria weights depend on geography and social and political conditions.
- After reviewing a great amount of literature on the transportation funding, the author feels that research on transportation funding needs proper

control and guidance so that the decision makers and the public are not misinformed or half-informed about the topic. The author recommends that a group of knowledgeable researchers should be set up as a review panel. This panel should be free from any bias towards any particular funding alternative. Any research or documentation pertaining to transportation funding should be reviewed by this panel before being presented to the public.

- From this research, the author finds that an increase of the fuel tax scores well on most of the important criteria; however, it performs poorly on public acceptance. Future research may concentrate on the reasons for public disapproval of the fuel tax increase and other funding methods in general, and recommendations to mend it. As mentioned in this report, the elected representatives at the state and national levels are not willing to increase fuel tax. Whether or not this opinion matches with the general public's opinion may be the first question to answer. If it does not match, research may identify how the elected leaders or the legislature may be informed of the correct opinion of the public in this regard. If it matches, research should identify the exact barrier for this disapproval and try to resolve it. The public may oppose the transportation taxes as any other taxes. They may not understand the actual cost to them due to the increase of fuel tax or the cost they incur in the long term if the projects are delayed due to lack of funding. In these cases, a campaign should be conducted to increase the public awareness in this topic. The public may be skeptical about the efficient use of their tax money. To address this, future research should design ways to

improve the public involvement in transportation planning and investment process.

- This research discovers a problem in using PROMETHEE for multi-criteria evaluation. Although the author does not analyze this problem in detail, he identifies that the outcome of the PROMETHEE method may change with the group of alternatives evaluated. The possible reason in this research may be that the number of alternatives evaluated is large and the scores of some alternatives are similar. As a remedy, the author analyzes the alternatives by first grouping them into similar alternatives and then evaluating the resultant shortlist of alternatives. He uses a broader set of preferred alternatives as the basis for his recommendations. Future research may analyze this problem more formally and provide guidelines for future use of this method. Some potential ideas are:
    - An index may be calculated for a group of alternatives to be analyzed using PROMETHEE. This index may represent the number of alternatives, the range of scoring and similarities in scores. Research may determine a range for this index when the PROMETHEE method is suitable.
    - While the shortlists may change depending on the group of alternatives evaluated, whether or not a shortlist is superior to another is not clear. Future research should provide guidance regarding this issue.

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Appendix A

Institutional Review Board Approval Letter

Office of Research Administration
Regulatory Services
817-272-3723
regulatoryservices@uta.edu
http://www.uta.edu/ra/oric/

Institutional Review Board
Notification of Exemption

September 25, 2012

Sasanka Bhushan Bhushan Pulipati
Dr. Stephen Mattingly
Civil Engineering
Box 19308

Protocol Number: 2013-0217

Protocol Title: *An Investigation of Innovative Financing Options for Infrastructure Development at Regional and State Levels*

Type of Review: **Exemption Determination**

The UT Arlington Institutional Review Board (IRB) Chair, or designee, has reviewed the above referenced study and found that it qualified for exemption under the federal guidelines for the protection of human subjects as referenced at Title Part 45CFR46.101(2(b) categories (2)(4).You are therefore authorized to begin the research as of December 17, 2012.

Pursuant to Title 45 CFR 46.103(b)(4)(iii), investigators are required to, "promptly report to the IRB ***any*** proposed changes in the research activity, and to ensure that such changes in approved research, during the period for which IRB approval has already been given, are **not initiated without prior IRB review and approval** except when necessary to eliminate apparent immediate hazards to the subject." Please be advised that as the principal investigator, you are required to report local adverse (unanticipated) events to the Office of Research Administration; Regulatory Services within 24 hours of the occurrence or upon acknowledgement of the occurrence.

All investigators and key personnel identified in the protocol must have documented Human Subject Protection (HSP) Training on file with this office. Completion certificates are valid for 2 years from completion date.

The UT Arlington Office of Research Administration; Regulatory Services appreciates your continuing commitment to the protection of human subjects in research. Should you have questions, or need to report completion of study procedures, please contact Robin Dickey at 817-272-9329 or robind@uta.edu. You may also contact Regulatory Services at 817-272-3723 or regulatoryservices@uta.edu.

Appendix B

Sample First Round Survey

Survey of Experts to Identify the Criteria to Evaluate Surface Transportation Funding Alternatives – Round 1

Survey Responder ID: M23

Sasanka Pulipati, a PhD student at UT Arlington, is working on research regarding future surface transportation funding policy under his supervising professor, Dr. Stephen Mattingly, Assistant Professor in the Department of Civil Engineering. In his research, he wants to obtain the opinion of a panel of experts regarding the criteria used in evaluating different funding alternatives. Traditionally, fuel tax has been the source of most of the highway funding. Examples for funding alternatives are increasing; fuel tax, charging a vehicle mileage fee, tolling highways and increasing statewide or local option sales tax are all now being considered to varying degrees.

The research team wants to respectfully thank you for your participation in this survey. Your opinion will help in finding a solution to the transportation funding problems faced by the nation.

The survey methodology is given below.

Delphi Survey Methodology

The survey is expected to be performed in three iterations using a Delphi approach.

In the first round, about twenty officials will be asked to select a set of criteria to evaluate different funding sources. The respondents will be surveyed individually and will be asked to provide their responses to the questionnaire sent to them by email. The list of survey respondents, partially or fully, will not be revealed to any of the respondents.

In the second round, the respondents will be asked to weigh the criteria in a pairwise comparison method. In this method, two criteria are taken at a time and the relative importance of one criterion over the other will be noted. The researcher will summarize the criteria and their average weights at the end of the second round.

The third round is for getting consensus among the experts regarding the criteria weights. In the third round, the author will show the resultant weights to each respondent and will ask if the respondent would like to revise his or her opinion. After any revisions in the third round, the researcher will present the final summary of criteria and their weights to the respondents. If significant differences remain after the third round, the experts may be consulted for a fourth round to get consensus.

Survey Round 1:

Herewith, the first round of questions is presented. Please fill in the responses and send this document by email. You can also print it and fax it. Please write Attn: Sasanka Pulipati on the Fax Cover Sheet. Email address and Fax number are provided below.

Email Address: sasankabhushan.pulipati@mavs.uta.edu

Fax Number: 817-272-2630

The research team greatly appreciates your expert opinions in this survey. The team will be glad to provide you with a summary of the study results after every round of survey. At the conclusion of the study, the results would be available upon request. Thank you again for your participation in this survey.

Questionnaire:
While responding to the survey, please note the following:

- The evaluation of funding alternatives is not related to any specific project or project type. The research team is evaluating the funding to satisfy the surface transportation needs in general in the next 20 to 25 years.
- Although it is feasible to implement some of the funding alternatives across the nation, in the context of this survey, please consider funding alternatives are evaluated for statewide or local implementation.
- Some examples for funding alternatives are: increasing fuel tax, charging a vehicle mileage fee, increasing vehicle registration fee, tolling highways and increasing sales tax.

Criteria for Evaluation

Question A1:
What criteria would you use to evaluate surface transportation funding alternatives?

Below, some main criteria are listed. Please indicate how important you think it is to consider each of the following criteria by placing an "X" in the appropriate box. Please provide your justification or any other comments regarding your opinion in the space provided below each criterion. Please read the descriptions of the criteria given on the last two pages of this survey.

Table A1. Main Criteria

Evaluation Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Revenue generation potential					
Comments:					
Equity and fairness					
Comments:					

Table A1. Main Criteria - Continued

Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Ease of implementation					
Comments:					
Political feasibility					
Comments:					
Improvement in transportation system performance and environment					
Comments:					

Question A2:
Can you think of any other criteria that should be considered in the evaluation of surface transportation funding alternatives?

Please write down below the additional criteria with some description and why you think the criterion should be considered.

Table A2. Additional Main Criteria

Criterion Description	Reason for Consideration

Sub-Criteria

To evaluate the funding alternatives more specifically, the main criteria may be divided into sub-criteria. In the following questions, each of the five main criteria has been divided into sub-criteria. Please refer to the descriptions of the criteria given on the last two pages of this survey.

Question A3:

Please indicate how important you think it is to consider these sub-criteria by placing an "X" in the appropriate box.

Please write any additional sub-criteria that you may feel are important in the space provided.

Please provide your justification or any other comments regarding your opinion in the space provided below for each criterion.

Table A3. Sub-criteria under Revenue Generation Potential Criterion

Sub-Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Short term revenue potential					
Revenue sustainability – Long term revenue potential					
Revenue predictability					
Ease of tax or fee increases when needed					
Additional sub-criteria:					
Comments:					

Table A4. Sub-criteria under Equity and Fairness Criterion

Sub-Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Equity in paying by benefit gained and cost imposed (user-pay)					
Ability to pay equity					
Geographical equity					
Connection with transportation					
Additional sub-criteria:					
Comments:					

Table A5. Sub-criteria under Ease of Implementation Criterion

Sub-Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Cost of implementation					
Ability to prevent evasion					
Simplicity of payment structure					
Less need for new technology					
Ability to use existing payment infrastructure					
Ease of co-ordination with bordering regions					
Additional sub-criteria:					
Comments:					

Table A6. Sub-criteria under Political Feasibility Criterion

Sub-Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Ease of explaining to the public					
Acceptability to public					
Less need for passing of new laws or amendments					
Additional sub-criteria:					
Comments:					

Table A7. Sub-criteria under Improvement in Transportation System Performance and Environment Criterion

Sub-Criterion	Very Important	Important	Moderately Important	Of Little Importance	Not Important
Congestion relief					
Environmental benefits					
Encouragement for proper spending by authorities					
Additional sub-criteria:					
Comments:					

Statewide implementation vs. local implementation:

Question A4:

Local option taxes are considered to be more politically feasible and to produce faster results. When revenue from local taxes is used, the project delivery is usually sped up because of fewer restrictions from federal or state governments.

However, there are concerns that localizing the funding for transportation improvements would eventually undermine the state's role in funding surface transportation projects. With less effort for statewide sources of funding, statewide connectivity as well as the transportation infrastructure outside the metropolitan areas may deteriorate.

The researcher would like to obtain your preference on this topic.

Do you prefer statewide implementation or local implementation of transportation funding solutions? Would a balanced approach be the best? Please provide your justification.

Answer:

Criteria Descriptions

Revenue generation potential:

The alternative that provides greater revenue will receive a better ranking. Each funding option should be evaluated not only for the revenue generated in short term, but also, its potential to generate stable and predictable revenues over the long term. When needed in future, it should be easy to increase the tax or fee.

Equity and Fairness:

This criterion evaluates the fairness of the user fee or tax system. Transportation funding options are evaluated for three concepts of equity, namely, user-pay, i.e., pay by benefits received and cost imposed, ability to pay and geographical equity.

As per the user pay concept, those who use a transportation system should pay for that system. The higher the cost imposed on the transportation system and environment by a certain group of users, the more that group should pay for the system. For example, trucks impose more damage to the roads than cars do and so trucks should pay more fee or tax than what cars pay.

Low-income drivers cannot afford to pay much; therefore, they should pay less than wealthier drivers for transportation. This is called the ability to pay concept.

Geographical equity examines whether the transportation funds are fairly distributed among the states, regions inside the states and communities inside the regions.

The way in which a tax is related to transportation is also taken as a factor related to equity. This is also called Transportation Nexus. For example, sales tax does not connect to transportation as well as gas tax does.

Ease of Implementation:

The easier it is for an alternative to be implemented, the better ranking it would get. Ease of implementation depends on the cost of implementation including administration cost, compliance cost and enforcement cost.

The tax rate and payment structure should be simple for the payers to understand it and to keep their records.

The system should prevent evasion of tax or fees. Need for use of new technology and changes in existing payment structure are expected to increase the difficulty in implementing a funding alternative.

A system should not make it difficult for the connecting regions to coordinate in preventing evasion of taxes or fees at the borders of the regions.

Political Feasibility:

Any policy that includes new taxes or fees needs to be accepted at the political level. Political feasibility depends on how easily a funding alternative can be explained to the public and how acceptable it is to the public. The feasibility of a funding alternative is increased when there is less need for new laws or amendments to existing laws.

Improvement in Transportation System Performance and Environment:

A funding alternative should also be evaluated for the improvement it produces in the transportation system performance and environment. A user fee or tax system gets better ranking when it encourages travelers to efficiently use the transportation system such that congestion is reduced. A funding alternative should encourage travelers to change their travel behavior such that they use high-emission fuels efficiently and reduce environmental pollution. On the spending side, a system gets preference when it encourages spending on projects that maximize the benefits in terms of both transportation system performance as well as environment.

Appendix C

Sample Second Round Survey

Survey of Experts to Identify the Criteria to Evaluate Transportation Funding Alternatives – Round 2

Survey Responder ID: M02

Thank you for providing your valuable response to the first round of this survey regarding the list of criteria and sub-criteria to be used in evaluation of transportation funding methods. So far, eighteen experts from MPOs, TxDOT and Texas Senate Committee for Transportation responded to the first round of the survey. Based on a review of the responses and the comments accompanying them, the research team modified the criteria. A five-page summary describing these modifications and the final list of criteria was sent to you. The team will use these criteria and the sub-criteria, listed below, in the evaluation hence-forth. Criteria descriptions are given in the next page.

Table B1. Criteria and Sub-criteria for the Evaluation of Funding Alternatives

Main Criteria	Sub-criteria
Revenue Generation (RG)	Revenue generation potential
	Revenue sustainability
	Revenue predictability
	Flexibility in investment
	Ease of tax or fee increases when needed
Equity and Fairness (EQ)	Equity in paying by benefit gained and cost imposed (user-pay)
	Ability to pay equity
	Geographical equity
Ease of Implementation (EI)	Cost of implementation
	Simplicity of payment structure
	Ability to prevent evasion
	Ability to use existing payment infrastructure
	Ease of co-ordination with bordering regions
Public Acceptance and Political Feasibility (PA&PF)	Ease of explaining to the public
	Acceptability to the public
	Less need for legislative action (addition, deletion or amendment of laws)
Potential Secondary Benefits (PSB)	Promotion of efficient use of system by changing travel behavior
	Promotion of fuel efficiency and use of low emission fuels

Criteria Descriptions:

Revenue Generation Criterion (RG):

Revenue generation potential: This measures the ability of a funding alternative to generate significant revenue using politically and economically viable rates to match the investment needs over the target time frame.

Revenue sustainability: This evaluates the extent to which the funding mechanism provides stable (or increasing) revenue over the years while responding to external factors such as changes in travel behavior and fuel efficiency. The funding alternative should provide increased revenue when transportation system usage increases. If the rate of tax or fee is indexed to inflation or a transportation cost index, the alternative gets better score for this sub-criterion.

Revenue predictability: The accuracy with which the revenue from a funding mechanism can be predicted. Better prediction allows the officials to respond to any adverse situations.

Flexibility in investment: The extent to which the mechanism is appropriate for a wide (and potentially changing) range of investments and can be redirected to meet changing objectives, market dynamics, technology options, etc. For example, broad based alternatives such as the gas tax or general taxes tend to have considerable flexibility, while narrowly focused mechanisms, such as facility-specific tolls, generally are inherently less flexible.

Ease of tax or fee increases when needed: The extent to which it is easy to adjust the tax or fee when needed by an action by the operators or local or regional policy makers. This pertains to the increase of the base rate of tax or fee. For example, increase of a countywide vehicle registration fee may be easier than increasing a statewide fuel tax.

Equity and Fairness Criterion (EQ): This criterion evaluates the fairness of the user fee or tax system. Transportation funding options are evaluated for three concepts of equity, namely, user-pay, i.e., pay by benefits received and cost imposed, ability to pay and geographical equity.

Equity in paying by benefit gained and cost imposed (User-pay): As per the user pay concept, those who benefit from a transportation system by using it should pay for that system. The higher the cost imposed on the transportation system and environment by a certain group of users, the more that group should pay for the costs. For example, cars and trucks should pay for the roads as they benefit from using it. Trucks impose more damage to the roads than cars do and so trucks should pay more fee or tax than what cars pay.

Ability to pay equity: Low-income drivers cannot afford to pay much; therefore, they should pay less percentage of their income than wealthier drivers for transportation. This is called the ability to pay concept.

Geographic equity: This evaluates the extent to which the cost allocation/impact of the mechanism can be structured to match the geographic distribution of the benefit of the funded investments. Geographic equity refers primarily to the extent to which the cost burden can be structured to match the benefit in terms of geography. There will be instances where some amount of cross-subsidization may be required to ensure important and necessary system improvements in places that are geographically disadvantaged in terms of population density, for instance.

Ease of Implementation Criterion (EI):

Cost of implementation: This includes the cost of initial implementation, on-going administration and cost of compliance relative to the revenue generated. Under this criterion, when two alternatives generate similar revenues, the alternative with less cost gets better ranking.

Simplicity of payment structure: The tax rate and payment structure should be simple for the payers to understand and to keep their records.

Ability to prevent evasion: The system should be such that evasion of charges can be prevented or reduced easily and with less cost.

Ability to use existing payment infrastructure: Using existing administrative and physical payment infrastructure is considered an advantage in this criterion. Any new payment infrastructure will take time to develop and includes costs related to transformation from old system to new system.

Ease of co-ordination with bordering regions: A system should not make it difficult for the connecting regions to coordinate in preventing evasion of taxes or fees at the borders of the regions. This kind of coordination may be needed at the borders of a state, metropolitan area or a county where a tax rate or a funding policy differs between the regions.

Public Acceptance and Political Feasibility Criterion (PA&PF):

Ease of explaining to the public: It should be easy to explain to the public about a funding alternative. Only then it will stand a chance of being accepted among public. The ease of explaining depends on factors such as how similar a new system is compared to the existing system, how the tax or fee is calculated, how it is connected with transportation and whether or not it is termed as a tax.

