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**REVIEW AND CRITIQUE MODOT'S STATE
REVENUE FORECASTING MODEL**

FINAL REPORT

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June 2007

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EXECUTIVE SUMMARY

Research efforts towards developing fuel demand models reached a peak in the aftermath of the oil price shocks of the 1970s. The recent increases in transportation fuel prices stemming from, among other things, the turmoil on the world oil markets have revived the interest of state governments, institutions, and agencies in getting the most accurate fuel consumption forecasts for budgeting purposes.

States have traditionally relied on fuel taxes to fund roadway construction, rehabilitation and maintenance. In planning their year-to-year activities and accompanying spending levels in each of these categories, states thus require forecasts of revenues that will be available from the Federal Highway Trust Fund (HTF), as well as from the fuel taxes, fees and other charges they levy on highway users. State highway user taxes and fees account for more than half of all revenue sources in Missouri's 2007 – 2011 Statewide Transportation Improvement Program (STIP).¹

HDR|HLB Decision Economics Inc. (HDR|HLB) has been retained by the Missouri Department of Transportation (MoDOT) to provide a review and critique of its current forecasting models of state highway user revenues. HDR|HLB has made a number of recommendations on the selection of the forecasting technique, the definition of dependent variables, the specification of the equations, and the construction of some explanatory variables to improve the reliability and accuracy of MoDOT's models. Based on those recommendations, HDR|HLB has developed new forecasting equations and revenue projections for the FY 2007 – FY 2012 period.

HDR|HLB's forecasts are based on a detailed econometric analysis of the different highway user revenues and their main determinants. The analysis relies on a literature review of fuel demand and highway user revenue forecasting, with a strong emphasis on models developed by state departments of transportation. It was found that highway user revenues in Missouri are primarily determined by socioeconomic factors such as population, personal income, and fuel price at the state and regional levels.

The forecasting models developed by HDR|HLB along with the model assumptions have been subject to a rigorous review by an independent panel of experts during a Risk Analysis Process (RAP) workshop facilitated by MoDOT and HDR|HLB on May 3rd, 2007. Because of the high uncertainty inherent in forecasting the demand for fuel, the projections are generated within a risk analysis framework: median forecasts (or most likely forecasts) are presented along with lower and upper forecasts.

Table E-1 below compares HDR|HLB's median projections (level and percentage change) with the revenue forecasts developed by MoDOT in 2006. HDR|HLB's estimates for FY 2007 are somewhat similar to MoDOT's. Over the long term, however, HDR|HLB's revenue projections are higher than MoDOT's, with the exception of net driver's license fees. The most striking difference in the two sets of projections is for net motor vehicle use tax revenue: HDR|HLB's

¹ More information on the *2007-2011 Statewide Transportation Improvement Program* is available at: http://www.modot.org/plansandprojects/construction_program/STIP2007-2011/index.htm

estimates are significantly higher than MoDOT's because it was assumed that the tax collection problems experienced by the Department of Revenue (DOR) over the last two fiscal years would not affect revenues after FY 2007. In other words, a level shift is highly expected for this revenue category in FY 2008.

Table E-1: Comparison of HDR|HLB's Projections with MoDOT's Projections (FY 2007 – FY 2012)

		FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	
Net Driver's License Fees	MoDOT	\$17,995 4.1%	\$18,727 4.1%	\$19,489 4.1%	\$20,282 4.1%	\$21,107 4.1%	\$21,966 4.1%	
	HDR HLB	\$17,778 2.8%	\$18,288 2.9%	\$18,703 2.3%	\$19,150 2.4%	\$19,650 2.6%	\$20,115 2.4%	
Net Motor Vehicle Fees	MoDOT	\$256,201 -3.4%	\$262,412 2.4%	\$268,775 2.4%	\$275,291 2.4%	\$281,966 2.4%	\$288,803 2.4%	
	HDR HLB	\$256,408 -3.3%	\$262,822 2.5%	\$270,511 2.9%	\$278,929 3.1%	\$286,126 2.6%	\$294,683 3.0%	
Net Motor Vehicle Sales Tax Revenue	MoDOT	SRF	\$100,891	\$105,158	\$108,244	\$111,846	\$114,858	\$117,235
		Amend. 3	\$51,827	\$81,029	\$111,210	\$114,911	\$118,005	\$120,447
Total		\$152,718 19.5%	\$186,187 21.9%	\$219,454 17.9%	\$226,757 3.3%	\$232,863 2.7%	\$237,682 2.1%	
HDR HLB		\$160,142 25.3%	\$196,801 22.9%	\$239,607 21.8%	\$253,641 5.9%	\$263,411 3.9%	\$276,016 4.8%	
Net Motor Vehicle Use Tax Revenue	MoDOT	\$41,776 -0.5%	\$42,853 2.6%	\$43,621 1.8%	\$44,508 2.0%	\$45,240 1.6%	\$45,813 1.3%	
	HDR HLB	\$42,665 1.6%	\$61,723 44.7%	\$64,127 3.9%	\$66,943 4.4%	\$70,348 5.1%	\$73,750 4.8%	
Net Fuel Tax Revenue	MoDOT	\$512,470 N/A	\$514,633 0.4%	\$520,029 1.0%	\$526,024 1.2%	\$531,799 1.1%	\$536,999 1.0%	
	HDR HLB	\$512,766 0.9%	\$523,730 2.1%	\$537,891 2.7%	\$553,859 3.0%	\$564,781 2.0%	\$577,846 2.3%	

Notes: (a) All amounts are net of refunds and are expressed in thousands of dollars.

(b) HDR|HLB's projections reflect the median estimates.

(c) Net Fuel Tax Revenue is the sum of Net Gasoline Tax Revenue and Net Diesel Fuel Tax Revenue and does not include Miscellaneous Fees. Therefore, HDR|HLB's estimate for Net Fuel Tax Revenue is the sum of the median values and not the median strictly speaking.

1. INTRODUCTION

Research efforts towards developing fuel demand models reached a peak in the aftermath of the oil price shocks of the 1970s. The recent increases in transportation fuel prices stemming from, among other things, the turmoil on the world oil markets have revived the interest of state governments, institutions, and agencies in getting the most accurate fuel consumption forecasts for budgeting purposes.

States have traditionally relied on fuel taxes to fund roadway construction, rehabilitation and maintenance. In planning their year-to-year activities and accompanying spending levels in each of these categories, states thus require forecasts of revenues that will be available from the Federal Highway Trust Fund, as well as from the fuel taxes, fees and other charges they levy on highway users. State highway user taxes and fees account for more than half of all revenue sources in Missouri's 2007 – 2011 Statewide Transportation Improvement Program.

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HDR|HLB's forecasts are based on a detailed econometric analysis of the different highway user revenues and their main determinants. The analysis relies on a literature review of fuel demand and highway user revenue forecasting, with a strong emphasis on models developed by state departments of transportation. It was found that highway user revenues in Missouri are primarily determined by socioeconomic factors (population, personal income, fuel price, etc.).

The forecasting models developed by HDR|HLB along with the model assumptions have been subject to a rigorous review by an independent panel of experts during a Risk Analysis Process workshop facilitated by MoDOT and HDR|HLB on May 3rd, 2007. Because of the high uncertainty inherent in forecasting the demand for fuel, the projections are generated within a risk analysis framework: median forecasts (or most likely forecasts) are presented along with lower and upper forecasts.

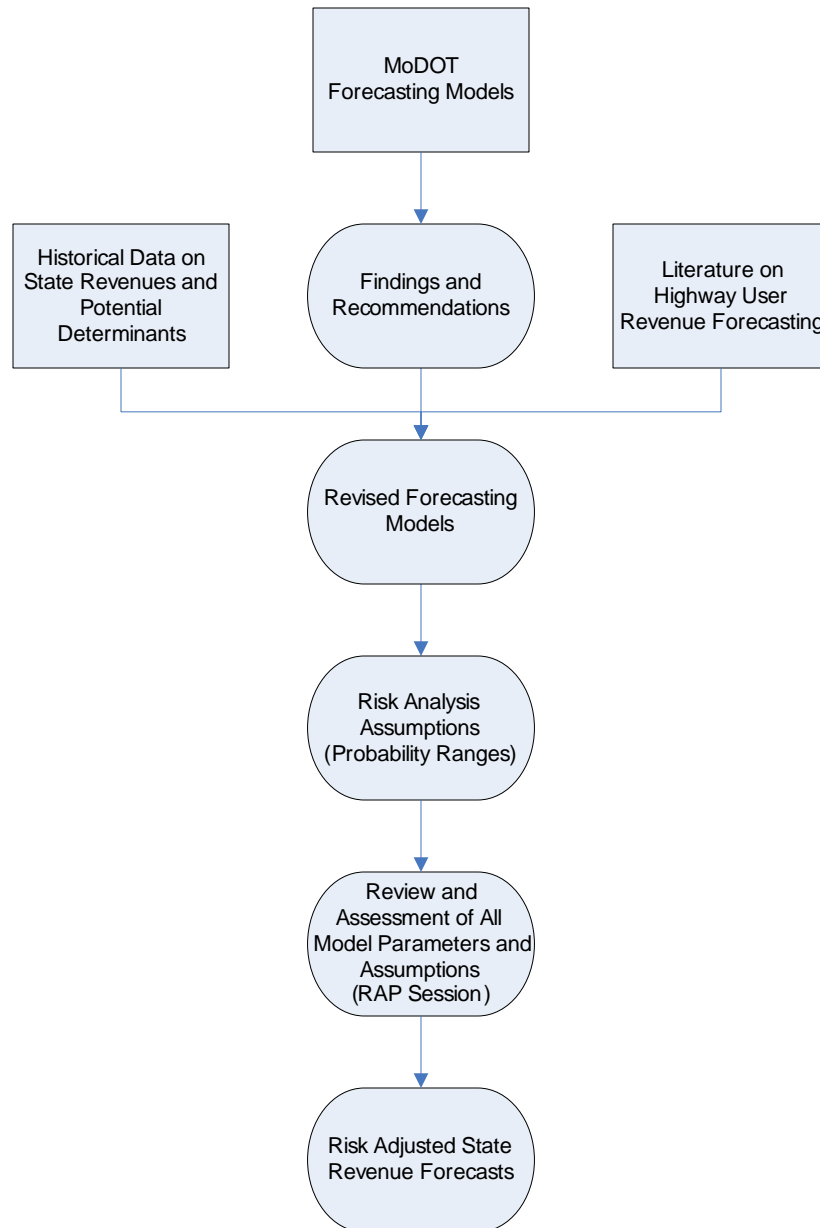
1.1 HDR|HLB's Approach

HDR|HLB's approach for developing projections of Missouri's highway user revenues for FY 2007 through FY 2012 is illustrated in Figure 1 on the following page. It comprises five major steps:

1. Review MoDOT's current forecasting models and revenue projections, and provide recommendations;
2. Based on those recommendations, update the forecasting models using regional demographic and socio-economic data;
3. Assign preliminary probability ranges to all model variables;

4. Conduct a RAP session with a panel of knowledgeable and independent experts to review the updated models and risk analysis assumptions; and,
5. Based on the RAP panel inputs, update all risk analysis assumptions and run Monte Carlo simulations to generate fuel consumption and revenue projections.

Figure 1: Overview of HDR|HLB's Approach



1.2 Organization of the Report

The report consists of seven chapters. Following this introduction, Chapter 2 presents historical data on the various variables to be estimated and projected. Chapter 3 provides a synopsis of the literature on highway user revenue forecasting models. Chapter 4 provides a review of the models developed by MoDOT to forecast revenues from state taxes and fees levied on highway users. Chapter 5 builds on the findings of the previous chapters to develop econometric models to forecast the different highway user revenue categories of interest to MoDOT. Forecasting assumptions for fiscal year 2007 through fiscal year 2012 are discussed in Chapter 6. Chapter 7 presents the revenue projections within a risk analysis framework.

The report also includes several appendices. Appendix A provides the complete equation output and correlograms of residuals for each equation estimated in SAS by MoDOT. Results of the augmented Dickey-Fuller unit root tests on residuals, and correlograms of residuals for all equations developed by HDR|HLB are presented in Appendix B and Appendix C respectively. Detailed responses to a number of key comments made by panel experts on technical aspects of the modeling process are included in Appendix D. Appendix E presents a primer of the Risk Analysis Process. Data sheets on all explanatory variables reviewed by panel experts during the risk analysis workshop are available in Appendix F. Detailed risk analysis results for all revenue categories and fiscal years are provided in Appendix G. A list of panel experts who attended the workshop and/or provided inputs on the forecasting assumptions can be found in Appendix H. References and data sources used during the course of the study are listed in Appendix I.

2. HISTORICAL TREND ANALYSIS

This chapter presents historical data on the variables to be estimated and projected: net driver's license fees; net motor vehicle fees; net motor vehicle sales tax revenue; net motor vehicle use tax revenue; net gasoline consumption; and, net diesel fuel consumption. All the data were provided by MoDOT and compiled on a fiscal year basis. They are displayed in tabular and graphical formats on the following pages.

Note that the data presented in this chapter only represent the portion of state revenues distributed to MoDOT and are *net* of refunds. HDR|HLB was not able to obtain gross revenue data for all revenue categories. Also, total refund data are not reported in this section since all dependent variables are net of refunds.

2.1 Net Driver's License Fees and Net Motor Vehicle Fees

Historical data on net driver's license fees and net motor vehicle fees (in millions of dollars) for the period FY 1985 – FY 2006 are reported in Table 1 and depicted in Figure 2 on the next page. Net driver's license fees and net motor vehicle fees totaled \$17 million and \$248 million respectively in FY 2006.

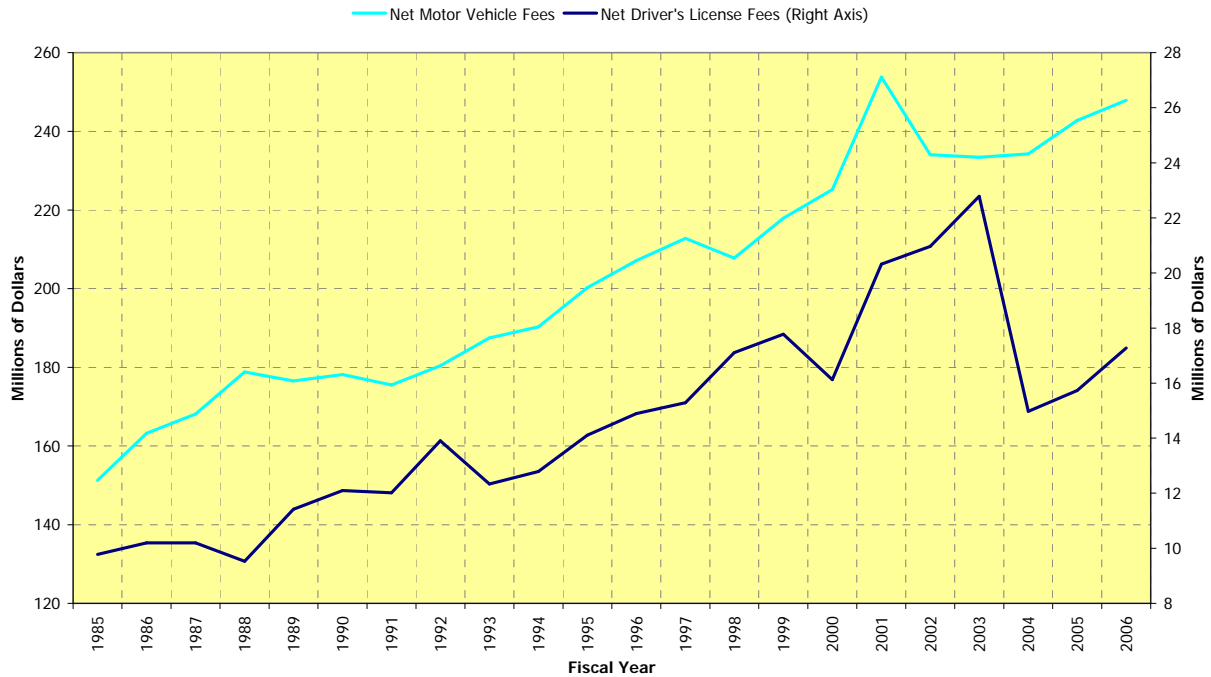
The spike in net motor vehicle fees in FY 2001 is due to a change in the registration period. Since July 1, 2000 residents of Missouri have the option to register their motor vehicles every two years rather than every year. Owners of "even" model year vehicles have the option during even years, while owners of "odd" model year vehicles have the option during odd years. As a consequence, there was an increase in revenues in FY 2001 (fees doubled for people who opted for a two-year registration) and a decrease in revenues in FY 2002 (people who opted for a two-year registration in FY 2001 did not pay any fees the following year).

