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In-Depth Analysis of the JACK Model

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TxDOT Project 0-6395: Modeling Revenue for Use in Developing Reasonable Expectations of Revenue for Long Range Plan Development

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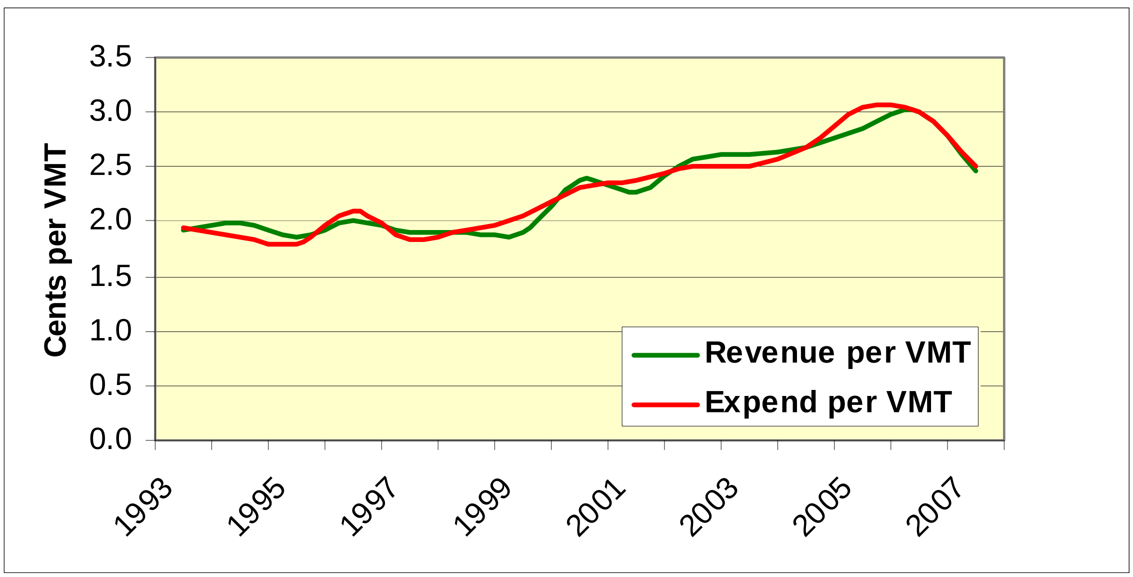
1.1 Introduction

1.1.1 Background

The Texas Transportation Commission ("the Commission") is responsible for planning and making policies for the location, construction, and maintenance of a comprehensive system of highways and public roads in Texas. In order for the Commission to carry out its legislative mandate, the Texas Constitution requires that most revenue generated by motor vehicle registration fees and motor fuel taxes be used for constructing and maintaining public roadways and other designated purposes.

The Texas Department of Transportation (TxDOT) assists the Commission in executing state transportation policy. It is the responsibility of the legislature to appropriate money for TxDOT's operation and maintenance expenses. All money authorized to be appropriated for TxDOT's operations must come from the State Highway Fund (also known as Fund 6, Fund 006, or Fund 0006). The Commission can then use the balance in the fund to fulfill its responsibilities.

However, the value of the revenue received in Fund 6 is not keeping pace with growing demand for transportation infrastructure in Texas. Additionally, diversion of revenue to non-transportation uses now exceeds $600 million per year. As shown in Figure 1.1, revenues and expenditures of the State Highway Fund per vehicle mile traveled (VMT) in Texas have remained almost flat since 1993. In the meantime, construction cost inflation has gone up more than 100%, effectively halving the value of expenditure.



Source: Office of the Comptroller, Annual Cash Reports

Figure 1.1: State Highway Fund: Revenues and Expenditures per VMT

Recently, as part of a comprehensive analysis of budget and funding options, a TxDOT special task force has examined the agency's current financial forecasting methods and has developed a model designed to estimate future State Highway Fund revenues and expenditures.

The Joint Analysis using Combined Knowledge (JACK) model is capable of projecting future TxDOT revenues and expenditures. One part of the model includes estimation of revenue diversions.

1.1.2 Diversions from the State Highway Fund

Diversion of transportation revenues to non-transportation uses is a matter of concern to TxDOT. As far back as November 5, 1946, voters approved an amendment to the Texas Constitution known as the "Good Roads Amendment," prohibiting the diversion of receipts from gasoline taxes and vehicle registration to non-highway purposes, in order to provide a guaranteed income for state highways. That amendment reserved 25% of the revenues for the Available School Fund and permanently set the remainder aside for state highways. In 1988 voters approved another amendment to ensure that federal funds reimbursing the state for highway work also are dedicated to highway purposes (Kite, 2008).

However, over the years diversion of funds to non-transportation purposes has continued to grow. JACK includes a statement that "[d]uring the last legislative session $1.57 Billion was diverted from the highway funds to other agencies." For fiscal years (FY) 2008 and 2009, JACK considers that diversions will continue. For its projections JACK makes the supposition that 50% of the diversions from the State Highway Fund could be ended starting in FY 2010. From 2010 to 2035, JACK estimates an annual recovery of $451.5 million, for a total of $11.7 billion, as shown in Table 1.1.

Table 1.1: JACK Forecast of Diversion Recovery

Period	Amount Recovered
FY 08-09	$0
FY 10-19	$4.515 billion
FY 20-35	$7.224 billion
Total	$11.739 billion

Source: TxDOT, 2008

1.1.3 Chapter Scope

This chapter aims to provide a framework for understanding diversions from the State Highway Fund to non-transportation uses (*Research Project Work Plan Task 7: Develop a series of mathematical expressions that will assist TxDOT in projecting future expenditures from Fund 006 on selected non-construction related activities*).

First, a general background of the State Highway Fund's history and components is provided. Then the State Highway Fund's most important revenues are analyzed. Finally, the State Highway Fund's expenditures and the most relevant legislative diversions are examined.

1.2 The Texas State Highway Fund

1.2.1 Creation

The State Highway Fund was created by the 35th Legislature in the Act of March 15, 1917. The latter provided that "all funds coming into the hands of the Commission derived from the registration fees or other sources provided for in this subdivision, as collected, shall be deposited with the State Treasurer to the credit of a special fund designated as *The State Highway Fund*."

Soon after, Sections 153.503 through 153.505 of the Texas Tax Code (TTxC) allocated motor fuel taxes to the State Highway Fund. These provisions are the current codification of statutes enacted in 1941 (Mattox, 1985). The approval in 1946 of Article VIII, section 7-a, an amendment to the Texas Constitution, gave constitutional status to dedications of funds already required by statute.

Article VIII, section 7-a does not actually establish a State Highway Fund, or refer to the fund by name. Unlike other constitutional dedications of revenue such as the Veterans' Land Fund or the Texas Growth Fund, Article VIII, sections 7-a and 7-b do not create or refer to a special constitutional fund (Abbott, 2004). Instead, these revenues are held in the State Highway Fund, which was created by statute prior to the adoption of article VIII, section 7-a.

1.2.2 Sources of Funds

The Texas Constitution article VIII, section 7-a, dedicates to highway purposes the net revenues derived from motor vehicle registration fees, and certain taxes on motor vehicle fuels and lubricants. The Constitution also dedicates in section 7-b federal revenues that reimburse the state for expenditures of funds "that are themselves dedicated for acquiring rights-of-way and constructing, maintaining, and policing public roadways." The provisions are silent about any other revenue source.

It is important to note that Section 7-a of the Texas Constitution expressly dedicates only certain revenues for highway purposes. The State Highway Fund is comprised of these funds, as well as other state and federal funds statutorily required to be placed in the Fund. Thus, not all funds in the State Highway Fund are constitutionally dedicated for highways; some are subject to legislative decision.

1.2.3 Uses of Funds

Monies constitutionally dedicated to the State Highway Fund "shall be used for the sole purpose of acquiring rights-of-way, constructing, maintaining, and policing such public roadways, and for the administration of such laws as may be prescribed by the Legislature pertaining to the supervision of traffic and safety on such roads."

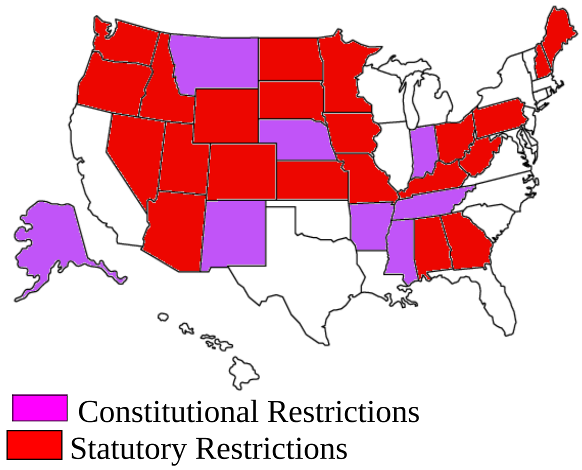
Currently, monies deposited in the State Highway Fund and required to be used for public roadways have these primary goals:

- to improve the state highway system or to mitigate adverse environmental effects that result directly from construction or maintenance of a state highway,
- to be used by the Department of Public Safety to police the state highway system and to administer state laws relating to traffic and safety on public roads (TRC §222.001)

Money in the State Highway Fund that is not required by the Texas Constitution or federal law to be spent for public roadways may be used by TxDOT for any function performed by the department (TRC §222.002). Whether a certain expense qualifies as a TxDOT maintenance or operational expense is not always clear. On several occasions TxDOT personnel have requested an opinion of the attorney general on whether particular items match federal aid (Mattox, 1985).

1.2.4 Restrictions in Other States

Thirty states restrict the use of their gas tax revenues solely to highway purposes, as shown in Figure 1.2. Texas allows diversions, including 25% for education, as described below.



Source: Puentes, 2003.

Figure 1.2: State Restrictions On Use of Gas Tax Revenues

1.2.5 Authorized Diversions

The “Legislature shall not have power to borrow, or in any manner divert from its purpose, any special fund that may, or ought to, come into the Treasury” (Tex. Const. art. VIII, § 7). Furthermore, money constitutionally dedicated to a particular purpose cannot be allocated to any other purpose (Monroe 2003).

Notwithstanding these principles, Article VIII, section 7-a, creates a constitutional exception for the diversion of gas tax and vehicle registration revenues by establishing that the Legislature is allowed to appropriate, allocate, and direct:

- all net revenues remaining after payment of all refunds allowed by law and expenses of collection derived from motor vehicle registration fees, and all taxes,

- exception: gross production and ad valorem taxes, on motor fuels and lubricants used to propel motor vehicles over public roadways,

However, one-fourth (1/4) or 25% of such net revenue shall be allocated to the Available School Fund, provided that the net revenue derived by counties from motor vehicle registration fees shall never be less than:

- the maximum amounts allowed to be retained by each County, and,

- the percentage allowed to be retained by each County under the laws in effect on January 1, 1945.

1.2.6 General Overview of Revenues and Expenditures of the State Highway Fund

Figure 1.3 is an illustration of revenues from all sources that come into the State Highway Fund. "Diversions: Round 1" are authorized deductions from state gas tax revenues managed by the State Comptroller before they reach Fund 6. "Diversions: Round 2" are authorized deductions from registration revenues, which are collected by county tax offices. Moreover, historically not all of the federal gas taxes collected from Texas have been returned to the State.

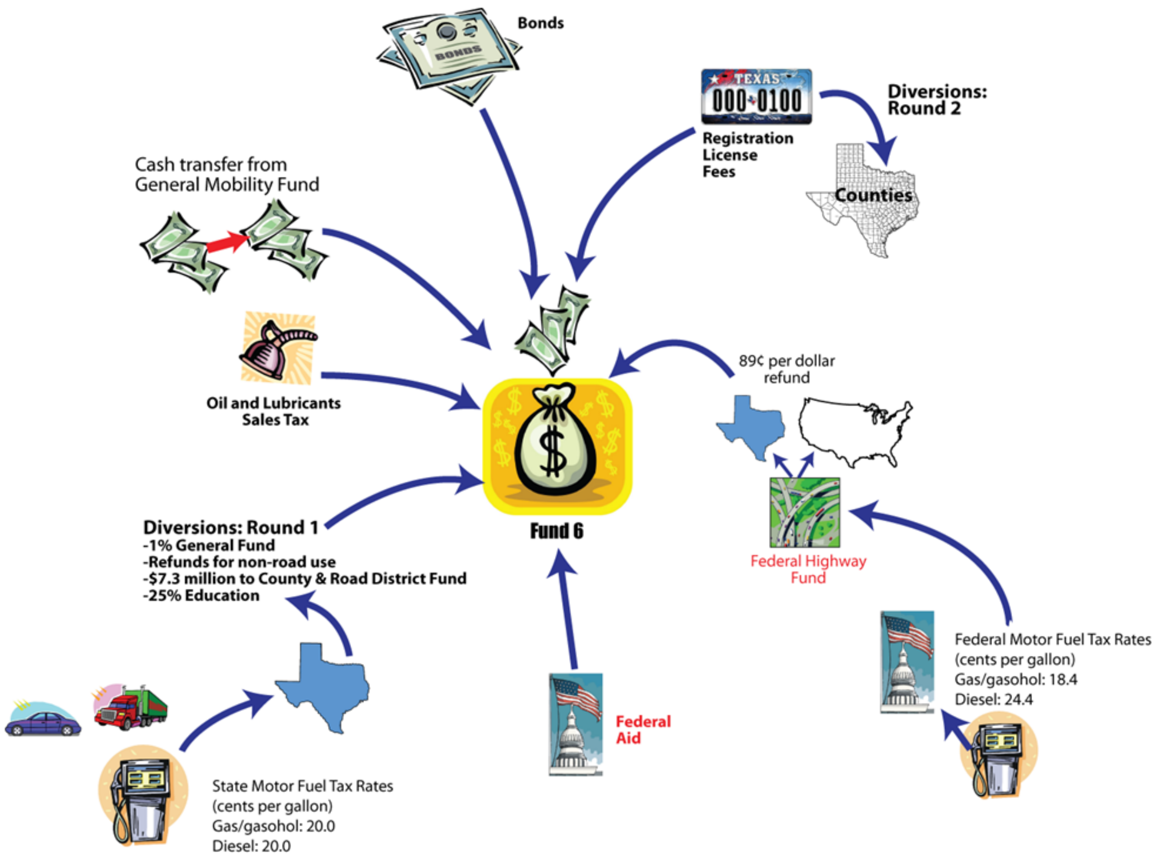


Figure 1.3: State Highway Fund: Revenues

Figure 1.4 illustrates agencies and purposes for which funds from the State Highway Fund are authorized to be diverted. Each of these will be discussed later in this chapter. The constitutional amendment of 1946 made the longstanding 75-25% Gas Tax-Available School Fund distribution a matter of organic law (TxDOT, undated).

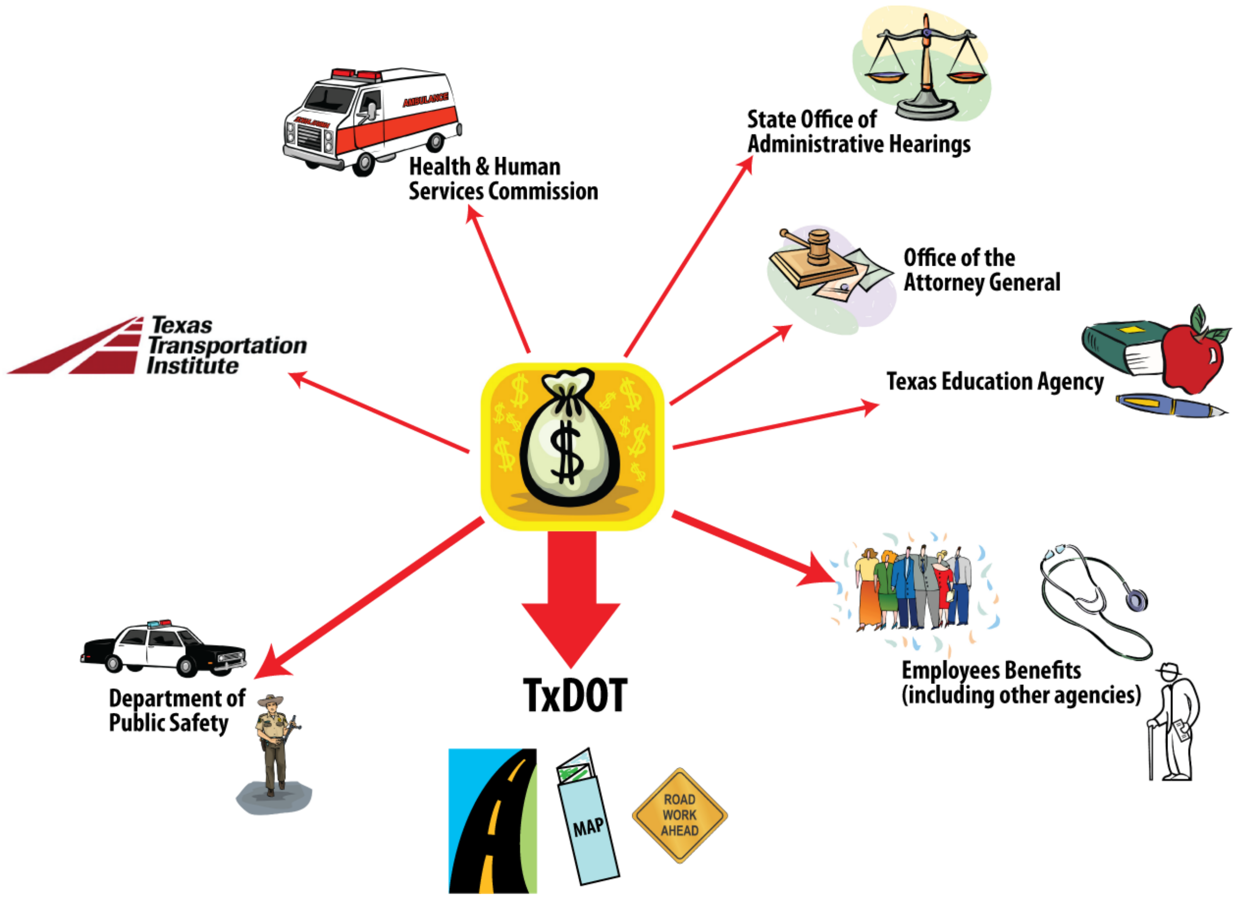
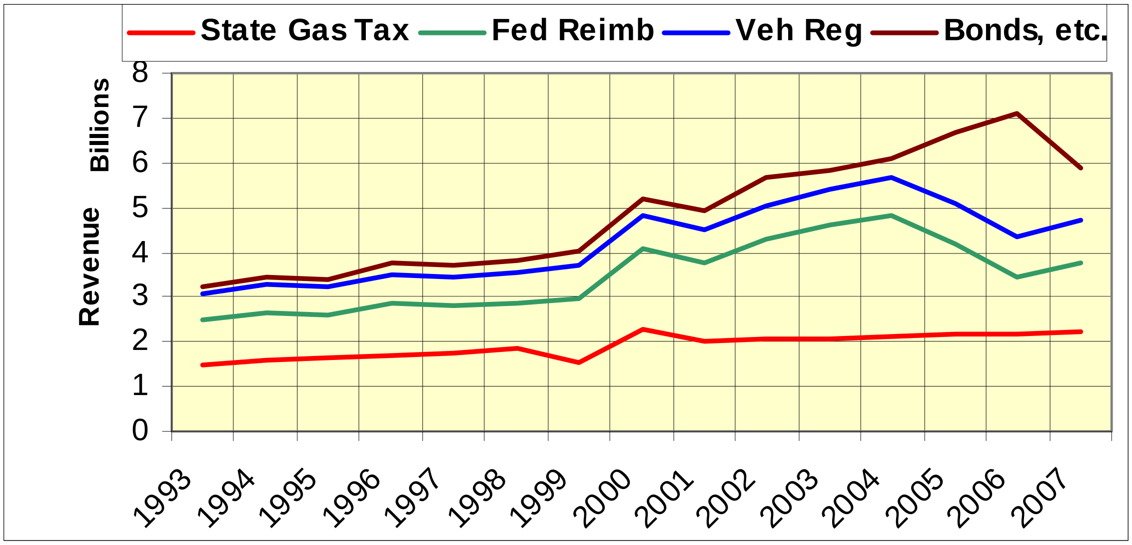


Figure 1.4: State Highway Fund: Expenditures

1.3 State Highway Fund Revenue History

Figure 1.5 shows annual State Highway Fund revenues by source (stacked) since 1993.



Source: Texas Comptroller, Annual Cash Report

Figure 1.5: State Highway Fund Revenues Since 1993

1.4 Revenue: Texas Fuel Tax

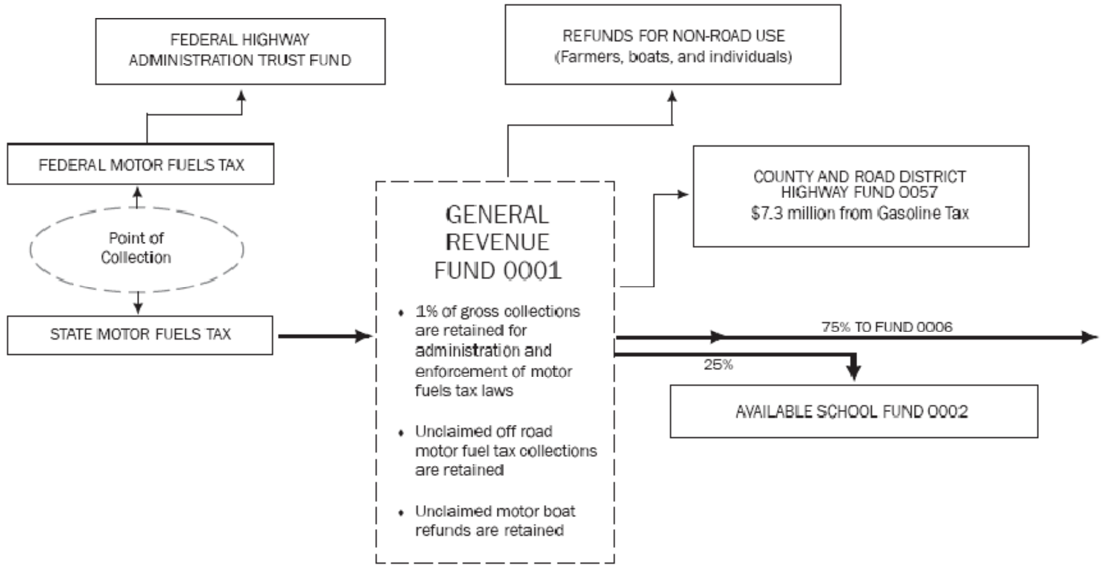
In 1923, the 38th Legislature passed Texas' first motor fuel tax: one cent a gallon. Over the years that tax rate has gradually increased, but since 1993 has been remained at 20 cents per gallon for both gasoline and diesel.

The fuel tax is a consumption tax. In general, the tax is charged on each gallon of fuel sold in Texas, which is used to propel vehicles on Texas' public roads. Gas tax exemptions can be divided into 3 categories:

- Reduced tax rates: transit companies pay 1 cent per gallon (Tax Code, 153.102).
- Exceptions: these might include gas sold to the federal government, for export purposes, to Texas public school districts, farmers, boat owners, or third parties that do not intend to use the gas on roads (Tax Code, 153.104).
- Discounts: these might include discounts for tax collection or credits for bad debts (Tax Code, 153.105).

1.4.1 Fuel Tax Collection and Allocation

Figure 1.5 illustrates how fuel gas money is collected and allocated to the State Highway Fund. Revenues are generated through taxes assessed on the sale of motor fuels including gasoline, diesel fuel, and liquefied gas. One percent of the gross amount collected is allocated to the Comptroller of Public Accounts for the administration and enforcement of state motor fuel tax laws (Legislative Budget Board, 2008). Unclaimed off-road collections and motor boat refunds are retained in the General Revenue Fund.



Source: Legislative Budget Board, 2008.

Figure 1.6: Collection and Allocation of State Motor Fuel Taxes

The comptroller shall allocate Texas gas taxes in the following way (TC §162.503):

- 25% of the tax shall be deposited to the credit of the available school fund.
- 50% of the tax shall be deposited to the credit of the State Highway Fund for the construction and maintenance of the state road system.
- from the remaining 25%, the comptroller shall deposit to the credit of the county and road district highway fund all the remaining tax receipts until a total of $7,300,000 has been credited to the fund each fiscal year; and after this amount has been attained, deposit to the credit of the state highway fund the remainder, which should be dedicated to the construction, improvement, and maintenance of farm-to-market roads.

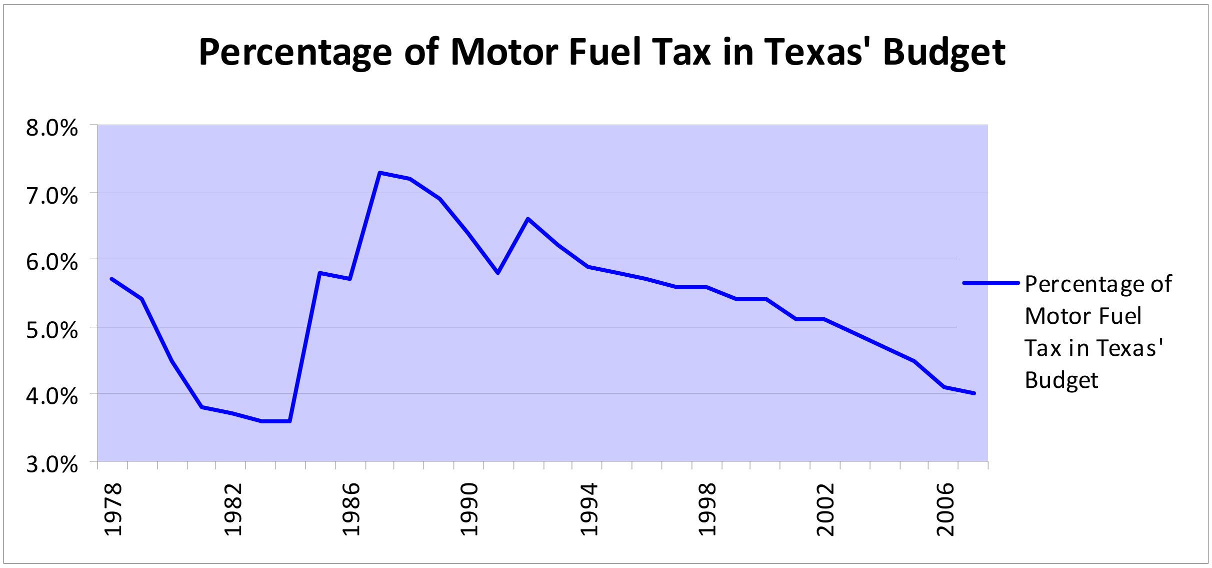
The comptroller shall allocate Texas diesel taxes in the following way (TC §162.503):

- 25% of the taxes shall be deposited to the credit of the Available School Fund.
- 75% of the taxes shall be deposited to the credit of the State Highway Fund.

The amount of state fuel tax *collected* has grown over the years, but as a component of the state budget it has actually diminished since 1987, as shown in Table 1.2 and Figure 1.6.

Table 1.2: State Fuel Tax Collections in Selected Years

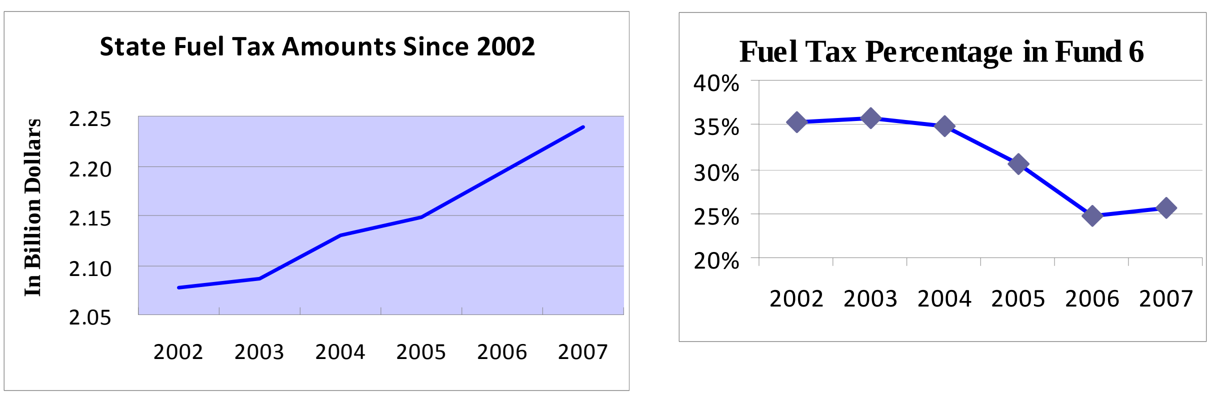
Year	State Fuel Taxes Collected	Percentage of State Budget
1990	$1,515,452,150	6.4%
2000	$2,688,158,301	5.4%
2007	$3,053,812,019	4.0%



Source: Texas Comptroller's Office, 2008.

Figure 1.7: Percentage of Motor Fuel Taxes in Texas Budget

Because of the *pre-deposit* diversions listed earlier, the actual amounts arriving in the State Highway Fund are less than the collections. As illustrated in Figure 1.7, even though the amount of fuel tax deposited has steadily grown, its weight in the State Highway Fund has declined, from about 35% in 2002 to about 25% in 2007. See Figure 1.5 to compare other components of the Fund.

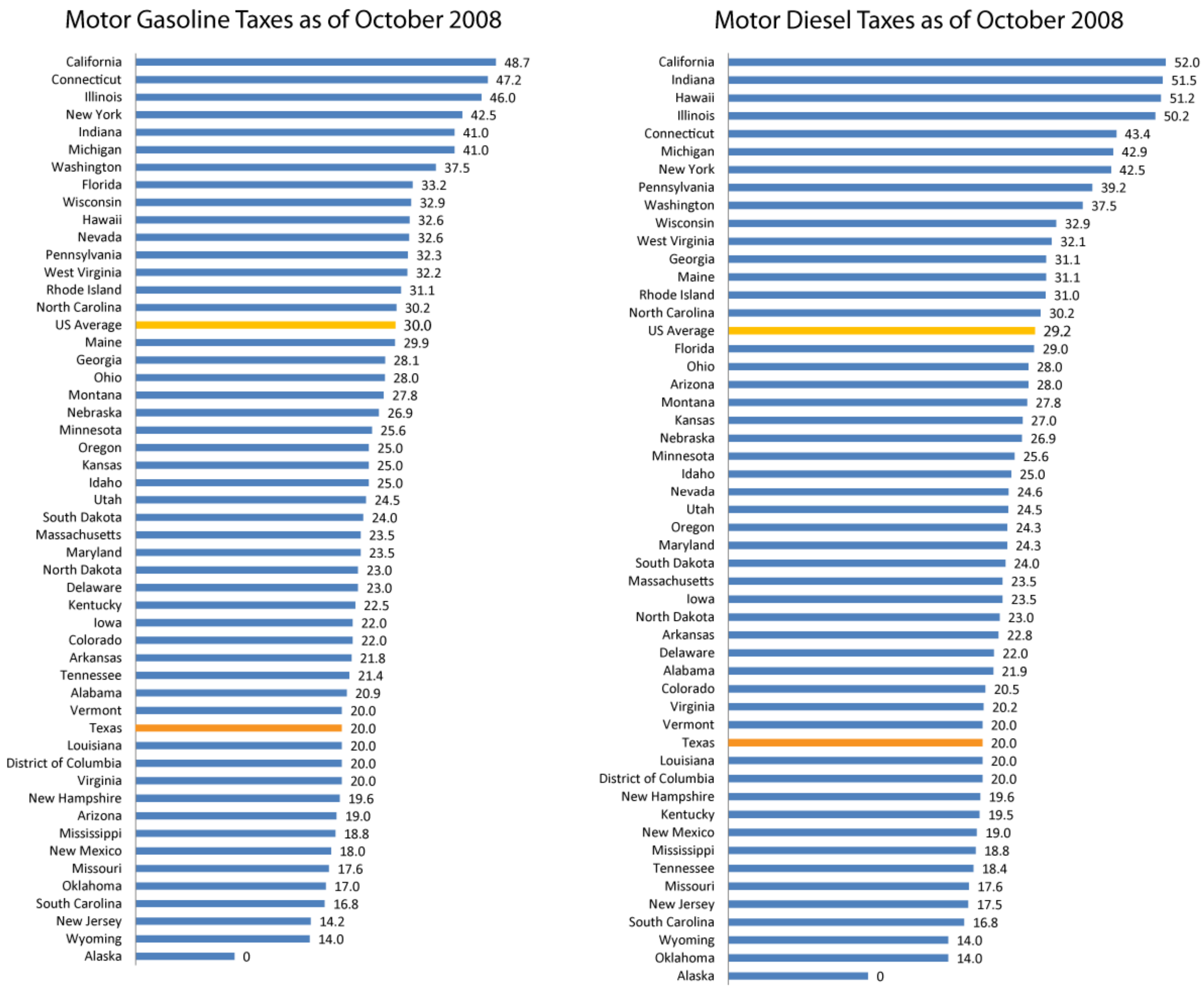


Source: Office of the Comptroller, Annual Cash Reports.

Figure 1.8: Fuel Taxes in the State Highway Fund

1.4.2 Fuel Tax Rates across the U.S.

The 2008 Texas gasoline tax rate is 20 cents for each net gallon or fractional part thereof (TC §162.102), and the 2008 diesel fuel tax rate is 20 cents for each net gallon (TC §162.202). As shown in Figure 1.9, Texas is well below the national average in fuel tax rates.



Source: API, 2008

Figure 1.9: Comparison of Fuel Taxes by State

1.5 Revenue: Federal Fuel Tax

The 2008 federal tax rates on gasoline and diesel are respectively 18.4 and 24.4 cents per gallon. From 1932, when Congress first enacted an excise tax on gasoline, until 1956, the proceeds of the federal gas tax went into general revenues, although the amount raised each year was used as an informal benchmark for federal highway spending. The Federal-Aid Highway Act of 1956 established the Highway Trust Fund (HTF) and stipulated that 100% of the gas tax be deposited into the fund. From 1956 to 1982, the HTF was used solely to finance expenditures in the federal highway program (Buechner, 2008).

The Surface Transportation Act of 1982 began allocating HTF revenues to non-highway uses. In that year, Congress raised the gas tax from four cents to nine cents per gallon and dedicated one cent to the newly-established Mass Transit Account (MTA). Each time there has been an increase in the amount of gas tax going into the HTF—1990, 1993, and 1997—20% of the increase has been allocated to the Transit Account and 80% to the Highway Account. Of the current federal gas tax, 2.86 cents per gallon is allocated to the MTA (Buechner, 2008).

1.5.1 Federal Transportation Aid to States

Two federal bills in the 1990s updated U.S. surface transportation policy—the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21). In 2005, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was enacted. With $244.1 billion in funding, SAFETEA-LU represents the largest surface transportation investment ever made in the U.S. (FHWA, 2005). SAFETEA-LU expires in 2009.

These federal bills established multiple programs and directed the funds to them, many for non-construction purposes. Because of these discretionary programs (where the funds are redistributed according to certain eligibility requirements) and demo projects (funding for specific projects), there is considerable inequity in the amounts received by each state compared to the amounts paid in. As shown in Table 1.3, over the last 50 years Texas has received an annual average of 80.3 cents per dollar of paid federal gas taxes, the lowest in the country. At the other extreme Alaska has received almost six dollars per federal gas tax dollar collected in its territory. For the life of SAFETEA-LU, Texas will be getting an average return of 83% of its gas tax payments and 51% in the case of transit funding (Ramirez, 2006).

Table 1.3: Federal Fuel Tax Biggest Losers

Biggest Losers in Federal Highway Program, 1956–2006

State	Return Share: 1956–2006
Texas	.803
Indiana	.808
North Carolina	.819
South Carolina	.830
Michigan	.837
Oklahoma	.838
Georgia	.840
Ohio	.845
Florida	.849

Source: *Highway Statistics 2006.*

Source: Utt, 2008

1.5.2 Strings Attached to Federal Money

The Congressional funding process is not a straightforward grant, but a restrictive program. It begins with authorized apportionments to the states, or allocations. Each state is limited in how much of that authorization can be obligated in a given year, i.e., contracted to be spent. The authority to spend the funds carries forward until the funds are spent, rescinded, or returned to the Federal Treasury. Only unobligated funds can be rescinded by Congress. Federal appropriations are made each fiscal year from revenues collected two years prior. Reimbursements for federal programs are limited during the annual appropriations process.

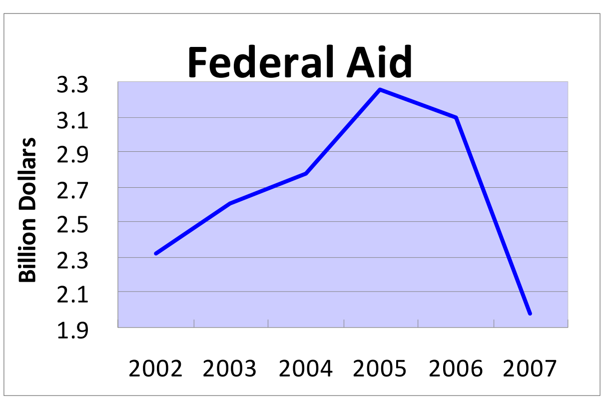
Even for funds allocated to Texas, after mandated deductions such as federally funded maintenance, border infrastructure, and recreation trails, TxDOT is left with only 30 cents per dollar for expansion projects. In effect, an estimated $1.6 billion in federal funds apportioned to Texas each year under SAFETEA-LU is not available for mobility needs (Ramirez, 2006). Moreover, "federal aid for transportation purposes shall be distributed to the various parts of the state for a funding cycle through the selection of highway projects in the state in a manner that is consistent with federal formulas" (TRC, 222.034).

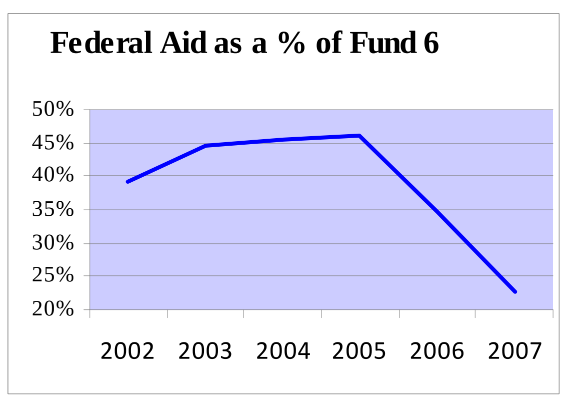
Over 95% of federal funds received in the State Highway Fund are reimbursements for highway planning and construction expenditures. The other 5% are grants received through programs such as airport improvements and safety regulations. On average, federal funds cover about 80% of TxDOT expenditure for planning and construction, but the range is from 50% to 100% depending on the program. Reimbursements to TxDOT are subject to penalties for failure to comply with certain provisions, such as clean air rules and safety regulations.

1.5.3 Rescissions

Rescission is Congressional cancellation of previous authority to spend federal funds, applying only to a state's unobligated balance in federal programs. In the last few years Congress has enacted a series of rescissions affecting the federal-aid highway program. In the case of Texas, these rescissions resulted in a nearly $400 million reduction in federal funds. These rescissions have resulted in delays on planned projects.

Since 2005, federal-aid funding has dramatically dropped, as illustrated in Figure 1.10. Before 2005, federal aid comprised 40 to 46% of the State Highway Fund. In 2007, federal aid accounted for only 23% of the revenue into the fund. See Figure 1.5 to compare other components of the State Highway Fund.





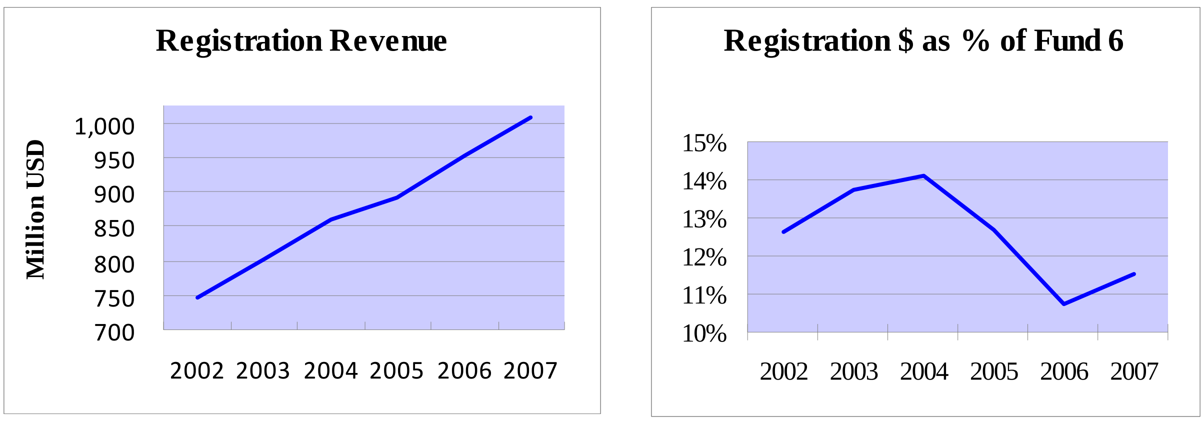
Source: Office of the Comptroller, Annual Cash Reports.

Figure 1.10: Federal Aid in the State Highway Fund

1.6 Revenue: Registration Fees

Since 1917, TxDOT has collected motor vehicle registration fees as a source of revenue for building and maintaining the state's transportation system (TxDOT, 2005). Fees are collected annually for the registration of motor vehicles, trailers, or semitrailers. Comparisons of Texas registration fee rates to other states will be presented in a later chapter of this report. With certain exceptions, revenue collected from vehicle registration fees is required to be deposited into the state treasury to the credit of the State Highway Fund.

In addition to registration fees, which are collected at the county level, TRC Chapter 501 authorizes TxDOT to collect fees for the issuance of titles and recording of vehicle ownership information of Texas residents. As illustrated in Figure 1.11, collections from registration and title fees have increased since 2002. As a percentage of revenue into the State Highway Fund, registration revenue has hovered in the range of 11-14%. See Figure 1.5 to compare other components of the State Highway Fund.



Source: Office of the Comptroller, Annual Cash Reports.

Figure 1.11: Registration Fees in the State Highway Fund

1.6.2 Diversion of Registration Fees

The Texas Transportation Commission is authorized to use money from registration fees to maintain state highways, but is not authorized to use it for any other purpose. The Commission, however, is allowed to allocate registration monies in order to match federal aid for state roads if the Commission is without sufficient funds from other sources. Thus, counties are allowed to retain the first $60,000 collected and $350 for each mile of county road maintained by the county up to 500 miles (Legislative Budget Board, 2008).

In fiscal year 2006, counties began receiving less revenue from motor vehicle registration fees and retaining more revenue from motor vehicle sales tax collections proportionally. This will continue each year through fiscal year 2015 to meet the equivalency amount of 5 percent of the motor vehicle sales tax collected during the previous year. No motor vehicle registration fees will be allocated for the 5 percent equivalency amount in 2015 and following years, as motor vehicle sales tax revenue will cover the full amount.

1.7 Other Revenues

Several state statutes, such as the Vernon Texas Civil Code, Texas Government Code, Texas Administrative Code, Texas Transportation Code, and others, establish the collection of certain revenues for deposit to the State Highway Fund. These revenues may include State borrowing, State-issued bonds, and fees related to vehicle certificates, special vehicle registrations, commercial transportation fees, and other charges. Appendix 2 of this report contains a listing of the State Highway Fund’s revenues, as compiled by the Comptroller’s Office.

For example, TxDOT develops travel literature, computer programs, and other intellectual property. The Administrative Code provides that any money related with these intellectual property rights paid to TxDOT shall be deposited in the state treasury to the credit the State Highway Fund. In addition, funds derived from the sale of excess land, utility relocation payments, permits issued to oversized and overweight vehicles and loads, or even DNA analysis of a blood sample or other specimen fees, shall also be placed in the State Highway Fund. Any civil penalties for violations concerning the sale or lease of motor vehicles also accrue to the State Highway Fund.

1.7.1 Bonds

The Commission may issue bonds and other public securities secured by a pledge payable from the State Highway Fund (Texas Constitution Article III, Section 49-p and TRC §222.003—the “Enabling Act”). The Enabling Act, provides that

i. the aggregate principal amount of such bonds and other public securities may not exceed $6 billion,

ii. the commission may issue bonds or other public securities in an aggregate principal amount of not more than $1.5 billion each year,

iii. $1.2 billion of the aggregate principal amount of such bonds or other public securities must be issued to fund safety projects that reduce accidents or correct or improve hazardous locations on the state highway system, and

iv. bonds and other public securities and credit agreements may not have a principal amount or terms that are expected to cause annual expenditures with respect thereto to exceed 10 percent of the amount deposited to the credit of the highway fund in the preceding year (TxDOT, 2007).

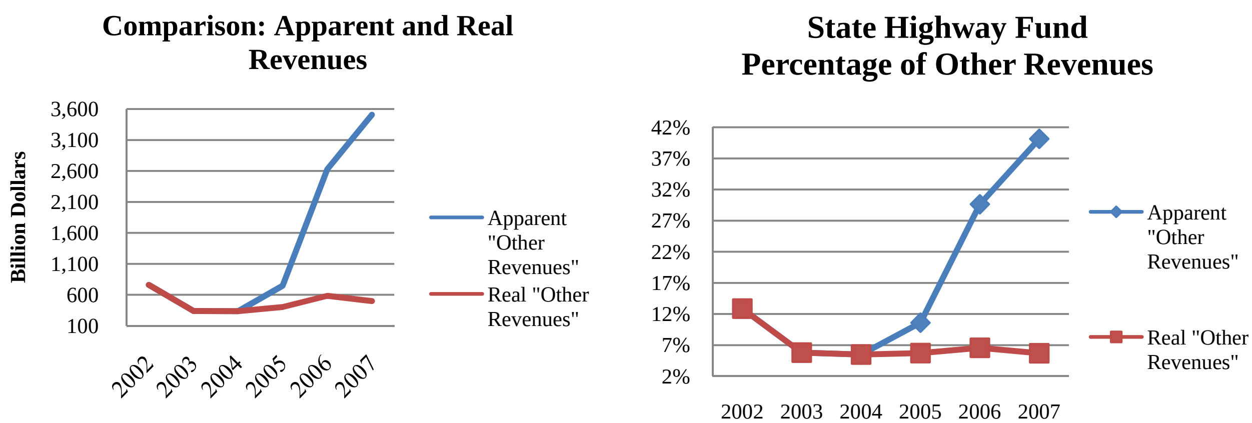
The Commission prescribes the applicable criteria for selecting the improvement projects eligible to be funded by bonds. The proceeds of bonds and other public securities issued may not be used for any purpose other than the established in Section 7-a Article VIII of the Texas Constitution or to pay any costs related to the bonds and other public securities. However, the Comptroller is required to do all necessary payments from the State Highway Fund for the principal, interests, and other costs related to the bonds or public securities that become due.

1.7.2 Debt

The Commission may also authorize TxDOT to issue short-term notes or borrow money from any source to carry out its functions (Texas Constitution Article III, Section 49-m and TRC §201.115). The time frame for such debt is a maximum of 2 years. The debt may be payable only as authorized by legislative appropriation. Additionally, TxDOT periodically transfers cash received in the State Highway Fund to a reserve note fund to ensure the timely payment of the notes (TRC §201.964).

1.7.3 Cash Transfers

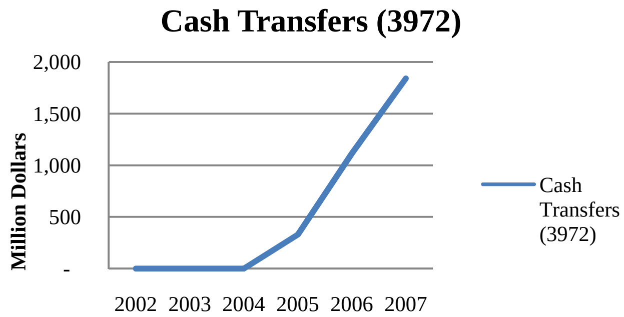
The issuance of bonds and commercial paper in addition to the significant increase of category 3972 (“other cash transfers between funds or accounts”) has been maintaining the State Highway Fund’s expenditures from fiscal years 2005 to 2007. These cash transfers come from the Texas Mobility Fund (TxDOT, 2008). Figure 1.12 shows all cash transfers to Fund 6, i.e., revenues other than fuel taxes, registration fees, and federal-aid money. Two scenarios are shown: in the first one (“apparent”), all of the Annual Cash Report categories are considered; and in the second one (“real”), all bonds, commercial paper, and revenues related to supplies and equipment have been subtracted.

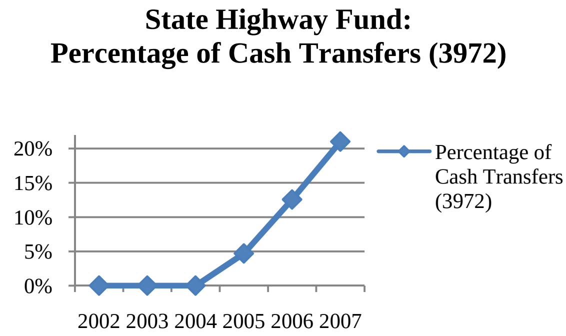


Source: Office of the Comptroller, Annual Cash Reports.

Figure 1.12: Other Resources in the State Highway Fund

The lines are identical for years 2002 to 2004. After 2003, the “real” other revenues category has been decreasing in value. As a result, the State Highway Fund had a deficit from fiscal years 2004 to 2006. To cover this deficit, beginning in 2004, the “other cash transfers between funds or accounts” category (primarily bonds) has steadily risen, as shown in Figure 1.13.



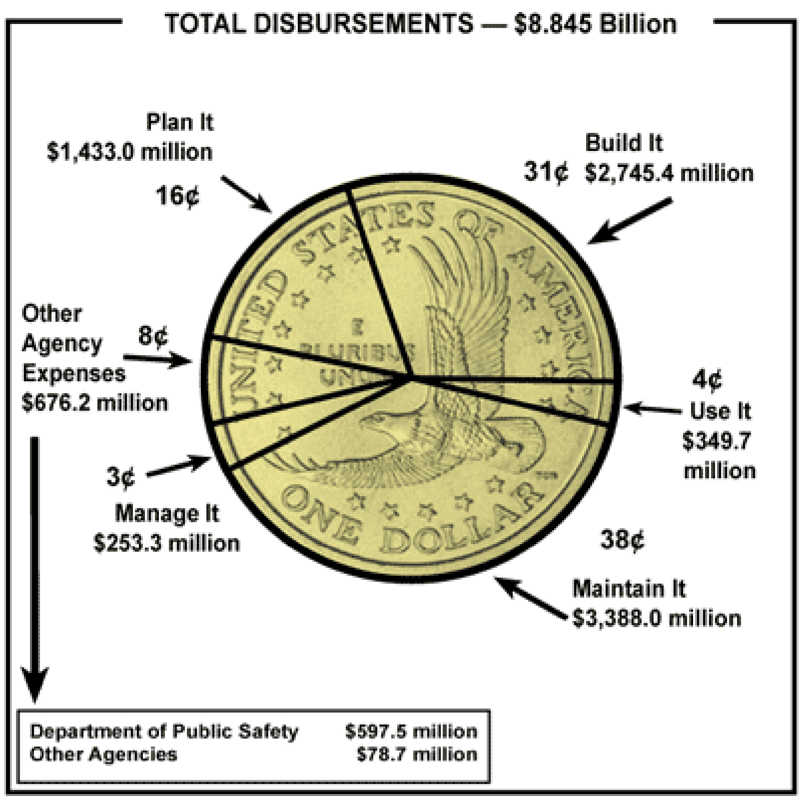


Source: Office of the Comptroller, Annual Cash Report

Figure 1.13: Cash Transfers to the State Highway Fund

1.8 Expenditures

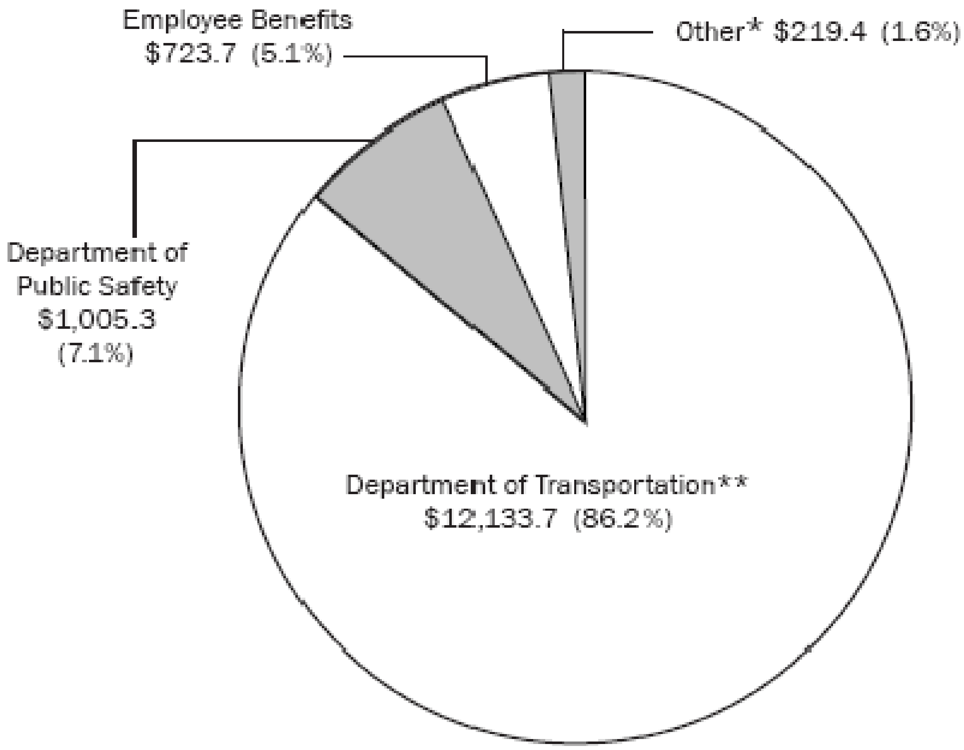
The graphic in Figure 1.14 shows the expenditures associated with the State Highway Fund for fiscal year 2007, as recorded by TxDOT. It shows that 8% of the State Highway Fund's revenues are diverted to other state agencies.



Source: TxDOT, 2007

Figure 1.14: State Highway Fund Main Expenditures, Fiscal Year 2007

The graphic in Figure 1.15 is a projection of State Highway Fund expenditures for the biennium 2008-2009, as estimated by the Texas Legislative Budget Board.



Source: Legislative Budget Board, 2008

Figure 1.15: Estimated Two-Year State Highway Fund Expenditures, 2008-2009

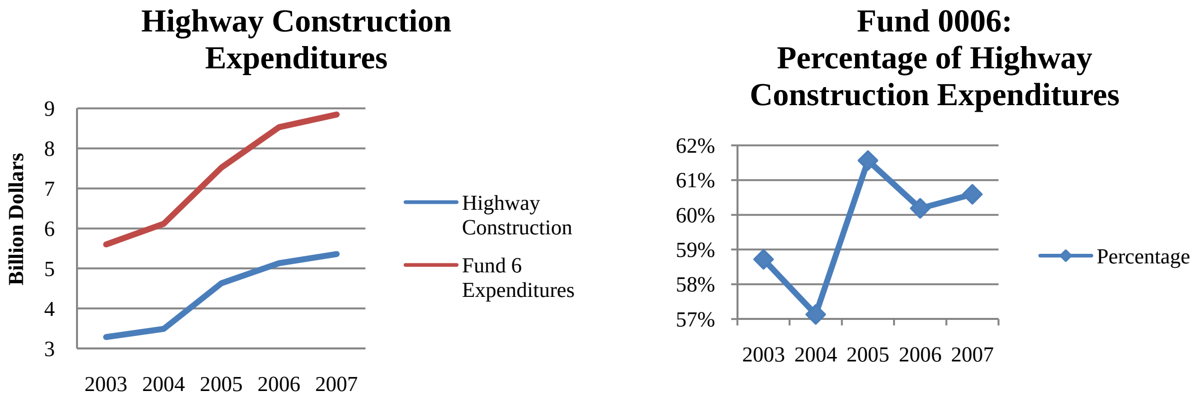
The Legislative Budget Board estimates that 86.2% of the fund's revenues would go to TxDOT. The category "Employee Benefits" will be discussed later. In addition, it is forecasted that about $1 billion will be directed to other agencies over the two-year period.

1.8.1 TxDOT

Funding is provided for planning, designing, researching, building, maintaining, and preserving the state transportation system, as well as maximizing the effectiveness and efficiency of transportation services, systems, programs, and resources. The State Highway Fund provides 100% of TxDOT's capital budget. Starting with fiscal year 2009, TxDOT will be appropriated funds to provide required health and human services to client transportation services through transfers to the Health and Human Services Commission.

1.8.2 Main Expenditure: Highway Construction

Highway construction is a major component of Fund 6 expenditures. Figure 1.16 represents TxDOT highway construction expenditures for fiscal years 2003 to 2007. The amount has increased from about $3 billion per year to about $5 billion, but as a percentage of Fund 6, it has remained steady in the 57-62% range.

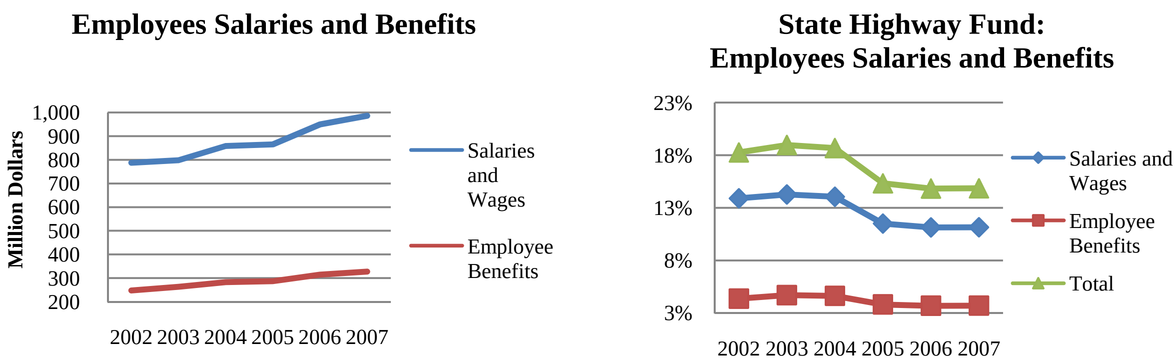


Source: Office of the Comptroller, Annual Cash Reports.

Figure 1.16: Highway Construction Expenditures

1.8.3 Employee Compensation (including TxDOT and DPS)

As is normal, over the years there has been a small increase in TxDOT's employee salaries and benefits. In addition, DPS employee salaries and benefits are paid from the State Highway Fund (see Legislative Diversions later). Figure 1.17 shows that even as the cost of salaries and benefits has increased slightly, their percentage draw on the State Highway Fund has decreased.

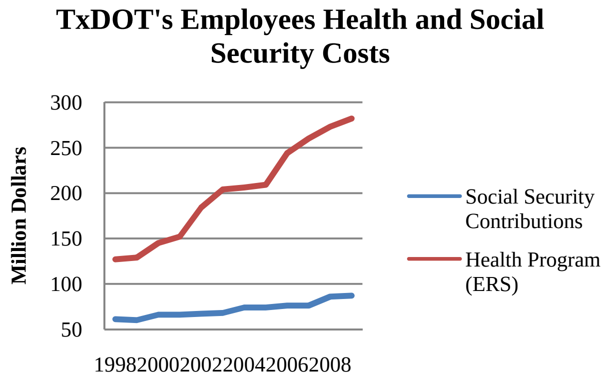


Source: Office of the Comptroller, Annual Cash Reports.

Figure 1.17: Funding from the State Highway Fund for Employee Salaries and Benefits

1.8.4 TxDOT's Employee Benefits

Employee benefits are a part of TxDOT expenditures. The Comptroller of Public Accounts pays for the benefit replacement pay, past salary adjustments, and social security for TxDOT employees. Figure 1.18 illustrates the costs related to health and social security benefits for TxDOT's personnel. Although the amounts have increased in the last decade, their proportional percentage related to the State Highway Fund's budget has remained steady in the range of 4 to 5% from fiscal years 2001 to 2007 (Combs, 2008).



Source: Bill No. 1, General Appropriations Act.

Figure 1.18: Health and Social Security Costs for TxDOT Employees

1.9 Expenditures: Legislative Diversions

The diversion of funds from the State Highway Fund for purposes unrelated to highways/transportation has been an on-going debate inside and outside the Capitol among transportation experts (Sugg, 2008). These diversions have drawn more interest as forecasts show the urgent need for new roads and growing maintenance costs.

In the last decade, a growing fraction of the State Highway Fund has been diverted to fund the following (Lavergne, 2008):

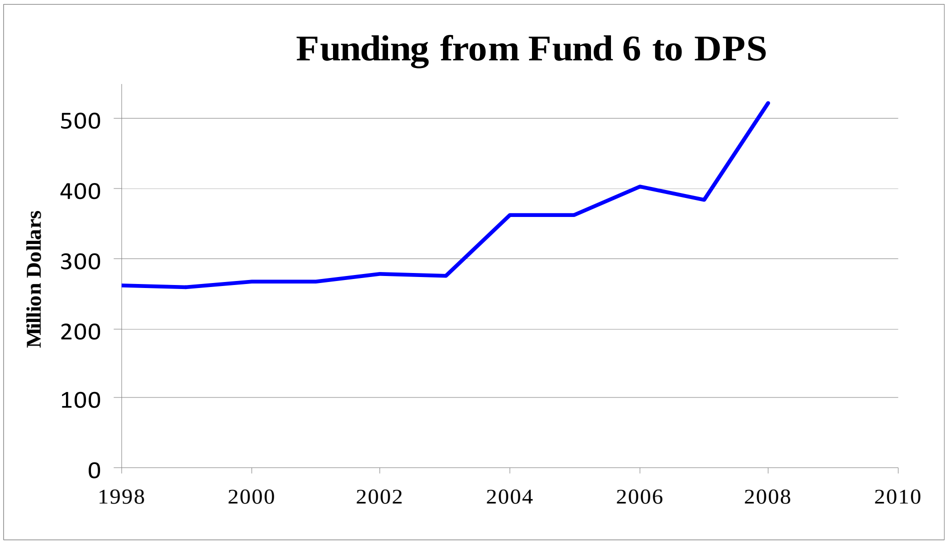
- the Department of Public Safety (including employees' salaries, benefits, insurance and retirement system),
- the Texas Education Agency (public school transportation),
- the Health and Human Services Commission (ambulance services),
- the Texas Transportation Institute,
- the Office of the Attorney General (transportation cases),
- the State Office of Administrative Hearings (for DPS' license verification program), and
- the Public Integrity Unit at the Travis County District Attorney's Office (motor vehicle tax fraud cases).

Most diversions started after fiscal year 2001. A list of all categories of diversions from 1998 to 2009 according to the Appropriations Bill is presented in Appendix 3.

1.9.1 Department of Public Safety

By far the largest diversion from the State Highway Fund has been to the Texas Department of Public Safety (DPS). DPS is the state police agency, charged with enforcing laws, preserving order, and protecting the rights, privileges, property, and well-being of Texas citizens. Funding for DPS derives from the Operators and Chauffeurs License Fund, the Motor Vehicle

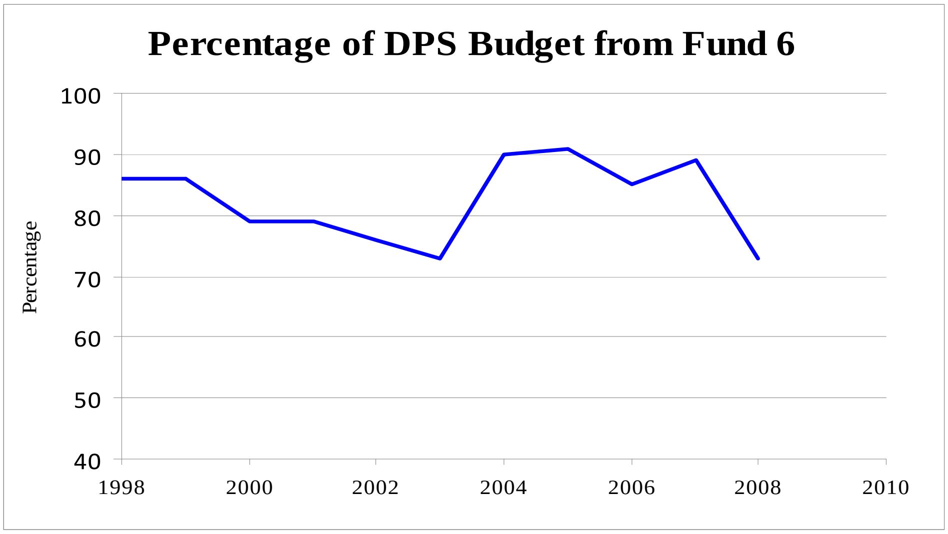
Inspection Fund, and the State Highway Fund. Figure 1.19 shows the amount of State Highway Fund money that has gone to DPS each year since 1998.