Acceptability to the public: This pertains how well a funding alternative is accepted by the public. Public acceptance is the key for a funding alternative being accepted by the elected officials.

Less need for legislative action: The feasibility of a funding alternative is increased when there is less need for legislative action by the elected officials (local or state level). This may include passing new laws, removing outdated laws or amending existing laws.

Potential Secondary Benefits Criterion (PSB):

Promotion of efficient use of system by changing travel behavior: This evaluates the extent to which the funding mechanism can promote efficient use of transportation system by encouraging travelers to make changes in their travel behavior. Such changes include but are not limited to reducing the frequency and distance of travel, traveling in off-peak periods and using alternative modes such as public transit and non-motorized modes. Any tool included in the funding mechanism that penalizes inefficient use helps the funding mechanism to get higher rating. For example, congestion pricing is seen as an alternative that discourages travel in congested time periods on certain roadways.

Promotion of fuel efficiency and use of low emission fuels: This evaluates the extent to which the funding mechanism encourages use of low emission fuels and increase of fuel efficiency by users.

Survey Round 2:

Herewith, the second round of questions is presented. Please fill in the responses and send this document by email. You can also print it and fax it. Please write Attn: Sasanka Pulipati on the cover sheet of the Fax. Email address and Fax number are provided below.

Email Address: sasankabhushan.pulipati@mavs.uta.edu
Fax Number: 817-272-2630

The research team greatly appreciates your expert opinions in this survey. The team will be glad to provide you with a summary of the study results after every round of survey. At the conclusion of the study, the results will be available upon request. Thank you again for your participation in this survey.

Questionnaire:

This and the next round of the survey are intended to help the research team establish a set of weights for the criteria and sub-criteria. These weights will signify the relative importance of one criterion over another.

While responding to the survey, please note the following:

- The evaluation of funding alternatives is not related to any specific project or project type. The research team is evaluating the funding to satisfy the surface transportation needs in general in the next 20 to 25 years.
- Although it is feasible to implement some of the funding alternatives across the nation, in the context of this survey, please consider funding alternatives are evaluated for statewide or local implementation.
- Some examples for funding alternatives are: increasing fuel tax, charging a vehicle mileage fee, increasing vehicle registration fee, tolling highways and increasing sales tax.

Main Criteria Weights:

In this part, first, the main criteria will be evaluated by comparing two criteria at a time. This is called a pairwise comparison method. To simplify the process, you will be presented with one criterion and will be asked to identify if it is more important, less important or equally important compared to another criterion. This process is repeated for all possible pairs. Please see how the criteria for choosing a hospital are compared pairwise in the example below.

Example 1: (Pairwise comparison of main criteria in choosing a hospital)

Suppose that a Decision Maker (DM) is comparing the criteria for choosing the best hospital to visit. Suppose that there are three main criteria namely Doctors' Qualifications (DQ), Accessibility (ACC) and Pharmacy (PH). In the following table, in ROW1 and ROW2, the first criterion – Doctors' Qualifications is being compared with Accessibility and Pharmacy, respectively. DM thought that DQ is more important than ACC. So, DQ is filled in the green box in ROW 1. Then, in ROW 2, DM considers DQ and PH are of same importance. So, he fills "SAME" in the green box.

Similarly, in ROW 3, Accessibility and Pharmacy are compared. DM thinks Pharmacy is more important and so, he fills PH in the green box.

Table B2. Example Pairwise Comparison Table

ROW 1	Doctors' Qualifications	DQ	**DQ**	ACC	Accessibility
ROW 2	Doctors' Qualifications	DQ	**SAME**	PH	Pharmacy
ROW 3	Accessibility	ACC	**PH**	PH	Pharmacy

Comments: (Example)

"I have a car and the distance traveled to reach the hospital is not a concern. Doctors' qualifications are the most important for me. Pharmacy is as important as Doctors' qualifications to me."

Question B1:

Now, in the following table (Table B3), in ROW 1 to ROW 4, Criterion 1 – Revenue Generation (RG) is compared with the rest of the criteria. Each row corresponds to one pair of criteria. Please take one row at a time. Please fill in the green box with the criterion (short form) you think is more important between the two. If you think both criteria have the same importance, please fill the green box with "SAME". Please write any comments or justifications for your decision in the space provided below the table.

For example, in ROW 1, if you consider Equity is more important than Revenue Generation, please fill EQ in the green box; if you think that RG is more important, please fill RG. If you suggest that both criteria have the same importance, or they are indifferent to each other, please fill the box with "SAME".

Table B3. Pairwise Comparison Table – RG with Remaining

	Criterion A		Preference	Criterion B	
ROW 1	Revenue Generation	RG		EQ	Equity and Fairness
ROW 2	Revenue Generation	RG		EI	Ease of Implementation
ROW 3	Revenue Generation	RG		PA&PF	Public Acceptance and Political Feasibility
ROW 4	Revenue Generation	RG		PSB	Potential Secondary Benefits

Comments:

Similarly, in Table B4, Table B5 and Table B6 that follow, "Equity and Fairness", "Ease of Implementation" and "Public Acceptance and Political Feasibility" are compared with other criteria in pairs. In every row, please fill in the green box with the criterion you think is more important between the two. If you think both criteria have the same importance, please fill the green box with "SAME". Please write any comments or justifications for your decision in the space provided below each table.

Table B4. Pairwise Comparison Table – EQ with Remaining

	Criterion A		Preference	Criterion B	
ROW 5	Equity and Fairness	EQ		EI	Ease of Implementation
ROW 6	Equity and Fairness	EQ		PA&PF	Public Acceptance and Political Feasibility
ROW 7	Equity and Fairness	EQ		PSB	Potential Secondary Benefits

Comments:

Table B5. Pairwise Comparison Table – EI with Remaining

	Criterion A		Preference	Criterion B	
ROW 8	Ease of Implementation	EI		PA&PF	Public Acceptance and Political Feasibility
ROW 9	Ease of Implementation	EI		PSB	Potential Secondary Benefits

Comments:

Table B6. Pairwise Comparison Table – PF with Remaining

	Criterion A		Preference	Criterion B	
ROW 10	Public Acceptance and Political Feasibility	PA&PF		PSB	Potential Secondary Benefits

Comments:

Sub-criteria Weights:

All the sub-criteria under one main criterion will be weighted as one group. Each sub-criterion will be assigned a score such that the total of all scores is 100.

Example 2:

In Table B7 given below, the sub-criteria corresponding to the Hospital Accessibility criterion (one of the criteria shown in Example 1) are shown. There are three sub-criteria. First, the DM thinks that Distance from home is the most important of the three and Transit availability is the least important. Then, he suggests the scores of 50, 20 and 30 for the three sub-criteria shown. The sum of the scores is 100.

Table B7. Example Sub-criteria Scores

Main Criterion	Sub-criteria	Score
Accessibility	Distance from home	50
	Transit availability	20
	Parking provisions	30
	Total	**100**

Comments (Example):

I rarely use transit. So, availability of transit is of less concern to me. I give 'distance from home' great importance compared to the 'parking provisions'.

Question B2:

Table B8 below shows the sub-criteria for the Revenue Generation criterion. Please fill the column "Score" as illustrated in the example above with the scores for each sub-criterion such that the total score is 100. Please provide your comments/justifications below the table.

Table B8. Sub-criteria Scores – Revenue Generation

Main Criterion	Sub-criteria	Score
Revenue Generation (RG)	Revenue generation potential	
	Revenue sustainability	
	Revenue predictability	
	Flexibility in investment	
	Total	**100**

Comments:

Question B3:
Table B9 below shows the sub-criteria for the Equity and Fairness criterion. Please fill the column "Score" with the scores as explained above. Please provide your comments/justifications below the table.

Table B9. Sub-criteria Scores – Equity and Fairness

Main Criterion	Sub-criteria	Score
Equity and Fairness (EQ)	Equity in paying by benefit gained and cost imposed (user-pay)	
	Ability to pay equity	
	Geographical equity	
	Total	**100**

Comments:

Question B4:
Table B10 below shows the sub-criteria for the Ease of Implementation criterion. Please fill the column "Score" with the scores as explained above. Please provide your comments/justifications below the table.

Table B10. Sub-criteria Scores – Ease of Implementation

Main Criterion	Sub-criteria	Score
Ease of Implementation (EI)	Cost of implementation	
	Simplicity of payment structure	
	Ability to prevent evasion	
	Ability to use existing payment infrastructure	
	Ease of co-ordination with bordering regions	
	Total	**100**

Comments:

Question B11:
Table B8 below shows the sub-criteria for the Public Acceptance and Political Feasibility criterion. Please fill the column "Score" with the scores as explained above. Please provide your comments/justifications below the table.

Table B11. Sub-criteria Scores – Public Acceptance and Political Feasibility

Main Criterion	Sub-criteria	Score
Public Acceptance and Political Feasibility (PA&PF)	Ease of explaining to the public	
	Acceptability to the public	
	Less need for legislative action (addition, deletion or amendment of laws)	
	Total	**100**

Comments:

Question B6:
Table B12 below shows the sub-criteria for the Effects on Transportation System Performance criterion. Please fill the column "Score" with the scores as explained above. Please provide your comments/justifications below the table.

Table B12. Sub-criteria Scores – Effects on Transportation System Performance

Main Criterion	Sub-criteria	Score
Potential Secondary Benefits (PSB)	Promotion of efficient use of system by changing travel behavior	
	Promotion of fuel efficiency and use of low emission fuels	
	Total	**100**

Comments:

(Please see Question B7 on next page)

Do the criteria weights depend on whether the funding alternatives evaluated are implemented statewide or locally?

Question B7:

The research team intends to use the criteria weights obtained in this survey to evaluate funding alternatives regardless of their implementation statewide or locally. Do you think this is a fair assumption or would your responses change depending on whether the funding alternatives evaluated are implemented statewide or locally?

Fill "x" in the appropriate box below.

It is a fair assumption	
Not a fair assumption. My responses would change.	

Comments:

Thank You!

Appendix D

Sample Third Round Survey

Survey of Experts to Identify the Criteria to Evaluate Transportation Funding Methods – Round 3

Survey Responder ID: M21

Thank you for providing your valuable opinion about the criteria and their weights to be used in evaluating transportation funding options. In total, 26 experts from MPOs, TxDOT and Texas Legislature Transportation Committee member offices provided their responses. A summary of resultant criteria weights and related statistics was sent to you last week. Please refer to this summary while responding to this third round survey. All your responses were included in the average weights calculated. The research team wants to build a consensus among the experts about the criteria weights. By showing a comparison of your original responses with the average weights, which are potential consensus weights, the research team wants to ask you if you are willing to accept the average weights or to revise your responses so that they are closer to the average weights.

Herewith, the third round questionnaire is presented. Please fill in the responses and send this document by email. You can also print it and fax it. Please write Attn: Sasanka Pulipati on the cover sheet of the Fax. Email address and Fax number are provided below.

Email Address: sasankabhushan.pulipati@mavs.uta.edu
Fax Number: 817-272-2630

The research team greatly appreciates your expert opinions in this survey. If a reasonable consensus is reached, this will be the last round of questionnaires. The team will be glad to provide you with a summary of the results after this round of survey. At the conclusion of the study, the results will be available upon request. Thank you again for your participation in this survey.

Questionnaire:

Main Criteria Weights:

In the second round survey, panel members weighted the main criteria using a pairwise comparison method. The research team calculated the weights based on these preferences and averaged them over all panel members. The resultant overall average weights were used to construct the pairwise comparison preferences again. Your original preferences are compared with these average preferences in Table C1 below. For any pair, if your preference does not match with overall average preferences, your preference is shown in RED. This table is only for your information.

Table C1. Main Criteria Pairwise Comparisons – Yours vs. Overall Average

	Criterion A	vs.	Criterion B	Preference	
				Yours	Overall
ROW 1	RG	vs.	EQ	RG	SAME
ROW 2	RG	vs.	EI	SAME	RG
ROW 3	RG	vs.	PA&PF	PA&PF	PA&PF/SAME
ROW 4	RG	vs.	PSB	SAME	RG
ROW 5	EQ	vs.	EI	SAME	EQ
ROW 6	EQ	vs.	PA&PF	SAME	PA&PF/SAME
ROW 7	EQ	vs.	PSB	PSB	EQ
ROW 8	EI	vs.	PA&PF	EI	PA&PF
ROW 9	EI	vs.	PSB	EI	EI
ROW 10	PA&PF	vs.	PSB	SAME	PA&PF

Calculation of weights from pairwise comparison:

In this calculation, the maximum and minimum weights possible are **36** and **4** (on a scale of 0 to 100), respectively. If a criterion is given higher importance over all other criterions, it gets a weight of **36**. If a criterion is given less importance over all other criterions, it gets a weight of **4**.

Question C1:

Table C2 below shows the main criteria weights calculated based on your response to the pairwise comparison question. These are compared with the overall average weights. Any weight that is more than 20% different from the corresponding average weight is shown in RED. Under the "Discussion" section below, some justifications are given supporting the average weights. Other comments are summarized in the summary document provided. These are mainly based on the panel members' responses and comments. Please refer to the summary report and the discussion here while making your decisions.

After learning about this group response, would you like to revise your opinion and update your weights to come closer to the average weights?

If so, please fill the last column with your revised weights on 100-point scale.

Table C2. Comparison of Main Criteria Weights

Main criteria	Your Weights	Overall Average	Your Revision
Revenue Generation (RG)	20	25	
Equity and Fairness (EQ)	12	25	
Ease of Implementation (EI)	28	15	
Public Acceptance and Political Feasibility (PA&PF)	20	28	
Potential Secondary Benefits (PSB)	20	7	
Total	**100**	**100**	**100**

OR, if you want to adopt the overall average weights as your revised weights, please fill this box with YES	

Comments:

Below, please accept a reason for revising your response by marking 'X'; OR Provide any other comments or reasons for revising or not revising your response.

a. I agree with the justifications and so, I revised.	
b. I do not completely agree with the reasons but I am willing to compromise to help reach consensus. So, I revised.	
Other:	

Discussion on Main Criteria:

1. PA&PF is slightly more important than RG and EQ
   a. Some respondents thought Revenue Generation is the most important, some thought Equity and some others thought Public Acceptance and Political Feasibility. Figure C1 shows how the weights given to RG, EQ and PA&PF are distributed. While weights for RG and EQ are more spread out, PA&PF weights are more concentrated towards higher side. Moreover, PA&PF got equal or higher weight compared to either RG or EQ in 21 out of 26 occasions.

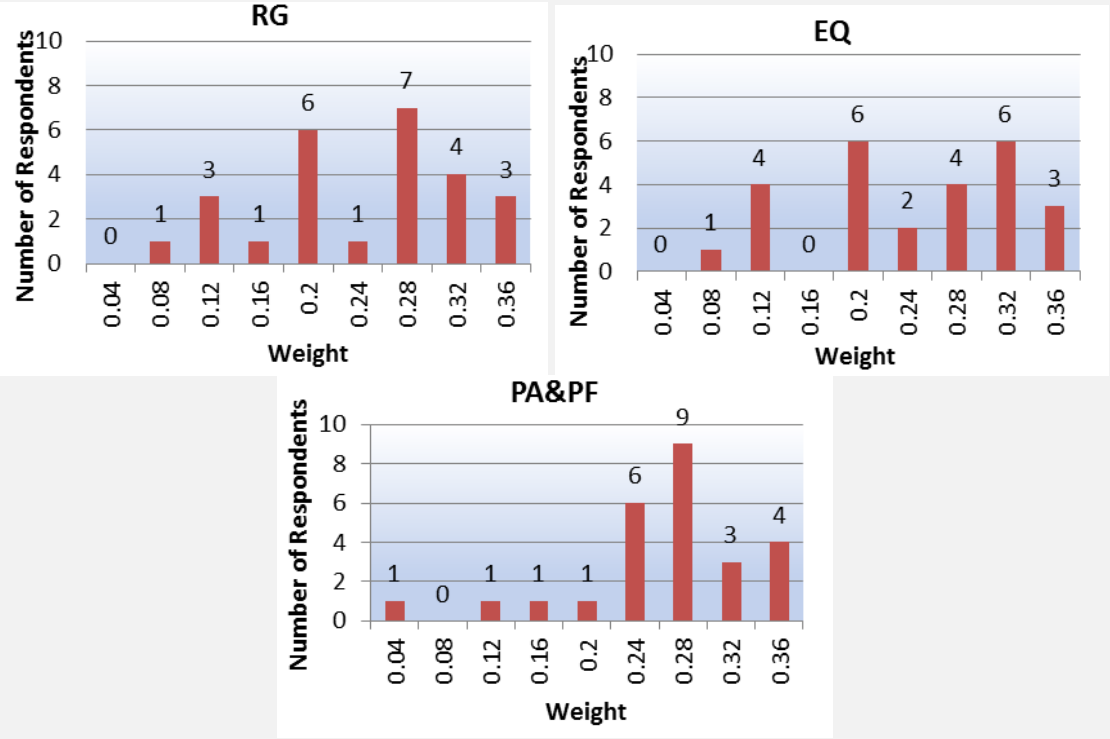

Figure C1. Distribution of weights – RG, EQ and PA&PF

2. RG, EQ and PA&PF are equally important and more important than others.
   a. Though revenue generation is critical for future funding, it would not be acceptable politically if not perceived fair and accepted by the public. Implementation issues can be more easily overcome.
   b. The main reason for searching for new alternatives is to provide enough funds for the future. So revenue generation is important. But we cannot charge whatever tax or fee. We have to charge it such that it is fair among all people. They must perceive it fair. With these two satisfied well, it may eventually get accepted among public.
3. EI criterion is less important
   a. Implementation issues can be overcome with technology and better policies.
4. PSB criterion is the least important
   a. The effect that a transportation related tax or fee can have on travel behavior or fuel usage is insignificant and so these secondary benefits need not be included in the evaluation.
   b. Potential secondary benefits are often difficult for voters to see. They look at their cost first.