In FY 2001, the Department of Revenue (DOR) also started shifting from three-year driver's licenses to six-year driver's licenses. Drivers who were born in an odd year were eligible in FY 2001 through FY 2003, while the remaining drivers were eligible in FY 2004 through FY 2006. As a result, there was an increase in revenues in fiscal years 2001, 2002 and 2003 (fees doubled for people who obtained a six-year driver's license). Since FY 2004 DOR has received driver's license fees from about one sixth of Missouri's drivers annually.

Table 1: Net Driver's License and Motor Vehicle Fees (FY 1985 – FY 2006)

Fiscal Year	Net Driver's License Fees		Net Motor Vehicle Fees	
	Millions of Dollars	% Change	Millions of Dollars	% Change
1985	9.8	N/A	151.3	N/A
1986	10.2	4.3%	163.2	7.9%
1987	10.2	0.0%	168.1	3.0%
1988	9.5	-6.6%	178.8	6.4%
1989	11.4	19.8%	176.5	-1.3%
1990	12.1	5.9%	178.2	0.9%
1991	12.0	-0.6%	175.5	-1.5%
1992	13.9	15.6%	180.4	2.8%
1993	12.3	-11.2%	187.5	3.9%
1994	12.8	3.7%	190.3	1.5%
1995	14.1	10.3%	200.2	5.2%
1996	14.9	5.6%	207.2	3.5%
1997	15.3	2.7%	212.8	2.7%
1998	17.1	11.9%	207.8	-2.4%
1999	17.8	3.9%	217.9	4.9%
2000	16.1	-9.3%	225.2	3.4%
2001	20.3	26.0%	253.8	12.7%
2002	21.0	3.2%	234.1	-7.8%
2003	22.8	8.7%	233.4	-0.3%
2004	15.0	-34.3%	234.3	0.4%
2005	15.7	5.1%	242.8	3.6%
2006	17.3	9.8%	247.9	2.1%

Figure 2: Net Driver's License and Motor Vehicle Fees (FY 1985 – FY 2006)



2.2 Net Motor Vehicle Sales Tax Revenue and Net Motor Vehicle Use Tax Revenue

Historical data on net motor vehicle sales tax and use tax revenues (in millions of dollars) for the period FY 1984 – FY 2006 are reported in Table 2 and depicted in Figure 3 below. Net motor vehicle sales tax revenue and net motor vehicle use tax revenue totaled \$103 million and \$42 million respectively last year.

In FY 1994 a revenue diversion concerning leased vehicles was corrected, which explains the increase in motor vehicle use tax revenue from FY 1994 onward.

Also MoDOT received 13 months of motor vehicle sales tax revenue in FY 2000 as the Department of Revenue closed the distribution time lag by one month.

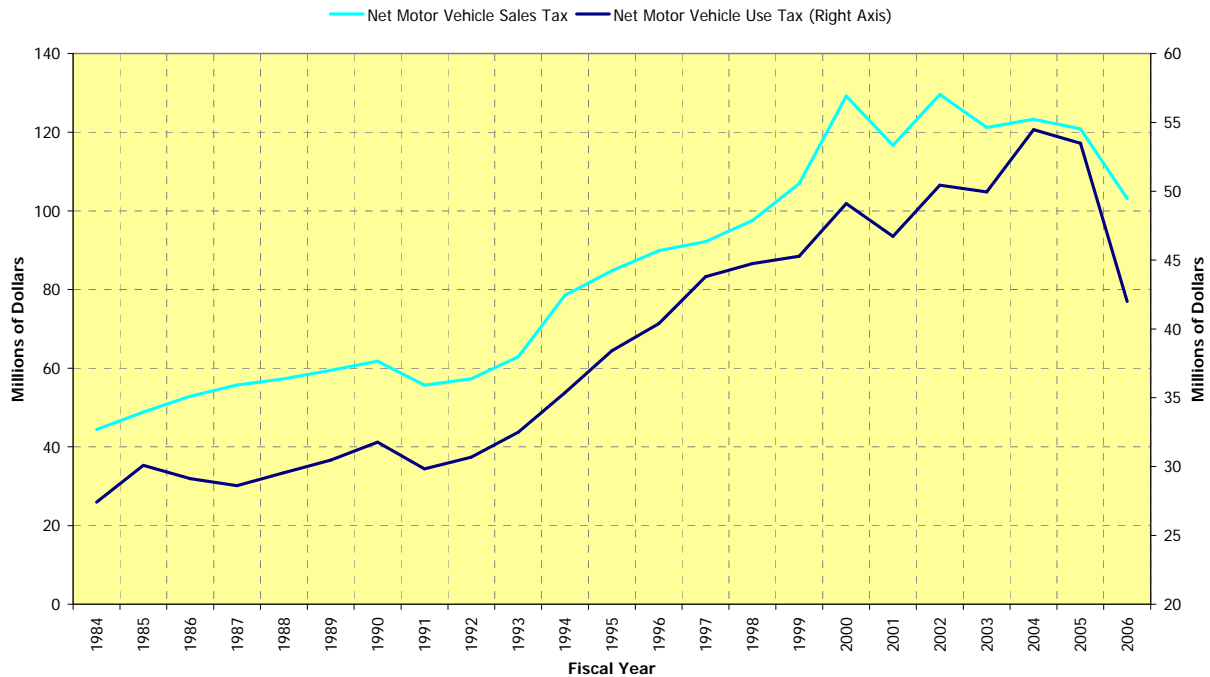
Motor vehicle use tax revenue declined dramatically in FY 2006 (-21.5 percent). The drop was due to tax collection problems. DOR implemented a new automated collection system that was not fully operational at once. As a result, use tax receipts were not distributed to MoDOT in a timely manner.

Also, in FY 2006 the implementation of Amendment 3 reduced the State Road Fund's share of taxable sales from 1.48 percent to 1.46 percent, which explains in part the decrease in motor vehicle sales tax revenue.

Table 2: Net Motor Vehicle Sales Tax and Use Tax Revenues (FY 1984 – FY 2006)

Fiscal Year	Net Motor Vehicle Sales Tax		Net Motor Vehicle Use Tax	
	Millions of Dollars	% Change	Millions of Dollars	% Change
1984	44.4	N/A	27.4	N/A
1985	48.8	9.9%	30.1	9.8%
1986	52.9	8.2%	29.1	-3.2%
1987	55.7	5.5%	28.6	-1.8%
1988	57.4	2.9%	29.6	3.3%
1989	59.4	3.6%	30.5	3.1%
1990	61.8	4.0%	31.8	4.3%
1991	55.7	-9.9%	29.8	-6.1%
1992	57.3	2.9%	30.7	2.8%
1993	62.9	9.8%	32.5	5.9%
1994	78.6	24.9%	35.4	8.8%
1995	84.7	7.9%	38.4	8.6%
1996	89.9	6.1%	40.4	5.2%
1997	92.2	2.5%	43.8	8.4%
1998	97.6	5.8%	44.7	2.2%
1999	106.9	9.6%	45.3	1.2%
2000	129.2	20.8%	49.1	8.4%
2001	116.6	-9.7%	46.7	-4.8%
2002	129.6	11.1%	50.4	7.9%
2003	121.2	-6.5%	50.0	-0.9%
2004	123.3	1.7%	54.5	9.0%
2005	120.9	-1.9%	53.5	-1.8%
2006	103.1	-14.7%	42.0	-21.5%

Figure 3: Net Motor Vehicle Sales Tax and Use Tax Revenues (FY 1984 – FY 2006)



2.3 Net Gasoline and Diesel Fuel Consumption

Missouri’s net gasoline and diesel fuel consumption (in gallons) for the period FY 1970 – FY 2006 is reported in Table 3 on the next page. Total net motor fuel consumption is the sum of net gasoline and diesel fuel consumption. Net gasoline consumption and net diesel fuel consumption amounted to 3.1 billion gallons and 950 million gallons respectively last year.

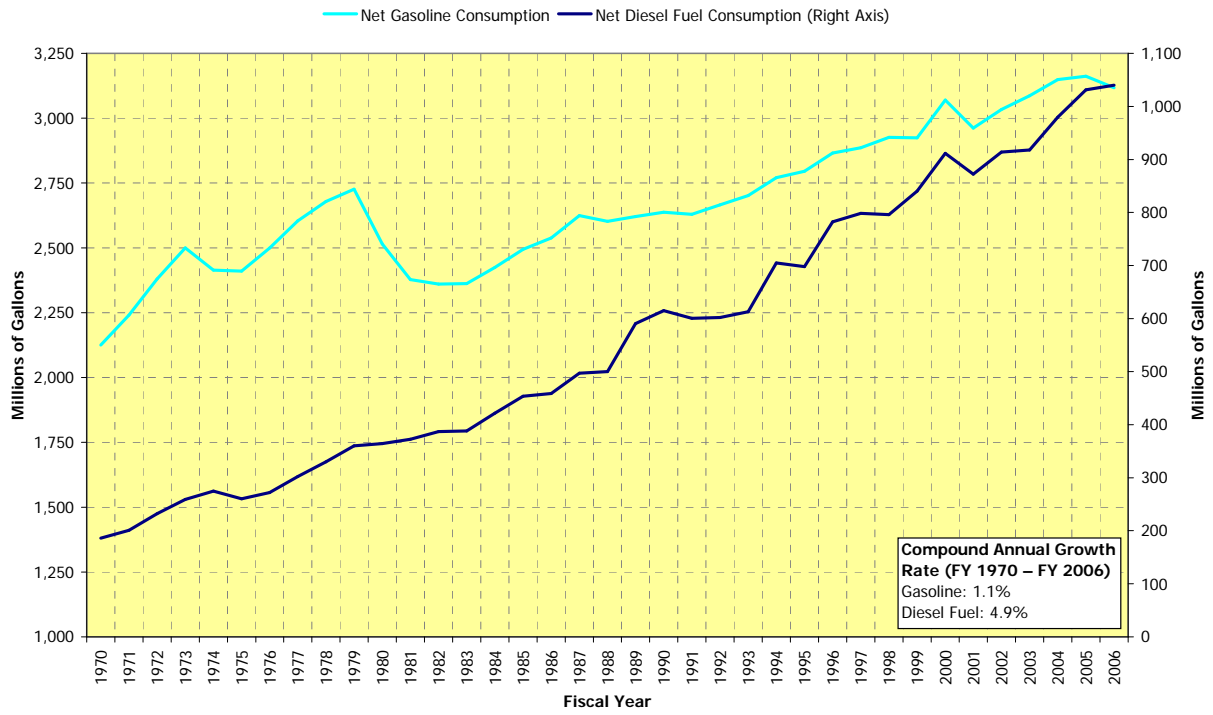
Diesel fuel consumption has been increasing at a faster pace than gasoline consumption, especially since the early 1980s. The annual compound growth rate over the last 36 years is 1.1 percent for gasoline consumption and 4.9 percent for diesel fuel consumption. The spike in gasoline and diesel consumption in FY 2000 is due to a change in the collection point of state motor fuel tax from the distributor to the terminal (to reduce tax evasion) that occurred on January 1, 1999. The table also clearly shows the effects of the oil price shocks on fuel consumption in FY 1974, FY 1980 and more recently in FY 2006.

Table 3: Net Fuel Consumption (FY 1970 – FY 2006)

Fiscal Year	Net Gasoline Consumption		Net Diesel Fuel Consumption		Total Net Motor Fuel Consumption	
	Millions of Gallons	% Change	Millions of Gallons	% Change	Millions of Gallons	% Change
1970	2,125.0	N/A	186.0	N/A	2,311.0	N/A
1971	2,241.0	5.5%	201.0	8.1%	2,442.0	5.7%
1972	2,380.0	6.2%	232.0	15.4%	2,612.0	7.0%
1973	2,500.0	5.0%	259.0	11.6%	2,759.0	5.6%
1974	2,414.0	-3.4%	275.0	6.2%	2,689.0	-2.5%
1975	2,410.0	-0.2%	260.0	-5.5%	2,670.0	-0.7%
1976	2,499.0	3.7%	272.0	4.6%	2,771.0	3.8%
1977	2,604.0	4.2%	302.0	11.0%	2,906.0	4.9%
1978	2,679.0	2.9%	330.0	9.3%	3,009.0	3.5%
1979	2,726.0	1.8%	360.0	9.1%	3,086.0	2.6%
1980	2,515.3	-7.7%	364.2	1.2%	2,879.5	-6.7%
1981	2,377.5	-5.5%	372.2	2.2%	2,749.7	-4.5%
1982	2,360.3	-0.7%	386.9	3.9%	2,747.2	-0.1%
1983	2,362.2	0.1%	388.2	0.4%	2,750.4	0.1%
1984	2,424.5	2.6%	421.7	8.6%	2,846.2	3.5%
1985	2,494.4	2.9%	453.5	7.6%	2,947.9	3.6%
1986	2,538.2	1.8%	458.7	1.1%	2,996.9	1.7%
1987	2,624.5	3.4%	497.2	8.4%	3,121.7	4.2%
1988	2,602.4	-0.8%	500.0	0.6%	3,102.4	-0.6%
1989	2,621.0	0.7%	590.4	18.1%	3,211.4	3.5%
1990	2,637.5	0.6%	615.2	4.2%	3,252.7	1.3%
1991	2,629.1	-0.3%	600.5	-2.4%	3,229.5	-0.7%
1992	2,666.2	1.4%	601.7	0.2%	3,267.9	1.2%
1993	2,701.7	1.3%	612.8	1.8%	3,314.5	1.4%
1994	2,770.5	2.5%	704.9	15.0%	3,475.4	4.9%
1995	2,795.3	0.9%	697.8	-1.0%	3,493.2	0.5%
1996	2,865.4	2.5%	782.4	12.1%	3,647.7	4.4%
1997	2,886.0	0.7%	798.2	2.0%	3,684.1	1.0%
1998	2,926.6	1.4%	796.0	-0.3%	3,722.6	1.0%
1999	2,924.3	-0.1%	840.4	5.6%	3,764.7	1.1%
2000	3,070.0	5.0%	911.6	8.5%	3,981.6	5.8%
2001	2,961.5	-3.5%	872.1	-4.3%	3,833.6	-3.7%
2002	3,033.1	2.4%	913.8	4.8%	3,946.9	3.0%
2003	3,086.7	1.8%	917.9	0.5%	4,004.6	1.5%
2004	3,149.5	2.0%	979.5	6.7%	4,129.1	3.1%
2005	3,162.0	0.4%	1,031.2	5.3%	4,193.1	1.6%
2006	3,117.6	-1.4%	1,040.2	0.9%	4,157.8	-0.9%

Figure 4 on the next page depicts net gasoline consumption and net diesel fuel consumption over the period FY 1970 – FY 2006.

Figure 4: Net Gasoline and Diesel Fuel Consumption (FY 1970 – FY 2006)



3. LITERATURE REVIEW

This chapter provides a synopsis of the literature on highway user revenue forecasting models. The purpose of the literature review is to identify and report on best practices adopted by state departments of transportation, as well as federal agencies and academia. It provides important background information and guidance for the development of a state highway user revenue forecasting model for the Missouri Department of Transportation.