Source: Bill No. 1, General Appropriations Act.

Figure 1.19: DPS Funding from the State Highway Fund

Figure 1.20 shows the percentages of DPS' total budget coming from the State Highway Fund. Clearly the State Highway Fund is a major source of funding for DPS.



Source: Bill No. 1, General Appropriations Act.

Figure 1.20: Percentage of DPS Funding from the State Highway Fund

1.9.2 Texas Education Agency

Since 2004, the Legislature has been diverting $50 million per year for the Texas Education Agency (TEA). That figure represents less than 0.5% of the TEA's overall budget, and less than 1% of the State Highway Fund's budget.

1.9.3 Health and Human Services Commission

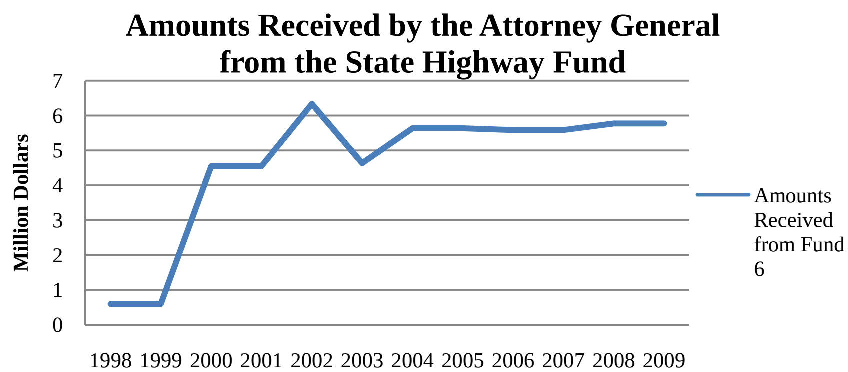
Since 2006, the Legislature has been diverting $10 million per year for the Texas Health and Human Services Commission (HHS). That figure represents less than 0.1% of the HHS's overall budget, and less than 1% of the State Highway Fund's budget.

1.9.4 Texas Transportation Institute

Starting fiscal year 2002, the Texas Transportation Institute (TTI) has been receiving money from the State Highway Fund, including about $4 million to support TTI's Transportation Safety Center and Transportation Study Center since 2004. The total of about $6 million from Fund 6 represents about 16% of TTI's budget.

1.9.5 Office of the Attorney General

The Attorney General (AG)'s purview includes transportation-related cases, such as right-of-way acquisitions. The amounts diverted from the State Highway Fund to the AG's office are shown in Figure 1.21. Even though in dollar terms the amount has increased more than 1000% in the last decade, as a fraction of the AG's budget those amounts have been small, ranging from 0.25% to a maximum of 1.7%.



Source: Bill No. 1, General Appropriations Act.

Figure 1.21: Attorney General Funding from the State Highway Fund

1.9.6 Judiciary Section

Diversions from the State Highway Fund to the Comptroller's Department of Motor Fuel Tax Frauds are appropriated to the Public Integrity Unit. Generally the amounts have been less than $1 million dollars. However, for this last biennium, the legislature appropriated almost $3.2 million to this entity (representing approximately 2% of its overall budget).

1.9.7 State Office of Administrative Hearings

From 1998 until 2003, the amounts appropriated by the Legislature to this entity were contingency sums. Starting fiscal year 2004 the actual amount was $3.7 million, growing to $4.1 million in fiscal year 2008.

1.9.8 December 2008: Proposals to End Legislative Diversions

In anticipation of the 2009 Legislative Session, Senator John Carona and House Representative David Leibowitz have introduced proposals to amend the Texas Constitution and the Texas Transportation Code in order to end legislative diversions from the State Highway Fund.

Related to the State Constitution, both propose for Article VIII, Section 7-a, a new subsection (a) that dedicates registration fees in their entirety for acquiring rights of way, constructing, maintaining, and policing state highways. However, both proposals still allow that counties retain a percentage of registration fees revenue.

A new subsection (b) of Section 7-a would deal with motor fuel and lubricant taxes. Both Carona (SJR No. 9) and Leibowitz (HJR No. 13) agree that 25% of the revenue should be allocated for the education fund. However, for the remaining 75% Rep. Leibowitz proposes that it should only be allocated for the construction of new highways, while Senator Carona proposes that the funds should be used for the construction *and maintenance* of public highways.

Senator Carona goes further and proposes a new Section 7-c enabling the Texas Comptroller of Public Accounts to automatically adjust the tax rate on motor fuels subject to legally established terms and conditions. Changes in the fuel tax rate would be based in whole or in part on one or more price or cost index published by the U.S. government.

Senator Carona has also proposed two amendments to the Texas Transportation Code. Firstly, by the same Senate Joint Resolution No. 9, he proposes a restriction on the power to issue general obligation bonds by adding a subsection to TRC, §222.004. This restriction limits the issuance to the maximum amount established by the Texas Constitution ($5 billion, Article III, Section 49-p) as well as the use of proceeds which may only be spent to finance other related funds (i.e., reserve funds) or to pay the expenses of the issuance. As well, the proposal includes an instruction for the comptroller to pay all principal, interests, and expenses related to the bonds or the payment of debt under credit agreements. This bill has a proposed effective date of September 2009.

Secondly, in Senate Bill No. 216, Corona proposes an amendment to Section 201.115(d) in order to allow the payment of debt with the State Highway Fund's money. Additionally, amending Section 222.001, this bill reestablishes the use of the State Highway Fund only to improve the highway system or to mitigate adverse environmental effects that result from highway construction or maintenance. It is important to note that the bill brings to an end all expenditures from the State Highway Fund to DPS. Furthermore, expenditures of the State Highway Fund used for any non-public highway related function performed by TxDOT would be prohibited, as the proposal eliminates Section 222.002 of the Transportation Code. This bill has a proposed effective date of September 2011.

Senator Carona's proposals aim to stop the funding of DPS and TxDOT's miscellaneous expenses (not related to highway maintenance and construction) with the State Highway Fund. In addition, Senator Carona proposes to reduce diversion of vehicle registration fund (by applying the 25% that goes to the education fund only to fuel and lubricant taxes). These developments require close monitoring because of their ramifications for TxDOT funding. Ultimately, it would be better to wait until the legislative session is over before making new projections of diversions from the State Highway Fund.

1.10 Chapter Conclusion

This chapter provided an overview of the Texas State Highway Fund's purposes, composition, and its most relevant revenues and expenditures categories. Approximately, 86% of the fund's revenue goes to TxDOT for planning, designing, research, construction, and maintenance of the state's roads. However, 7% of the monies are diverted by the Legislature solely to fund DPS' activities. Other smaller percentages are diverted to other purposes, as reported biannually in the Appropriations Bills.

Regarding the State Highway Fund's revenues and expenditures, the following observations may be drawn:

- Although the principal revenue amounts (fuel taxes, registrations) have been increasing for the last 5 years, they are struggling to keep up with demands. The issuance of bonds and commercial paper in addition to the significant increase of category 3972 ("other cash transfers between funds or accounts") has been maintaining the State Highway Fund's expenditures from fiscal years 2005 to 2007. These cash transfers come from the Texas Mobility Fund (TxDOT, 2008).

- Notwithstanding the bonds and commercial paper issuances during fiscal year 2006 (bonds: approximately 628 million dollars; commercial paper 300 million) the balance of the State Highway Fund suffered a deficit during fiscal years 2005 (almost 500 million dollars) and 2006 (more than 300 million dollars). During fiscal year 2007, State Highway Fund's balance was maintained in positive numbers mainly because of the aforementioned cash transfers.

- Diversions related to the State Highway Fund have several causes.
    - "Federal Diversions" happen *before* the revenues reach the fund. Texas has one of the worst rates of return of transportation dollars from the federal government, only receiving 86 cents for each dollar charged on federal fuel taxes (Utt, 2008). Additionally, rescissions have affected the reliability of federal funds.
    - Diversions of State Fuel Taxes happen *before* the revenues reach the fund. These include the constitutionally allocated 25% to education, and in the case of gasoline taxes an additional percentage is allocated to county roads.
    - Diversions of Vehicle Registration fees happen *before* the revenues reach the fund. Counties retain registration monies, although it has been stipulated that these retained amounts may decrease by 2015.
    - Additional diversions from the State Highway Fund happen *after* the revenues reach the fund. By far, this category of diversions is the most controversial of all. The legislature has been appropriating money from the State Highway Fund for non-highway purposes to several Texas agencies.

Chapter 2. Evaluation of the JACK Model

2.1 Scope

2.1.1 Workplan Task 3: Assess the accuracy and validity of the JACK model

A. Using actual data from past years as JACK model inputs, compare historic(al) levels of revenue with revenue projections produced by the JACK model.

B. Using actual data from past years as JACK model inputs, compare historic(al) levels of expenditures with expenditure projections produced by the JACK model.

2.2 JACK model processes

The JACK model includes two major calculation processes: one for revenue forecasting and the other for expenditure projection. The total available revenue is estimated by considering vehicle registration fees, state motor fuel taxes, returns on federal motor fuel taxes, mobility funds and proposition bonds, other agency revenues, and other federal reimbursements. The total expenditure is projected based on construction expenditures (lettings, including bridges), maintenance and overhead expenses, bond payback amounts, and mobility fund restoration.

Figures 2.1–2.4 illustrate the inputs and calculation processes of the JACK model. The first figure gives a general overview of the revenue and expenditure estimation models, and the next three figures provide details of the respective processes.

No significant errors were noted in the general flow of the calculations, but there are a few unconnected or unclear modules. For example, the Minimum Consultant Budget estimate is not connected to any other calculation. The constant $160 million associated with ROW expenditures is not clear. Otherwise the entire process appears logical and defensible.

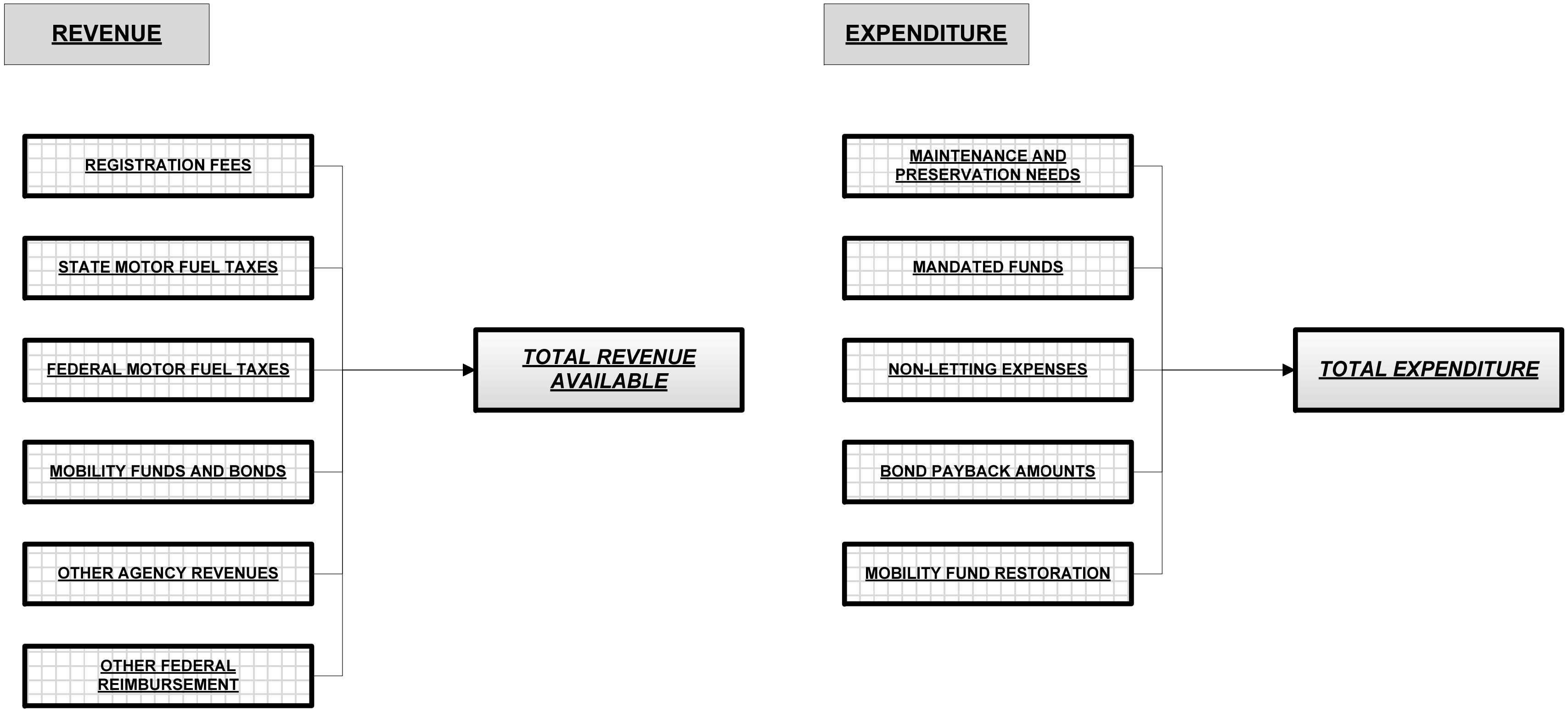


Figure 2.1: General Overview of Revenue and Expenditure Estimation in JACK (Source: from CTR Analysis of JACK)

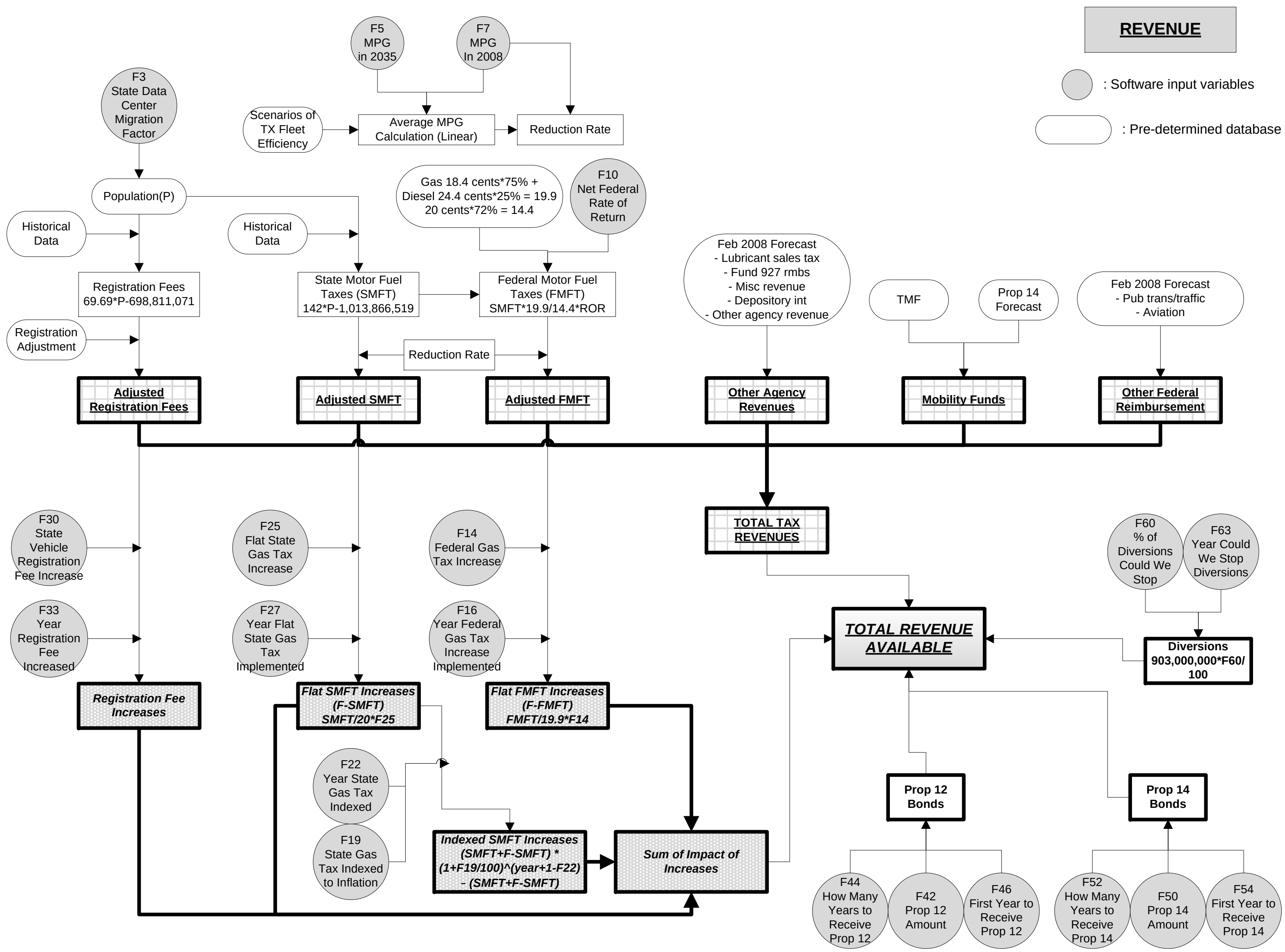


Figure 2.2: Detailed Revenue Estimation Process in JACK (Source: from CTR Analysis of JACK)

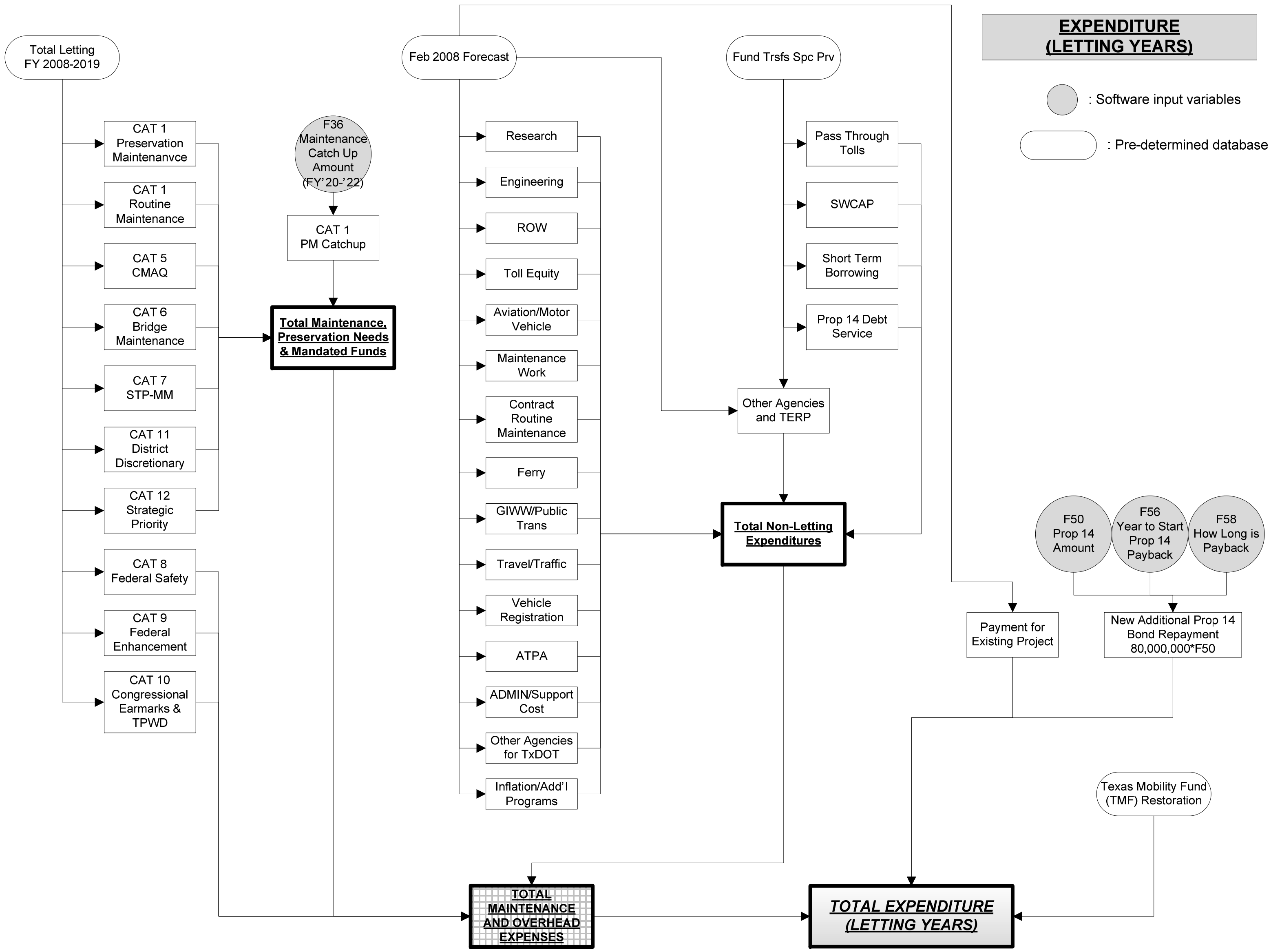


Figure 2.3: Detailed Letting Expenditure Estimation Process in JACK (Source: from CTR Analysis of JACK)

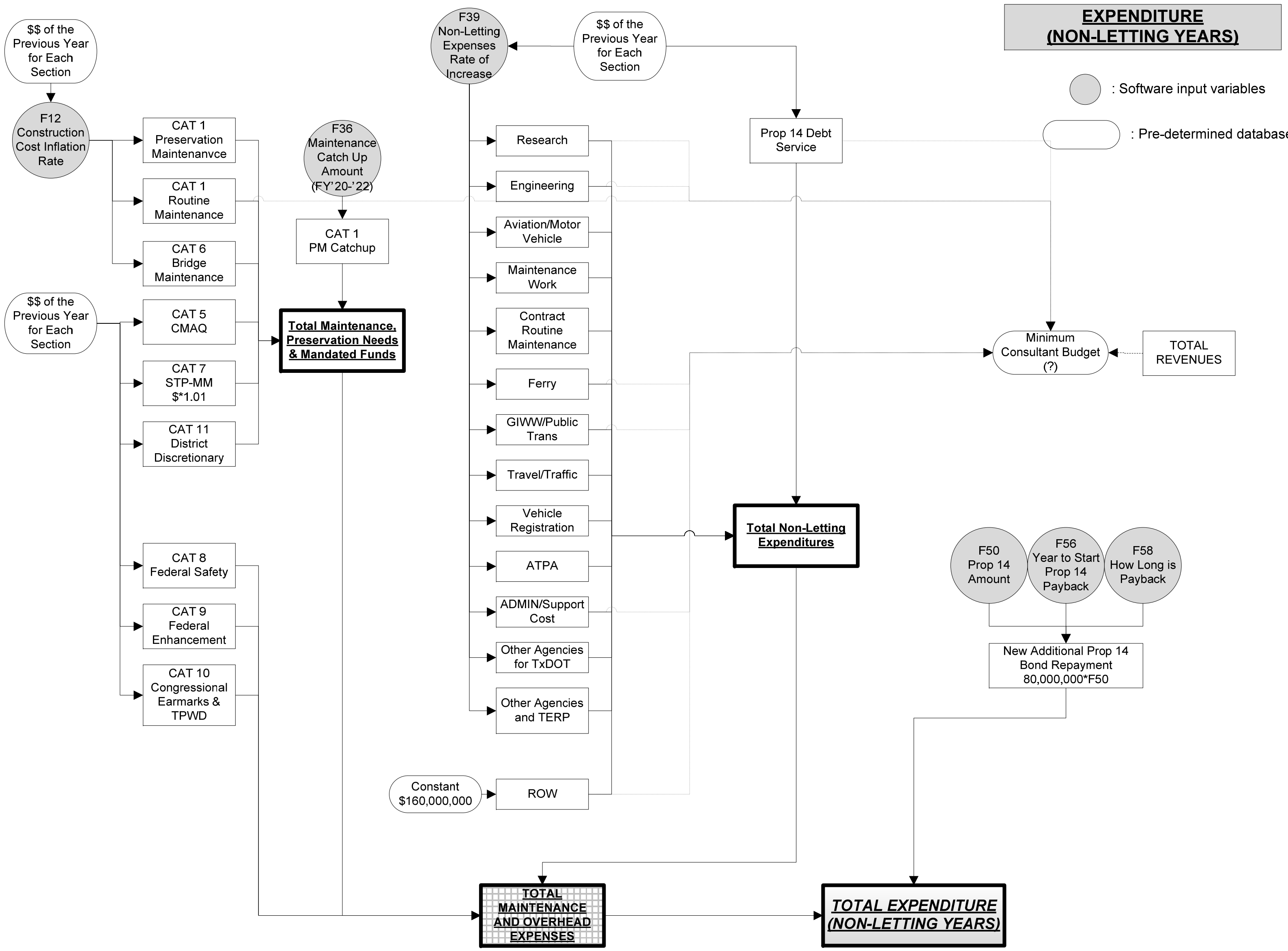


Figure 2.4: Detailed Non-Letting Expenditure Estimation Process in JACK (Source: from CTR Analysis of JACK)

2.3 Evaluation of Inputs and Model Assumptions

To evaluate the JACK model performance, the researchers first examined the data inputs and model assumptions. For this analysis, data was collected on the historical annual Highway Fund revenues and expenditures, and the actual values of model inputs from 1982 to 2007. It is recognized that the model equations are based on data from 1993-2007, but because the model makes projections to 2035 (approximately 25 years), the researchers decided to collect data going back about the same duration, to 1982. The objective of this portion of the analysis was to test how the data has behaved historically, and to evaluate the assumptions in the model.

2.3.1 Population

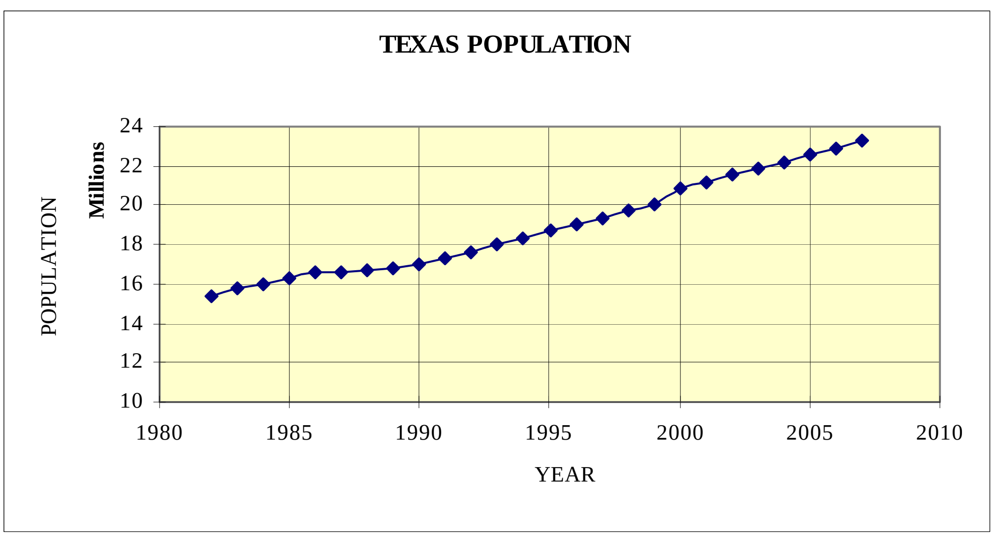
- Data source:
  JACK model (the spreadsheet contains Texas population figures going back to 1982).

The population in Texas has consistently grown since 1982, at a rate of about 1.68% per year compounded. The growth rate since 1993 has been fairly linear, at about 350,000 persons per year except for a one-time jump of 800,000 in 2000. See Table 2.1 and Figure 2.5.

Table 2.1: Population Growth in Texas from 1982-2007

	1982	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**
Population	15,331,415	15,751,676	16,007,086	16,272,734	16,561,113	16,621,791	16,667,022
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Population	16,806,735	16,986,335	17,339,904	17,650,479	17,996,764	18,338,319	18,679,706
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Population	19,006,240	19,355,427	19,712,389	20,044,141	20,851,820	21,183,522	21,519,983
	2003	**2004**	**2005**	**2006**	**2007**		
Population	21,860,876	22,206,348	22,556,054	22,907,237	23,259,917		

Source: JACK Model



Source: JACK Model (from U.S. Census and Texas State Data Center projections)

Figure 2.5: Population Growth in Texas from 1982-2007

2.3.2 Texas vehicle registrations

- Data source:
  U.S. Department of Transportation Federal Highway Administration: Highway Statistics 1982-2007 (**Note:** data from TxDOT's Vehicle Title and Registration Division VTR was not available in time for this analysis.) Data for FY 2007 is a linear projection of 1982-2006 historical data.

The number of vehicles registered in Texas has seen a steady increase over the years (see Table 2.2 and Figure 2.6), with a higher rate of increase since 1997. It must be noted that classifications changed in 1996 and 1997, when some passenger cars were reclassified as vans and SUVs. Amazingly, in the period when the number of light vehicles almost doubled, the number of trucks registered in Texas has remained the same. This number belies the evidence on Texas roads, suggesting that trucks operating in Texas may be registering elsewhere (see Chapter 6 for registration data in other states).

Figure 2.7 shows that the vehicle fleet mix in Texas is changing. Since 1982, the number of passenger cars as a percentage of the fleet has decreased from about 70% to about 50%, but the number of light trucks, vans, and SUVs has increased (from about 25% to 46%). These trends might suggest that the number of less fuel-efficient large passenger vehicles will continue to increase, but recent gas price increases could have the opposite effect, encouraging more alternative-fuel (and fewer gas-tax-paying) vehicles.

Table 2.2: Texas Vehicle Registrations Over Time

	1982	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**
Passenger Car	7,992,738	8,159,008	8,417,227	8,662,591	8,449,972	8,398,231	8,455,744
Van/Pickup Truck/SUV	2,862,415	2,991,825	3,215,261	3,337,245	3,364,285	3,375,523	3,425,580
Truck	494,131	490,800	487,383	490,635	486,991	465,583	474,814
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Passenger Car	8,551,270	8,714,154	8,666,111	8,686,680	8,880,679	8,698,528	8,604,958
Van/Pickup Truck/SUV	3,539,528	3,604,460	3,548,472	3,585,996	3,781,151	4,248,884	4,378,377
Truck	403,346	419,915	418,215	429,020	390,821	609,985	626,624
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Passenger Car	7,579,106	7,085,404	7,455,714	7,738,292	7,616,183	7,724,309	7,808,911
Van/Pickup Truck/SUV	5,391,568	5,089,782	5,305,781	5,739,823	5,849,780	6,088,657	6,291,279
Truck	440,025	670,203	482,581	508,016	518,736	466,260	482,139
	2003	**2004**	**2005**	**2006**	**2007**		
Passenger Car	7,841,637	8,735,544	8,911,818	8,805,921	9,094,609		
Van/Pickup Truck/SUV	6,469,613	7,559,481	7,927,291	8,098,921	8,772,879		
Truck	493,270	524,936	540,881	543,978	499,638		

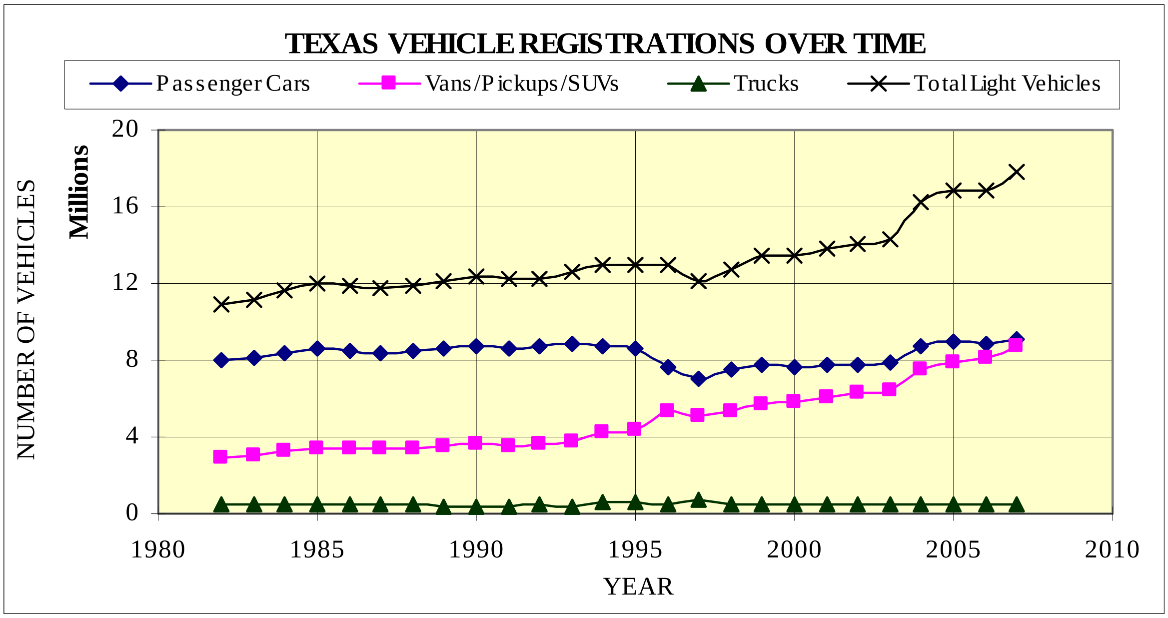


Figure 2.6: Texas Vehicle Registrations Over Time

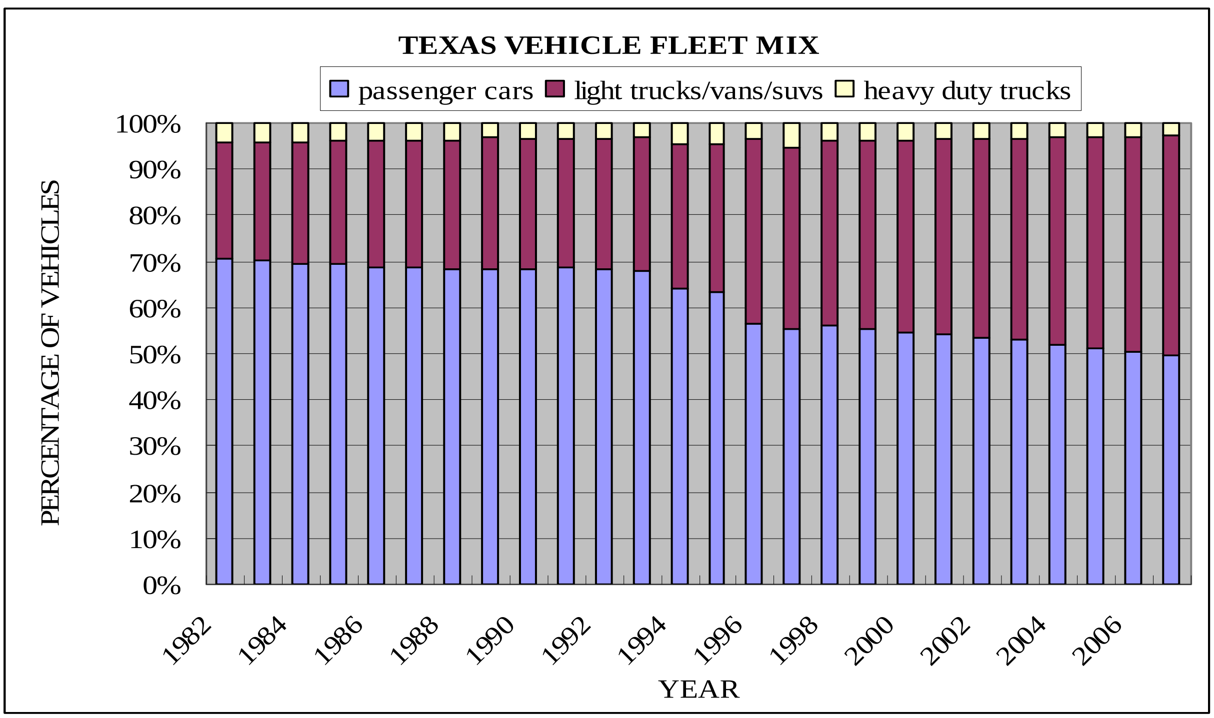


Figure 2.7: Texas Vehicle Registrations Over Time By Vehicle Types

2.3.3 Vehicle fuel efficiency in miles per gallon (MPG)

- Data source:
  U.S. Department of Energy, Energy Information Administration, Annual Energy Review 2007. The fuel efficiency is calculated from motor vehicle mileage (miles per

vehicle) and fuel consumption (gallons per vehicle). Data for FY 2007 is a linear projection of 1982-2006 historical data.

Note: Federal fuel efficiency numbers were used, because Texas numbers were not available in time for this analysis.

Keeping pace with technology developments, vehicle fuel efficiency has improved since 1982, as shown in Table 2.3 and Figure 2.8. The best improvements were seen in the period 1987–1991. Since 1991, fuel efficiency for passenger cars has continued to improve, but slowly. Rates for vans, pickup trucks, and SUVs were flat from 1991 through 2002, fell in 2003 and 2004, and recovered in 2005. Fuel efficiency for heavy trucks is lower than for other vehicle types and has remained fairly flat, although recently truck operators have been adapting various strategies to improve fuel efficiency in response to higher fuel prices.

Table 2.3: Fuel Efficiency By Vehicle Class Over Time

Fuel efficiency (MPG)	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**
Passenger Car	16.9	17.1	17.4	17.5	17.4	18.0	18.8
Van/Pickup Truck/SUV	13.5	13.7	14.0	14.3	14.6	14.9	15.4
Truck	5.5	5.6	5.7	5.8	5.8	5.9	6.0
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Passenger Car	19.1	20.2	21.1	21.0	20.5	20.7	21.1
Van/Pickup Truck/SUV	16.1	16.1	17.0	17.3	17.4	17.3	17.3
Truck	6.1	6.0	6.0	6.0	6.1	6.1	6.1
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Passenger Car	21.2	21.5	21.6	21.4	21.9	22.2	22.0
Van/Pickup Truck/SUV	17.2	17.2	17.2	17.1	17.4	17.6	17.5
Truck	6.2	6.4	6.1	6.0	5.8	5.9	5.8
	2003	**2004**	**2005**	**2006**	**2007**		
Passenger Car	22.2	22.5	22.1	22.4	23.4		
Van/Pickup Truck/SUV	16.2	16.2	17.7	18.0	18.3		
Truck	6.7	6.7	6.0	5.9	6.3		

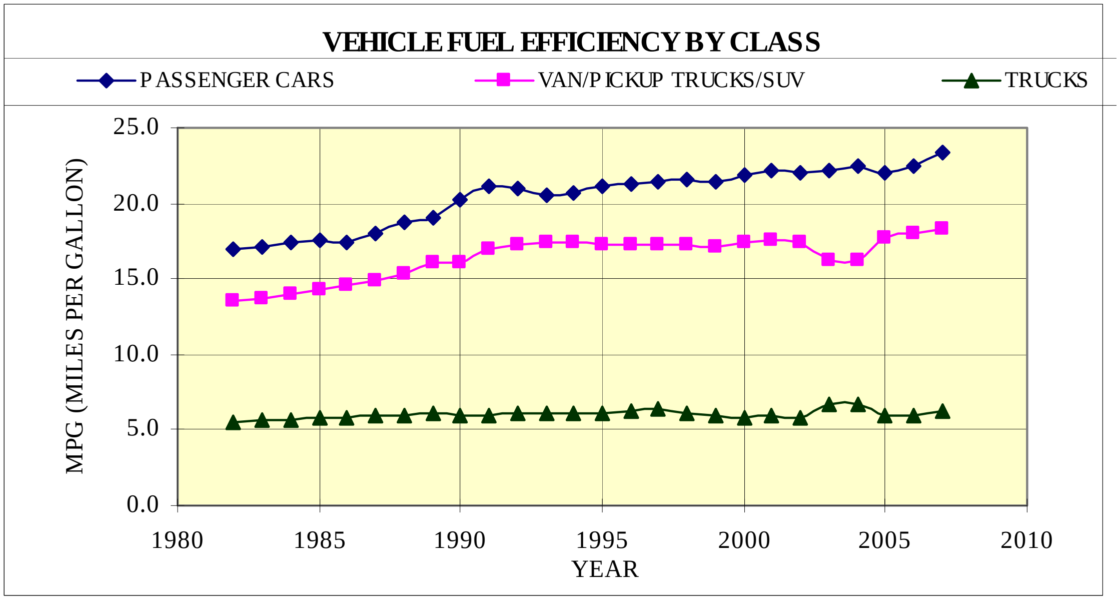


Figure 2.8: Fuel Efficiency By Vehicle Class Over Time

2.3.4 Texas average MPG weighted by the number of registered vehicles in Texas

- Data source:
  The average MPG was calculated by weighting the MPG data of each vehicle category with the number of registered vehicles in each category in Texas.

  For instance, in 1982, the average MPG = 16.9 × 70.43% (passenger cars) + 13.5 × 25.22% (van/pickup truck/SUV) + 5.5 ×4.35% (truck) = 15.55 MPG.

From 1982 to 1991, the composite fleet fuel efficiency improved significantly, from 15.55 mpg to 19.44 mpg, as shown in Table 2.4 and Figure 2.9. Then in the period 1992 to 2003 the figure stagnated. However, since then there has been a steady gain of about 1.8% per year. Increasing fleet fuel efficiency will reduce future gas tax collections.

Table 2.4: Composite Texas Fleet Fuel Efficiency Over Time

	1982	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**
MPG	15.55	15.72	16.06	16.19	16.20	16.72	17.35
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
MPG	17.81	18.58	19.44	19.44	19.17	18.99	19.22
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
MPG	19.13	19.01	19.28	19.07	19.44	19.69	19.51
	2003	**2004**	**2005**	**2006**	**2007**		
MPG	19.04	19.19	19.57	19.84	20.48		

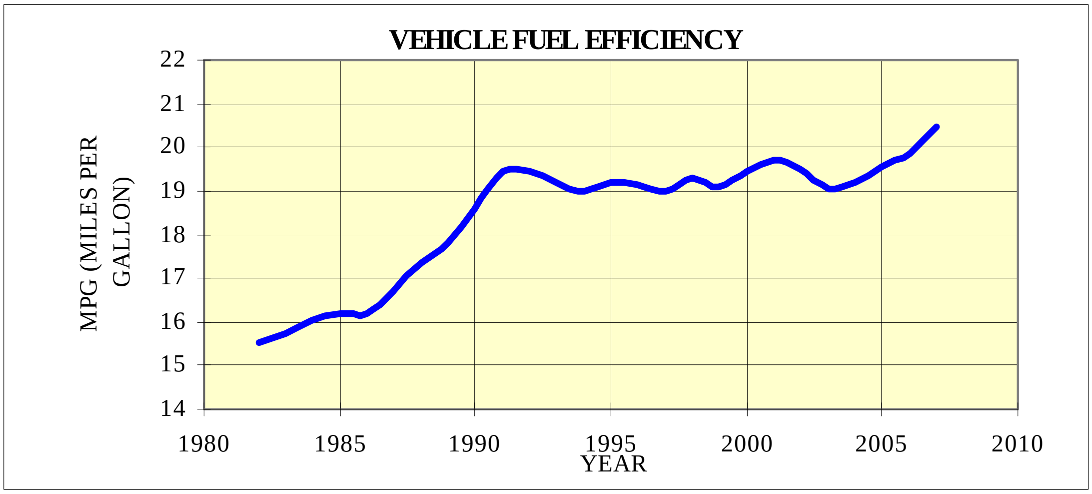


Figure 2.9: Composite Texas Fleet Fuel Efficiency Over Time

2.3.5 Registration revenue

- Data source:
  Texas Department of Transportation: Actual cash revenue and expenditure 1982-2008.

Registration revenues in Texas have shown an increase over time consistent with increasing number of registered vehicles (Table 2.5). Registration fee increases in 1984 created a jump in revenues in the period 1985-1987, then revenues flattened in the period 1988-1991 (Figure 2.10). There has been an almost straight-line increase since then, with drops in 1992 and 2002. There were economic slowdowns in those two years.

Figure 2.11 shows registration revenue in relation to Texas population. The trend is the same as shown in Figure 2.10. The JACK model estimates registration revenue as a function of state population. The graph suggests that the relationship is somewhat linear. This relationship will be examined later in the Model Performance section.

Table 2.5: Texas Registration Revenue Over Time

Registration	1982	1983	1984	1985	1986
Revenue ($)	282,337,100	276,243,700	298,369,770	473,489,662	557,293,358
	1987	1988	1989	1990	1991
Revenue ($)	621,476,830	623,653,752	625,085,410	632,482,665	642,353,235
	1992	1993	1994	1995	1996
Revenue ($)	578,738,077	586,068,536	604,195,927	602,369,620	621,586,174
	1997	1998	1999	2000	2001
Revenue ($)	637,673,921	675,657,385	705,111,741	744,564,667	751,970,852
	2002	2003	2004	2005	2006
Revenue ($)	730,019,458	789,133,763	845,783,923	875,128,731	932,713,282
	2007				
Revenue ($)	984,246,908				

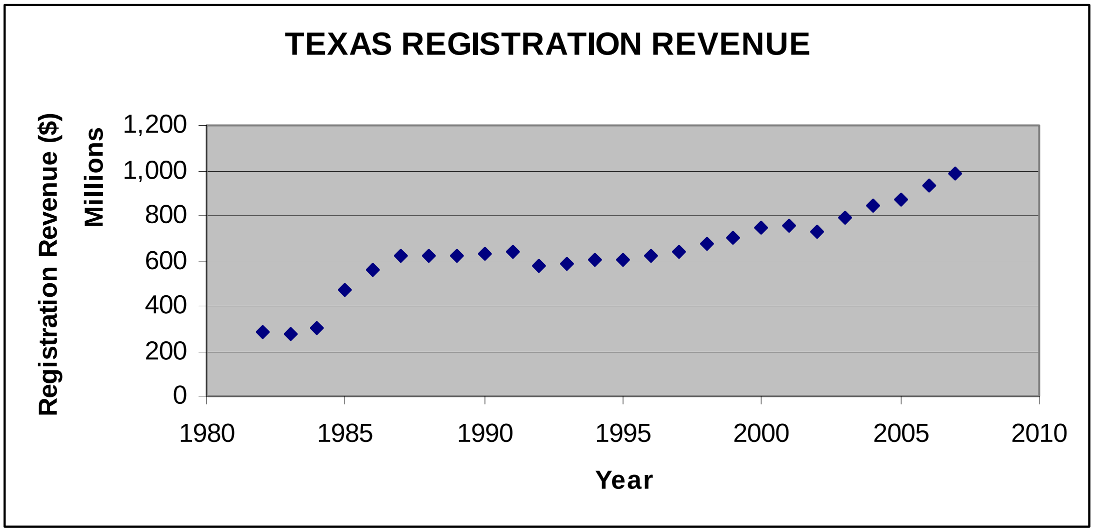


Figure 2.10: Texas Registration Revenue Over Time

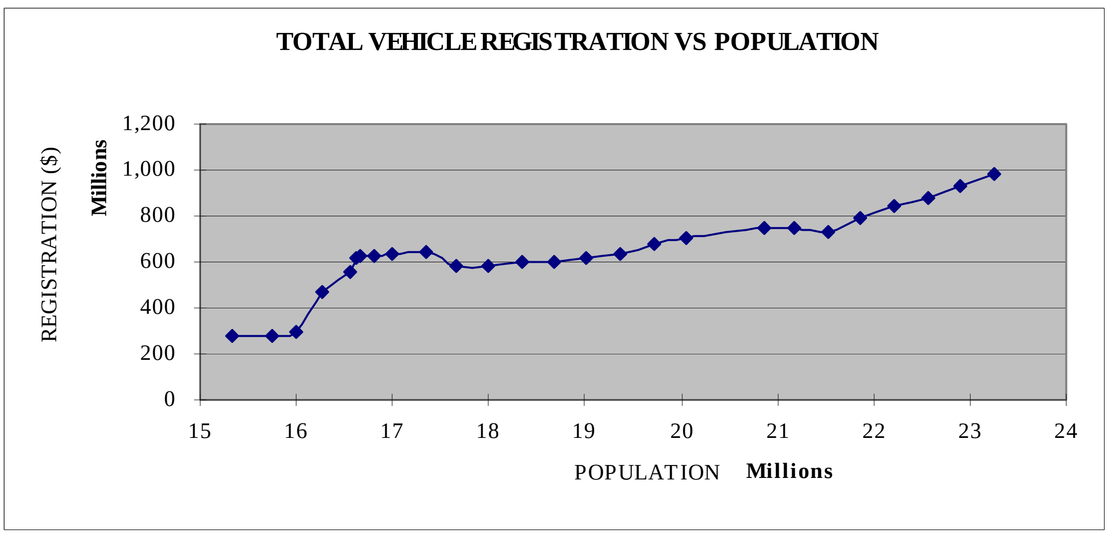


Figure 2.11: Texas Registration Revenue vs Population

2.3.6 State motor fuel tax rates in Texas (gasoline/diesel)

- Data sources:
  Texas Department of Transportation, and U.S. Department of Transportation, Federal Highway Administration, Highway Statistics

The gasoline tax rate and the diesel tax rate in Texas were different until 1984 when they were equalized (Table 2.6). Since 1992 both rates have been fixed at 20 cents per gallon. Figure 2.12 shows the trends. There has not been a state fuel tax increase since 1992.

Table 2.6: State Motor Fuel Tax Rates

Gasoline/Diesel	1982	1983	1984	1985	1986	1987	1988
Tax rate ($/gal)	0.05/0.065	0.05/0.065	0.05/0.065	0.10/0.10	0.10/0.10	0.15/0.15	0.15/0.15
	1989	1990	1991	1992	1993	1994	1995
Tax rate ($/gal)	0.15/0.15	0.15/0.15	0.15/0.15	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20
	1996	1997	1998	1999	2000	2001	2002
Tax rate ($/gal)	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20
	2003	2004	2005	2006	2007		
Tax rate ($/gal)	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20		

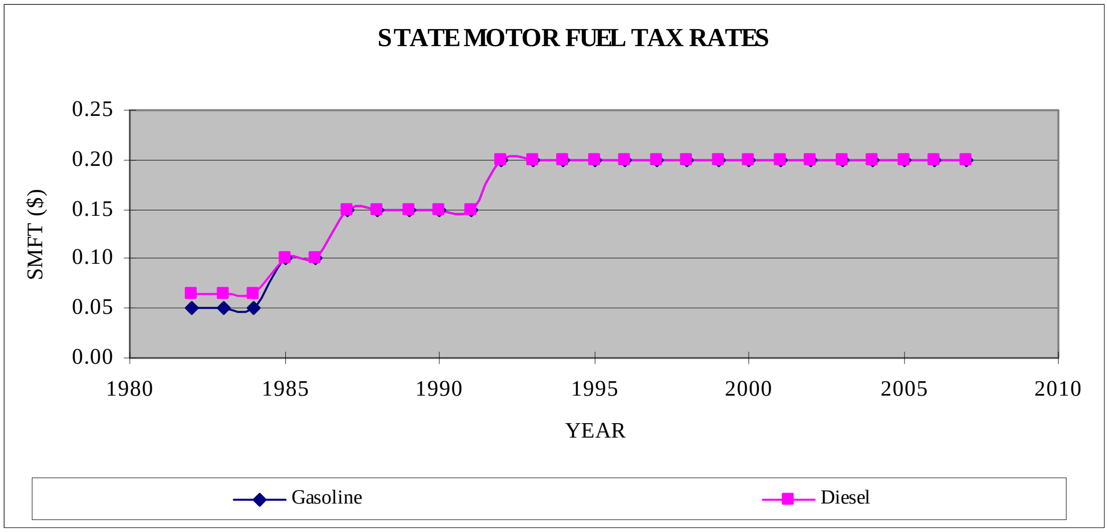


Figure 2.12: State Motor Fuel Tax Rates

2.3.7 State motor fuel taxes (SMFT) revenue

- Data source:
  Texas Department of Transportation: Actual cash revenue and expenditure 1982-2008

State Motor Fuel Tax (SMFT) revenue has increased along with the state motor fuel tax rate increases of 1985, 1997, and 1992 (Table 2.7). The stair stepping trend of the SMFT revenue from 1982 to 1992 (as seen in Figure 2.13) mimics the trend of the state fuel tax rates shown in the previous figure. The big drop in 1999 and the big jump in 2000 seem to be caused by a transfer of some of the 1999 revenue to the next year, 2000. These two data points appear to balance out each other. After 1992, the SMFT revenue amount has continued to increase, but at an apparently declining rate.

Table 2.7: State Motor Fuel Tax Revenue Over Time

	1982	1983	1984	1985	1986
SMFT ($)	360,553,800	359,968,100	379,725,787	736,314,192	751,200,765
	1987	**1988**	**1989**	**1990**	**1991**
SMFT ($)	935,230,424	1,079,061,004	1,099,176,979	1,108,340,383	1,105,310,246
	1992	**1993**	**1994**	**1995**	**1996**
SMFT ($)	1,278,151,983	1,506,893,260	1,587,715,216	1,631,624,420	1,693,053,064
	1997	**1998**	**1999**	**2000**	**2001**
SMFT ($)	1,737,012,675	1,837,490,735	1,556,149,219	2,229,946,013	2,021,827,183
	2002	**2003**	**2004**	**2005**	**2006**
SMFT ($)	2,078,114,281	2,087,006,313	2,130,041,610	2,148,324,685	2,194,180,196
	2007				
SMFT ($)	2,238,201,981				

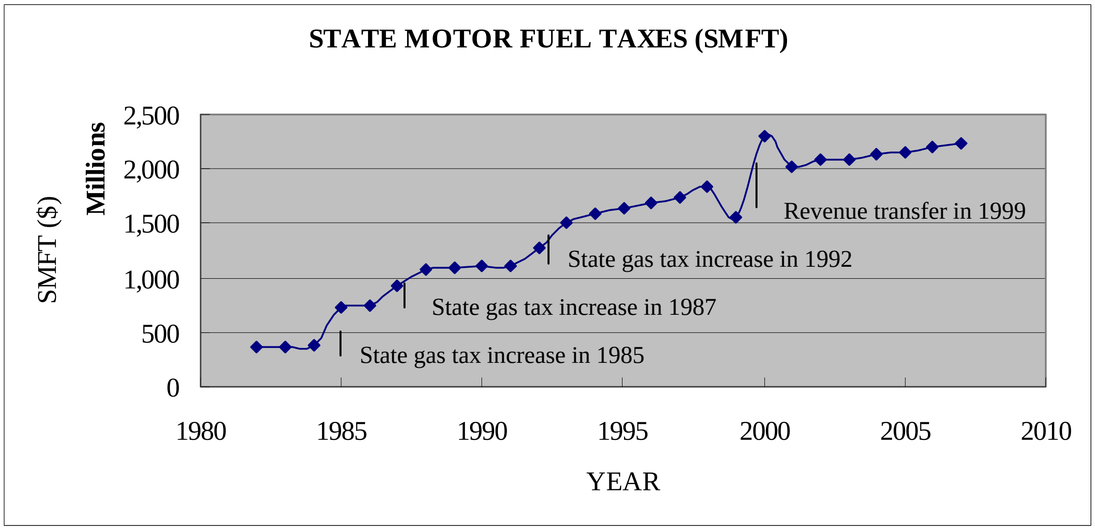


Figure 2.13: State Motor Fuel Tax Revenue Over Time

The JACK model assumes a straight-line relationship between SMFT and state population. Figure 2.14 shows the SMFT revenue trend since 1982 compared to state population. Obviously, during the period 1984-1992 the tax increases influenced the changes in revenue. During the non-tax-increase period since 1993 revenue has increased along with population. The relationship between SMFT and population will be examined in the section on JACK Model Performance.

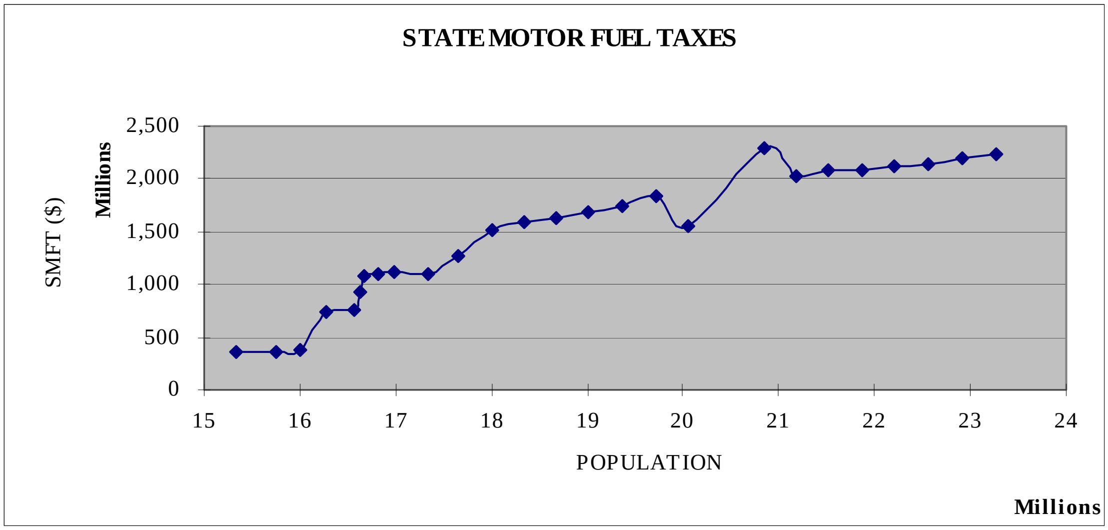


Figure 2.14: State Motor Fuel Tax Revenue vs. Population

2.3.8 Federal motor fuel taxes in Texas (Gasoline/Diesel)

- Data source:
  U.S. Department of Transportation, Federal Highway Administration, Highway Statistics

The federal gasoline tax rate and the diesel tax rate were equal up to 1984. Since then, diesel has been taxed at 6 cents per gallon more than gasoline, as shown in Table 2.8. Both rates were increased in 1990 and 1993, but have remained flat since then (Figure 2.15).

Table 2.8: Federal Motor Fuel Tax Rates

Gasoline/diesel	1982	1983	1984	1985	1986	1987	1988
Tax rate ($/gal)	0.04/0.04	0.04/0.04	0.09/0.09	0.09/0.15	0.09/0.15	0.091/0.151	0.091/0.151
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Tax rate ($/gal)	0.091/0.151	0.091/0.151	0.141/0.201	0.141/0.201	0.141/0.201	0.184/0.244	0.184/0.244
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Tax rate ($/gal)	0.183/0.243	0.183/0.243	0.184/0.244	0.184/0.244	0.184/0.244	0.184/0.244	0.184/0.244
	2003	**2004**	**2005**	**2006**	**2007**		
Tax rate ($/gal)	0.184/0.244	0.184/0.244	0.184/0.244	0.184/0.244	0.184/0.244		

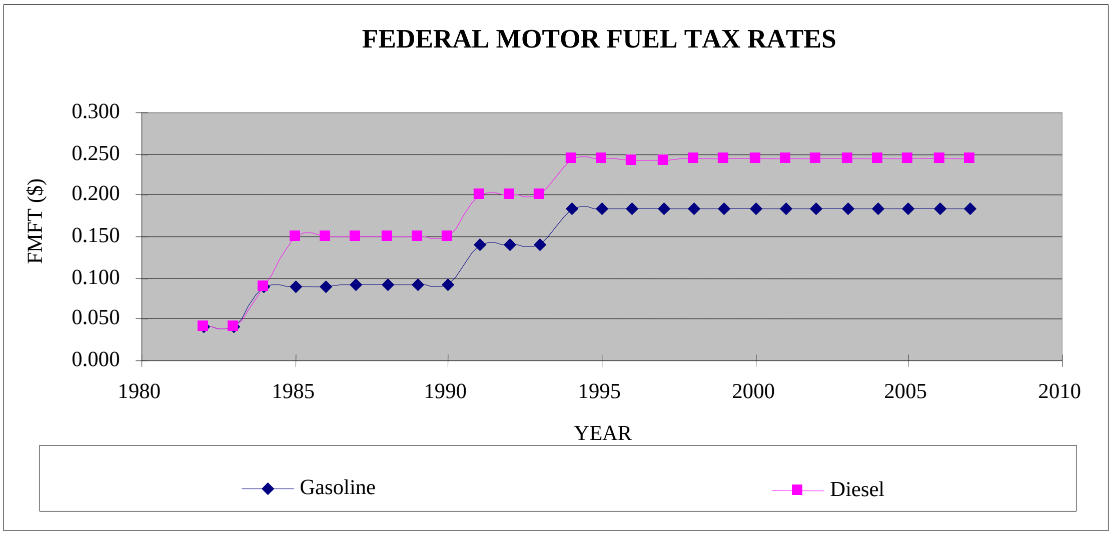


Figure 2.15: Federal Motor Fuel Tax Rates

2.3.9 Federal motor fuel tax (FMFT) revenue

- Data source:
  Texas Department of Transportation: Actual cash revenue and expenditure 1982-2008

  Note: The JACK model calculates the amount of the federal motor fuel taxes returned to Texas as *"FMFT = actual total tax revenue - actual adjusted registration - actual state motor fuel taxes - actual other agency revenues - actual mobility funds - actual other federal reimbursement."*

The amount of money Texas received from FMFT increased more or less evenly over the period 1982-1998, then saw a sharp increase in the period 1998-2004, due to the federal SAFETEA-LU legislation provisions to spend down the Federal Highway Trust Fund. However, because of federal budget difficulties in 2004, the FMFT dropped from almost $2.7 billion in 2004 to about $1.2 billion in 2006, back in line with the historical trends of 1982-1998, as shown in Table 2.9 and Figure 2.16.

Table 2.9: Texas Federal Motor Fuel Tax Revenue Over Time

	1982	**1983**	**1984**	**1985**	**1986**
FMFT ($)	390,056,100	450,076,800	552,616,624	637,711,256	908,199,350
	1987	**1988**	**1989**	**1990**	**1991**
FMFT ($)	836,576,233	899,656,700	934,352,977	1,010,029,246	981,530,107
	1992	**1993**	**1994**	**1995**	**1996**
FMFT ($)	879,226,220	978,752,061	1,074,158,611	987,422,651	1,191,997,660
	1997	**1998**	**1999**	**2000**	**2001**
FMFT ($)	1,074,929,809	1,034,648,615	1,432,084,697	1,779,776,255	1,735,293,616
	2002	**2003**	**2004**	**2005**	**2006**
FMFT ($)	2,220,667,371	2,513,794,247	2,679,368,594	2,058,214,748	1,240,517,271
	2007				
FMFT ($)	1,509,570,720				

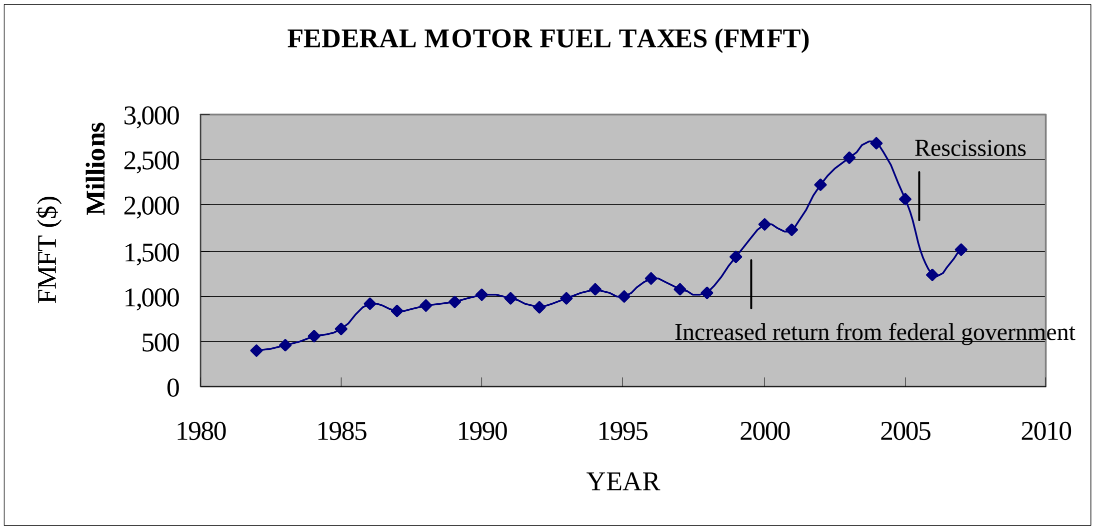


Figure 2.16: Texas Federal Motor Fuel Tax Revenue Over Time

The JACK model estimates future FMFT based on a straight-line relationship between FMFT and SMFT. However, Figure 2.17 shows that the correlation between the historical values of those two variables is weak, and has worsened in recent years. Thus, alternative methods for FMFT revenue estimation need to be investigated.