Sub-criteria Weights:

In the following five questions, each question corresponds to the sub-criteria under one main criterion. Each question contains a table showing your original weights on the 100-point scale along with overall average weights. Any weight that is more than 20% different from the corresponding average weight is shown in RED. Under the "Discussion" section below, some justifications are given supporting the average weights. Other comments are in the summary document provided. These discussions are mainly based on the members' comments. Please refer to the summary report and the discussion here while making your decisions.

Question C2: Revenue Generation Criterion
Table C3 shows the sub-criteria weights for the Revenue Generation criterion.

After learning about this group response, would you like to revise your opinion and update your weights to come closer to the average weights?

If so, please fill the last column with your revised weights on 100-point scale.

Table C3. Summary of Sub-criteria Weights – Revenue Generation

Sub-criteria	Your Weight	Overall Average	Your Revision
Revenue generation potential	50	28	
Revenue sustainability	30	28	
Revenue predictability	10	24	
Flexibility in investment	5	10	
Ease of tax or fee increase when needed	5	10	
Total	**100**	**100**	**100**

OR, if you want to adopt the overall average weights as your revised weights, please fill this box with YES

Comments:

Below, please accept a reason for revising your response by marking 'X'; OR Provide any other comments or reasons for revising or not revising your response.

a. I agree with the justifications and so, I revised.	
b. I do not completely agree with the reasons but I am willing to compromise to help reach consensus.	
Other:	

Discussion on RG Criterion:

1. RG - Revenue generation potential, sustainability and predictability are more important. Flexibility of investment and Ease of increase in tax or fee when needed are very less important
   a. At present we first need funds. And once we set up a funding method, we want it to run for a long time. Ability to predict allows us to plan better. Flexibility of investment and ease of increase in tax or fee can be overcome by making some adjustments to the policy. So they are minor issues.
2. RG – Revenue sustainability is more important
   b. Although revenue potential is important, the biggest problem in funding is having a source you can count on year after year.

Question C3: Equity and Fairness Criterion

Table C4 shows the sub-criteria weights for the Equity and Fairness criterion.

After learning about this group response, would you like to revise your opinion and update your weights to come closer to the average weights?
If so, please fill the last column with your revised weights on 100-point scale.

Table C4. Summary of Sub-criteria Weights – Equity and Fairness

Sub-criteria	Your Weight	Overall Average	Your Revision
Equity in paying by benefit gained and cost imposed (user-pay)	30	52	
Ability to pay equity	50	26	
Geographical equity	20	22	
Total	**100**	**100**	**100**

OR, if you want to adopt the overall average weights as your revised weights, please fill this box with YES	

Comments:

Below, please accept a reason for revising your response by marking 'X'; OR
Provide any other comments or reasons for revising or not revising your response.

a. I agree with the justifications and so, I revised.	
b. I do not completely agree with the reasons but I am willing to compromise to help reach consensus.	
Other:	

Discussion on EQ Criterion:

1. EQ - User pay equity is the most important
   a. User pay fits very well with our objectives. The funding alternative should charge users by their extent of use or cost imposed. Charging by the use will bring about changes in certain travel behavior also which is helpful for planning organizations.
   b. If equity in paying by benefit gained and cost imposed (user-pay) is achieved, then ability to pay and geographical equity should potentially balance out.
2. EQ – Ability to pay is less important than user-pay
   a. Everyone has a choice to pay and use based on their budgets. It is difficult to measure ability to pay and difficult to implement.
3. Geographic equity is important but cannot be a defining factor. There must be a balance struck that emphasizes the good of society as a whole.

Question C4: Ease of Implementation Criterion

Table C5 shows the sub-criteria weights for the Ease of Implementation criterion.
After learning about this group response, would you like to revise your opinion and update your weights to come closer to the average weights?
If so, please fill the last column with your revised weights on 100-point scale.

Table C5. Summary of Sub-criteria Weights – Ease of Implementation

Sub-criteria	Your Weight	Overall Average	Your Revision
Cost of implementation	25	26	
Simplicity of payment structure	25	26	
Ability to prevent evasion	20	18	
Ability to use existing payment infrastructure	15	16	
Ease of co-ordination with bordering regions	15	14	
Total	**100**	**100**	**100**

OR, if you want to adopt the overall average weights as your revised weights, please fill this box with YES	

Comments:
Below, please accept a reason for revising your response by marking 'X'; OR
Provide any other comments or reasons for revising or not revising your response.

a. I agree with the justifications and so, I revised.	
b. I do not completely agree with the reasons but I am willing to compromise to help reach consensus.	
Other:	

Discussion on EI Criterion:
These sub-criteria received mixed opinions. Most of the panel members gave weights in the range of 10 to 30 to all sub-criteria. Some members think that each sub-criterion plays important role when looking at how to implement an alternative. Some thought cost was most important. Simplicity of payment structure was favored because it allowed people to understand it better; Simple system would be less costly and have fewer chances for evasion. Some think prevention of evasion is more important because it increases cost of enforcement and reduces fairness. One member asked why one should tie to existing infrastructure as new system may be an easier, more efficient and less vulnerable to evasion.

Question C5: Public Acceptance and Political Feasibility criterion

Table C6 shows the sub-criteria weights for the Public Acceptance and Political Feasibility criterion.

After learning about this group response, would you like to revise your opinion and update your weights to come closer to the average weights?

If so, please fill the last column with your revised weights on 100-point scale.

Table C6. Summary of Sub-criteria Weights – Public Acceptance and Political Feasibility

Sub-criteria	Your Weight	Overall Average	Your Revision
Ease of explaining to the public	40	34	
Acceptability to the public	40	46	
Less need for legislative action	20	20	
Total	**100**	**100**	**100**

OR, if you want to adopt the overall average weights as your revised weights, please fill this box with YES	

Comments:

Below, please accept a reason for revising your response by marking 'X'; OR
Provide any other comments or reasons for revising or not revising your response.

a. I agree with the justifications and so, I revised.	
b. I do not completely agree with the reasons but I am willing to compromise to help reach consensus.	
Other:	

Discussion on PA&PF Criterion:

1. PA&PF - Acceptability to public sub-criterion is very important.
   a. Public acceptance is the key. However the alternative is, we can try and explain better but eventually public should accept for it to go through.
2. PA&PF – Less need for legislative action sub-criterion is less important.
   a. As long as the public understands the tax or fee, they expect the legislative body to be able to implement it.
   b. New legislation will be needed. But it has to be sold to people and understood.

Question C6: Potential Secondary Benefits criterion

Table C7 shows the sub-criteria weights for the Potential Secondary Benefits criterion.

After learning about this group response, would you like to revise your opinion and update your weights to come closer to the average weights?

If so, please fill the last column with your revised weights on 100-point scale.

Table C7. Summary of Sub-criteria Weights – Potential Secondary Benefits

Sub-criteria	Yours	Overall Mean	Your Revision
Promotion of efficient use of system by changing travel behavior	50	54	
Promotion of fuel efficiency and use of low emission fuels	50	46	
Total	**100**	**100**	**100**

OR, if you want to adopt the overall average weights as your revised weights, please fill this box with YES	

Comments:

Below, please accept a reason for revising your response by marking 'X'; OR
Provide any other comments or reasons for revising or not revising your response.

a. I agree with the justifications and so, I revised.	
b. I do not completely agree with the reasons but I am willing to compromise to help reach consensus.	
Other:	

Discussion on PSB Criterion:

- Most members thought both sub-criteria are equally important
- Overall, encouragement of travel behavior was favored more because positive travel behavior changes reduce fuel use.
- In some cases, improvement in fuel efficiency has negative effect on revenue generation.

Thank You!

Appendix E

Summary of First Round Survey

Expert Survey - Criteria Descriptions Based on the Opinions Obtained in Round 1

Revenue Generation: (Earlier called "Revenue Generation Potential")

Summary of opinions: Overall, the revenue generation potential criterion was considered highly important. Almost all members thought both the revenue sustainability and revenue predictability are very important or important. About two-thirds of the panel members considered short term revenue potential is only moderately important.

Some members suggested indexing the tax to an index so that it automatically increases. The sub-criterion "ease of tax or fee increases when needed" pertains to the increase of the base rate of tax or fee. For example, increase of countywide vehicle registration fee may be easier than increasing a statewide fuel tax. Indexing can be applied to all the alternatives and can be considered as an option by itself. One member suggested including flexibility, the ability to use the revenue to different purposes, in the list of sub-criteria.

Resultant modifications: The "short term revenue potential" criterion has been removed. Instead the team added another sub-criterion called "revenue generation potential". Earlier, the team planned to evaluate the funding alternatives based on a quantitative forecast of revenue. But the team realized that such an estimation of revenue would change when the base rate changes slightly. Hence, the team decided to use this criterion to evaluate the options qualitatively based on the concept rather than exact rate. Revenue sustainability is evaluated as a characteristic of the funding alternative rather than actual long term revenue. A sub-criterion called "Flexibility in investment" is added.

Revenue Generation Criterion (RG):

Revenue generation potential: This measures the ability of a funding alternative to generate significant revenue using politically and economically viable rates to match the investment needs over the target time frame.

Revenue sustainability: This evaluates the extent to which the funding mechanism provides stable (or increasing) revenue over the years while responding to external factors such as changes in travel behavior and fuel efficiency. The funding alternative should provide increased revenue when transportation system usage increases. If the rate of tax or fee is indexed to inflation or a transportation cost index, the alternative gets better score for this sub-criterion.

Revenue predictability: The accuracy with which the revenue from a funding mechanism can be predicted. Better prediction allows the officials to respond to any adverse situations.

Flexibility in investment: The extent to which the mechanism is appropriate for a wide (and potentially changing) range of investments and can be redirected to meet changing objectives, market dynamics, technology options, etc. For example, broad based alternatives such as the gas tax or general taxes tend to have considerable flexibility, while narrowly focused mechanisms, such as facility-specific tolls, generally are inherently less flexible.

Ease of tax or fee increases when needed: The extent to which it is easy to adjust the tax or fee when needed by an action by the operators or local or regional policy makers. This pertains to the increase of the base rate of tax or fee. For example, increase of a countywide vehicle registration fee may be easier than increasing a statewide fuel tax.

Revenue Generation (RG)	Revenue generation potential
	Revenue sustainability
	Revenue predictability
	Flexibility in investment
	Ease of tax or fee increases when needed

Equity and Fairness:

Summary of opinions: Compared to revenue generation potential and political feasibility, the panel gives slightly less importance to Equity and fairness criterion. On the sub-criteria, about 60% of the panel gives all of the equity concepts are important or very important. The panel stressed on the user pay equity. The panel gives less importance to ability to pay concept. More than 15% considered ability to pay as less important or not important. Some suggest that equity is too difficult to assess because it involves many variations. Some justify less importance of ability to pay as the choice to use is in the hands of the user and his comfort of spending. About half of the panel suggested that geographic equity is 'important' while about 40% thought it was 'moderately important'. Connection with transportation criterion was given higher importance level compared to ability to pay and geographical equity. But some members suggested that any tax or fee can somehow be attributed to transportation.

Resultant Modifications: All three equity concepts remain as sub-criteria. The "geographical equity" sub-criterion is defined more clearly. The "Connection with transportation" is removed because it fits better under the "Ease of explaining to public" criteria under public acceptance and political feasibility.

Equity and Fairness Criterion (EQ): This criterion evaluates the fairness of the user fee or tax system. Transportation funding options are evaluated for three concepts of equity, namely, user-pay, i.e., pay by benefits received and cost imposed, ability to pay and geographical equity.

Equity in paying by benefit gained and cost imposed (User-pay): As per the user pay concept, those who benefit from a transportation system by using it should pay for that system. The higher the cost imposed on the transportation system and environment by a certain group of users, the more that group should pay for the costs. For example, cars and trucks should pay for the roads as they benefit from using it. Trucks impose more damage to the roads than cars do and so trucks should pay more fee or tax than what cars pay.

Ability to pay equity: Low-income drivers cannot afford to pay much; therefore, they should pay less percentage of their income than wealthier drivers for transportation. This is called the ability to pay concept.

Geographic equity: This evaluates the extent to which the cost allocation/impact of the mechanism can be structured to match the geographic distribution of the benefit of the funded investments. Geographic equity refers primarily to the extent to which the cost burden can be structured to match the benefit in terms of geography. There will be instances where some amount of cross-subsidization may be required to ensure important and necessary system improvements in places that are geographically disadvantaged in terms of population density, for instance.

Equity and Fairness (EQ)	Equity in paying by benefit gained and cost imposed (user-pay)
	Ability to pay equity
	Geographical equity

Ease of Implementation:

Summary of opinions: Compared to other criteria, the panel gave less importance to ease of implementation. Particularly, “Less need for new technology” and “Ability to use existing payment infrastructure” were given low importance. “Cost of implementation” and “Simplicity of payment structure” both were considered as highly important. “Ease of co-ordination with bordering regions” was given medium importance.

Members commented that people should understand well how the tax or fee is being calculated and should be able to pay it easily. New technology was not a big concern to the members.

Resultant modifications: The team removed the sub-criterion “Less need for new technology”.

Ease of Implementation Criterion (EI):

Cost of implementation: This includes the cost of initial implementation, on-going administration and cost of compliance relative to the revenue generated. When two alternatives generate similar revenues, the alternative with less cost gets better ranking.

Simplicity of payment structure: The tax rate and payment structure should be simple for the payers to understand and to keep their records.

Ability to prevent evasion: The system should be such that evasion of charges can be prevented or reduced easily and with less cost.

Ability to use existing payment infrastructure: Using existing administrative and physical payment infrastructure is considered an advantage in this criterion. Any new payment infrastructure will take time to develop and includes costs related to transformation from old system to new system.

Ease of co-ordination with bordering regions: A system should not make it difficult for the connecting regions to coordinate in preventing evasion of taxes or fees at the borders of the regions. This kind of coordination may be needed at the borders of a state, metropolitan area or a county where a tax rate or a funding policy differs between the regions.

Ease of Implementation (EI)	Cost of implementation
	Simplicity of payment structure
	Ability to prevent evasion
	Ability to use existing payment infrastructure
	Ease of coordination with bordering regions

Public Acceptance and Political Feasibility (Earlier called "Political Feasibility")

Summary of opinions: In the first round of this survey, the "Political Feasibility" criterion not only represented the feasibility among elected officials but also represented public acceptance. The latter part of this criterion seemed to be masked by the word "Political". One can expect the politicians to represent the public opinion from their districts. To avoid this confusion, the title is changed as "Public acceptance and political feasibility".

Political feasibility was given high importance, only less than the revenue generation. In the sub-criteria, almost all panel members suggested that ease of explaining to the public and public acceptance was very important or important. "Less need for passing of new laws and amendments" was given slightly less importance than the above two. One member suggested that "ability to describe revenue source as something besides a tax" be a sub-criterion. One member reminded about repealing any old laws to keep the total regulation.

Resultant modifications: The main criteria will be called "Public acceptance and political feasibility". Ability to describe revenue source as something besides tax is also an advantage in explaining to the public. So, the team decided to include this into the description of this sub-criterion. Similarly, the team realized that "Connection (of a funding option) with transportation" (a sub-criterion in "Equity" criterion) also facilitates ease of explaining to the public. So the team decided to merge these two sub-criteria.

Public Acceptance and Political Feasibility Criterion (PA&PF):

Ease of explaining to the public: It should be easy to explain to the public about a funding alternative. Only then it will stand a chance of being accepted among public. The ease of explaining depends on factors such as how similar a new system is compared to the existing system, how the tax or fee is calculated, how it is connected with transportation and whether or not it is termed as a tax.

Acceptability to public: This pertains how well a funding alternative is accepted by the public. Public acceptance is the key for a funding alternative being accepted by the elected officials.

Less need for legislative action: The feasibility of a funding alternative is increased when there is less need for legislative action by the elected officials (local or state level). This may include passing new laws, removing outdated laws or amending existing laws.

Public Acceptance and Political Feasibility (PA&PF)	Ease of explaining to the public
	Acceptability to public
	Less need for legislative action (adding, removing or amending laws)

Potential Secondary Benefits (Earlier called "Improvement in Transportation System Performance and Environment"):

Summary of opinions: The criterion "Improvement in Transportation System Performance and Environment" is pertaining to indirect or secondary benefits of the funding mechanism. Many members of the panel suggested that this criterion is misplaced or it is less important. One member suggested that these benefits are not measurable. Some suggested that it is hard to get a change in travel behavior of people. One member reminded of the performance measures that are required by MAP-21 which promote proper spending.

Resultant modifications: The research team realized from the comments that the criterion title and sub-criteria were misleading and they could be taken for congestion relief and environmental benefits that would be achieved after the revenue was spent. As these benefits are minor and are due to the encouragement a funding mechanism provides for an efficient use of the system, the main and sub-criteria are changed.

First, to indicate the nature of the benefits, the name of the criterion is changed as "Potential secondary benefits". Two types of efficiency benefits are considered as two different criteria under this main criterion. The team realized that including "Encouragement for proper spending by authorities" as a sub-criterion would not be appropriate in this criteria list because this evaluation is about revenue generating alternatives and not revenue spending alternatives. It would not be feasible to identify how and which funding alternatives would encourage proper spending. Hence, the team decided to remove this sub-criterion from the list.