The literature review is structured as follows. Section 3.1 presents some of the major models developed to date by state departments of transportation. In each case, a brief history of the development and purpose of the model is provided as background, where available. A discussion on the methodology employed and key explanatory variables used in the models follows. Section 3.2 summarizes the findings of other studies. A list of references is available in Appendix H, at the end of the report.

3.1 State Forecasting Models

This section presents four models developed by state departments of transportation to forecast highway user tax revenues in Arizona, California, Indiana, and Wisconsin.

3.1.1 California Department of Transportation: Motor Vehicle Stock, Travel and Fuel Forecast

The California Motor Vehicle Stock, Travel and Fuel Forecast (MVSTAFF) report has been published annually by the California Department of Transportation (Caltrans), in cooperation with the Federal Highway Administration, since 1984. The MVSTAFF process is a recursive procedure estimating the following vehicle characteristics, for each year of the forecast period:

- Motor vehicle stock (average number of currently registered vehicles) by six body types, two fuel types, and 25 model years or age groups;
- Fuel economy of the total fleet and each model year fleet; and
- Vehicle travel (in miles) and fuel consumption for the total fleet and each model year fleet.

The process consists of four major parts:

1. Inventories

Base year estimates and future year projections of the socioeconomic variables (population, personal income, fuel price, etc.) are assumed to be the causative factors for acquiring vehicles and generating travel, base year fuel consumption, and explicit assumptions about new vehicle fuel economy. The base year vehicle stock is stratified by vehicle type and model year, and derived estimates of the on-road fuel economy for each stratum of vehicles in the base year fleet.

2. Stratified Rate Model

When applied to the base year inventory, this model estimates base year vehicle miles of travel, fuel consumption and fuel economy for each vehicle type and the total fleet. When applied in the forecasting model, the Stratified Rate Model first updates the composition and fuel economy of the fleet by one year and then estimates the next year's stratified fleet, vehicle travel, fuel consumption and fuel economy. Imbedded in the Stratified Rate Model are sub-models, which forecast the total number of vehicles by vehicle type such as new vehicles, in-migration vehicles, and scrappage of old vehicles. The sub-models also forecast the fuel economy of new vehicles under explicit socioeconomic assumptions.

3. Statewide Aggregate VMT and VFC Model

This model accepts the vehicle fleet fuel economy from the Stratified Rate Model and socioeconomic data from the inventory. It estimates next year's statewide vehicle miles of travel (VMT) and vehicle fuel consumption (VFC) without regard to vehicle body type. Because the Aggregate Model is more directly linked to socioeconomic variables, the VMT forecasts from the model are used as control totals for the forecast years.

4. Comparison/Adjustment Model

This model compares and adjusts the total VMT and VFC from the Stratified Rate Model to match that from the Aggregate Model. As part of the comparison/adjustment process, statewide total diesel fuel is forecasted with a Diesel Fuel Consumption Model, and gasoline fuel is computed as the difference between total fuel and diesel fuel. Following the comparison/adjustment step, future year VMT, VFC, and vehicle fuel economy for each vehicle type are then calculated.

The above sequence produces the next year forecast. The process is then recursively applied to produce forecasts for each succeeding year in the forecast period.

3.1.2 Arizona Department of Transportation: Highway User Revenue Fund Forecasting Process

The State of Arizona taxes motor fuels and collects a variety of fees relating to the registration and operation of motor vehicles in the State. These revenues are deposited into the Arizona Highway User Revenue Fund (HURF) and are then distributed to the cities, towns and counties of the State and to the State Highway Fund. They represent the primary source of revenues available to the State for highway construction, improvements and other related expenses.

Since 1986, the Arizona Department of Transportation (ADOT) has estimated revenues flowing into HURF using a regression-based approach. To account for the uncertainty inherent in the forecasting process ADOT introduced the Risk Analysis Process (RAP) in 1992. The RAP relies upon a probability analysis and the independent evaluation of the model's variables by a panel of local experts. This results in a series of forecasts with specified probabilities of occurrence, rather than a single or "best guess" estimate.

HDR|HLB Decision Economics Inc. has been in charge of updating the HURF model and projections annually since 1997. In 2005, after an in-depth evaluation and consultation with experts, the structure of the HURF model was changed with the aim of improving the model's forecasting accuracy. The new model consists of seven equations: gasoline consumption; use fuel consumption; motor carrier fee and apportioned revenue; vehicle license tax revenue; county and miscellaneous registration revenue; driver license fee revenue; and title and miscellaneous revenue. Each equation is estimated with historical annual data using the ordinary least square (OLS) method. Key socioeconomic variables used to predict highway user revenues include the following: population, employment, personal income, and gross state product. The equations also include a number of dummy variables to account for the effects of various regulatory and legislative factors.

3.1.3 Wisconsin Department of Transportation

The Wisconsin Department of Transportation (WisDOT) was among the first state agencies to develop an econometric model of gasoline demand for forecasting purposes. The model was one of a series of multiple-time-series models used to forecast state tax revenues. The approach followed by WisDOT is discussed in a paper published by Wolfgram in 1983.

A single equation econometric model of quarterly gasoline demand was developed within a more general multiple-time-series framework. Gasoline demand was assumed to be a function of real gasoline price, real disposable income, vehicle fleet, and fuel efficiency. Dummy variables were introduced to account for the 1973 oil embargo and 1979 fuel shortage. To correct for seasonal autocorrelation in the residuals, a seasonal autocorrelation term was added. The equation was estimated with a log-linear functional form, thus allowing the parameters to be interpreted as short-run elasticities. Gasoline consumption was also estimated indirectly by means of a model where the dependent variable was vehicles miles traveled.

The results of the modeling effort highlight the advantages that a multiple-time-series framework has in terms of model identification and forecasting. In particular, it allows the restrictions placed on the model to be tested for consistency with the data. The econometric analysis reveals the importance of diagnostic checking in the model-building process and the sensitivity of the parameter coefficients (gasoline price especially) to the specification of the model's disturbance structure. The forecasting performance of alternative specifications of the gasoline demand model is evaluated, and it is shown that the multiple-time-series specifications are clearly superior. The results also indicate that direct and indirect models of gasoline demand are both consistent with the data.

3.1.4 Indiana Department of Transportation: INDOTREV

Since the early 1990s the Indiana Department of Transportation (INDOT) has been using the INDOTREV software to generate long-term highway revenue forecasts. The software is a joint effort of INDOT, Perdue University and the Federal Highway Administration. A key characteristic of INDOTREV is that it accounts for the vehicle mix. The software can also provide revenue projections under various tax policies.

Indiana highway user revenues were disaggregated into seven major categories: registration, driver license, international registration plan, gasoline tax, special fuel tax, motor carrier surtax and motor carrier fuel use tax. Registration revenue was divided into seven motor vehicle

categories: automobiles, motorcycles, light duty trucks, tractors, buses, trailers and semitrailers. Light duty trucks, tractors, trailers, and semitrailers were further divided into farm and non-farm categories.

Separate regression equations were developed for each category of motor vehicle to estimate vehicle registration (number of vehicles registered) and vehicle use (number of vehicle miles traveled). Both vehicle registration and vehicle use were found to be heavily shaped by the state socioeconomic environment (population, gross state product, and per capita personal income). In particular, per capita personal income was found to be a key explanatory variable of personal vehicle travel.

The fleet fuel efficiency was determined in a two-step process: firstly, the proportion of vehicles by age cohort was computed; secondly, the relative miles of travel for the various age cohorts were estimated. Fuel consumption (in millions of gallons) was subsequently estimated by dividing VMT of each vehicle category by its respective fleet fuel efficiency. All fuel consumption by automobiles and motorcycles was considered to be gasoline, whereas 96 percent of the light-duty truck fuel consumption was considered to be gasoline. Fuel consumed by tractors, buses and the remaining 4 percent of light-duty trucks was taken as special fuel.

3.2 Other Research Studies

Other research efforts have been conducted by federal agencies and academia to forecast fuel tax revenue and other highway user fees. This section presents the findings of three key studies.

3.2.1 U.S. Department of Energy: Short-Term Integrated Forecasting System

This Short-Term Integrated Forecasting System (STIFS) model is maintained by the Energy Information Administration (EIA), a unit of the U.S. Department of Energy (DOE). It is used to generate short-term (up to 8 quarters), monthly forecasts of U.S. supplies, demands, imports, stocks, and prices of various forms of energy. It was originally developed in the early 1970s by the now reorganized Bureau of Mines, and has been continually updated since then to incorporate the effects of price shocks and other causal factors not anticipated at the time of development.

The model results support many publications, including the monthly *Short-Term Energy Outlook*. In addition to statistical reports and other publications, the EIA offers a spreadsheet model intended for sensitivity analysis. The PC Short-Term Energy Model (PC-STEOM) presents EIA's latest monthly national energy forecast in an Excel-like presentation for information, analysis and reports. Behind the scenes, the PC-STEOM model includes a simulation engine that rapidly updates the forecast to reflect any changes made to the data.

The STIFS model consists of over 300 equations – of which about 100 are estimated – divided into seven sub-models: Petroleum Products Supply Model; Petroleum Products Demand Model; Other Petroleum Products Demand Model; Energy Prices Model; Electricity Model; Coal Model; and Natural Gas Model. The equations are estimated with the OLS method.

Within the Petroleum Products Demand Model the demand for motor gasoline is estimated by means of two equations: motor gasoline deliveries (barrels) and highway travel activity (miles

traveled). The first equation requires projected highway travel data from the second one. The determinants of motor gasoline deliveries are highway travel, inflation-adjusted average retail motor gasoline prices, and several dummy variables to account for seasonality in gasoline deliveries, modifications to the Reid Vapor Pressure² (RVP) standards previously implemented, and the implementation of reformulated gasoline regulations since 1995. Highway travel activity is explained by real disposable income, inflation-adjusted cost per mile (i.e., retail gasoline price) with a lag of twelve months and a polynomial degree of two,³ and several dummy variables pertaining to weather-related disruptions in travel and changes in reporting methodology for vehicle miles traveled.

A main critique of the model is that it does not explicitly take into account the average fuel mileage in the automobile fleet. At best, its motor gasoline deliveries equation includes a major driver of fleet fuel economy (real gasoline price) through which it implicitly accounts for changes in consumer choice of vehicle in reaction to fuel pricing.

3.2.2 Kouris (1982)

A study by George Kouris of the Organization for Economic Cooperation and Development (OECD), International Energy Agency (IEA) in 1982 provides an excellent overview of the issues involved in estimating fuel demand for road transport in the United States.

Kouris reviewed previous approaches which he classifies into reduced form and structural form approaches. Under the reduced form approach, fuel demand is a function of income and price primarily and to a lesser extent variables such as temperature, consumer preferences, social emulation, etc. The structural form approach focuses on the economy of the vehicle fleet and the rate of utilization. Naturally these two approaches are interrelated. For example, fuel economy of the fleet is heavily influenced by the price of fuel.

Kouris also provided elasticities from previous studies for both the short- and long-run periods. Of particular interest is the analysis of the causal factors of fuel economy trends and the ability to forecast them. Existing regression-based models to predict fleet fuel economy were described and a comparison of resulting elasticity coefficients was presented. References cited by the author represent a good cross section of research up to the early 1980s.

3.2.3 Gillen (1999)

Gillen assessed how well states forecast revenues from taxes and fees levied on highway users and whether the models they employ in forecasting revenues are adequate.

Gillen distinguishes three broad forecasting approaches. A simple approach would be to develop a model that uses previous values of revenues in each category perhaps with a weighting

² RVP is a method of determining vapor pressure of gasoline and other petroleum products. It is widely used in the petroleum industry as an indicator of the volatility (vaporization characteristics) of gasoline.

³ Polynomial distributed lags (PDL) are used to reduce the effects of collinearity in distributed lag settings by imposing a particular shape on the lag coefficients. The specification of a polynomial distributed lag has three elements: the length of the lag (the number of time periods it covers), the degree of the polynomial (the highest power in the polynomial), and the constraints on the lag coefficients. A near end constraint says that the immediate effect of x on y is zero, whereas a far end constraint says that the effect of x on y dies off at the end. It is also possible to impose both constraints or no constraint at all.

structure on more recent values. This approach simply matches a function to the data and extrapolates the values to create a forecast. A second approach would utilize some econometric time series techniques, such as the Box-Jenkins or ARIMA. Univariate Box-Jenkins models are sophisticated extrapolation methods using past values to generate forecasts. When lack of information or specification errors make econometric models impractical, the Box-Jenkins model is considered a superior form of time-series forecasting. The third approach, causal forecasting, develops an econometric model that explains the underlying causes or sources of variation in the factors that effect revenues from fuel taxes and registration fees. These would utilize relevant demographic and economic variables in a set of behavioral equations to produce the forecast. It is the richest approach since once the model parameters are estimated they can be used to develop forecasts of the dependent variables.

The models used by most states to forecast travel and other variables affecting fuel tax revenues appear to be accounting identities or simple statistical relationships predicting one of the components of revenues. They are simplistic and non-behavioral. One common but disturbing feature of such models is their implicit assumption that the demands for travel, vehicles, and fuel are not responsive to changes in social, demographic and economic variables. This leads to the implication that there is no response of fuel use to changes in fuel prices, either through the number and type of vehicles owned or the amount each one is driven; in economic terms, the demand for fuel is assumed to be perfectly inelastic.

Gillen proposed a modeling approach that could serve as the basis for all states to develop forecasts. His approach consists of a system of three equations: two relationships (VMT and fleet fuel efficiency) and one accounting identity (total fuel consumption). This would provide the requisite information to forecast fuel tax and registration fee and other fee revenues. The first two equations are estimated via regression analysis, while the third equation combines the results of the first two.

The main determinants of VMT are assumed to be household income, vehicle price, fuel price, average fleet fuel efficiency, and average household size. Fleet fuel efficiency could be explained by personal income, fuel price and some vehicle technological factor to account for the continuing progress in engine design. Fuel consumption would then be obtained by dividing VMT by fleet fuel efficiency.

3.3 Summary of Findings

The following points highlight the main findings of the highway user revenue forecasting models reviewed:

- The level of disaggregation of highway user revenues varies from state to state, Caltrans' MVSTAFF model being the most disaggregated;
- Most forecasting models rely on a regression analysis of vehicle ownership and vehicle use;
- The level of modeling sophistication varies from state to state, from the simplistic (e.g., trend model) to the relatively sophisticated (e.g., multiple-time-series framework);

- The models illustrate the relative importance of the socioeconomic variables (such as population, personal income, and gross state product) and their influence on highway user revenues; and
- Vehicle fuel efficiency is either treated as an exogenous variable (HURF forecasting process) or an endogenous variable (INDOTREV).

4. REVIEW OF MODOT'S FORECASTING MODEL

This chapter provides a review of the models developed by MoDOT to forecast revenues from state taxes and fees levied on highway users. Section 4.1 presents an overview of different forecasting methods and their usage in highway revenue forecasting. The different revenue categories of interest to MoDOT are presented in Section 4.2. MoDOT's forecasting models are examined separately in Section 4.3. Additional technical information on each model is provided in Appendix A.

4.1 Overview of Forecasting Methods

Today decision makers and researchers can choose from among a wide variety of forecasting techniques, ranging from intuitive judgments to highly sophisticated statistical models. Overall, there are two distinct approaches to forecasting: a qualitative approach and a quantitative approach. Qualitative forecasting methods (such as consensus forecasting) rely on subjective information: people's intuition, experience, knowledge and value systems. Quantitative forecasting methods can be divided into explanatory (regression analysis) and non-explanatory (time series analysis) methods. In general, quantitative methods outperform qualitative methods in terms of forecasting accuracy. Therefore, this memorandum will focus on the former ones.