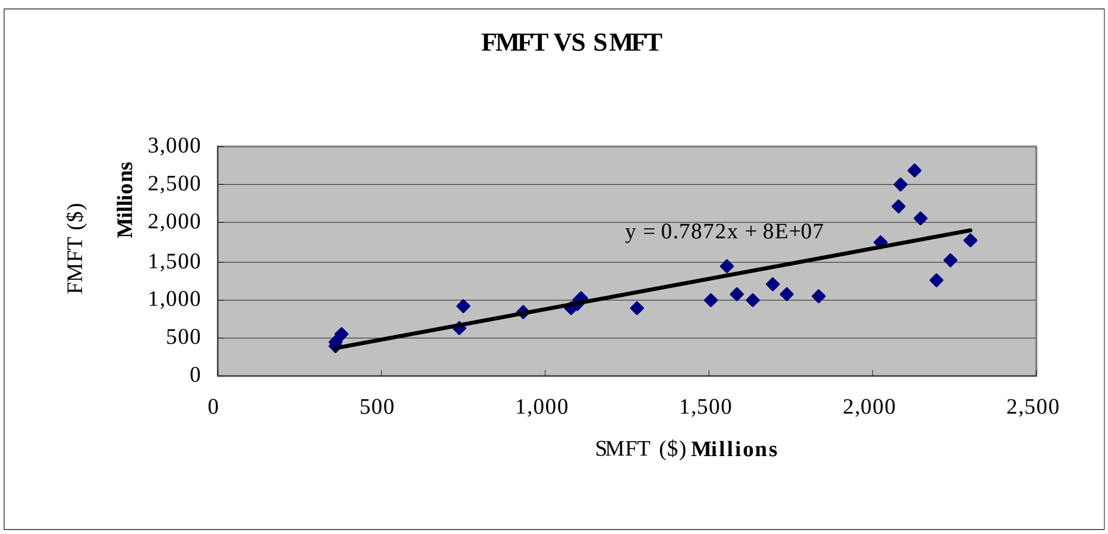


Figure 2.17: Federal Motor Fuel Tax Revenue vs. State Motor Fuel Tax Revenue

2.3.10 Total revenue

- Data source:
  Texas Department of Transportation: Actual cash revenue and expenditure 1982-2008

The total revenue of the State Highway Fund has consistently grown over the years (Table 2.10 and Figure 2.18). The trend appears to be fairly linear from 1982–1999, but since then it has been erratic. Figure 2.19 shows total revenue in relation to state population, and the two variables appear to be well correlated, again with more erratic behavior recently. The relationship between Total Revenue and population will be explored later in the Model Performance section.

Table 2.10: Total Revenue over Time

	1982	1983	1984	1985	1986
Revenue ($)	1,432,857,209	1,432,823,000	1,606,456,967	2,235,884,704	2,596,901,931
	1987	**1988**	**1989**	**1990**	**1991**
Revenue ($)	2,611,292,287	2,849,079,170	2,978,338,062	2,918,055,620	2,871,124,853
	1992	**1993**	**1994**	**1995**	**1996**
Revenue ($)	2,803,054,214	3,240,644,919	3,443,918,239	3,410,909,067	3,748,706,986
	1997	**1998**	**1999**	**2000**	**2001**
Revenue ($)	3,704,835,562	3,827,534,918	4,009,894,833	5,208,070,033	4,927,206,149
	2002	**2003**	**2004**	**2005**	**2006**
Revenue ($)	5,682,078,157	5,824,924,180	6,087,717,992	6,674,258,841	7,093,860,976
	2007				
Revenue ($)	5,785,713,148				

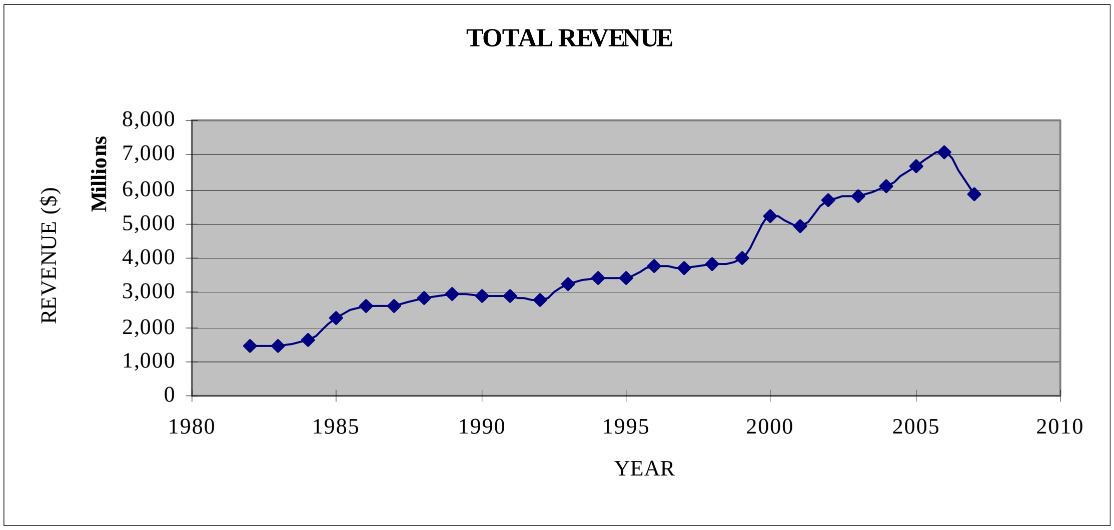


Figure 2.18: Total Revenue over Time

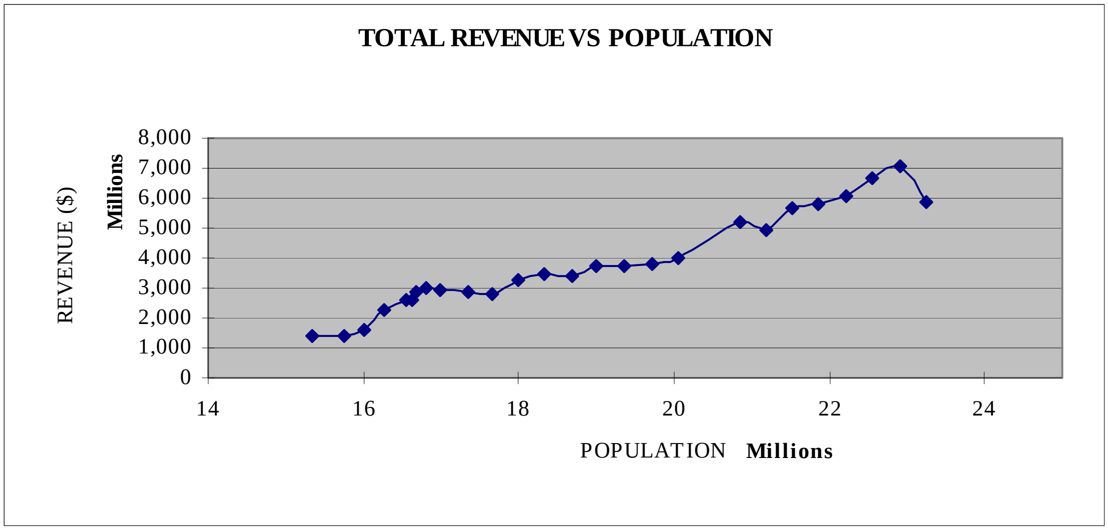


Figure 2.19: Total Revenue vs Population

2.3.11 Total expenditure

- Data source:
  Texas Department of Transportation: Actual cash revenue and expenditure 1982-2008.

Total expenditures from the State Highway Fund have grown over the years (Table 2.11 and Figure 2.20). In the JACK model, the expenditure forecast relies on the Finance Division (FIN) forecast and total contracted letting amounts, not on independent predictors. Therefore, there is no way to check model expenditures as a function of historical inputs. However, it is intuitive that expenditures would depend on revenues. Figure 2.21 shows that historical expenditures have closely matched historical revenues. Thus, it is fair to say that future expenditures (excluding bond and toll funded projects) will also closely match future revenues.

Table 2.11: Total Expenditure Over Time

	1982	**1983**	**1984**	**1985**	**1986**
Expenditure ($)	1,464,798,889	1,624,632,600	1,568,834,219	1,689,741,838	2,612,443,234
	1987	**1988**	**1989**	**1990**	**1991**
Expenditure ($)	2,748,510,580	3,282,859,774	2,904,141,656	2,978,701,586	2,886,974,524
	1992	**1993**	**1994**	**1995**	**1996**
Expenditure ($)	2,751,074,658	3,260,931,139	3,232,043,475	3,280,165,482	3,934,079,634
	1997	**1998**	**1999**	**2000**	**2001**
Expenditure ($)	3,573,520,538	3,870,020,967	4,316,875,118	5,088,859,629	5,118,674,071
	2002	**2003**	**2004**	**2005**	**2006**
Expenditure ($)	5,495,130,394	5,592,565,484	6,111,718,755	7,159,116,011	7,059,692,997
	2007				
Expenditure ($)	5,992,931,445				

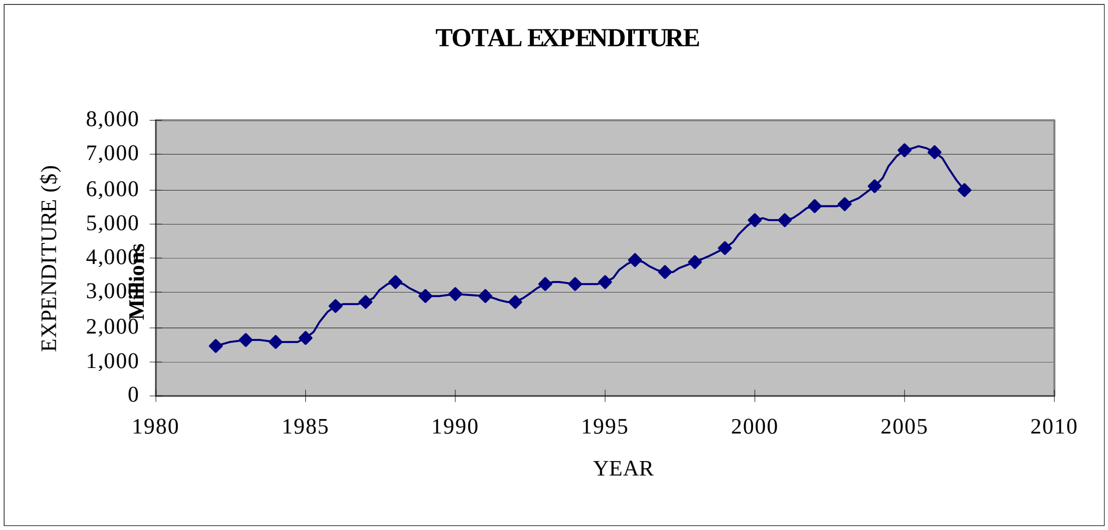


Figure 2.20: Total Expenditure Over Time

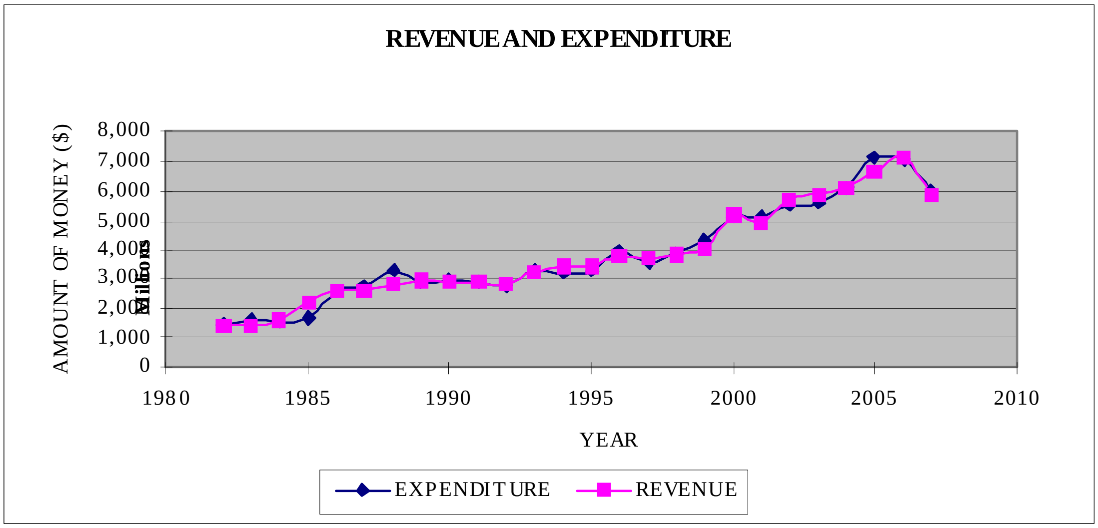


Figure 2.21: Total Revenues and Expenditure Over Time

2.4 JACK Model Performance

In this section, the JACK models for estimating revenues are evaluated. The objective was to statistically evaluate estimation error, and identify systematic bias, if any. Where such statistical bias was found, alternative formulations were evaluated to see if the bias could be reduced. It is recognized that the JACK models are based on 1993–2007 data, a 15 year span. The researchers obtained historical data from 1982 to 2007, inputted the predictor values into the models, and compared estimated revenue to actual historical revenue numbers.

2.4.1 Inputs/Assumptions

The following are input variables to JACK, and the values assumed for this analysis:

- MPG numbers as calculated earlier
- Net federal rate of return: 0.685. The rate of return is the fraction of federal gas taxes returned to the state by the federal government compared to the amount collected from the state.
- Construction cost inflation rate: 4% (has no effect—actual expenditures used)
- Proposition 14 amount: $0.333 billion (Data source: An Texas audit report on TxDOT's financial forecasting and fund allocation, August 2008, Report No. 08-045)
- How many years to receive proposition 14: 3
- First year to receive proposition 14: 2006
- Year to start proposition 14 payback: 2006
- How long is payback: 20
- What percentage of diversions could we stop: 50% (has no effect—actual numbers used)
- What year could we stop diversions: 2010 (has no effect)
- Current state fuel tax rate: (Gas tax rate*75% + diesel tax rate*25%, assuming a 75-25 mix of gas and diesel vehicles)
- State gas tax increases: historical numbers as presented earlier
- Federal gas tax increases: historical numbers as presented earlier

2.4.2 Registration revenue

- JACK equation: Registration Revenue ($) = 69.69*Population – 698,811,071 (straight-line relationship based on 1993-2007 data). This formula in effect states that registration revenue increases by $69.69 for each person added to the state population.
- Alternate formulation: Registration Revenue ($) = 142*Population -2,319,299,721 (straight-line relationship based on 2002-2007 data). This formula in effect states that registration revenue increases by $142 for each person added to the state population.

Figure 2.22 illustrates the registration revenue models.

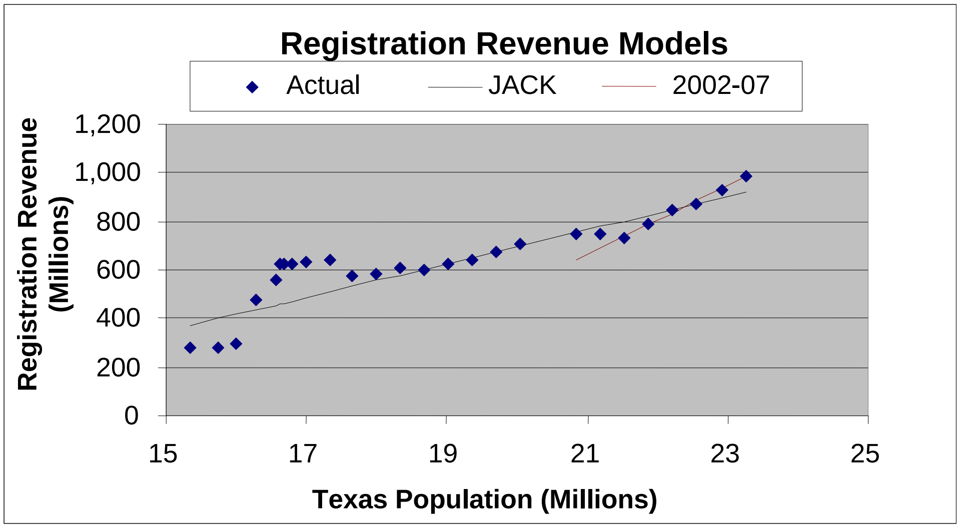


Figure 2.22: Model Estimation of Registration Fees

The alternate formulation is based on our observation that the last 6 revenue points appear to have a straight-line relationship to population. The resulting model therefore more closely fits recent trends. **Note:** Other formulations were tested, but only one is shown. The percentage errors for both formulations are shown in Table 2.12. Figure 2.23 is a plot of the percentage error of both formulations versus time.

Table 2.12: Estimation of Registration Revenue

YEAR	POPULATION	ACTUAL REGISTRATION REVENUE	JACK MODEL ESTIMATE OF REG REVENUE	JACK Error	ALTERNATE MODEL 2002-07	2002-07 Error
1993	17,996,764	586,068,536	555,383,412	-5.53%		
1994	18,338,319	604,195,927	579,186,380	-4.32%		
1995	18,679,706	602,369,620	602,977,640	0.10%		
1996	19,006,240	621,586,174	625,733,795	0.66%		
1997	19,355,427	637,673,921	650,068,637	1.91%		
1998	19,712,389	675,657,385	674,945,318	-0.11%		
1999	20,044,141	705,111,741	698,065,115	-1.01%	526,968,301	-33.81%
2000	20,851,820	744,564,667	754,352,265	1.30%	641,658,719	-16.04%
2001	21,183,522	751,970,852	777,468,577	3.28%	688,760,403	-9.18%
2002	21,519,983	730,019,458	800,916,544	8.85%	736,537,865	0.89%
2003	21,860,876	789,133,763	824,673,377	4.31%	784,944,671	-0.53%
2004	22,206,348	845,783,923	848,749,321	0.35%	834,001,695	-1.41%
2005	22,556,054	875,128,731	873,120,332	-0.23%	883,659,947	0.97%
2006	22,907,237	932,713,282	897,594,276	-3.91%	933,527,933	0.09%
2007	23,259,917	984,246,908	922,172,545	-6.73%	983,608,493	-0.06%

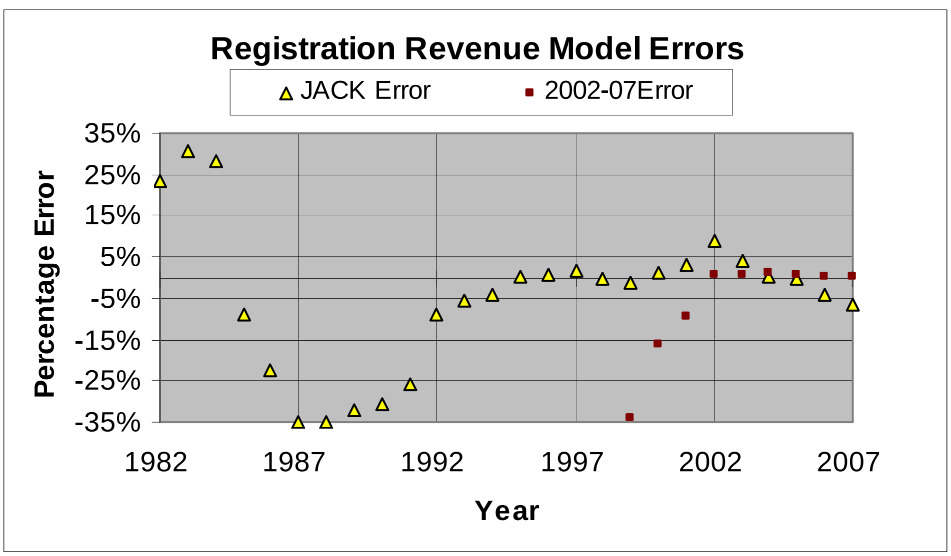


Figure 2.23: Error Rate—Registration Revenue Over Time

The error since 1993 is scattered on both sides of zero error and is lowest in the middle years, as is to be expected of a regression formula. Average error for the period 1993-2007 is

2.84%, i.e., if the formula had been in use in that period, in any given year the estimate would have been off by 2.84% on average, a quite reasonable number. However, note that the error in the last 2 years has been increasing, indicating that another variable may be influencing model error. The alternate formulation is an almost perfect fit, with an average error of just 0.66%. Before 2002, the error in that model is very large. However, the error in the last 2 years is less than 0.1%. We conclude that the JACK formula for predicting registration revenue based on population performs reasonably well, but other variables may be influencing recent trends. The model needs to be updated as trends change.

2.4.3 State Motor Fuel Taxes (SMFT)

- JACK equation: SMFT ($) = 142*Population – 1,013,866,519
  (straight-line relationship based on 1993-2007 data). This formula in effect states that SMFT collected increases **$142** for each person added to state population.
  SMFT rate in Year X = (gas tax rate in Yr X) * 75% + (diesel tax rate in Year X) * 25%. This formula assumes a 75-25 gas-diesel vehicle fleet mix. This assumption needs to be examined in future research.
  Adjusted SMFT ($) = SMFT * (SMFT rate in Year X) / 20
- Alternate formulation: SMFT Revenue ($) = 97.2*Population - 30,968,254
  (straight-line relationship based on 2001-2007 data). This formula in effect states that SMFT collected increases **$97.20** for each person added to state population.

Figure 2.24 illustrates the SMFT revenue model.

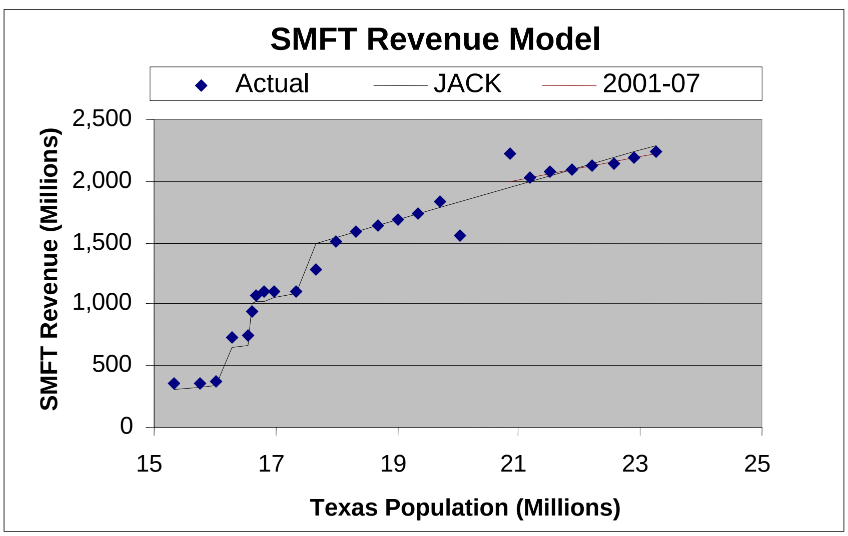


Figure 2.24: Model Estimation of State Motor Fuel Taxes

The alternate formulation is based on the observation that the last seven revenue points appear to have a straight-line relationship to population. The resulting model therefore more closely fits recent trends. **Note:** Other formulations were tested, but only one is shown. The percentage errors for both formulations are shown in Table 2.13.

Table 2.13: Estimation of SMFT Revenue

YEAR	POPU-LATION	Actual SMFT	JACK SMFT adj. For Tax Rate	JACK Error	Alternate Model Estimated SMFT	Alternate Model Error
1993	17,996,764	1,506,893,260	1,541,673,969	-2.26%		
1994	18,338,319	1,587,715,216	1,590,174,779	-0.15%		
1995	18,679,706	1,631,624,420	1,638,651,733	-0.43%		
1996	19,006,240	1,693,053,064	1,685,019,561	0.48%		
1997	19,355,427	1,737,012,675	1,734,604,115	0.14%		
1998	19,712,389	1,837,490,735	1,785,292,719	2.92%		
1999	20,044,141	1,556,149,219	1,832,401,503	-15.08%		
2000	20,851,820	2,229,946,013	1,947,091,921	14.53%	1,995,828,650	11.73%
2001	21,183,522	2,021,827,183	1,994,193,605	1.39%	2,028,070,085	-0.31%
2002	21,519,983	2,078,114,281	2,041,971,067	1.77%	2,060,774,094	0.84%
2003	21,860,876	2,087,006,313	2,090,377,873	-0.16%	2,093,908,894	-0.33%
2004	22,206,348	2,130,041,610	2,139,434,897	-0.44%	2,127,488,772	0.12%
2005	22,556,054	2,148,324,685	2,189,093,149	-1.86%	2,161,480,195	-0.61%
2006	22,907,237	2,194,180,196	2,238,961,135	-2.00%	2,195,615,183	-0.07%
2007	23,259,917	2,238,201,981	2,289,041,695	-2.22%	2,229,895,679	0.37%

Figure 2.25 is a plot of the percentage error of both formulations over time.

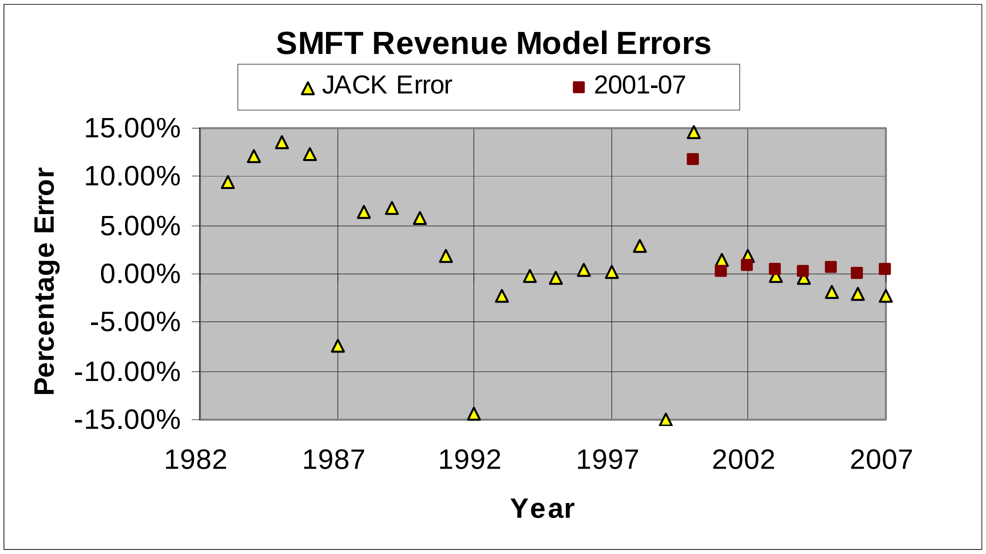


Figure 2.25: Error Rate—SMFT Revenue Over Time

It is seen that the JACK error is scattered on both sides of zero error, as is to be expected of a regression formula. The errors for 1999 and 2000, as noted before, are due to a transfer of revenue, and essentially cancel each other. Average error for the period 1993-2007 is 3.05%, i.e., if the formula had been in use in that period, in any given year the estimate would have been expected to be off by 3.05%, a reasonable number. However, note that the error in the last 5 years has been increasing, indicating that another variable may be influencing model error. The alternate formulation is an almost perfect fit, with an average error of just 0.38%. Before 2001, the error in the alternate formulation is very large. We conclude that the JACK formula for predicting SMFT revenue based on population performs reasonably well, but other variables may be influencing recent trends. The model needs to be updated as trends change.

2.4.4 Federal Motor Fuel Tax (FMFT) Return

- The JACK model derives future FMFT values from estimated SMFT values.
- JACK equation: FMFT = SMFT × (Composite fleet state fuel tax rate/ Composite fleet federal fuel tax rate) × Federal rate of return (ROR)
- Composite fleet federal fuel tax rate = 0.75 × (federal gas tax rate in each year) + 0.25 × (federal diesel tax rate in each year). This formula assumes a 75-25 gas-diesel vehicle fleet mix. This assumption needs to be examined in future research.
- Federal rate of return (ROR) = 0.685

The JACK FMFT estimates and the percentage errors are shown in Table 2.14.

Table 2.14: Estimation of FMFT Revenue

YEAR	POPULATION	Actual FMFT	Compos. Fed. fuel tax rate (cents)	JACK Estimated FMFT	JACK Error
1993	17,996,764	978,752,061	0.156	823,716,402	15.84%
1994	18,338,319	1,074,158,611	0.199	1,083,823,375	-0.90%
1995	18,679,706	987,422,651	0.199	1,116,864,055	-13.11%
1996	19,006,240	1,191,997,660	0.198	1,142,696,015	4.14%
1997	19,355,427	1,074,929,809	0.198	1,176,321,781	-9.43%
1998	19,712,389	1,034,648,615	0.199	1,216,810,885	-17.61%
1999	20,044,141	1,432,084,697	0.199	1,248,919,054	12.79%
2000	20,851,820	1,779,776,255	0.199	1,327,089,176	25.44%
2001	21,183,522	1,735,293,616	0.199	1,359,192,506	21.67%
2002	21,519,983	2,220,667,371	0.199	1,391,756,430	37.33%
2003	21,860,876	2,513,794,247	0.199	1,424,749,299	43.32%
2004	22,206,348	2,679,368,594	0.199	1,458,185,340	45.58%
2005	22,556,054	2,058,214,748	0.199	1,492,031,163	27.51%
2006	22,907,237	1,240,517,271	0.199	1,526,019,936	-23.01%
2007	23,259,917	1,509,570,720	0.199	1,560,153,593	-3.35%

Figures 2.26 and 2.27 are plots of the JACK estimates and actual FMFT versus time, and of the percentage error versus time.

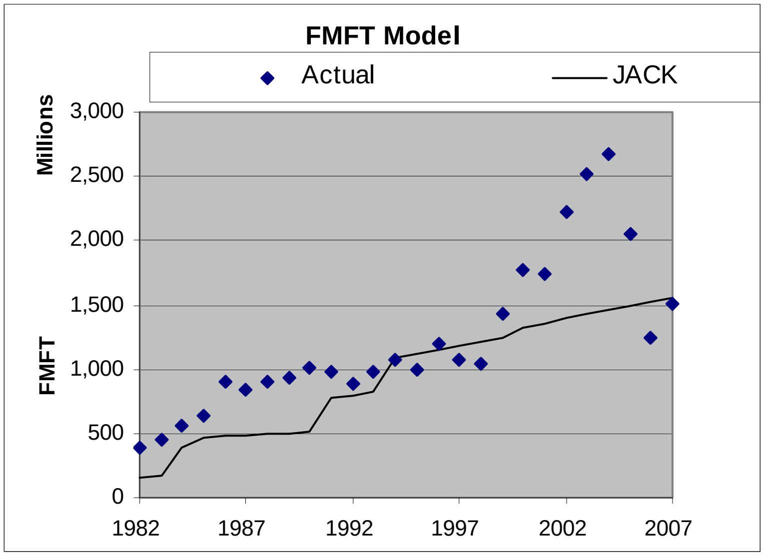


Figure 2.26: Actual Federal Motor Fuel Tax Returns and JACK Estimates

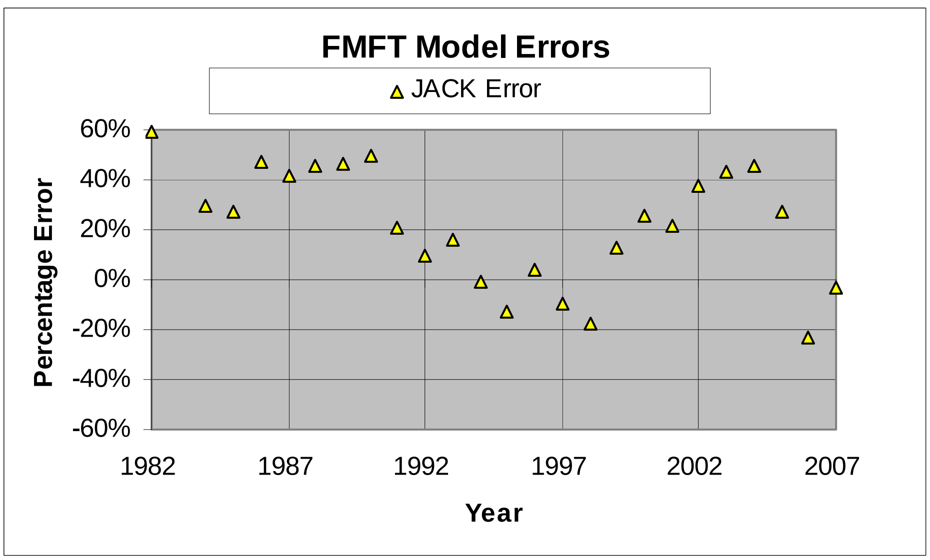


Figure 2.27: Percentage Error in JACK FMFT Estimates Over Time

It is seen that the JACK error is scattered on both sides of zero error, as is to be expected of a regression formula. Average error for the period 1993-2007 is 20.07%, i.e., if the formula had been in use in that period, in any given year the estimate would have been off by 20.07% on average, a very high level. However, most of the error is in the 1998-2005 period, when the federal government was spending down the Federal Highway Trust Fund, making federal returns unpredictable. We conclude that predicting FMFT revenue from SMFT is logical and reasonable over the long term, but likely to be significantly affected by federal policy.

2.4.5 Effect of vehicle fuel efficiency on gas tax revenues

- JACK equation: Adjusted SMFT = Estimated SMFT × (Current composite fleet fuel efficiency/Composite fleet fuel efficiency in Year X)

It is logical that as vehicles become more fuel efficient, the amount of gas tax revenue collected per vehicle mile driven will be less. However, it appears that the formula used in JACK is too simplistic. It assumes that we can compute a composite fleet fuel efficiency by combining the fuel efficiencies of separate classes of vehicles in proportion to the number of vehicles registered in Texas. Implicit in that formula is an assumption that each vehicle is driven the same number of miles.

Instead, consider the following formulation:

Let G = the number of gallons of gasoline consumed by vehicles in Texas
Let D = the number of gallons of diesel consumed by vehicles in Texas
Then SMFT = (G * gas tax rate g) + (D * diesel tax rate d)
G= Miles driven by gas vehicles VMTg/ Average fuel efficiency of gas vehicles MPGg
D = Miles driven by diesel vehicles VMTd/ Avg. fuel efficiency of diesel vehicles MPGd
G may be calculated from G1+G2+…Gm, where m is a specific class of gas vehicles.

Similarly, D may be calculated from G1+ …Gn, where n is a specific class of diesel vehicles. The latter may be particularly important, as the MPG for heavy trucks is significantly different from that for other diesel vehicles. The fuel efficiencies of specific classes of gas and diesel vehicles MPGgm and MPGdn are available.

Then SMFT = g * SUM(VMTgm/ MPGgm) + d * SUM(VMTdn/ MPGdn)

Now we have introduced a new complication: estimating the VMT for each class of vehicle. TxDOT collects VMT for passenger vehicles and trucks. We could take the VMT for passenger vehicles and split it among gas and diesel vehicles based on driving rates among those. Alternatively, we could make an assumption that passenger diesel vehicles drive more than passenger gas vehicles in proportion to the extra fuel tax they pay, and therefore their VMT can be grouped with passenger gas vehicles. The latter simplification would allow us to apply the gas tax rate to all passenger vehicle VMT and the diesel tax rate to all truck VMT.

However, a simpler solution may be available. Note that the total fuel tax collected is a function of the gallons of gas and diesel used in Texas. The State Comptroller publishes these numbers. It should be a simple exercise to collect that data and develop trend lines. However, this solution may only be viable for short-range forecasting, not out to 2035. On the other hand, any other way of forecasting gas tax revenue over the long range is likely to have as much uncertainty. It is recommended that this formulation be explored in further research.

2.4.6 Total revenue

- The JACK model projects total revenue from estimations of registration fees, state motor fuel taxes, and federal motor fuel taxes, with all the estimates based on population as the independent variable. With this formulation, it ought to be possible to derive a relationship between total revenue and population.

- To test the Total Revenue-Population relationship, two models were created: one for data from 1983-2007, and the other for 1993-2007 data as was used for the JACK models.
- 1983-2007 data: Total Revenue = 635.8328*Population-8,203,378,573. In effect this formula states that $635.83 in total revenue is collected per additional head of population in Texas.
- 1993-2007 data: Total Revenue = 714.2245*Population-9,885,134,455. In effect this formula states that $714.22 in total revenue is collected per additional head of population in Texas.

The estimates of total revenue using the two models, and the respective percentage errors are shown in Table 2.15.

Table 2.15: Estimation of Total Revenue

Year	Population	Actual Total Revenue	1983-2007 Estimate	1983-2007 Error	1993-2007 Estimate	1993-2007 Error
1982	15,331,415					
1983	15,751,676	1,432,823,000	1,812,053,683	-20.93%	1,365,098,460	4.96%
1984	16,007,086	1,606,456,967	1,974,451,738	-18.64%	1,547,518,540	3.81%
1985	16,272,734	2,235,884,704	2,143,359,450	4.32%	1,737,250,850	28.70%
1986	16,561,113	2,596,901,931	2,326,720,277	11.61%	1,943,218,197	33.64%
1987	16,621,791	2,611,292,287	2,365,301,340	10.40%	1,986,555,911	31.45%
1988	16,667,022	2,849,079,170	2,394,060,693	19.01%	2,018,860,999	41.12%
1989	16,806,735	2,978,338,062	2,482,894,801	19.95%	2,118,647,447	40.58%
1990	16,986,335	2,918,055,620	2,597,090,372	12.36%	2,246,922,167	29.87%
1991	17,339,904	2,871,124,853	2,821,901,139	1.74%	2,499,449,809	14.87%
1992	17,650,479	2,803,054,214	3,019,374,911	-7.16%	2,721,270,084	3.01%
1993	17,996,764	3,240,644,919	3,239,554,272	0.03%	2,968,595,315	9.16%
1994	18,338,319	3,443,918,239	3,456,726,144	-0.37%	3,212,542,264	7.20%
1995	18,679,706	3,410,909,067	3,673,791,196	-7.16%	3,456,369,223	-1.32%
1996	19,006,240	3,748,706,986	3,881,412,224	-3.42%	3,689,587,806	1.60%
1997	19,355,427	3,704,835,562	4,103,436,772	-9.71%	3,938,985,716	-5.94%
1998	19,712,389	3,827,534,918	4,330,404,920	-11.61%	4,193,936,722	-8.74%
1999	20,044,141	4,009,894,833	4,541,343,723	-11.70%	4,430,882,129	-9.50%
2000	20,851,820	5,208,070,033	5,054,892,523	3.03%	5,007,746,259	4.00%
2001	21,183,522	4,927,206,149	5,265,799,534	-6.43%	5,244,655,954	-6.05%
2002	21,519,983	5,682,078,157	5,479,732,474	3.69%	5,484,964,643	3.59%
2003	21,860,876	5,824,924,180	5,696,483,425	2.25%	5,728,438,776	1.68%
2004	22,206,348	6,087,717,992	5,916,145,854	2.90%	5,975,183,342	1.88%
2005	22,556,054	6,674,258,841	6,138,500,399	8.73%	6,224,951,935	7.22%
2006	22,907,237	7,093,860,976	6,361,794,069	11.51%	6,475,775,438	9.54%
2007	23,259,917	5,875,713,148	6,586,039,581	-10.79%	6,727,668,134	-12.66%

Figures 2.28 and 2.29 are plots of the estimates and actual total revenues versus population, and of the percentage error versus time.

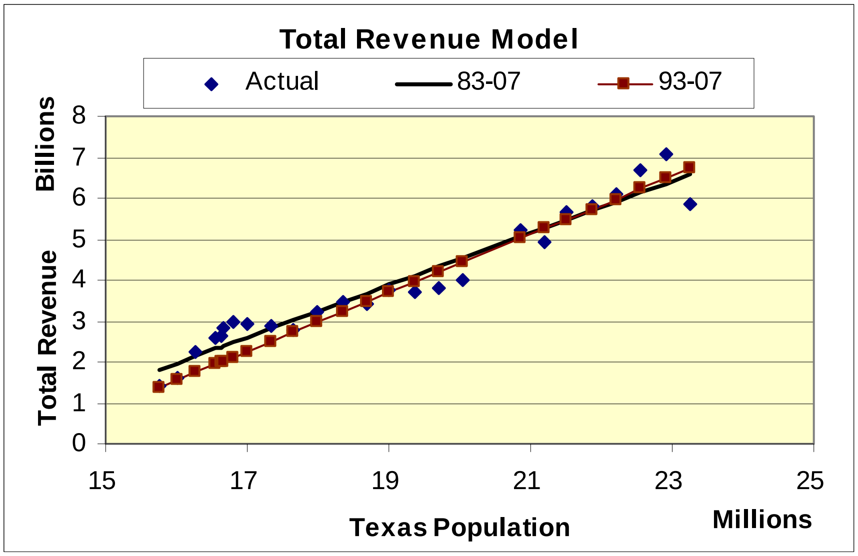


Figure 2.28: Model Estimation of Total Revenues

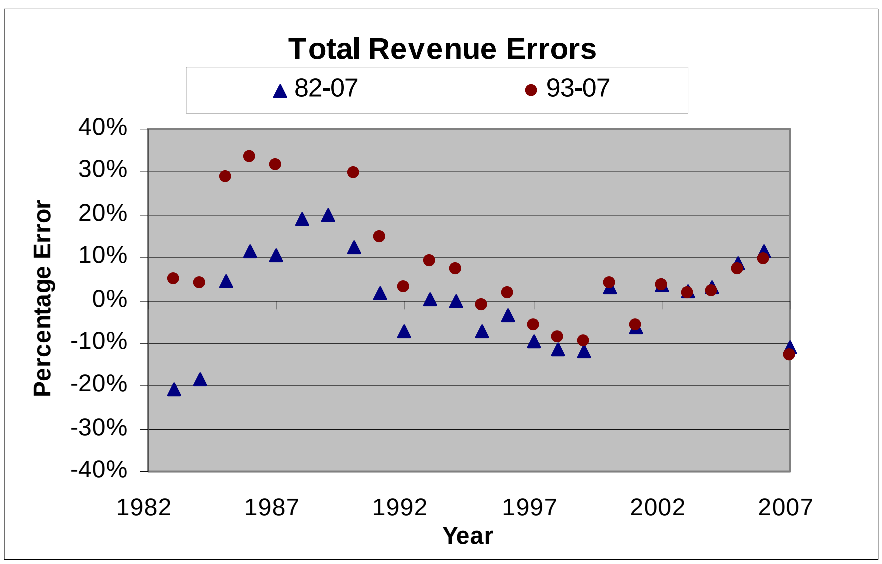


Figure 2.29: Percentage Error in Total Revenue Estimates Over Time

It is seen that the errors in the models are scattered on both sides of zero error, as is expected of regression formulas. Average error in the 1983-2007 model is 6.22% for the 1993-2007 period, i.e., if the formula had been in use in that period, in any given year the estimate would have been off by 6.22% on average. Average error in the 1993-2007 model is 6.01%, an insignificant improvement. The errors in both models seem to be influenced by the erratic FMFT. We conclude that predicting total revenue from population gives adequate results if an average error of about 6% is acceptable.

2.5 Sensitivity Analysis

Sensitivity analyses were performed to assess the internal consistency of the JACK model. The researchers evaluated the output revenue estimates for each model input over its valid range while holding the other variables fixed. The objective was to identify the input variables that have the most effect on the model estimates, and the levels of input values for which the model shows the largest changes.

2.5.1 Variables Evaluated

Three input variables were considered:

(1) State data center population migration factor

- Range: 0.0, 0.25, 0.5, 1.0, and actual 2000-2004 factor observed

(2) Vehicle fuel efficiency in miles per gallon (MPG)

- Range: low, low-medium, medium, and high, as defined in JACK (see Figure 2.34 later).

(3) Net federal rate of return (ROR) available for highway projects

- Assumed Possible Range of values: 0.6, 0.685, 0.8, 0.9, 1.0, and 1.1

2.5.2 Base Scenario

For this analysis, when one of the above inputs is varied, the other values are held fixed as listed below:

(1) State data center migration factor: 0

(2) State and federal fuel tax rates: 2008 values

(3) MPG in year 2035: medium

(4) MPG in year 2008: 18.6

(5) Net federal ROR: 0.685

(6) Prop 12

- Amount: $5 billion
- Years to receive proceeds: 4 years
- First year to receive: 2010

(7) Prop 14

- Amount: $1.5 billion
- Years to receive proceeds: 3 years
- First year to receive: 2009

2.5.3 Variable 1: State Data Center Population Migration Factor

The Zero Migration (0.0) Scenario: This scenario assumes net migration is zero, resulting in growth only through natural increase (births and deaths). In general, this scenario produces the lowest population projections.

The One-Half Migration (0.5) Scenario: This scenario is an approximate average of the zero (0.0) and 1990-2000 (1.0) scenarios. It assumes rates of net migration one-half of those of the 1990s. It is unlikely that migration growth will stay at the same rate as in the 1990s.

The 1990-2000 Migration (1.0) Scenario: The 1990-2000 scenario assumes that the trends of the 1990s will characterize those occurring in the future of Texas. The 1990s was a period characterized by rapid growth. It is seen here as the high growth alternative.

The 2000-2004 Migration Scenario: The 2000-2004 projection scenario takes into account post-2000 population trends. In Texas overall the post-2000 period resulted in reduced levels of net migration. Under this scenario the 2000-2004 migration rates are assumed to prevail from 2000 through 2040.

Figure 2.30 shows the five population growth scenarios for different migration factors. The bigger the migration factor, the faster is the population increase. In 2007, the Texas population was around 23 million. When the migration factor equals to 0, the population in the next 30 years will increase to 26 million. But when the migration factor is set to 1, the population will double by 2035 to nearly 46 million. If any values between 0 and 1 are selected for the migration factor, then the population in 2035 will be between 26 and 46 million.

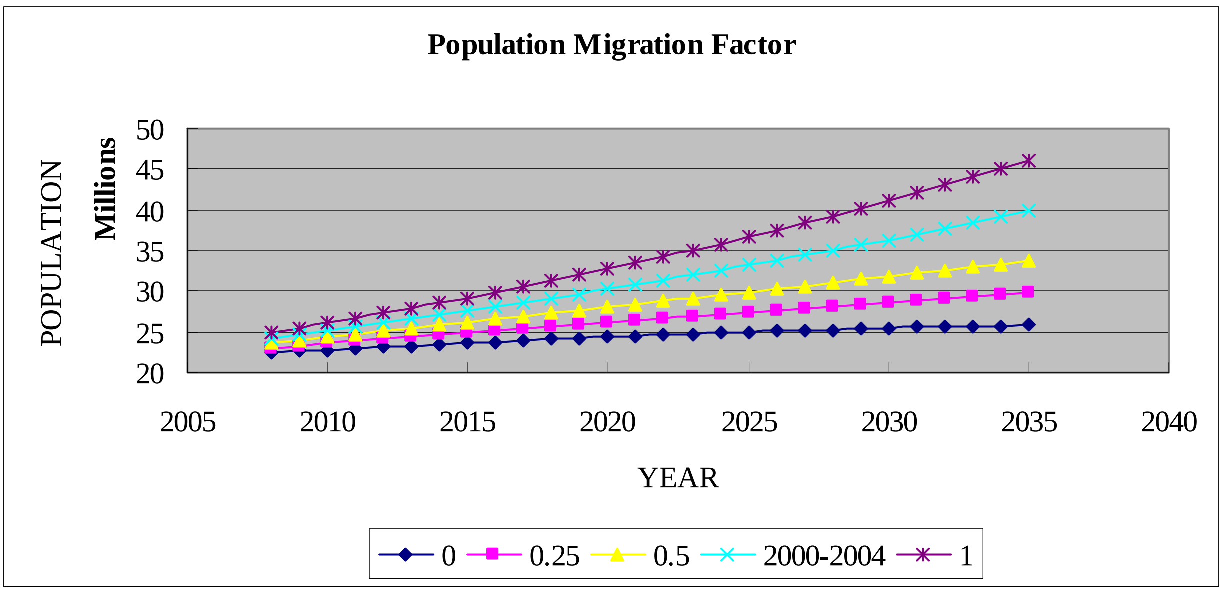


Figure 2.30: Texas Population Growth Under Different Migration Factors

Sensitivity of Registration Revenues to Population

The registration revenue from 2008 to 2035 is calculated by using population as the predictor through the regression equation developed in the J.A.C.K model. Figure 2.31 shows the trend of the registration revenue is very similar to that of the population trend shown above.

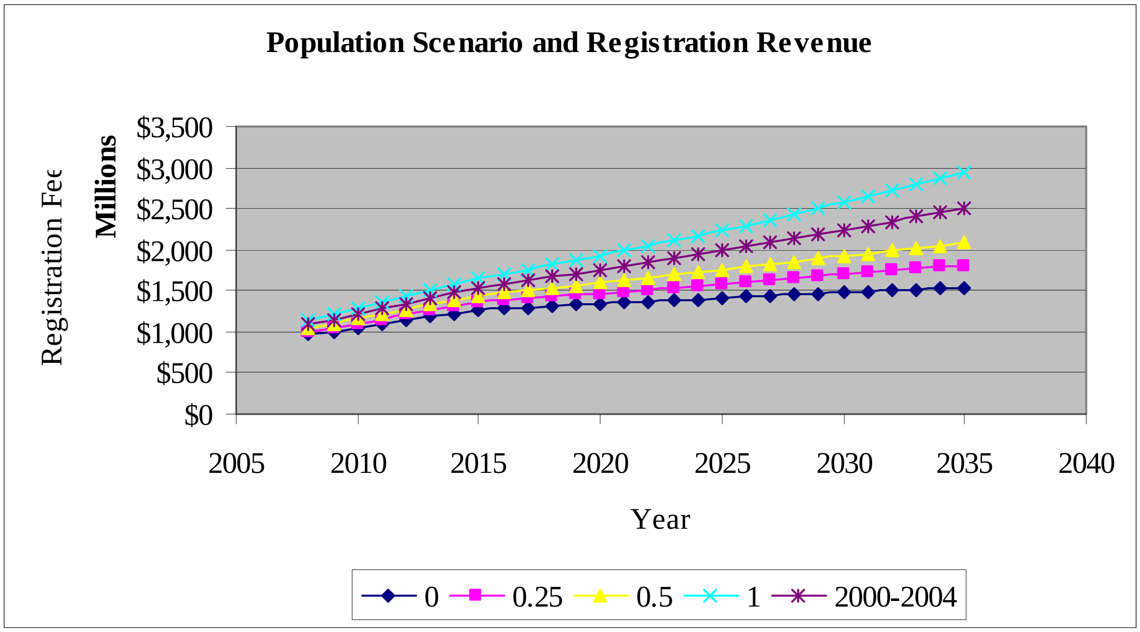


Figure 2.31: JACK Registration Revenue Estimates for Different Population Scenarios

The trend of the curve is upward for all population scenarios. This is because the model uses a positive linear relationship of registration revenue to population. However, different migration factors will result in a great difference in registration revenue. When the migration factor is set to 1, the annual registration revenue by 2035 is $3 billion, twice that of a migration factor of 0 ($1.5 billion).

Table 2.16 shows the effect of different population scenarios in two ways: the average number of years it takes to see a $1 billion increase in revenue, and the average change in revenue per 10 years. These indices are both measures of the sensitivity of the revenue estimate to population assumptions. It is seen that the higher migration rates produce faster changes in registration revenue, meaning that the model is increasingly sensitive to higher migration rates.

Table 2.16: Sensitivity of Registration Revenue to Migration Factors

	Migration factor	Number of years for $1 billion increase in revenue	Change in registration fee revenue over 10 years
1	0	50	$0.2 billion
2	0.25	33.33	$0.3 billion
3	0.5	25	$0.4 billion
4	2000-2004	20	$0.5 billion
5	1	16.67	$0.6 billion

Sensitivity of SMFT to Population

Similar to the registration revenue, the SMFT revenue is also a function of the population. As shown in Figure 2.32, from 2008 to 2035 SMFT decreases even as population increases, due to the effect of changing fuel efficiency in all the MPG scenarios.

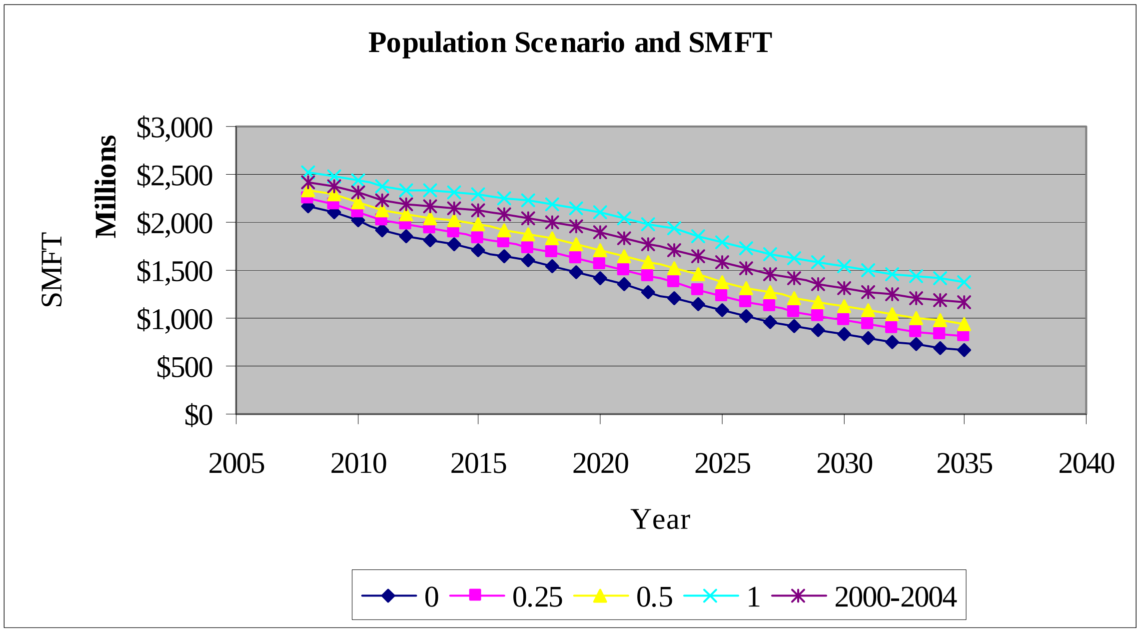


Figure 2.32: JACK SMFT Revenue Estimates for Different Population Scenarios

The highest SMFT revenue will occur when the migration factor is 1, generating $1.5 billion per year by 2035, about twice as much as when a migration factor of 0 is assumed. In addition, as shown in Table 2.17, lower migration rates produce faster changes in SMFT revenue, meaning that the model is decreasingly sensitive to higher migration rates.

Table 2.17: Sensitivity of SMFT Revenue to Migration Factors

	Migration factor	Number of years for $1 billion decrease in revenue	Change in SMFT revenue Per 10 years
1	0	16.67	-$0.6 billion
2	0.25	16.67	-$0.6 billion
3	0.5	20	-$0.5 billion
4	2000-2004	20	-$0.5 billion
5	1	25	-$0.4 billion

Sensitivity of Total Revenue to Population Projections

In JACK, future total revenues are calculated by using projections of state population to estimate future SMFT, FMFT, and registration revenues. The previous graphs showed registration revenue increasing over time as population increases, while SMFT decreases even as population increases, due to the effect of greater future fuel efficiency. Because JACK assumes that FMFT is a function of SMFT, FMFT will also decline over time. Figure 2.33 shows how different population scenarios affect the total annual revenue in the 2008 to 2035 period.

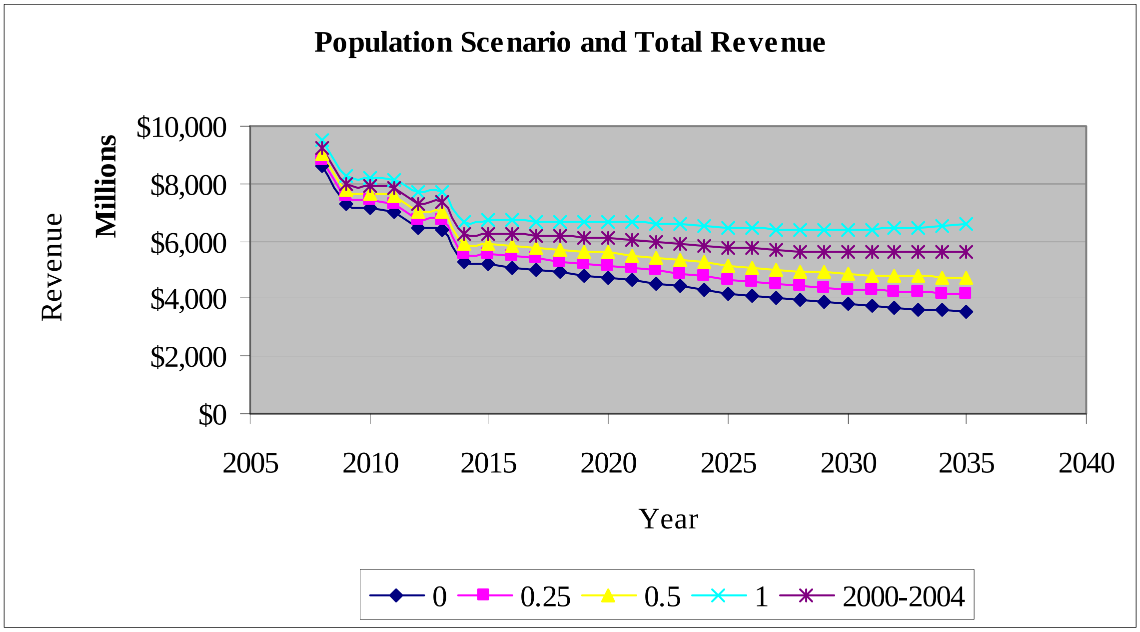


Figure 2.33: JACK Total Revenue Estimates for Different Population Scenarios

The revenue trend is decreasing even as population increases, if fuel tax rates remain the same. The drop-off in total revenue in 2009-2015 for all population scenarios is due to the effect of Prop 12 (from 2010 to 2014), Prop 14 (from 2009 to 2012) and the Mobility Fund (from 2008 to 2009). The highest total revenue will occur when the migration factor is 1, generating $6.4 billion per year by 2035, almost twice as much as when a migration factor of 0 is assumed ($3.6 billion). Table 2.18 shows that lower migration rates produce faster changes in total revenue, meaning that the model is decreasingly sensitive to higher migration rates.

Table 2.18: Sensitivity of Total Revenue to Migration Factors

	Migration factor	Number of years for $1 billion decrease in revenue (2014 - 2035)	Change in revenue per 10 years (2014-2035)
1	0	11.11	-$0.9 billion
2	0.25	14.28	-$0.7 billion
3	0.5	16.67	-$0.6 billion
4	2000-2004	25	-$0.4 billion
5	1	100	-$0.1 billion

2.5.4 Variable 2: Vehicle Fuel Efficiency in Miles per Gallon (MPG)

Vehicle Fuel Efficiency Scenarios

There are four MPG scenarios in JACK: LOW, LM (low-medium), MED, and HIGH from 2008 to 2035 as shown in Figure 2.34. LOW represents the lowest improvement of fuel efficiency while HIGH represents the most aggressive fuel efficiency improvement. If the scenario is set to LOW, then the MPG by the year of 2035 will be only 40 mpg. If the scenario is set to HIGH, then the MPG will reach 120 mpg by 2035. Other scenarios will result in intermediate values of MPG. The MPG scenarios affect only SMFT and FMFT revenues.

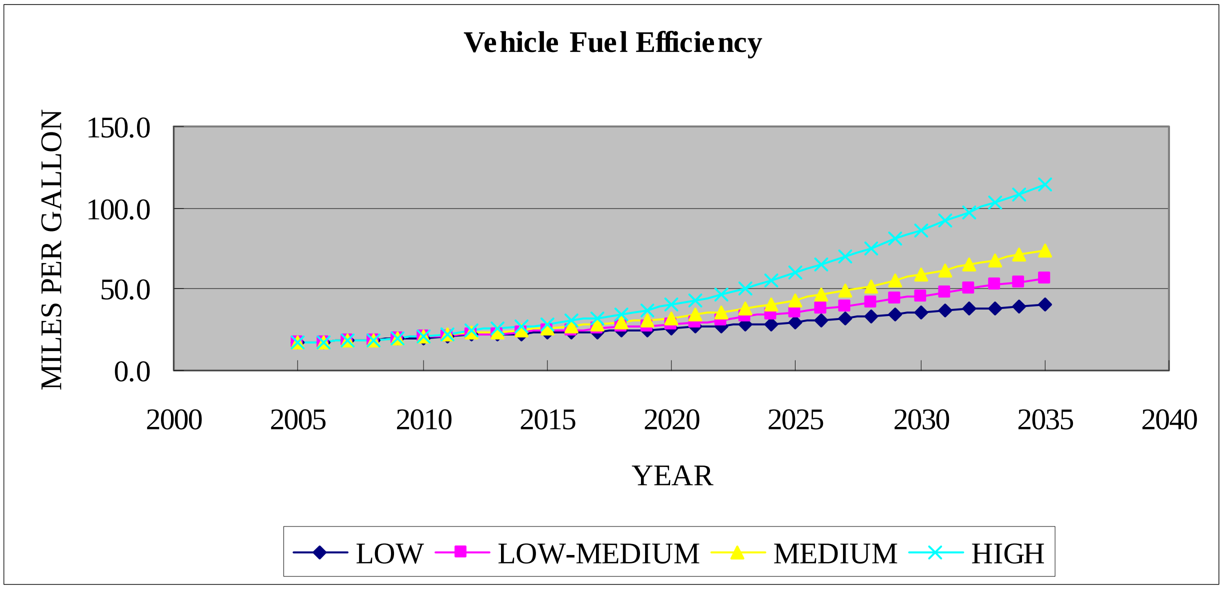


Figure 2.34: Alternative Fuel Efficiency Scenarios Included in JACK

Sensitivity of SMFT to Fuel Efficiency

Figure 2.35 shows the effect of different scenarios of fuel efficiency on SMFT revenue.

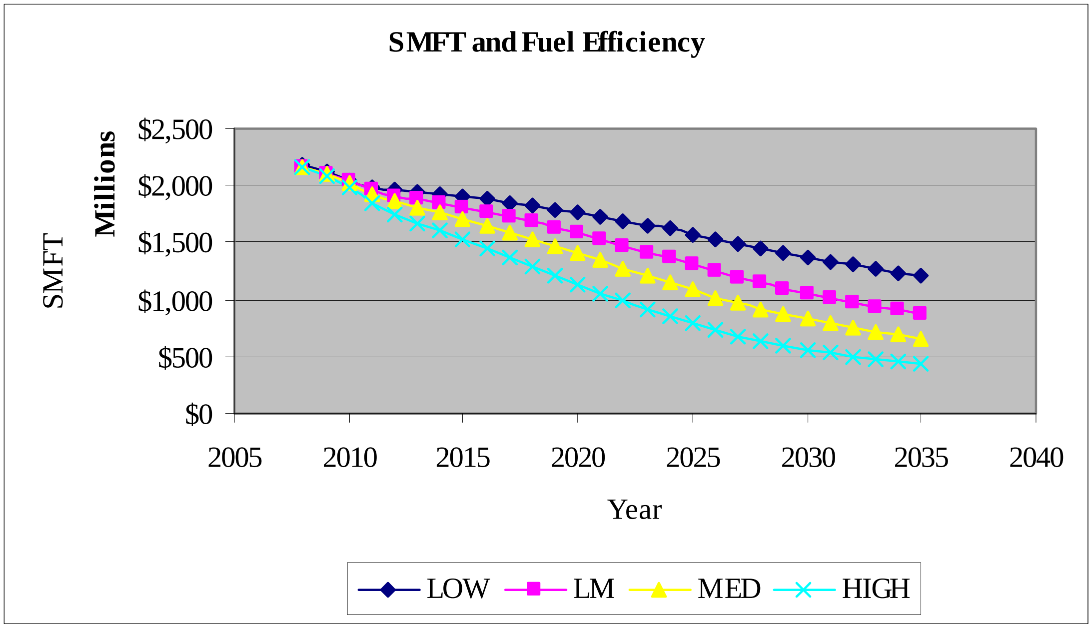


Figure 2.35: JACK SMFT Revenue Estimates for Different Fuel Efficiency Scenarios

SMFT decreases under all scenarios. If the HIGH fuel efficiency scenario is used, then SMFT revenue will be just $0.5 billion by the year of 2035. However, if the LOW scenario is used, the SMFT revenue will be $1.25 billion at 2035. Other scenarios of fuel efficiency will result in intermediate values of SMFT revenue. As shown in Table 2.19, higher MPG scenarios produce faster declines in revenue, meaning that the model is increasingly sensitive to higher fuel efficiency.

Table 2.19: Sensitivity of SMFT to Fuel Efficiency

	MPG	Number of years for $1 billion decrease in revenue	Change in SMFT revenue over 10 years
1	Low	33.33	-$0.3 billion
2	Low-Medium	20	-$0.5 billion
3	Medium	16.67	-$0.6 billion
4	High	14.28	-$0.7 billion

Sensitivity of Total Revenue to Fuel Efficiency

Because JACK assumes that FMFT is a function of SMFT, FMFT has the same sensitivity behavior to MPG scenarios as SMFT does. Figure 2.36 shows the effect of different fuel efficiency scenarios on future total revenue. The general trend is that higher fuel efficiency results in lower total revenue, assuming other input factors remain as in the base scenario.