Potential Secondary Benefits Criterion (PSB):

Promotion of efficient use of system by changing travel behavior: This evaluates the extent to which the funding mechanism can promote efficient use of transportation system by encouraging travelers to make changes in their travel behavior. Such changes include but are not limited to reducing the frequency and distance of travel, traveling in off-peak periods and using alternative modes such as public transit and non-motorized modes. Any tool included in the funding mechanism that penalizes inefficient use helps the funding mechanism to get higher rating. For example, congestion pricing is seen as an alternative that discourages travel in congested time periods on certain roadways.

Promotion of fuel efficiency and use of low emission fuels: This evaluates the extent to which the funding mechanism encourages use of low emission fuels and increase of fuel efficiency by users.

Potential secondary benefits	Promotion of efficient use of system by changing travel behavior
	Promotion of fuel efficiency and use of low emission fuels

Appendix F

Summary of Second Round Survey

Survey of Experts to Identify the Criteria to Evaluate Surface Transportation Funding Alternatives
Summary of second round of the survey

Based on the responses obtained in the first round, the main criteria and sub-criteria were refined. Round 2 of the survey included the final list of criteria with descriptions and asked the panel to weigh the criteria. Round 2 of the survey was conducted during February and March 2013. In total, 26 experts from MPOs, TxDOT and Texas Legislature Transportation Committee member offices have responded. In this round, there were three main questions.

- Pairwise comparison of main criteria
- Weighting of sub-criteria under each main criteria using a 100-point scale
- Question to verify if the respondent's opinion would change depending on whether the alternatives are implemented statewide or locally

Results:

Pairwise comparison tables were prepared using the responses for the first part where the panel members compared two criteria at a time. Using the pairwise comparison tables, the main criteria weights were calculated for each member. Sub-criteria were weighted by each panel member on the 100-point scale.

Main criteria and sub-criteria weights were summarized and average weights were found. Sub-criteria weights under each main criterion add up to 100 and are called local weights. These were multiplied with main criteria weights to find average global criteria weights. The total of all global criteria is 100.

Resultant overall average weights for main criteria and sub-criteria are given in Table 1 below. For easier understanding, all weights are given in 100-point scale (i.e., their total is 100). Sub-criteria global weights are shown in the last column.

Although the panel members differ in their opinions, these average weights may direct towards a potential consensus opinion. Some key inferences are:

1. Public acceptance and political feasibility has the highest weight. Revenue generation and Equity criteria are right below. These three together cover more than 75%.

2. Revenue generation potential, revenue sustainability and revenue predictability cover 80% of the revenue generation criterion.

3. User-pay equity covers more than 50% of Equity criterion.

4. Acceptability to public covers close to 50% of the public acceptance and political feasibility criterion. Adding ease of explaining to public to this makes it 80%.

5. Overall, user pay equity, ease of explaining to public and acceptability to the public are the three criteria that stand out. Together, they account for about 36% of the overall weight.

Table 1. Overall Average Weights – Main Criteria and Sub-criteria

Main Criteria	Main Criteria Weights (100-point scale) (A)	Sub-criteria	Sub-criteria Local Weights (B)	Global Weights (100-point scale) (AxB)/100
Revenue Generation (RG)	25	Revenue generation potential	28	7.0
		Revenue sustainability	28	7.0
		Revenue predictability	24	6.0
		Flexibility in investment	10	2.5
		Ease of tax or fee increases when needed	10	2.5
Equity and Fairness (EQ)	25	Equity in paying by benefit gained and cost imposed (user-pay)	52	13.0
		Ability to pay equity	26	6.5
		Geographical equity	22	5.5
Ease of Implementation (EI)	15	Cost of implementation	26	3.9
		Simplicity of payment structure	26	3.9
		Ability to prevent evasion	18	2.7
		Ability to use existing payment infrastructure	16	2.4
		Ease of co-ordination with bordering regions	14	2.1
Public Acceptance and Political Feasibility (PA&PF)	28	Ease of explaining to the public	34	9.5
		Acceptability to the public	46	12.9
		Less need for legislative action	20	5.6
Potential Secondary Benefits (PSB)	7	Promotion of efficient use of system by changing travel behavior	54	3.8
		Promotion of fuel efficiency and use of low emission fuels	46	3.2

Figure 1 shows overall average weights for the main criteria.

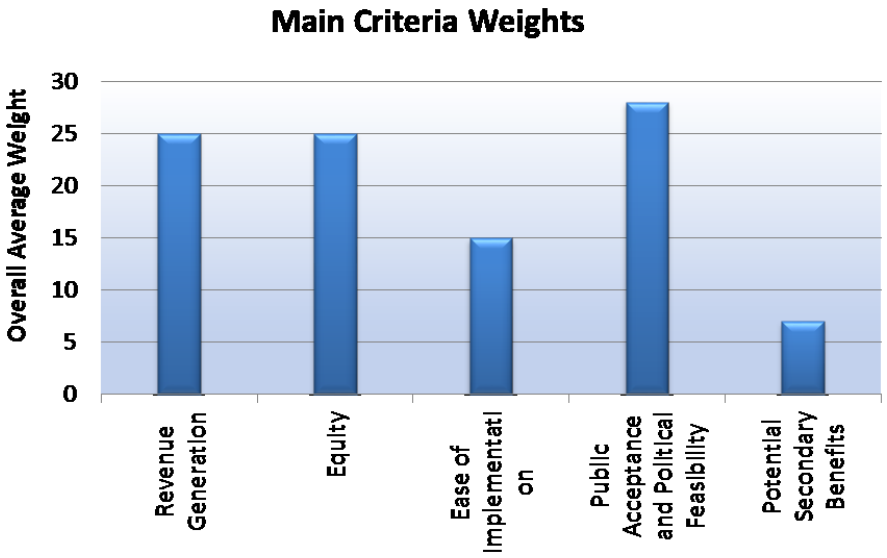

Figure 1. Overall Average Main Criteria Weights

To understand the main criteria weights, Table 2 shows the pairwise comparison table that is inferred from the average main criteria weights. It shows that Revenue generation and Equity are equally important. RG, PA&PF and EQ are clearly above EI and PSB. All these comparisons are shown in GREEN. The weight of PA&PF is slightly higher than RG and EQ. So, it is difficult to say if PA&PF is more important than or equally important as the RG or EQ criterion. So these two comparisons are shown in YELLOW.

Table 2. Pairwise Comparison Inferred from the Average Main Criteria Weights

	Criterion A	Preference	Criterion B
ROW 1	RG	SAME	EQ
ROW 2	RG	RG	EI
ROW 3	RG	PA&PF/ SAME	PA&PF
ROW 4	RG	RG	PSB
ROW5	EQ	EQ	EI
ROW6	EQ	PA&PF/ SAME	PA&PF
ROW7	EQ	EQ	PSB

Table 2. Pairwise Comparison Inferred from the Average Main Criteria Weights – Contd.

	Criterion A	Preference	Criterion B
ROW8	EI	PA&PF	PA&PF
ROW9	EI	EI	PSB
ROW10	PA&PF	PA&PF	PSB

Figure 2 shows overall average global weights for all the criteria.

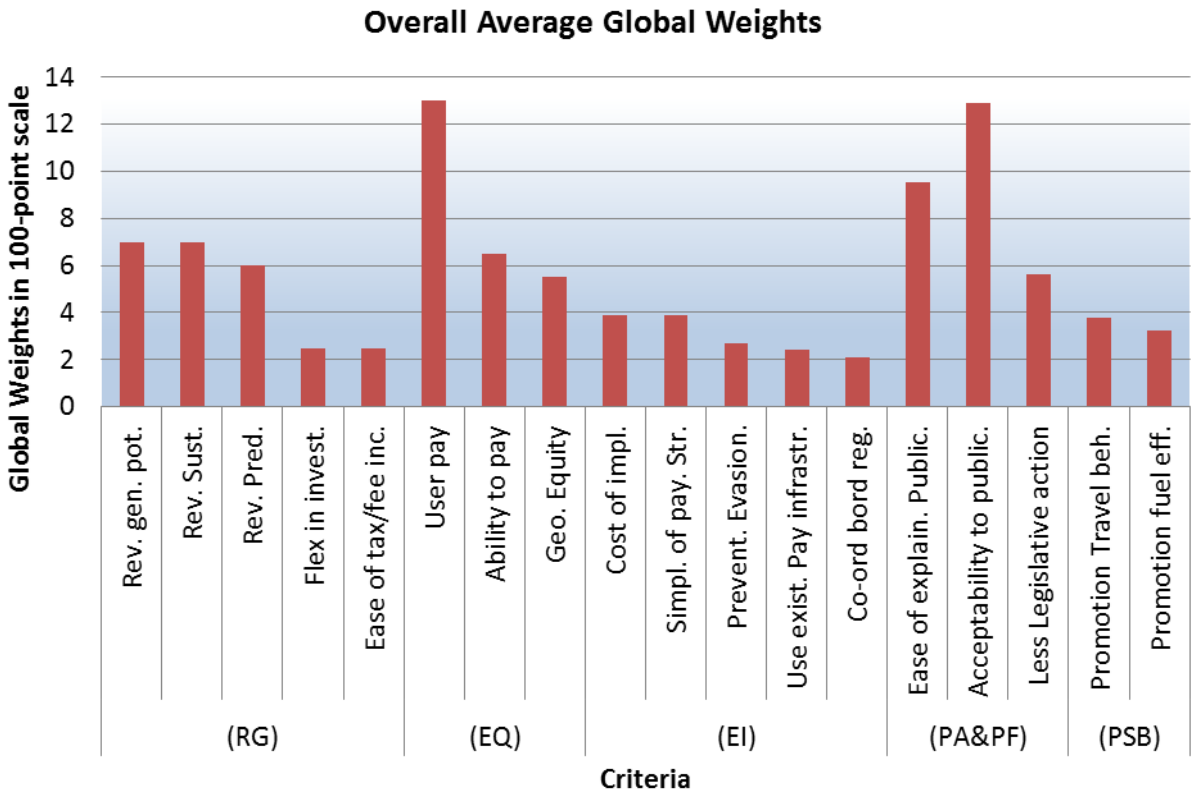

Figure 2. Overall Average Weights for All Criteria

Important judgments inferred and justifications based on members' comments:

Here is a summary of the comments or justifications given by the panel members in correlation with a set of judgments. First, all the comments or justifications that support the average weights shown above are given. Then some other comments are listed.

Main Criteria – Supporting average weights:

5. RG, EQ and PA&PF are equally important
    a. "Revenue generation alone won't convince the public to vote for, or support, a revenue method unless they perceive it as fair."
    b. "Revenue generation is critical for future funding but would not be acceptable politically if not equitable and accepted by the public. Implementation issues can be more easily overcome."
    c. The main reason for searching for new alternatives is to provide enough funds for the future. So revenue generation is important. But we cannot charge whatever tax or fee. We have to charge it such that it is fair among all people. They must perceive it fair. With these two satisfied well, it may eventually get accepted among public.
6. EI criterion is less important
    a. Implementation issues can be overcome with technology and better policies.
7. PSB criterion is the least important
    a. Potential secondary benefits are often difficult for voters to see. I believe they look at their cost first.

Sub-criteria – Supporting average weights:

3. RG - Revenue generation potential, sustainability and predictability are more important. Flexibility of investment and Ease of increase in tax or fee when needed are very less important
    a. At present we first need funds. And once we set up a funding method, we want it to run for a long time. Ability to predict allows us to plan better. Flexibility of investment and ease of increase in tax or fee can be overcome by making some changes to the policy. So they are minor issues.
    b. A funding alternative that will last a number of years and is easy to predict will more than likely have higher potential than one without those characteristics.
4. RG – Revenue sustainability is more important
    a. Although rev potential is important, the biggest problem in funding is having a source you can count on year after year.
5. EQ - User pay equity is the most important
    a. User pay fits very well with our objectives. The funding alternative should charge users by their extent of use or cost imposed. Charging by the use will bring about changes in certain travel behavior also which is helpful for planning organizations.
    b. If equity in paying by benefit gained and cost imposed (user-pay) is achieved, then ability to pay and geographical equity should potentially balance out.
6. EQ – Ability to pay is less important
    a. Everyone has a choice to pay and use based on their budgets. It is difficult to measure ability to pay and difficult to implement

7. EI – Simplicity of payment structure is more important
    a. How payments are implemented will be a big part of public acceptance.
8. PA&PF - Acceptability to public sub-criterion is very important.
    a. Public acceptance is the key. However the alternative is, we can try and explain better but eventually public should accept for it to go through.
9. PA&PF – Less need for legislative action sub-criterion is less important.
    a. As long as the public understands the tax or fee, they expect the legislative body to be able to implement it.
    b. New legislation will be needed. But it has to be sold to people and understood.

Main criteria – Other comments:

1. Revenue generation criterion is the most important
    a. The main reason for searching for new alternatives is to provide enough funds for the future. So revenue generation is the most important.
2. Public acceptance and political feasibility criterion is the most important
    a. No funding option can get through without being accepted by the public and politicians. If an idea or concept is not largely supported by the public then more than likely, it will not sustain longevity and will fail. So I think PA&PF is the most important.
3. Equity is less important than EI criterion.
    a. For a small region like ours implementation issues are more important, especially the simplicity of payment structure.
    b. Everyone benefits from transportation facilities, whatever mode one travels by. The choice is ours to pay and use any system based on our budgets. So, equity is less important in developing a funding alternative.
    c. Equity is difficult to measure and if equity increases, complexity and cost of implementation increase.
4. Ease of implementation criterion is the least important, even less than the Potential secondary benefits criterion
    a. Implementation issues can be solved over time by better technology. A funding alternative should encourage better travel behavior, and fuel efficiency. I think this is more important than implementation issues.
    b. “Having secondary benefits will obviously help garner public support.”

Sub-criteria – Other comments:

1. RG – Sustainability and predictability are more important
    a. Although rev potential is important, the biggest problem in funding is having a source you can count on year after year.
2. RG – Revenue generation potential is more important than sustainability and predictability
    a. If the funding mechanism selected cannot generate the revenue needed then it is not much better than the current method. Sustainability and predictability go hand-in-hand. One does not matter

without the other and neither is very useful if the revenue generated is insufficient for current and future need

3. EQ – Ability to pay is more important than user pay
   a. User pay equity is less important, in my opinion, than ability to pay. It is also difficult to determine
4. EQ – Ability to pay and geographic equity are more important than user pay.
   a. Any funding alternative that is developed should be done so in a fair and equitable manner however, no system is perfect so it would be extremely difficult to have one that is fair to everyone. However, ability to pay and geographical equity are more important. It does no good to impose a fee that many cannot afford; it actually defeats the purpose of the fee. Geographical locations should be considered because different areas have different fees, costs of living, and taxes. Areas that have lower costs for the general public might be ones that may have higher funding alternative costs.
5. EI – All sub-criteria are equally important
   a. I believe when looking at how to implement a funding alternative that each of the sub criteria plans an important role. I do not think one outweighs the other.
6. EI – Cost of implementation is the most important.
   a. Cost will have biggest factor on approval. Using existing systems and consistency are also important to be successful and not increase costs substantially. Evasion and payment structure are more easily curable.
7. EI - Simplicity of payment structure and ability to use existing infrastructure are more important
   a. These two factors help people to understand the system better. Simple systems may be less costly and have fewer chances for evasion.
8. EI - Ability to use existing infrastructure is not important
   a. Why tie ourselves to the existing payment infrastructure? Maybe an easier, more efficient, less vulnerable to evasion system can be developed.
9. EI - Prevention of evasion is very important.
   a. Evasion increases the cost of enforcement and reduces the fairness
8. EI – first three are more important than the last two sub-criteria.
   b. How payments are implemented will be a big part of public acceptance.
9. EI – Simplicity is less important. Simplicity is more a function of PA&PF than of implementation.
10. PA&PF - When a funding alternative is presented to the public, I believe that if it is easy to explain then it will receive a higher chance of acceptance than an alternative that is complex and confusing. Legislation as a sub-component of this criterion certainly plays a role but one that is less than the other two sub-criteria.
11. PA&PF - If the proposal can be easily explained to the public then it most likely will be easier for the public to accept the proposal.
12. PSB - Doesn't the concept of promoting more efficient use of the system by "encouraging" people to change their mode of travel through higher fees contradict the concept of ability to pay equity? I scored these two sub-criteria equally, as in equally unimportant. I prefer PSB to not be included in determining a funding mechanism.

13. PSB - Public seems more attune to fuel efficiency and environment than changing behavior
14. PSB - A funding alternative that can change travel behavior is important and can have a significant effect on fuel efficiency. The more efficient travel behavior is I think it will make travel more efficient which would aid in reducing emissions.

Variation in Opinions:

Panel members differ in their opinions regarding the criteria weights. This section presents graphs showing the average weight and the variation in the weights given by the panel members.

Variation in Main Criteria Weights:

Figure 3 shows a Box and Whisker plot for the main criteria weights. The box for each criterion shows the middle half (middle 50% are in the box, 25% of respondents are below the box, 25% of respondents are above the box) of the weights. Whiskers are lines extended from the box showing the lowest and highest weight given.

For example, one may look at the revenue generation (RG) criterion. If all the weights obtained from the panel members for the RG criterion are sorted in descending order, the lowest is 8 and highest is 36. Out of 26 responses, the middle 13 (half) are between weights 20 and 31. There are about 6 responses below 20 and 6 responses above 31.