4.1.1 Time Series Analysis (ARIMA Models)

Time series forecasting techniques use time series (or historical) data to generate forecasts. A time series is treated as a combination of different components (including trend, seasonal pattern, level shift, outliers and random error), which can be clearly identified and separated out. Time series models typically consider only one variable (i.e., the variable to be estimated); in this case, they are called univariate.

The most popular time series models are autoregressive integrated moving average (ARIMA) models, developed by Box and Jenkins (1976). An ARIMA model is simply a weighted average of past observations. It is generally defined as an ARIMA(p,d,q) model where p , d , and q are integers greater than or equal to zero and refer to the order of the autoregressive, differencing, and moving average components of the model respectively.⁴ When an ARIMA model includes other time series as input variables, it is sometimes referred to as an ARIMAX model.

ARIMA models offer several advantages to forecasters: they require a minimum of information; the choice of weights is wide, thus allowing for the identification of more subtle patterns in the data; and they provide accurate short-term (up to one year) forecasts under normal and stable conditions. However, they also suffer from a number of drawbacks: they are complex and

⁴ In general, ARIMA modeling consists of four steps. The first step is model *identification*, in which the nature of the correlation between current and past values of the residuals is identified by means of the autocorrelation function (ACF) and partial autocorrelation function (PACF). If the time series appears non-stationary (i.e., the mean and the variance of the series are not constant over time), it must be differenced (at least once). The second step is model *estimation*, in which the orders p and q are selected and the model parameters are estimated. The third step is model *validation*, in which diagnostic statistics (e.g., Akaike information criterion and Schwarz Bayesian criterion) are examined to determine how well the model fits the data. The fourth step is *forecasting*, in which the estimated model is used to forecast future values of the time series. The accuracy of forecasts can be assessed by measuring the forecasting error (mean square error and mean absolute percentage error).

difficult to understand; they require expertise of the modeler (especially with regard to model estimation and selection); their relative forecasting ability decreases as the forecast horizon increases, or when confronted with changing or exceptional conditions; they do not provide any explanation for the movement of variables (causal analysis); and they prevent any policy scenario or “what if” analysis.

4.1.2 Regression Analysis (Multivariate Regression Models)

Explanatory or causal methods involve the determination of factors that relate to the variable to be estimated. For instance, gasoline consumption can be influenced by demographic (number of people age 16 and older), economic (personal income and unemployment rate) and technological (passenger car fuel economy) factors. The strength of the relationship between the variables is measured with historical or cross-sectional data through regression analysis. Multivariate regression analysis can be defined as a statistical technique for estimating the relationship between the dependent variable (i.e., the variable to be explained and forecast) and multiple independent or explanatory variables. It is considered the most important statistical technique in econometrics.

In the same way as ARIMA models, multivariate regression models have their own strengths and weaknesses. Multivariate regression models are more powerful than time series models, since the model parameters can be used to develop forecasts of the dependent variable. They also are superior to times series models in terms of long-term forecasting accuracy. They are easy to implement and cheap to maintain. However, multivariate regression analysis requires large amounts of data. It also requires sound theoretical knowledge and understanding of the issue at hand to prevent misspecification of the model. When using historical data, multivariate regression models tend to be plagued with autocorrelation of the residuals, which affects the reliability of the parameter estimates.

The literature review conducted by HDR|HLB shows that multivariate regression analysis is more often than not the appropriate technique to estimate and forecast highway user revenues (Varma and Sinha, 1997), though some attempts have been made to integrate econometric and time-series analysis techniques (Wolfgram, 1983). Gillen (1999) stresses the predominant influence of socioeconomic variables on fuel consumption and vehicle ownership, and suggests a modeling approach. He argues that ARIMA modeling should be used only when lack of information makes econometric modeling impractical.

4.2 MoDOT’s State Revenues

State highway user tax revenues account for about half of MoDOT’s annual revenues.⁵ They can be aggregated into three major categories:

- 1) Motor Fuel Tax: This is a tax on the sale of motor fuel (gasoline, diesel, and blends) paid by the fuel supplier and passed on to the final consumer. The state tax rate is 17 cents per gallon.⁶ MoDOT’s share is estimated at 73 percent of total receipts.

⁵ Missouri Department of Transportation, *Annual Financial Report for the Year Ended June 30, 2006*.

⁶ There are exceptions to the motor fuel tax for non-highway vehicles such as farm tractors and fuel sold to the U.S. government or agencies (*Missouri Revised Statutes*, Section 142.815).

2) Motor Vehicle Sales and Use Taxes

- *Motor Vehicle Sales Tax:* The motor vehicle sales tax is a tax on the purchase of any new or used motor vehicle or trailer in Missouri. The tax rate is 4.225 percent.⁷
- *Motor Vehicle Use Tax:* The motor vehicle use tax is a tax on vehicles purchased out of the state and titled in Missouri or a tax on the sale of a vehicle between individuals within Missouri. The tax rate is 4 percent.

3) Driver's License Fees and Motor Vehicle Fees

- *Driver's License Fees:* A driver's license fee is imposed every three years or six years on operators of motor vehicles in Missouri for the issuance of a driver's license. The fee varies from \$10 to \$22.50 for a three-year license depending on the type of license. Other driver's license fees include: commercial driver's license road/written test fee; nondriver identification card fee; instruction permit fee; organ donor contribution; processing fee for the issuance of licenses and other documents;⁸ reinstatement fee; and miscellaneous fees.
- *Motor Vehicle Fees:* A one or two-year fee is imposed for the registration of motor vehicles. The fee varies based on the gross weight of property carrying commercial vehicles, horsepower of motor vehicles other than commercial, or seating capacity for passenger-carrying commercial motor vehicles. Other motor vehicle fees include: alternative fuel decal fee; antiterrorism contribution; blindness education, screening and treatment contribution; certificate of title fee; children's trust contribution; duplicate plate fee; grade crossing safety fee; processing fee for the issuance of licenses and other documents;⁹ registration fee; World War II Memorial contribution; and miscellaneous fees.

4.3 MoDOT's Forecasting Models

MoDOT needs the most accurate revenue projections possible for budgeting (Financial Plan) and planning purposes (Statewide Transportation Improvement Program). In 2006 MoDOT developed econometric models to forecast state revenues. In all there are seven equations:

- Motor vehicle fees (net of refunds);
- Driver's license fees (net of refunds);
- Motor vehicle sales tax revenue (net of refunds) deposited to the State Road Fund;
- Motor vehicle use tax revenue (net of refunds);
- Gross gasoline tax revenue;¹⁰

⁷ Due to the passage of Constitutional Amendment 3 in November 2004, beginning in FY 2006, the portion deposited to the General Fund is transferred to the State Road Bond Fund in increments. By FY 2009, 100 percent of the proceeds deposited to the General Fund will be transferred to the State Road Bond Fund.

⁸ Processing fees were introduced in FY 2004 for state-owned branch offices.

⁹ Processing fees were introduced in FY 2004 for state-owned branch offices.

¹⁰ Revenues reflect an allowance of 0.1 percent to suppliers for losses in storage and handling.

- Gross diesel tax revenue;¹¹ and
- Total refunds for all of the above state revenues.¹²

The models were estimated in SAS/ETS[®], using the ARIMA procedure. Detailed SAS outputs are provided in Appendix A. Projections were generated for the period extending from FY 2007 to FY 2012. Monthly forecasts were developed for gasoline and diesel tax revenues. For all other variables of interest, the forecasts were developed on an annual basis.

4.3.1 Motor Vehicle Fees and Driver's License Fees

Motor vehicle fees and driver's license fees (net of refunds) were estimated separately with annual data covering the period FY 1986 to FY 2006. Because vehicle registration fees and driver's license fees increased in FY 1985, prior observations were not considered in the analysis. The original data were log transformed and first differenced to make the series stationary.¹³ The data for FY 2004, FY 2005 and FY 2006 were further adjusted by removing processing fees.

Both models comprise a constant and two dummy variables¹⁴ to account for statutory changes. Dummy variables for FY 2001 and FY 2002 were included in the motor vehicle fee equation, and dummy variables for FY 2001 and FY 2004 were included in the driver's license fee equation.

Since July 1, 2000 residents of Missouri have the option to register their motor vehicles every two years rather than every year. Owners of "even" model year vehicles have the option during even years, while owners of "odd" model year vehicles have the option during odd years. As a consequence, there was an increase in revenues in FY 2001 (fees doubled for people who opted for a two-year registration) and a decrease in revenues in FY 2002 (people who opted for a two-year registration in FY 2001 did not pay any fees the following year). In FY 2001, DOR also started shifting from three-year driver's licenses to six-year driver's licenses. Drivers who were born in an odd year were eligible in FY 2001 through FY 2003, while the remaining drivers were eligible in FY 2004 through FY 2006. As a result, there was an increase in revenues in fiscal years 2001, 2002 and 2003 (fees doubled for people who obtained a six-year driver's license). Since FY 2004 DOR has received driver's license fees from about one sixth of Missouri's drivers annually.

Figure 5 and Figure 6 below show net motor vehicle fees and net driver's license fees respectively. The graphs include historical data from FY 1986 to FY 2006 as well as fitted and projected values from FY 1986 to FY 2012. The 95 percent confidence interval (as calculated by the model) is represented by means of lower and upper limits.

¹¹ Revenues reflect an allowance of 0.1 percent to suppliers for losses in storage and handling.

¹² Motor fuel tax refunds typically account for more than 90 percent of total refunds.

¹³ A time series variable (X_t) is "first differenced" by taking the difference of adjacent time periods, where the earlier time period is subtracted from the later time period ($X_t - X_{t-1}$).

¹⁴ In time series analysis, a dummy variable is one that takes the values 0 or 1 to indicate the absence or presence of an "event" that has an impact on the dependent variable.

Figure 5: Net Motor Vehicle Fees with MoDOT's Projections (FY 1986 – FY 2012)

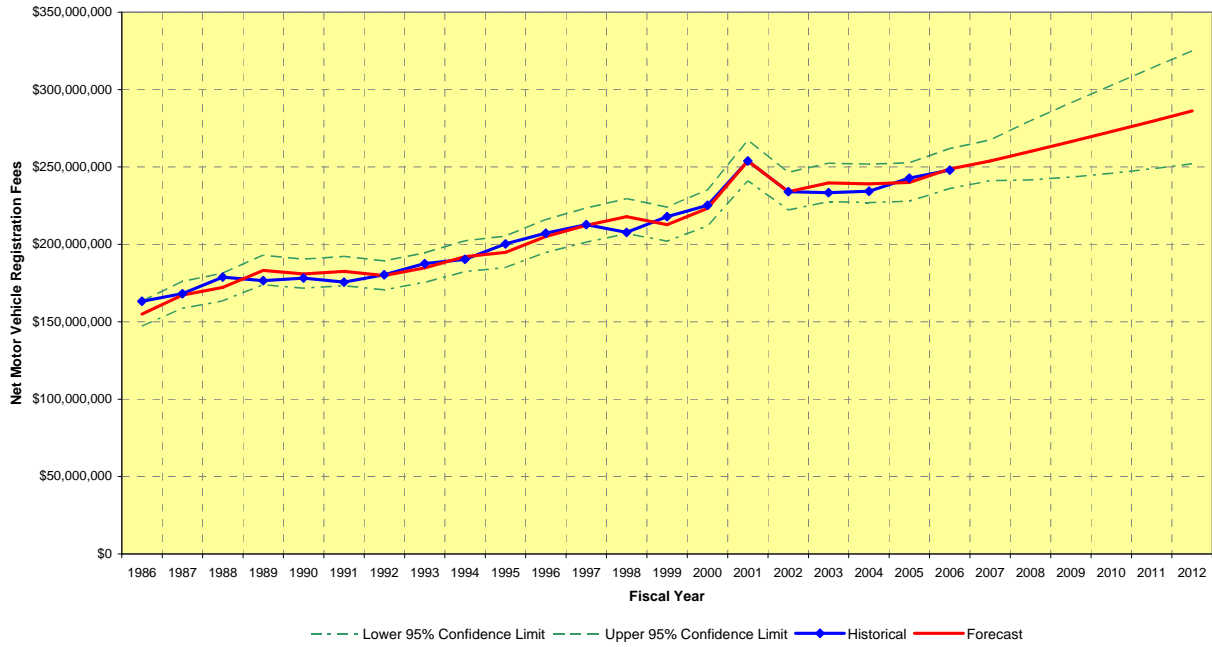
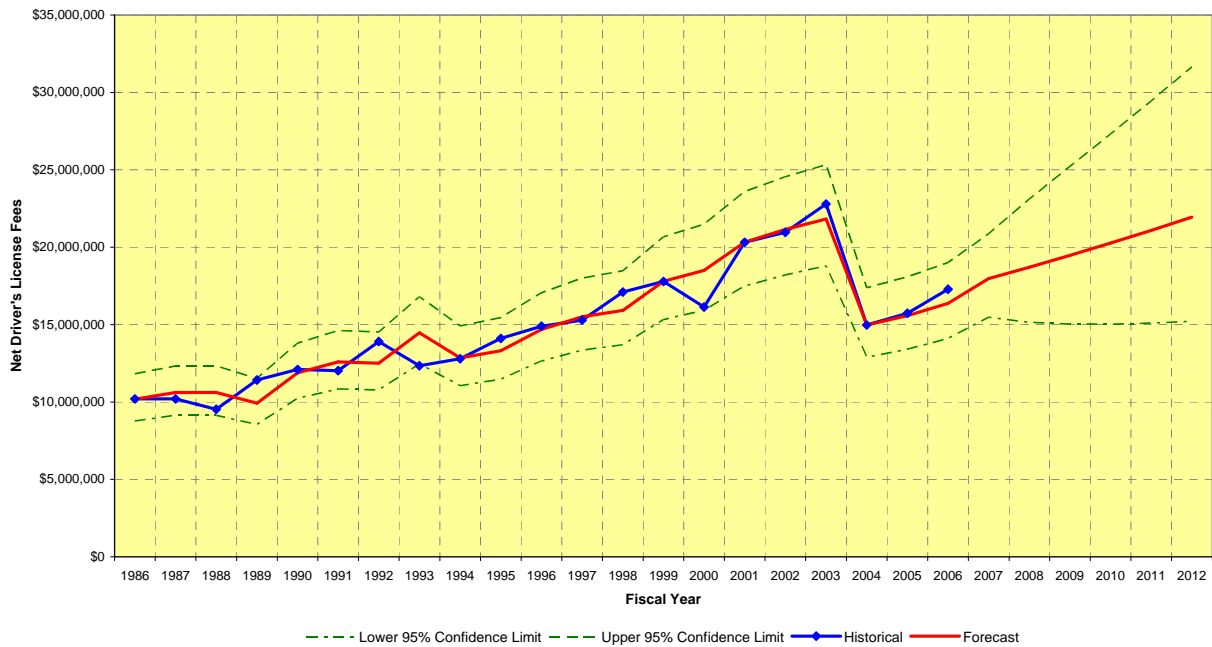


Figure 6: Net Driver's License Fees with MoDOT's Projections (FY 1986 – FY 2012)



The complete equation output and correlograms of residuals are available in Appendix A.

Findings and Recommendations

- Both models do not include autoregressive (AR) or moving average (MA) terms. Therefore, they are not ARIMA models strictly speaking.
- As shown in Figure 5, the motor vehicle fee model failed to account for the declines in revenues in fiscal years 1991 and 2003, which were due to economic slowdowns. Because of the format of the data (the data were first differenced), the fitted values account for the declines in revenues with a one year lag.
- In the same way, as shown in Figure 6, the driver's license fee model failed to account for the increase in revenues in FY 1992 (+ 15.6 percent). No explanation could be given by MoDOT staff for this one-time increase. However, it is suggested to add a dummy variable for that year.
- Though some socioeconomic variables were initially considered to explain motor vehicle revenues, some of them were disregarded in the analysis (personal income and new vehicle consumer price index) while others were not retained in the final model (employment and gasoline price).
- The correlograms for the motor vehicle fee model indicate a significant autocorrelation at lag 3 (see Table 29 on page 57).
- No socioeconomic variables were considered in the analysis of driver's license fees. Among potential determinants is population.
- In both models, the dependent variable is net of refunds. To the extent possible, it is suggested to estimate gross motor vehicle fees and driver's license fees, because they better reflect the actual demand.