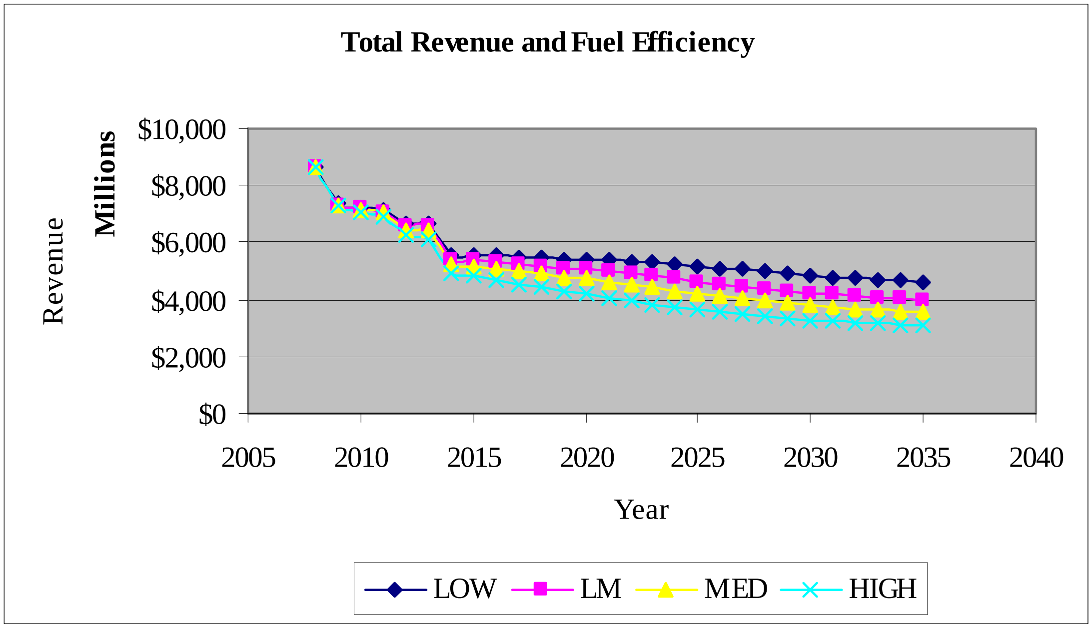


Figure 2.36: JACK Total Revenue Estimates for Different Fuel Efficiency Scenarios

As seen from the graph, the revenue difference starts to increase after 2012 due to divergence of the MPG scenarios. By 2015 the respective MPG numbers are LOW (22.9), LM (24.1), MED (25.5), and HIGH (28.6), whereas by 2030 they are LOW (35.2), LM (46.0), MED (58.5), and HIGH (86.5). If the fuel efficiency scenario is set to HIGH, then the total revenue will only be $3 billion in 2035. If the LOW scenario is used, the total revenue will be $4.8 billion. As shown in Table 2.20, higher MPG scenarios produce faster declines in revenue, meaning that the model is increasingly sensitive to higher fuel efficiency.

Table 2.20: Sensitivity of Total Revenue to Fuel Efficiency

	MPG	Number of years for $1 billion decrease in revenue (2014-2035)	Change in revenue over 10 years (2014-2035)
1	Low	20	-$0.5 billion
2	Low-Medium	14.28	-$0.7 billion
3	Medium	11.11	-$0.9 billion
4	High	11.11	-$0.9 billion

2.5.5 Variable 3: Net Federal Rate of Return (ROR) Available for Highway Projects

Sensitivity of FMFT to Federal Rate of Return

Figure 2.37 shows the effect of ROR on future FMFT revenue.

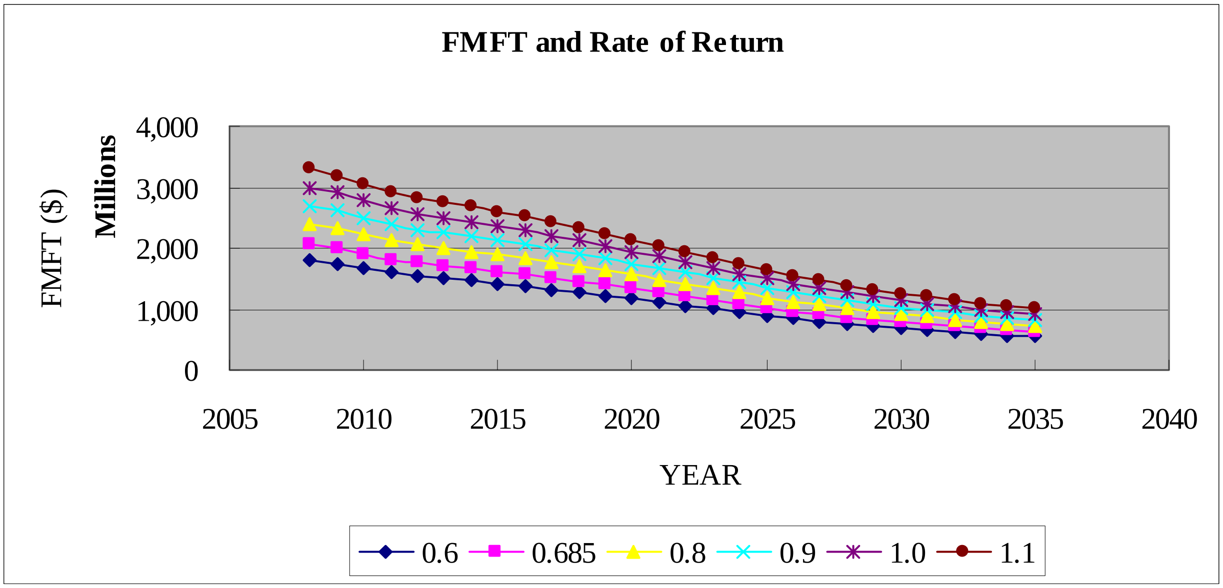


Figure 2.37: JACK FMFT Revenue Estimates for Different Federal ROR Scenarios

The general trend of the curves is decreasing because of improvement in fuel efficiency. When the ROR is set to be 0.6, the FMFT revenue in 2035 will be $0.5 billion. But if ROR of 1.1 is assumed, the FMFT revenue will be $1 billion in 2035. As shown in Table 2.21, higher ROR produces faster declines in FMFT revenue, meaning that the model is increasingly sensitive to higher ROR.

Table 2.21: Sensitivity of FMFT Revenue to Federal ROR

	ROR	Number of years for $1 billion decrease in revenue	Change in FMFT revenue over 10 years
1	0.6	20	-$0.5 billion
2	0.685	20	-$0.5 billion
3	0.8	16.67	-$0.6 billion
4	0.9	14.28	-$0.7 billion
5	1.0	12.5	-$0.8 billion
6	1.1	11.11	-$0.9 billion

Sensitivity of Total Revenue to Federal Rate of Return

Figure 2.38 shows the effect of different scenarios of net federal rate of return (ROR) on future total revenue.

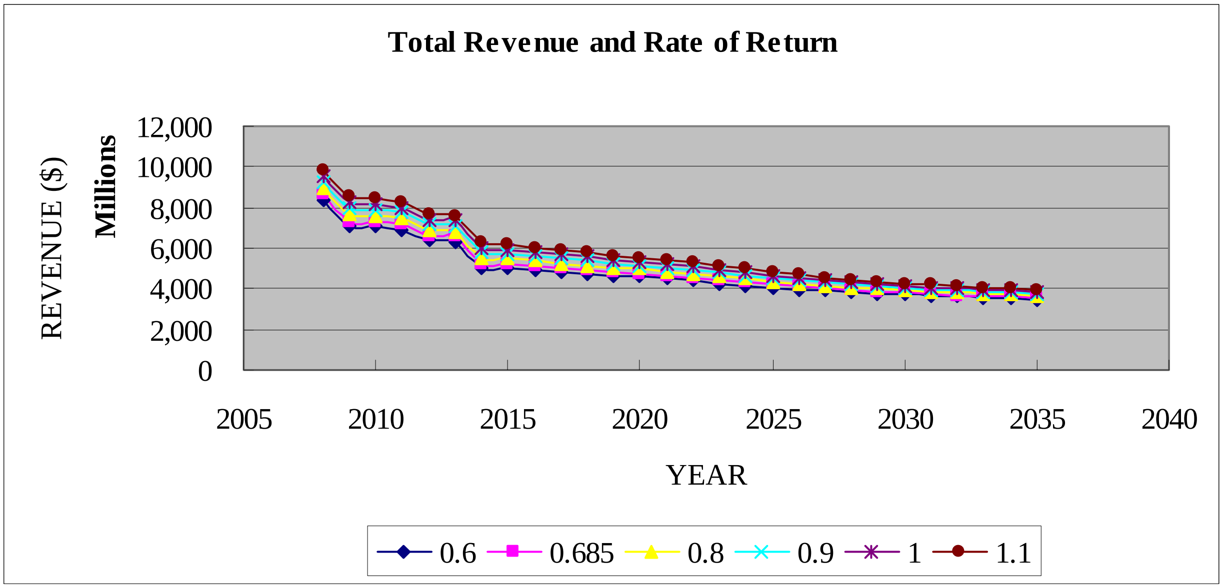


Figure 2.38: JACK Total Revenue Estimates for Different Federal ROR Scenarios

The general trend of total revenue is decreasing under all ROR scenarios. This finding is consistent with the previous ones showing that fuel efficiency improvement will reduce total revenue if no fuel tax increase is applied. The graph shows higher ROR leads to higher total revenue. When ROR of 1.1 is used, the total revenue by the year of 2035 will be $4 billion. However, when ROR of 0.6 is used, the total revenue will be $3.5 billion. Compared with the earlier graphs of the effect of Migration Factors and MPG, the effect of ROR seems to be much smaller. As shown in Table 2.22, higher ROR produces slightly faster declines in total revenue, meaning that the model is somewhat sensitive to increasing ROR.

Table 2.22: Sensitivity of Total Revenue to Federal ROR

	ROR	Number of years for $1 billion decrease in revenue (2014-2035)	Change in Revenue per 10 years (2014-2035)
1	0.6	12.5	-$0.8 billion
2	0.685	11.11	-$0.9 billion
3	0.8	10	-$1.0 billion
4	0.9	10	-$1.0 billion
5	1.0	10	-$1.0 billion
6	1.1	10	-$1.0 billion

2.5.6 Summary of Sensitivity Analyses

In the JACK model, revenue estimation is influenced by several variables, including population migration factors, composite vehicle fleet fuel efficiency, and federal rate of return on gas taxes. Table 2.23 summarizes the sensitivity analyses on these variables, using as benchmarks the change in revenue over 10 years as well as the years to change revenue by $1 billion.

Table 2.23: Summary of Revenue Changes Due to Variation of Individual Inputs

Data	Variable	Range Description	Range	Change in revenue over 10 years (Billion)	Years to change revenue by $1 billion
Registration Revenues	Population	Migration Factor	0	$0.2	50
			0.25	$0.3	33.33
			0.5	$0.4	25
			2000-2004	$0.5	20
			1	$0.6	16.67
State Motor Fuel Taxes	Population	Migration Factor	0	-$0.6	16.67
			0.25	-$0.6	16.67
			0.5	-$0.5	20
			2000-2004	-$0.5	20
			1	-$0.4	25
	Fuel Efficiency	MPG	Low	-$0.3	33.33
			Low-Medium	-$0.5	20
			Medium	-$0.6	16.67
			High	-$0.7	14.28
Federal Motor Fuel Taxes	Rate of Return		0.6	-$0.5	20
			0.685	-$0.5	20
			0.8	-$0.6	16.67
			0.9	-$0.7	14.28
			1	-$0.8	12.5
			1.1	-$0.9	11.11
Total Revenue	Population	Migration Factor	0	-$0.9	11.11
			0.25	-$0.7	14.28
			0.5	-$0.6	16.67
			2000-2004	-$0.4	25
			1	-$0.1	100
	Fuel Efficiency	MPG	Low	-$0.5	20
			Low-Medium	-$0.7	14.28
			Medium	-$0.9	11.11
			High	-$0.9	11.11
	Rate of Return		0.6	-$0.8	12.5
			0.685	-$0.9	11.11
			0.8	-$1.0	10
			0.9	-$1.0	10
			1	-$1.0	10
			1.1	-$1.0	10

Considering Total Revenue first, it is seen that variation in ROR has the smallest effect. For the full range of ROR scenarios, there is only a 25% difference in how annual revenue behaves, and the range in the number of years to see a $1 billion change is 10-12.5 years. For the full range of MPG scenarios, there is an 80% difference in how annual revenue behaves, and the range in the number of years to see a $1 billion change is 11-20 years. For the full range of population migration scenarios, there is an 800% difference in how annual revenue behaves, and the range in the number of years to see a $1 billion change is 11-100 years. Therefore, it is clear that, of the three factors, total revenue is most sensitive to the population migration factor.

Examining SMFT revenues next, it is seen that this figure is less sensitive to population assumptions compared to MPG. For the full range of population migration scenarios, there is a 33% difference in how SMFT revenue behaves, and the range in the number of years to see a $1 billion change is 17-25 years. For the full range of fuel efficiency scenarios, there is a 233% difference in how SMFT revenue behaves, and the range in the number of years to see a $1 billion change is 14-33 years. Therefore, it is clear that, of the two factors, SMFT is more sensitive to MPG assumptions.

Comparing the effect of population migration factors on registration revenues and SMFT, it is seen that SMFT is less sensitive than registration revenues. For the full range of population migration scenarios, there is a 200% difference in how registration revenue behaves, and the range in the number of years to see a $1 billion change is 17-50 years. For the full range of population migration scenarios, there is a 33% difference in how SMFT revenue behaves, and the range in the number of years to see a $1 billion change is 17-25 years. Therefore, it is clear that registration revenue is more sensitive to the population migration factor than SMFT is.

This analysis indicates that the model performance will be affected primarily by the accuracy of the population estimate, with the fuel efficiency estimate running second. Therefore it is very important that the population and fuel efficiency estimates through 2035 are as accurate as possible.

2.6 Chapter summary and continuing work

2.6.1 Model processes

The model processes were documented in flow charts and examined for completeness. No significant errors were noted in the general flow of the calculations, but there are a few unconnected or unclear modules. Otherwise the entire process appears logical and defensible.

2.6.2 Evaluation of model inputs and assumptions

To evaluate the JACK model performance, data was collected on the historical annual Highway Fund revenues and expenditures, and the actual values of model inputs from 1982 to 2007. Historical data trends and assumptions were examined. The fundamental assumption in the model that population is a predictor of registration revenues and fuel taxes was also explored and found to be statistically reasonable.

2.6.3 JACK model performance

The JACK formulas for estimating revenues were evaluated. The researchers inputted historical data from 1982 to 2007 into the models, and compared model estimates to actual historical revenue. Estimation error was examined and compared to alternative formulas.

Average error in the registration revenue model for the period 1993-2007 is 2.84%, i.e., if the formula had been in use in that period, in any given year the estimate would have been off by 2.84% on average, a reasonable number. However, it was noted that the error in the last 2 years has been increasing. Overall, this specific model performed reasonably well on the historical inputs.

Average error in the SMFT model for the period 1993-2007 is 3.05%, i.e., if the formula had been in use in that period, in any given year the estimate would have been off by 3.05% on average, a reasonable number. However, it was noted that the error in the last 5 years has been increasing. Overall, the JACK formula for predicting SMFT revenue based on population performed reasonably well on the historical inputs.

Average error for the FMFT model for the period 1993-2007 is 20.07%, i.e., if the formula had been in use in that period, in any given year the estimate would have been off by 20.07% on average, a very high level. However, most of the error is in the 1998-2005 period, when the federal government was spending down the Federal Highway Trust Fund. Predicting FMFT revenue from SMFT was found to be logical and reasonable over the long term, but is likely to be significantly affected by federal policy.

Average error in the total revenue model for the period 1993-2007 is 6.01%, i.e., if the formula had been in use in that period, in any given year the estimate would have been off by 6.01% on average. The error seems to be influenced by the erratic FMFT numbers. Predicting total revenue from population was found to be statistically adequate if an average error of about 6% in any given year is acceptable.

The formulas used in JACK for calculating composite fleet fuel efficiency and composite fuel tax rate need to be strengthened to reflect the importance of these inputs. The composite fleet fuel figure is weighted by the percentages of each vehicle class registered and their respective fuel efficiencies, but that calculation assumes that each class is driven the same number of miles per year. Similarly, the composite fuel tax rate is weighted 75% gas vehicles and 25% diesel vehicles, not taking account of the respective miles driven. It is recommended that additional research be done on these items.

2.6.4 Sensitivity analysis

To assess the internal consistency of the JACK models, sensitivity analysis was performed. The researchers evaluated the output revenue estimates over the valid range of each model input while holding the other input variables fixed. Three variables were evaluated: population migration factor (POP), fuel efficiency scenarios (MPG), and rate of return on FMFT (ROR).

Considering Total Revenue, it was found that it was least sensitive to ROR and most sensitive to POP. Over the full range of population migration factors, there is an 800% difference in how annual revenue behaves. SMFT was found to be more sensitive to MPG assumptions than to POP. Comparing the effect of population migration factors on registration revenues and SMFT, it was found that SMFT is less sensitive than registration revenues.

This analysis indicates that the model performance will be affected primarily by the accuracy of the population estimate, with the fuel efficiency estimate running second. Therefore it is very important that the population and fuel efficiency estimates through 2035 are as accurate as possible. In continuing work, alternative population models will be examined. In a later chapter fuel efficiency projections will be analyzed.

Chapter 3. Estimating Future Fuel Tax Receipts

3.1 Scope

Task 1: Develop reliable expressions for estimating future receipts from State Motor Fuel Taxes, Vehicle Registration Fees, and Federal Motor Fuel Taxes

A. Develop a statistically reliable mathematical expression of the relationship between state's population and motor fuel taxes receipts.

B. Develop a statistically reliable mathematical expression of the relationship between the state's population and vehicle registration fees.

C. Research known receipts of federal motor fuel tax (FMFT) revenue received by the state and develop a statistically reliable mathematical expression of the relationship between the state's population and FMFT revenue or between the state's motor fuel tax revenue and FMFT. FMFT revenue projections should include gross revenue collected from the federal tax and a rate of return on revenue to the state.

3.2 Population Trends

The J.A.C.K model was created on the basis of population trends over the past 20 years in Texas. These population trends need to be examined. Texas is ranked as one of the fastest growing states in the U.S. (Table 3.1).

Table 3.1: Ten Fastest Growing States in U.S. (Numeric)

Ten Fastest Growing States in Numerical Terms in the United States, 1990-2000

State	1990 Population*	2000 Population*	Numerical Change 1990-2000	Percent Population Change 1990-2000
California	29,760,021	33,871,648	4,111,627.00	13.80
Texas	**16,986,510**	**20,851,820**	**3,865,310**	**22.80**
Florida	12,937,926	15,982,378	3,044,452	23.50
Georgia	6,478,216	8,186,453	1,708,237	26.40
Arizona	3,665,228	5,130,632	1,465,404	40.00
North Carolina	6,628,637	8,049,313	1,420,676	21.40
Washington	4,866,692	5,894,121	1,027,429	21.10
Colorado	3,294,394	4,301,261	1,006,867	30.60
Illinois	11,430,602	12,419,293	988,691	8.60
New York	17,990,455	18,976,457	986,002	5.50

Source: Institute for Demographic and Socioeconomic Research

The state's population has changed significantly over the last century, especially in comparison to the overall population of the United States (Table 3.2).

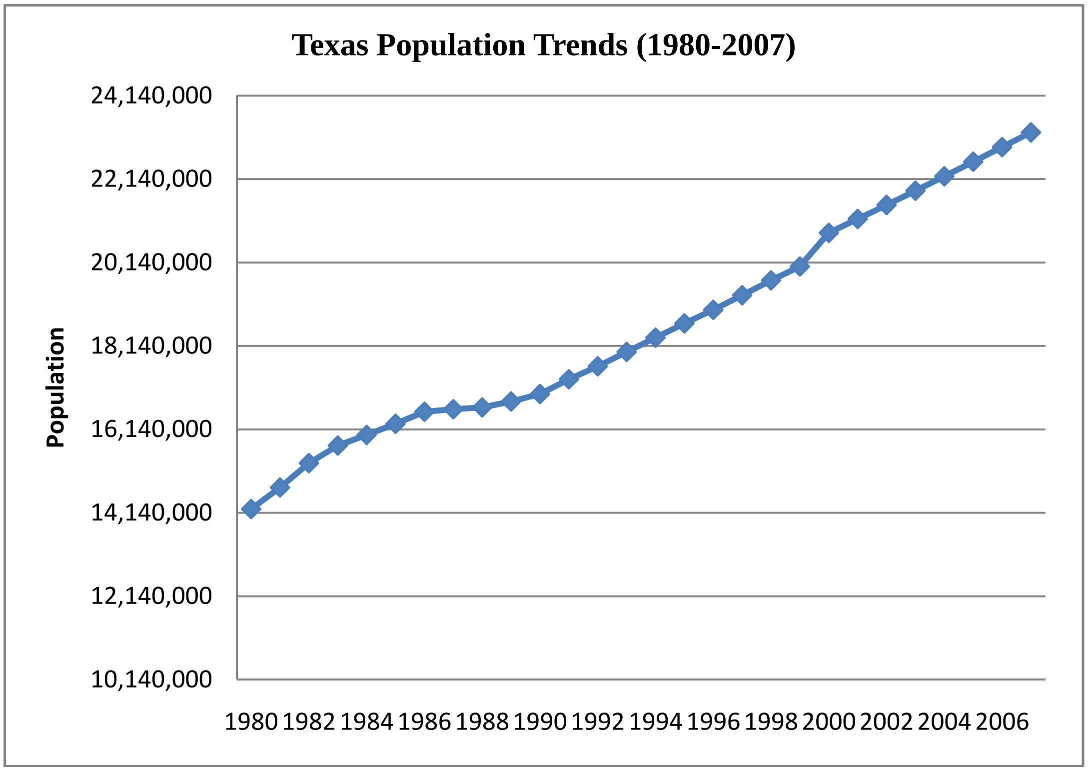
Table 3.1: Total Population and Percent Population Change in Texas and the United States, 1850-2005

Year	Total Population		Percent Change	
	Texas	U.S.	Texas	U.S.
1850	212,592	23,191,876		
1860	604,215	31,443,321	184.20	35.60
1870	818,579	39,818,449	35.50	26.60
1880	1,591,749	50,155,783	94.50	26.00
1890	2,235,527	62,947,714	40.40	25.50
1900	3,048,710	75,994,575	36.40	20.70
1910	3,896,542	91,972,266	27.80	21.00
1920	4,663,228	105,710,620	19.70	14.90
1930	5,824,715	122,775,046	24.90	16.10
1940	6,414,824	131,669,275	10.10	7.20
1950	7,711,194	150,697,361	20.20	14.50
1960	9,579,677	179,323,175	24.20	19.00
1970	11,196,730	203,302,031	16.90	13.40
1980	14,229,191	226,545,805	27.10	11.40
1990	16,986,510	248,709,873	19.40	9.80
2000	20,851,820	281,421,906	22.80	13.20
2005	22,859,968	296,410,404	9.60	5.30

*All values for the decennial dates are for the indicated census year. Values for 2005 are as estimated by the U.S. Bureau of the Census.

Source: Derived from U.S. Bureau of the Census Estimates for dates indicated by the Texas State Data Center, The University of Texas at San Antonio

Historically Texas has been a state with a rapid growth in population and it is still one of the fastest growing states in the U.S. (Figure 3.1).



Source: U.S. Census

Figure 3.1: Texas Population Trends 1980-2007

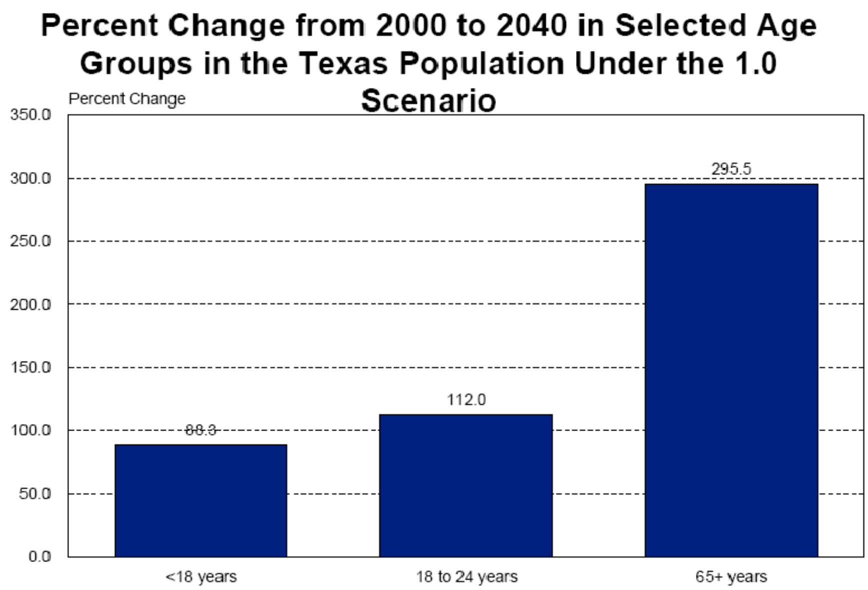
3.2.2 Demographics

Population alone does not take into account demographics. According to a recent article published in the Planning's November 2008 issue, the fertility rate in the United States is on the rise as the number of children born per woman is increasing steadily. In fact, the number of babies born in the U.S. last year was the largest number since the baby boomers in the 1950s—a new record of approximately 4.3 million. With the 2010 census count only 16 short months away, planners anticipate that the 2010 data will show how the "U.S. population is changing into a land of the fairly old and the fairly young" (PLANNING, 2008, p.34). Individuals born between 1946 and 1964, commonly referred to as "Baby Boomers," are living longer and aging, giving rise to the average age of Americans at 37 years old (PLANNING, 2008). From a planning perspective, this is a major problem; not only with regard to the strain on resources and public service but also on the tax revenue stream as the younger age group generally does not pay taxes or drive.

According to a presentation by the Institute for Demographic and Socioeconomic Research at the University of Texas at San Antonio, Texas will be undergoing some vast changes in demographics, particularly in its rate of population growth, increase in non-Anglo population growth, and aging of the population.

An area of concern of Texas's growing population is its aging population. In 2007, it was estimated that 8% of the population is between the ages of 0 and 4, 14.4% between 5 and 14, 44.8% between 15 and 44, 23% between 45 and 64, and 9.9% above 65 (Texas Department of State Health Services Center for Health Statistics).

According to projections made by the Institute for Demographic and Socioeconomic Research, from 2000 to 2040 there will be a 90% increase of the age group younger than 18, a 112% increase of the age group between 18 and 65 years, and an astonishing 300% increase of the age group older than 65 years (Figure 3.2).



Source: Institute for Demographic and Socioeconomic Research

Figure 3.2: Age Projection Increases from 2000 to 2040

If these projections are compared with the 2007 age distributions by DSHS, it can be inferred that these projections cannot be taken lightly. For example, the 15-44 year group will be 48 to 77 years old by 2040 and the 45-65 year group will be 78 to 97 years old. These age groups currently have the greatest percentages of the age distribution of Texas and will form a significant part of the population by 2040. These aging groups tend to drive less and their effect on future vehicles miles driven cannot be underestimated. A decrease in vehicles miles driven will mean less fuel consumed and less fuel tax revenue generated.

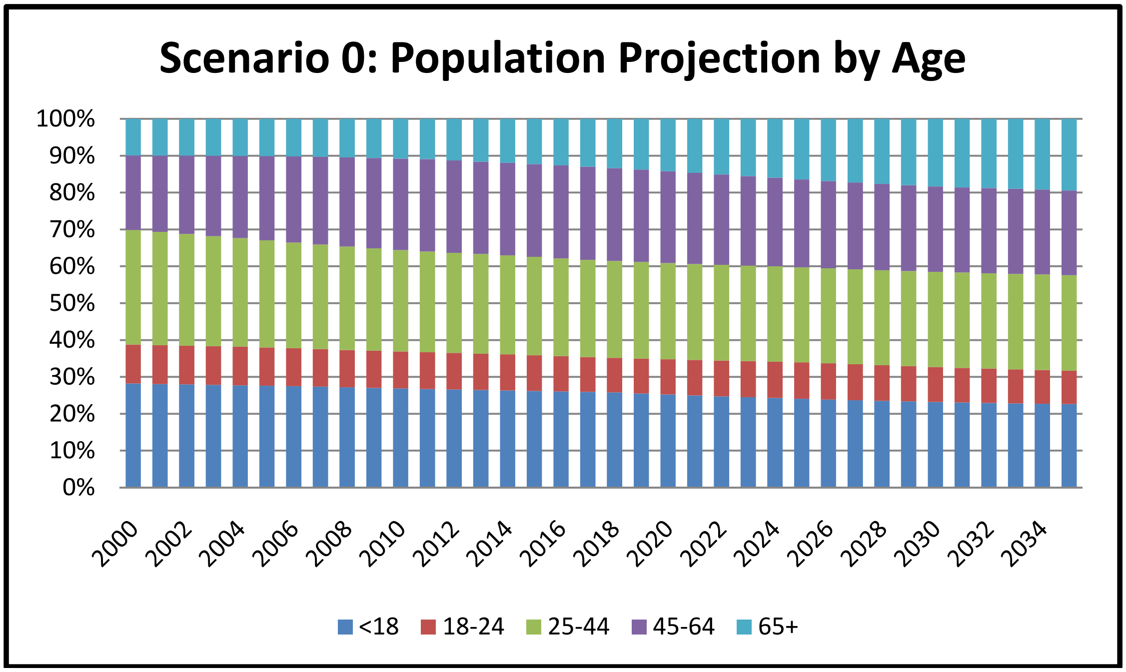
Demographics should be integrated as a factor affecting the fuel stream revenues. Without accounting for age groups that comprise the driving group and substantially contribute to the Texas Mobility Fund, the JACK Model makes a poor and inaccurate assumption of its revenue base or revenue projections. According to former state demographer, Steve Murdock, the Texas population mix is changing. It is predicted to become disproportionately younger, as well as less educated (in comparison to other states). Demographics changes in Texas are also predicted to have an adverse effect on the gas tax revenue stream as it is derived from automotive vehicles that run on gasoline and recent popularity in the hybrid vehicles along with new technologies on the market compromise this stream.

3.3 Effects of Population Changes on Fuel Consumption

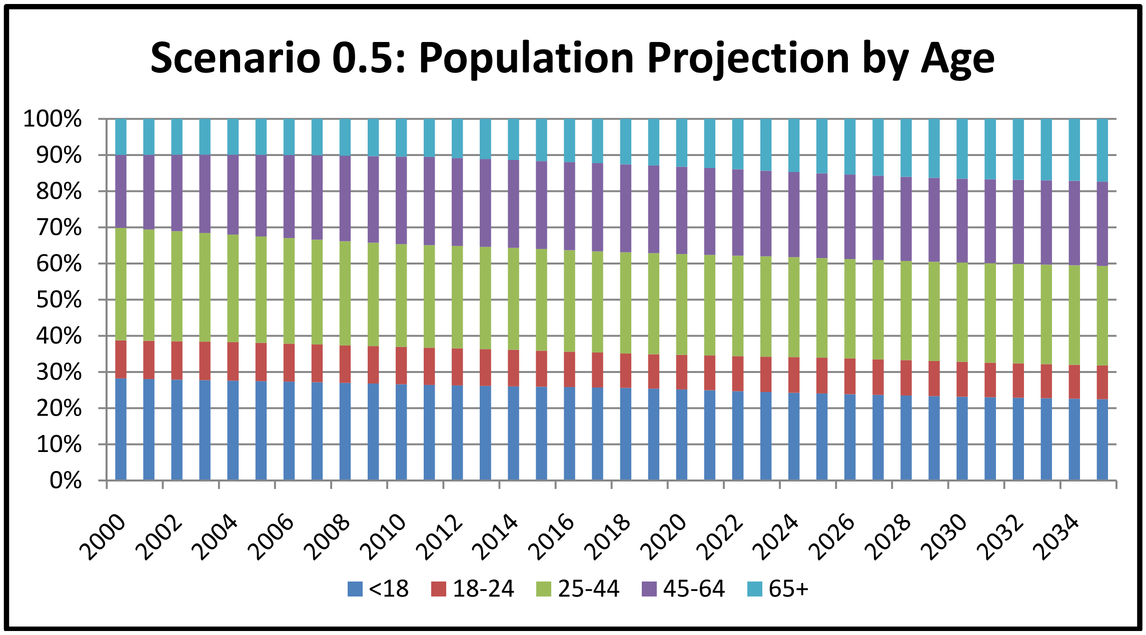
Population demographics indirectly influence the overall usage of motor fuel. For example, it is known that as people get older their driving behavior changes and they tend to drive less because of decreased visual acuity, slow reaction times, and fatigue. An aging population is therefore a matter of concern because retirees drive less, and thus will use less fuel, which in turn affects fuel tax revenues.

3.3.1 Population Trend Investigation

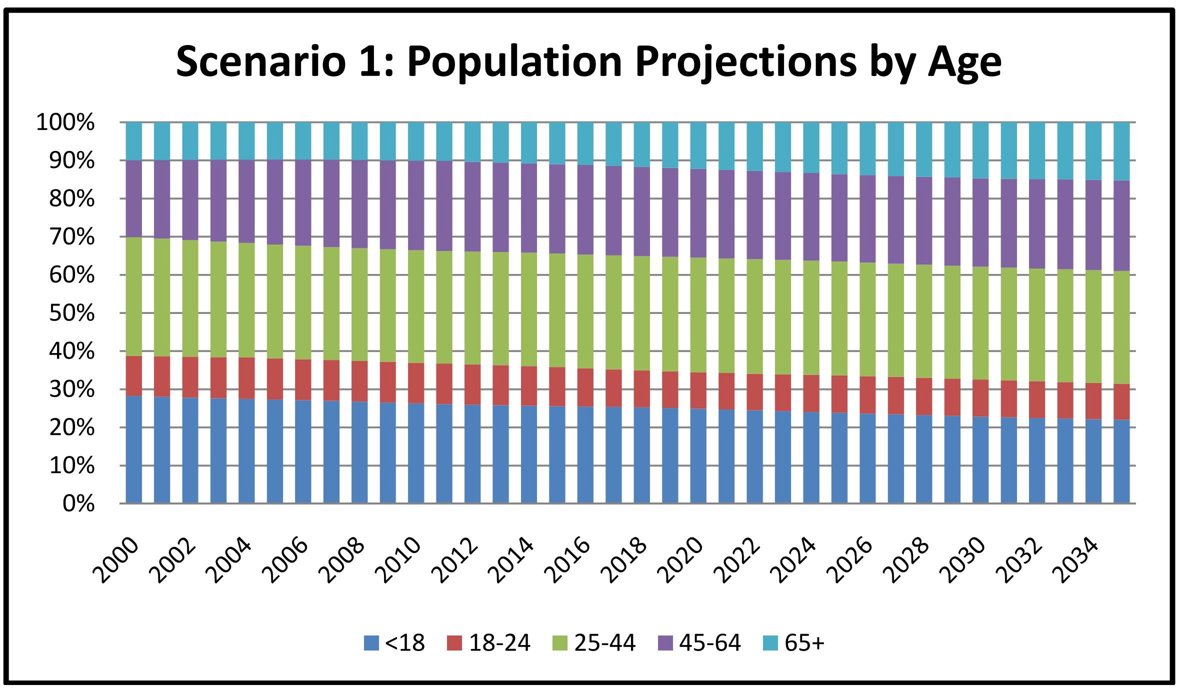
To assess the validity of this assumption, the researchers used data from the Office of the State Demographer of Texas. The population projections, for the different scenarios previously discussed, were obtained from the State Demographer as well. Figure 3.3(a–d) contains four graphs representing the percentage of change in different groups for each of the four main population projection scenarios.



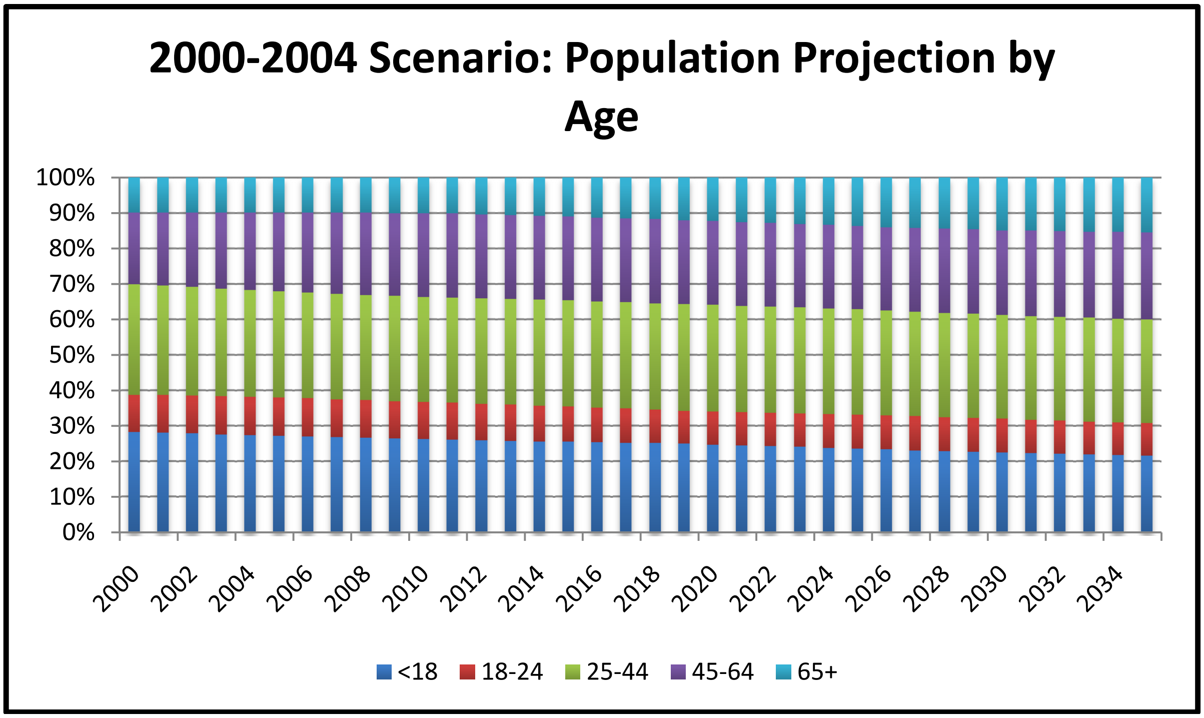
(a) Scenario 0



(b) Scenario 0.5



(c) Scenario 1



(d) 2000–2004 Scenario

Figure 3.3: Changes in each of the four main population projection scenarios

Each scenario clearly shows an increase in percentage of persons in the 65+ bracket. The figures show that the over 65 bracket in Texas could grow to be 20% of the population in 2035. The 65+ bracket was only 10% of the population in 2000. While the over 65 bracket is growing, the under 18 bracket is projected to shrink. The percentage of the population under 18 could shrink to just over 21% of the population in 2035, when it was 28% of the population in 2000.

In the most general terms, an aging population can greatly affect a nation's economy in two ways. The first, which will soon be demonstrated by the retirement of the Baby Boomer generation, is a possible decrease in economic development due to the shrinking of the labor force. There is also the issue of the social security system becoming bankrupt. The second is the issue of public health. An aging population will most likely indicate larger health care expenses and a strain on Medicare. The aging population in the U.S. will most likely affect the government's methods for funding, which can result in a larger strain on Fund 006.

An aging population will also have an effect on infrastructure. The baby boomers, unlike previous generations, have generally been more "on the go," While today's over 65 population tends to travel less, the new generation of persons over 65 will be more active. While the age at which persons still drive has increased, many elderly people do not drive. With the aging population and decrease in drivers, there will be less vehicle miles traveled and most likely less vehicles registered. A decrease in the number of drivers will also result in transit becoming more popular in urban areas. Travel safely and accommodating persons with disabilities also becomes an issues with the over 65 population. Highway designs and signage may need to be adjusted to reflect the capabilities of an aging population; cities will have to become more age friendly. These changes will affect TxDOT revenue and expenditures.

3.4 Chapter Conclusion and Continuing Work

The JACK model currently has no method which can take the changing population demographic into account in its future revenue calculations. The researchers plan to run sensitivity analysis on each of the different population groups. Creating an element of JACK that can factor in demographic changes will make the model's projections more accurate.

Chapter 4. Fuel Efficiency Trends

4.1 Chapter Scope

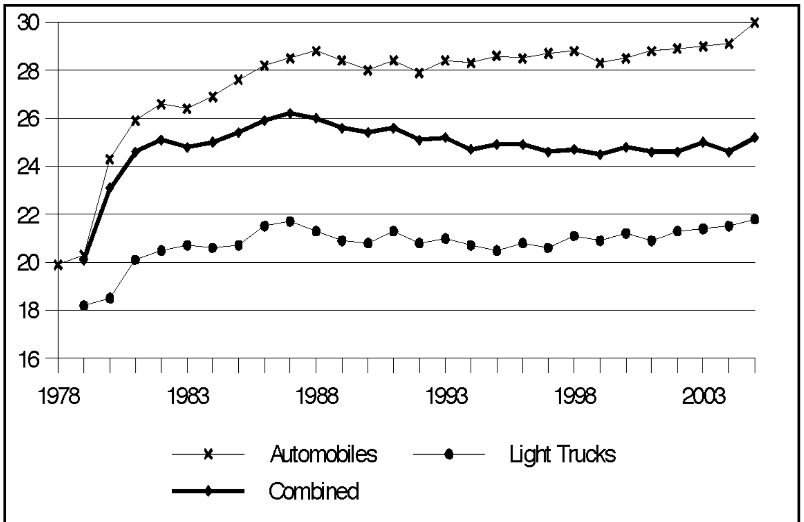
Research Work Plan Task 2: Estimate revenue impacts of potential future improvements in motor vehicle fuel efficiency:

a) Based on publicly available and sourced projections of fuel efficiency produce a range of likely fleet wide fuel efficiencies for Texas through 2035.

b) Assess the effect of changes in vehicle fuel efficiency on state and federal motor fuel tax revenues.

4.1.1 Background

National and state transportation programs rely heavily on fuel taxes. As of October 2008, the federal fuel tax rate was 18.4 cents per gallon (cpg) for gasoline and 24.4 cpg for diesel fuel. The State of Texas applies an additional 20 cpg tax on motor fuel for most uses. Currently, these taxes are not indexed to the price of fuel or any inflation rate, and have not been increased since 1993. In the meantime, as shown in Figure 4.1, vehicle fuel efficiency has increased in the U.S., resulting in less fuel tax revenue per mile driven on the highway network.



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Summary of Fuel Economy Performance*, March 2005.

Figure 4.4: Changes in U.S. Vehicle Fuel Efficiency Since 1978

The figure also shows significant differences in fuel efficiency among vehicle types. Thus, the composition of the vehicle fleet has an effect on the amount of each type of fuel consumed. For example, large passenger vehicles (now grouped with light trucks which have lower fuel economy) have proliferated. At the same time nationally there has been growth in the number of diesel-consuming heavy trucks with low fuel efficiency. These trends are important in predicting future fuel consumption and fleet fuel efficiency.

Vehicle fuel efficiency in the U.S. has been driven by legislated fuel economy standards. Fuel economy is determined under the Energy Independence & Security Act of 2007 (formerly the Energy Policy & Conservation Act, 1975—as amended). In 2007 Congress amended the Corporate Average Fuel Economy (CAFE) rules for passenger vehicles and light trucks after a ten-year hiatus. Fuel economy standards are likely to see further tightening in light of concerns regarding global warming. These factors all complicate the process of predicting future fuel efficiency.

4.2 Legislative Forces

Due to poor air quality in industrial towns in the 1940s and 1950s, the federal government began to implement emissions and air quality legislation [United States Environmental Protection Agency website (US EPA)]. Measures included the banning of leaded fuel and regulation of motor vehicle emissions, which in turn led to improved vehicle fuel efficiency.

4.2.1 Clean Air Act

In 1970, there was a comprehensive federal response to address air pollution through the Clean Air Act, which required that automobile emissions standards be met within an aggressive timeframe. The act focused primarily on pollutants identified as having direct human health effects, and created provisions for areas that were in non-attainment, requiring them to produce an emissions inventory for each pollutant that violated the mandated standards. Once the standards were in place, severe fines of up to $10,000 were charged for each automobile that did not meet the new standards, forcing the auto industry to comply (Margolis, 1977).

4.2.2 Corporate Average Fuel Economy (CAFE) Standards

Fuel prices have also played a role in improving fuel efficiency. As a result of the Arab oil embargo in the early 1970s, the price of crude oil tripled. Higher fuel costs brought into the spotlight the poor fuel economy of U.S. vehicles [there had been a decline in new car fleet fuel economy from 14.8 mpg in Manufacture Year (MY) 1967 to 12.9 mpg in MY 1974 (Yacobucci, 2007)]. Because transportation is a large consumer of petroleum, one way to reduce U.S. dependency on foreign oil is to improve vehicle fuel efficiency.

Congress established CAFE standards under subchapter V of the Motor Vehicle Information and Cost Savings Act (MVICSA), part of the Energy Policy Conservation Act (EPCA) of 1975 (Gerrard, 2007). The Act established certain CAFE standards for MY 1978 passenger cars (NHTSA, and Yacobucci, 2007). The CAFE standards also called for new car feet fuel economy standards to eventually be doubled. The EPCA granted the National Highway Traffic Safety Administration (NHTSA) authority to establish CAFE standards for not only cars, but also other classes of vehicles such as light duty trucks (sport utility vehicles, vans, and pick-up trucks). Standards set forth by the NHTSA took effect for MY 1979 for light trucks, while standards for cars were effective for MY 1978 (Yacobucci, 2007).

CAFE is “the sales weighted average fuel economy, expressed in miles per gallon, of a manufacturer’s fleet of passenger cars or light trucks with a gross vehicle weight rating of 8,500 lbs. or less, manufactured for sale in the United States, for any given model year” (NHTSA 2008). Fuel economy is derived by taking the average mileage traveled by an automobile per gallon of fuel that is consumed, as measured in accordance with the testing and evaluation protocol set forth by the EPA. In 2006, NHTSA issued additional rules to further increase fuel economy standards for light duty trucks through MY 2011, as shown in Table 4.1.

Table 4.2: Fuel Economy Standards for Passenger Cars and Light Trucks: Model Years 2000 through 2011 (in miles per gallon)

Model Year	Passenger cars	Light trucks
2000-2004	27.5	20.7
2005	27.5	21.0
2006	27.5	21.6
2007	27.5	22.2
2008-2010	27.5	23.5
2011	27.5	24.0

Source: U.S. Department of Transportation and National Highway Traffic Safety Administration

Failure to meet CAFE standards can result in fines on manufacturers of up to $5.50 per tenth of a mile per gallon (mpg) for each tenth under the target value. However, manufacturers can earn "credits" to offset deficiencies in their CAFE performances. The amount of credit a manufacturer earns is determined by multiplying the tenths of a mile per gallon that the manufacturer exceeded the CAFE standard in that model year by the amount of vehicles they manufactured in that model year. These credits can be applied to any three consecutive model years immediately prior to or subsequent to the model year in which the credits are earned. Light trucks that exceed 8,500 lbs gross vehicle weight rating (GVWR) do not have to comply with CAFE standards. These vehicles include pickups, sport utility vehicles, and large vans (CAFE, 2008).

4.2.3 Recent Changes to Fuel Economy Standards

In December 2007, the EPA revised its method of calculating the fuel economy of new vehicles, in order to provide consumers with a more realistic mpg estimate. Taking effect for all MY 2008 vehicles, the change is considerable. The EPA reported that "miles per gallon in city driving may drop by as much as 30 percent for gas-sippers like hybrids" and "on average, city mileage for all vehicles is expected to be about 12 percent lower; highway estimates could be as much as 8 percent lower" (New York Times, 2006).

The Energy Independence and Security Act of 2007 requires fleetwide fuel economy of 35 mpg by 2020 as calculated by the new method (Sissine 2007). The bill also "directs the Secretary to study the fuel efficiency of work trucks and commercial medium-duty or heavy-duty on-highway vehicles to determine appropriate test procedures, methodologies, and metrics for measuring such efficiency" (Govtrack.us, 2007).

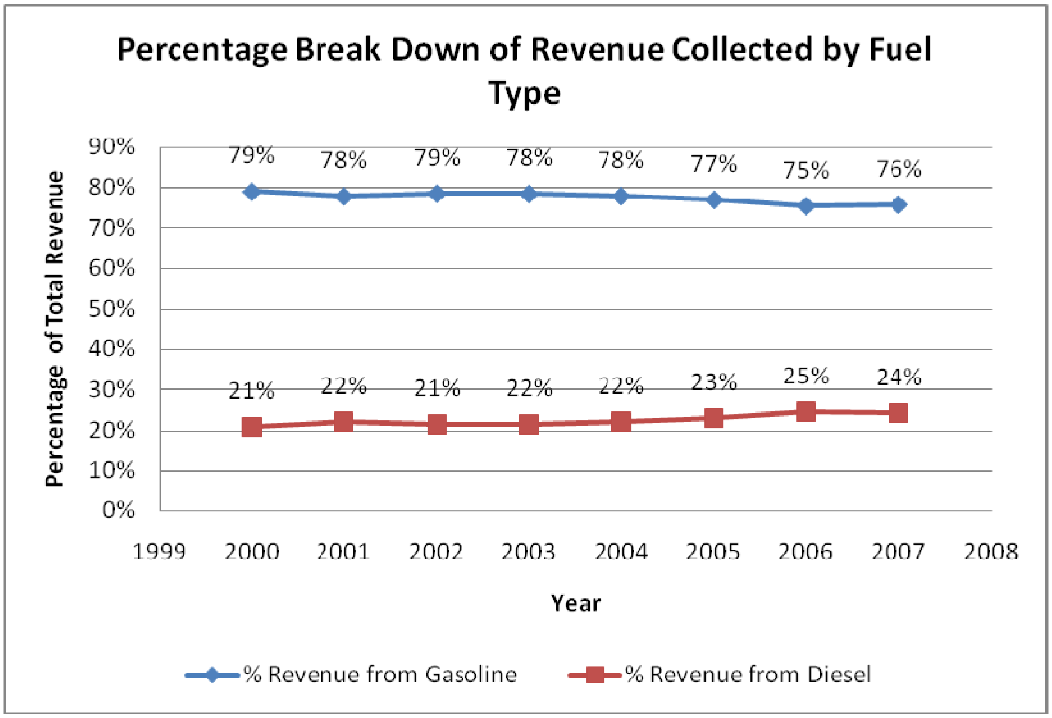
Undoubtedly, federal legislation has been instrumental in forcing improvements in U.S. vehicle fuel efficiency. Most of the gains seen in the last 30 years are due to federal mandates. In the future, market forces are also likely to play a role due to fuel prices and motorist choices. Those factors will be discussed later in this chapter.

4.3 The JACK Model for Fuel Revenue Estimation

The JACK model estimates future fuel tax revenues using a composite fuel tax rate. JACK assumes that 25% of fuel taxes come from diesel and 75% from gasoline. The federal tax rates of 24.4 cpg for diesel and 18.4 cpg for gasoline are combined to a composite motor fuel tax of 19.9 cpg. However, this assumption may lead to errors.

4.3.1 Gasoline and Diesel Consumption

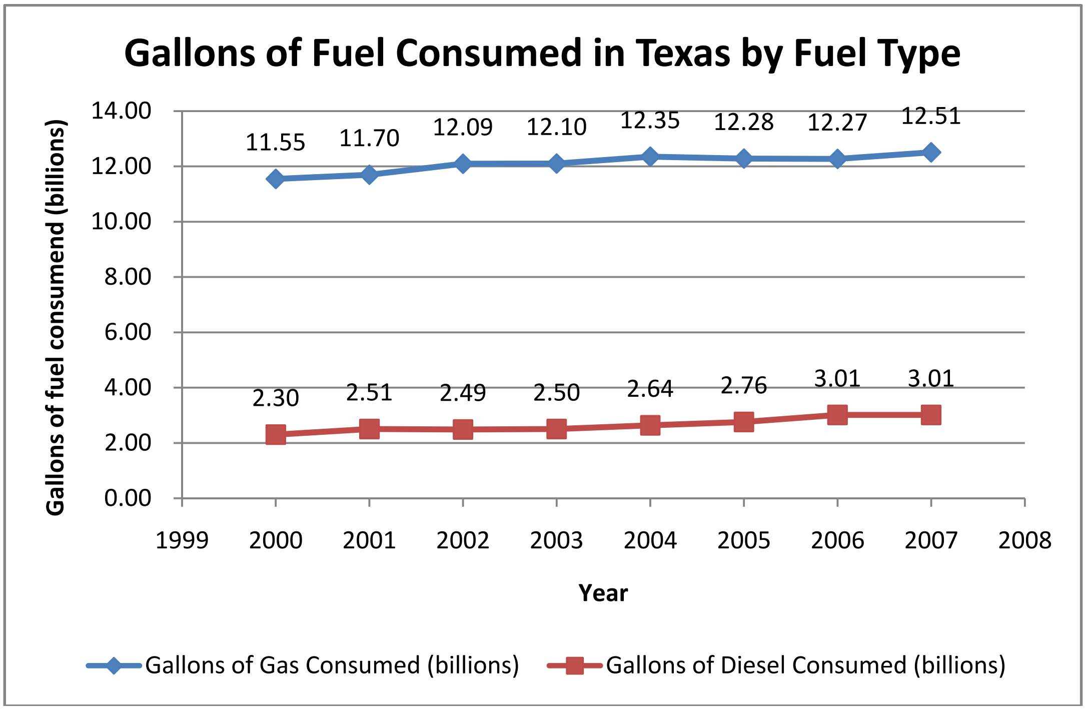
From 2000 to 2007, the fraction of total fuel tax revenue in Texas derived from gasoline sales decreased from 79% to 76%, while the diesel fraction rose from 21% to 24%, as shown in Figure 4.2.



Source: State of Texas Annual Cash Reports from 2001 to 2007

Figure 4.5: Motor Fuel Tax Revenue by Fuel Type

The trends in the revenue fractions are due to trends in the proportion of gasoline to diesel consumed. Figure 4.3 shows the total gallons of each fuel consumed in Texas each year from 2000-2007. Diesel has gone from 17% to 19% of total gallons used, while gasoline has dropped from 83% to 81% (State of Texas Annual Cash Reports, 2001-2007).



Source: State of Texas Annual Cash Reports from 2001 to 2007

Figure 4.6: Gallons of Fuel Consumed in Texas by Fuel Type

These data suggest that JACK's assumption of 25% as the proportion of diesel fuel tax is too high. Moreover, that proportion is likely to change in the future. To avoid the error in using a composite fuel tax rate, it may be better to do a revenue calculation for each fuel type separately.

4.3.2 JACK Model Fuel Economy Inputs

The JACK model uses assumptions of current and future Texas fleet fuel economy in miles per gallon (MPG) to calculate future revenues. Projections of future fleet fuel economy are taken from scenarios developed by Cambridge Systematics [Texas Fleet Fuel Efficiency Revisions (Cambridge Systematics, 2008), provided by TxDOT to the research team], critiqued later in this chapter. A reduction rate (RR) is calculated for each year from 2008 to 2035 using the following formula:

$$RR = \frac{Present\ MPG}{Future_X\ MPG}$$

Where the subscript X represents a given year from 2008 to 2035.

The fuel tax revenue for year X is calculated by multiplying the reduction rate by the present fuel tax revenue:

$$Fuel\ Tax\ Revenue_X = RR_X \times\ Fuel\ Tax\ Revenue_{Present}$$

The JACK model assumes a current Texas fleet fuel economy of 17.9 mpg that was derived from the Cambridge Systematics (CS) report. Our review of the Cambridge report found that this value is based on U.S. fleet estimates of fuel used and average vehicle miles traveled (VMT). However, our research indicated that typical Texas VMT is different from the U.S. average. Therefore, two estimates were calculated for our analysis: one weighted by VMT, and the other weighted by energy consumption. Indirect estimates were also made by weighting the U.S. estimates with Texas vehicle registration data.

4.3.3 Present Fleetwide Fuel Economy Calculations

U.S. VMT data for the three primary vehicle classes (passenger cars, light trucks, and heavy trucks) was obtained from FHWA (2008), and U.S. gasoline and diesel consumption data was obtained from Davis & Diegel (2008). Because VMT for each vehicle class was not broken into gas and diesel, we calculated it by using the energy factor (BTU) for each engine class. For example, the calculation for gasoline car VMT is:

$$VMT_{gasoline\ car} = VMT_{car} \times \frac{BTU_{gasoline\ car}}{BTU_{car}}$$

We also used the BTU factor to split out the fuel consumed within each vehicle class. Taking the calculated gallons consumed in each engine class and dividing it into the VMT for each engine class gives the net fuel economy for that class. For example, the calculation for gasoline car MPG is:

$$MPG_{gasoline\ car} = \frac{VMT_{gasoline\ car}}{Gasoline\ Consumption}$$

The estimate of U.S. fleet average fuel economy, weighted by VMT:

$$US\ Fleet\ MPG_{VMT} = \left(MPG_{vehicle\ type} \times \frac{US\ VMT_{vehicle\ type}}{US\ VMT_{total}}\right).$$

Table 4.2 summarizes our calculation of present fuel economy for passenger cars, light trucks, and heavy trucks using gasoline and diesel fuel.

Table 4.3: U.S. Fuel Economy by Vehicle and Fuel Type.

	VMT – Gasoline (Millions)	VMT – Diesel (Millions)	Gasoline Consumption (Billion Gal)	Diesel Consumption (Billion Gal)	MPG Gasoline	MPG Diesel	MPG Com-bined
Car	1,673,239	9,431	80.8	0.4	20.7	23.5	20.7
Light-duty truck	1,039,969	49,043	62.5	2.6	16.6	18.9	16.7
Heavy-duty truck	22,439	200,084	4.6	35.8	4.9	5.6	5.5

Texas fleet fuel economies were estimated by using the same equations. The ratios for VMT and BTU consumption were altered to better reflect the Texas vehicle fleet. Texas vehicle registration information is from the Texas Vehicle Title and Registration Division (VTR) database. For example, the following equation was used to estimate BTUs consumed by cars.

$$BTU_{carTX} = BTU_{carUS} \times \frac{\# Cars_{VTR}}{\# Cars_{US}}$$

These indirect Texas fuel economy calculations were necessary due to lack of Texas data on fuel consumption and VMT. Table 4.3 shows the Cambridge Systematics present fuel economy estimate as well as ours. The difference between 17.9 and 18.03 is small, and given the assumptions in our calculations, not significant.

Table 4.4: Comparison of Current Fuel Economy Estimations

Source	Fuel Economy (MPG)
Cambridge Systematics	17.9
U.S. Fleet Average (VMT weighted)	18.03
TX Fleet Average (VMT weighted)	18.03
U.S. Fleet Average (BTU weighted)	15.77
TX Fleet Average (BTU weighted)	16.00

The BTU weighted figures are much lower. Figure 4.4 shows the impact on future revenue of using these MPG figures.

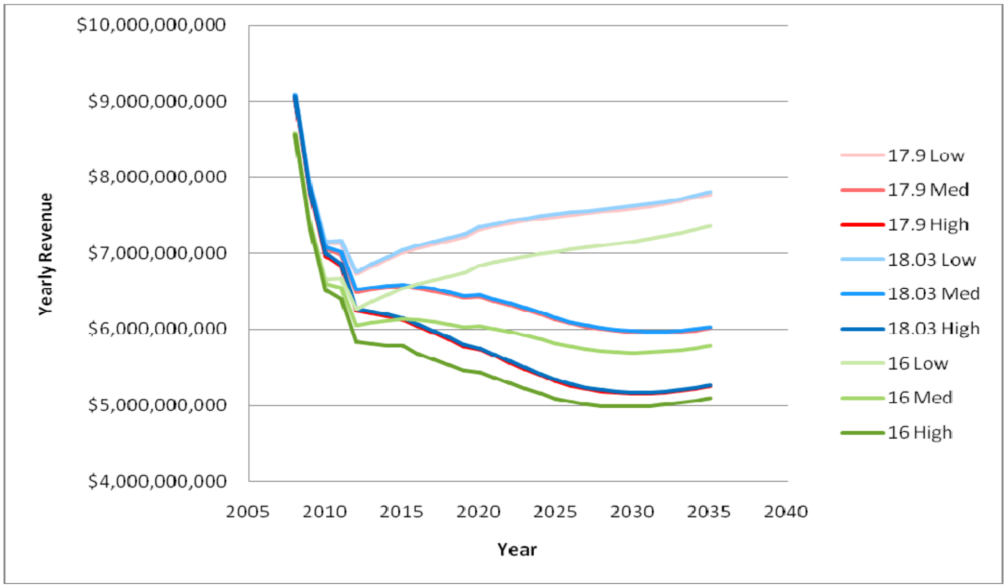


Figure 4.7: Assumptions of Present Fuel Efficiency and Effects on Revenue Projections

Changing present fuel economy from 17.9 to 18.03 mpg has little impact on the projected revenue. Conversely, when applying the "low" fuel economy scenario of 16.00 mpg, total revenue significantly decreased by about $420 million. When applying the "medium" scenario, the revenue decreased by about $230 million and by about $150 million when applying the "high" scenario. (Note: The figure shows a substantial decrease in revenue projected to occur between the 2008-2010 timeframe, as a result of changes in The Texas Mobility Fund. The 2008 value of this fund is $2.6 million, but diminishes to $1.1 million in 2009 and $0 thereafter.)

A gradual increase from 2010-2035 for the low scenario is also depicted in the graph, due to population growth causing increases in vehicle registrations and vehicle-miles traveled (VMT). When applying the low scenario, fuel tax revenue increases mainly because of increased VMT, which grows at a substantially faster rate than the rate at which fuel economy can improve. In the medium and high scenarios, fuel economy improvement rates overcome population growth and VMT, resulting in a decrease in fuel tax revenue.

4.4 Cambridge Systematics Fuel Economy Projections

The fuel economy projections used by the JACK model are from a Cambridge Systematics (CS) study, cited as Cambridge Systematics, 2008. Primary model inputs include vehicle fleet composition, proportion of new vehicles in fleet, future market penetration rates for diesel and hybrid vehicles, fuel economy growth rates by vehicle type (and any policies forcing a change in these trends), and fleet-wide VMT growth rate (weighted by vehicle fleet composition). Of these inputs, fuel economy growth rates and market penetration were determined by CS to be the most sensitive.

4.4.1 CS Fuel economy scenarios

Nine scenarios were considered by CS, consisting of combinations of low, medium, and high projections of fuel economy growth (MPG) and market penetration (MP) of hybrids and diesel vehicles. The scenarios are the following:

- Low MP and low MPG
- Low MP and high MPG
- Low MP and medium MPG
- Medium MP and low MPG
- Medium MP and high MPG
- Medium MP and medium MPG
- High MP and low MPG
- High MP and high MPG
- High MP and medium MPG

All nine scenarios assume that 7% of vehicles are new and that fleet compositions are comprised of 51% cars, 40% light-duty trucks, and 9% heavy-duty vehicles. High and low market penetration assumptions derived from a TechCast survey (that included input from Business Week and Bosch Corporation). The CS assumptions of hybrid market penetration are shown in Table 4.4. The medium values for scenarios are simply the arithmetic averages of low and high values. As a basis for comparison, the current market penetration of hybrid vehicles is 2.5%, and that of diesel is 0.1% (EPA 420-S-08-003).

Table 4.5: Market Penetration of Hybrid and Diesel Vehicles (%)

	2006	2008	2010	2025
Hybrid (high)	1.6	2.5	15	75
Diesel (high)	3.6	0.1	6	20
Hybrid (low)	1.6	2.5	4	15
Diesel (low)	3	0.1	6	20

Source: Cambridge Systematics, 2008, and EPA 420-S-08-003

High fuel economy growth rate assumptions utilized in the CS model applied trends from 1983 to 2003 for diesel and gasoline passenger cars, as well as for heavy-duty vehicles. In addition, the hybrid vehicle fuel economy was assumed to increase by 19.5% per year, achieving a goal of 100 mpg by 2012. Gasoline truck fuel economy was assumed to increase by 7.1% per year, reflecting new Corporate Average Fuel Economy (CAFÉ) standards that require an achievement of 24 mpg by 2011. The low fuel economy growth rate assumptions assumed trends from 1983 to 2003 for all vehicle types, except for light-duty trucks, which are assumed to still meet 2011 standards. These fuel economy projections did not include the recent change in CAFÉ standards, requiring new vehicle fleets to reach 35 mpg by 2020.

The fuel economy projections for each vehicle type were averaged by CS, weighted by the vehicle fleet composition (51% cars, 40% light duty trucks, and 9% heavy duty trucks). This fleet composition is based on Texas vehicle registration data, with trucks separated into light and heavy duty categories using U.S. truck VMT data derived from the Cambridge Systematics report. This same fleet composition is used for gasoline and diesel vehicles. However, this methodology is problematic because the majority of diesel vehicles, 92%, are heavy duty vehicles (Davis and Diegel 2008).