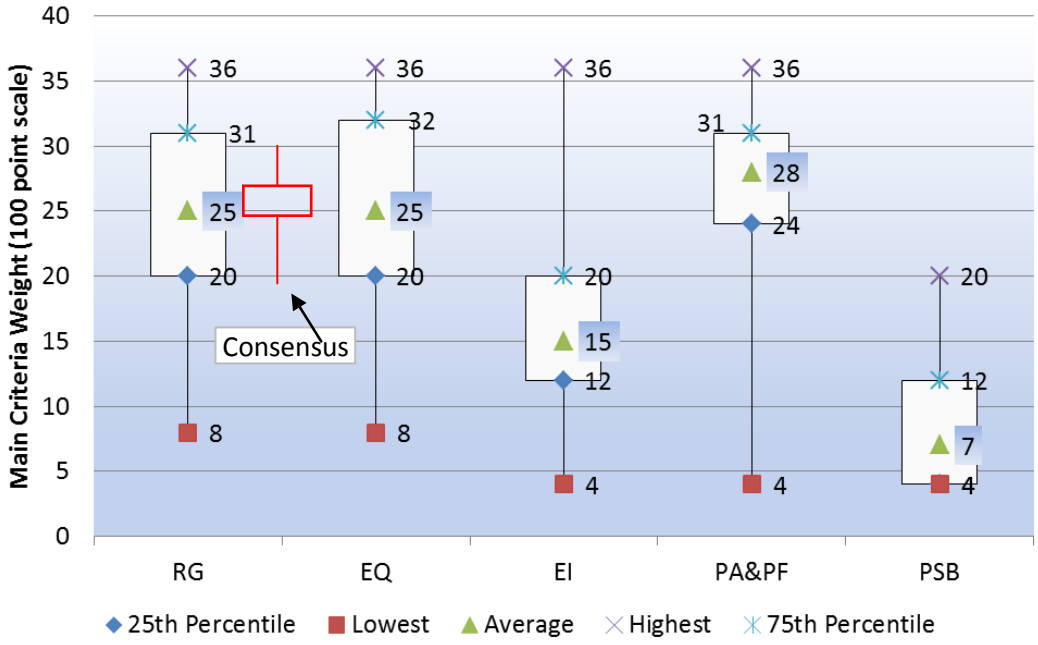

Figure 3. Average and Variation in Main Criteria Weights

As seen in the graph, while the boxes for RG, EQ and PA&PF have the same upper level, both RG and EQ show more variation (box length) downwards. That is why the average weight of PA&PF is higher than RG and EQ. The variation in the weights means that the averages shown are less certain and calls for a sensitivity analysis to understand the change in the decision on the best funding strategy when the weights were different.

When the responses are close to consensus, the height of the boxes will be close to zero and the whiskers (lines extending from the box) will have less extension. To illustrate the consensus scenario, a RED box and lines are shown in the graph next to the RG criterion. The consensus can be achieved when the panel members, especially those who assigned weights that are outside the boxes or close to the ends of the boxes, are willing to accept the average weights or revise their original weights to bring them closer to the average weights.

Variation in Sub-criteria Weights:

Figure 4 through Figure 8 show the average weight and variation in the sub-criteria under each main criterion.

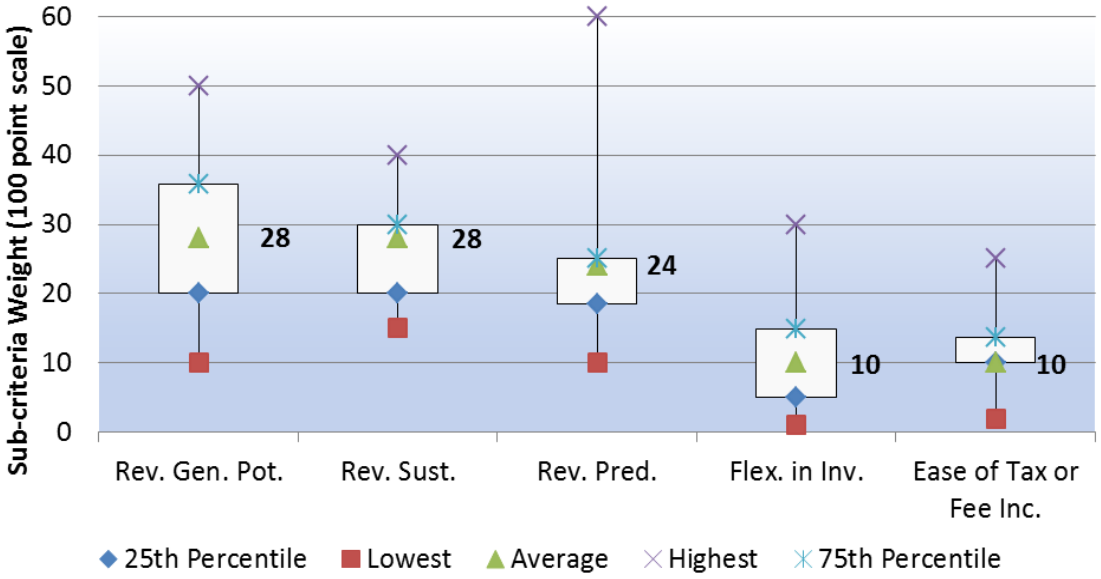

Figure 4. Average and Variation for Sub-criteria Weights – Revenue Generation

One can see from these charts that some of the sub-criteria weights are varying significantly. The objective of the consensus process is to reduce the heights of all the boxes and reduce the extension of lines. This can be achieved if the panel members either accept the average weights calculated or revise their original weights to bring them closer to the average weights.

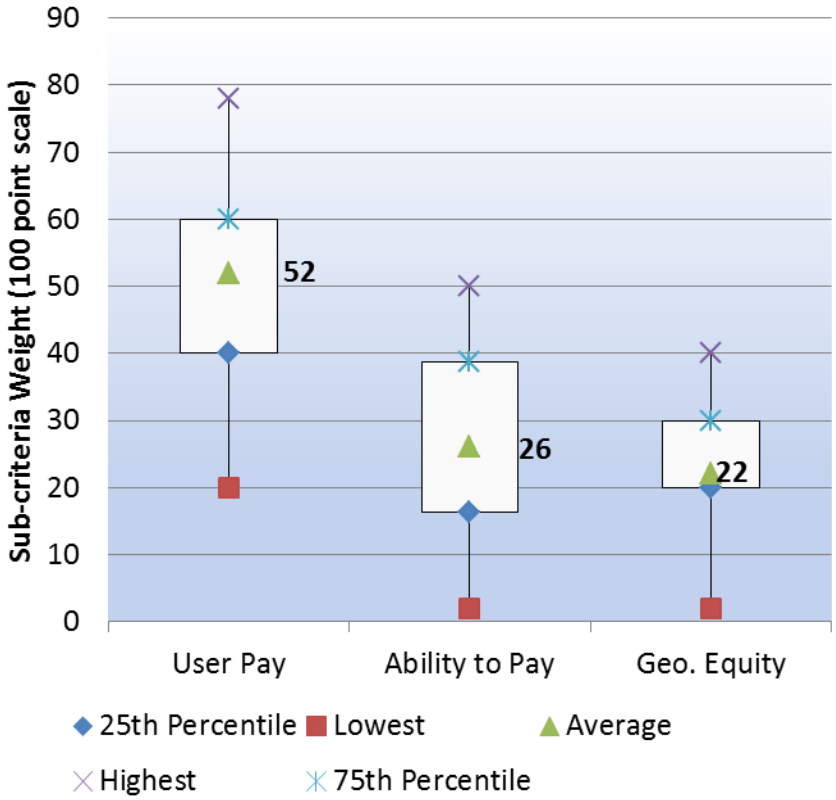

Figure 5. Average and Variation for Sub-criteria Weights – Equity and Fairness

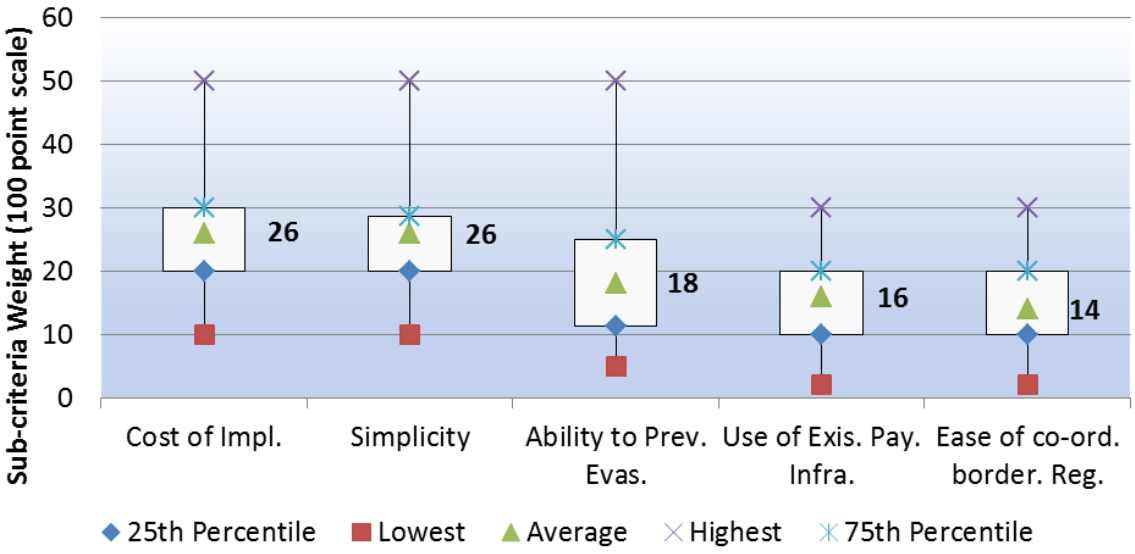

Figure 6. Average and Variation for Sub-criteria Weights – Ease of Implementation

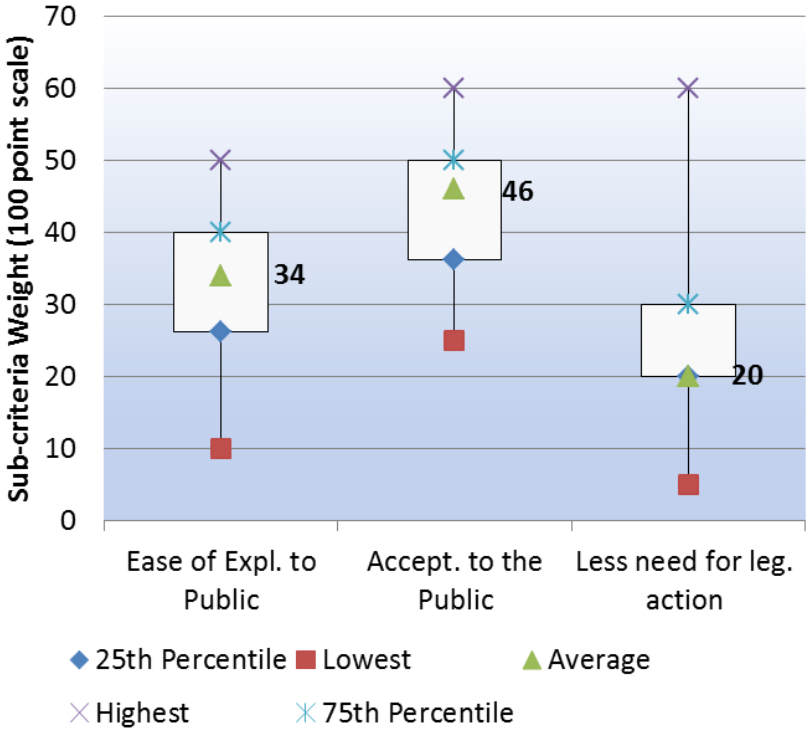

Figure 7. Average and Variation for Sub-criteria Weights – Public Acceptance and Political Feasibility

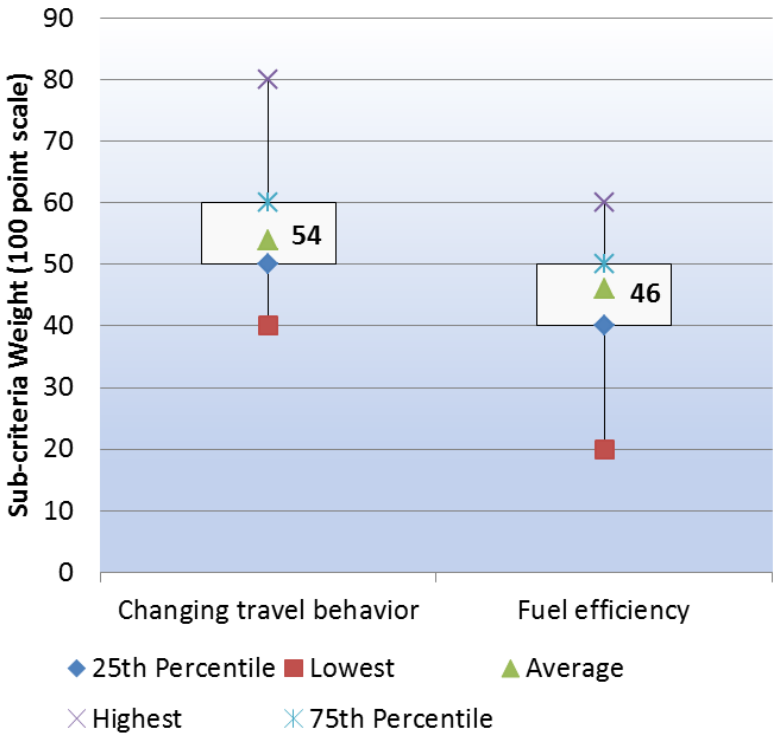

Figure 8. Average and Variation for Sub-criteria Weights – Potential Secondary Benefits

Appendix G

Summary of Third Round Survey

Survey of Experts to Identify the Criteria to Evaluate Surface Transportation Funding Alternatives
Summary of third round of the survey (Draft)

This is the summary of the third and final round of this interactive survey. The research team wants to extend its gratitude to all the members of the expert panel for providing their valuable input on this survey.

The survey started with an initial list of criteria. Based on the responses obtained in the first round, the main criteria and sub-criteria were refined. About 20 members responded in the first round survey. In the second round survey, the members assigned evaluated the relative importance of the criteria using the pairwise comparison method and the 100-point scale method. 26 members participated in the second round. The research team prepared a summary showing the calculated weights for the main criteria and sub-criteria based on the responses. The variation in criteria weights as well as various comments given by the members were summarized and presented. In Round 3, the members were asked to revisit their weights in light of the average weights and the comments and see if they would like to move their responses closer to the consensus opinion. Overall, 16 members responded. Panel members from TxDOT withdrew from the panel and were not able to respond. Some members from MPOs and Legislative Committees have not responded.

Results:

For the main criteria, the members were shown the weights calculated from their original pairwise comparison response and the overall average weights (calculated by averaging the weights given by all panel members) on 100-point scale. For the sub-criteria, they were shown their original 100-point scale weights and the overall average weights. They were asked to provide their revised weights in an adjacent table. Along with their revised response, the members provided the reason for their revision: 1) they agreed to the justification behind the consensus opinion; or 2) they were able to compromise even if they did not completely agree with the justification.

The research team summarized all the revised weights and calculated average weights for main criteria and sub-criteria. Sub-criteria weights under each main criterion add up to 100 and are called local weights. These were multiplied with main criteria weights to find average global criteria weights. The total of all global criteria weights is 100. For those members, who did not respond to the third round, the second round response was maintained.

The resultant overall average weights for main criteria and sub-criteria are given in Table 1 below. For easier understanding, all weights are given on a 100-point scale (i.e., their total is 100). The sub-criteria global weights are shown in the last column.

In the third round, many members revised their responses and assigned weights that were closer to the average weights. Some members agreed to adopt the average response as their own, at least for some groups of sub-criteria. Some members reiterated their stand and did not revise. One member revised his response away from the average response. Overall, the third round was a valuable interactive process. At the end, the variation in the criteria weights reduced, but the range of responses often

remained large. The average weights after the third round were close to the result of the second round.

First, this summary presents the resultant overall average responses; then, it presents some of the significant differences remaining and any comments justifying them. At the end, this document presents the plots showing the variation in the criteria weights.

As a next step, the research team recommends that a formal discussion among the officials representing different organizations including metropolitan planning organizations, regional mobility authorities, Texas Department of Transportation and the Legislative Committees may be conducted to discuss the priorities and address any differences among them. This summary can be used as a starting point, because it already includes the opinions of many officials and points out the major differences in opinion still remaining. Once the evaluation criteria system is finalized, an evaluation of various funding alternatives can be performed against this system to identify the best funding strategy for the future.

Criteria Weights:

Table 1 shows the overall average weights of the main criteria and sub-criteria at the end of the third round survey. Some key inferences are:

1. The public acceptance and political feasibility (PA&PF), revenue generation (RG) and equity (EQ) criteria have similar weights and are significantly higher than the other two criteria. PA&PF criterion has a slightly higher weight than the RG and EQ criteria. These three together cover about 75% of the total importance. The potential secondary benefits criterion, which contained promotion of changes in travel behavior and promotion of fuel efficiency as sub-criteria, received only about 6% of the overall weight.

2. The revenue generation potential, revenue sustainability and revenue predictability sub-criteria cover about 80% of the revenue generation criterion.

3. The user-pay equity sub-criterion covers more than 50% of the equity criterion.

4. The acceptability to the public sub-criterion covers close to 50% of the public acceptance and political feasibility criterion. Adding the ease of explaining to the public sub-criterion to this makes it about 80%.

5. Overall, user pay equity, ease of explaining to public and acceptability to the public are the three sub-criteria that stand out. Together, they account for about 35% of the overall weight.