4.3.2 Motor Vehicle Sales and Use Taxes

Motor vehicle sales tax revenues (net of refunds) were estimated with annual data covering the period FY 1985 to FY 2006. The original data were log-transformed and first-differenced to make the series stationary. Only vehicle sales tax revenues flowing into the State Road Fund were estimated. The FY 2006 estimate was consequently adjusted by removing Amendment 3 revenues.

The motor vehicle sales tax model consists of four explanatory variables: employment in Missouri, retail gasoline price (before taxes) for the Midwest region,¹⁵ and two dummy variables to control for statutory changes in FY 1994 and FY 2000. The model does not include a constant. Gasoline price data were deflated using the U.S. Consumer Price Index (CPI) for all urban consumers for all items less energy. This removes all inflationary movements from the nominal gasoline price variable, allowing gasoline price to be expressed in constant dollars (or 2006 dollars). Both employment and gasoline price data were log transformed and first differenced.

¹⁵ Petroleum Administration for Defense District (PADD) 2: Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio, Oklahoma, Tennessee, and Wisconsin.

The FY 1994 dummy variable accounts for a permanent increase in sales tax revenue, as a revenue diversion concerning leased vehicles was corrected. The FY 2000 dummy variable accounts for a one time change in revenue distribution that resulted in MoDOT receiving thirteen months of revenue that year.

Motor vehicle use tax revenues (net of refunds) were estimated with annual data covering the period FY 1985 to FY 2006. The original data were log transformed and first differenced to make the series stationary.

The motor vehicle use tax model includes only one explanatory variable: motor vehicle sales tax revenue. Sales tax revenue data were log transformed and first differenced. There is no constant in the model.

Figure 7 and Figure 8 below show net motor vehicle sales tax revenue and net motor vehicle use tax revenue respectively. The graphs include historical data from FY 1985 to FY 2006 as well as fitted and projected values from FY 1985 to FY 2012. The 95 percent confidence interval (as calculated by the model) is represented by means of lower and upper limits.

Figure 7: Net Motor Vehicle Sales Tax Revenue (FY 1985 – FY 2012)

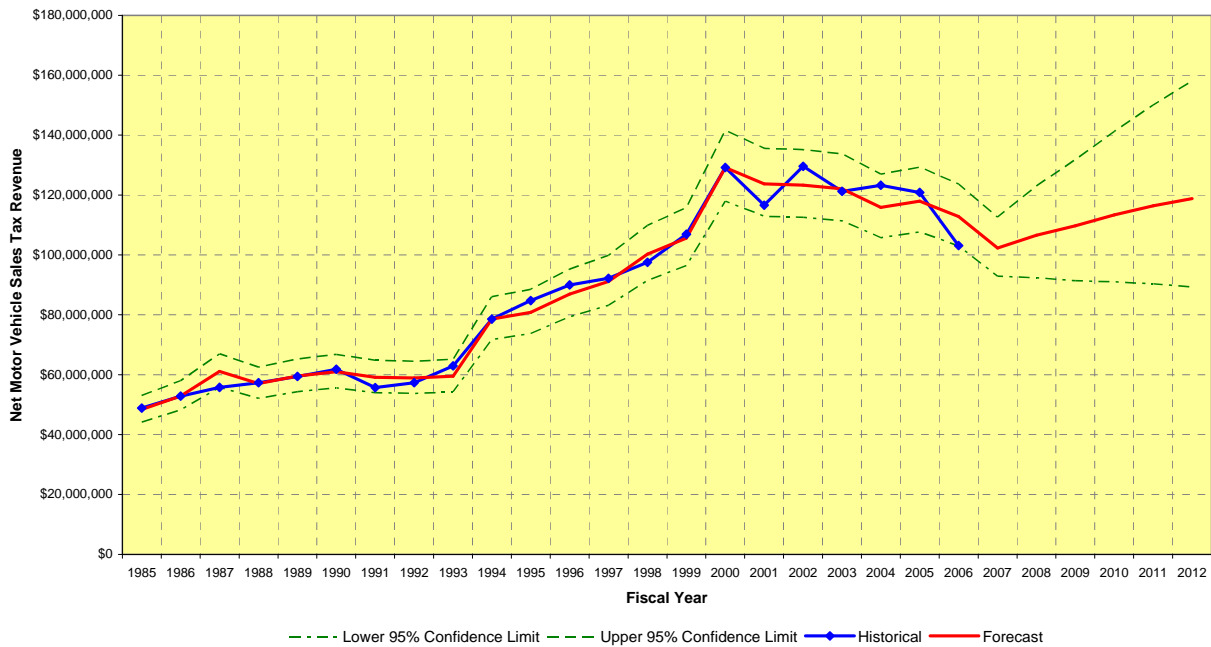
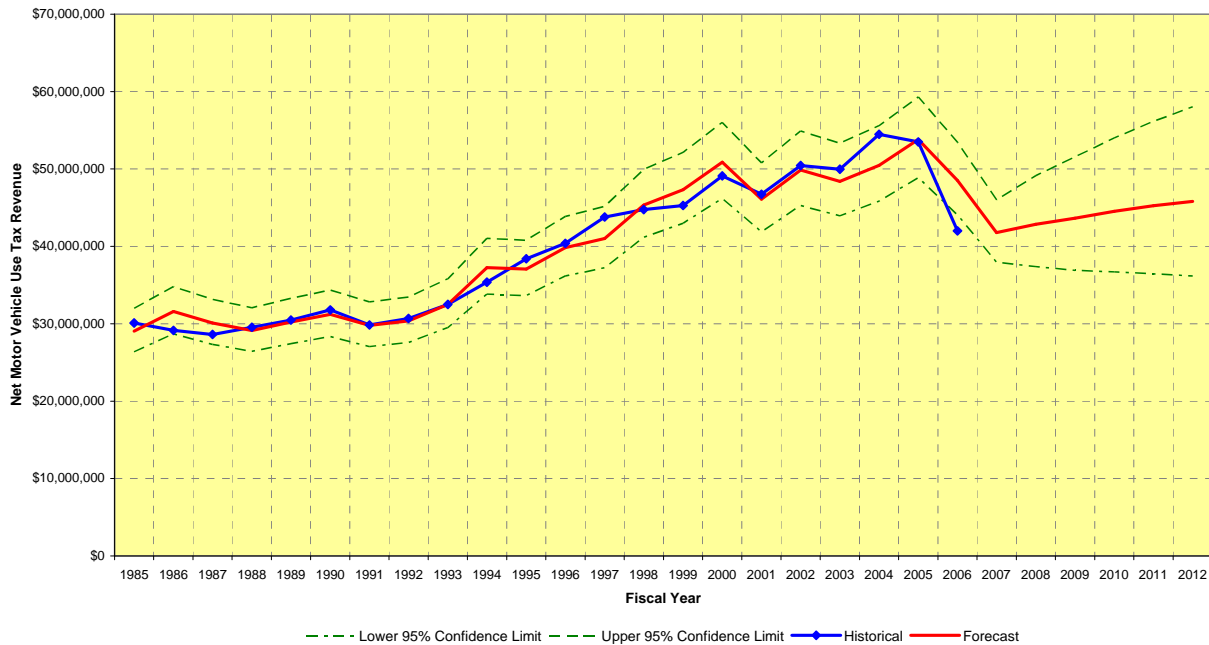


Figure 8: Net Motor Vehicle Use Tax Revenue (FY 1985 – FY 2012)



The complete equation output and correlograms of residuals are available in Appendix A.

Findings and Recommendations

- Both models do not include autoregressive (AR) or moving average (MA) terms. Therefore, they are not ARIMA models strictly speaking.
- In both models, the dependent variable is net of refunds. To the extent possible, it is suggested to estimate gross motor vehicle sales tax revenue and gross motor vehicle use tax revenue, because they better reflect the actual demand.
- The dummy variable for FY 1994, which controls for the permanent increase in motor vehicle sales tax revenue, was not constructed properly. The variable should take the value of 1 from FY 1994 onward (and not in FY 1994 solely).
- As shown in Figure 8, motor vehicle use tax revenue declined dramatically in FY 2006 (-21.5 percent). The drop was due to tax collection problems. DOR implemented a new automated collection system that was not fully operational at once. As a result, use tax receipts were not distributed to MoDOT in a timely manner.¹⁶ It is suggested to include a dummy variable for FY 2006 in the model to account for this temporary anomaly.
- The motor vehicle use tax model is very simplistic and non-behavioral. Though some socioeconomic variables (e.g., employment and personal income) were initially

¹⁶ Motor vehicle use tax receipts distributed to MoDOT in FY 2007 are also affected.

considered in the analysis, they were not retained in the final model. It is suggested to use variables describing socioeconomic conditions of neighboring states relative to Missouri.

4.3.3 Motor Fuel Tax

Gross gasoline tax revenue and gross diesel tax revenue were estimated with monthly data.¹⁷ The starting point of the sample period varies for each model (March 2000 for gasoline tax revenue and June 2003 for diesel tax revenue). All amounts are gross state receipts before distribution to MoDOT. To account for seasonality, the monthly data were log transformed and then differenced at lag 12.

The diesel tax model only consists of a first-order moving average term. The gasoline tax model consists of a constant, retail gasoline price (before taxes) for the Midwest region, and five dummy variables to control for possible accounting anomalies.¹⁸ Gasoline price data were deflated using the U.S. CPI for all urban consumers for all items less energy. Gasoline price data were further adjusted by taking the natural log.

Figure 9 and Figure 10 below show gross gasoline tax revenue and gross diesel tax revenue respectively. The graphs include historical data up to June 2006 as well as fitted and projected values up to June 2012. The 95 percent confidence interval (as calculated by the model) is represented by means of lower and upper limits.

¹⁷ Revenues are reported by DOR for the month they are collected. The actual sale of fuel takes place one month earlier and the distribution of receipts to MoDOT takes place one month later. For instance, gasoline tax receipts reported by DOR for February 2007 correspond to gasoline sales for the month of January 2007 and are distributed to MoDOT in March 2007.

¹⁸ In August 2001, August 2002, February 2003, January 2004 and February 2004.

Figure 9: Gross Gasoline State Tax Revenue (March 2001 – June 2012)

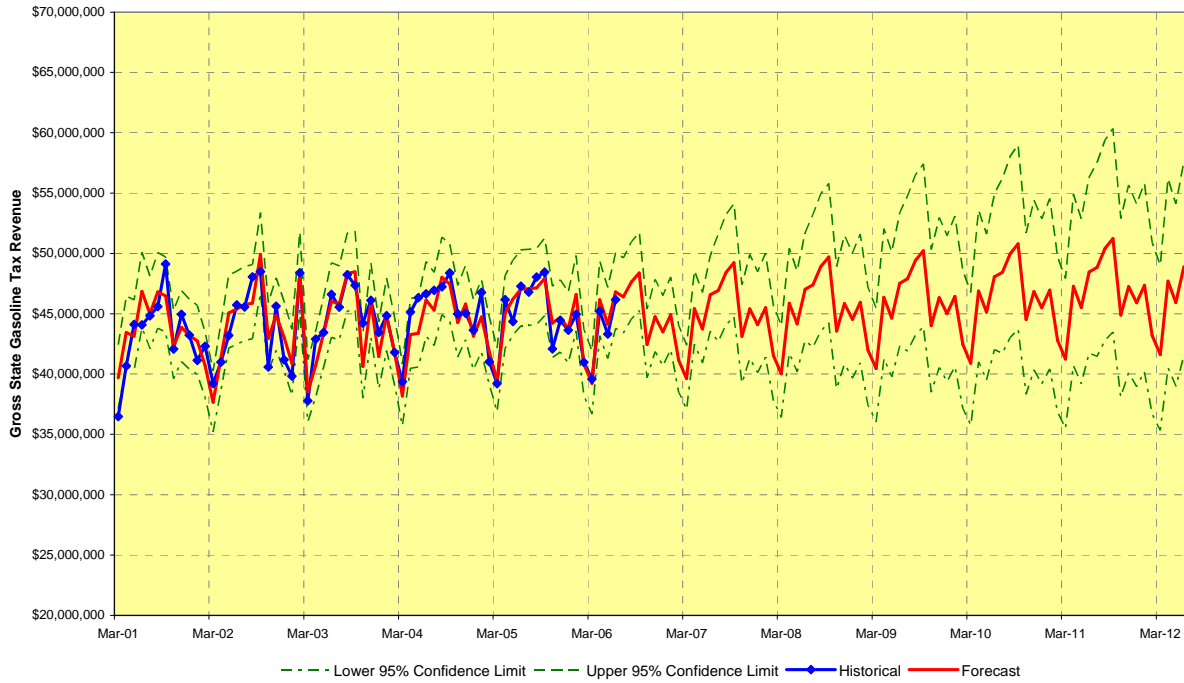
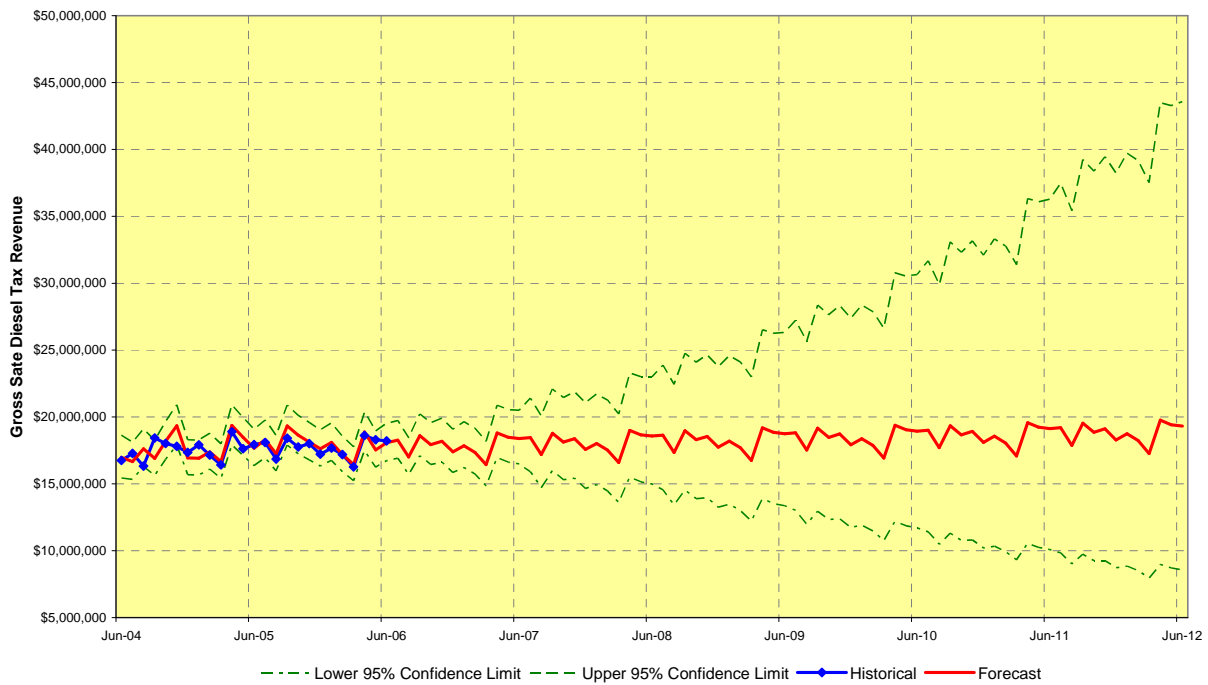


Figure 10: Gross Diesel State Tax Revenue (June 2004 – June 2012)



The complete equation output and correlograms of residuals are available in Appendix A.