Moreover, because the fuel economy estimates are being used to predict fuel consumption, we believe it would be better to use a fleet composition based specifically on the Texas fuel consumption or VMT data, rather than vehicle registrations. For example, heavy-duty vehicles only represent 10% of vehicle registrations, but consume 20% of diesel and gasoline fuel (in BTU). Because the portion of fuel economy that the heavy-duty vehicles comprises is so small, basing average fleet wide fuel economy on vehicle registrations would result in values that are too high, resulting in biased values. As a result, using the 2035 assumptions of the Cambridge Systematics fuel economy projection model provided a 41 mpg when applying the "low" scenario, 74.7 mpg using the "medium" scenario, and 114.4 mpg using the "high" scenario.

4.4.2 Critiquing and Modifying the Cambridge Systematics Model

In critiquing the Cambridge Systematics spreadsheet for fuel economy projections, we used the data provided as a base and applied the input assumptions adjusting them to address the aforementioned issues. When applying the new assumptions, fleet wide fuel economy projections for the year 2035 were estimated to be in the range of 29.0-55.3 mpg in contrast to the 2006 fleet wide fuel economy of 17.9 mpg, and Cambridge Systematics projections previously identified. With regard to assumptions, the most substantial differences occurred primarily where:

- the average fuel economy growth of conventional vehicles was adjusted (higher) to include the 2007 CAFE standards for light duty vehicles;
- where the assumptions regarding current hybrid vehicle fuel economy was adjusted;
- and where the fleet composition was adjusted to reflect vehicle miles traveled (VMT) and fuel type.

It should be noted that the distinction between the low-end and high-end projections is the assumption on hybrid fuel economy growth. The high-end model assumes that hybrid cars will progress at a rate to meet 100 mpg by 2025 (due to market penetration of plug-in hybrid vehicles). We think that this is an optimistic, but achievable goal assuming that plug-in hybrids dominate the hybrid market by the end of the study period (2025). The following steps outline the modifications made to the Cambridge Systematics model for estimating future fleets' fuel economy.

1. Fuel economy growth rates were modified to meet 2020 CAFÉ requirements: fleet average of 35 mpg by 2020, and a minimum of 27.5 for all light-duty vehicles (LDV). This was interpreted as cars achieving 35 mpg by 2020, and trucks meeting 27.5 mpg by 2020 (after meeting 24 mpg by 2011)
2. Rate for gasoline cars from 2006 to 2020 = $\left[\left(\frac{35}{19.3}\right)^{\left(\frac{1}{14}\right)}\right] - 1$, where 19.3 is the fuel economy in 2006 (Cambridge Systematics 2008), 35 is the target for 2020, and 14 is the number of years to accomplish this improvement.
3. Rate for gasoline trucks from 2011 to 2020 = $\left[\left(\frac{27.5}{24}\right)^{\left(\frac{1}{9}\right)}\right] - 1$, where 24 is the fuel economy required in 2011, 27.5 is the mpg required in 2020, and 9 is the number of years to accomplish this improvement.
4. Rate for hybrid cars from 2006 to 2025 = $\left[\left(\frac{100}{36.3}\right)^{\left(\frac{1}{19}\right)}\right] - 1$, where 36.3 is the average hybrid fleet fuel economy for model year 2009 Department of Energy (DOE 2008), 100 is anticipated fuel economy of hybrids in 2025 (assuming PHEVs will be a substantial portion of market), and 19 is the number of years to accomplish this improvement. This rate was only used in the "high" forecast, and is the only difference between the high and low forecasts. This rate of fuel economy improvement for hybrid vehicles changed from 1.4% (current rate of improvement) to 5.5%.

5. The fuel economy improvement rate for diesel cars and trucks were determined with similar formulas. Table 4.5 shows the fuel economy improvement rates used in the Cambridge Systematics model, and Table 4.6 shows the modification of these rates to include new 2020 CAFE standards.

Table 4.6: Cambridge Systematics Fuel Economy Improvement Rates

	2006-2012	2012-2030
Conventional Gasoline Car	1.4%	1.4%
Conventional Diesel Car	1.4%	1.4%
Conventional Gasoline Truck	7.1%	1.3%
Conventional Diesel Truck	1.3%	1.3%

Table 4.7: Modified Fuel Economy Improvement Rates

	2006-2012	2012-2020	2020-2025
Conventional Gasoline Car	4.3%	4.3%	1.4%
Conventional Diesel Car	1.9%	1.9%	1.4%
Conventional Gasoline Truck	7.1%	1.5%	1.3%
Conventional Diesel Truck	1.3%	1.5%	1.3%

When applying these modified fuel economy improvement rates in the Cambridge model and keeping all other assumptions constant, the 2025 prediction for fleet-wide fuel economy increases from 27.1 mpg to 31.7 mpg.

1. The fleet composition used in calculating VMT growth was altered based on VMT, rather than registered vehicles. The fleet composition used in the Cambridge model based on registered vehicles (and then VMT of truck types) was 51% cars, 40% light trucks, and 9% heavy trucks.
    a. Using U.S. VMT data, the fleet composition is 56% cars, 36% LDT, and 8% HDT (FHWA 2008).
    b. As a consequence of using the U.S. VMT data, this adjusted annual VMT growth to 1.100% (up from 1.067%).
    c. When using this fleet composition, with all other assumptions kept the same, the 2025 fleet wide fuel economy decreases very slightly from 27.1 mpg to 27 mpg.

2. The fleet composition used in averaging the fuel economy of different fuel types was altered based fuel consumption (Davis & Diegel 2008):
    d. Diesel car = 1%, light trucks = 7%, heavy trucks = 92%
    e. Gasoline car = 55%, light trucks = 42%, heavy trucks = 3%
    f. These values were used in “MPG New Forecast” Tabs.
    g. When using these fleet compositions to calculate the future market shares of gasoline and diesel vehicles, with all other assumptions kept the same, the 2025 fleet wide fuel economy estimates decrease from 27.1 mpg to 25.8 mpg.

3. The current (2009) fuel economy of hybrids was also adjusted by averaging the fuel economy achieved by car hybrids and LDT hybrids using combined city and highway fuel economy (DOE, 2008).

h. The average fuel economy of hybrid cars in 2009 is 36.3 mpg (up from 34.4 mpg),

i. The fuel economy of hybrid trucks/SUVs is 24.8 mpg (down from 30 mpg).

j. When using these values for present hybrid vehicle fuel economy, with all other assumptions kept the same, the 2025 fleet wide fuel economy decreases very slightly from 27.1 mpg to 27 mpg.

4. Results:
   k. When including all 4 assumption changes, the high-end forecast of fleet wide fuel economy in 2035 is 55.3 mpg.
   l. When including all assumption changes, except the increased rate of hybrid fuel economy improvements, the low-end forecast of fleet wide fuel economy in 2035 is 29.0 mpg.

Evidenced from the results of these modifications to the original Cambridge Systematics assumptions, changes to the present fuel economy and overall fleet composition do not have a considerable effect on the fuel economy projections. However, modifying the rate of fuel economy improvements, and changing fleet composition to reflect fuel type results in a relatively large effect on the fuel economy projections.

It should be noted however, that that the assumptions having the least amount of certainty have the most substantial affects on the fuel economy projections. For example, the rate of hybrid vehicle fuel economy improvements, and their corresponding market penetrations, has a relatively large impact on fleet wide fuel economy projections. Increasing the rate of fuel economy improvement to 100 mpg hybrid fleet in 2025 (thanks to plug-ins) increases the fleet wide 2035 fuel economy from 29.0 mpg to 55.3 mpg. This same effect would be seen if the model included a rapid increase in the efficiency and market penetration of other alternative vehicle technologies such as fuel cell vehicles and bio-fueled vehicles.

In general, because these fuel economy projections are lower than the Cambridge Systematics fuel economy projections, the JACK-estimated 2035 revenue will be higher. Table 4.7 shows total revenue projections for year 2035 using our recommended low and high projections in comparison to the Cambridge Systematics' low, medium, and high projections; the differences are quite dramatic.

Table 4.8: The Effect of Fuel Economy Projections on 2035 Revenue

New Scenario	Total Revenue ($Billion)	Cambridge Systematics Scenario	Total Revenue ($Billion)
Low	9.4	Low	7.8
		Med	6.0
High	6.8	High	5.3

4.5 JACK Usage of Non-CS MPG Scenarios

A critical part of the JACK Model revenue prediction is the yearly average mpg calculation, which is also closely linked to the Reduction Rate utilized in the calculation as one of two main components generating revenues from fuel taxes, SMFT and the FMFT. For model revenue accuracy predictions, it is critical to achieve the most accurate Reduction Rate as possible. In using the JACK model, one can choose between pre-determined scenarios, or enter one's own value for the year 2035 to generate a prediction of average mpg for a given year. Figure 4.5 shows how the mpg varies with several scenarios pre-determined.

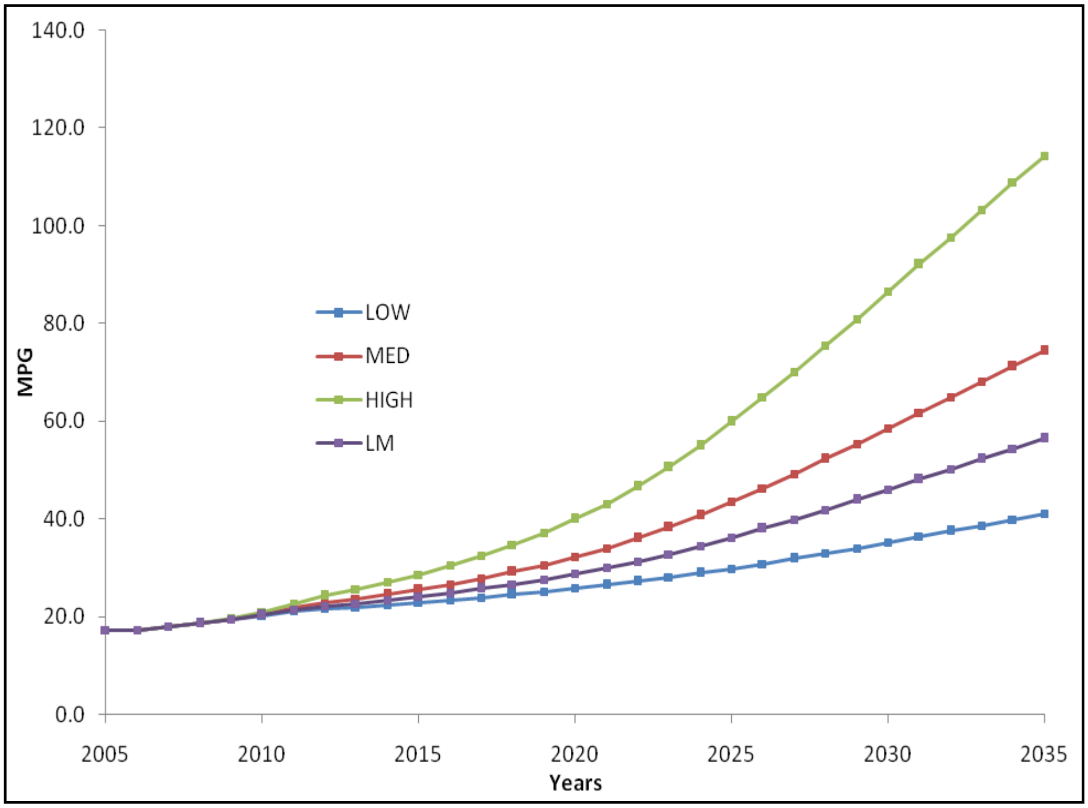


Figure 4.8: MPG Evolution on Pre-Determined JACK Scenarios

The three scenarios depicted above are the values obtained when applying the "low," "med," "high," or "LM" in the 2035 mpg box. For the purposes of revenue predictions, the model allows for the selection of one of these scenarios, which then provides a correlated value for the average mpg calculation for each year.

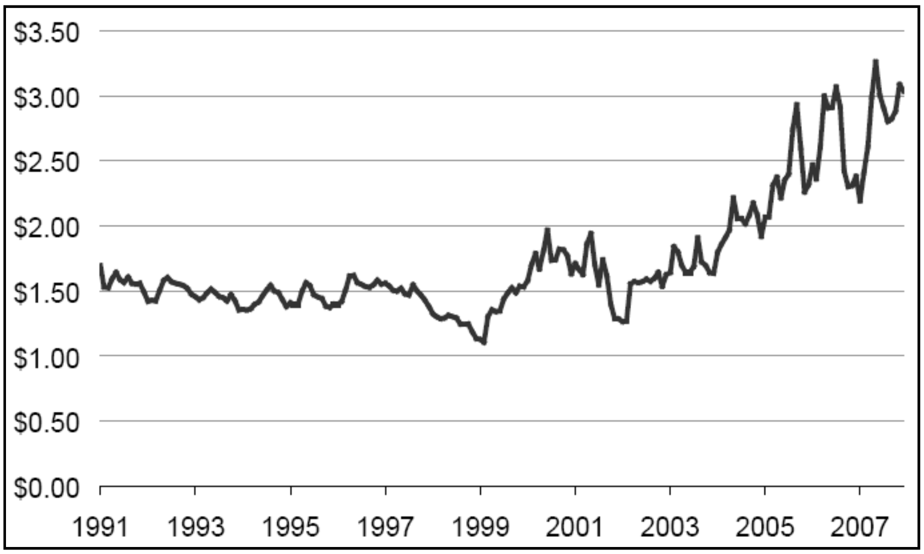
When a value is entered as a 2035 predicted MPG, the system has, of course, no pre-determined scenario to rely on; instead it uses a straight line fit for the intervening years. The annual increase is the difference between the projected mpg and the current mpg, divided by the 27 years that the model predicts. The problem with this approach is that it does not match the other exponential growth lines, creating possibly large errors in intervening years. The researchers recommend a change in the JACK model to use an exponential fitted line on a user-inputted MPG.

4.6 Effects of Commuter Choices on Fuel Tax Revenue

Fuel tax revenue is a function of fuel consumption, which in turn depends on commuter choices. Commuter behavior is affected by a multitude of factors, but two are likely to play strong roles in the future: fuel prices and environmental concerns.

4.6.1 Fuel Prices and VMT

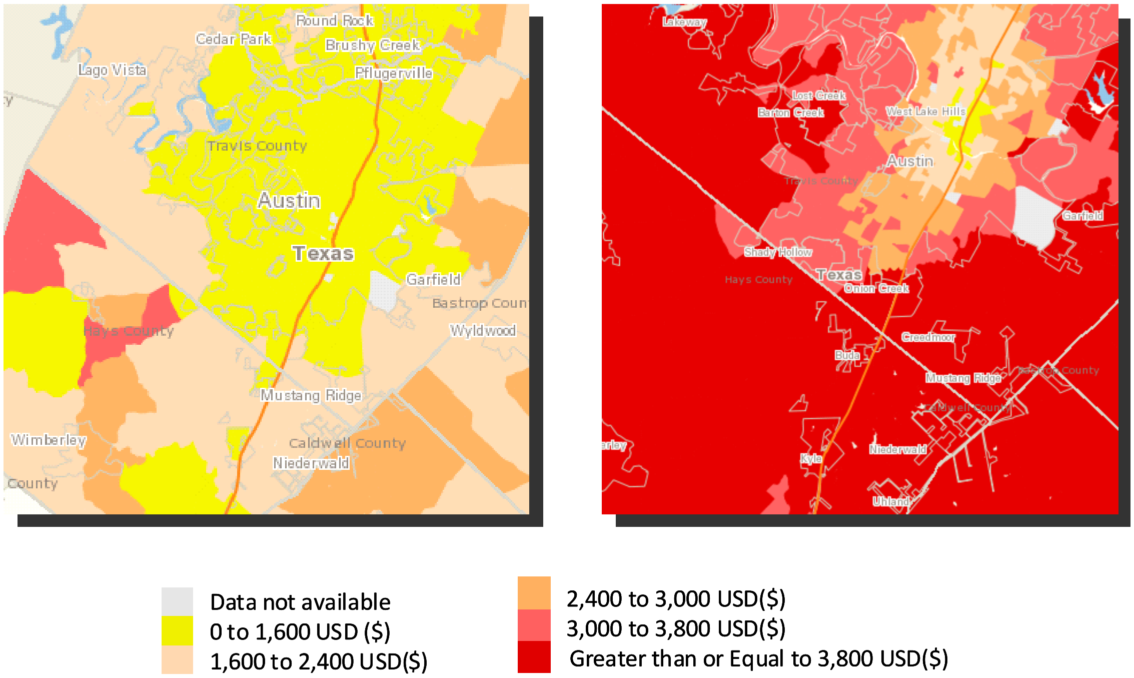
In the U.S., relatively low gas prices from 1982 through 2004 helped spur the growth of driving. Figure 4.6 shows the real price of gasoline since 1991 in inflation-adjusted 2008 dollars. Prices were flat until 2003, but saw a 100% increase from then to 2008.



Source: Energy Information Administration

Figure 4.9: Real price of gasoline since 1991 in inflation adjusted 2008 dollars

The effects of recent gas price increases on commuters in the Austin—San Marcos Metropolitan Region of Texas are depicted in Figure 4.7. The colors show the average household spending on gasoline in 2000 and 2008, respectively. Tellingly, the area spending less than $1600 per household has shrunk to just the urban core, while commuters in the suburbs have seen their expenses grow from about $2000 to over $3800.

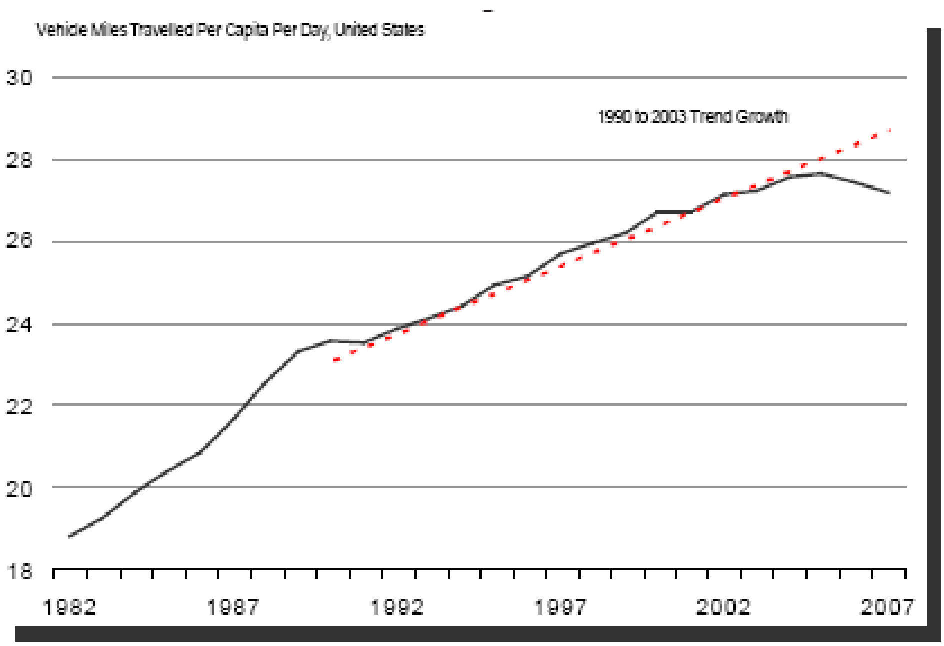


Source: http://htaindex.cnt.org

Figure 4.10: Comparison of Household Spending on Gasoline in 2000 and 2008

Previously stable gas prices and rising incomes had fueled growth in personal travel. Between 1984 and 2001, real per capita incomes increased by 28 percent, while the per mile cost of car travel fell by 42 percent (Polzin, 2006). In the early 1980s, the average American drove fewer than 20 miles per day, but by 2004, this figure had increased to 27 miles per day. But in the past three years, vehicle travel per capita in the U.S. has begun to decline, as shown in Figure 4.8.

According to the U.S. Department of Transportation, total vehicle miles traveled per person per day reached a peak of 27.6 in 2005 and declined to 27.2 in 2007. This represents a departure from the trend between 1990 and 2003. The U.S. DOT reported that Americans drove 10.7 billion fewer VMT in September 2008 than the same month in 2007, a total of 4.4% less, for the 11th straight month of lower VMT. Over this 11-month period, there has been 90 billion fewer VMT (Transport Topics, 2008). The decline in driving has had the effect of reducing gas sales (Campoy, 2008). As a result of this continued decline, the Federal Highway Trust Fund has collected $3 billion less between October 2007 and September 2008, yet its spending has increased by $2 billion (Transport Topics, 2008). These events forced the federal government to inject $8 billion into the Federal Highway Trust Fund in September 2008 to keep it solvent.



Source: Impresa Calculations, US DOT data

Figure 4.11: VMT per person per day in the US 1982-2007

Experts estimate that while gas consumption might decline only about 2 to 3 percent in response to a 10 percent increase in fuel prices in the short run, in the long run, gas consumption would be likely to decline 8 to 10 percent in response to that level of increase. Families that spend a large portion of their income on gas are being deprived of flexibility and are also losing the ability to absorb the costs. The popularity of alternative transportation modes has increased.

Use of public transit in Austin, for example, has rapidly increased compared to last year. Capital Metro reported plans to purchase an additional eight new buses to expand its growth due to increased ridership (it reported a 12 percent growth in ridership in July compared to June 2008) (Capital Metro, 2008). It can be inferred that an increase in fuel price does affect the mode choice of consumers, and Capital Metro is an example here in Texas.

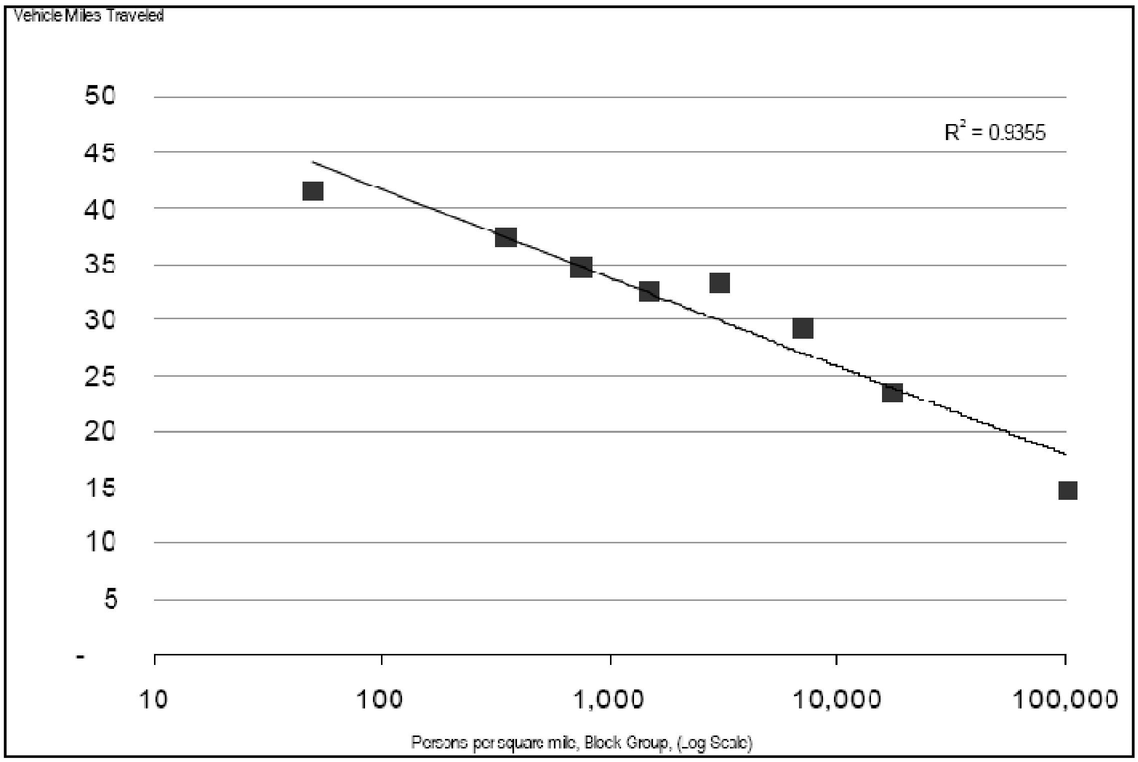
Consumer decision making in vehicle purchases is also changing. October reports of vehicle sales in 2008 show manufacturers experiencing deep declines due to the financial downturn in the global economy since September 2008 (Bunkley, 2008). For example, GM reported a 45% decline in sales and Ford a 30% decline. Even manufacturers with efficient fleets reported considerable drops with sales falling 33% at Nissan, 25% at Honda, 31% at Hyundai, and 23% at Toyota. Current commuter trends toward economical means of travel will continue and this will affect housing choices.

4.6.2 Housing Choices

Decisions about where to live or work, which neighborhood to move to, and which job to take all profoundly influence travel behavior in the long run (Congressional Budget Office, 2002). Low gas prices in the past encouraged suburban sprawl, as families chose cheaper and larger exurban housing. Living in the suburbs resulted in long commutes by these households, leading to high fuel consumption. However, as fuel prices increased over the last few years, the cost of transportation increased. Cortright (2008) noted that:

> "…households most affected by the rise in gas prices were those who had stretched the family budget to buy a house on the suburban fringe. These families spent a higher fraction of their income on gas than the typical household and had less flexibility to accommodate the higher price of gas than others. And for the same reasons, as gas prices rose, houses in these far-flung neighborhoods tended to lose their market appeal first and fastest."

Urban form is highly influential in shaping automobile expenditures, and compact mixed use developments generally are associated with lower rates of vehicle ownership and auto-dependency; people who live in low-density suburbs drive much farther than those living in cities (Bureau of Transportation Statistics, 2003). Figure 4.9 illustrates this relationship.



Sources: Computed from National Household Travel Survey, 2002.

Figure 4.12: Density Reduces Vehicle Miles Traveled

Cities with the lowest vehicle miles traveled are cities that have incorporated neighborhoods with a "combination of density, a mix of land uses and transportation alternatives that enable households to travel less. Almost all of these places are located in the more central and close-in neighborhoods of these metropolitan areas" (Cortright, 2008, p.18). Cortright also reported that

> "over a period of years, individual households have substantial alternatives to reduce their energy consumption. Households can, for example, purchase vehicles with higher fuel efficiency. But the high mobility of American households also gives them huge opportunities to reduce their fuel consumption. The average American moves once every seven years. Even before the big run up in gas prices, many Americans were already moving to take a new job or to shorten their commute to an existing job."

In 2005, about 4 million people moved in connection with a new job and 1.3 million people moved to shorten their commute (Bureau of the Census 2006). A 2005 Harris Poll showed that 28 percent of the population responded to high gas prices by looking for a place to live closer to work (Harris Interactive Incorporated 2005). A Gallup poll taken in 2007 showed that 10 percent of the population reported changing jobs to shorten their commute in response to higher gas prices (Overberg and Copeland 2007). The opportunity for moving households closer to their jobs is extraordinary. One estimate is that the typical household drives three to seven times farther than if they lived in the nearest similar neighborhood to their place of work (Anas, Arnott et al. 1998).

In cities across the United States, living in denser, revitalized neighborhoods is becoming increasingly popular. In the future, the most desirable places to live will most likely be in the urban core (Brueckner, 2005). It is likely that elevated gas prices will continue to draw people back to places in the state or city that are most fuel-efficient neighborhood. For example, a study conducted in 2006 by the Center for Transit Oriented Development (CTOD) found that more and more households want to live near transit oriented development. Further, by 2030 the CTOD projects that 16 million households will want to live near transit (based on data collected in 2000).

Urban trends like New Urbanism, Smart Growth, and Transit-Oriented Development being promoted by agencies like the EPA (EPA, 2008) are likely to shape our behavior too. New Urbanism and Smart Growth call for an integrated, environmentally sensitive approach to land use and transportation planning that promotes public transit, walking, and mixed land use features [e.g., homes, offices, and shops (NAHB, 2008)]. As transportation is a derived demand, elasticity of demand is dependent upon land use and the availability of other non-auto modes of transport. For example, Kahn (Kahn, 2000) found that suburban households drove 31 to 35% more than their urban counterparts.

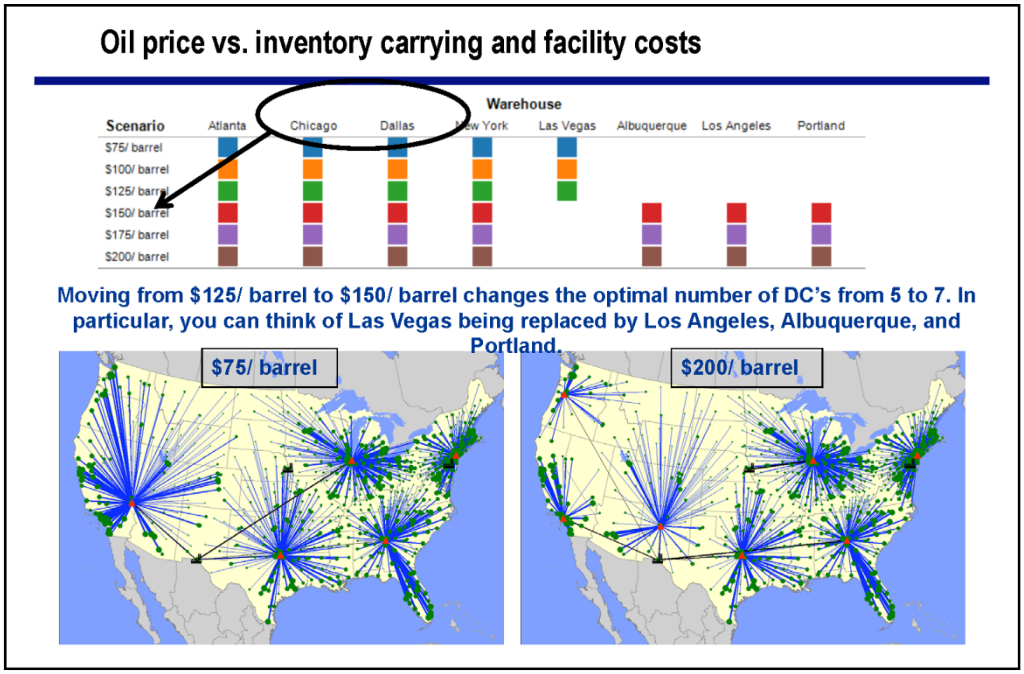
The U.S. Department of Energy's forecast for annual oil prices in 2009 is $92 per barrel compared to a 2007 average of $72 per barrel (Energy Information Administration 2008). Given that these forecasts represent marked changes from the housing and energy outlooks of just a few years ago, it seems likely that the pattern of changes we are seeing in consumer behavior are likely to continue into the future (Cortright, 2008).

4.6.3 Driving choices

Commuter responses to fuel prices are a critical element in reviewing future travel demand. Hughes, Knittel, and Sperling (Hughes et al., 2008) found evidence of a shift in the short-run price elasticity of gasoline demand. The authors studied the price and income elasticities of two datasets covering the periods November 1975 through November 1980 and March 2001 through March 2006. They found strong evidence of a structural change in the demand for gasoline, with the demand being significantly more inelastic in the period from 2001-2006 compared to 1975 through 1980. They postulate that the shift in short run elasticity may include "more permanent changes, in the vehicle stock (e.g., the purchase of more fuel efficient vehicles)."

Hughes et al. also found a negative coefficient on the interaction between increasing incomes and changes in gas prices with greater sensitivity to price changes for groups with higher incomes. They postulate that part of this sensitivity may be because as incomes rise, discretionary trips increase, while those at the lower income spectrum have already minimized trips, leaving little room for adjustment to higher prices. The responses to increased fuel prices in 2008, which also impacted food prices, may change this elasticity dynamic for future commuters.

Another area that provides insight into the impact of oil price on transportation demand is the review of transportation costs as part of logistics costs. Simchi-Levi notes that since 2003 transportation costs as a percentage of total logistics costs have increased to almost 52% of constituent costs. Simchi-Levi found that for every $10 increase in per barrel of oil there was an additional $0.04 cents per mile increase in transportation rates (Simchi-Levi, 2008). Simchi-Levi found that the tipping point in the elasticity for one manufacturer came at the $150-a-barrel mark. At this point, as shown in Figure 4.10, the group would move from five distribution centers to seven to cut diesel costs. This change would also impact diesel tax revenues, and other registration revenues as trucking resources shift to these new distribution center routes.



Source: Simchi-Levi, 2008

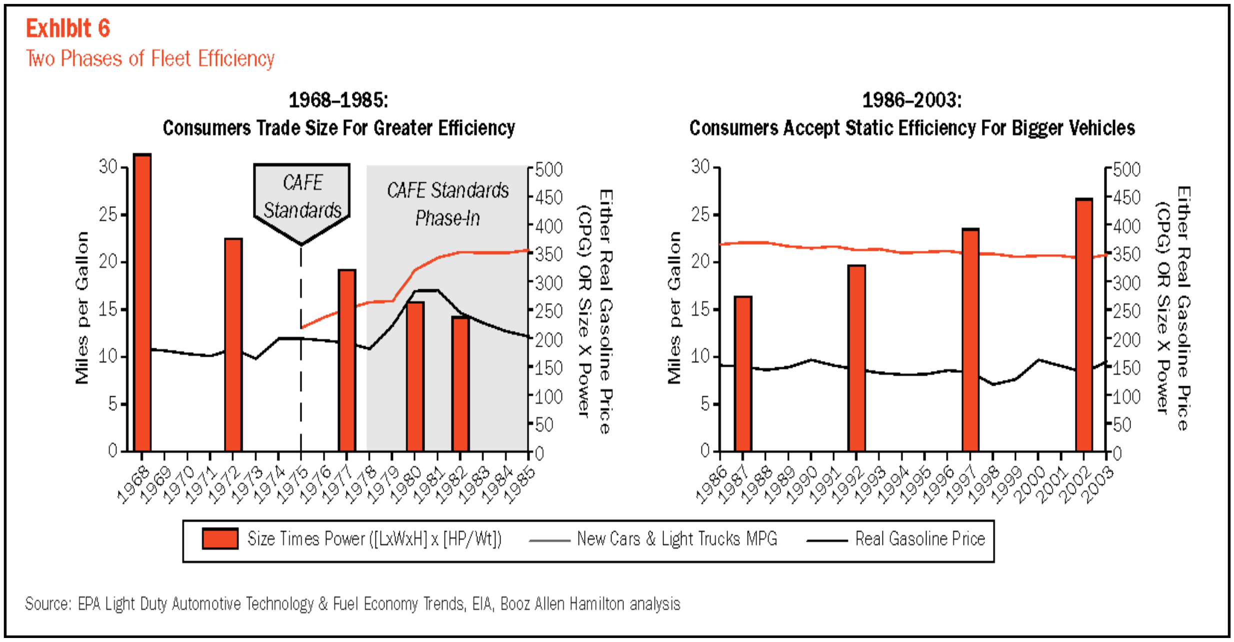
Figure 4.13: Scenario of Distribution Center Shifts at $75 and $200 a barrel

4.7 Market Penetration of Alternatively Fueled Vehicles

Shifting to an alternative vehicle mix that is less reliant on gasoline will require many activities to happen. According to U.S. Congressman Lloyd Doggett, it will require "a shift from our over-dependence on fossil fuels, but also our over-dependence on fossilized thinking" (U.S. Congressman Doggett, 2008).

4.7.1 Fuel Efficiency and Fuel Consumption

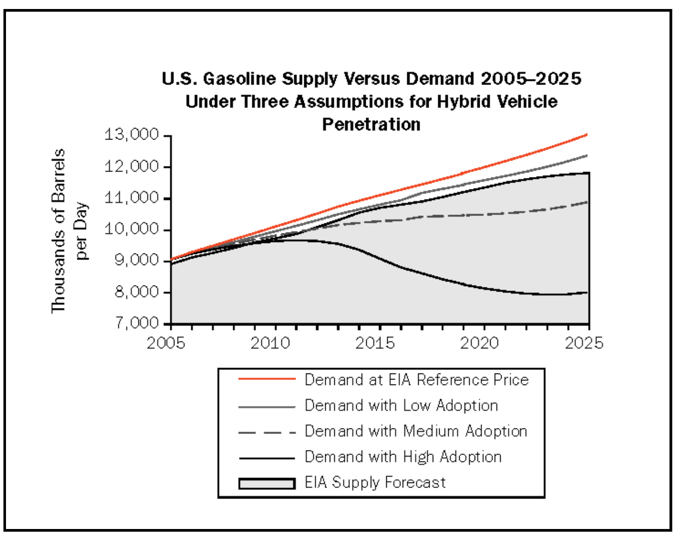
Figure 4.11 shows historical trends in fleet efficiency. Two distinct phases are seen: the 1968-1985 period with improving efficiency and smaller vehicles, followed by the 1986-2003 period, with decreasing efficiency. At first, consumers traded size for greater efficiency, but then accepted static efficiency for larger vehicles.



Source: Booz Allen Hamilton, 2004

Figure 4.14: Fleet Efficiency: Two Phases in U.S.

The types of vehicles in the fleet have a strong effect on overall fuel consumption. In studying scenarios for U.S. gasoline demand, Booz Allen Hamilton analyzed how the gasoline supply would look under three assumptions for the penetration of hybrid vehicle engine technologies. As shown in Figure 4.12, under high adaptation of the technology, supply drops from an estimated 11 billion barrels a day in 2025 to under 8 billion barrels a day (lower than current rates). Clearly, gasoline demand drops if there is high hybrid penetration. But even at medium penetration, gasoline consumption flattens, with serious consequences for gas tax revenues.



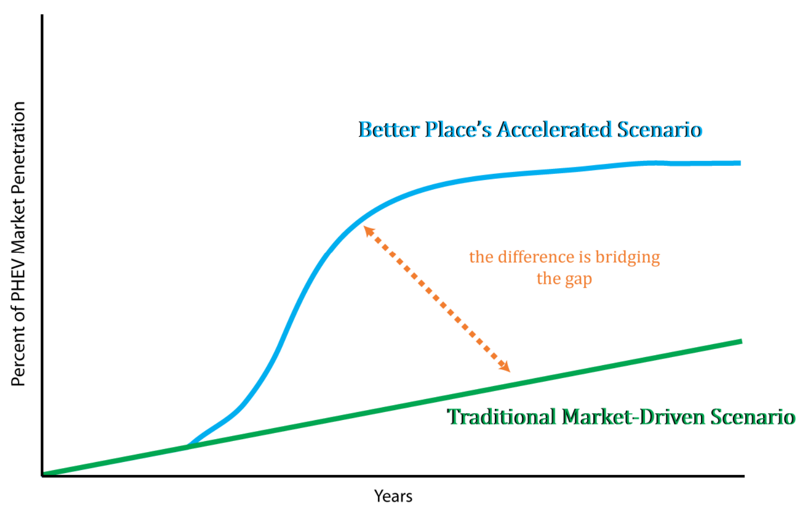
Source: Quarls at Booz Allen Hamilton, 2004

Figure 4.15: Gasoline Supply Under 3 Hybrid Assumptions

4.7.2 Changes Required to Business Practices

The shift to alternative fuel vehicles is still a *"picture for the future"* according to many experienced pundits. For example, at a recent alternative car exposition held in Austin, Texas, Ed Kajer (Kajer, 2008) noted that for the past 20 years we have seen many technologies put forward that would revolutionize the car industry. However, none have come to fruition and he posited a few factors that lie behind this. Number one was a sustainable business case was never made for the major automobile manufacturers to become a partner. He also noted that there were multiple critical steps that would have to align in a perfect symmetry for an alternative fuel vehicle market penetration to occur. This ran the gamut from being able to make it out from under R&D costs, battery maturity (if electric vehicles were the chosen technology), through volume manufacture to credit availability for purchasers. Looking specifically at plug-in-hybrids, for example, the biggest issue today is energy delivery and storage, which Kajer called a 'game changer' in this market. Kajer noted that battery use, time to charge, residual value, and cost to charge were all key components here.

Market penetration of hybrid and alternative vehicles will require new business approaches. Sven Thesen of Better Place Project noted that for their electric vehicle project the traditional business plan was "turned on its head" (Thesen, 2008). Better Place has worked with Nissan/Renault to retool a factory in Turkey and expects to produce 150,000 electric vehicles by 2012 for its two initial market roll-outs in Israel and Denmark. The difference is in Figure 4.13, which compares traditional market driven scenario to Better Place's accelerated roll-out scenario.



Source: Thesen, 2008

Figure 4.16: Accelerated Business Scenario

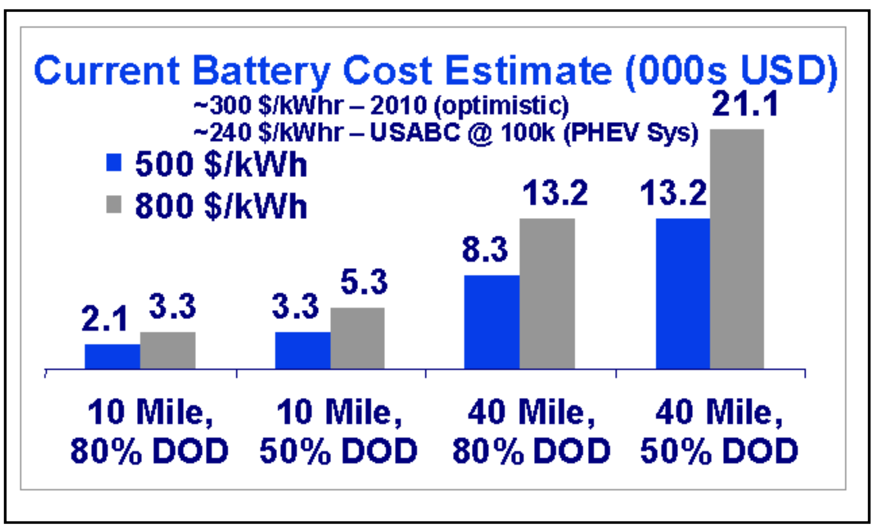
However, there are costs and risk with bridging this gap. Better Place has also opted to target countries as opposed to states or smaller jurisdictions for their roll-out. Another factor that complicates this business model (as an atypical model that might be translated for the vehicle manufacture industry) is that the roll-out of these plans is occurring in countries that have small, relatively homogenous populations, as well as shorter commute trips. They are also assisted by the short shipping distance and delivery time from factory to market.

Mark Duvall (Duvall, 2008) noted that if the U.S. market achieved 1 million plug-in vehicles within the next eight years he would consider this to be “success.” This was because currently there are:

- No large scale manufacturers (especially here in the U.S.) producing components to make the roll-out easy, compatible, and reasonably priced.
- Projects will need public funding for profit companies to enter the market.
- The smart-grid is not yet in place and the current grid is not yet sophisticated enough to supply electricity to users at different cost rates and hours.
- End user infrastructure is not in place and will require readily available financing. For example, cities will need to be able to issue bonds to finance plug-in- infrastructure.

4.7.3 Improvements Required in Battery Technology

Another issue is the capacity of batteries as a fuel source, especially in terms of their charging and discharging cycles. According to recent analysis by Boskovitch (Boskovitch, 2008) to deliver hybrid functionality, batteries must be capable of regular deep discharge at approximately ~70-80% of operation (DOD). This means the battery must maximize energy content and deliver full power even while DOD is occurring. A typical electric car uses around 250-350 watt-hours per mile. However, the battery requirements for plug-in hybrids require a combination of charging and discharging cycles over and above watt hours per mile used in regular electric vehicles. Plug-in hybrid batteries also must operate at a variable DOD and must be optimized for shallow DOD over a long life span. As Figure 4.14 shows, achieving 300 Kwhr by 2010 is optimistic, based on the current DOD capacity of batteries, battery size, and their energy storage capacity. For a plug-in to achieve a 40-mile range, at a 50% DOD, at 500 kWh, will cost around $20,000.



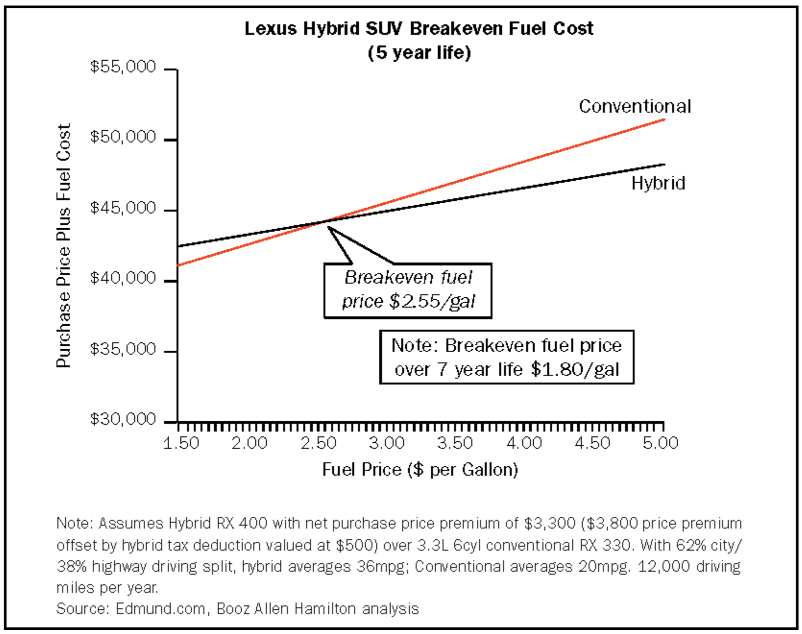
Source: Boskovitch, Ricardo Inc, 2008

Figure 4.17: Battery Costs Estimates in Thousands of US$

Boskovitch notes that battery cost is still a contentious subject, driven by "differing views on materials, costs, rate of technical improvement, permissible depth of discharge (DOD), range etc." (Boskovitch, 2008).

4.7.4 Buyer Costs

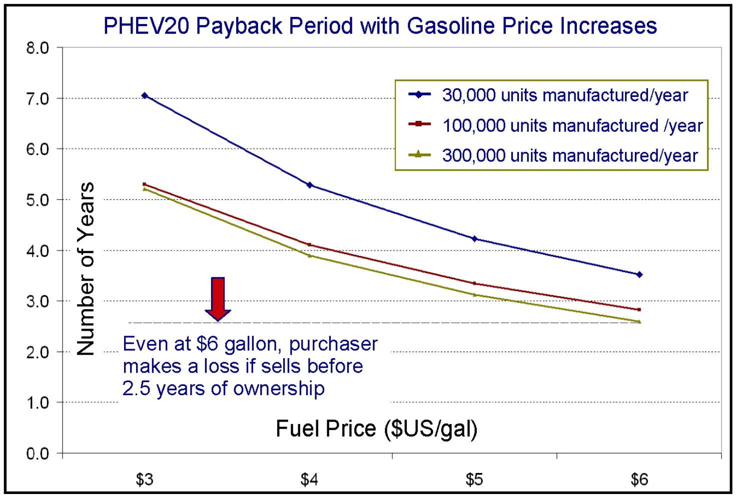
Another major hurdle that will have to be overcome is the extra costs that alternative fuel vehicles pose for a consumer. For example, a collaborative project by Ricardo, QinetiQ, and PSA Puegeot Citroen found that a parallel hybrid-electric diesel represented an improvement of about 30% in fuel economy. However, the extra costs for the additional hybrid powertrain came in at approximately US $5,600 more than a conventional vehicle (Green Car Congress). Booz Allen Hamilton estimated the breakeven point of the Lexus Hybrid versus conventional vehicle to sit at around $2.55 a gallon as shown in Figure 4.15.



Source: Quarls Booz Allen Hamilton 2004

Figure 4.18: Breakeven Fuel Cost

Ricardo also looked at the payback period for a plug-in-hybrid electric vehicle (PHEV) and found that even at $6 a gallon it will be almost three years before an owner breaks even (Figure 4.16). This calculation also depends on the number of vehicles manufactured. Break-even will occur faster as manufacturing totals increase and the purchase price of these vehicles begins to lessen.



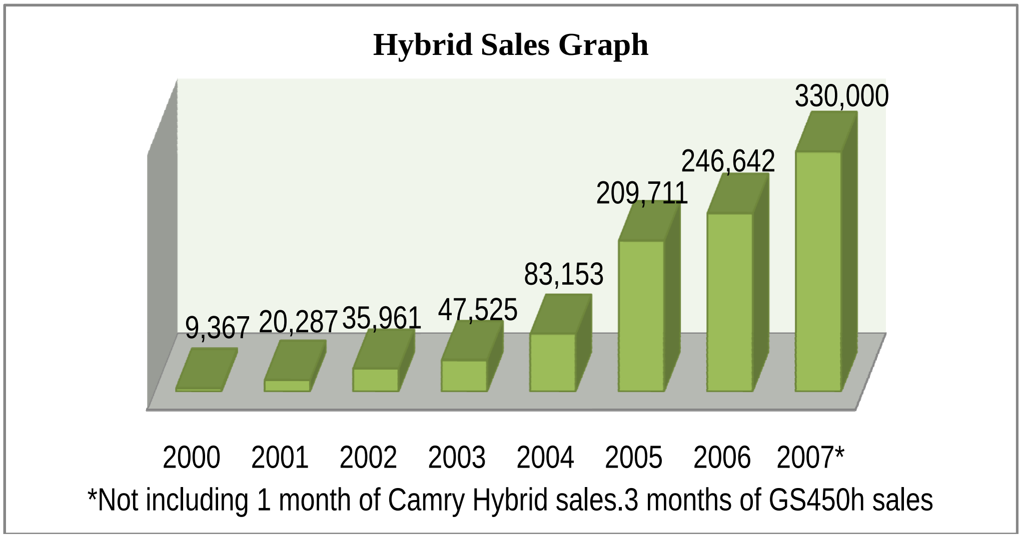
Source: Boskovitch, Ricardo, 2008

Figure 4.19: Payback period for a Plug In Hybrid with Automatic Gas Price Increases

4.7.5 Popularity of alternative fuel vehicles

The use of electric vehicles (EV) has many potential public policy benefits, including reducing the U.S. dependence on foreign oil, particularly because only 3 percent of electricity generated in the U.S. is derived from petroleum. Instead of operating on a gas or diesel engine, an electric vehicle is powered by an electric motor that is supplied energy through a battery charged with a central charging station installed in the vehicle owner's garage or from a portable charger. However, experts warn that the viability of the EV on a long term basis is questioned, especially in states like California, where electricity costs are rising. Furthermore, the market penetration of the EV has not been well received, especially by customers. In 1998, only about 3,500 privately owned EVs were in use, primarily in California. Today, there are only a handful of automotive manufacturers that produce EVs and the majority of those are on a lease basis or only available for purchase in fleets.

Although hybrid vehicles have been sold in the United States since the Honda Insight was introduced to the market in 1999, sales for the vehicle didn't substantially take off until around 2005, as shown in Figure 4.17. In 2007, approximately 350,000 hybrid sales were sold, an increase of about 40% over total 2006 sales (U.S. Department of Energy, 2008). California remained the top state for hybrid registrations in 2007, with 26 percent of the market share, followed by Florida (5.5 percent), New York (5 percent), and Texas (4.9 percent). Texas added 37 percent more hybrid vehicles compared to 2006, according to the data collected by R.L. Polk & Co. (Houston Business Journal, 2008).



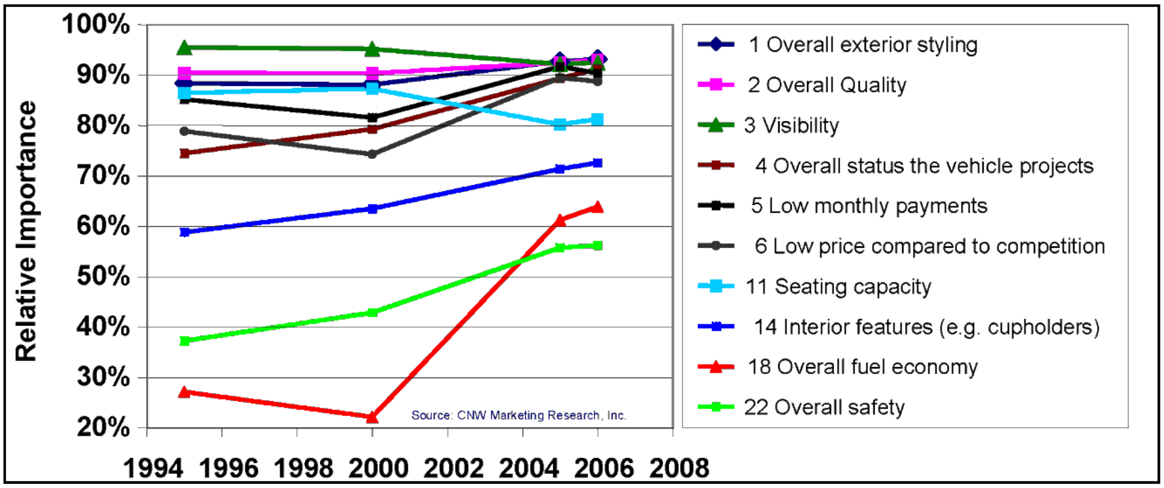
Source: Electric Drive Transportation Association.

Figure 4.20: Hybrid Sales U.S.

Despite increasing sales of hybrids and growing interest,

> "industry analysts say a combination of factors, including often-hefty price premiums and an acceptance by consumers of $3-per-gallon gasoline, will temper sales of hybrids this year…recent introduction of new hybrids like the Saturn Green Line Aura and Vue and the Chevrolet Tahoe Hybrid SU have boosted sales but not enough for experts to predict the long term sales according to a J.D. Power and Associates" (Ann Arbor Business Review, 2008).

As Figure 4.18 shows, the relative importance that consumers have placed on fuel efficiency began to shift dramatically upwards only as gas prices increased after 2000.



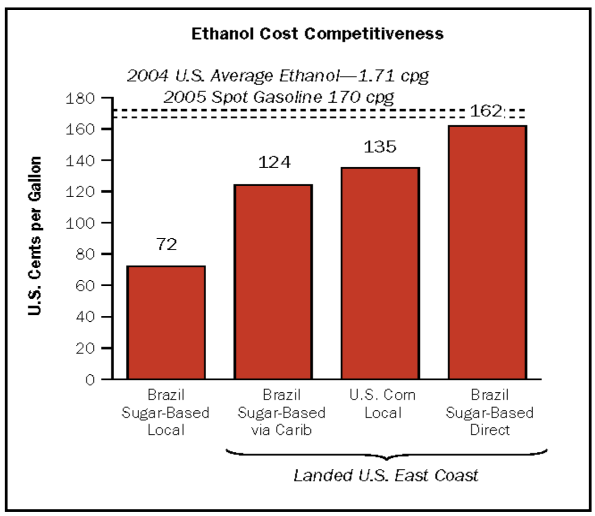
Source: Boskovitch, Ricardo 2008

Figure 4.21: Consumer Preferences when Purchasing a Vehicle

4.7.6 The mix of fuels going forward

The next issue that will play a pivotal role in development of alternative fueled vehicles is the availability of alternative fuels. For example, UBS Investments and Ricardo Inc. in 2007 noted that they were 'bullish' on improved diesel vehicle penetration in the U.S. (UBS, 2007). In this investment update on global auto research they recommended shifting into diesel commodities. This was based on a projected forecast of 1.5 million diesel sales by 2012.

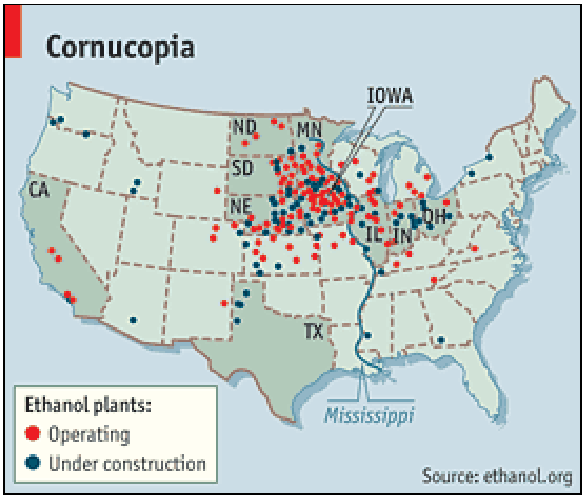
Ethanol was also seen throughout 2006/2007 as a fuel for the future, with GM and other manufacturers creating large FlexFuel car campaigns (GM, 2008). However, as can be seen in Figure 4.19, while ethanol's cost competitiveness could match the spot price of gasoline in 2005, other factors come into play in increasing its market share over the long run. The biggest of these is that the infrastructure to supply ethanol is still in infancy at multiple stages along the supply and distribution curve and at the end-point—the consumer. While ethanol plant construction took off in 2007, the dramatic increase in the cost of corn led to a backlash against an industry using a food staple for the food and feed industry to produce vehicular fuels (Monbiot, 2007).



Source: Quarls at Booz Allen Hamilton, 2004

Figure 4.22: Ethanol's Cost Competitiveness

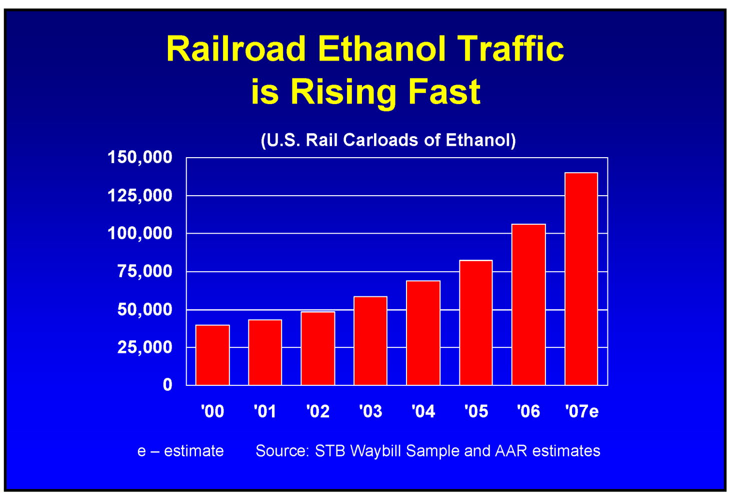
Admittedly part of the shift to ethanol was to implement the Renewable Fuel Standards (RFS) mandates passed under the Energy Policy Act of 2005, which mandates RFS of 7.5 billion gallons by 2012. Governor Rick Perry of Texas requested an exemption from the EPA for this statewide fuel objective and was turned down by the EPA in the summer of 2008. As 2008 draws to the close the ethanol industry is now reportedly seeing its first bankruptcies. Vera Sun, one of the nation's largest ethanol producers, announced at the end of October 2008 that it had filed for bankruptcy (Galbraith, 2008). Figure 4.20 shows ethanol plants in the U.S. as well as those under construction in 2007.



Source: The Economist

Figure 4.23: Ethanol Plant Construction

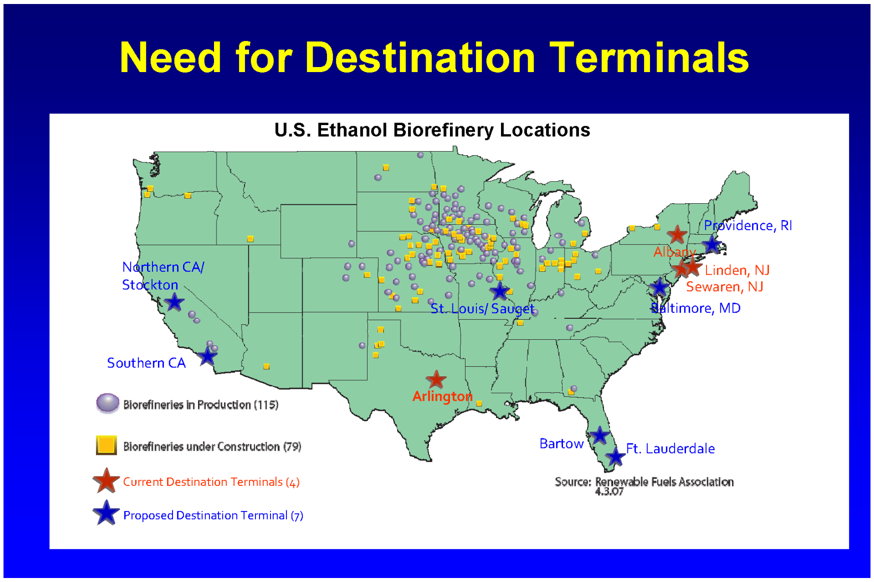
Because of its corrosive nature, ethanol cannot be distributed through existing pipelines in the U.S. Therefore, ethanol is reliant for its supply chain on the rail industry for the long-haul, and the trucking industry to the final distribution points (Rocky, 2007). Figure 4.21 shows that ethanol increased its share of railroad traffic after 2004.



Source: Rockey, AAR, 2007

Figure 4.24: Railroad Ethanol Shipments 200-2007

The biggest hurdle to still be overcome is the need for destination terminals if biofuels are to hold market share. Figure 4.22 shows the Association of American Railroad analysis on the need for destination terminals.



Source: Rockey, AAR, 2007

Figure 4.25: Destination Terminals for Biofuels in the U.S

Plug-in hybrids also have 'fuel' issues as their potential implementation into the market place is reviewed. The major issue upon this industry is the ability of the electricity manufacturing industry to be able to supply electricity at competitive prices, without overloading the U.S. electricity grid.

4.8 Through the Crystal Ball

The research team developed a range of likely fleet-wide fuel efficiencies for Texas through 2035. This endeavor is very unscientific because of the many unknown variables, such as future innovative technologies and unforeseen policy changes, particularly with the onset of a new presidency. Looking to Europe doesn't help as a predictor because Europe has different emissions legislation, different vehicle safety standards, and a different freight delivery system than the U.S.

In addition, two other factors are completely unpredictable:

1. Land use patterns that could dramatically change and alter commuting patterns.
2. The effect of demographic changes on VMT.

Our extensive literature review and analysis of market penetration of fuel efficient as well as hybrid vehicles (both light duty and heavy duty) does not indicate a 'dramatic' shift in the U.S. fleet. Seven things must occur to improve market penetration and drive the shift to greater fuel efficiency:

1. The public demands greater fuel efficiency.
2. Legislation is pushed through—continuously—that mandates a shift to higher fuel economy across the entire fleet, not just the small light sub-compact fleet where it currently has the most effect.

3. Technological breakthroughs occur that lead to dramatic uptake of alternative-fuel vehicles.
4. Consumers demand such vehicles.
5. Such vehicles are manufactured in sufficient quantities to lower the prices.
6. Manufacturers drop the current ‘hybrid’ premiums.
7. Consumers have access to easy credit to make a 3-5 year breakeven period attractive.

Assuming CAFE requirements do not change very much in the near future, new cars in 2020 will achieve 35 mpg and new light-duty trucks will achieve 27.5 mpg. The rate of improvement in heavy-duty vehicle fuel economy is nearly zero, so it can be assumed that 2020 fuel economy will be equal to present fuel economy (5.5 mpg). From 2020 through 2035, we assume that fuel economy will improve at historic rates to 43-55 mpg for cars, 33-45 mpg for light-duty trucks, and 6-8 mpg for heavy-duty trucks. Weighting based on VMT and BTU, 2020 new vehicle average fuel economy will be only 26-35 mpg, and 2035 new vehicle average fuel economy will be 35-45 mpg.

4.9 Chapter Conclusion

The JACK model for projecting TxDOT revenue, along with its embedded Cambridge Systematics model for projecting Texas fleet fuel economy, is quite complex and has many assumptions. Among them, those directly pertaining to fuel economy and fuel consumption were examined in this chapter.

JACK assumes that 25% of fuel revenue is from diesel, and then uses this to calculate an average fuel tax rate of 19.9 cents per gallon. Because the proportion of diesel consumed has, and likely will, change over time, the model should be more sensitive to these potential changes. It would be more accurate to calculate revenue from each fuel type separately.

Another important assumption is the current Texas fleet fuel economy. The JACK model default value is 17.9 mpg, which was obtained from the Cambridge Systematics analysis. Calculations show that this is a reasonable assumption when weighting by vehicle type and VMT but is biased by a high of 2 mpg when weighting by vehicle type and fuel consumption (in BTU). This 2 mpg difference changes total 2035 revenue by $150-420 million, depending on the fuel economy projection scenario chosen (high, medium, or low).

Choosing a fuel economy projection can alter 2035 total revenue substantially. The difference between the low and high scenario is over $2.5 billion dollars in 2035. However, it should be noted that even in the low scenario, total revenue is projected to decrease by $1.3 billion from 2008 to 2035, according to the JACK model.

In addition, other changes in human behavior, vehicle and travel choices, vehicle technologies available, and demographic factors have the potential to impact vehicle fleet fuel economy, as well as vehicle miles traveled. All of these cannot be easily or accurately quantified, making a prediction of future fuel efficiency mostly guesswork.

The JACK model utilizes a range of future fuel efficiencies: the low end at 41.0 mpg (by 2030) and on the high end, 114.4 mpg. The research team’s projection is that by 2035 Texas will see a composite fleet fuel efficiency of around 35 mpg on the low end to around 45 mpg on the high end.

Chapter 5. Construction Inflation Rates

5.1 Introduction

For effective budgeting of highway projects, it is important to closely monitor changes in highway construction costs. For this purpose TxDOT maintains a Highway Construction Index (HCI) that compares the cost of business in a defined period to the cost of business in the base year (1997). This chapter provides a review of the HCI, and the development of a method to forecast highway construction inflation.