6. Although the ease of implementation criterion has a weight of 18% and the potential secondary benefits criterion has a weight of 6%, the former has five sub-criteria while the latter has only two. For this reason, some of the sub-criteria under the ease of implementation criterion have similar global weights as the sub-criteria under the potential secondary benefits criterion.

Table 1. Overall Average Weights – Main Criteria and Sub-criteria

Main Criteria	Main Criteria Weights (100-point Scale) (A)	Sub-criteria	Sub-criteria Raw Weights (B)	Final Weights (100-point Scale) ((AxB)/100)
Revenue Generation (RG)	24	Revenue generation potential	26	6.2
		Revenue sustainability	28	6.7
		Revenue predictability	24	5.8
		Flexibility in investment	12	2.9
		Ease of tax or fee increases when needed	10	2.4
Equity and Fairness (EQ)	25	Equity in paying by benefit gained and cost imposed (user-pay)	54	13.5
		Ability to pay equity	24	6.0
		Geographical equity	22	5.5
Ease of Implementation (EI)	18	Cost of implementation	26	4.7
		Simplicity of payment structure	28	5.0
		Ability to prevent evasion	18	3.2
		Ability to use existing payment infrastructure	16	2.9
		Ease of co-ordination with bordering regions	12	2.2
Public Acceptance and Political Feasibility (PA&PF)	27	Ease of explaining to the public	34	9.2
		Acceptability to the public	46	12.4
		Less need for legislative action (addition, deletion or amendment of laws)	20	5.4
Potential Secondary Benefits (PSB)	6	Promotion of efficient use of system by changing travel behavior	52	3.1
		Promotion of fuel efficiency and use of low emission fuels	48	2.9

Figure 1 shows overall average weights for the main criteria.

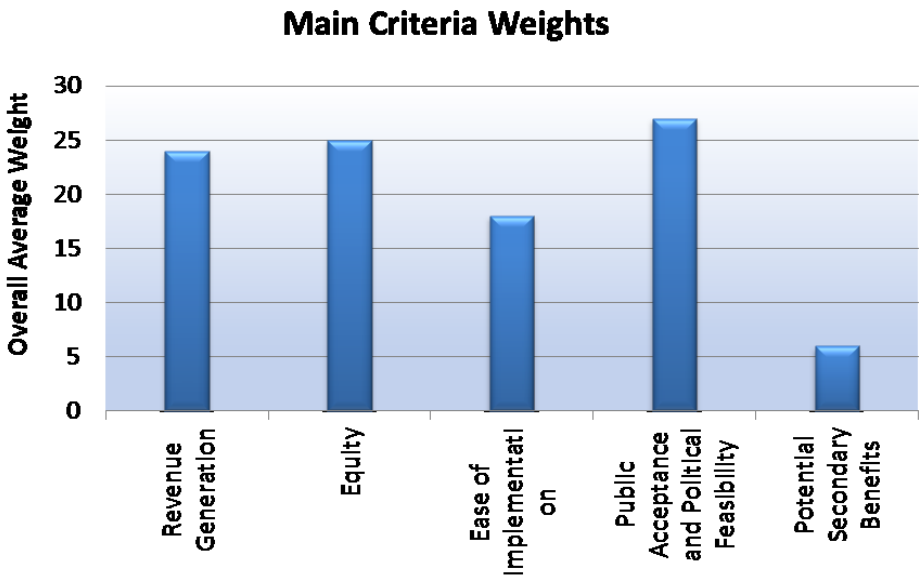

Figure 1. Overall Average Main Criteria Weights

Figure 2 shows overall average global weights for all the criteria.

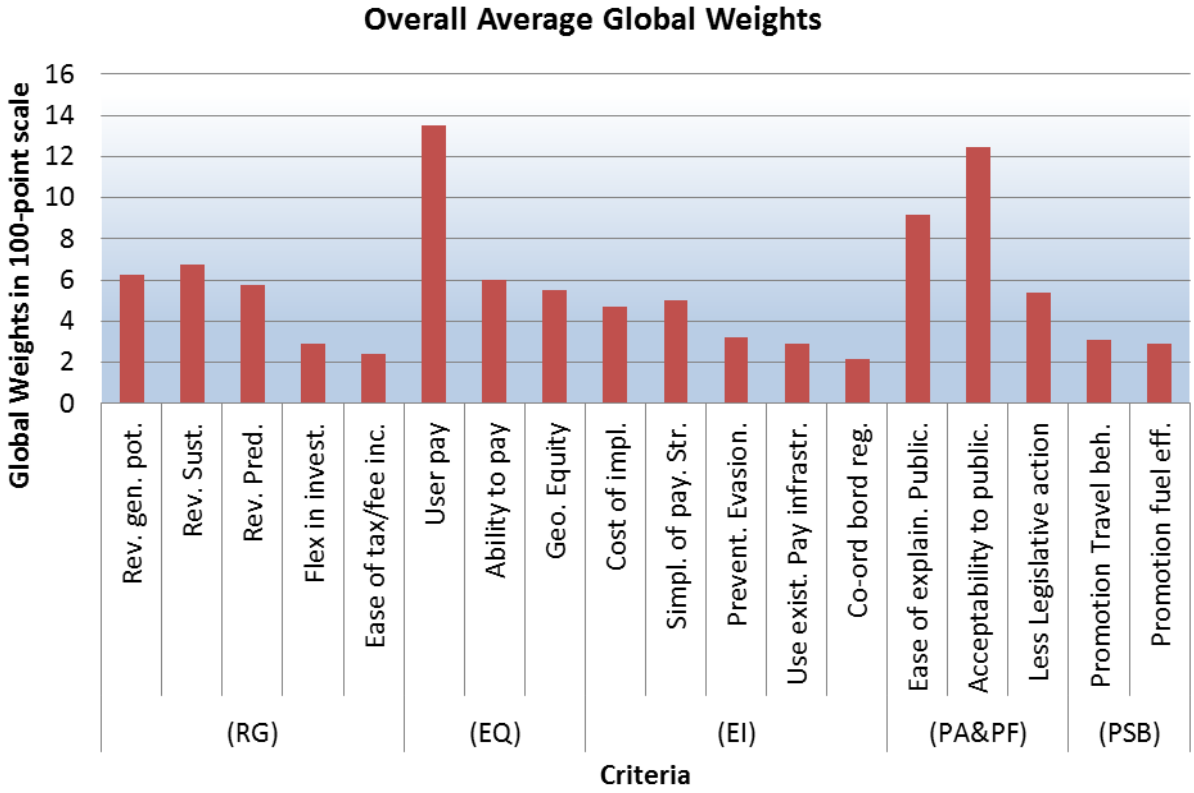

Figure 2. Overall Average Weights for All Criteria

Summary of Differences:

1. The revenue generation criterion is the most important.

Comments from the member (who gave a weight of 40 to RG criterion):
"…RG is THE ONLY reason we are trying to develop a new funding mechanism. If our elected officials had acted on the gas tax, it would have increased periodically to account for inflation or it would have been changed to self-adjust for inflation by converting it to an ad valorem tax or being tied to some indices."

2. The equity criterion is less important.

Comments from the member:
"I believe others are overemphasizing equity and fairness. None of our current funding mechanisms are fair and equitable. As long as they are PA&PF they don't have to be."

3. The potential secondary benefits criterion should not be included in the evaluation

75% of the members assigned weights between 4% and 10% to the Potential secondary benefits criterion. Two members assigned 12%; one of them did not respond to the third round survey. One member recommended that this criterion should not be included as a criterion for selecting a funding alternative. Moreover, because this criterion has only two sub-criteria, even a small main criterion weight gives the sub-criteria more importance than a sub-criterion under one of the other criteria.
Comments from the member (rephrased):
"…one can increase fees and add special charges until the whole system operates at LOS A by pricing most people out of their cars and into alternative modes. But this is not a good idea"
"Fuel efficiency is being achieved through technology and will continue to improve. Encouraging use of fuels such as ethanol does not lower emission levels but has caused an increase in all staple food costs and eroded engine parts very effectively. For these reasons and the fact that I still do not think the PSB criteria should be used I am changing my weights to zero. I think the reason most participants weighted the sub-criteria equally may actually be because they are equally UNIMPORTANT."

4. The potential secondary benefits should not be of very low importance.

Comments from the member:
"I feel others are failing to recognize the significant ways a specific funding source could have secondary benefits of significance"

5. Under the revenue generation criterion, the flexibility in investment should not be very less important than the revenue predictability criterion.

Comments from the member:
"I agree with the relative importance of why predictability is more important than flexibility, but I believe flexibility should be almost as important. With funding scarce, the flexibility to use the funds for a variety of modes and project types is an important tool in planning."

6. Under the revenue generation criterion, the revenue generation potential should be given greater importance.

Comments from the member:
"If a particular option cannot generate any revenue what value is predictability and sustainability?"

7. Under the equity and fairness criterion, ability to pay equity is not important.

Comments from the member:
"The cost of transportation is not just a factor of taxes/fees; there is also the issue of time, purpose for the trip, etc. Private companies do not charge different prices to customers based on their ability to pay. The consumer decides what quantity/quality of product/service to buy based on their own ability to pay."

Variation in Opinions:

This section presents graphs showing the average weight and the variation in the weights given by the panel members.

Variation in Main Criteria Weights:

Figure 3 shows a Box and Whisker plot for the main criteria weights. The box for each criterion shows the middle half of the weights (i.e., middle 50% are in the box, 25% of respondents are below the box, 25% of respondents are above the box). Whiskers are lines extended from the box showing the lowest and highest weights given. For comparison purposes, Figure 4 shows similar graph resulted from the second round survey.

For example, one may look at the revenue generation (RG) criterion. If all the weights obtained from the panel members for the RG criterion are sorted in descending order, the lowest is 8 and highest is 40. Out of 21 responses, the middle 10 (half) are between weights 20 and 28. There are about five responses below 20 and five responses above 28.

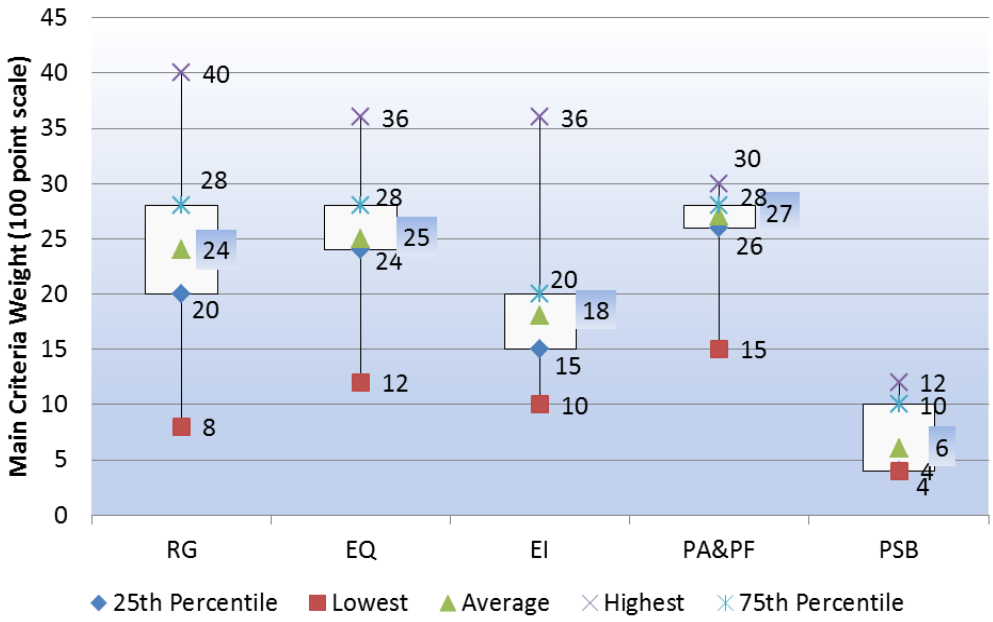

Figure 3. Average and Variation in Main Criteria Weights

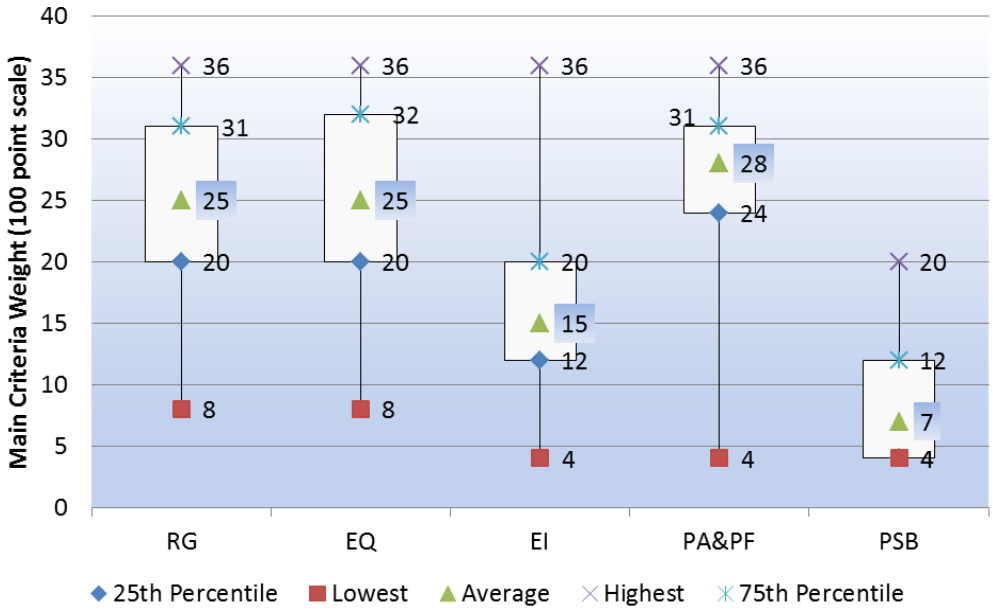

Figure 4. Average and Variation in Main Criteria Weights from Second Round

When compared with a graph showing the variation in main criteria weights that resulted from the second round survey (shown in Figure 4), one can see that the height of the boxes has reduced, which means the variation has reduced. One can also see from the lengths of the vertical lines (whiskers), that in most cases, the range (from

lowest to highest values) has contracted compared to the second round results. The variation in the weights meant that the averages shown tended to be less certain and calls for a sensitivity analysis to understand if the best funding approach decision changes when the weights were different.

Variation in Sub-criteria Weights:

Figure 5 through Figure 9 show the average weight and variation in weights of the sub-criteria under each main criterion. The average weights are rounded to multiples of two.

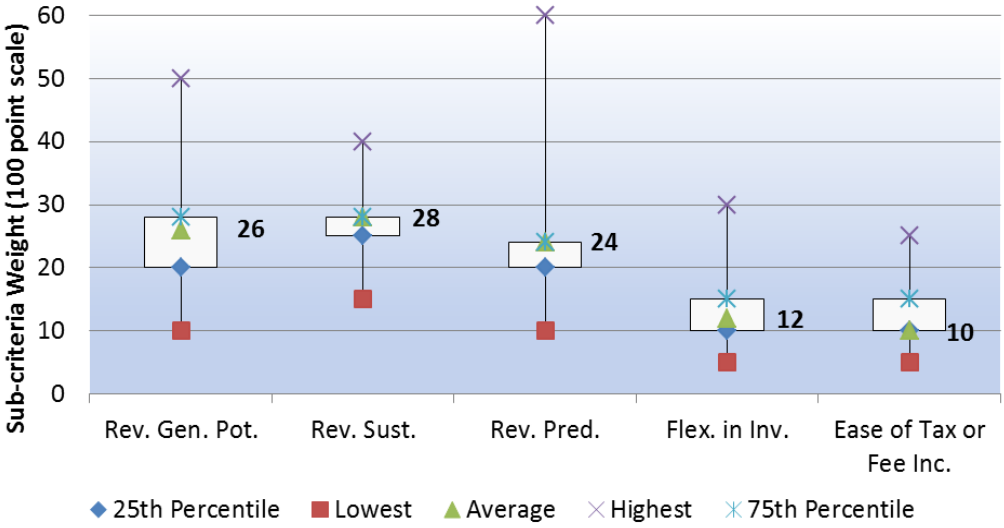

Figure 5. Average and Variation for Sub-criteria Weights – Revenue Generation

From these figures, the evidence shows that the panel members have chosen to assign criteria weights that are closer to the average weights. The middle 50% range significantly reduces compared to the second round results. Still, the overall range of weights is large for many criteria. As mentioned before, for those members who did not respond to the third round, the second round response has been maintained. One can suppose that these members may have followed the trend of the other members and the differences may have been further reduced.