Findings and Recommendations

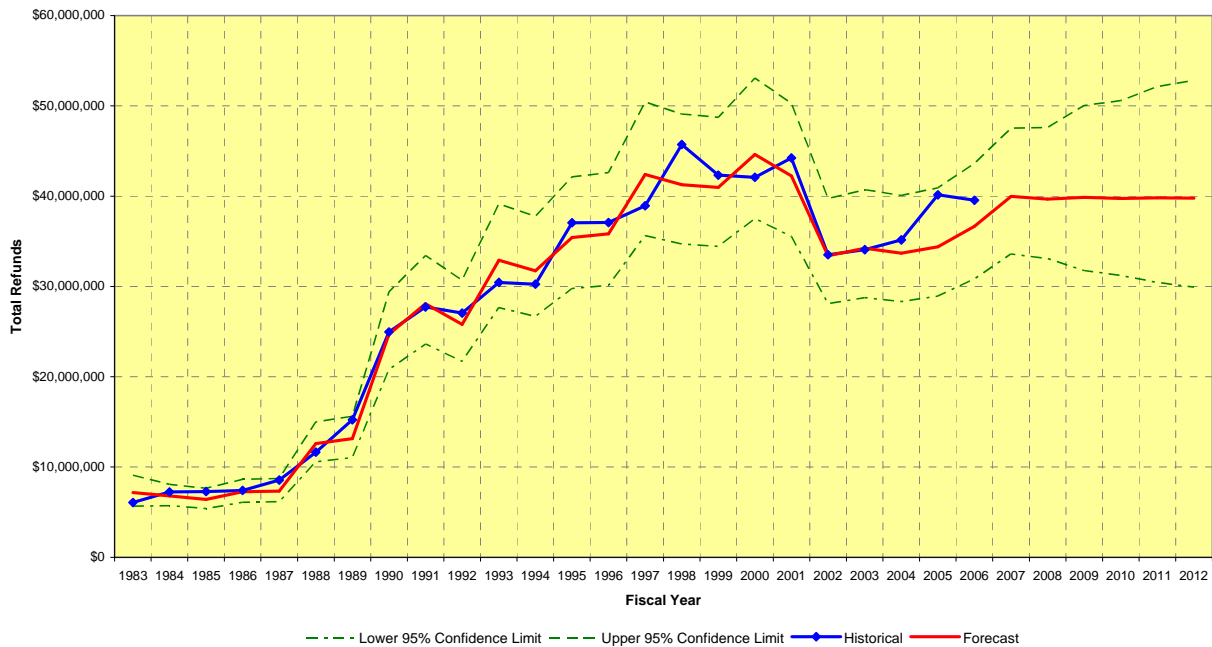
- Both models were estimated over relatively short sample periods. This could affect the accuracy of the forecasts. Typically, it is recommended that the estimation period be equal or greater than the forecasting period. As evidenced in Figure 10, there is a very high degree of uncertainty associated with the gross diesel revenue projections. The magnitude of the forecast error is very large after FY 2009.
- The gasoline tax model is not an ARIMA model in the sense that it does not contain any autoregressive or moving average terms.
- In the gasoline tax model, the dummy variables for August 2001 (dum200108) and August 2002 (dum200208) are not statistically significant at the 5 percent level (see Table 36 on page 64).
- The diesel tax model did not have as good a fit as the gasoline tax model for the same time period. Consequently it was estimated over a shorter sample period.
- The diesel tax model is non-behavioral. In other words, it does not account for potential behavioral relationships between diesel tax revenue and socioeconomic (e.g., employment and gross state product) or technological (e.g., truck fuel economy) variables.
- The use of monthly data to estimate fuel tax revenue has several drawbacks: there is some seasonality in the data (motor vehicle fuel consumption tends to peak in summer and bottom out in winter); the data may be affected by accounting/reporting anomalies; potential explanatory variables that are not available on a monthly basis (e.g., population, personal income, gross state product, fuel economy, etc.) cannot be tested in the analysis; it provides little information on the long-term trend.
- In light of the above, HDR|HLB recommends forecasting fuel tax revenue in the following way:
 - Perform a regression analysis of *annual* gasoline and diesel fuel consumption instead of monthly gasoline and diesel tax revenue. Fuel consumption data (expressed as net gallons of fuel taxed) are available from DOR back to January 1979. The analysis will thus be free of the drawbacks associated with monthly data discussed above.
 - Derive annual fuel tax revenue from fuel consumption based on the current tax rate of 17 cents per gallon and the supplier/distributor allowance of 0.1 percent.
 - Derive monthly fuel tax revenue from annual fuel tax revenue through interpolation, accounting for the seasonality observed in the historical monthly data.

4.3.4 Total Refunds

Total refunds were estimated with annual data covering the period FY 1983 to FY 2006. The model includes a first-order autoregressive term, the state fuel tax rate and two dummy variables for FY 1990 and FY 2002 to control for changes in refund legislation. There is no constant in the model. All continuous variables were log transformed.

Figure 11 below shows historical refund data from FY 1983 to FY 2006 as well as fitted and projected values from FY 1983 to FY 2012. The 95 percent confidence interval (as calculated by the model) is represented by means of lower and upper limits.

Figure 11: Total Refunds (FY 1983 – FY 2012)



The complete equation output and correlograms of residuals are available in Appendix A.

Findings and Recommendations

- Given the disparate nature of the variable to be predicted (sum of refunds for all revenue categories of interest to MoDOT), the ARIMA approach seems appropriate. As indicated earlier in Section 4.1.1, when lack of information on the determinants of the variable to be predicted makes econometric modeling impractical, ARIMA modeling is superior to regression analysis.
- It is suggested to perform a regression analysis of gross revenues (instead of net revenues) and derive refunds based on recent observations (refunds as a percentage of gross revenues), whenever possible. Alternately, if all revenue categories to be estimated are net of refunds there is no need for a refund model.

5. REGRESSION ANALYSIS

Based on the findings of the historical trend analysis, the literature review and the review of MoDOT's forecasting model, HDR|HLB has performed a multivariate regression analysis of net driver's license fees, net motor vehicle fees, net motor vehicle sales tax revenue, net motor vehicle use tax revenue, net gasoline consumption, and net diesel fuel consumption in Missouri. This chapter presents the results of the regression analysis for each of the six equations estimated.

The general approach followed by HDR|HLB is laid out in Section 5.1. Conceptual models are depicted by means of structure and logic diagrams in Section 5.2. Regression results for each model are provided in Section 5.3.

5.1 General Approach

HDR|HLB performed a multivariate regression analysis to develop a forecasting model of state highway user revenues in Missouri. Multivariate regression analysis relates the dependent variable (i.e., the variable to be explained and forecast) to a set of independent or explanatory variables. The present analysis used socioeconomic data on Missouri (e.g., population and personal income) or the region (e.g., gross state product) to determine quantitatively which factors – as well as the extent to which changes in these factors – affect each of the six variables to be estimated.

HDR|HLB's approach to developing an econometric model consists of the following steps:

1. Select the appropriate dependent variable (e.g., net gasoline consumption);
2. Identify all key explanatory variables (e.g., regional gross state product) based on the findings of the literature review and the review of MoDOT's state revenue forecasting model;
3. Estimate the equation with the appropriate regression technique (ordinary least squares, two-stage least squares, etc.) and functional form (linear, double-log or semi-log);
4. Select a model that performs best, based on the regression statistics (i.e., R-squared, t-statistics and F-statistic); and
5. Assess the model accuracy.

5.2 Conceptual Models

Figure 12 through Figure 17 on the following pages depict structure and logic diagrams (flowcharts) for estimating the various dependent variables. Each structure and logic diagram shows how the selected explanatory variables (e.g., population in Missouri) are combined together to arrive at tax revenue/refund forecasts (e.g., net driver's license fees).

The equations developed by HDR|HLB were reviewed by a panel of experts during the risk analysis session held on May 3rd, 2007. Two equations were re-specified and re-estimated based on the findings of the risk analysis session:

- The net motor vehicle sales tax revenue equation was estimated with the following explanatory variables: nominal personal income in Missouri, nominal gasoline price in Missouri, dummy variable for FY 1994 – FY 2006, and dummy variable for FY 2001; and,
- The net motor vehicle use tax revenue equation was estimated with the following explanatory variables: nominal per capita personal income in the region, and dummy variable for FY 2006.

In addition, the net diesel fuel consumption equation was re-estimated with updated diesel fuel consumption data for FY 2006. A first-order autoregressive term was also added to correct for possible serial correlation in the error terms.

Detailed responses to a number of key comments made by panel experts on technical aspects of the modeling process are available in Appendix D.

Figure 12: Structure and Logic Diagram for Estimating Net Driver’s License Fees

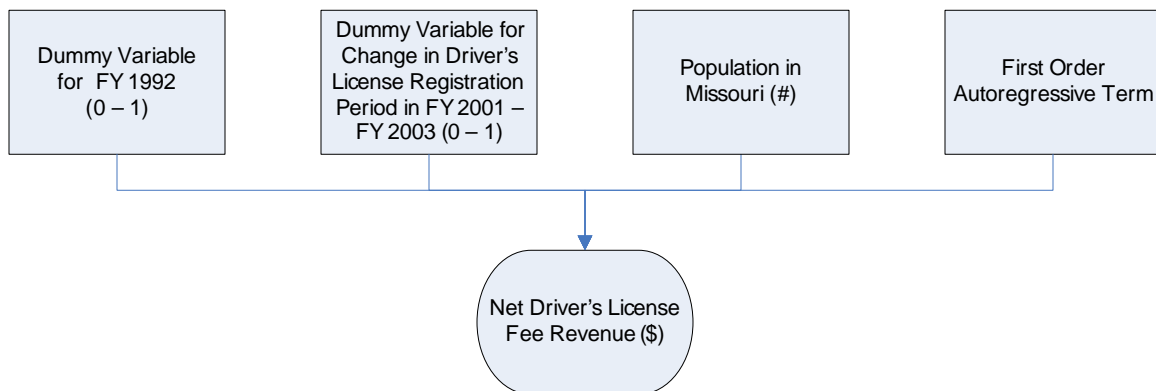


Figure 13: Structure and Logic Diagram for Estimating Net Motor Vehicle Fees

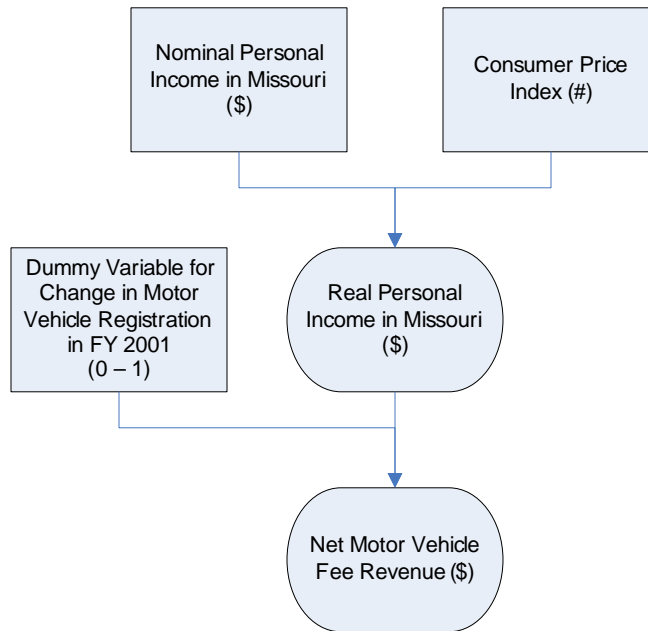


Figure 14: Structure and Logic Diagram for Estimating Net Motor Vehicle Sales Tax Revenue

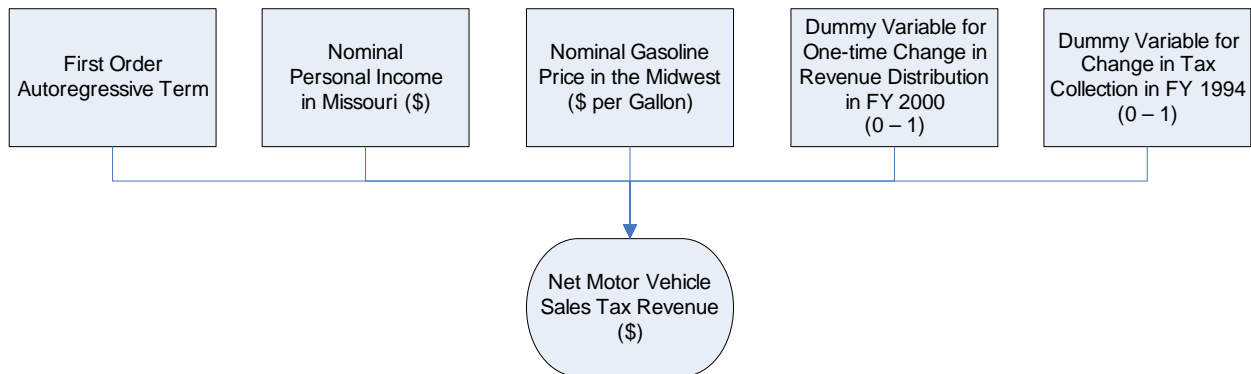


Figure 15: Structure and Logic Diagram for Estimating Net Motor Vehicle Use Tax Revenue