5.1.1 Background

During the last several years the construction industry has been experiencing a higher inflation rate than the overall economy. According to Bureau of Labor Statistics (BLS), inflation in highway and street construction is much higher than residential construction, non-residential construction, and the overall economy. The cost of highway construction materials such as fuel, steel, concrete and oil-based materials has been rising higher than general inflation. From the year 2003 to 2007, the cumulative increase in highway and street construction cost was around 43%, a great contrast to the 28% increase in residential and non-residential construction and 13% for the overall economy.

5.1.2 Chapter Scope

Task 5: Develop a methodology for estimating a range of future construction inflation rates.

A. Identify the appropriateness of one or more symptomatic indicators of construction inflation rates for use in projecting such rates.

B. Develop a confidence bands for the relationship between symptomatic indicator(s) and the construction inflation rate.

This chapter is organized as follows:

- Review of TxDOT's Highway Construction Index
- Comparison of HCI with other cost indexes
- Identification of symptomatic indicators of construction inflation rates.
- Forecasting of construction inflation.

5.2 HCI Review

TxDOT maintains a Highway Construction Index (HCI) to compare the cost of business in a defined period to the cost of business in base year 1997. This index is a weighted average of four representative categories in highway construction costs that are divided into elements and further subdivided into control items.

5.2.1 Control Items

These control items, 34 in total, are considered to be representative of the bid items that are usually included in a highway construction project. Table 5.1 shows the various control items that are included in the HCI.

Table 5.1: Highway Cost Index Control Items

HCI Item Definition		
Category	***Element***	***Control Item***
Earthwork	Excavation	Roadway Excavation
	Embankment	Roadway Embankment
Subgrade and Base Course	Lime Treated Subgrade or Base	Lime
		Lime Treatment
		Plant Mix
	Cement Treated Subgrade or Base	Cement
		Cement Treatment
		Cement Treatment Plt Mix
	Asphalt Treated Subgrade or Base	Asphalt Treatment Plt Mix
	Flexible Base	Flexible Base
Surfacing	Surface Treatment	Surface Treatment Asphalt
		Surface Treatment Aggregate
	Bituminous Mixtures	Hot Mix Asphaltic Concrete
	Concrete Pavement	Continuous Reinforced Concrete Pavement
		Jointed Reinforced Concrete Pavement
		Jointed Non-Reinforced Concrete Pavement
Structures	Structural Concrete	Class A Concrete
		Class C Concrete
		Class S Concrete
		Bridge Rail (Rigid)
		Bridge Slab
	Metal for Structures	Metal for Structures
	Precast Prestressed Conc Structural Members	Regular Beams
		Box Beams
	Foundations	Steel H Piling
		Concrete Piling
		Drilled Shafts
	Drainage	Corrugated Metal Pipe
		Reinforced Concrete Pipe
		Reinforced Concrete Pipe (Sewer)
		Concrete Box Culvert
		Concrete Box Sewer
	Riprap	Concrete Riprap
	Retaining Walls	Retaining Walls

Source: Technical Memo: Review and Analyze the Current Methodology of Developing the HCI" by Anderson and Damnjanovic

The composite HCI index is built up from the item level, to the element level, to the category level, and then finally to the functional level or composite index, representing all 34 items.

5.2.2 Calculating the HCI

Figure 5.1 and Table 5.2 demonstrate the calculation process for the HCI.

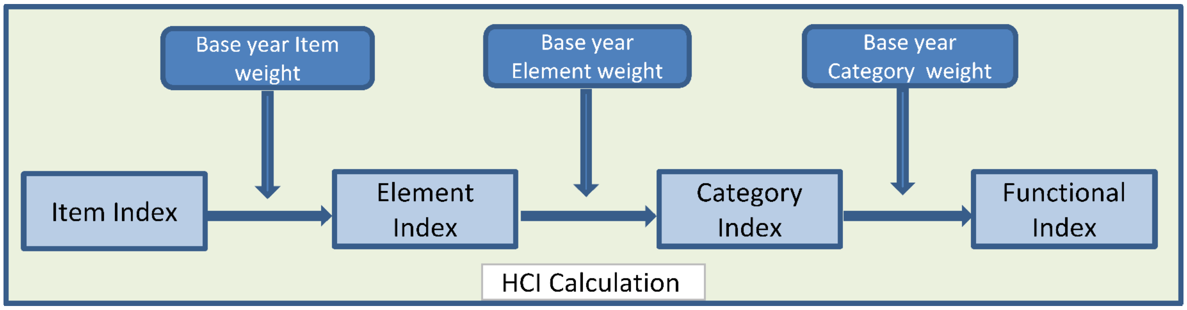


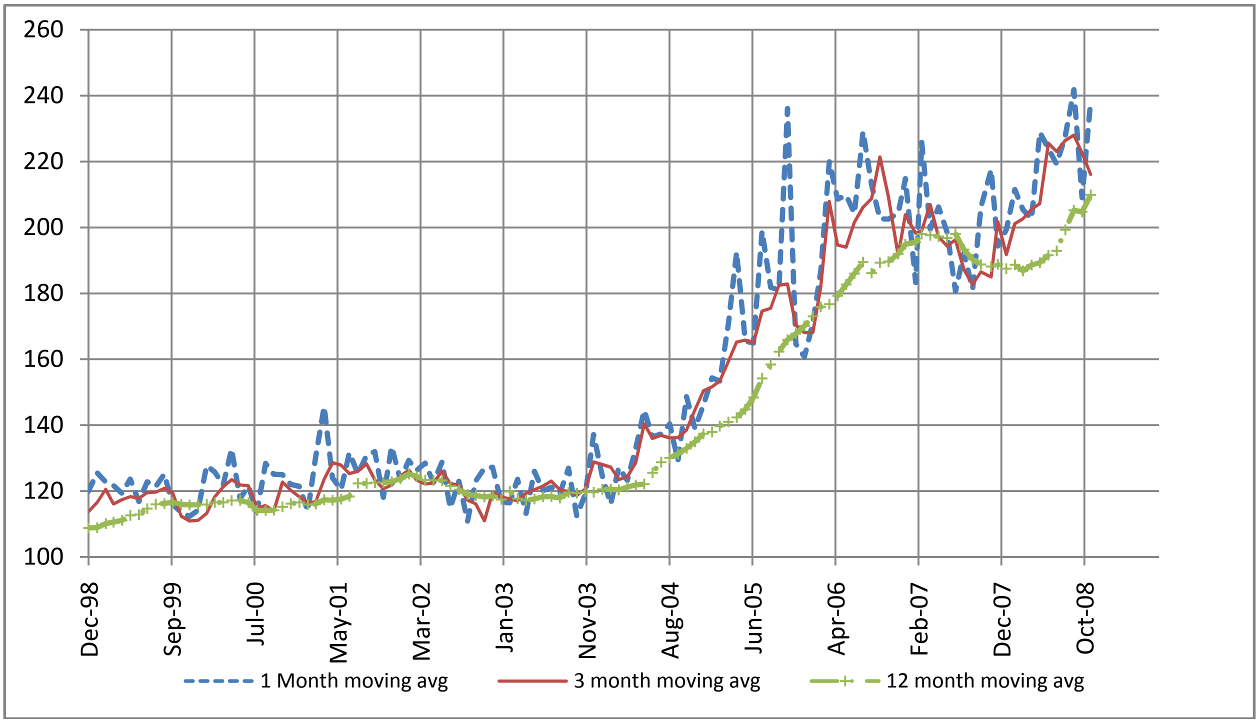
Figure 5.1: Calculation Process for HCI

Table 5.2: Calculation Process for HCI

1. Current Item Index = (Current Period Unit Price / Base period unit price) X 100 Current Period Unit Price = Current period total $ / Current period total quantity Base period unit price = Base period total $/ Base period total quantity 2. Element Index = Sum of element index components Element Index Component = (Base year Item weight X Current item index) /100 Base year item weight = (Base period $ for item / Sum of all base period $ for all items in index) X 100 Base period $ = Base period unit price X Base period quantity 3. Category Index = Sum of category index components Category index components = (Base period element weight X Element Index) / 100 Base period element weight = Base period $ for element / Sum of all base period $ for all elements in category 4. Functional Index = Sum of functional area index components Functional Area index component = (Base period category weight X Category Index)/ 100 Base period category weight = Base period $ for category / Sum of all base period $ for all categories in functional area

Source: Anderson and Damnjanovic

TxDOT calculates the HCI in terms of one month, three month, and twelve month moving average. As shown in Figure 5.2, the one month moving average graph has a lot of spikes while the twelve month moving average graph is fairly smooth. Hence the twelve month moving average graph will be used for the purpose of evaluation and comparison.



Source: ftp://ftp.dot.state.tx.us/pub/txdot-info/cst/hci_binder.pdf

Figure 5.2: TxDOT HCI Since 1997

5.2.3 Control Items and Weights

Table 5.3 lists the HCI control items according to their weightage by cost on the final index value. From this table we can see that Hot Mix Asphalt Concrete has the largest cost weightage. As this item is in the surfacing category, that particular category gets the largest cost weighage among all. If we look at element cost weightage in the surfacing category, we find that the bituminous mixture has the largest weightage.

Table 5.3: Cost Weightage of HCI control items

SN	**Item**	**Total Weightage**
1	HMAC	26.83
2	Flexible base	7.66
3	Continuous Re concrete pavement	6.95
4	Surface treatment aggregate	4.80
5	Roadway Embankment	4.61
6	Surface treatment asphalt	4.55
7	Jointed non Re concrete pavement	4.11
8	Retaining wall	4.00
9	Roadway Excavation	3.43
10	Regular Beam	3.17
11	Bridge Slab	2.99
12	Class C	2.74
13	Concrete Box Culvert	2.51
14	Reinforced Concrete Pipe (Sewer)	2.16
15	Drilled shaft	2.02
16	Lime	1.90
17	Metal for structure	1.86
18	Concrete Riprap	1.65
19	Plant Mix	1.55
20	Asphalt stabilized base	1.55
21	Lime Treatment	1.49
22	Bridge Rail	1.40
23	Reinforced Concrete Pipe	1.35
24	Concrete Box Sewer	1.18
25	Cement	0.67
26	Concrete Piling	0.62
27	Jointed Re concrete pavement	0.54
28	Cement Treatment	0.51
29	Box Beam	0.47
30	Class S	0.46
31	Corrugated Metal Pipe	0.13
32	Class A	0.09
33	Plant Mix	0.04
34	Steel H Piling	0.02

Figures 5.3 and 5.4 illustrate the comparative weights of the four primary item categories in HCI, and the comparative weights of three primary types of surfacing.

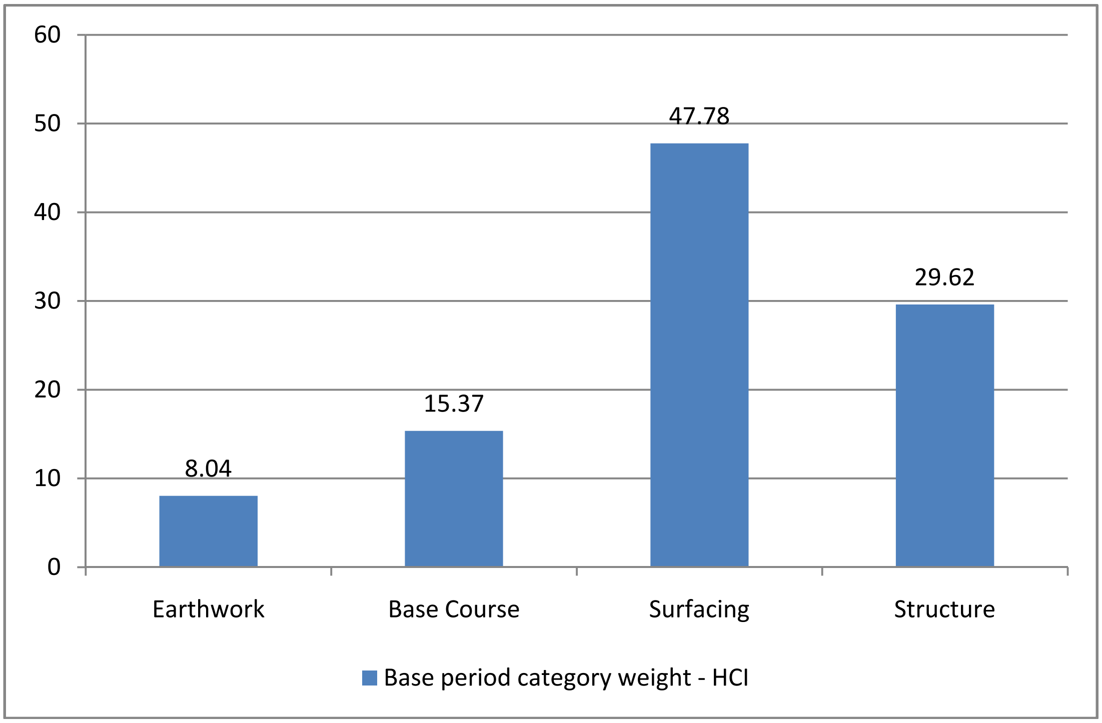


Figure 5.3: HCI category cost weightage

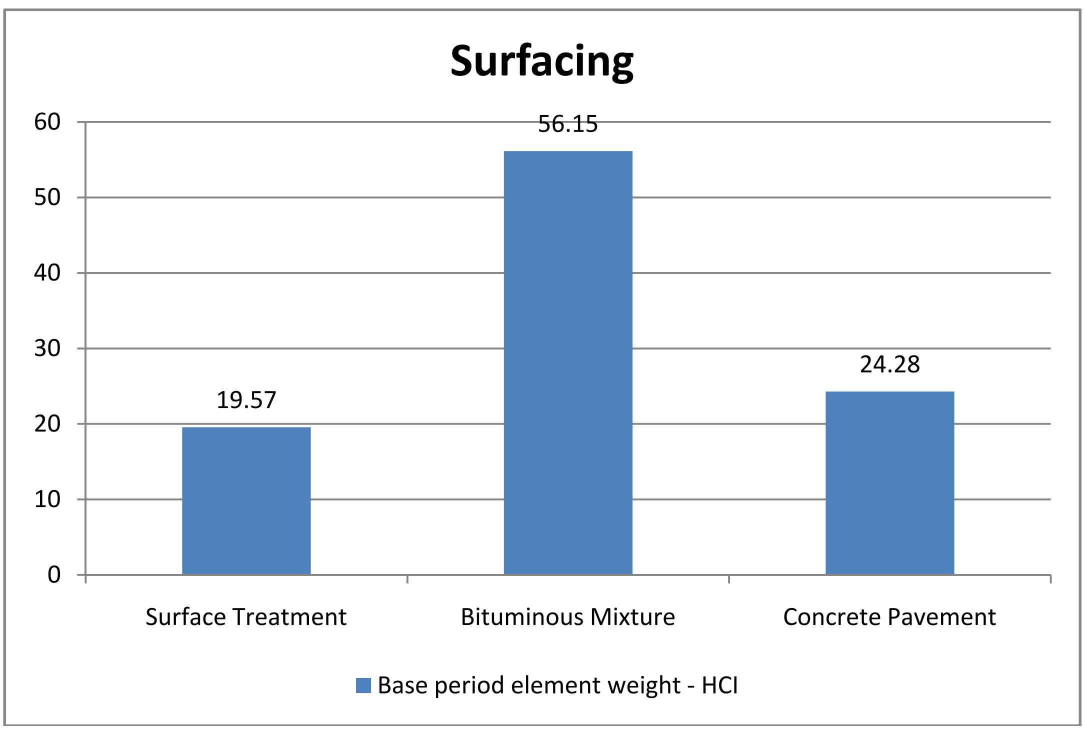


Figure 5.4: HCI category weightage

It is clear that surfacing-related items such as hot mixed asphalt concrete, flexible base, continuous reinforcement concrete pavement, etc. are the items causing the greatest impact on highway construction cost. These items are mainly composed of petroleum-related products and steel, which have seen a sharp price increase during the last three to four years. This finding explains why the HCI has increased in recent years.

5.3 Comparison of HCI with other cost indexes

Like Texas, other states and agencies also maintain their own cost indexes to record the highway construction cost over the years. For example, the construction industry weekly magazine Engineering News Record (ENR) has published construction cost indexes going back to 1913. All of these cost indexes are calculated in different ways but their final objective is the same, that is, to track the construction trend. In this section, we will compare the HCI to other indexes to determine if it is a reasonable measure of construction inflation.

The purpose of comparison of the HCI with other indexes is to check whether the construction cost trend obtained by the HCI is similar to trends obtained by other indexes. Though these indexes are from different states, construction cost trends should not be substantially different, as the components used for highway construction are similar from state to state, and they should be closely related to national indexes.

5.3.1 Construction Cost Indexes

The Federal Highway Administration (FHWA) prepares a cost index for all states and one composite index for all federal projects. The Producer Price Index (PPI) of the Bureau of Labor Statistics (BLS) of US Department of Labor contains various data to track the construction cost at a national level. For highways, the BLS prepares the BHWY-Highway and Street Construction.

The data used by the BLS for the PPI is quite different from all the rest because it calculates industry data required for material and services of a particular type of construction. The index includes the prices of materials and services used directly or indirectly in highway construction from more than 180 industries. It does not include labor cost and it is only available at the national level.

We have selected several available indexes for the purpose of comparison with a base year of 1997 because the HCI data is available from that date onwards. Other indexes are converted to this base year using Equation 1:

Index of Year X (for base 1997) = (Index value for Year X /Index value for 1997)*100

The states chosen for our comparison are Washington, California, Colorado, Oregon, and Utah and at the national level, FHWA, PPI – Highway and street construction and ENR construction cost index. The reason these states were chosen over the others is because these were the only DOTs that published an annual highway construction cost index. Figure 5.5 presents a graph comparing these indexes.

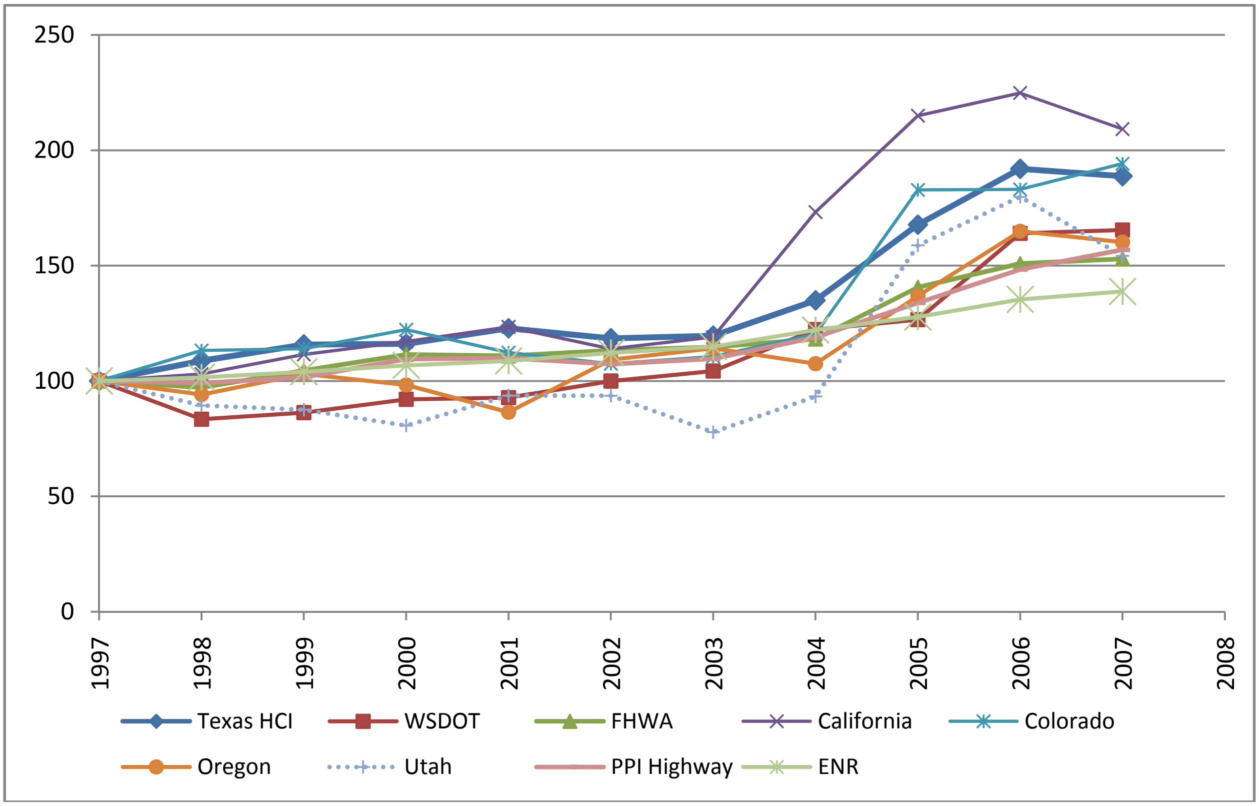


Figure 5.5: Comparison of indexes

The graph shows that, from the year 1997 to 2003 all indices are increasing at an almost flat rate, but after the year 2003 there are sudden changes in the trend of all the indexes. After 2006 all indexes either started flattening or started decreasing. The reason for this will be analyzed in the next section. Here we notice that Texas HCI is slightly higher than all the indexes except for the California construction cost index. Also, the ENR construction cost index doesn't exhibit a significant change after 2003 and its change is much less than other indexes probably because the ENR index combines all types of construction.

5.3.2 Is HCI Different from Other Indexes?

Although it is evident by looking at the graph that the HCI trend is close to all other indexes, we wanted to check the amount of variance in the same direction. For this process we did an analysis of variance (ANOVA) in two samples. The first sample includes the HCI and second sample does not. The ENR construction cost index was not included because it is not specific to highway construction.

Overview of ANOVA

1. It is a statistical method to compare population parameter between two or more samples.
2. This is done with an ANOVA table. This table basically compares two sources of variation: the variation within each population against the variation among sample means from the different populations. If the latter variation is large relative to the former, then there is evidence of differences between population means. The key value in the ANOVA

table is the *p-value*, i.e., the probability that the means are different. A small p-value is evidence of different population means. Besides the ANOVA table, it is informative to look at confidence intervals for all differences between pairs of means. Confidence intervals that do not include 0 are evidence of means that are not equal.

3. The test statistic is based on the Fisher or F-Distribution of the sample (for ratios with different degrees of freedom in the numerator and denominator)

   $F = MS_{Between} / MS_{Within}$

   where MS = Mean Square

   Large F value indicates that the samples are different.

4. Assumption:
   - Random samples are independent
   - Population variance are equal (largest / smallest < 4)
   - The distribution in each group is Normal.

Performing ANOVA

From the data collected, all the samples are independent and the largest and smallest variance ratio is less than four except in the case of California. But, because it is present in both samples it can be used for our comparison. For normality test, performing the quantile-quantile (Q-Q) test on California would be sufficient to say that all other indexes are also normally distributed because the California cost index has the largest variation after 2003 (see Figure 5.6).

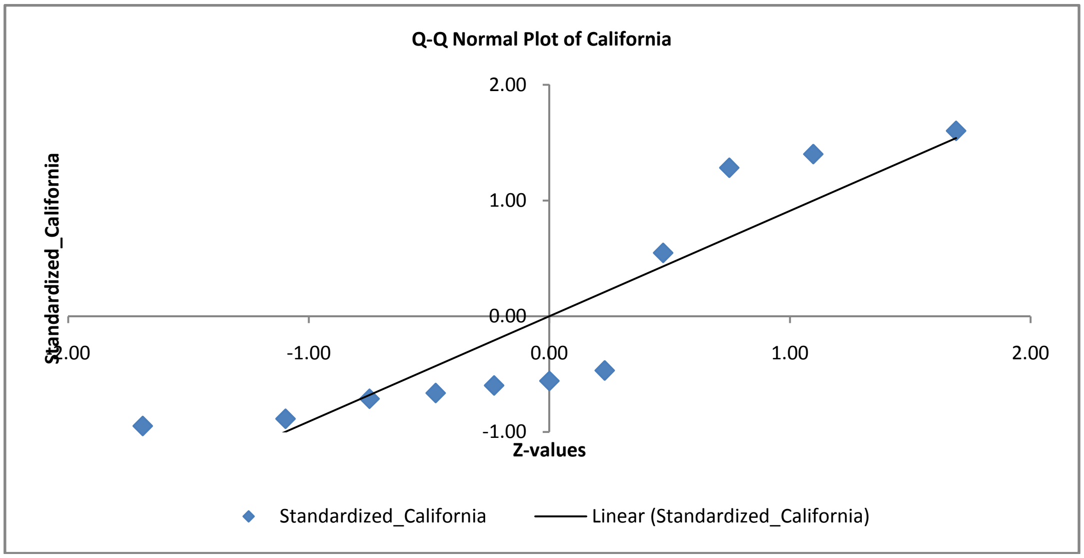


Figure 5.6: Q-Q normal plot of California

In the above Q-Q plot for California, we see that most of the data are distributed along a line at 45 degree from axes. The trend line is also very close to a 45 degree line. Hence, we can say that the data exhibits a normal distribution.

Tables 5.4 and 5.5 present the results of the samples.

Table 5.4: First Sample (Without HCI)

Summary stats for samples

	FHWA	PPI	WSDOT	California	Colorado	Oregon	Utah
Sample sizes	11	11	11	11	11	11	11
Sample means	119.509	117.744	112.492	146.409	132.762	115.891	109.914
Sample standard deviations	19.626	19.885	29.101	48.941	35.242	26.424	35.972
Sample variances	385.197	395.430	846.879	2395.199	1241.973	698.222	1294.015
Weights for pooled variance	0.143	0.143	0.143	0.143	0.143	0.143	0.143

Number of samples	7
Total sample size	77
Grand mean	122.103
Pooled variance	1036.702
Pooled standard deviation	32.198

OneWay ANOVA table

Source	SS	DF	MS	F	p-value
Between variation	11106.206	6	1851.034	1.786	0.1146
Within variation	72569.141	70	1036.702		
Total variation	83675.347	76			

Confidence intervals for mean differences

Confidence level	95.0%

Table 5.5: Second Sample (With HCI)

Summary stats for samples

	HCI	FHWA	PPI	WSDOT	California	Colorado	Oregon	Utah
Sample sizes	11	11	11	11	11	11	11	11
Sample means	135.035	119.509	117.744	112.492	146.409	132.762	115.891	109.914
Sample standard deviations	32.411	19.626	19.885	29.101	48.941	35.242	26.424	35.972
Sample variances	1050.500	385.197	395.430	846.879	2395.199	1241.973	698.222	1294.015
Weights for pooled variance	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125

Number of samples	8
Total sample size	88
Grand mean	123.720
Pooled variance	1038.427
Pooled standard deviation	32.225

OneWay ANOVA table

Source	SS	DF	MS	F	p-value
Between variation	12715.973	7	1816.568	1.749	0.1093
Within variation	83074.140	80	1038.427		
Total variation	95790.113	87			

Confidence intervals for mean differences

Confidence level	95.0%

Clearly, the F distribution of the second sample is less than for the first sample, which means that the variance of HCI falls somewhere in the combined variance of the group.

Observing the trend in the chart and by analysis of variance, we can say that HCI behaves similarly to other indexes.

5.3.3 Is the HCI Closer to the FHWA Index or to the PPI?

By general observation of the earlier chart, it appears that the HCI is more closely related to the FHWA cost index than to the PPI. We will verify it by doing analysis of variance on two samples, first between the HCI and the FHWA index (Table 5.6), then between the HCI and the PPI-Highway and Street construction (Table 5.7).

Table 5.6: HCI & FHWA

Summary stats for samples					
	HCI	FHWA			
Sample sizes	11	11			
Sample means	135.035	119.509			
Sample standard deviations	32.411	19.626			
Sample variances	1050.500	385.197			
Weights for pooled variance	0.500	0.500			
Number of samples	2				
Total sample size	22				
Grand mean	127.272				
Pooled variance	717.849				
Pooled standard deviation	26.793				
OneWay ANOVA table					
Source	SS	DF	MS	F	p-value
Between variation	1325.964	1	1325.964	1.847	0.1892
Within variation	14356.970	20	717.849		
Total variation	15682.935	21			
Confidence intervals for mean differences					
Confidence level	95.0%				

Table 5.7: HCI & PPI

Summary stats for samples					
	HCI	PPI			
Sample sizes	11	11			
Sample means	135.035	117.744			
Sample standard deviations	32.411	19.885			
Sample variances	1050.500	395.430			
Weights for pooled variance	0.500	0.500			
Number of samples	2				
Total sample size	22				
Grand mean	126.390				
Pooled variance	722.965				
Pooled standard deviation	26.888				
OneWay ANOVA table					
Source	SS	DF	MS	F	p-value
Between variation	1644.459	1	1644.459	2.275	0.1471
Within variation	14459.296	20	722.965		
Total variation	16103.755	21			
Confidence intervals for mean differences					
Confidence level	95.0%				

The lower F-value for the first indicates that the HCI is closer to the FHWA index than it is to the PPI-Highway and Street construction. This means that the HCI is an acceptable measure of highway construction inflation.

5.4 Indicators of construction inflation

In this section we identify some elements that may be causes of construction inflation.

5.4.1 Construction Inputs

According to BLS, the cost of inputs to construction industries increased at about the same rate as other prices in the overall economy up until the year 2003. After that year those inputs started increasing rapidly, as shown in Figure 5.7.

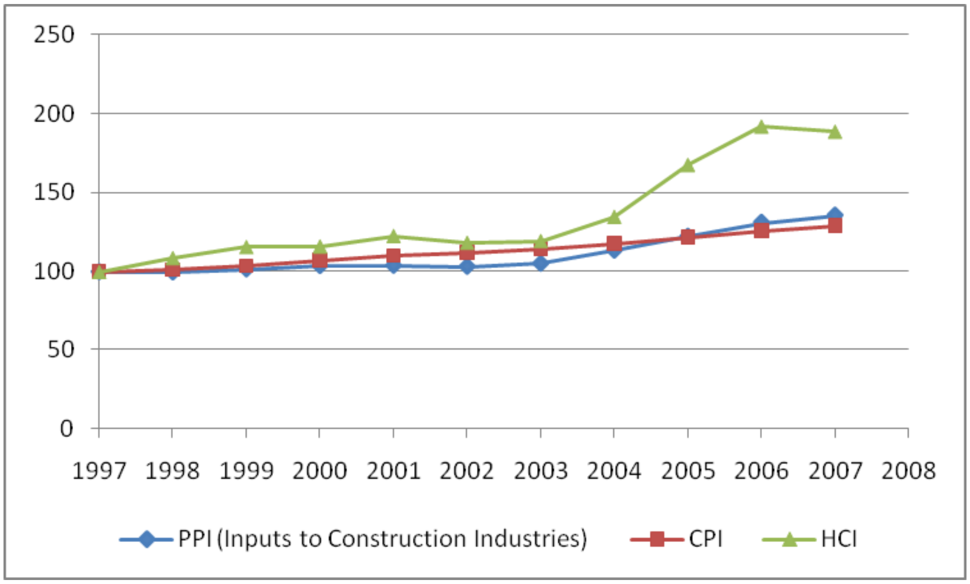


Figure 5.7: Cost Index of BLS Construction Inputs Compared to CPI and HCI, 1997-2007

From 1997 to 2007 inputs to construction industries increased 35% while general inflation (cumulative percentage increase) was 29%. In the same time period the HCI increased 88.8%. After year 2003, all indices started increasing rapidly. However, the HCI showed an actual decrease after 2006. To see the changes after 2003 in better detail, the above data is re-plotted with base year 2003 in Figure 5.8.

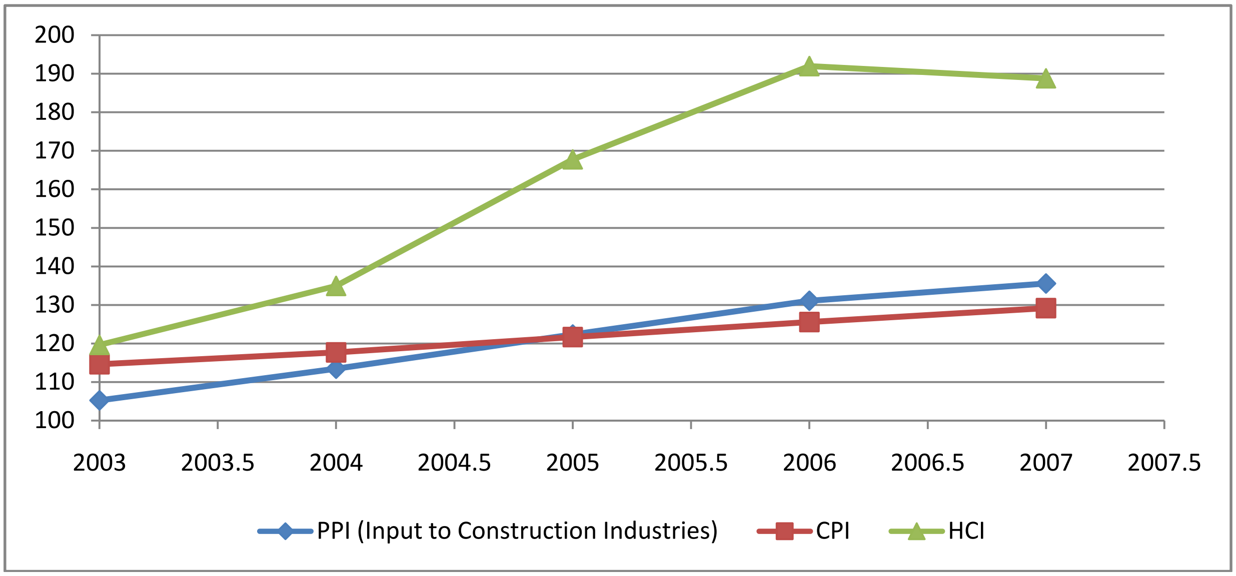


Figure 5.8: Cost Index of BLS Construction Inputs Compared to CPI and HCI, 2003-2007

From 2003 to 2007, the cumulative increase in inputs to construction industries was 28.8% while for general inflation it was 12.7%, and for the HCI it was 57.8%. Clearly, inputs to construction industries are increasing faster than the overall economy in the period from 2003 to 2007 and therefore forcing up the HCI.

5.4.2 Effect of Inputs on Segments of the Construction Industry

Other forces could also be pushing up the HCI, or the HCI could be exaggerating the effects. In Figure 5.9 we look at different segments of the construction industry to see how they have reacted to increasing costs of inputs.

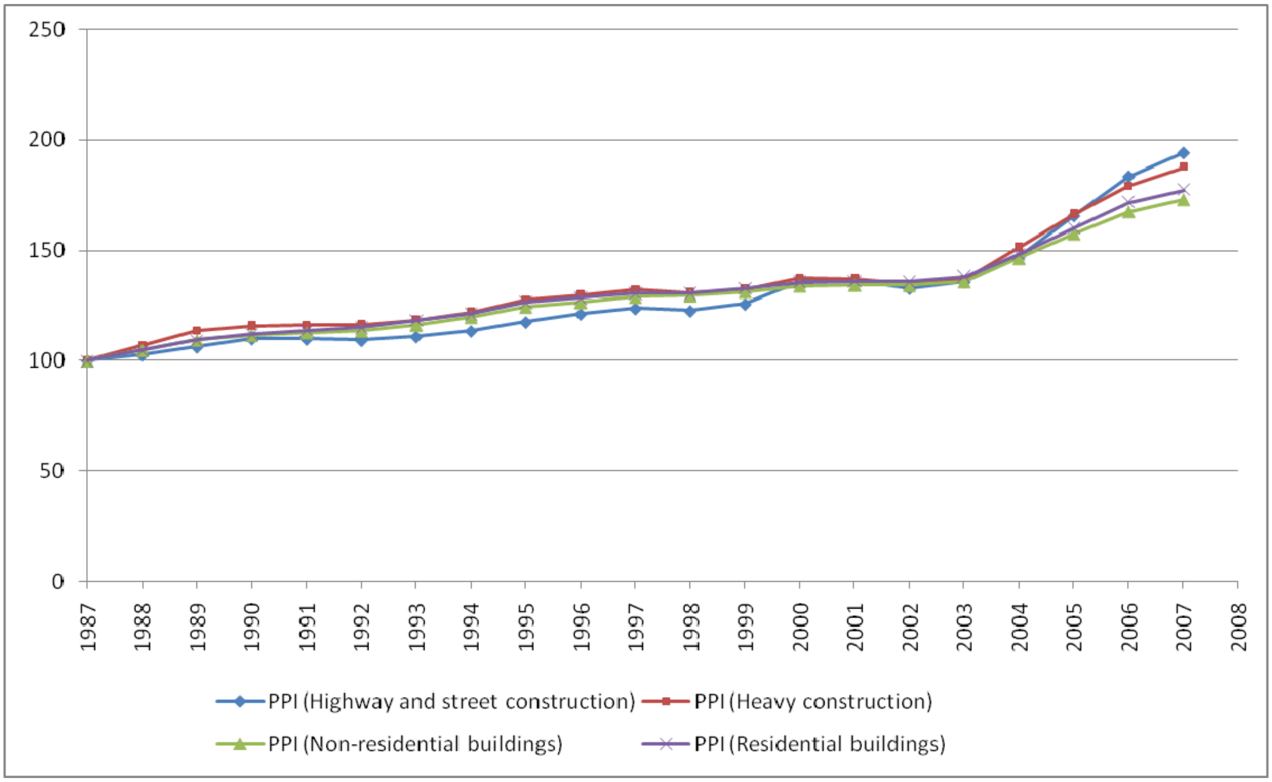


Figure 5.9: Cost Indexes of PPI Construction Inputs and BLS Segments, 1987-2007

We see that, from 1987 to 2003, highway and street construction, heavy construction, residential construction, and non-residential construction all increased at almost the same rates, about 38%. However, in just four years from 2003-2007 the rates all jumped. Figure 5.10 shows these recent increases in more detail, with the CPI included for comparison.

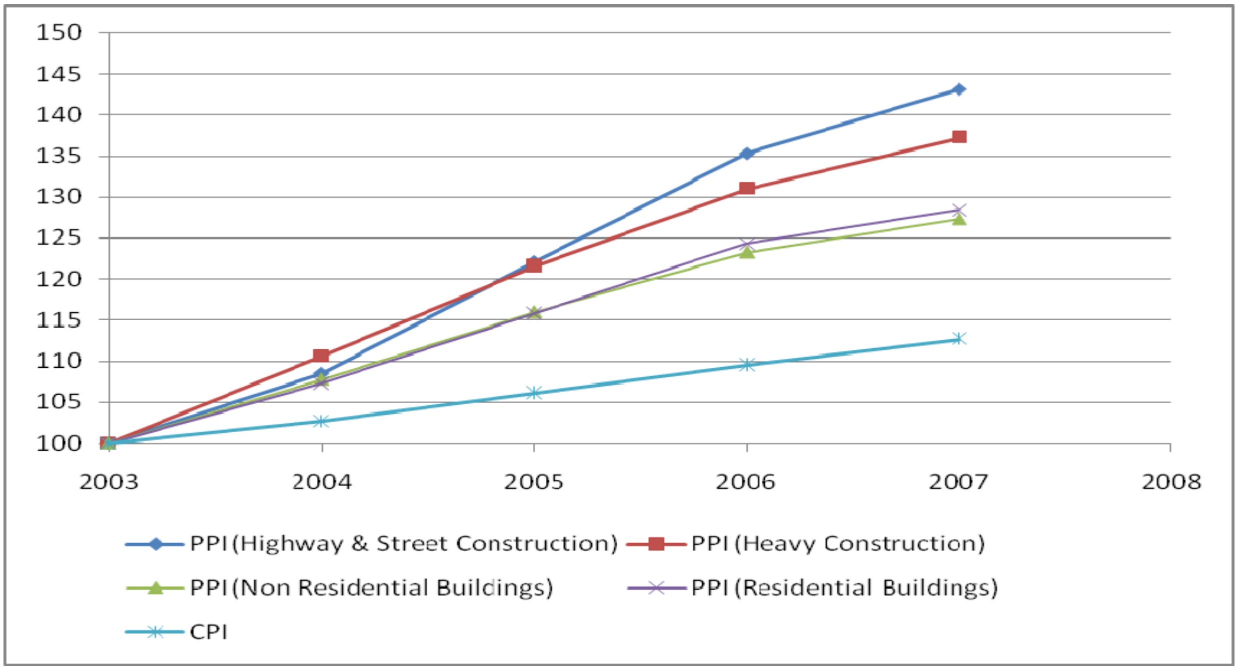


Figure 5.10: Cost Indexes of CPI and BLS Segments, 2003-2007

From 2003 to 2007, highway and street construction increased 43%, heavy construction 37%, residential 28%, and non-residential 27%, while the CPI increased just 12%. Of all types of construction, highway and street construction experienced the greatest increase. So, what are the forces causing highway construction costs to increase faster than other types of construction and the general economy?

5.4.3 Effects of Specific Construction Inputs

We can start by examining in more depth the inputs to construction. Figure 5.11 shows the cost indexes of four construction inputs over the period 1987-2007: No. 2 diesel, steel mill products, concrete products, and petroleum-based products.

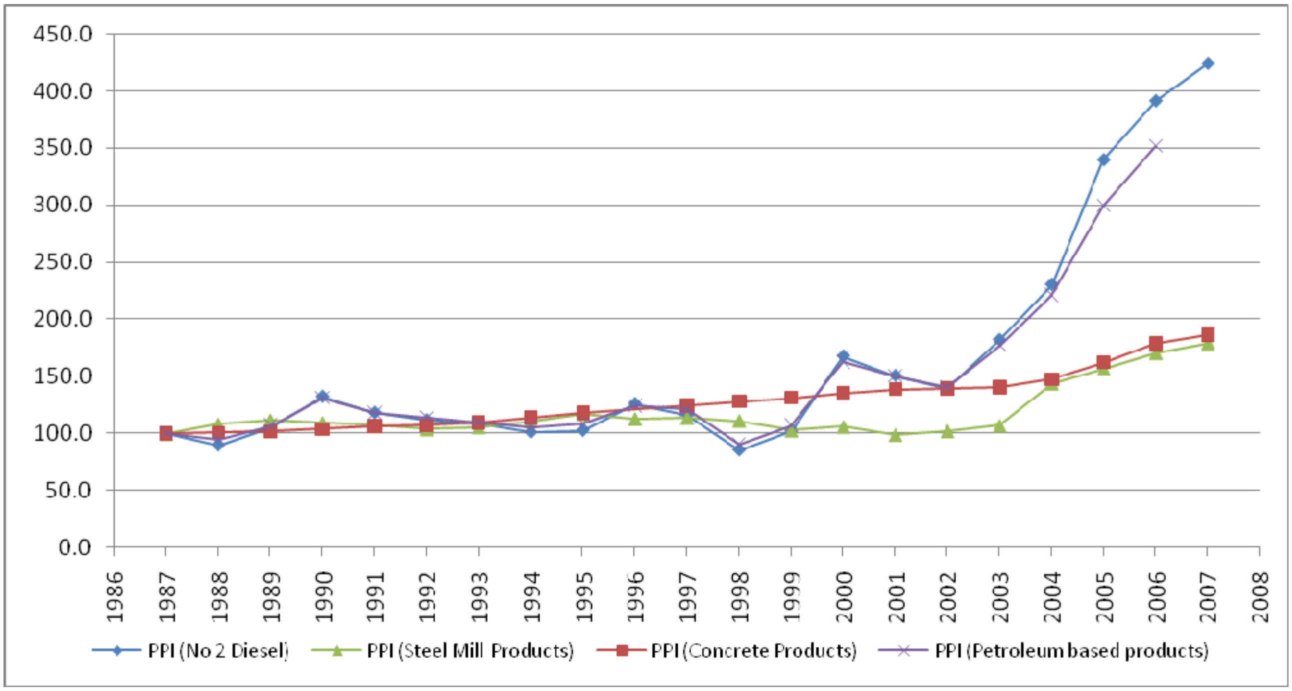


Figure 5.11: Cost Indexes of Construction Inputs, 1987-2007

Price increases in these materials were fairly smooth from 1987 to 2002. However, diesel and petroleum products started increasing rapidly after 2002 while steel mill products and concrete products started increasing after 2003. For example, diesel fuel price per gallon increased from $1.40 in December 2002 to $4.25 in December 2007. This chart indicates that diesel and petroleum product prices are the most influential forces in construction inflation. The increases in non-petroleum items appear to depend on the amount of energy input for those items: for example, from 1987 to 2007 the increase in steel prices tracks petroleum and diesel increases, increasing at about 20% of their rate.

Figure 5.12 overlays the cost increases in a number of construction materials with the HCI and the CPI for the period 2003-2007.

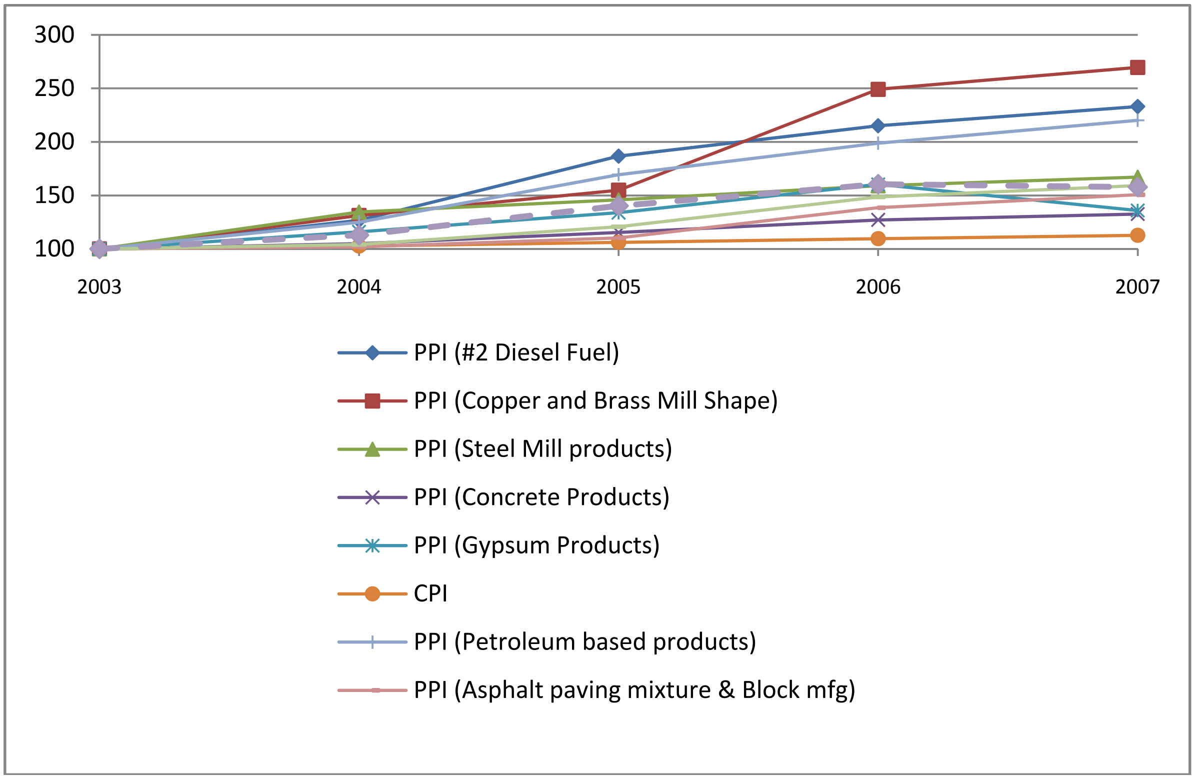
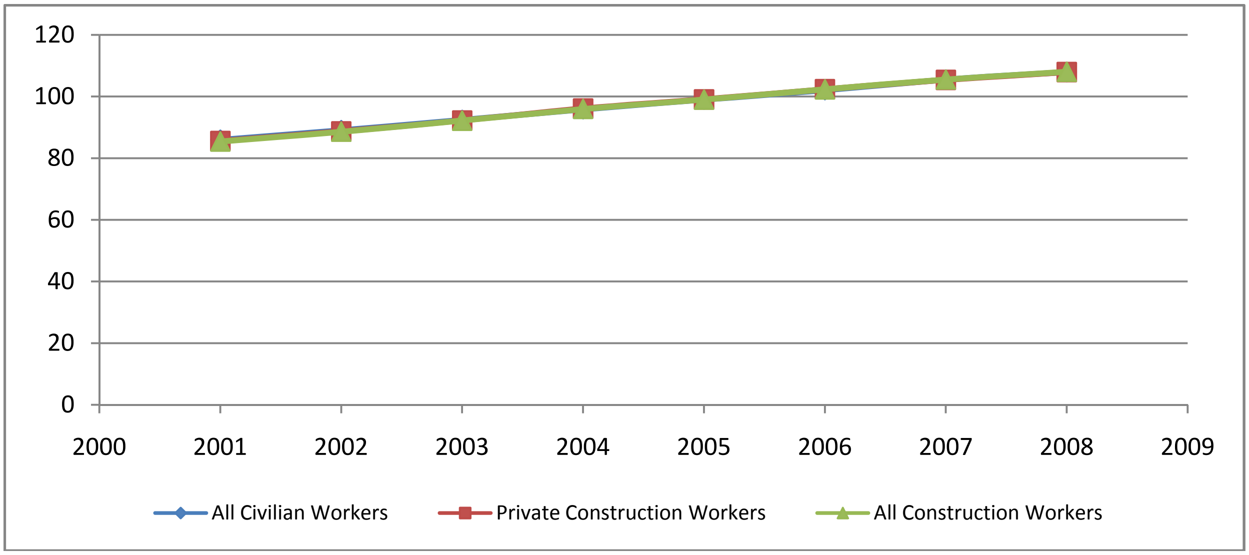


Figure 5.12: Cost Indexes of Construction Inputs, 2003-2007 with CPI and HCI

From the year 2003 to 2007, copper and brass mill shapes increased 169%, No. 2 diesel fuel increased 133%, petroleum refineries 120%, steel mill products 67%, asphalt paving mixture and block manufacturing 51%, and concrete products 32%. Clearly, increasing material prices have been forcing up the HCI. On the other hand, labor costs have been increasing more sedately, as seen in Figure 5.13. The increase in labor wage rates has been almost constant for the last seven years in all sectors, at about 3.5% per year.



Source: BLS

Figure 5.13: Employment Cost Index, 2001-2008

5.4.4 Effect of Energy Prices on Construction Inflation

The foregoing showed that increases in material prices are the primary forces in construction inflation. The relative level of energy input for those materials appears to determine the price increases. For example, residential construction has less petroleum-related inputs than heavy construction, accounting for its lower inflation rates. According to Association of General Contractor (AGC), petroleum refineries, asphalt products, and petroleum lubricating oil and grease manufacturing (NAICS code 324) accounted for only 7% of the single-unit residential index, but 38% of the highway PPI. This difference appears to be the reason why highway and street construction has seen higher inflation than all other types of construction.

By way of illustration, consider the effect of fuel prices. Contractors pay fuel surcharges on delivery of materials. In addition to this, fuel also affects other prices that are not material-intensive, such as excavation. Diesel is used in cranes, dozers, and other earth moving equipment. Excavation cost, as demonstrated in Figure 5.14, has also experienced significant increases since 2003. The chart shows excavation cost in $/CY for Washington, California, Colorado, and for FHWA. There is a sudden increase after 2003 and then a decrease after 2006, which follows almost the same pattern as fuel cost trends.

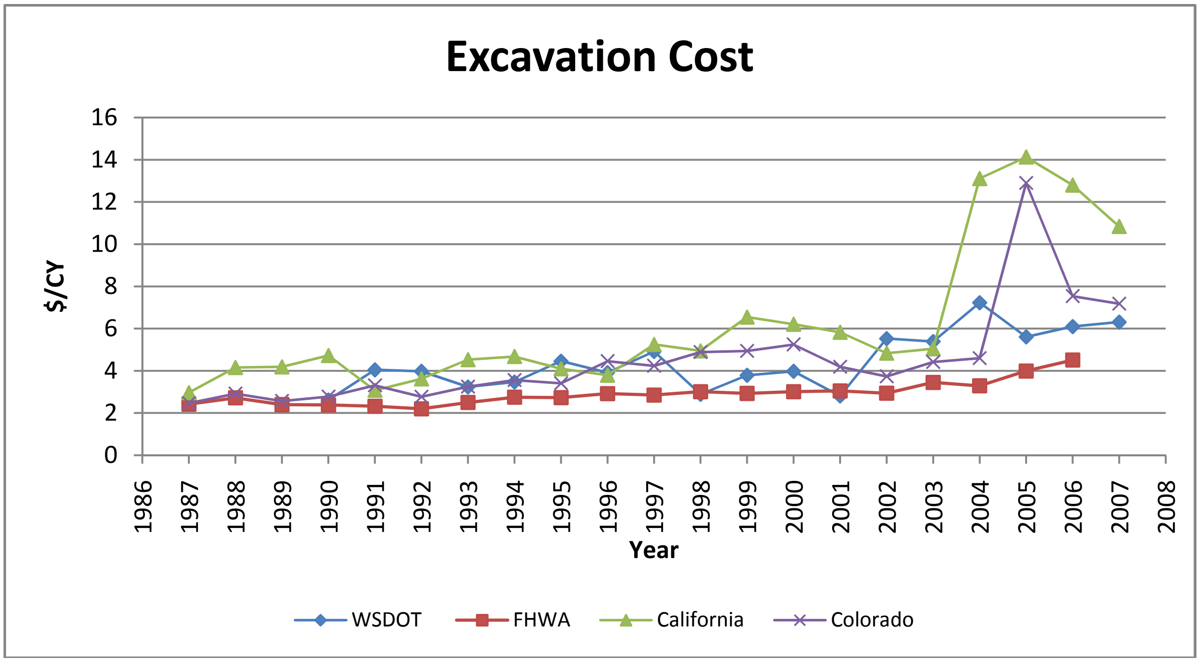


Figure 5.14: Changes in Excavation Costs (Effect of Diesel Prices)

From this analysis, it is clear that diesel, petroleum-related products, and steel prices are affecting construction cost because the construction cost trend is following the same pattern as cost trends of these materials. However, to predict the amount by which these materials are affecting the construction cost, we must know the relative weighting of these materials in overall highway construction cost.

5.4.5 Contribution of Specific Inputs to Construction Inflation

The following is a summary of findings on the weights of cost components from sources:

1. Labor accounts for roughly half (50%) of the cost of a construction project. *(Source: AGC Construction inflation alert march 2008)*
2. Petroleum refineries, asphalt products and petroleum lubricating oil and grease manufacturing (NAICS code 324) accounted for 38% of the highway PPI. *(Source: AGC Construction inflation alert march 2008).* Because PPI includes only non-labor components of construction, 38% of the non-labor costs (50%) is equivalent to 19% of overall construction. Therefore, petroleum related products contributed about 19% to construction costs in 2008.
3. Concrete and related materials compose 27.3% of PPI non-labor construction cost. Again using 50% for non-labor costs, concrete related materials contribute around 13.7% of total cost.
4. Steel and related materials correspond to 12.6% of non-labor cost. Again using 50% for non-labor costs, steel related materials contribute around 6.3% of total cost. For comparison, WSDOT estimates that reinforcement and structural steel costs range from 4% to 13% of total cost *(Source: WSDOT).*

The weightage of the above components are in the range of findings of AGC, BLS, and WSDOT. We verified by plotting an index based on these weightages vs. HCI and PPI-highway and street and construction. Starting from base year 1997, we obtained the percentage price changes for each component from the corresponding PPIs. For labor we used the employment cost index of all construction workers. For concrete and related materials we used the PPI for concrete ingredients and related products; for asphalt, the PPI for Petroleum and coal products; for fuel, the PPI for No. 2 Diesel; for Steel, the PPI for Iron and Steel; and for other materials we used the PPI for All Commodities. Table 5.8 shows the percentage changes in respective components from 1998 to 2007. The combined percentage change is the weightage average of all the components.

Table 5.8: Percentage Increase Year Over Year in PPI of Selected Construction Components

Yearly % increase in highway cost components

Component	%age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Labor	50	0	3.5	3.5	3.5	3.5	3.7	4	4.1	3.1	3.3	3.1
Petroleum & related	19	0	-22.55	15.84	46.88	-6.65	-6.17	23.48	22.87	33.69	17.51	10.53
Steel	6.3	0	-3.16	-6.94	2.28	-5.92	4.01	6.49	33.66	5.36	9.00	7.83
Concrete and related	13.7	0	3.57	3.09	2.25	2.24	2.22	1.39	3.41	8.75	10.55	7.42
Other	11	0	1.55	2.19	3.37	2.82	1.60	2.30	2.67	3.37	3.23	2.86

Table 5.9 shows the calculated composite cost index based on the respective weights of selected components and PPI cost increases for the period 1997-2007.

Table 5.9: Composite Cost Index Using Selected Components and PPI, 1997-2007

Year	Index	% Change
1997	100	
1998	97.9266	-2.073430
1999	102.8102	4.987020
2000	114.6106	11.477880
2001	115.4478	0.730447
2002	117.0752	1.409690
2003	125.6380	7.313887
2004	137.2930	9.276679
2005	150.8287	9.858957
2006	161.9069	7.344869
2007	170.6101	5.375467

Figure 5.15 shows the calculated ‘new index’ and compares it to the HCI and PPI.

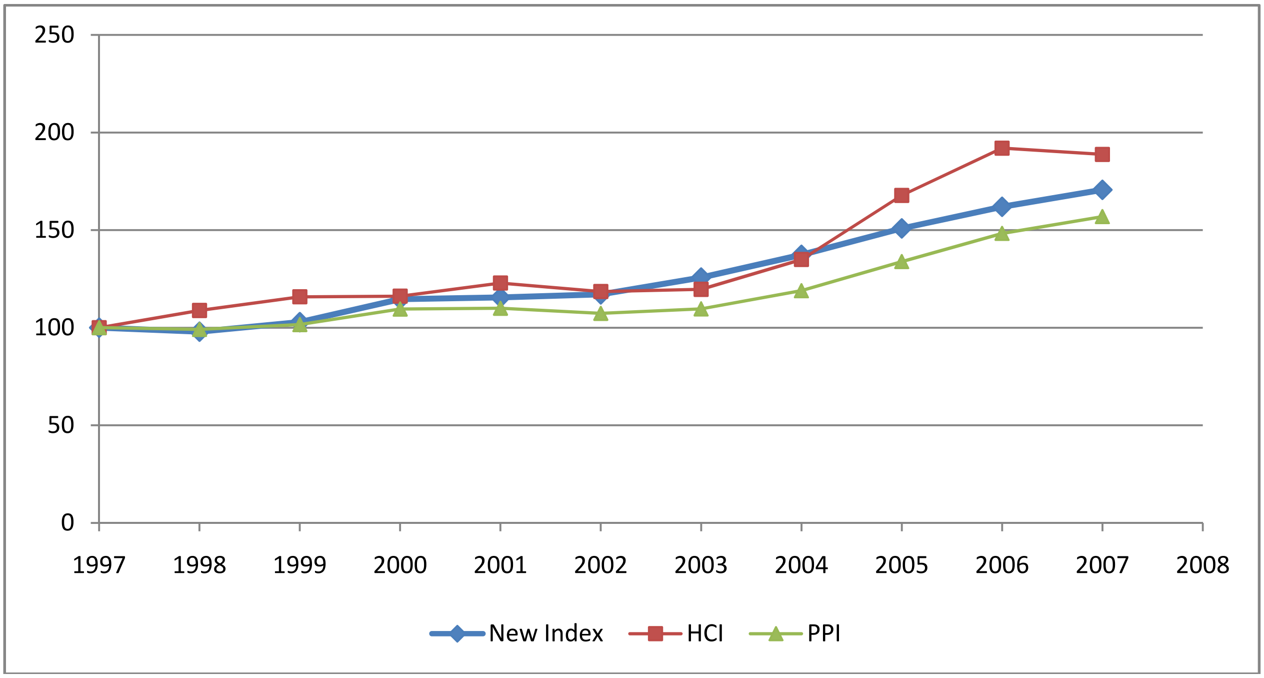


Figure 5.15: Composite Cost Index Compared to HCI and PPI

The new index is very close to the HCI and PPI. That means that our assumptions of weightage exhibit fairly good results. Hence, we can conclude that the components described above are symptomatic indicators of construction inflation. However, it must be noted that the weights assumed for construction components were based on cost weights in 2008 and are inherently affected by actual prices in any given year. Thus, if the price of cement were to suddenly skyrocket, the weightage of the concrete element would increase significantly and further exaggerate the effect. The same thing would happen if one year, say, the amount of steel used were to double. That is why indexes such as HCI, which are based on fixed weightages, tend to show exaggerated swings. However, there is no other easy way to estimate component weights or to combine component effects.

5.5 Forecasting of construction inflation

The highway construction inflation rate is an important input in expenditure estimation in the JACK model, as the purchasing power of highway funds depends on the inflation rate. Take the national highway construction between 2003 and 2005, for example. Nominal expenditures increased moderately, but real expenditures declined significantly due to the high rates of highway construction inflation. Thus, proper forecast of the highway construction inflation rates will improve the accuracy in expenditure estimation in the JACK model, and thus provides a more reliable tool for decision makers. In this section, the development of a methodology for forecasting highway construction inflation is discussed.

5.5.1 Published Forecasts

At the federal level, the FHWA has published a Bid Price Index (BPI) forecasting 2.0%-2.5% annual inflation rate for next 10 years. Several states also make predictions based on the construction market characteristics in their states. For example, Ohio DOT has published its predicted inflation rate through 2010, as shown in Figure 5.16. Their linear predictions are based upon the experience and understanding of the changes affecting the construction industry in Ohio. Also, it is mentioned in the report that they believe that the most important cost drivers of construction cost inflation for the next five years will be energy, steel, and cement. The prediction has a median value of 5% from 2005 to 2010, much higher than the BPI.

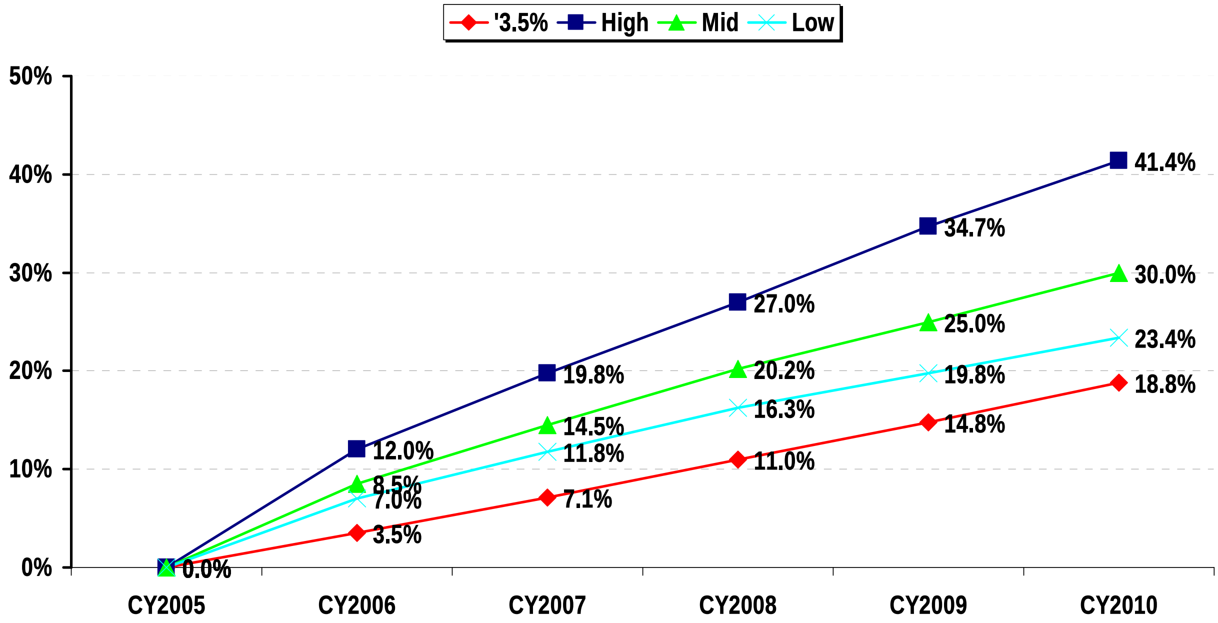


Figure 5.16: Predicted Compounded Inflation Growth CY2005-CY2010 from ODOT

5.5.2 Forecasting Techniques

Generally, inflation rate is hard to forecast. There are lots of macroeconomic models that have been developed to explain and predict the inflation rate (CPI). Among all of those models, forecasts based on past inflation, which includes univariate time series models such as ARIMA models and, more recently, nonlinear or time-varying univariate models, is one of the best performing models.

In this research we adopted similar approaches to analysis of highway inflation rate, and HCI was treated as a univariate indicator of highway construction inflation in Texas. Results show that using available HCI data, univariate models are not suitable for predicting HCI and the results were unsatisfactory. One of the main reasons is that a stationary process is an important assumption of any time series model, but the process is not stationary if we treat HCI as a stochastic process. Autocorrelation analysis, which is a mathematical tool to detect non-randomness in data and further identify an appropriate time series model if the data are not random, is the normal way to test autocorrelation.

Figure 5.17 shows the results of autocorrelation analysis using 1987-based HCI data from 1987 to 2003. The coefficients that are autocorrelations for data values at varying time lag decay quite slowly, indicating that the whole process is not stationary and the future value is hard to predict based only on available historical data.