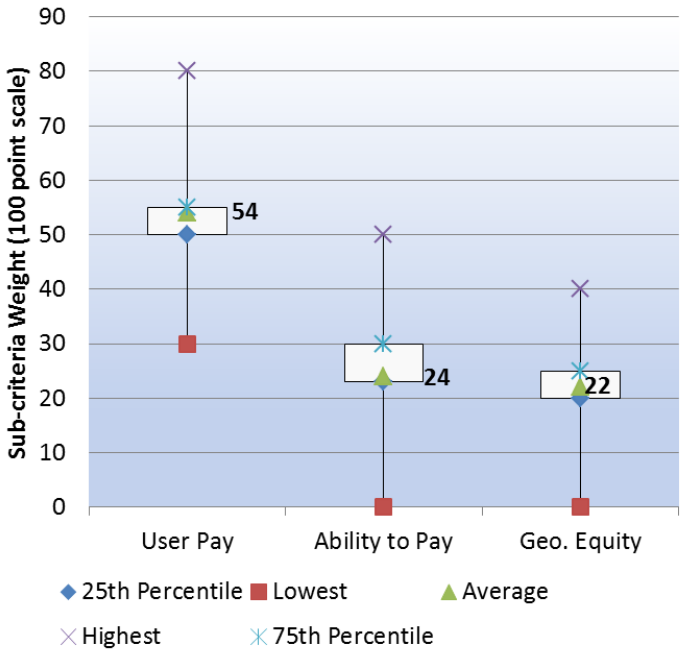

Figure 6. Average and Variation for Sub-criteria Weights – Equity and Fairness

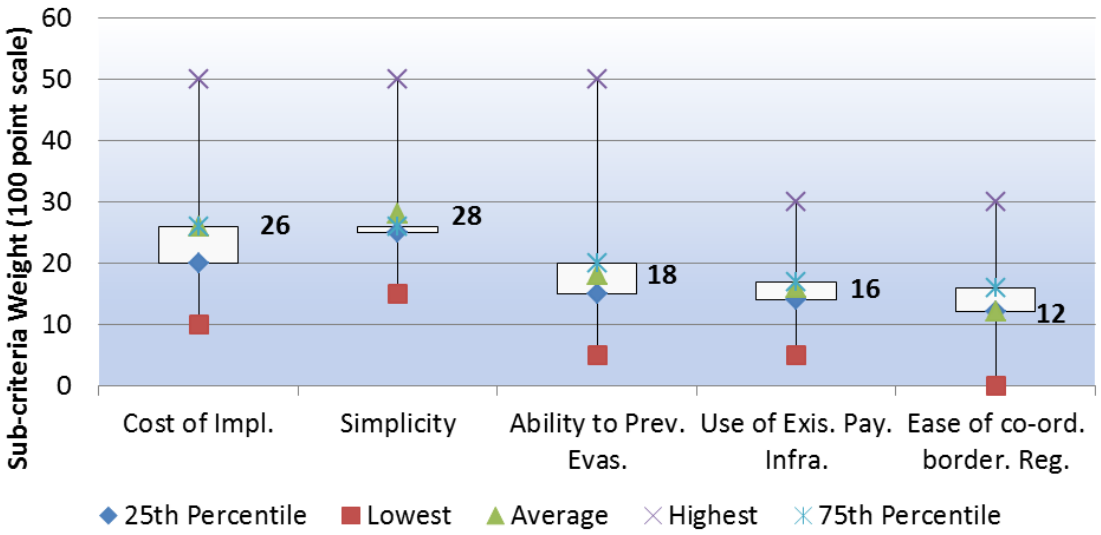

Figure 7. Average and Variation for Sub-criteria Weights – Ease of Implementation

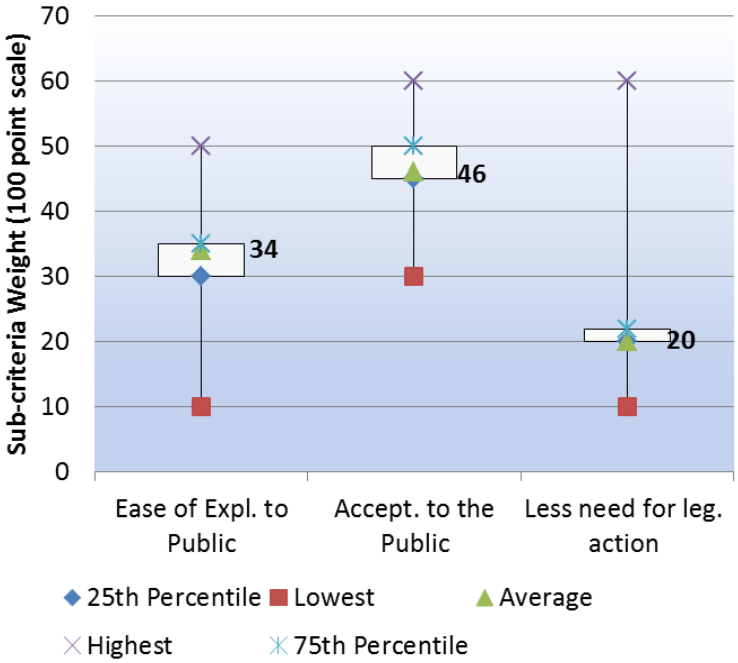

Figure 8. Average and Variation for Sub-criteria Weights – Public Acceptance and Political Feasibility

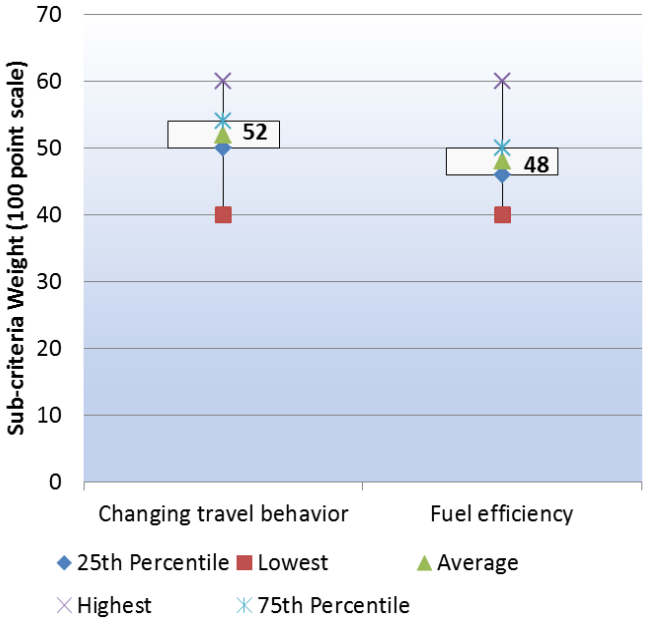

Figure 9. Average and Variation for Sub-criteria Weights – Potential Secondary Benefits

Appendix H

Explanation of Funding Alternatives

A1: Fuel tax - fixed increase

Currently you are paying a statewide tax of 20 cents per gallon of gasoline or diesel you buy for your motor vehicle use. This is in addition to a federal level fuel tax. To improve funding for highways and transit, the government wants to increase the tax you are paying on gasoline and diesel by 10 cents per gallon starting from September 1, 2013. With this increase your gasoline and diesel taxes would be 30 cents per gallon excluding the federal gasoline and diesel taxes. These taxes will be included in your price of gasoline or diesel. Taxes on motor fuels are easy to administer and they are normally understood as transportation user charges.

A2: Fuel tax – increase and index to inflation

Currently you are paying a statewide tax of 20 cents per gallon of gasoline or diesel you buy for your motor vehicle use. This is in addition to a federal level tax. To improve funding for highways and transit, the government wants to increase the tax you are paying on gasoline and diesel by 10 cents per gallon starting from September 1, 2013. With this increase, your state level gasoline and diesel taxes would be 30 cents per gallon excluding the federal gasoline and diesel taxes. Taxes on motor fuels are easy to administer and they are normally understood as transportation user charges.

Construction cost of a mile of roadway is increasing every year. To catch up with this increase and continue to be able to provide a safe and efficient transportation system, the government wants to index the fuel taxes to a transportation cost index that represents such increases in costs. So, starting this year, every year on September 1st, this fuel tax will be increased at a rate that transportation cost index increases, usually between 1% to 3% per year.

For example, if the transportation cost index grows 2% in between 2013 and 2014, the fuel tax on September 1, 2014 will be 30.6 cents per gallon. Every year on August 1st, a public announcement is made indicating the actual increase in fuel tax for the next year. These taxes will be included in your price of gasoline or diesel.

Q: What is Transportation cost index. Why are you changing the fuel tax along with that?

A: "Highway cost index" means the 12-month moving average of the price of materials and labor compiled by the Texas Department of Transportation and incorporated into state highway projects.

A3: Sales tax on motor fuels - New

Currently you are paying a statewide tax of 20 cents per gallon of gasoline or diesel you buy for your motor vehicle use. This is in addition to a federal level tax. This tax has not been changed since 1991. As the construction costs increased due to inflation, the government is not able to keep up with the prices. The government plans to replace the current fuel tax with a sales tax of 7.5% on the fuel price so that as the fuel price increases, the revenue also increases to fund the transportation improvements. For this purpose the base fuel price will be calculated as a statewide average of wholesale price of unleaded regular gasoline price for a six month period. Hence, in every year, on January 1st and July 1st, the base gas price will be changed. For example, if from December 1st 2013 to May 31st, 2014, the average wholesale price of gasoline was $3.5 excluding the federal gas tax, the amount of tax added to the gasoline price will be $3.5*0.075 =26 cents per gallon. This tax amount will not change until January 1, 2015. In any case, the base gas price will not be less than $3.30. A tax on Diesel price will also be calculated in similar way. Taxes on motor fuels

are easy to administer and they are normally understood as transportation user charges.

Q: So, what is the difference in what I pay for gas tax? Will I know the actual amount of tax only before that particular six month period?

B: Carbon tax - New

Motor vehicle usage is producing about 50% of the carbon dioxide emissions in the USA. To penalize excessive use of petroleum based fuels and to encourage the increased use of low-carbon emitting fuels, the government wants to introduce a carbon tax. According to the Environmental Protection Agency, one gallon of gasoline or diesel emits about 19-22 pounds of CO2. (Office of Transportation and Air Quality 2005) European spot price for Carbon dioxide credits has ranged from 1cent to 2 cents per pound.(National Surface Transportation Infrastructure Financing Commission 2009) This means with one gallon of gasoline, CO_2 worth of about 20 to 40 cents is emitted. The government wants to charge a carbon tax of 25 cents per gallon of gasoline or diesel. The revenue collected from this will be used mainly for the programs to reduce environmental pollution. Some examples are, improving traffic signals, subsidies for encouraging low-carbon emission vehicle use and investing in developing cleaner fuels for motor vehicles.

Q: We are already paying a fuel tax. What is this new tax? How are we paying it? Why only motor vehicles should pay? What about the rest of 50%? I drive less. I do not pollute more. Why are you charging me this additional tax?

C: Vehicle registration fee - fixed increase statewide

Currently, every year, you are paying a vehicle registration fee of $50.75 per year plus other charges plus any county level registration fees to register your car. To

improve funding for highways and transit, the government wants to increase the fee you are paying to $80.75 per vehicle per year. Similarly, the registration fee for trucks is increased by $60. The new fees will be charged starting from September 1, 2013. Vehicle registration fees are common in all the states and are easy to administer. All the revenue from vehicle registration fees is deposited in the Texas Highway Fund. The revenue is primarily used for covering the cost of registering system. After the costs are covered, the remaining revenue is used to build and maintain public highways. (Not completely based on transportation use).

Q: I use the car very limitedly. I do not drive as much. There are many people who drive more than 15000 miles a year, why should I pay equal to them? Where does this money go? Is not the registration fee supposed to pay for registration? How can you spend it on highway and transit construction?

D: General sales tax - fixed percent point increase statewide

Currently on most of the consumer goods other than food and other basic necessities, there is a statewide sales tax of 6.25% plus any local sales tax. Maximum sales tax is 8.25%. To improve funding for highways and transit, the government wants to increase the statewide sales tax by 0.25%, making it 6.50%. Hence, the maximum sales tax, including both the statewide sales tax and local sales tax will be 8.50%. The revenue collected from this additional 0.25% tax will be deposited into Texas Highway Fund and will be dedicated to building and maintaining highway and transit facilities for the public. Sales taxes are very much established and they can be administered with no additional difficulty and cost.

Q: If you want money for building roads, why don't you ask those who use them a lot? I do not drive a lot. Why should I pay for someone else's needs?

E1: Tolling all new freeway capacity with fixed tolls

Currently, many urban areas in Texas have tolled highways. Users of these highways pay a toll to travel on them. Tolls may be collected electronically by reading toll tag information or capturing a video of a vehicle and sending a bill by mail. Vehicles do not need to stop to pay a toll. Tolls will be fixed during all days and all times of the day. Tolls will be increased every year based on the inflation. Texas government collects fuel taxes and vehicle registration fees and other taxes to fund the maintenance and building of highways and transit facilities. The government wants to spend more money to maintain and facilitate efficient use of existing infrastructure with the money collected by these fees and taxes. The government wants to generate revenue for construction of any new highways or highway lanes through tolls. From this year, any new highway or any lanes of existing highway will be designated as tolled facilities and you will need to pay tolls if you want to travel on those highways or lanes. Every road will have toll collection locations where overhead gantries will be set up. Tolls will be collected electronically by reading toll tags stuck to your car or by noting your vehicle license plate information through video tolling. In the case of video tolling you will get a bill at your residence and you will have to send that payment through check or credit card. Tolls paid through video tolling will cost you about 50% more than tolls paid through toll tags. To set up a toll tag account, you will have to give your credit card information. Every time you pass under a toll collection point, your credit card will be charged the corresponding toll. Collecting toll means that the costs for the tolled highway including capital construction cost and on-going maintenance cost will be retrieved from the users of that highway as much as possible. So, tolling is considered one of the most accurate ways of charging based on the use of a roadway facility. The

revenue obtained from tolling a roadway will be utilized to pay any debts incurred on that roadway, maintain that roadway or that corridor. Any additional revenue may be used for other transportation improvements along the corridor or in that area.

Q: What is a toll road? How do we pay tolls? How much toll will it be? How is the toll calculated? How will I know which one is toll road and which one is not?

E2: Tolling all new freeway capacity with variable tolls

Currently, many urban areas in Texas have tolled highways. Users of these highways pay a toll to travel on them. Tolls may be collected electronically by reading toll tag information or capturing a video of a vehicle and sending a bill by mail. Vehicles do not need to stop to pay a toll. Tolls on the highway may vary at different times of a day or different days of a week based on the congestion level at that time period. Tolls will be increased every year based on the inflation. Texas government collects fuel taxes and vehicle registration fees and other taxes to fund the maintenance and building of highways and transit facilities. The government wants to spend more money to maintain and facilitate efficient use of existing infrastructure with the money collected by these fees and taxes. The government wants to generate revenue for construction of any new highways or highway lanes through tolls. Collecting toll means that the costs for the tolled highway including capital construction cost and on-going maintenance cost will be retrieved from the users of that highway as much as possible. So, tolling is considered one of the most accurate ways of charging based on the use of a roadway facility. The revenue obtained from tolling a roadway will be utilized to pay any debts incurred on that roadway, maintain that roadway or that corridor. Any additional revenue may be used for other transportation improvements along the corridor or in that area.

E3: Tolling new freeway capacity statewide and existing urban freeways with fixed tolls (Phased in from 2015 to 2020)

Currently, many urban areas in Texas have tolled highways. Users of these highways pay a toll to travel on them. Tolls may be collected electronically by reading toll tag information or capturing a video of a vehicle and sending a bill by mail. Vehicles do not need to stop to pay a toll.

Texas government collects fuel taxes and vehicle registration fees and other taxes to fund the maintenance and building of highways and transit facilities. The government wants to spend more money to maintain and facilitate efficient use of existing infrastructure with the money collected by these fees and taxes. The government wants to generate revenue for construction of any new highways or highway lanes through tolls. Collecting toll means that the costs for the tolled highway including capital construction cost and on-going maintenance cost will be retrieved from the users of that highway as much as possible. In addition, the government wants to collect tolls on the all existing freeways in the urban areas. These tolls will be in the range of 2 cents to 5 cents per mile. The objective of these tolls is to generate just enough revenue to maintain the freeway. Tolls will be fixed during all days and all times of the day. Tolls will be increased every year based on the inflation.

Tolling is considered one of the most accurate ways of charging based on the use of a roadway facility. The revenue obtained from tolling a roadway will be utilized to pay any debts incurred on that roadway, maintain that roadway or that corridor. Any additional revenue may be used for other transportation improvements along the corridor or in that area. In addition to tolling all new capacity, all existing freeway capacity in urban areas will be tolled with a small toll rate 2 cents-5cents per mile. The

objective is to collect tolls without diverting significant traffic out of the highway. Tolls vary by gantry but are fixed in all times of a day.

E4: Tolling new freeway capacity statewide and existing urban freeways with variable tolls (Phased in from 2015 to 2020)

Currently, many urban areas in Texas have tolled highways. Users of these highways pay a toll to travel on them. Tolls may be collected electronically by reading toll tag information or capturing a video of a vehicle and sending a bill by mail. Vehicles do not need to stop to pay a toll.

Texas government collects fuel taxes and vehicle registration fees and other taxes to fund the maintenance and building of highways and transit facilities. The government wants to spend more money to maintain and facilitate efficient use of existing infrastructure with the money collected by these fees and taxes. The government wants to generate revenue for construction of any new highways or highway lanes through tolls. Collecting toll means that the costs for the tolled highway including capital construction cost and on-going maintenance cost will be retrieved from the users of that highway as much as possible. In addition, the government wants to collect tolls on the all existing freeways in the urban areas. These tolls will be in the range of 2 cents to 5 cents per mile. The objective of these tolls is to generate just enough revenue to maintain the freeway. Tolls on the highway may vary at different times of a day or different days of a week based on the congestion level at that time period. Tolls will be increased every year based on the inflation.

Tolling is considered one of the most accurate ways of charging based on the use of a roadway facility. The revenue obtained from tolling a roadway will be utilized to pay any debts incurred on that roadway, maintain that roadway or that corridor. Any

additional revenue may be used for other transportation improvements along the corridor or in that area. In addition to tolling all new capacity, all existing freeway capacity in urban areas will be tolled with a small toll rate 2 cents-5cents per mile. The objective is to collect tolls without diverting significant traffic out of the highway. Tolls vary by gantry but are fixed in all times of a day.

F1: VMT charges - Flat rate (Phased in from 2020 to 2025)

Currently you are paying a statewide tax of 20 cents per gallon of gasoline or diesel you buy for your motor vehicle use. This is in addition to a federal level fuel tax. To improve funding for highways and transit, the government wants to increase the tax you are paying on gasoline and diesel by 10 cents per gallon starting from September 1, 2013.