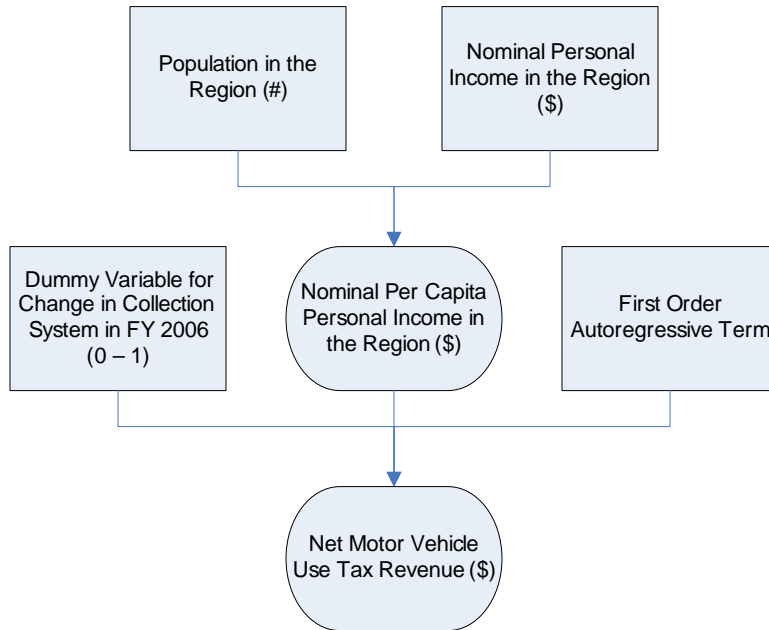


Figure 16: Structure and Logic Diagram for Estimating Net Gasoline Consumption

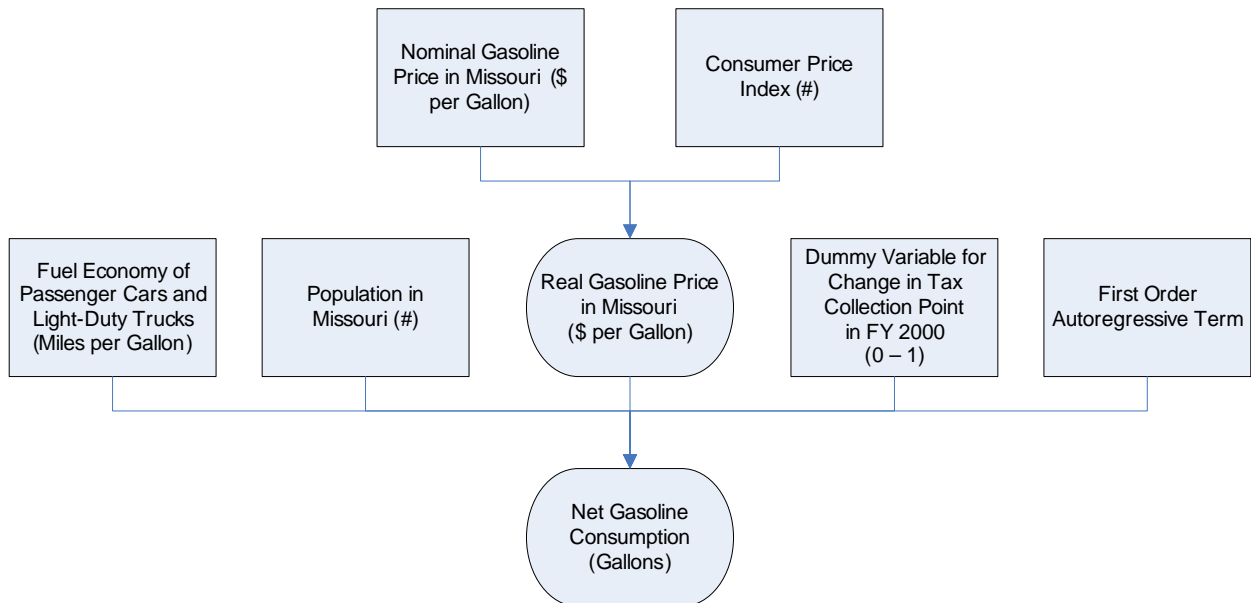
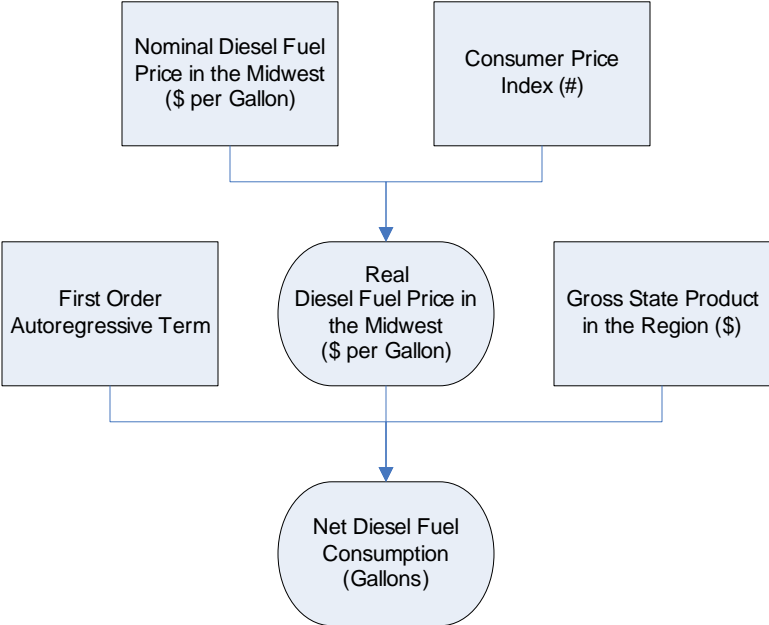


Figure 17: Structure and Logic Diagram for Estimating Net Diesel Consumption



5.3 Regression Results

All six equations were estimated in E-Views (a statistical software package) with historical fiscal year data using the ordinary least squares method. A double-log functional form (or constant elasticity model) was preferred to other functional forms because it was found to better fit the data. In a double-log model the dependent variable *and* the explanatory variables, are expressed in the log form. As a consequence, the regression coefficients can be directly interpreted as *elasticity* estimates – i.e., they indicate the percentage change in the dependent variable brought about by a one-percent change in the associated explanatory variable, other things being equal.

Table 4 through Table 9 below show the regression outputs for all six equations. Results of the augmented Dickey-Fuller unit root tests on residuals, and correlograms of residuals are also available in Appendix B and Appendix C respectively.

Table 4: Regression Output of Net Driver's License Fee Equation

Dependent Variable: Log(Net Driver's License Fees)
 Method: Least Squares
 Sample (adjusted): 1987 2006
 Included observations: 20 after adjustments
 Convergence achieved after 8 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-38.75728	14.50086	-2.672757	0.0174
Log(Population in Missouri)	3.115553	0.934608	3.333538	0.0045
FY 2001-03 Dummy Variable	0.312123	0.059049	5.285794	0.0001
FY 1992 Dummy Variable	0.132338	0.063806	2.074061	0.0557
First-Order Autoregressive Term	0.604097	0.206510	2.925269	0.0104
R-squared	0.921361	Mean dependent var		9.595164
Adjusted R-squared	0.900391	S.D. dependent var		0.234198
S.E. of regression	0.073915	Akaike info criterion		-2.159487
Sum squared resid	0.081951	Schwarz criterion		-1.910554
Log likelihood	26.59487	F-statistic		43.93641
Durbin-Watson stat	1.746351	Prob(F-statistic)		0.000000
Inverted AR Roots	0.60			

Table 5: Regression Output of Net Motor Vehicle Fee Equation

Dependent Variable: Log(Net Motor Vehicle Fees)
 Method: Least Squares
 Sample: 1986 2006
 Included observations: 21

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	5.241319	0.235477	22.25832	0.0000
Log(Real Personal Income in Missouri)	1.043081	0.035225	29.61234	0.0000
FY 2001 Dummy Variable	0.099260	0.020214	4.910558	0.0001
R-squared	0.982562	Mean dependent var		12.22418
Adjusted R-squared	0.980624	S.D. dependent var		0.138238
S.E. of regression	0.019242	Akaike info criterion		-4.931855
Sum squared resid	0.006665	Schwarz criterion		-4.782638
Log likelihood	54.78448	F-statistic		507.1086
Durbin-Watson stat	1.401120	Prob(F-statistic)		0.000000

Table 6: Regression Output of Net Motor Vehicle Sales Tax Revenue Equation

Dependent Variable: Log(Net Motor Vehicle Sales Tax Revenue)

Method: Least Squares

Sample (adjusted): 1986 2006

Included observations: 21 after adjustments

Convergence achieved after 30 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Log(Personal Income in Missouri)	0.962342	0.004740	203.0179	0.0000
Log(Gasoline Price in Midwest)	-0.363974	0.095310	-3.818838	0.0015
FY 1994-FY 2006 Dummy Variable	0.206791	0.057078	3.622939	0.0023
FY 2000 Dummy Variable	0.161944	0.045330	3.572552	0.0025
First-Order Autoregressive Term	0.672558	0.190618	3.528308	0.0028
R-squared	0.978802	Mean dependent var		11.33929
Adjusted R-squared	0.973502	S.D. dependent var		0.329914
S.E. of regression	0.053704	Akaike info criterion		-2.806418
Sum squared resid	0.046145	Schwarz criterion		-2.557722
Log likelihood	34.46738	F-statistic		
Durbin-Watson stat	1.687102	Prob(F-statistic)		
Inverted AR Roots	0.67			

Table 7: Regression Output of Net Motor Vehicle Use Tax Revenue Equation

Dependent Variable: Log(Net Motor Vehicle Use Tax Revenue)

Method: Least Squares

Sample (adjusted): 1986 2006

Included observations: 21 after adjustments

Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Log(Per Capita Personal Income in Region)	1.050354	0.002648	396.7192	0.0000
FY 2006 Dummy Variable	-0.302025	0.041959	-7.198125	0.0000
First-Order Autoregressive Term	0.627689	0.109020	5.757577	0.0000
R-squared	0.971578	Mean dependent var		10.5686
Adjusted R-squared	0.968420	S.D. dependent var		0.22570
S.E. of regression	0.040109	Akaike info criterion		-3.46288
Sum squared resid	0.028957	Schwarz criterion		-3.31366
Log likelihood	39.36021	F-statistic		
Durbin-Watson stat	2.473132	Prob(F-statistic)		
Inverted AR Roots	0.63			

Table 8: Regression Output of Net Gasoline Consumption Equation

Dependent Variable: Log(Net Gasoline Consumption)
 Method: Least Squares
 Sample (adjusted): 1972 2006
 Included observations: 35 after adjustments
 Convergence achieved after 8 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-12.10031	4.183582	-2.892331	0.0072
Log(Real Gasoline Price in Missouri)	-0.151575	0.032775	-4.624712	0.0001
Log(Fuel Economy of PC & LDT)	-0.495597	0.141508	-3.502243	0.0015
Log(Population in Missouri)	2.230448	0.288234	7.738318	0.0000
FY 2000 Dummy Variable	0.044540	0.014064	3.167001	0.0036
First-Order Autoregressive Term	0.701408	0.119198	5.884390	0.0000
R-squared	0.970846	Mean dependent var		21.71256
Adjusted R-squared	0.965819	S.D. dependent var		0.091716
S.E. of regression	0.016957	Akaike info criterion		-5.161509
Sum squared resid	0.008338	Schwarz criterion		-4.894878
Log likelihood	96.32641	F-statistic		193.1402
Durbin-Watson stat	1.506203	Prob(F-statistic)		0.000000
Inverted AR Roots	0.70			

Table 9: Regression Output of Net Diesel Fuel Consumption Equation

Dependent Variable: Log(Net Diesel Fuel Consumption)
 Method: Least Squares
 Sample (adjusted): 1972 2006
 Included observations: 35 after adjustments
 Convergence achieved after 33 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	9.832367	0.363794	27.02729	0.0000
Log(Real Diesel Fuel Price in Midwest)	-0.121792	0.047203	-2.580193	0.0148
Log(Gross State Product in Region)	0.743377	0.017946	41.42337	0.0000
First-Order Autoregressive Term	0.329197	0.182198	1.806806	0.0805
R-squared	0.992438	Mean dependent var		20.08733
Adjusted R-squared	0.991706	S.D. dependent var		0.459896
S.E. of regression	0.041882	Akaike info criterion		-3.400688
Sum squared resid	0.054378	Schwarz criterion		-3.222934
Log likelihood	63.51204	F-statistic		1356.174
Durbin-Watson stat	1.759288	Prob(F-statistic)		0.000000
Inverted AR Roots	0.33			

6. FORECASTING ASSUMPTIONS

This chapter summarizes the assumptions used in HDR|HLB's model to forecast state highway user revenues from FY 2007 to FY 2012. Forecasting assumptions for each explanatory variable identified in the regression analysis are presented within a risk analysis framework to account for the uncertainty inherent in the forecasting process: each variable is assigned a central or median estimate and a range (i.e., a probability distribution) representing an 80 percent confidence interval.¹⁹

The median estimates are based on recent projections published by independent sources at the state or national level.²⁰ The lower and upper 10 percent estimates are derived from an historical analysis of statistical uncertainty (as measured by the standard deviation) in the explanatory variables. All projections and ranges originally developed by HDR|HLB were subjected to a rigorous review by an independent panel of experts, and augmented accordingly to reflect the experts' views.

HDR|HLB revised the original forecasting assumptions for some model variables based on the inputs provided by the experts during the risk analysis workshop. The following adjustments were made:

- *Annual Growth in Gasoline Price in Missouri*: Estimates for FY 2011 and FY 2012 were revised upward; ranges were widened for all fiscal years;
- *Annual Growth in Consumer Price Index in the Midwest*: The FY 2007 estimate was slightly revised upward (based on latest CPI data released by the Bureau of Labor Statistics);
- *Annual Population Growth in Missouri*: Estimates were revised upward for the entire forecasting period; population is increasing at a slower decreasing rate;
- *Annual Population Growth in the Region*: Estimates were revised upward for the entire forecasting period; population is increasing at a slower decreasing rate;
- *Annual Growth in Personal Income in Missouri*: Estimates for FY 2008 through FY 2012 were revised downward; personal income is increasing at a constant rate from FY 2009 to FY 2012;
- *Annual Growth in Personal Income in the Region*: Estimates for FY 2008 through FY 2012 were revised downward; personal income is increasing at a constant rate from FY 2009 to FY 2012.

The forecasting assumptions are presented in Table 10 through Table 18 below.

¹⁹ For more information, read the Risk Analysis Primer in Appendix E.

²⁰ See Appendix H for a complete list of data sources.

Table 10: Annual Growth in Gasoline Price in Missouri (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	1.0%	-4.0%	6.0%
2008	0.0%	-14.6%	14.6%
2009	-3.5%	-19.3%	12.3%
2010	-3.2%	-20.2%	13.8%
2011	2.0%	-16.2%	20.2%
2012	2.0%	-17.4%	21.4%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

Table 11: Annual Growth in Diesel Fuel Price in the Midwest (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	3.5%	-2.5%	9.5%
2008	-4.1%	-18.4%	10.2%
2009	-4.7%	-19.0%	9.6%
2010	-1.8%	-16.1%	12.5%
2011	-1.6%	-15.9%	12.7%
2012	-2.2%	-16.5%	12.1%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

Table 12: Annual Growth in Consumer Price Index in the Midwest (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	2.1%	1.7%	2.5%
2008	2.3%	1.3%	3.3%
2009	2.2%	1.2%	3.2%
2010	2.2%	1.2%	3.2%
2011	2.2%	1.2%	3.2%
2012	2.2%	1.2%	3.2%

Table 13: Annual Growth in Motor Vehicle Fuel Economy (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	0.50%	-0.60%	1.60%
2008	0.50%	-0.82%	1.82%
2009	0.50%	-1.04%	2.04%
2010	0.50%	-1.26%	2.26%
2011	0.50%	-1.48%	2.48%
2012	0.50%	-1.70%	2.70%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

Table 14: Annual Population Growth in Missouri (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	0.76%	0.56%	0.99%
2008	0.75%	0.55%	0.98%
2009	0.74%	0.54%	0.97%
2010	0.73%	0.53%	0.96%
2011	0.72%	0.52%	0.95%
2012	0.71%	0.51%	0.94%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

Table 15: Annual Population Growth in the Region (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	0.60%	0.39%	0.81%
2008	0.58%	0.37%	0.79%
2009	0.56%	0.35%	0.77%
2010	0.54%	0.33%	0.75%
2011	0.52%	0.31%	0.73%
2012	0.50%	0.29%	0.71%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

Table 16: Annual Growth in Personal Income in Missouri (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	4.8%	3.5%	6.1%
2008	4.9%	3.2%	6.6%
2009	5.0%	2.7%	7.3%
2010	5.0%	2.6%	7.4%
2011	5.0%	2.5%	7.5%
2012	5.0%	2.4%	7.6%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

Table 17: Annual Growth in Personal Income in the Region (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	4.9%	3.6%	6.2%
2008	5.0%	3.4%	6.6%
2009	5.2%	3.4%	7.0%
2010	5.2%	3.1%	7.3%
2011	5.2%	2.9%	7.5%
2012	5.2%	2.6%	7.8%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

Table 18: Annual Growth in Gross State Product in the Region (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit ^(a)	Upper 10% Limit ^(a)
2007	4.5%	3.4%	5.6%
2008	5.3%	4.0%	6.6%
2009	5.5%	3.7%	7.3%
2010	5.4%	3.6%	7.2%
2011	5.1%	3.3%	6.9%
2012	5.0%	3.2%	6.8%

Note: (a) Indicates the upper and lower limits of an 80% confidence interval.

7. REVENUE PROJECTIONS

This chapter presents the state highway user revenue projections (distributed to MoDOT) for FY 2007 through FY 2012. The results are presented within a risk analysis framework. HDR|HLB generated the revenue forecasts based on the assumptions laid out in Chapter 6, and the regression coefficients presented in Chapter 5. Annual projections are presented in graphic and tabular forms in Section 7.1. Monthly projections for net gasoline tax revenue and net diesel fuel tax revenue from July 2007 to June 2012 are included in Section 7.2. A comparison of HDR|HLB's median projections with MoDOT's projections is presented in Section 7.3.