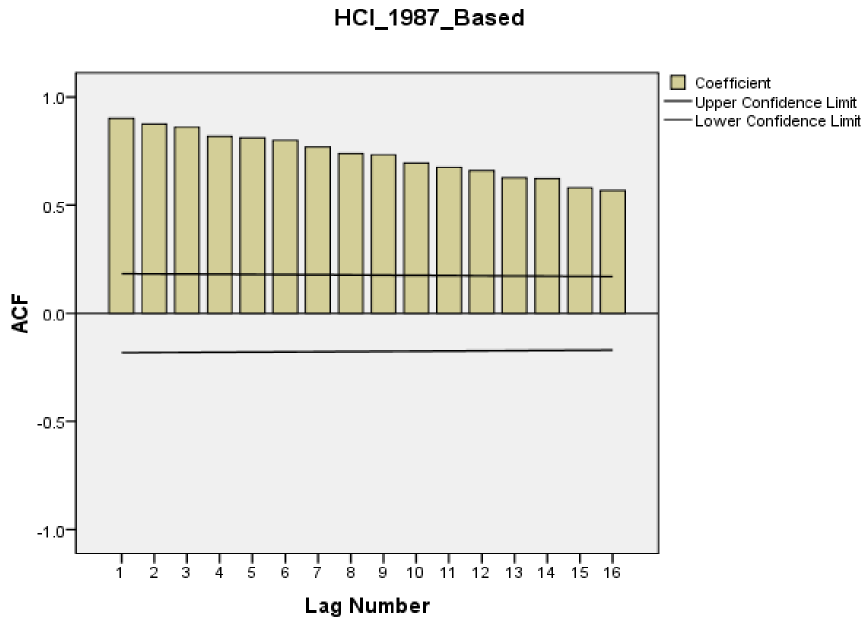


Figure 5.17: Autocorrelation analysis using HCI data from 1987 to 2003

5.5.3 Our Methodology

Thus, we considered a practical method to forecast HCI, which can include our earlier findings on highway construction inflation, and the-state-of-the-art in predicting commodity price, labor cost, and other inflation indicators from other research. There are three main steps of this methodology:

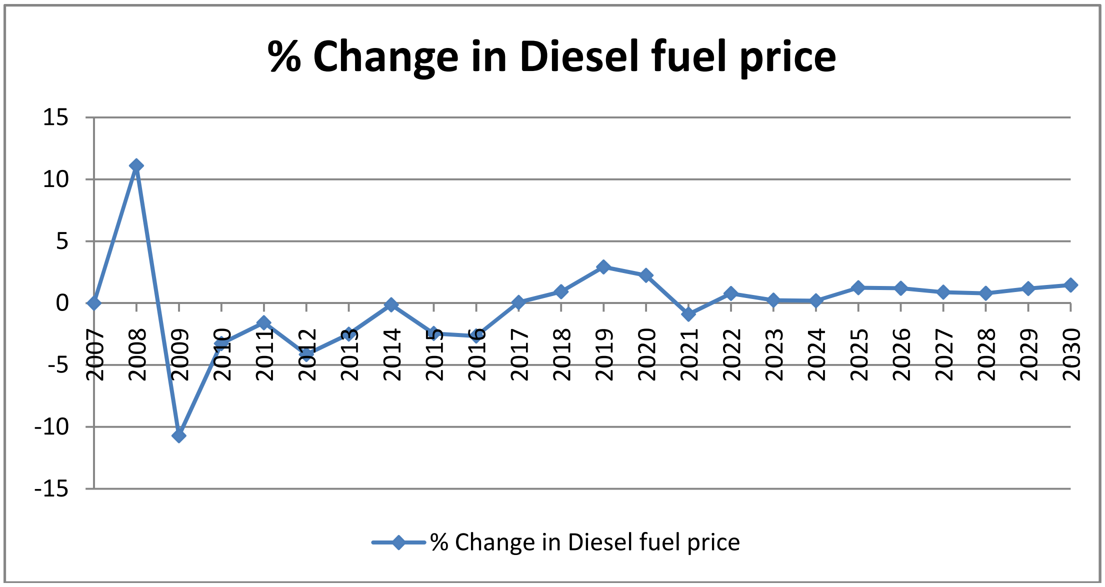
1. **Identify weight of most important indicators:**

   These were presented in the previous section. The weights of the five most important indicators—fuel, asphalt, steel, aggregate and concrete, and labor—were estimated. Correlations between fuel index and asphalt were obtained from historical data.

2. **Forecast an inflation range for each indicator:**

   Labor – According to BLS's Employment Cost Index (ECI), labor cost is increasing at an almost constant rate of 3.5% for last 5 to 6 years. We will consider 3.5% for future predictions.

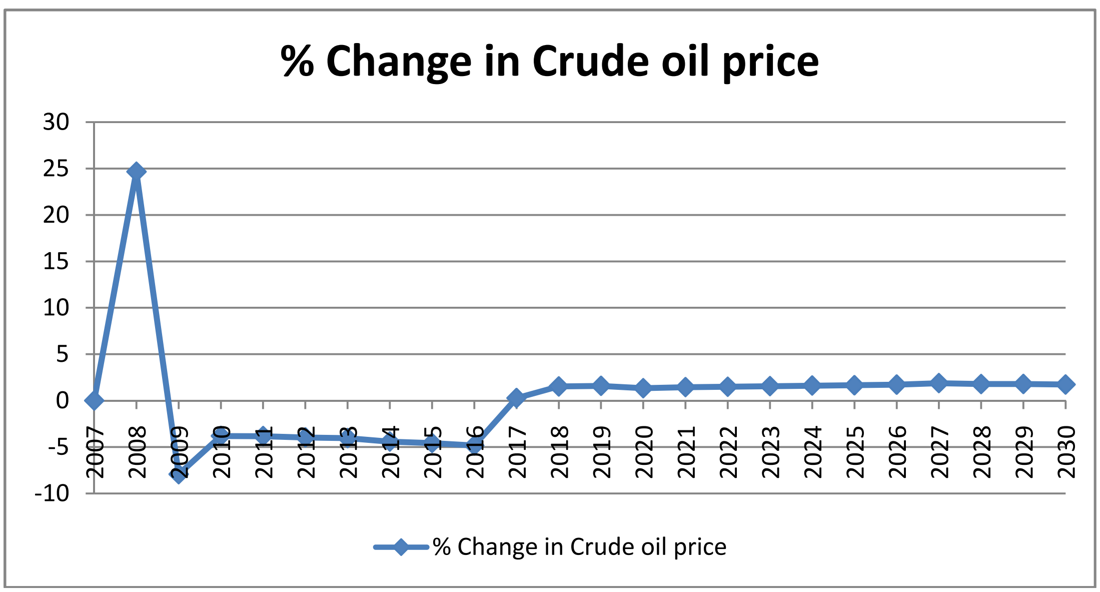
   Petroleum and Related – Energy Information Administration (Official energy statistics from U.S. Government) has predicted diesel fuel prices for 30 years (Figure 5.18).



Source: *http://www.eia.doe.gov/oiaf/forecasting.html*

Figure 5.18: Diesel fuel price predictions

The chart shows that diesel fuel prices are going to drop after next year then will return to 2007 prices for the future. According to EIA, for the next 30 years the price for crude oil will drop dramatically and then come up again by the year 2017 and level off through the year 2030 (Figure 5.19).



Source: http://www.eia.doe.gov/oiaf/forecasting.html

Figure 5.19: Crude oil price predictions

The petroleum and related products price is mainly dominated by diesel and crude oil prices. Figure 5.18 and Figure 5.19 show that diesel and crude oil prices will be following almost same pattern for next 30 years. For prediction purposes, we will use the crude oil price prediction as it has less variance in its projected values.

Steel: According to AGC, steel demand is going to continue for the next few years. Hence, for the percentage increase, we will take the median of the last 10 years, and then after 2017, when percent changes in oil price increase are going to level off, we will take the same percentage increase as crude oil. Therefore, from 2008 to 2017, we will use a 4% increase and from 2018 to 2030 a 1.7% increase.

Concrete and related products: This material is also affected by demand; hence, we will take the median of the last 10 years. That means a 3.1% increase.

Other Material: 2.75% (Median of CPI for the last 10 years)

Table 5.10 summarizes the projected percentage inflation in each component with its estimated standard deviation to provide upper and lower bounds. The distribution of projected percentage change for labor for each year is assumed as lognormal distribution, considering that the yearly change for labor cost is usually positive. Distributions for other components are assumed as normal distribution.

Table 5.10: Projected Percentage Inflation for Major Construction Components

Wt.	Labor		Petroleum		Steel		Concrete		Other	
	Mean	STDV	Mean	STDV	Mean	STDV	Mean	STDV	Mean	STDV
Year	50		19		6.3		13.7		11	
2009	3.5	1	-7.93	2	4	2	3.1	1	2.75	1
2010	3.5	1	-3.81	2	4	2	3.1	1	2.75	1
2011	3.5	1	-3.82	2	4	2	3.1	1	2.75	1
2012	3.5	1	-3.97	2	4	2	3.1	1	2.75	1
2013	3.5	1	-4.04	2	4	2	3.1	1	2.75	1
2014	3.5	1	-4.42	2	4	2	3.1	1	2.75	1
2015	3.5	1	-4.57	2	4	2	3.1	1	2.75	1
2016	3.5	1	-4.83	2	4	2	3.1	1	2.75	1
2017	3.5	1	0.28	2	4	2	3.1	1	2.75	1
2018	3.5	1	1.53	2	1.7	2	3.1	1	2.75	1
2019	3.5	1	1.59	2	1.7	2	3.1	1	2.75	1
2020	3.5	1	1.34	2	1.7	2	3.1	1	2.75	1
2021	3.5	1	1.45	2	1.7	2	3.1	1	2.75	1
2022	3.5	1	1.5	2	1.7	2	3.1	1	2.75	1
2023	3.5	1	1.56	2	1.7	2	3.1	1	2.75	1
2024	3.5	1	1.62	2	1.7	2	3.1	1	2.75	1
2025	3.5	1	1.65	2	1.7	2	3.1	1	2.75	1
2026	3.5	1	1.72	2	1.7	2	3.1	1	2.75	1
2027	3.5	1	1.89	2	1.7	2	3.1	1	2.75	1
2028	3.5	1	1.79	2	1.7	2	3.1	1	2.75	1
2029	3.5	1	1.79	2	1.7	2	3.1	1	2.75	1
2030	3.5	1	1.73	2	1.7	2	3.1	1	2.75	1
2031	3.5	1	1.73	2	1.7	2	3.1	1	2.75	1
2032	3.5	1	1.73	2	1.7	2	3.1	1	2.75	1
2033	3.5	1	1.73	2	1.7	2	3.1	1	2.75	1
2034	3.5	1	1.73	2	1.7	2	3.1	1	2.75	1
2035	3.5	1	1.73	2	1.7	2	3.1	1	2.75	1

3. Conduct a Monte Carlo Simulation:

A Monte Carlo simulation is a process of using a random number generator to simulate a value of a variable based on its statistical distribution, mean, and standard deviation. For each year and each component, a series of values are generated to provide a confidence band. In this case we selected a lower bound of 5% and an upper bound of 95%, which gives us a 90% confidence that the estimate will be between the lower and upper values.

5.5.4 Simulation Results

Table 5.11 shows the results of the projected highway construction inflation rates, which were calculated by a Monte Carlo simulation.

Table 5.11: Projected Highway Construction Inflation Rates

	Yearly Inflation Rates (%)				Accumulated Inflation Rates (%)		
Year	Average	High(95%)	Low(5%)	STDV	Average	High(95%)	Low (5%)
2009	1.25	2.99	-0.08	0.67	101.25	102.99	99.92
2010	2.03	3.86	0.66	0.69	103.31	106.97	100.58
2011	2.04	3.85	0.64	0.70	105.41	111.08	101.22
2012	1.97	3.63	0.70	0.64	107.49	115.12	101.93
2013	1.93	4.00	0.34	0.81	109.56	119.72	102.28
2014	1.98	3.88	0.52	0.73	111.73	124.37	102.81
2015	1.93	3.76	0.53	0.70	113.89	129.04	103.36
2016	1.67	3.38	0.36	0.66	115.79	133.40	103.73
2017	2.73	4.43	1.43	0.65	118.95	139.31	105.21
2018	2.86	4.59	1.53	0.67	122.35	145.71	106.82
2019	2.90	4.65	1.56	0.67	125.90	152.48	108.49
2020	2.84	4.60	1.49	0.68	129.48	159.50	110.10
2021	2.86	4.71	1.45	0.71	133.18	167.01	111.70
2022	2.89	4.75	1.45	0.72	137.03	174.94	113.32
2023	2.89	4.63	1.55	0.67	140.99	183.04	115.08
2024	2.91	4.75	1.49	0.71	145.09	191.74	116.79
2025	2.93	4.77	1.51	0.71	149.35	200.88	118.55
2026	2.92	4.73	1.52	0.70	153.71	210.38	120.36
2027	3.00	4.67	1.71	0.64	158.32	220.21	122.41
2028	2.96	4.76	1.57	0.69	163.00	230.69	124.34
2029	2.93	4.74	1.55	0.69	167.78	241.63	126.26
2030	2.90	4.70	1.52	0.69	172.65	252.98	128.18
2031	2.92	4.69	1.55	0.68	177.69	264.85	130.17
2032	2.92	4.73	1.52	0.70	182.87	277.37	132.15
2033	2.90	4.70	1.52	0.69	188.18	290.41	134.16
2034	2.92	4.69	1.55	0.68	193.67	304.03	136.24
2035	2.90	4.65	1.56	0.67	199.29	318.17	138.36

The results are graphed in Figures 5.20 and 5.21.

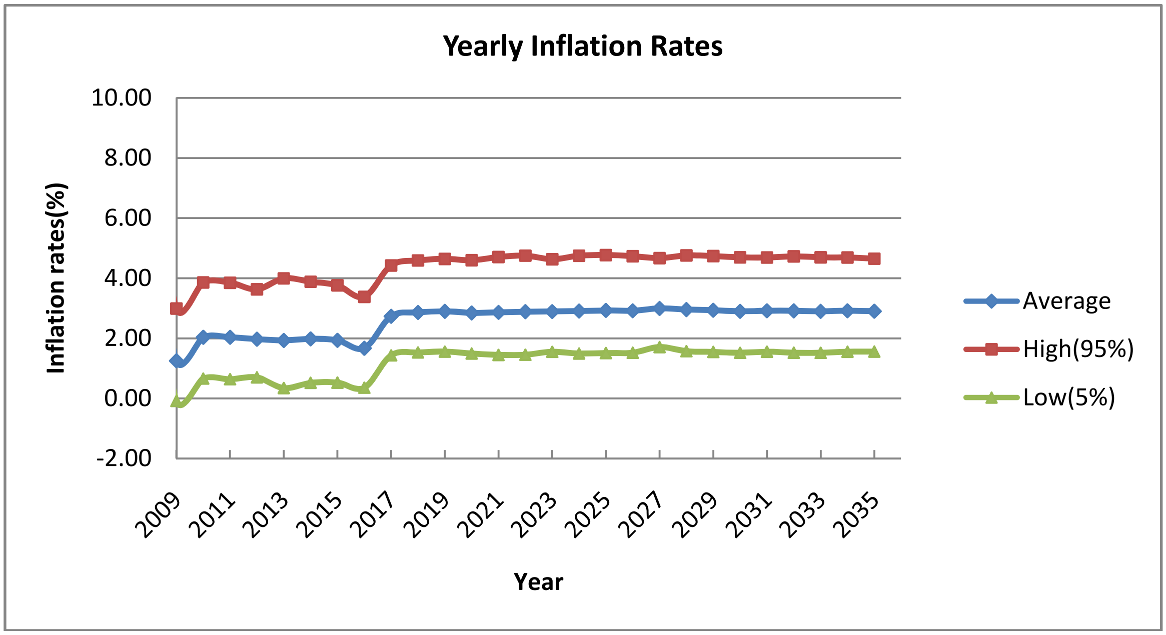


Figure 5.20: Projected Yearly Inflation Rates from 2009 to 2035

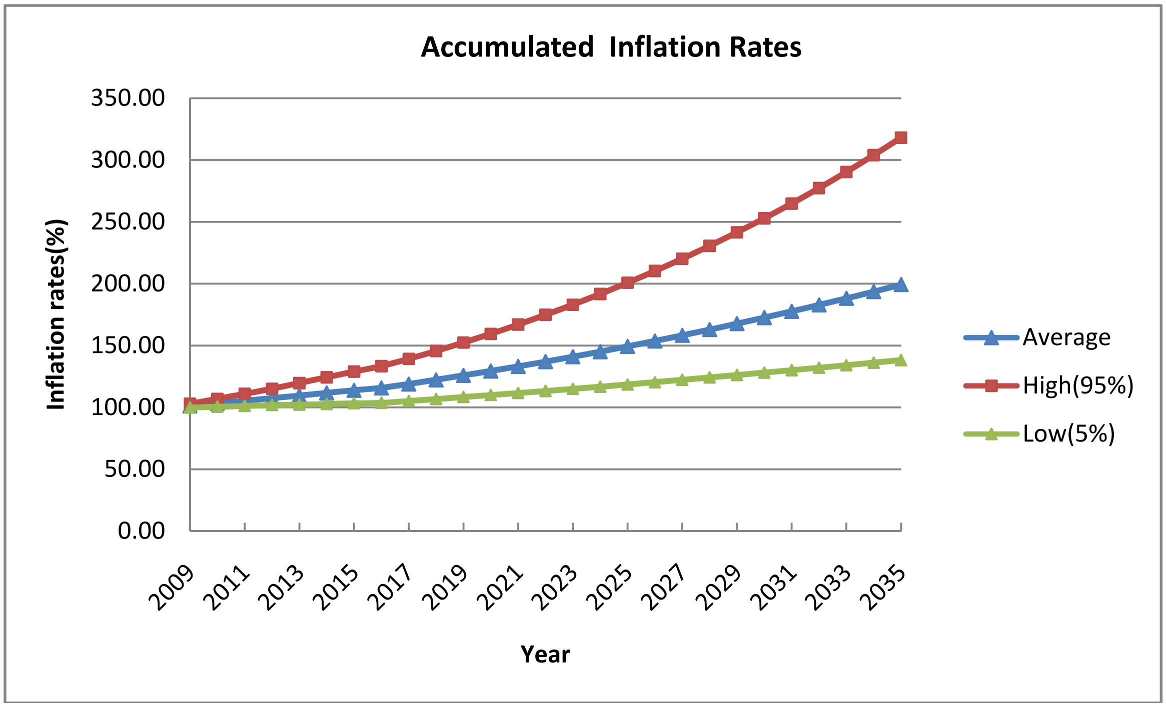


Figure 5.21: Projected Accumulated Inflation Rates from 2009 to 2035

Using these results, Table 5.12 gives our predictions for the HCI up to the year 2035.

Table 5.12: HCI Forecast up to 2035

Year	HCI		
	Average	High	Low
1997	100		
1998	108.82		
1999	115.83		
2000	116.17		
2001	122.87		
2002	118.52		
2003	119.64		
2004	134.96		
2005	167.78		
2006	191.99		
2007	188.81		
2008	209.87		
2009	212.49	216.15	209.70
2010	216.82	224.50	211.09
2011	221.22	233.12	212.43
2012	225.59	241.60	213.92
2013	229.93	251.26	214.66
2014	234.49	261.02	215.77
2015	239.02	270.82	216.92
2016	243.01	279.97	217.70
2017	249.64	292.37	220.80
2018	256.78	305.80	224.18
2019	264.23	320.01	227.69
2020	271.74	334.74	231.07
2021	279.50	350.50	234.42
2022	287.58	367.15	237.82
2023	295.90	384.15	241.52
2024	304.50	402.40	245.11
2025	313.44	421.59	248.80
2026	322.59	441.52	252.60
2027	332.27	462.15	256.90
2028	342.09	484.15	260.95
2029	352.12	507.11	264.98
2030	362.34	530.93	269.01
2031	372.92	555.84	273.19
2032	383.79	582.12	277.34
2033	394.93	609.48	281.56
2034	406.46	638.07	285.93
2035	418.25	667.74	290.38

A graph of the projected HCI is shown in Figure 5.22, for a more visual appraisal of the inflation rate.

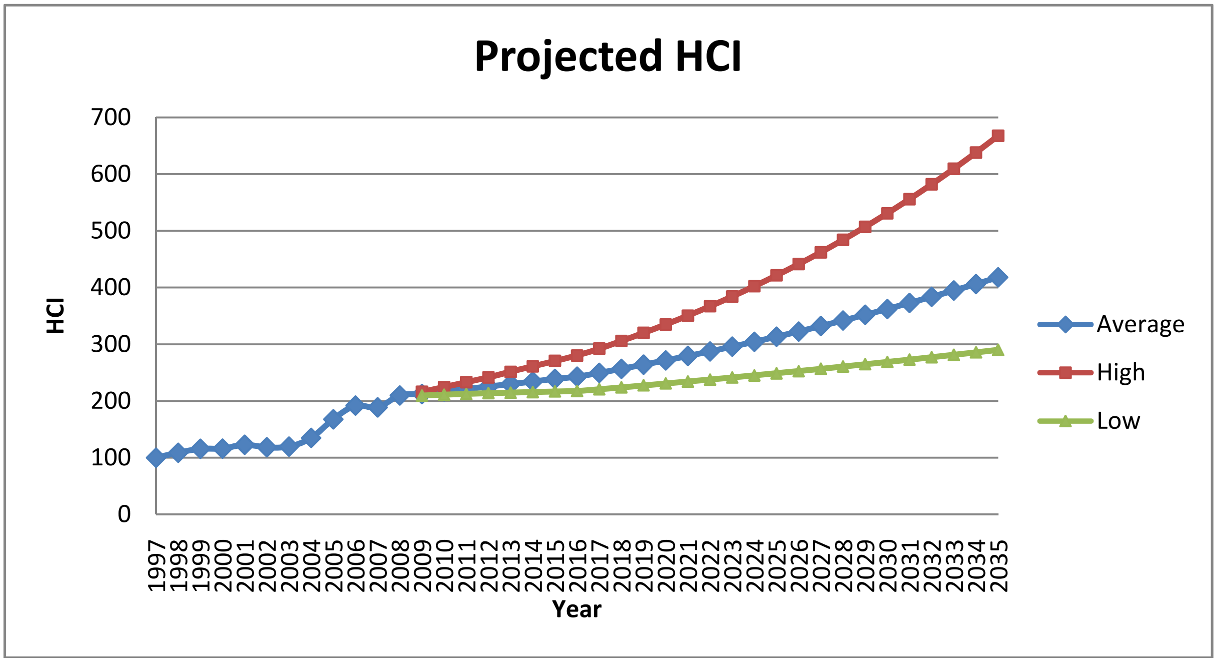


Figure 5.22: Projected HCI up to 2035

Starting from an index of 100 in base year 1997, the predicted HCI for the year 2035 is 418.25, with a 90% confidence interval of 290.38 to 667.74. Starting from the year 2008 HCI of 209.87, the predicted construction inflation rate over the next 27 years is equivalent to 2.6% per year compounded, with a 90% confidence range of 1.15% to 4.4%.

5.5.5 Projection of Expenses in JACK

When our projected inflation is inserted in the JACK Model, a distribution of revenue vs. total maintenance and overhead expenses is obtained. Figure 5.23 demonstrates how the expenses vary depending on three different scenarios: 1) construction inflation is not accounted for; 2) the inflation rate used is based on our prediction; and 3) the inflation rate used is set as the default input in the current version of the JACK Model.

Considering that the JACK Model treats the inflation rate as a constant in the estimation process, we used the constant 2.6% compounding rate as the new input, which gives equivalent accumulated inflation compared with our projected rates for the next 27 years. The revenue remains the same on all scenarios, as the inflation is considered in estimation of expenses but not for the revenue. In addition, from the comparison between the scenario using our projection which is 2.6% and the one using the default value of 5%, it leads to an overall difference of $16.65 billion in the accumulated maintenance and overhead expenses estimation through 2009 to 2035.

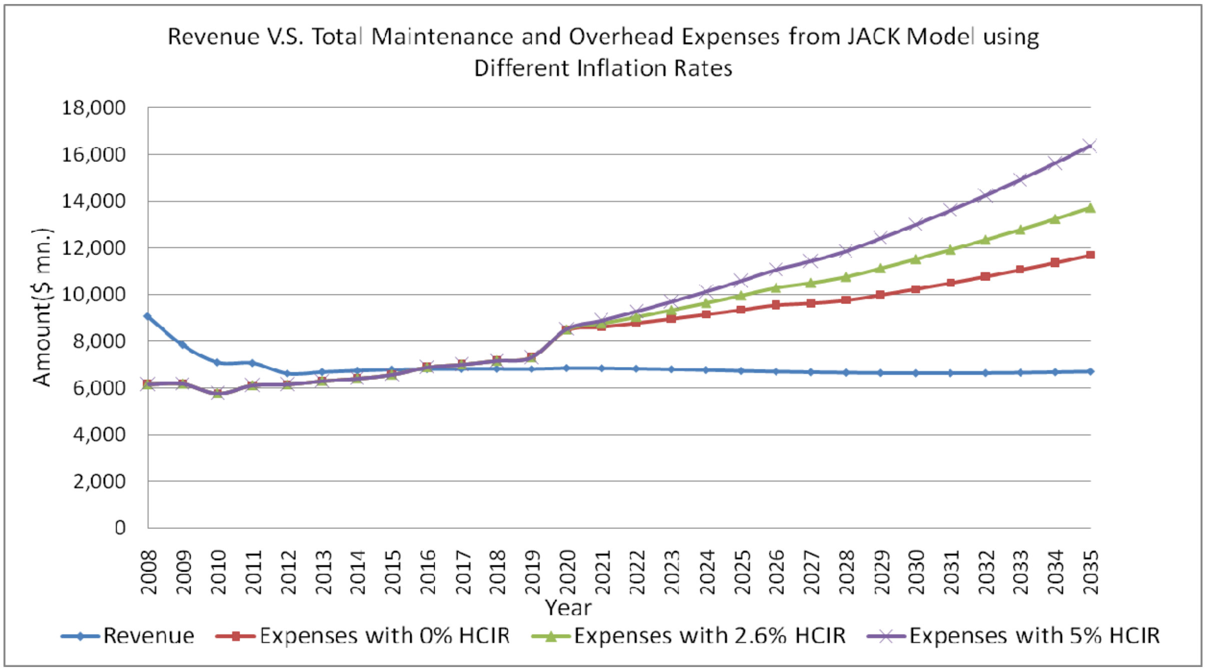


Figure 5.23: Revenue vs. Total Maintenance and Overhead Expenses from JACK Model

5.6 Chapter Conclusion

Based on our findings regarding construction inflation, we come to the following conclusions:

1. After analyzing the trends of diesel, petroleum-related products, and steel, we conclude that prices of these materials can be used as symptomatic indicators for the prediction of construction inflation as they all follow the same trend as construction costs.
    a. According to Association of General Contractor (AGC), petroleum refineries, asphalt products and petroleum lubricating oil and grease manufacturing (NAICS code 324) accounted for 38% of the highway PPI but only 7% of the single-unit residential index. Increases in petroleum-related products are much higher than any other type of construction ingredients. This is the reason why an increase in highway and street construction is higher than all other types of construction.
    b. Diesel is used in various equipments, such as tower cranes, dozers, earth movers, etc. Contractors also pay fuel surcharges on delivery of materials. In addition to this, fuel also affects other material prices that are not directly related. For example, excavation cost in some states has also experienced significant increases in 2003, though it is not related to any specific material. This increase in cost is related to an increased in fuel charges for excavation and disposal.
    c. The index for steel mill products went up fairly smoothly from 1987 to 2002. However, steel mill products started increasing after 2003 and are predicted to continue the same trend.
2. Generally, inflation rate is hard to forecast. With the use of an autocorrelation analysis using HCI data from 1987 (base year) to 2003, the coefficients decay very slowly; this

indicates that the process is not stationary and that it is hard to predict a future value based only on historical data.

3. A practical method to forecast the HCI for future years is to identify the weight of the most relevant indicators from raw commodities in the development of the HCI and reliable forecasts for each of them, and use a Monte Carlo simulation to compute the average value and confidence bands of the predicted HCI.
4. Starting from an index of 100 in base year 1997, the predicted HCI for the year 2035 is 418.25, with a 95% confidence interval of 290.38 to 667.74. Starting from the year 2008 HCI of 209.87, the predicted construction inflation rate over the next 27 years is 2.6% per year compounded, with a 95% confidence range of 1.15% to 4.4%.

Chapter 6. Benchmarking Texas Vehicle Registration Fees

6.1 Introduction

Vehicle registration fees and motor fuel taxes are the primary sources of revenue for many state departments of transportation (DOTs) in the U.S. In 2007, vehicle registration fees contributed about $1 billion to the Texas highway fund revenue of almost $6 billion. This chapter focuses on comparing Texas vehicle registration fees to those in other states.

6.1.1 Chapter Scope

Research Work Plan Task 6: In coordination with TxDOT Vehicle Titles and Registration (VTR) review the studies and data VTR has gathered on current state vehicle registration fees throughout the U. S. and compare those fees with vehicle registration fees (for both personal and commercial vehicles) in Texas.

6.1.2 Background

It is a legal requirement in the U.S. for most types of motor vehicles to be registered with a state DOT or department of motor vehicles (DMV) if they are to be used on public roads. The state DOT records the vehicle's details (make, model, vehicle ID, etc.), details of the party currently responsible for the vehicle (name, address, and other contact information), and the registration expiration date. The DOT provides a unique number on specified license plates that must be displayed on the vehicle. In addition, most DOTs now provide a sticker showing the expiry month/year of registration, plus other data, and require that the sticker be visibly displayed, either on the plate or inside the windshield. Linking the vehicle ID to its owner and contact information is a necessity to ensure financial responsibility (Persad et al., 2007).

TxDOT charges vehicle owners in Texas approximately $60-70 annually to register passenger vehicles. In addition, there is annual inspection fee of $12.50, with an additional $16 fee for emissions inspection in air-quality non-attainment counties. Using a scale of fees for different vehicle types, TxDOT raises about $1 billion per year from vehicle registration.

There are significant differences in vehicle registration fees among the states, with the potential for jurisdiction shopping by vehicle owners. Many states are considering charging higher registration fees. For example, Colorado has proposed raising its registration fee by $100. In this chapter we identify peer states comparable to Texas in terms of population, vehicles registered, and vehicle miles traveled (VMT). We then compute registration revenue scenarios for Texas if its fees were similar to those in the peer states selected.

6.1.3 Chapter Outline

This chapter is organized as follows:

- Vehicle registration fees around the U.S.
- Jurisdiction shopping by vehicle owners.
- Texas peer states according to population, vehicles registered, and VMT.
- Potential Texas registration revenue scenarios.

6.2 Vehicle Registration Fees Around the U.S.

6.2.1 Data Source

Data on vehicle registration fees across the U.S. for the year 2006 were obtained from the FHWA website (FHWA, 2008). More recent data was not available in time for this study. Data is available in at least five categories: Automobile, Single-Unit truck, 3-Axle truck, 5-Axle truck, and Twin Semi-Trailer. Some states have more than five vehicle categories, so a typical vehicle for each of the categories was selected in order to make the data comparable among all states.

6.2.2 Comparison of Registration Fees

Figures 6.1–6.5 show the fees in all states where data was available, for each of the five vehicle categories. Texas is highlighted in a different color, and the arithmetic average fee is shown as a horizontal line. Table 6.1 is a summary of the results.

Table 6.1: Texas Rankings in Registration Fees

Category	Average	Texas lies**	Cheapest	Most Expensive
Automobile	$ 39.07	#42 $ 50.80	Arizona $ 8.00	Hawaii $ 167.50
Single-Unit	$ 179.23	#31 $ 180.07	Georgia $ 38.00	Mississippi $ 503.50
3-Axle	$ 623.36	#17 $ 460.60	New Mexico $ 118.00	Illinois $ 1,538.00
5-Axle	$ 1,298.62	#11 $ 855.60	Wyoming $ 120.00	Idaho $ 3,218.00
Semi-Twin*	$ 1,653.93	Not Allowed	Wyoming $ 180.00	Idaho $ 4,533.75

*There are only 17 states that allow this category.
**This is ranking from the lowest cost to the highest (a high number means more expensive)

It is seen that Texas is higher than average in automobile fees, about average on single-unit truck fees, and far lower than most states on multi-axle truck fees. However, truck registrations in Texas are relatively low because of the practice known as jurisdiction shopping, as discussed in the next section.

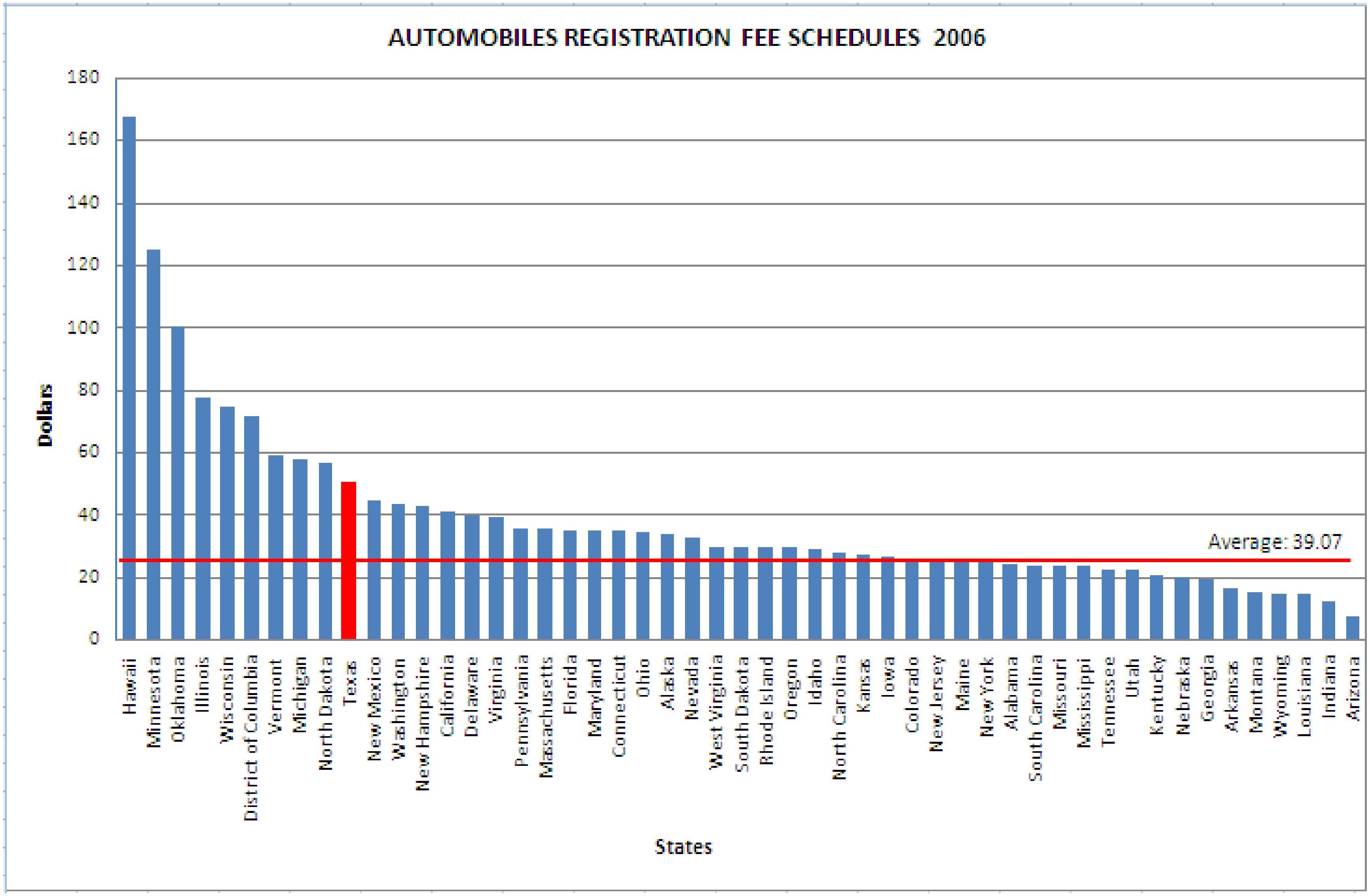


Figure 6.1: Automobile Registration Fee Data

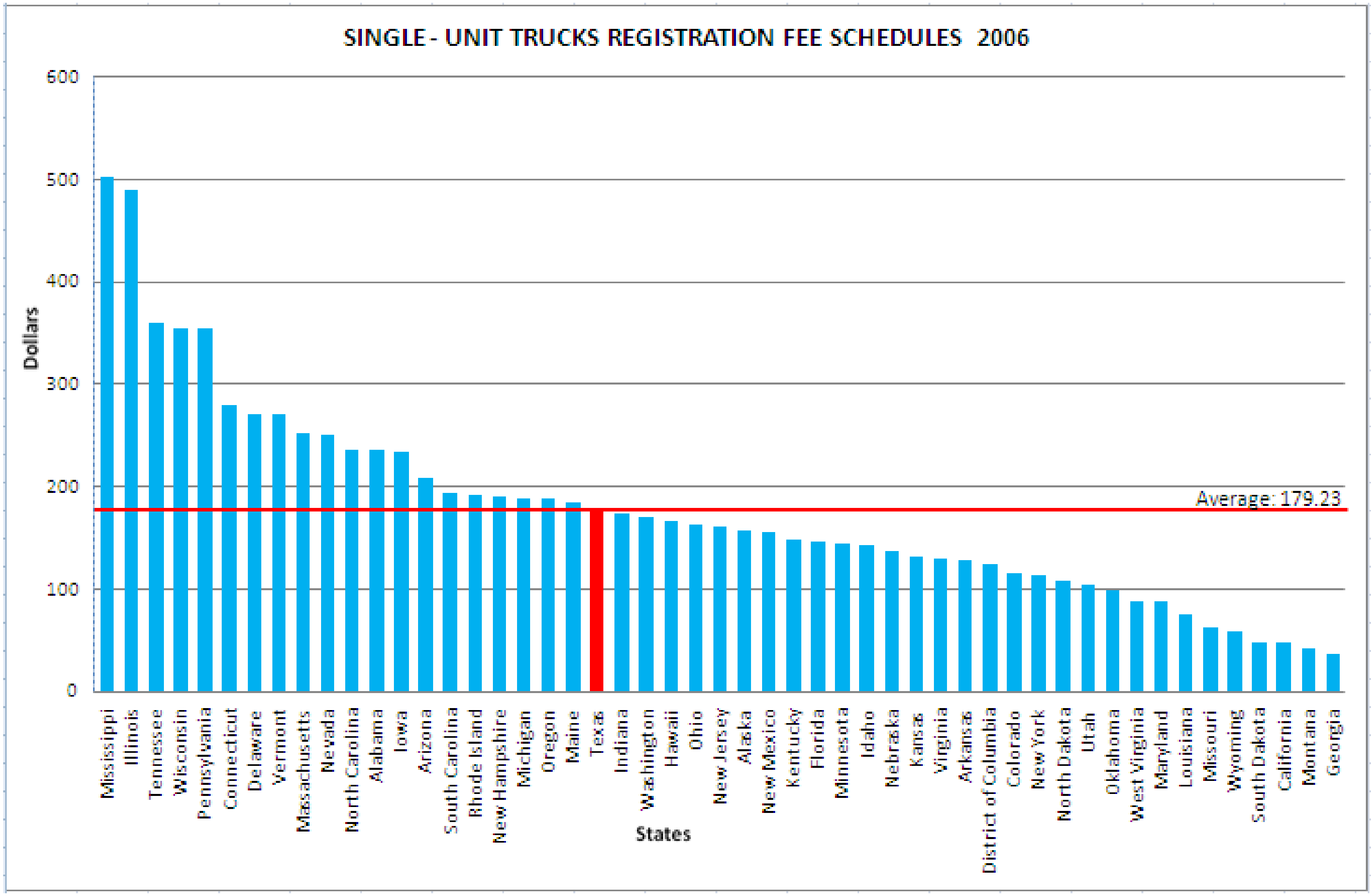


Figure 6.2: Single Unit Truck Registration Fee Data

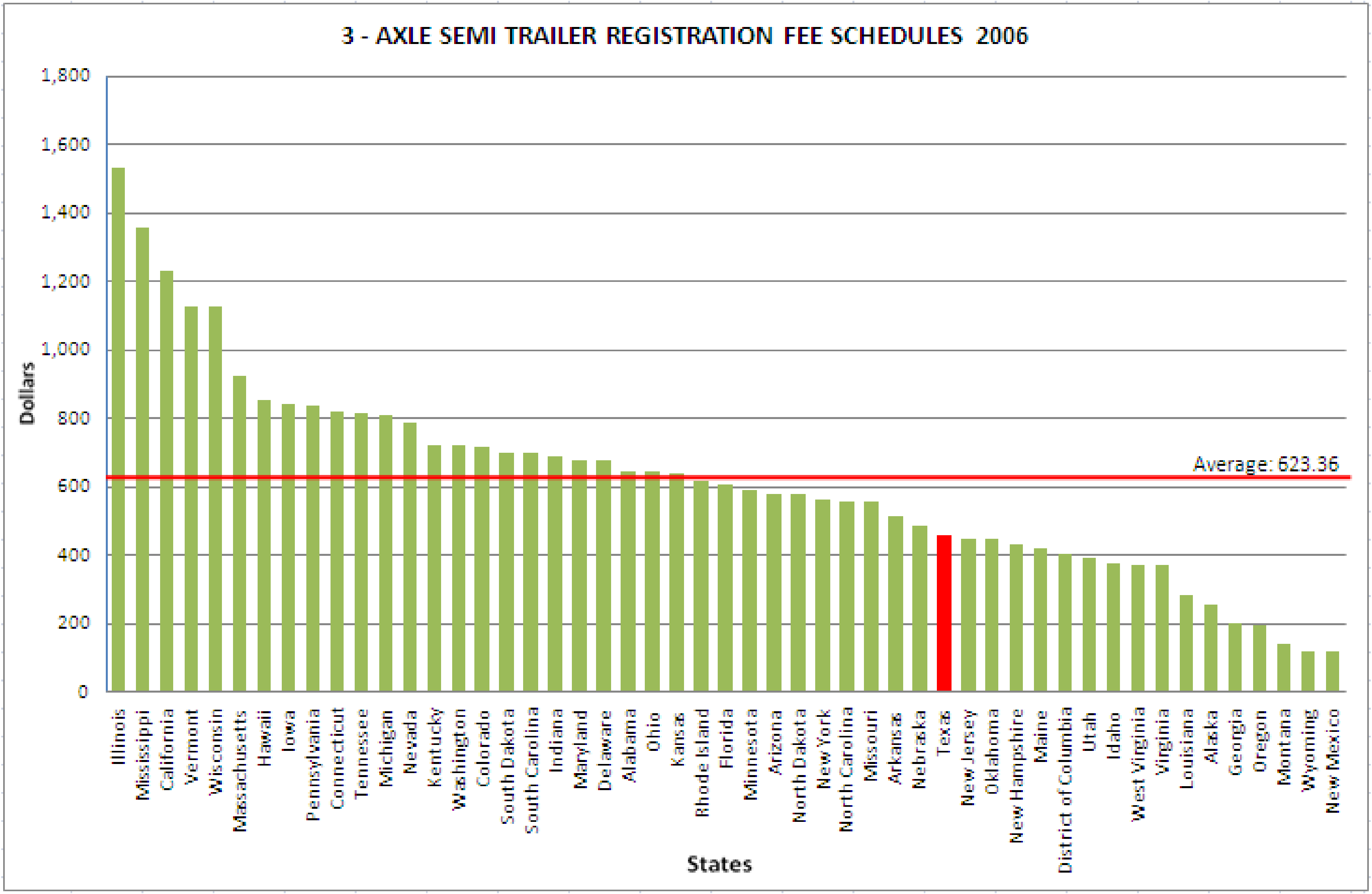


Figure 6.3: 3-Axle Trailer Registration Fee Data

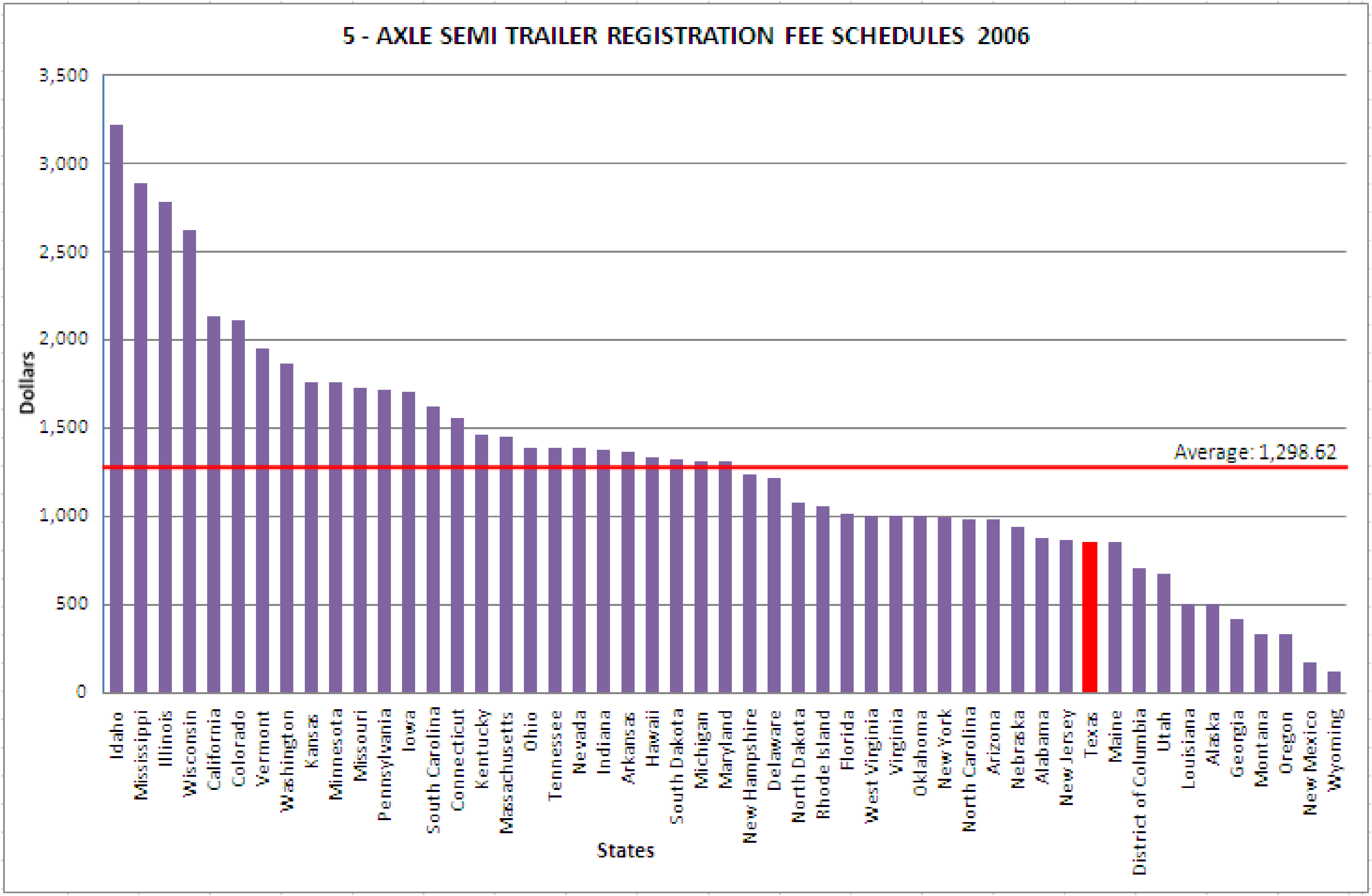


Figure 6.4: 5-Axle Semi Trailer Registration Fee Data

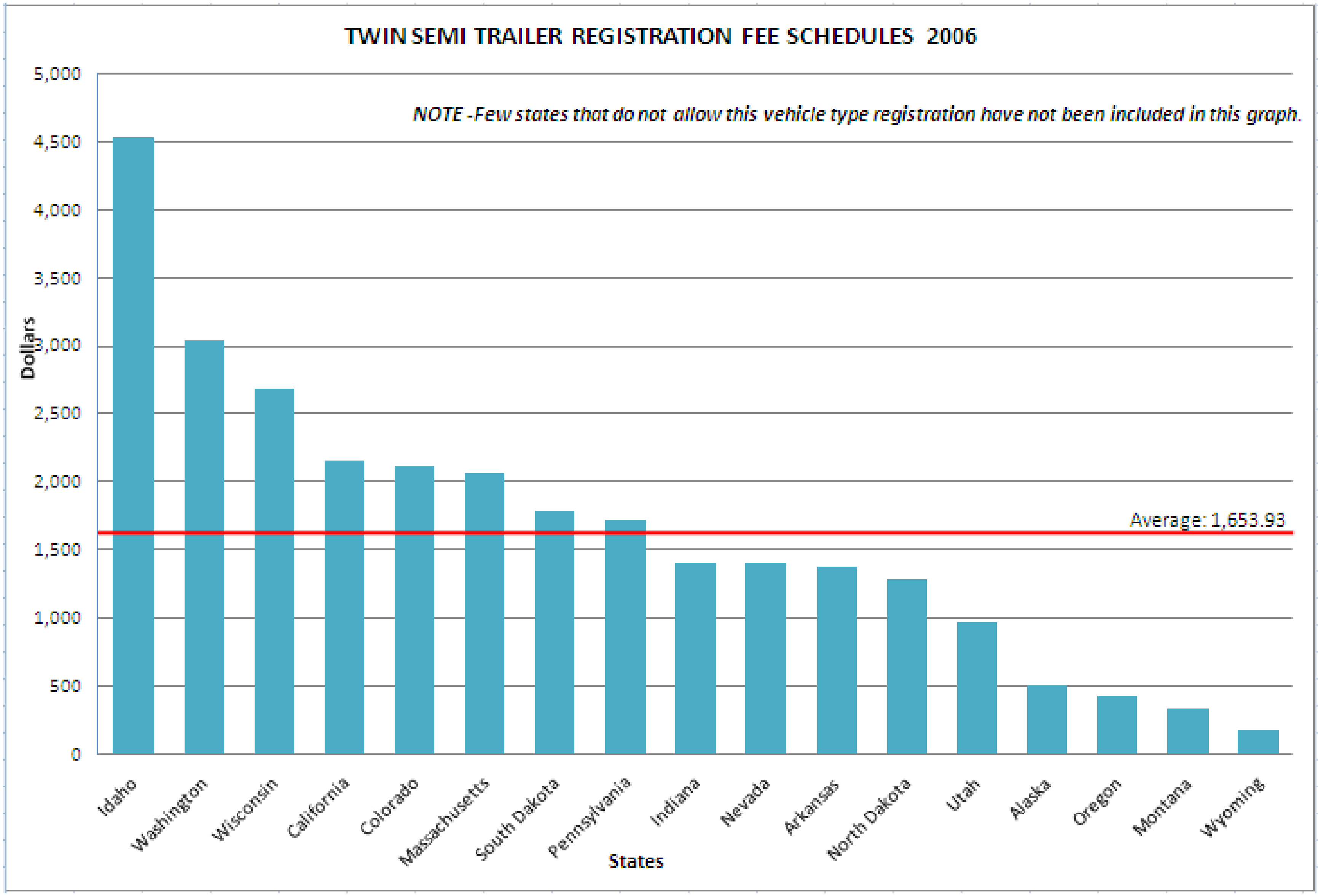


Figure 6.5: Twin Semi Trailer (often known as Long Combination Vehicles) Registration Fee Data

6.3 Jurisdiction Shopping

Jurisdiction shopping is the practice of vehicle owners searching for the most convenient jurisdiction in which to register their vehicles. Most states require that vehicle owners register in the county of their residence, and that regulation works reasonably well for individual-owned non-commercial vehicles. But for commercial vehicles such as interstate trucks owned by corporations, residence is not applicable and the rules are more complex.

6.3.1 Non-Commercial Vehicles

The National Conference of State Legislatures (NCSL) Transportation Program (Olszonowicz, 1999) reviewed the subject of non-commercial vehicle registration shopping in 1999. Olszonowicz examined recent activities and trends regarding motor vehicle registration and license plates for 1998-99. He found that some vehicle owners have attempted to avoid higher taxes in their home state by driving to a neighboring state that has lower taxes to illegally register their vehicles.

For example, Minnesotans were registering their cars in Wisconsin where a flat fee of $45 (as of September 1999) was charged. In comparison, registration for an upscale, late-model vehicle in Minnesota cost at least $300 in 1999. Olszonowicz noted that consequently, the state patrol was taking action to catch violators, who faced a fine of up to a $3,000 and could even face one year of imprisonment, and were required to pay the unpaid taxes.

Another trend Olszonowicz found was in registration fee collection methods was the shift to more user-friendly registration fee renewal processes. Some of these strategies include the following: the use of technology including internet, telephone, mobile DMVs (providing the services on the road), automated teller machines, drop boxes, or mail-in registration.

6.3.2 Commercial Vehicles

The number of motor carriers hauling interstate shipments in the United States has risen dramatically in recent decades. In 2004, Jasek, Ojah, and Hoover produced a report sponsored by TxDOT on heavy truck registration in Texas, highlighting the issue of jurisdiction shopping (Jasek, et al., 0-4065, 2004). They found that the proliferation of interstate motor carriers has given rise to the need for more robust federal and inter-jurisdictional administrative frameworks. An important development was the establishment in 1973 of the International Registration Plan (IRP), a streamlined registration regime for motor carriers operating in two or more jurisdictions. Though differences in truck registration protocol have diminished, discrepancies in registration cost and procedures persist, encouraging owners to search for more attractive locations to register their vehicles.

In the past 10 years jurisdiction shopping has contributed to the geographic redistribution of tens of thousands of truck registrations in the United States (Ojah, 2004). According to Ojah, annual savings accruing to carriers that shop for base jurisdictions can total thousands of dollars per vehicle. Savings for large fleets could potentially reach $1 million or more per year. Unlawful registration practices have been responsible for a considerable amount of jurisdiction shopping. However, state discrepancies in registration costs and convenience have prompted some trucking firms to engage in a legitimate form of jurisdiction shopping.

6.3.3 Fraudulent Jurisdiction Shopping

It is unlawful under the International Registration Plan (IRP) administration to obtain a cheaper registration. Fraudulent jurisdiction shopping occurs when an owner operator or carrier exploits lax enforcement of regulations to obtain a cheaper registration. Historically, this activity has involved corrupt third-party registration agencies and complicit state IRP personnel. In the Southwest region, registrants sought the financial advantages of registering in "low fee" jurisdictions such as in Oklahoma during the 1990s, but could not legally do so without establishing a place of business there. So third-party registration agents in Oklahoma attempted to circumvent the IRP's Place of Business rules by allowing out-of-state registrants to use their addresses to qualify for Oklahoma IRP plates. Also, investigations revealed that those addresses were listed as the established place of business for more than 1000 trucking firms. Such place of business violations were compounded by widespread mileage estimation fraud.

6.3.4 Legitimate Jurisdiction Shopping

Legitimate jurisdiction shopping occurs when motor carriers with bona fide established places of business in multiple jurisdictions have the option of selecting where to register their fleets. This decision may have little to do with where the carrier's operations are focused. This type has been also responsible for considerable geographic shifts in apportioned heavy truck registrations. Although not illegal, this activity is viewed as tantamount to tax evasion. For example, if a trucking firm accrues most of its mileage in U.S. Midwest but includes a terminal in Oklahoma where there is not much activity, this is skirting the legal system.

The justification for legal base plate shopping lies primarily in the disparity among non-apportioned fees and taxes that some jurisdictions assess on motor carriers. Non-apportioned fees deter registrations because only carriers that base plates in a jurisdiction, not those traveling through it, incur them. The financial stakes involved in a carrier's base plate decision highlight the importance of jurisdiction shopping issues for both industry and the public sector. Trucking firms rationalize their choice of where to register as a business decision; one that they are entitled to under the provisions of the IRP.

6.3.5 Causes of Jurisdiction Shopping

Jasek found that IRP requires the issuance of one license plate per power unit, the payment of all registration fees to a single base jurisdiction, and the apportionment (proportionate distribution) of those fees to the other jurisdictions on the basis of mileage percentages. The cost of the registration is determined by the gross registered weight of the vehicle(s), the percentage of miles traveled in each jurisdiction, and the annual apportioned registration fees in those jurisdictions.

Apportioned Fees

Table 6.2 highlights the formula for apportioning the fees for a tractor trailer operating in three states. There is little financial advantage to a legitimate carrier for jurisdiction shopping if only apportioned registration fees are taken into account. However, non-apportioned fees also play a role, especially those taxes incurred only by trucks that base plates in that jurisdiction, not by those traveling through.

Table 6.2: Sample Apportioned Fee Calculation for 80,000 lb Tractor-Trailer

State	Mileage	% Total Miles	Full year Fees	Apportioned Fee
Oklahoma	40,000	40	x $954.00	= $381.60
Kansas	30,000	30	x $1735.00	= $520.50
Arkansas	30,000	30	x $1350.00	= $405.00
Totals	100,000	100		$1307.10

Non apportioned Fees

Ad Valorem Tax is an annual property tax that some jurisdictions assess on motor carriers. This tax is levied on the purchase price or depreciated value of the carrier's vehicle(s) and varies from state and among individual counties and municipalities where the registrants take advantage here. Jasek found that in Texas ad valorem taxes are locally assessed taxes. A number of states, including the only three states with over 100,000 apportioned power unit registrations (Oklahoma, Illinois, and Indiana), either do not have an ad valorem tax or exempt motor carriers from paying it.

Accessorial and Incidental Fees are added expenses that carriers incur as a result of registering in a given jurisdiction, for example, excise fees, application fees, and emission surcharges. Individual charges of this kind often range up to $50. Although the low value of these fees makes it unlikely that they alone would justify jurisdiction shopping, they can handicap carriers registering in certain states.

Registration Convenience

Registration convenience used to be viewed as having little bearing on a motor carrier's choice of where to base plate. However, there are three programs (the International Registration Plan IRP, the International Fuel Tax Agreement IFTA, and the Single State Registration System SSRS) related to vehicle registration that significantly overlap but are frequently administered separately by states. Lack of administrative coordination among them imposes a costly burden on the carrier community. Differing levels of customer service and registration convenience may also influence a carrier's decision on where to base plate, but these issues are generally secondary considerations that figure more prominently in a jurisdiction's success in retaining carriers as opposed to attracting them.

6.3.6 Remedies for Jurisdiction Shopping

Several States have been working in this area to find solutions.

Ad Valorem Tax

Some States tried to discourage this tax evasion by instituting higher fines for offenses or by tightening the definition of vehicle's operational base. States such as Maine have apportioned these fees also in the same fashion as their registration fees.

Accessorial and Incidental Fees

Jasek (Jasek et al., 2003) found that a key to improving this would also include fee apportionment. Texas already incorporates a 10% diesel vehicle emissions reduction surcharge into its annual apportioned registration fees. California too imposes an $82 motor vehicle fee,

$34 registration fee, and $3 cargo theft interdiction program fee on all apportioned carriers entering the state.

Registration Convenience

Some states have improved registration procedures to reduce registration inconvenience. For example, employees in Nebraska Motor Carrier Services are trained to handle IFTA, IRP, and SSRS to administer these programs from the same computer system which eventually saves state resources and reduce processing delays. Idaho arranged for Joint Program administration which provides inter-jurisdictional carriers with the additional option of paying for and receiving receipted copies of the Federal Heavy Vehicle Use Tax (HVUT) at its one – stop shop. This is beneficial as it eliminates the need for carriers to make an extra trip to the tax office.

Finally, Jasek (Jasek et al., 2003) made several recommendations for Texas:

- Fee apportionment, which is favored by industry and the public sector, should be considered for other fees and taxes such as ad valorem taxes.
- Carriers want a one-stop shop that is streamlined for quicker service. Texas should explore innovative registration solutions, which would also reduce agency costs.
- Texas should reconsider how plates, especially trailer plates are issued. Frequent plate issuance for both power units and trailers imposes added administrative costs and burdens for carriers. This inconvenience increases with the size of fleet. By moving to permanent plates that need to be replaced only when they become illegible, Texas can save money for both the state and the carrier.
- Texas should evaluate the initiatives undertaken by other jurisdictions that have received positive response from the motor carriers such as published newsletter, online newsletters, participation in workshops and conferences, and videos.

6.4 Identification of Peer States Comparable to Texas

The objective of this portion of the analysis was to identify states that are comparable to Texas. Four criteria were selected: Population, Vehicles Registered, VMT, and Registration Revenue. Data for the year 2006 was obtained from previously cited sources.

6.4.1 Texas and Nearest Ten States in Ranking

Figures 6.6–6.13 show the respective data in two ways. In each case the overall 50-state ranking is shown with Texas highlighted, followed by a chart with the nearest 10 states in ranking, in more detail.