The government is concerned that due to increase in fuel efficiency, the revenue from the fuel tax is going to decline in the future and so, it will not be sufficient to fulfill the transportation needs in the future. Moreover, since fuel tax charges the road users indirectly, it is expected that the government would face difficulties in charging all the users fairly. For example, electric and hybrid type vehicles are not charged a fuel tax. They need a separate tax system. Also, users of older vehicles that consume more fuel, mainly low income population would have to pay more in fuel taxes for the same travel distance. Due to these reasons, the government wants to move towards a more direct use based charging – charging a mileage based tax. In this case, all automobile users will be charged a fixed amount of 2.5 cents per mile traveled. This mileage based tax system will be gradually replacing the fuel tax system between 2020 and 2025. That is, by 2025, all users will be paying a tax based on the distance they traveled. The tax will be collected every year at the time of registering

your vehicle. You will pre-purchase an amount of mileage for the following year. At the end of the year, when you come for the renewal of your registration, your odometer reading will be noted and you will be refunded any mileage you did not use. If you traveled more than what you purchased, you will be charged extra. There will not be any penalty. This process will continue for the next year and so on. For example, suppose that you purchased a mileage of 10,000 for the year 2021. You will pre-pay $250 at the time of your registration. Suppose that you traveled 9,000 miles in 2021. Then at the time of your next renewal, you will be refunded the extra amount - $25. At that time, you will have to purchase your mileage for the next year.

F2: VMT charges - Comprehensive rates (Phased in from 2020 to 2035)

Currently you are paying a statewide tax of 20 cents per gallon of gasoline or diesel you buy for your motor vehicle use. This is in addition to a federal level fuel tax. To improve funding for highways and transit, the government wants to increase the tax you are paying on gasoline and diesel by 10 cents per gallon starting from September 1, 2013.

The government is concerned that due to increase in fuel efficiency, the revenue from the fuel tax is going to decline in the future and so, it will not be sufficient to fulfill the transportation needs in the future. Moreover, since fuel tax charges the road users indirectly, it is expected that the government would face difficulties in charging all the users fairly. For example, electric and hybrid type vehicles are not charged a fuel tax. They need a separate tax system. Also, users of older vehicles, that consume more fuel, mainly low income population would have to pay more in fuel taxes for the same travel distance. Due to these reasons, the government wants to move towards a more direct use based charging – charging a mileage based tax. In

this case, all automobile users will be charged a tax per mile traveled. The actual tax rate for each traveler will depend on the vehicle type, the time of trip and the location of travel. The government identifies the tax rates for each user class based on an overall average of 2.5cents per each mile traveled by all users in the state. This mileage based tax system will be gradually replacing the fuel tax system between 2020 and 2035. That is, by 2035, all users will be paying a tax based on the distance they travel, the location where their miles are accumulated, the time when their travel occur and the type of vehicle they use. The tax will be collected every year at the time of registering your vehicle. You will pre-purchase an amount of mileage for the following year. At the end of the year, when you come for the renewal of your registration, your odometer reading will be noted and you will be refunded any mileage you did not use. If you traveled more than what you purchased, you will be charged extra. There will not be any penalty. This process will continue for the next year and so on. For example, suppose that you purchased a mileage of 10,000 for the year 2021. You will pre-pay $250 at the time of your registration. Suppose that you traveled 9,000 miles in 2021. Then at the time of your next renewal, you will be refunded the extra amount - $25. At that time, you will have to purchase your mileage for the next year.

G: Re-allocating revenue from the tax on the sale of motor vehicles, tires and parts to transportation improvements.

Currently, the revenue collected from tax on motor vehicle sales, rent, motor vehicle parts and motor vehicle tires is sent to general fund and is used for various purposes across Texas. The government wants to transfer all the revenue collected from these sales taxes into the Texas highway fund and use it to fund transportation improvements.

H: Freight Weight-Mile Tax

Currently, in Texas, all heavy and light vehicles are charged a fuel tax to account for the benefit they gained by using the roadways and the costs imposed on the system by doing so. The revenue collected from these taxes is used by the State to maintain and construct roadway and bridge facilities. But, heavy vehicles cost significantly more than what light vehicles do by causing wear and tear to the roadways and producing other external effects on environment. Studies show that, although fuel consumption increases with vehicle size and weight, it does not increase proportionately with cost responsibility. Above 26,000 pounds registered weight, the overall weight and axle loads become important factors in damaging the pavements, bridges, and other structures. Therefore, a diesel fuel tax would not be an accurate measure of cost responsibility for heavy vehicles.

For the above reason, the Texas government wants to charge a tax on truck movements based on the amount of weight carried and miles traveled in the state. This will be in addition to federal and state fuel tax and federal heavy vehicle use tax. This tax is similar to the Oregon's weight-mile tax (Oregon Legislative Committee Services 2000). Actual tax rate per mile for different classes of weight and number of axles will be specified in a fair way based on a highway cost allocation study. Preliminarily, for trucks with a weight between 26,000 to 80,000 pounds, the tax rate will be between 3 cents and 14 cents per mile. For trucks with weight more than 80,000 pounds, the tax rate will be between 10 cents and 20 cents per mile depending on the number of axles. The truck operators will have to pay at the end of every quarter for all the movements occurred in that quarter. The truck operators should maintain logs with GPS tracks and weight monitors for audit by the state comptroller.

I: VMT charges on electric and CNG vehicles – flat rate

Currently, all automobiles operating with liquid fuels such as gasoline, diesel and gasohol, are paying a fuel tax. This is to account for the benefit gained by using the roadways and any costs imposed on the transportation system. But, vehicles operating with alternative fuels such as electricity and compressed natural gas are not paying any charges but are using the roadways. To improve the fairness in the fuel tax system, the government wants to collect a charge on electric vehicles and CNG vehicles based on the miles they traveled. This tax will be called VMT tax on alternative fuel vehicles and will be collected at the time of annual vehicle registration renewal. This tax is not charged on the vehicles that are charged a fuel tax.

At the time of vehicle registration or renewal, you will pre-purchase an amount of mileage for the following year. At the end of the year, when you come for the renewal of your registration, your odometer reading will be noted and you will be refunded any mileage you did not use. If you traveled more than what you purchased, you will be charged extra. There will not be any penalty. This process will continue for the next year and so on. For example, suppose that you purchased a mileage of 10,000 for the year 2021. You will pre-pay $250 at the time of your registration. Suppose that you traveled 9,000 miles in 2021. Then at the time of your next renewal, you will be refunded the extra amount - $25. At that time, you will have to purchase your mileage for the next year. This rate should be equivalent to the tax burden imposed on a gasoline vehicle with higher fuel efficiency compared to 85% of all gasoline vehicles in terms of miles per gallon.

J: Vehicle registration fee increase for electric and CNG fuel vehicles

Currently, all automobiles operating with liquid fuels such as gasoline, diesel and gasohol, are paying a fuel tax. This is to account for the benefit gained by using the roadways and any costs imposed on the transportation system. But, vehicles operating with alternative fuels such as electricity and compressed natural gas are not paying any charges but are using the roadways. To improve the fairness in the fuel tax system, the government wants to increase the vehicle registration fee for electric and CNG vehicles. That means, electric and CNG vehicles will pay an additional fee of $75 in lieu of fuel tax. So, while regular cars with 6000 pounds or less weight pay $50.75 as registration fee, electric and CNG vehicles will pay $125.75. This is excluding any other statewide and local fees paid along with the registration. This additional fee of $75 is calculated assuming that the vehicle has about average annual mileage of about 10,000 and assuming a fuel efficiency of 27 mpg.

K1: Sales tax on vehicle sales - fixed percent point increase

Currently any vehicle sales in Texas are subject to a tax of 6.25% at the time of sale. (TCPA 2011b) The government wants to increase this to 7.25%. The additional revenue generated will be used to fund the maintenance and construction of roadway and transit facilities across the state. Sale of vehicles is connected to transportation use and so the government wants to use this revenue for the transportation improvements.

K2: Sales tax on motor vehicle tires - fixed percent point increase

Currently there is a sales tax of up to 8.25% including state tax and any local taxes on purchase of motor vehicle tires in Texas. (TCPA 2013c) The government wants to increase this by one percent point. The additional revenue generated will be

used to fund the maintenance and construction of roadway and transit facilities across the state. Sale of motor vehicle tires is connected to travel and use of transportation facilities and so the government wants to use this revenue for the transportation improvements.

L: Drivers license fees - fixed increase statewide

Currently, Texas Department of Public Safety charges a fee for obtaining and renewing your drivers license (Texas Department of Public Safety 2011). The government wants to add a surcharge on drivers license fees and dedicate the resulting revenue to certain transportation system improvements. Especially, this revenue will be dedicated to driver safety programs. Owners of Texas Drivers license may have to pay from $5 to $10 extra.

M: Vehicle registration fee increase locally

Currently, in addition to state level vehicle registration fee, most of the counties in Texas collect local registration fees ranging from $5 to $11.50 per vehicle. The government wants to allow certain counties located in busy metropolitan areas, namely, Dallas Fort Worth, Houston, Austin and San Antonio to increase local vehicle registration fee based on the corresponding local funding requirements. These regions are highly populated and suffer from significantly higher level of congestion compared to other smaller regions. Hence their funding needs may be significantly different from the needs overall statewide or other smaller areas. Actual increase may be between $5 and $50 depending on local needs. The revenue obtained from this local registration fee will be dedicated to local transportation projects and transit improvements.

N: Increase in allowance for local general sales tax

Currently, in addition to state general sales tax of 6.25%, most of the counties in Texas collect local sales tax ranging from 0.25% to 2%. In some urban areas, up to 1% of this local sales tax is used by the local transit authorities. Currently, Texas government has a cap of 8.25% on total sales tax including state and local sales tax. The government wants to increase this cap by 0.5% and allow the cities and counties to increase or impose new local sales taxes and dedicate the revenue to transportation. All such new revenue must be spent on local transportation projects, especially transit projects. Such local sales tax for transportation will need a popular vote by the voters in the county.

This additional revenue will help some major urban areas including Dallas Fort Worth, Houston, Austin and San Antonio which are highly populated and suffer from significantly higher level of congestion compared to other smaller regions. Their funding needs may be significantly different from the needs overall statewide or other smaller areas.

O: Local option fuel tax – New addition to the state fuel tax

Currently, a statewide tax on fuels is imposed for the use in motor vehicles. This is in addition to any federal fuel taxes. The government wants to allow certain counties located in busy metropolitan areas, namely, Dallas Fort Worth, Houston, Austin and San Antonio to impose additional fuel tax with the approval by a popular vote from the voters. All such new revenue must be dedicated to local transportation projects, especially transit projects. A full list of dedications should be shown to the voters at the time of voting.

This additional revenue will help some major urban areas including Dallas Fort Worth, Houston, Austin and San Antonio which are highly populated and suffer from significantly higher level of congestion compared to other smaller regions. Their funding needs may be significantly different from the needs overall statewide or other smaller areas.

Appendix I

Scoring Table from the NSTIFC Report

Criterion	Weight	Alternative Scores												
		Motor Fuels	Truck & Trailer sales tax	Truck Tire Taxes	HVUT	Veh Registration Fee	DL Surcharge	Vehicle Sales Tax	Auto-related sales tax	Automobile Tax	Bicycle Tire Tax	Carbon Tax	Imported Oil Tariff	Sales Tax on Motor Fuels
Revenue Stream Considerations														
Revenue potential	0.14	5	2	1	2	5	4	4	4	5	1	5	5	5
Sustainability	0.08	2	4	3	4	4	4	5	5	3	4	2	2	2
Flexibility	0.045	5	5	4	4	5	5	5	5	5	2	5	5	5
Justification for dedication	0.045	5	5	5	5	5	5	5	5	5	5	5	3	5
Implementation & Administration Considerations														
Public acceptance/political viability	0.09	2	4	4	3	2	1	2	2	3	3	2	3	2
Appropriateness for Federal use	0.07	5	4	4	5	3	2	2	2	4	4	5	5	3
Ease/cost of implementation & administration	0.07	5	5	5	4	4	4	3	2	4	4	5	3	3
Ease/cost of compliance	0.045	4	5	5	3	4	4	3	2	4	4	4	4	3
Economic Efficiency/Impact Considerations														
Promotion of efficient investment	0.07	2	2	2	2	2	2	2	2	2	2	2	2	2
Promotion of efficient use	0.14	3	2	3	3	2	2	2	2	3	2	3	3	3
Enables charges for adverse side effects	0.035	3	2	2	3	3	2	3	2	2	4	3	3	3
Equity Considerations														
User/beneficiary equity	0.1	4	4	4	4	3	3	3	3	4	4	4	2	4
Equity across income groups	0.035	2	3	3	3	2	2	3	2	3	3	2	3	2
Geographic equity	0.035	2	3	3	3	3	3	3	3	3	3	2	2	2
Weighted Score	1	3.575	3.365	3.24	3.315	3.32	2.985	3.11	2.925	3.64	2.955	3.575	3.27	3.25

Criterion	Weight	Alternative Scores											
		General Sales Tax	Dedicated Income Tax	General Fund Allocations	Container Fees	Freight Sales Tax	Harbor Maintenance Tax	Customs Duties	Freight Ton-Based Tax	Freight Ton-Mile Tax	Facility Level Tolling & Pricing Mechanisms	Cordon Pricing	VMT Mechanism
Revenue Stream Considerations													
Revenue potential	0.14	5	5	5	2	5	2	4	4	4	4	2	5
Sustainability	0.08	5	5	3	4	5	4	5	3	3	4	2	4
Flexibility	0.045	5	5	5	4	5	3	4	4	4	4	4	5
Justification for dedication	0.045	1	1	1	4	5	3	4	5	5	4	4	4
Implementation & Administration Considerations													
Public acceptance/political viability	0.09	1	1	4	4	2	3	3	2	2	3	2	2
Appropriateness for Federal use	0.07	2	5	5	4	4	5	5	4	4	2	1	5
Ease/cost of implementation & administration	0.07	1	5	5	4	2	5	5	1	1	3	2	1
Ease/cost of compliance	0.045	1	5	5	4	2	4	4	1	1	4	3	4
Economic Efficiency/Impact Considerations													
Promotion of efficient investment	0.07	1	1	1	3	2	3	3	2	2	5	1	5
Promotion of efficient use	0.14	1	1	1	2	2	2	2	3	4	4	3	5
Enables charges for adverse side effects	0.035	1	1	1	3	2	2	2	3	3	2	3	5
Equity Considerations													
User/beneficiary equity	0.1	1	1	1	4	2	3	3	2	2	5	4	5
Equity across income groups	0.035	2	4	3	3	3	3	3	3	3	3	3	3
Geographic equity	0.035	2	2	2	4	3	3	3	3	3	5	5	3
Weighted Score	1	2.2	2.94	3.015	3.3	3.14	3.09	3.54	2.855	2.995	3.8	2.6	4.14

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Biographical Information

Pulipati Sasanka Bhushan was born to Mrs. Lakshmi Devi and Mr. Markandeya in the state of Andhra Pradesh in India on 25th May 1981. He received his secondary education at Sri Malayalaswami Oriental Sanskrit High School, Koilkuntla, Andhra Pradesh. He obtained his Bachelor's degree in Civil Engineering from the Birla Institute of Technology and Science (BITS), Pilani, Rajasthan, India. He worked as a Highway Engineer at RITES Ltd., New Delhi, India for two years (2002-2004). At RITES Ltd., he took part in one of the prestigious highway projects in India, the North-South and East-West Corridor[26] project. He also worked in Afghanistan for the detailed field survey and soil investigation for transmission line between Kabul and Phul-E-Khumri, which was materialized later in 2011.

Sasanka earned his Master of Science degree in Civil Engineering from the University of Texas at Arlington (UTA) in 2006 with a specialization in Transportation Engineering. His thesis was titled "Regional prioritization of corridors for traffic signal retiming." During his study at UTA, he served as a Graduate Teaching Assistant in the Department of Civil and Environmental Engineering, where he taught Geodesy Lab.

He joined C&M Associates, Inc. in 2006. He continued to work there until 2012, where he grew from an Intern Modeler to a Senior Transportation Engineer. He worked on a number of projects related to traffic and revenue studies for toll roads and bridges. His areas of focus were travel demand modeling, socioeconomic forecasting, revenue

[26] The North-South and East-West Corridor is the second phase of the National Highways Development Project (NHDP) in India. It consists of building 7,300 kilometers of four/six lane expressways connecting Srinagar, Kanyakumari, Porbandar and Silchar.

forecasting and probabilistic risk analysis. He obtained his professional engineer license in Texas in 2010.

Sasanka started to work part time on his PhD in civil engineering at UTA in 2008. He obtained his degree in December 2013. He conducted his doctoral research titled “Evaluation of surface transportation funding alternatives using criteria system established through a Delphi survey of Texas transportation experts” under the guidance of Dr. Stephen P. Mattingly. He returned to his home country at the end of 2013. He aims to make a difference with his knowledge and experience. He plans to work as a professor and wishes to contribute to the field of transportation engineering with valuable research.

Sasanka worked as the president of the student chapter of the Institute of Transportation Engineers at UTA. He made the chapter to be recognized as an active student chapter in Texas. He received the “Outstanding student award” from the Texas Institute of Transportation Engineers (TexITE) in 2005 and 2006. He was also initiated to Tau Beta Pi, an all engineering honors society in 2005. He has presented or is going to present his research in various international conferences including the Annual Meeting of the Transportation Research Board. He authored two articles in TexITE newsletters. He is married to Sreelatha.