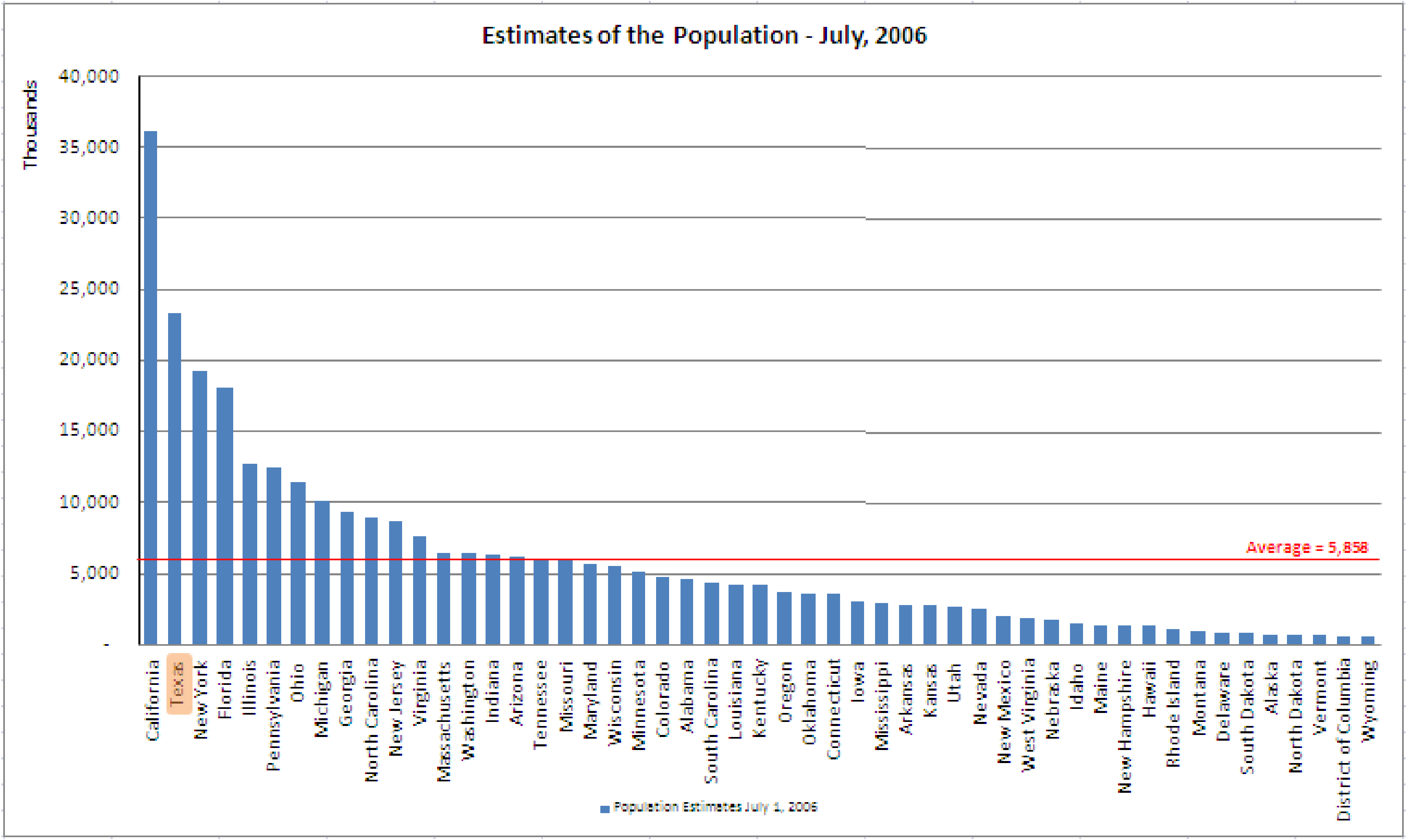


Figure 6.6: Ranking of States by Population

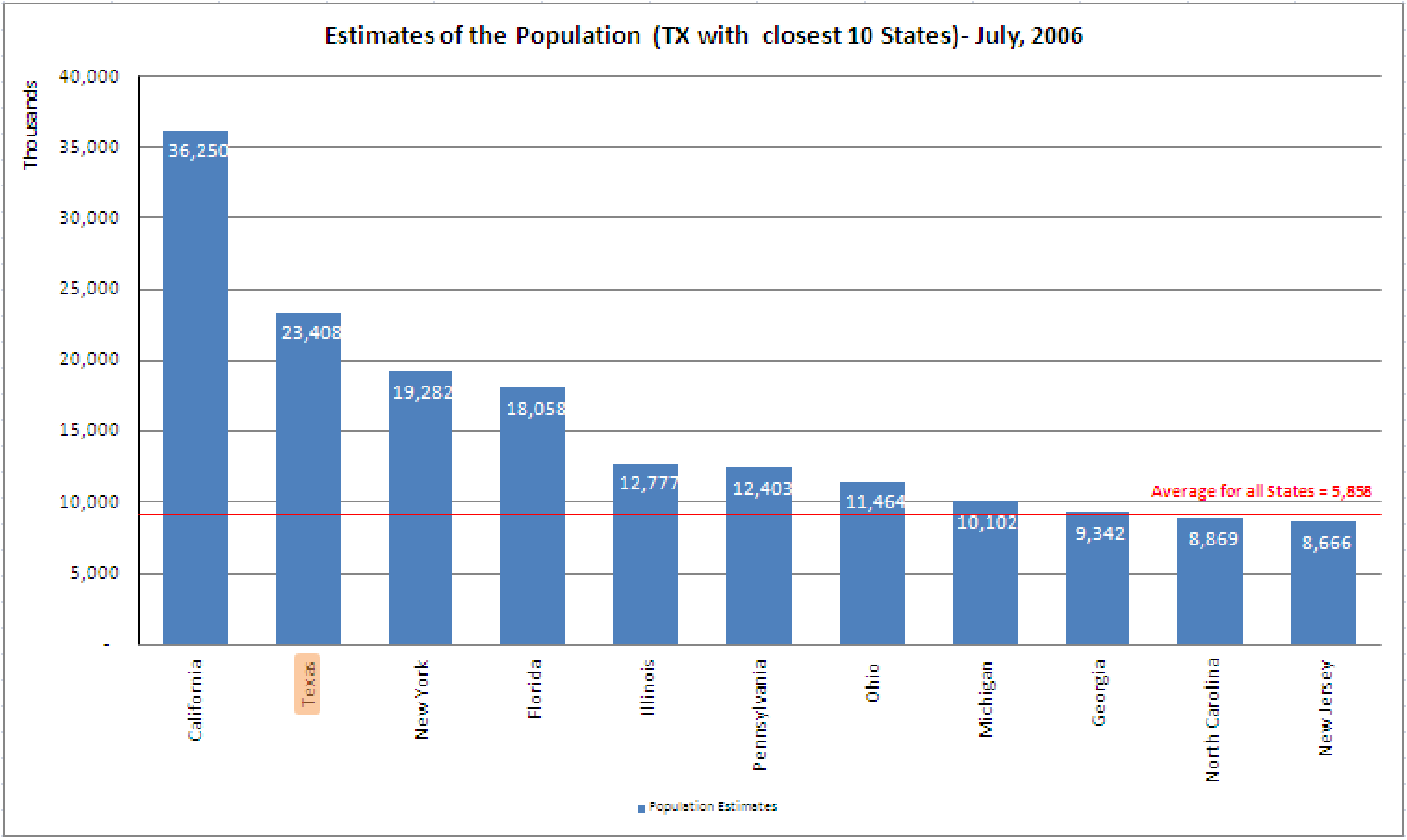


Figure 6.7: Nearest Ten States to Texas in Population

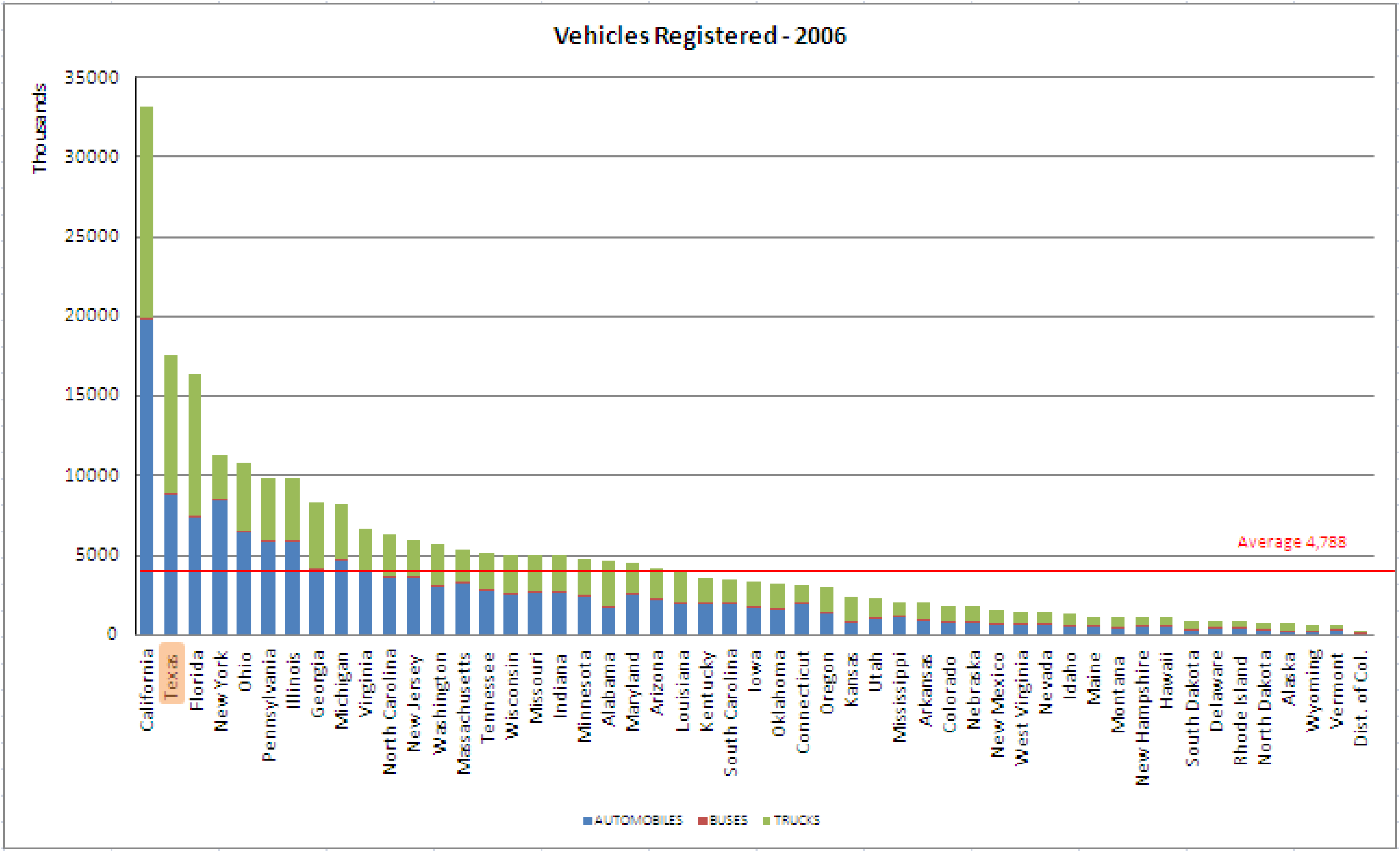


Figure 6.8: Ranking of States by Vehicles Registered

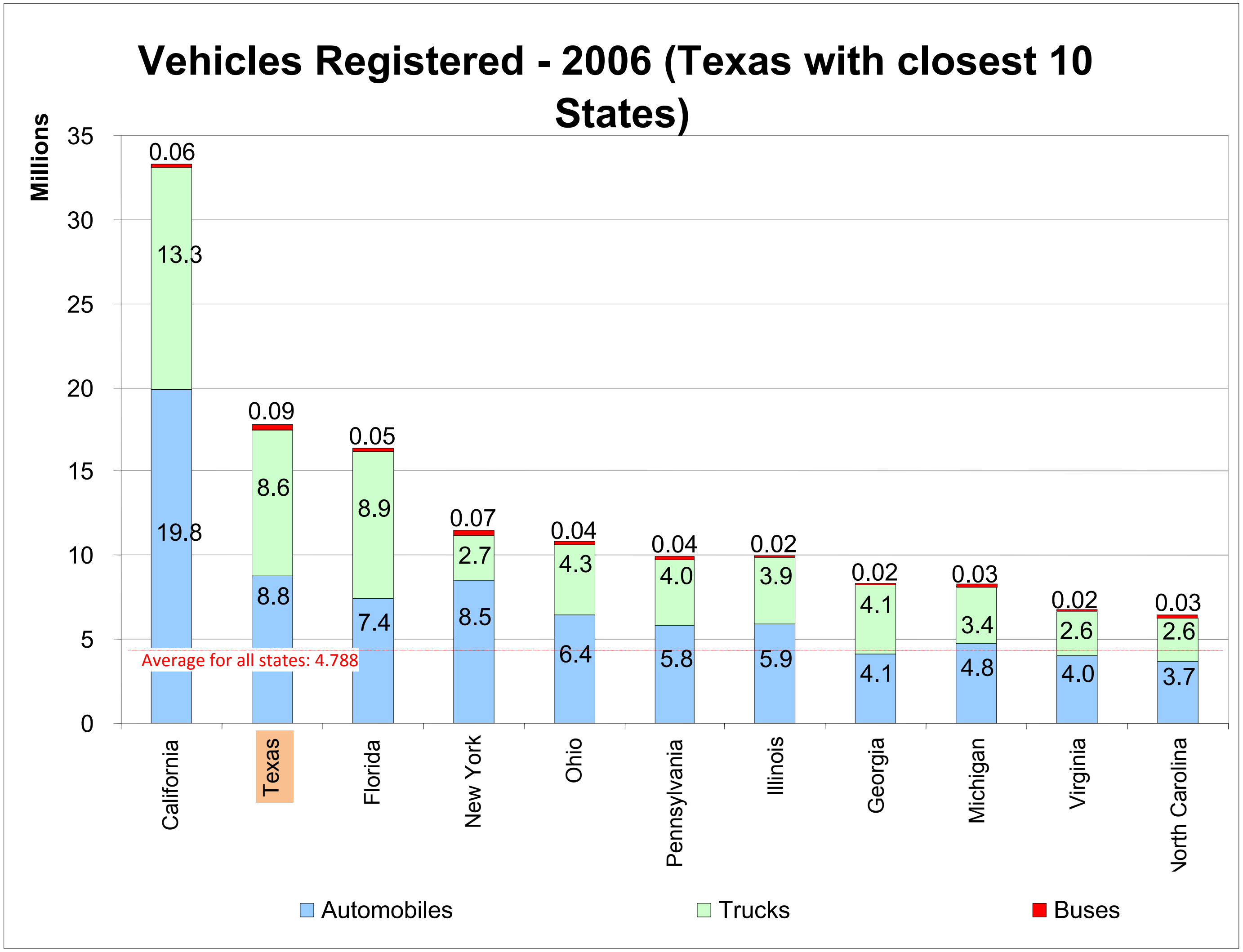


Figure 6.9: Nearest Ten States to Texas in Vehicles Registered (Millions)

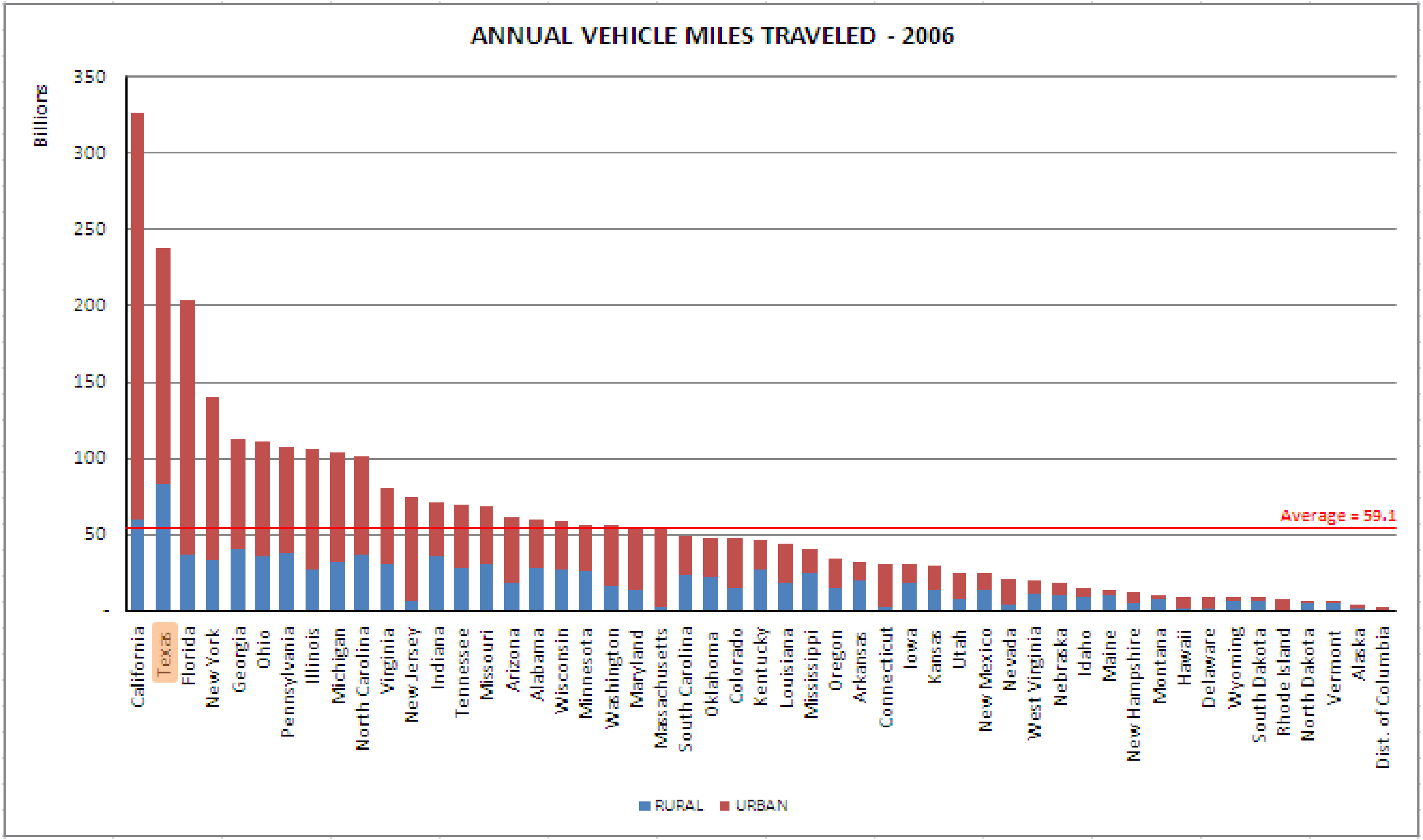


Figure 6.10: Ranking of States by Annual VMT

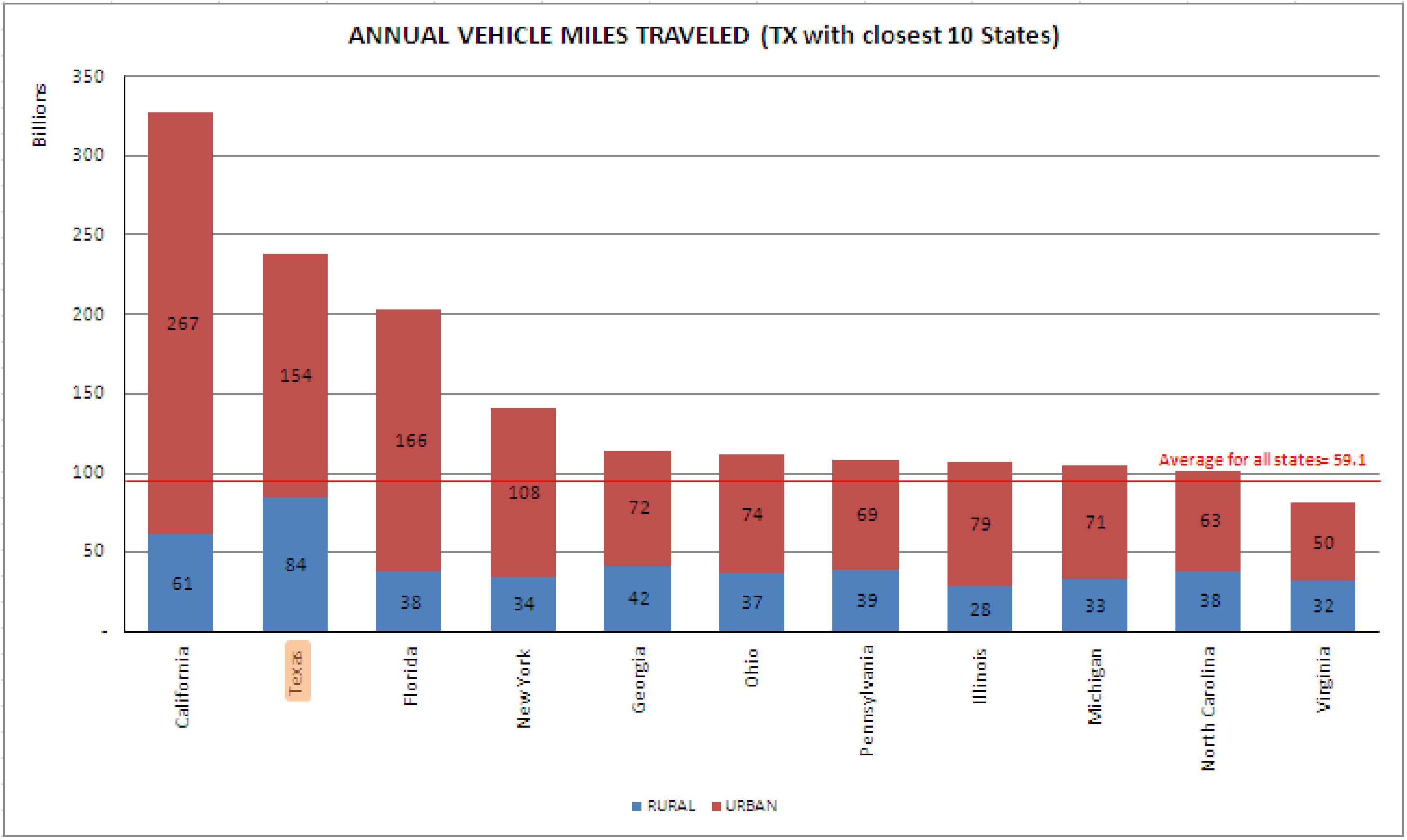


Figure 6.11: Nearest Ten States to Texas in Annual VMT

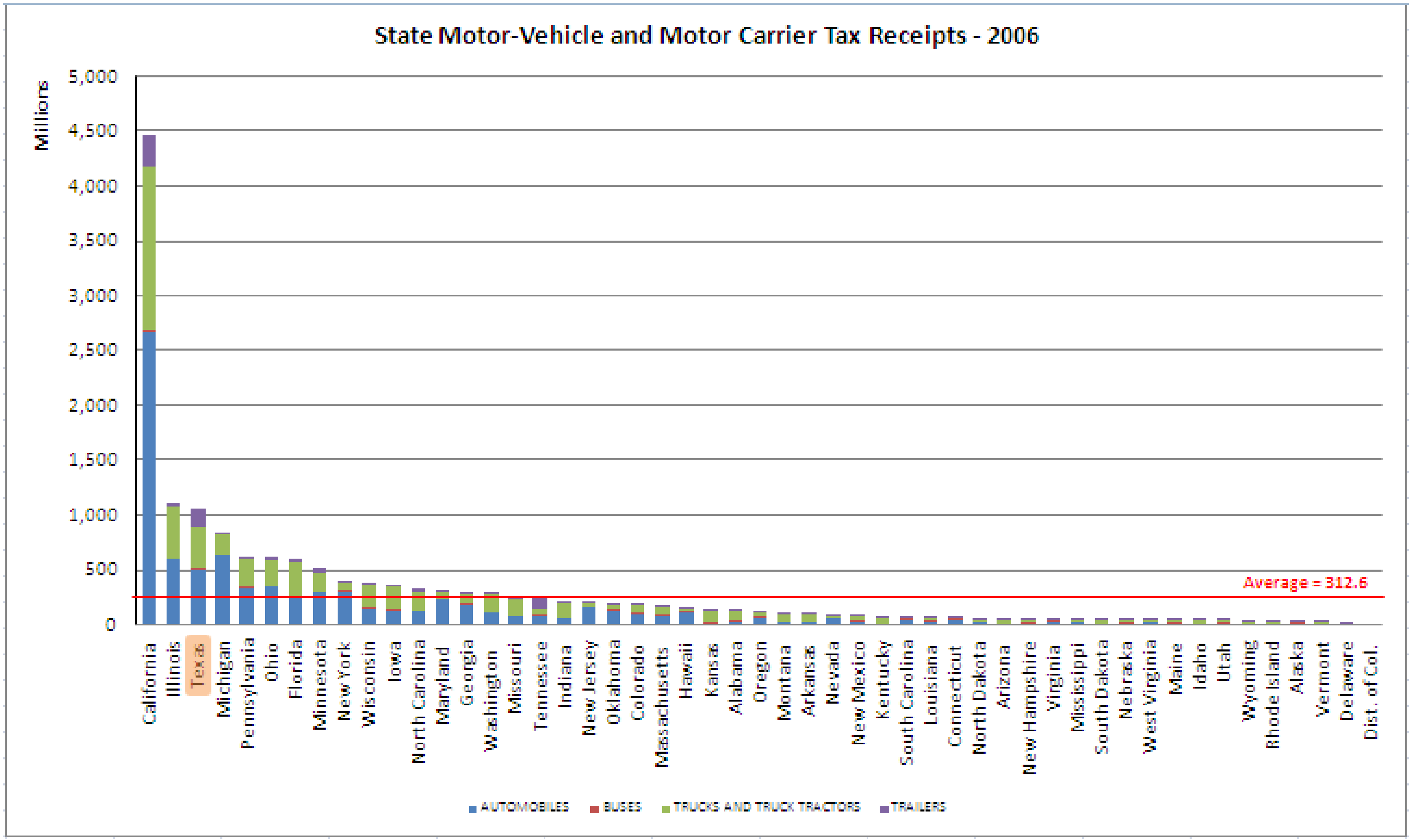


Figure 6.12: Ranking of States by Motor Vehicle and Motor Carrier Tax Receipts

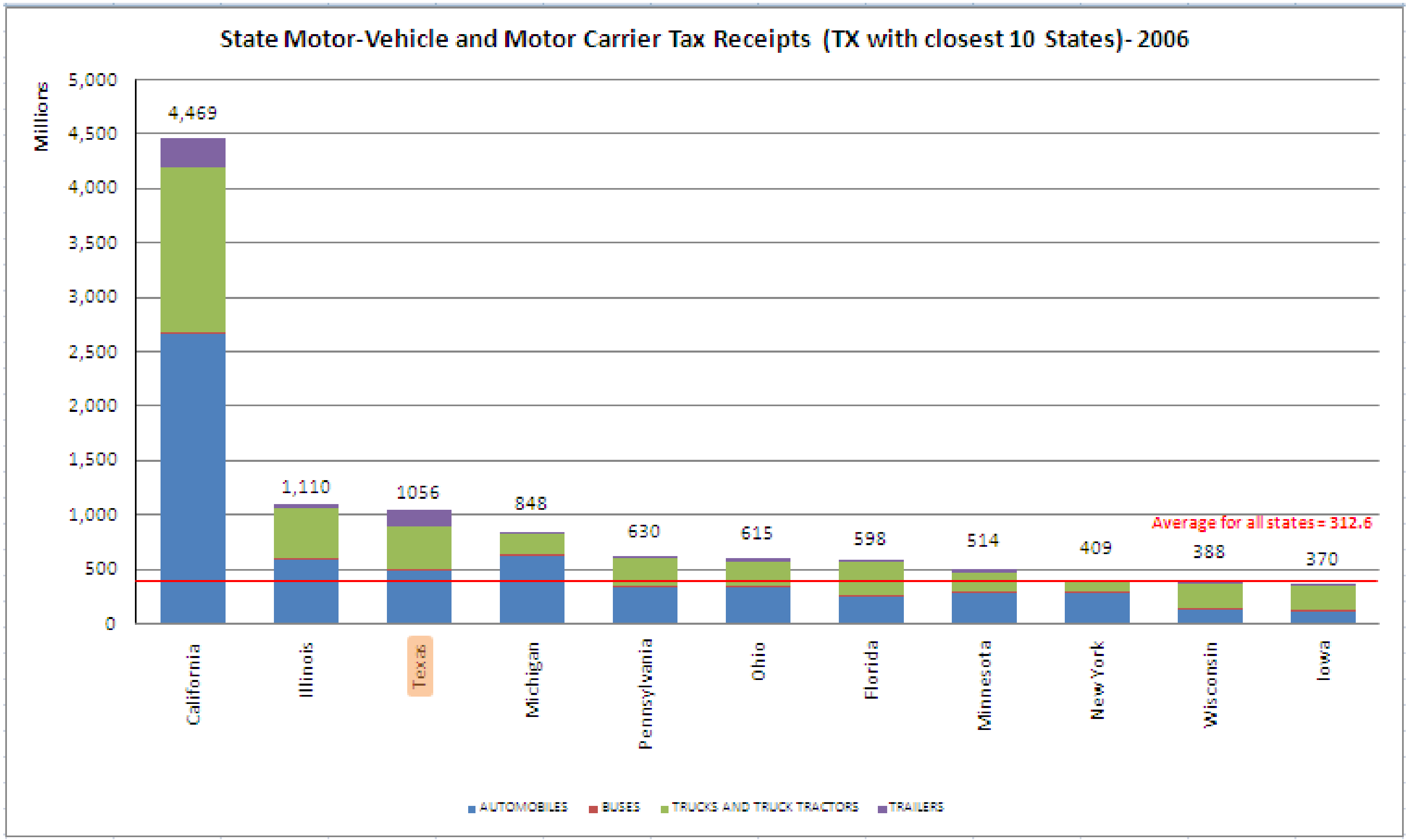


Figure 6.13: Nearest Ten States to Texas in Motor Vehicle and Carrier Tax Receipts

From the charts it is seen that the 10 most comparable states to Texas are (Table 6.3):

Table 6.3: Comparable States to Texas by Population, Vehicles, VMT and Revenue

Rank	Revenue	Population	VMT	Registered Vehicles
1	California	California	California	California
2	Illinois	Texas	Texas	Texas
3	Texas	New York	Florida	Florida
4	Michigan	Florida	New York	New York
5	Pennsylvania	Illinois	Georgia	Ohio
6	Ohio	Penssylvania	Ohio	Pennsylvania
7	Florida	Ohio	Pennsylvania	Illinois
8	Minnesota	Michigan	Illinois	Georgia
9	New York	Georgia	Michigan	Michigan
10	Wisconsin	North Carolina	North Carolina	Virginia
11	Iowa	New Jersey	Virginia	North Carolina

After counting how frequently each of the states appears close to Texas for the four categories above, we selected the states that appear the most frequently (in descending order):

1. California
2. Florida
3. Georgia
4. Illinois
5. Michigan
6. New York
7. North Carolina
8. Ohio
9. Pennsylvania
10. Virginia

These are the most comparable States to Texas regarding these categories. This data was used for the second part of our analysis.

6.4.2 State Ranking by Revenue Metrics

Figures 6.14–6.16 show a different set of registration revenue metrics: registration dollars paid per state resident, per vehicle registered, and per mile driven in the state. The average amount is shown as a horizontal line, and the median state (i.e., the middle state out of all fifty states) in the ranking is arrowed. The values for the peer states are of particular interest.

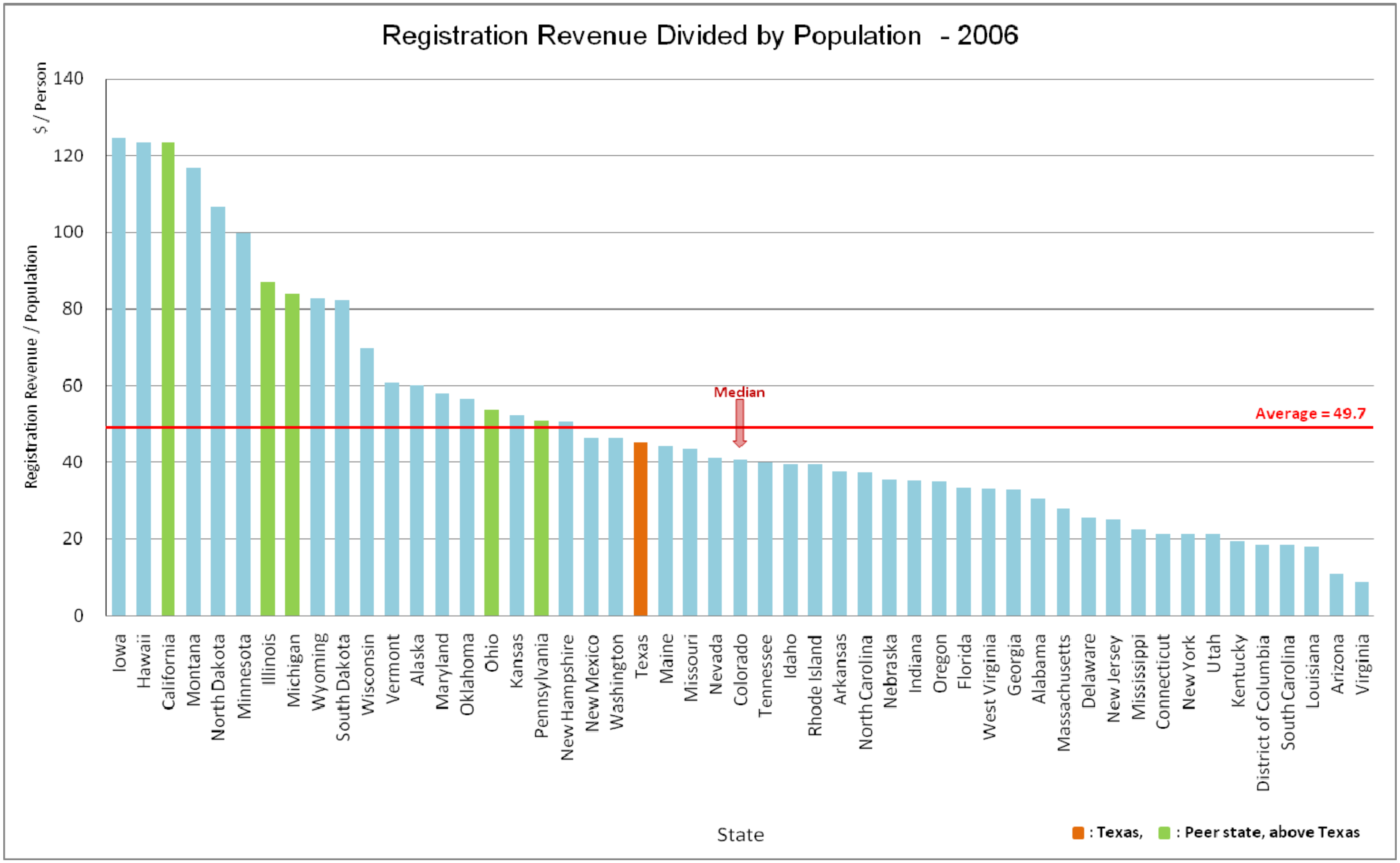


Figure 6.14: State Registration Revenue Collected per Resident

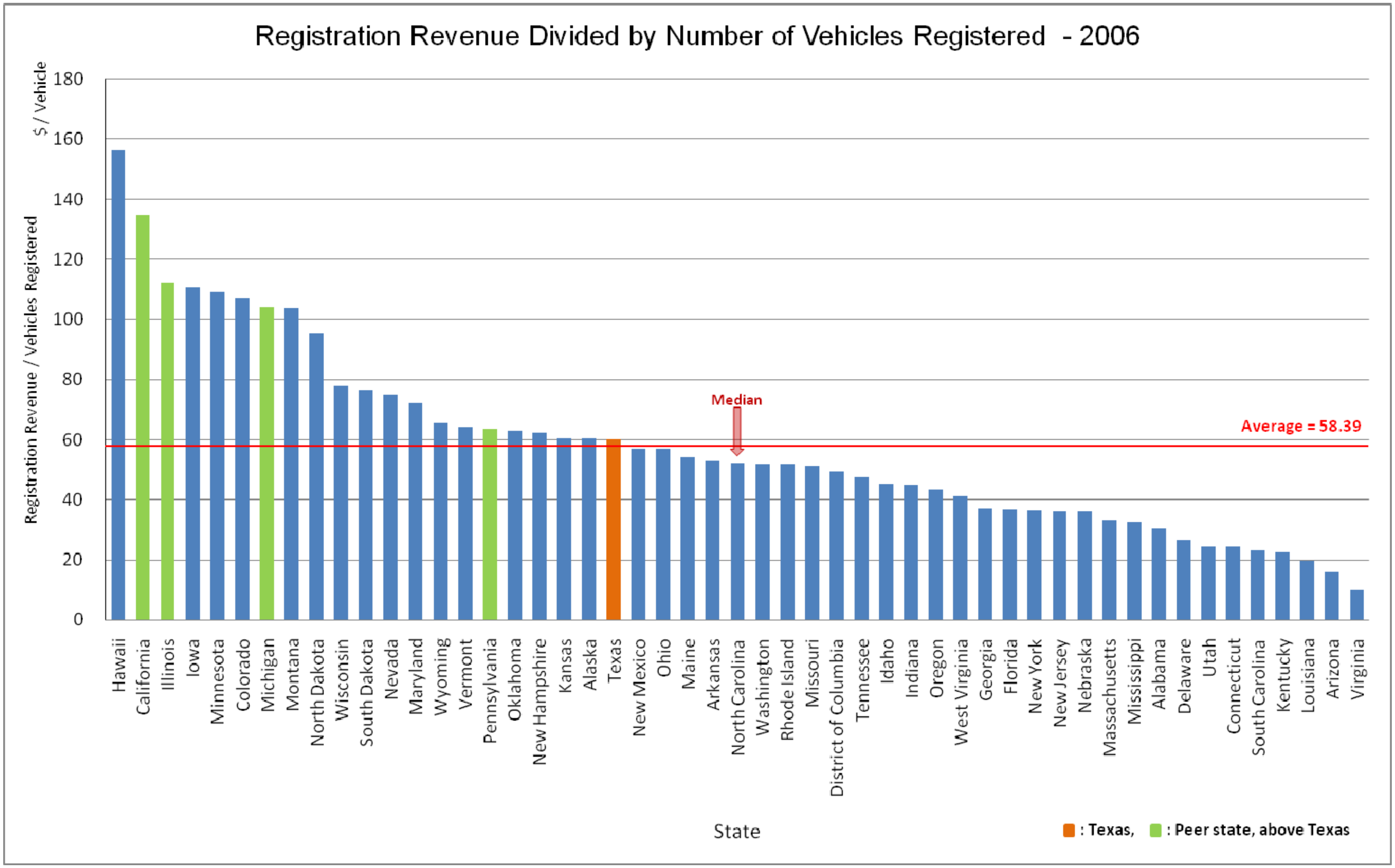


Figure 6.15: State Registration Revenue Collected per Vehicles Registered

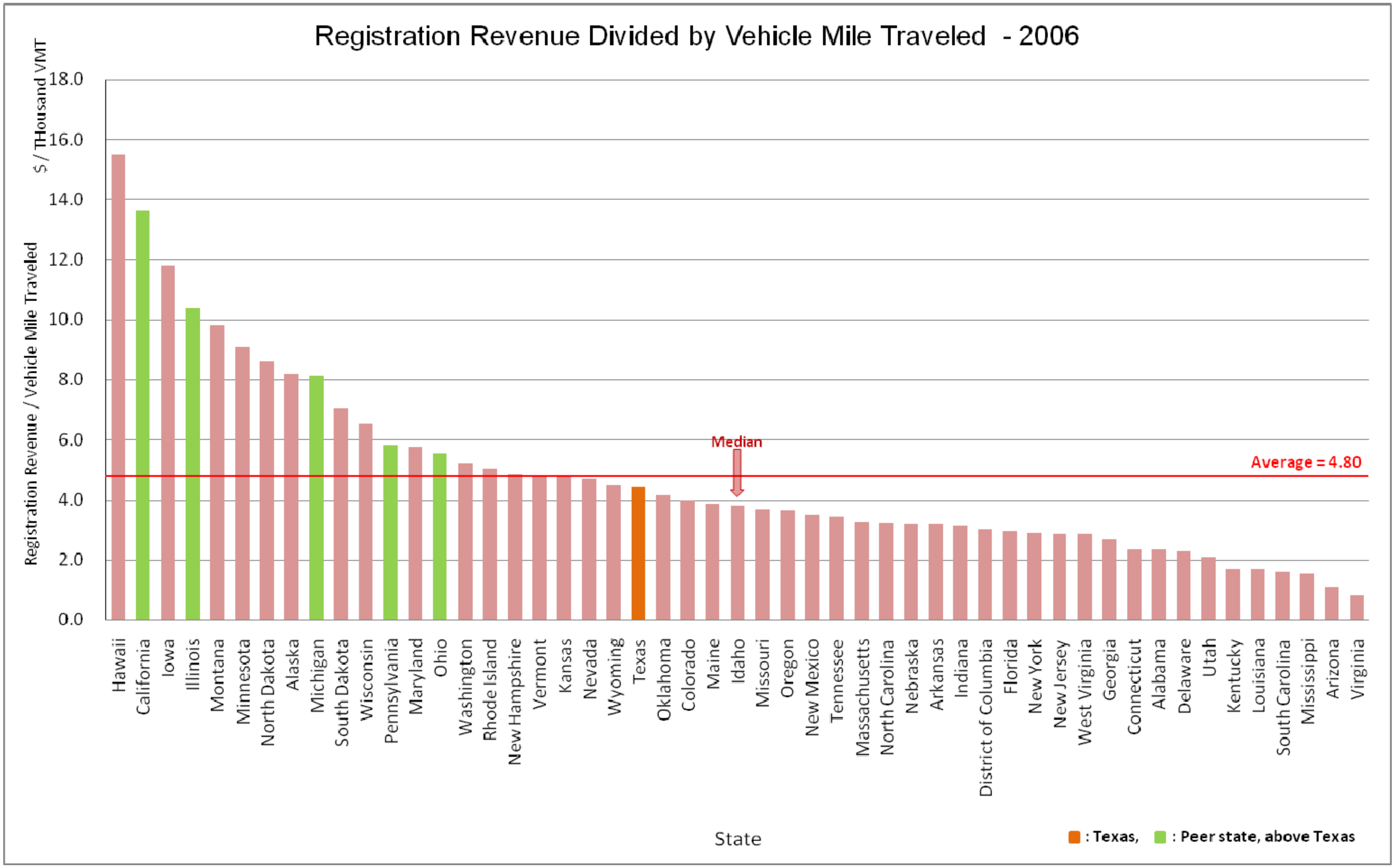


Figure 6.16: State Registration Revenue Collected per VMT

Table 6.4 shows the ranking of Texas in the three metrics calculated. Texas is 21 or 22 in all three rankings. The peer states identified earlier are highlighted for comparison.

Table 6.4: State Rankings in Revenue Metrics

Rank	Revenue / Vehicle	Revenue / VMT	Revenue / Population
1	Hawaii	Hawaii	Iowa
2	California	California	Hawaii
3	Illinois	Iowa	California
4	Iowa	Illinois	Montana
5	Minnesota	Montana	North Dakota
6	Colorado	Minnesota	Minnesota
7	Michigan	North Dakota	Illinois
8	Montana	Alaska	Michigan
9	North Dakota	Michigan	Wyoming
10	Wisconsin	South Dakota	South Dakota
11	South Dakota	Wisconsin	Wisconsin
12	Nevada	Pennsylvania	Vermont
13	Maryland	Maryland	Alaska
14	Wyoming	Ohio	Maryland
15	Vermont	Washington	Oklahoma
16	Pennsylvania	Rhode Island	Ohio
17	Oklahoma	New Hampshire	Kansas
18	New Hampshire	Vermont	Pennsylvania
19	Kansas	Kansas	New Hampshire
20	Alaska	Nevada	New Mexico
21	Texas	Wyoming	Washington
22		Texas	Texas

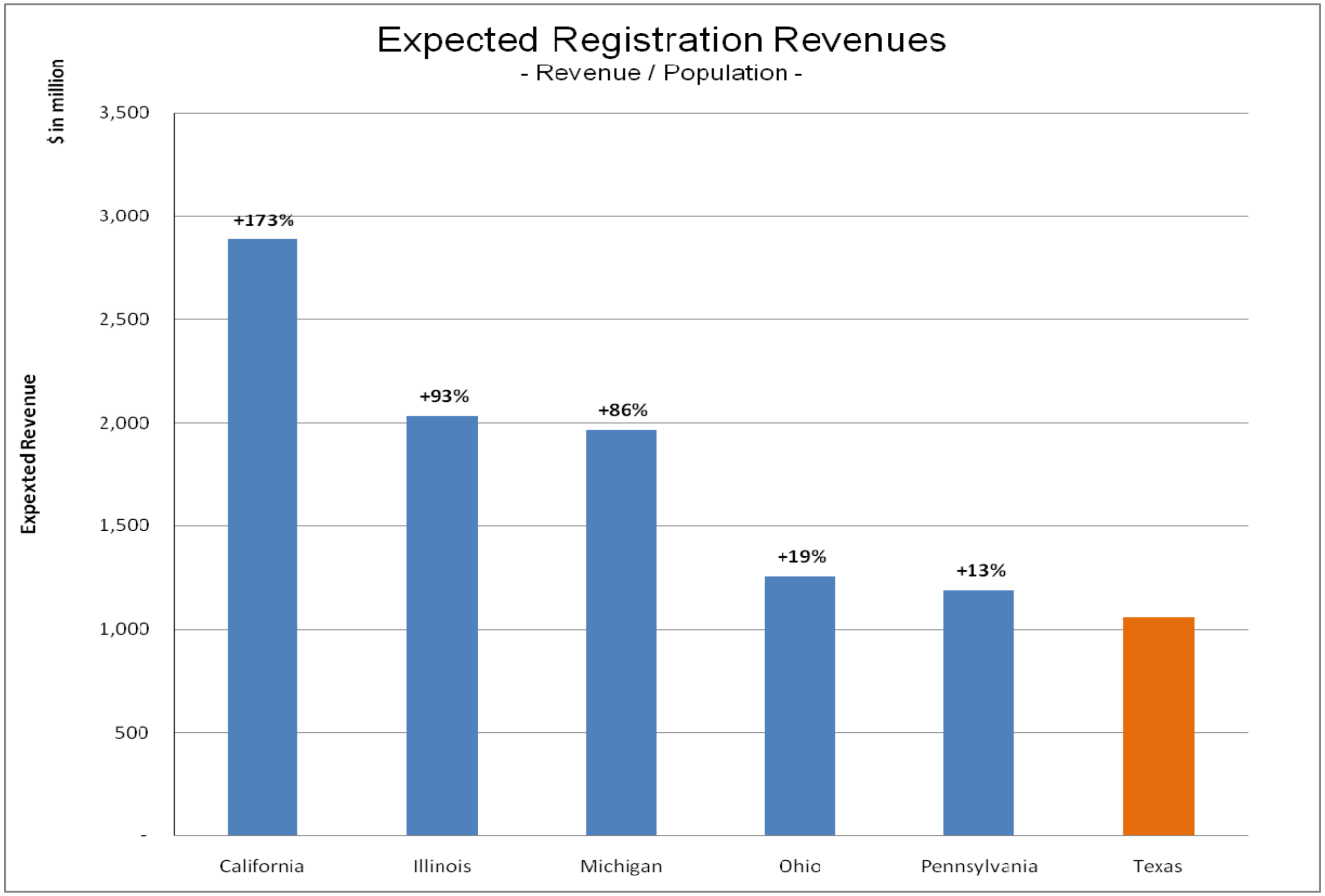
California, **Illinois**, **Michigan**, **Ohio**, and **Pennsylvania** are five peer states that are consistently higher than Texas in the revenue metrics.

6.4.3 Potential Texas Registration Revenue Scenarios

Figures 6.17–6.20 show the expected registration revenue for Texas if the state were to choose to raise registration fees to a level consistent with the metrics presented. Our calculation is as follows:

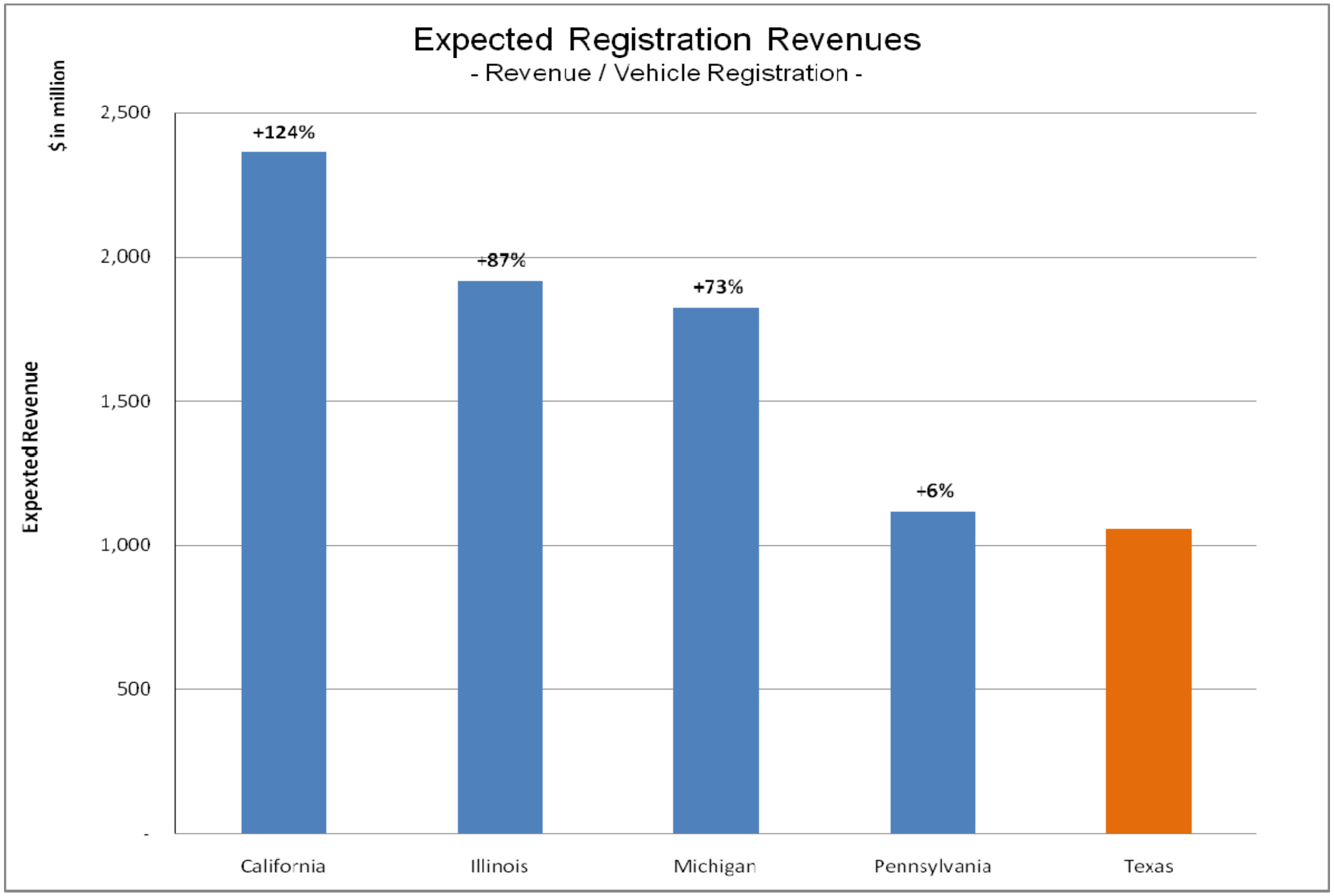
1. Compute the value per metric for each peer state (Revenue per person, per vehicle, and per VMT).
2. Multiply the metric of the peer state by the corresponding Texas data (Population, VMT, and Vehicles Registered).
3. Calculate the increase in percentage that this revenue represents for Texas.

Note: We did not use the actual vehicle registration rates of the peer states, as Texas will have to choose what rates it wants to set based on the preferred metric.



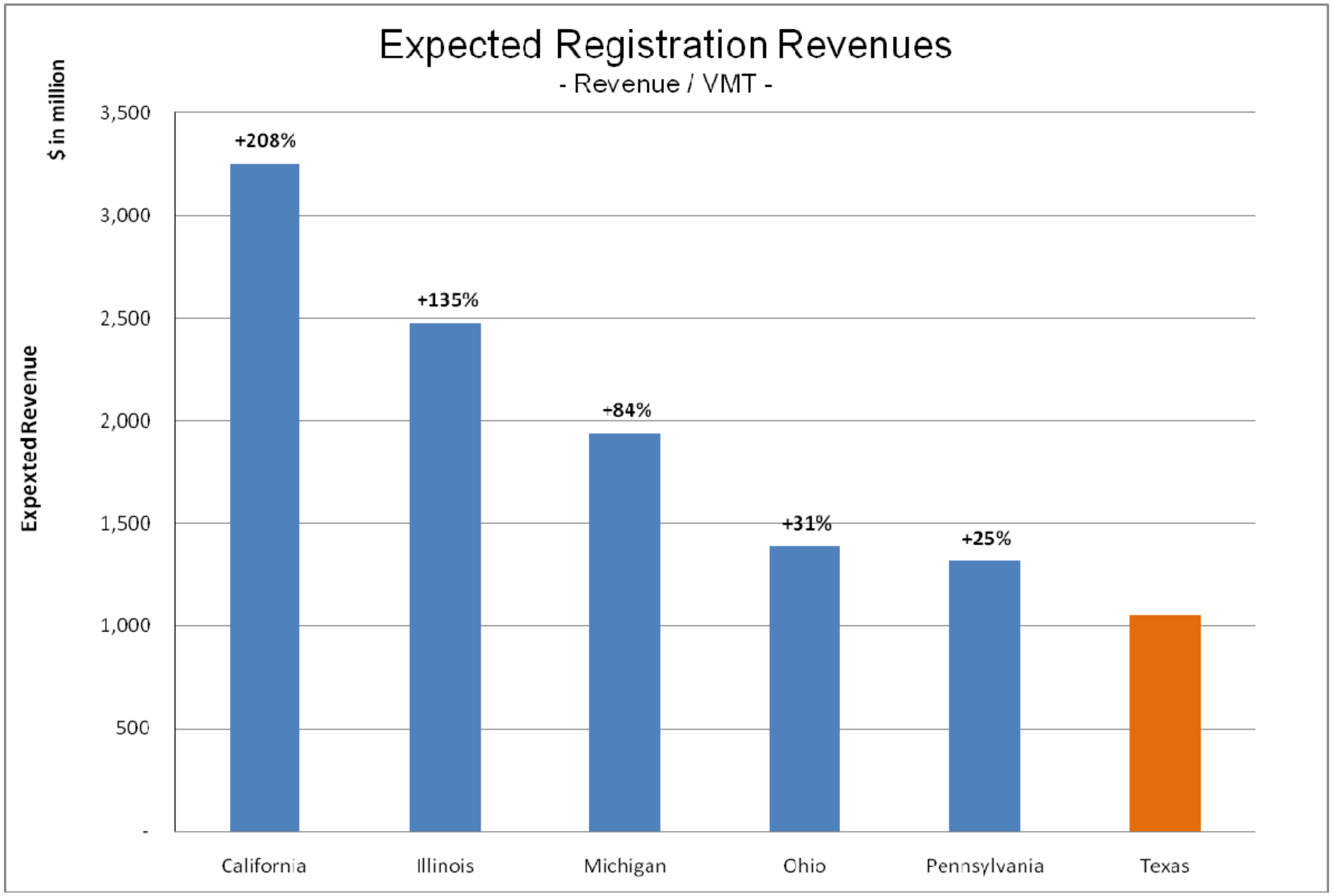
Category	California	Illinois	Michigan	Ohio	Pennsylvania	Texas
RFR/ Population	2,886	2,034	1,966	1,256	1,189	1,056
	+ 173%	+ 93%	+ 86%	+ 19%	+ 13%	0%

Figure 6.17: Expected Registration Revenues per Population



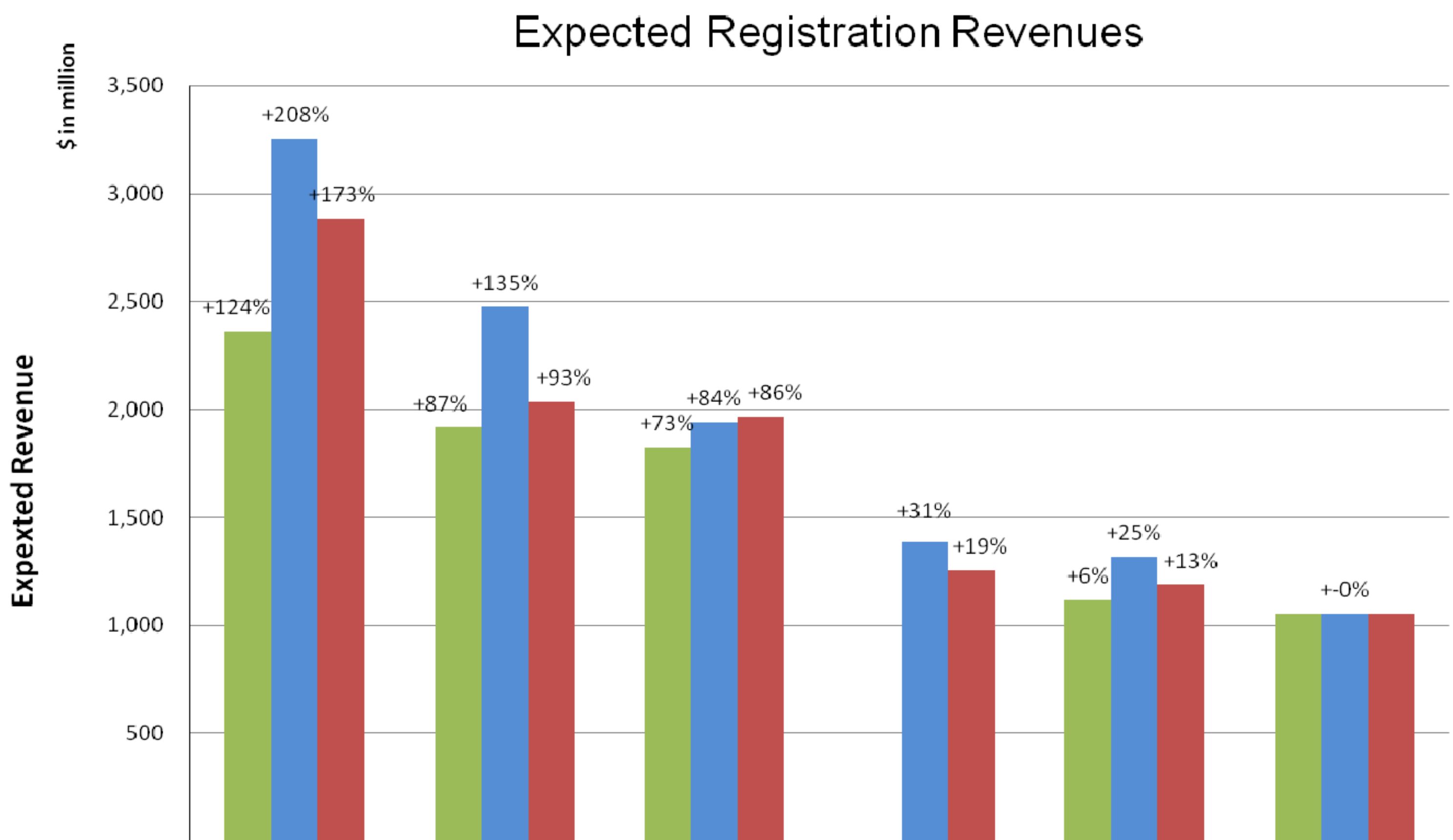
Category	California	Illinois	Michigan	Pennsylvania	Texas
RFR/ Vehicle Registered	2,362 + 124%	1,917 + 87%	1,824 + 73%	1,117 + 6%	1,056 0%

Figure 6.18: Expected Registration Revenues if Texas Used other States Registration Fees



Category	California	Illinois	Michigan	Ohio	Pennsylvania	Texas
RFR/VMT	3,253 + 208%	2,476 + 135%	1,940 + 84%	1,387 + 31%	1,318 + 25%	1,056 0%

Figure 6.19: Expected Registration Revenues per VMT



	California	Illinois	Michigan	Ohio	Pennsylvania	Texas
RFR/ Vehicle Registered	2,362	1,917	1,824	N/A	1,117	1,056
RFR/VMT	3,253	2,476	1,940	1,387	1,318	1,056
RFR/ Population	2,886	2,034	1,966	1,256	1,189	1,056

Figure 6.20: Expected Registration Revenues

6.5 Chapter Conclusion

In this chapter, vehicle registration fees across the U.S. were compared. It was found that Texas is somewhat higher than average in passenger vehicle fees, but lower than average in truck fees. Yet, Texas has a lower proportion of trucks registered than other states. The primary reason identified is jurisdiction shopping. On this issue, two points can be noted:

- As long as cost and service discrepancies persist among IRP jurisdictions, interstate motor carriers will be motivated to search for more accommodating environments in which to register.
- The provision of broader range of registration options, such as online registration renewal and fee payment simplifies the registration process and reduces both registrant and agency costs.

Population, vehicles registered, vehicle miles traveled, and registration revenue in each state were examined to select ten peer states to Texas for a closer look. Three metrics were calculated, namely, revenue per person, per vehicle, and per VMT. It was found that Texas was lower than five peer states on these metrics. These states are **California**, **Illinois**, **Michigan**, **Ohio**, and **Pennsylvania**.

Using these states as benchmarks, we developed several scenarios that the TxDOT can consider to increase registration revenue. The scenario preferred by TxDOT will depend on the desirability of increasing the fees for all or some of the vehicle categories.

Finally, it must be noted that, as an alternative to higher registration fees, the idea of a road access fee has been floated. Vehicle owners would be charged a flat rate for having access to the road network, a more direct justification of a vehicle registration fee. Along similar lines, the idea of a road maintenance fee has been suggested, especially for heavy vehicles.

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Texas Constitution
Texas Transportation Code
Texas Tax Code
Texas Administrative Code

Appendix 2: Revenues and Expenditures of Fund 6, 2002-2007

Revenue

Federal Receipts Matched -- Transp. Programs
Motor Fuel Lubricants Sales Tax
Motor Vehicle Certificates
Motor Vehicle Registration Fees
Tow Truck Registration
Special Vehicle Registrations
Motor Vehicle Inspection Fees
Assigned Vehicle Identification Number Fees
Driver License Fees
Driver Record Information Fees
Commercial Transportation Fees
Voluntary Driver License Fee - Donor
State Highway Toll Project Revenue
Abandoned Motor Vehicles
Outdoor Signs On Rural Roads
Equipment Lease To County Automated Registration & Title Syst.
Oil And Gas Lease Bonus
Oil And Gas Lease Rental
Oil Royalties From Other State Lands
Gas Royalties From Other State Lands
Hard Mineral - Prospect And Lease
Royalties Other Hard Minerals
Land Easements
Land Sales
Food And Drug Fees
Controlled Substances Act Forfeited Money
Dormitory, Cafeteria And Merchandise Sales
Federal Receipts Not Matched
Recovery Audit Reibursements - State
Court Costs
Arrest Costs
Judgments And Settlements
Fees For Copies And Filing Of Records
Conference, Seminars And Training Registration Fees
State Grants, Pass Through Revenue
Fees For Administrative Services
Unemployment Taxes

Unemployment Assessments
Unexpected Contributions
Controlled Substance Reimbursement Of Related Costs
Recoveries From Crime Victim Restitution
Grants - Cities/Counties
Grants / Donations
Recovery Audit Reimbursements -- Federal
Sale Of Public Building Bonds
Rental Of Lands
Rental (Other)
Sale Of Furniture
Sale Of Buildings
Sale Of Publications/Advertising
Sale Of Surplus Property
Other Surplus Or Salvage Property/Materials Sale
Telecomunications Service From Local Funds
Sale Of Operating Supplies
Supplies/Equipment
Interagency Sale Of Supplies/Equipment/Services
Supplies/Equipment Local Funds
Supplies/Equipment Federal Funds
Forfeitures
License Suspension Fee, Child Support Obligor
Insurance And Damages
Insurance Recovery After Loss - Other Financing Sources
Returned Checks Fees
Warrants Voided By Statute Of Limitations - Default Fund
Repayment Of Travel Advances
Repayment Of Petty Cash Advances
Repayment Of Loans, Political Subdivision
Default Deposit Adjustments - Suspense
Returned Checks -Default Fund
Political Subdivision Administrative Fees, Failure To Appear
Other Miscellaneous Governmental Revenue
Reimbursements - Third Party
Subrogation Recoveries
Rental Of Housing To State Employees
Issuance Of Commercial Paper
Interest On State Deposits And Treasury Investments
Interest On Local Deposits
Interest (Others)
Sale Of General Obligation/Revenue Bonds
Allocations From Fund 001 To 0002, 0006, 0057

Interagency Transfers, Federal Pass Trhough Revenue
Other Cash Transfers Between Funds Or Accounts
Other Cash Transfers Within Fund Or Account Between Agencies
Unexpected Cash Balance Forward

Expenditures

Interfund Transfers
Salaries And Wages
Employee Benefits
Supplies And Materials
Other Expenditures
Public Assistance Payments
Intergovernmental Payments
Travel
Professional Services And Fees
Payment Of Principal - Debt Service
Payment Of Interest - Debt Service
Highway Construction
Capital Outlay
Repairs And Maintenance
Communication And Utilities
Rentals And Leases
Claims And Judgments
Cost Of Goods Sold
Printing And Reproductions

Appendix 3: Recipients of Monies from Fund 6: 1998-2009

General Appropriations Act: Categories Of Expenditures From 1998 To 2009

I. Other Agencies

Office Of The Attorney General
Comptroller (Social Security Contributions)
Employees Retirement Syst (Health Program)
Veterans Commission (Retirement Syst)
Veterans Commission (Social Security)

Health And Human Services Commission (Medicaid Match)

Higher Education Employees Group Insurance Contributions
Texas Education Agency
Education Employees (Retirement And Social Security)

Texas Transportation Institute
Texas Transportation Institute (Transportation Safety Centre)
Texas Transportation Institute (Transportation Studies Centre)

Department Of Health -- (100% Ems Grants Specifically Authorized)
Department Of Health (Capital Budget)

Rehabilitation Commission (Retirement Syst)
Rehabilitation Commission (Social Security) -- Support To The Comptroller's Office

Judiciary Section -- Comptroller's Department - Motor Fuel Tax Fraud
Public Integrity Unit

Department Of Criminal Justice (Capital Budget)

Department Of Public Safety (Total Budget)
Department Of Public Safety (Capital Budget)
Acquisition Of Land And Other Real Property (Capital Budget)
Construction Of Buildings And Facilities (Capital Budget)
Repair Or Rehabilitation Of Buildings And Facilities (Capital Budget)
Acquisition Of Information Resource Technologies (Capital Budget)
Transportation Items (Vehicles) (Capital Budget)
Acquisition Of Capital Equipment And Items (Capital Budget)
Sb 1074 Implementation - Cameras (Capital Budget)

Youth Commission (Retirement)
Youth Commission (Social Security)

Texas Workforce Commission Reimbursements To The Unemployment Compensation Benefit Account (Retirement)
Texas Workforce Commission Reimbursements To The Unemployment Compensation Benefit Account (Social Security)
Worker's Compensation Commission (Retirement)
Worker's Compensation Commission (Social Security)

Other Appropriations And Adjustments (Service Transfers)
Other Appropriations And Adjustments (Year 2000 Conversion)

State Office Administrative Hearings
Worker's Compensation Commission (Social Security)

Social Security And Benefit Replacement Pay

Contingency Appropriations

II. Texas Department Of Transportation

Department Of Transportation (Overall Budget)

Department Of Transportation (Fund 6's Percentage Within The Capital Budget)
Acquisition Of Land & Other Real Property (Capital Budget)
Construction Of Buildings And Facilities (Capital Budget)
Repair And Rehabilitation Of Buildings And Facilities (Capital Budget)
Acquisition Of Information Resource Technologies (Capital Budget)
Transportation Items (Capital Budget)
Acquisition Of Capital Equipment And Items (Capital Budget)

Public Transportation From Fund 6
Rural Transportation Contractors
Urban Public Transportation Contractors
Gross Weight And Axle Fees

Traffic Enforcement Program (Step)

County And Municipal Airports (Texas Transportation Code, Section 22.055)
Aviation Education
Aviation Services
Grant Funds (Remaining As Of 08/31)

Appropriations For Transportation Services
Reimbursements And Revenue Appropriation
Additional Reimbursements To Fund 6
Lease Payment Airplane
Lease Payment Fuel Trucks
Houston District Office Headquarters