7.1 Annual Revenue Projections

Figure 18 through Figure 23 on the next pages show annual projections for driver's license fees (including processing fees), motor vehicle fees (including processing fees), motor vehicle sales tax revenue, motor vehicle use tax revenue, gasoline tax revenue (distributed to MoDOT) and diesel fuel tax revenue (distributed to MoDOT). All revenue projections are net of refunds; therefore total refund projections are not shown. The charts also include historical data up to FY 2006. Revenue forecasts are depicted at three different probability levels: 10 percent, 50 percent (the median), and 90 percent. Those values were calculated through simulations in @RISK (a risk analysis software), using the Latin hypercube sampling method.

Note that detailed annual projections at all three probability levels are reported in Table 19 through Table 24.

Several key points are noteworthy:

- The decline in net motor vehicle fees in FY 2007 is due to a change in the tax collection procedure process. Since June 2006 trucking companies have been allowed to pay registration fees throughout the year as opposed to December only. As a result, MoDOT received more fees in June 2006 (and FY 2006) than usual.
- The large increases in net vehicle sales tax revenue from FY 2007 to FY 2009 are due to the implementation of Amendment 3. Starting in FY 2006, the State Road Bond Fund (SRBF) receives 25 percent increments of 1.5 percent of taxable sales until FY2009.
- Net motor vehicle use tax revenue declined dramatically in FY 2006 (-21.5 percent). The drop was due to tax collection problems. The Missouri Department of Revenue implemented a new automated collection system that was not fully operational at once. As a result, use tax receipts were not distributed to MoDOT in a timely manner. Motor vehicle use tax receipts distributed to MoDOT in FY 2007 are also affected.
- For gasoline and diesel fuel revenue projections, it was assumed that the tax rate (\$0.17 per gallon) and the MoDOT's share of state revenues (about 73 percent) would remain the same throughout the forecasting period.

Figure 18: Net Driver's License Fees (FY 1985 – FY 2012)

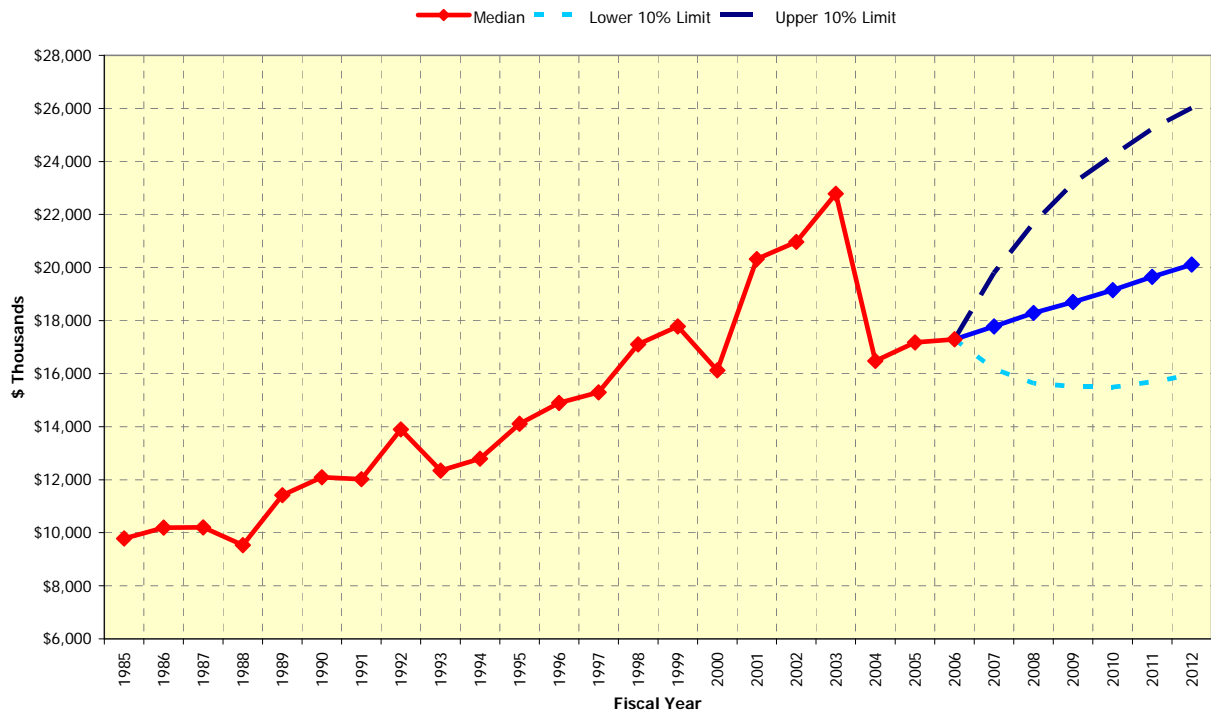


Figure 19: Net Motor Vehicle Fees (FY 1985 – FY 2012)

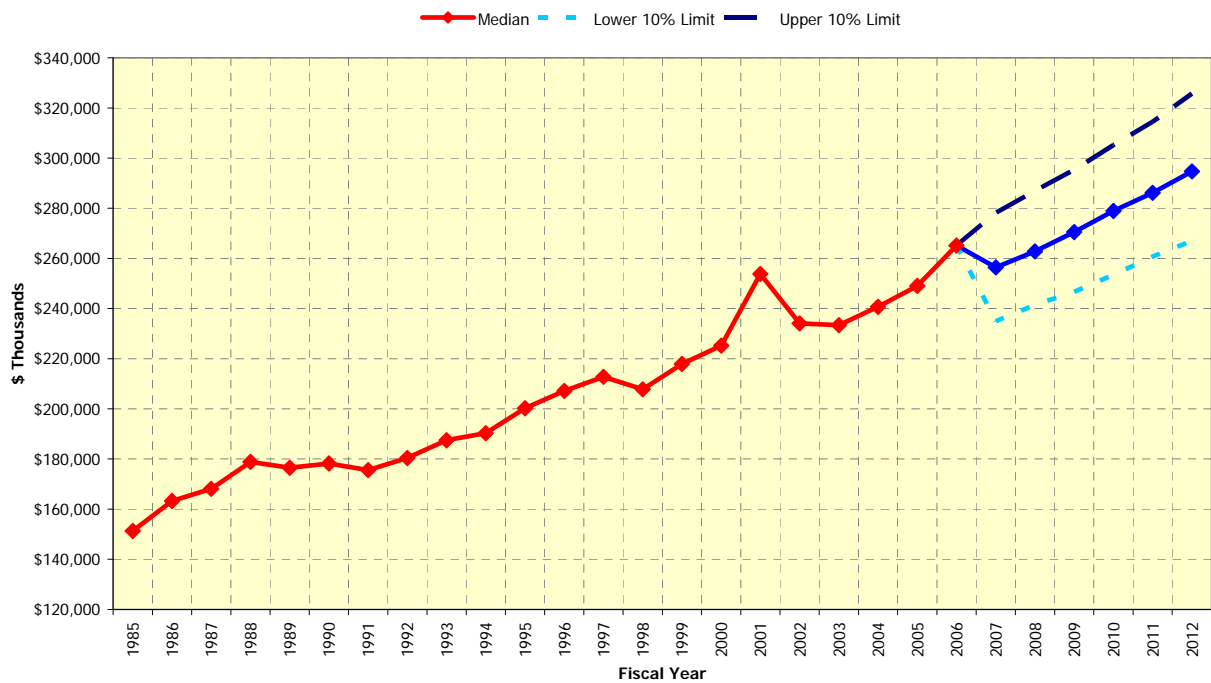


Figure 20: Net Motor Vehicle Sales Tax Revenue (FY 1984 – FY 2012)

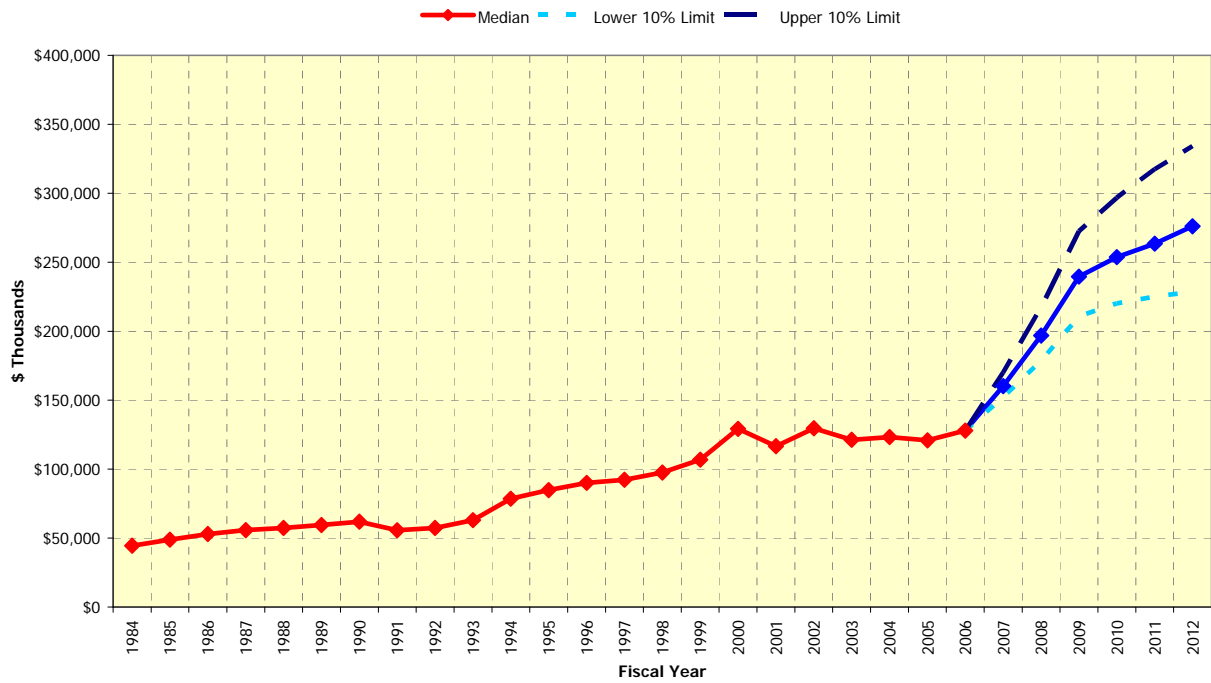


Figure 21: Net Motor Vehicle Use Tax Revenue (FY 1984 – FY 2012)

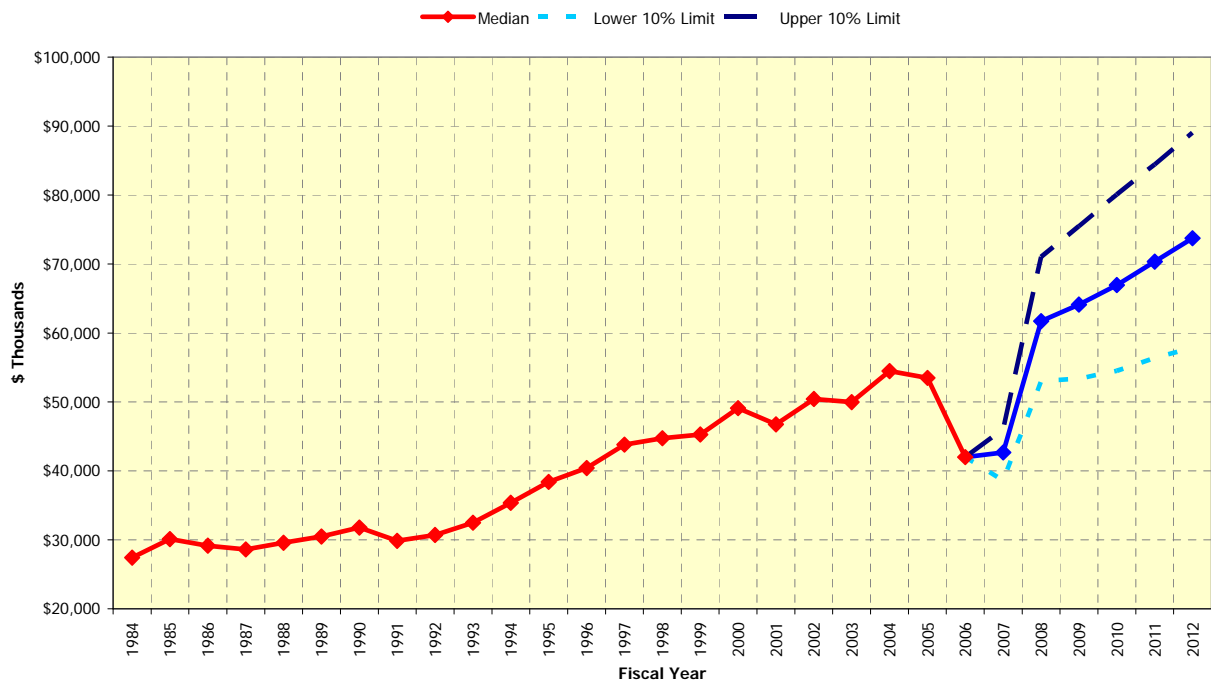


Figure 22: Net Gasoline Tax Revenue (FY 2001 – FY 2012)

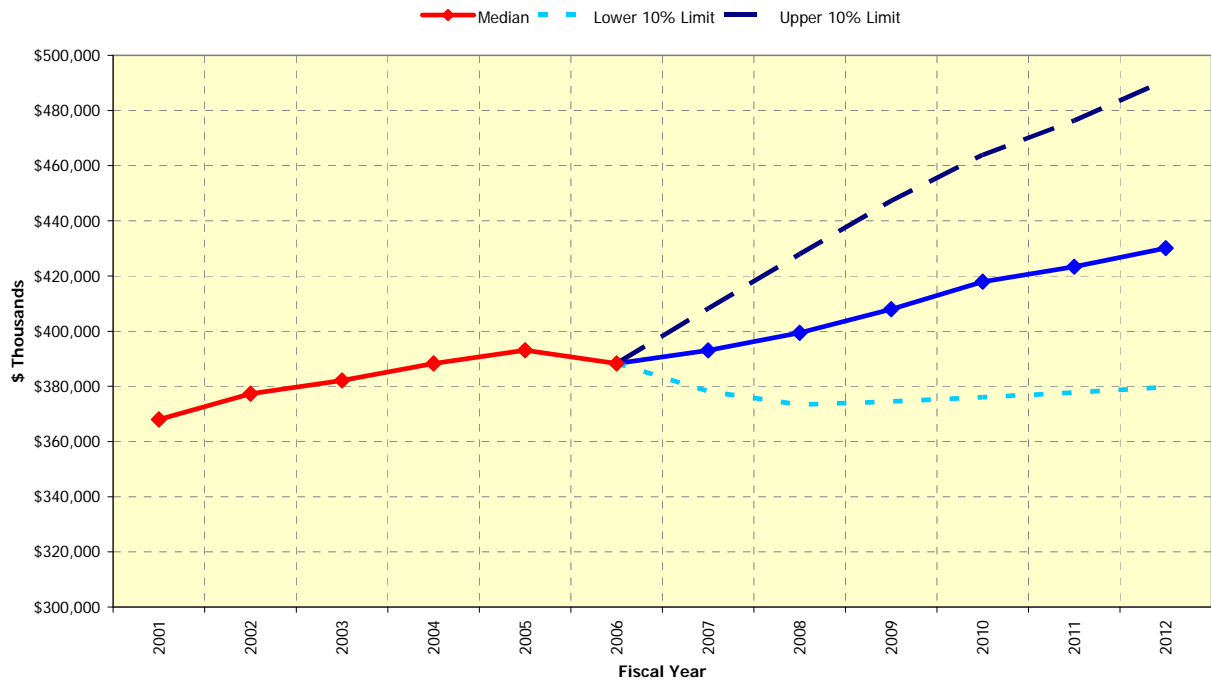


Figure 23: Net Diesel Fuel Tax Revenue (FY 2001 – FY 2012)

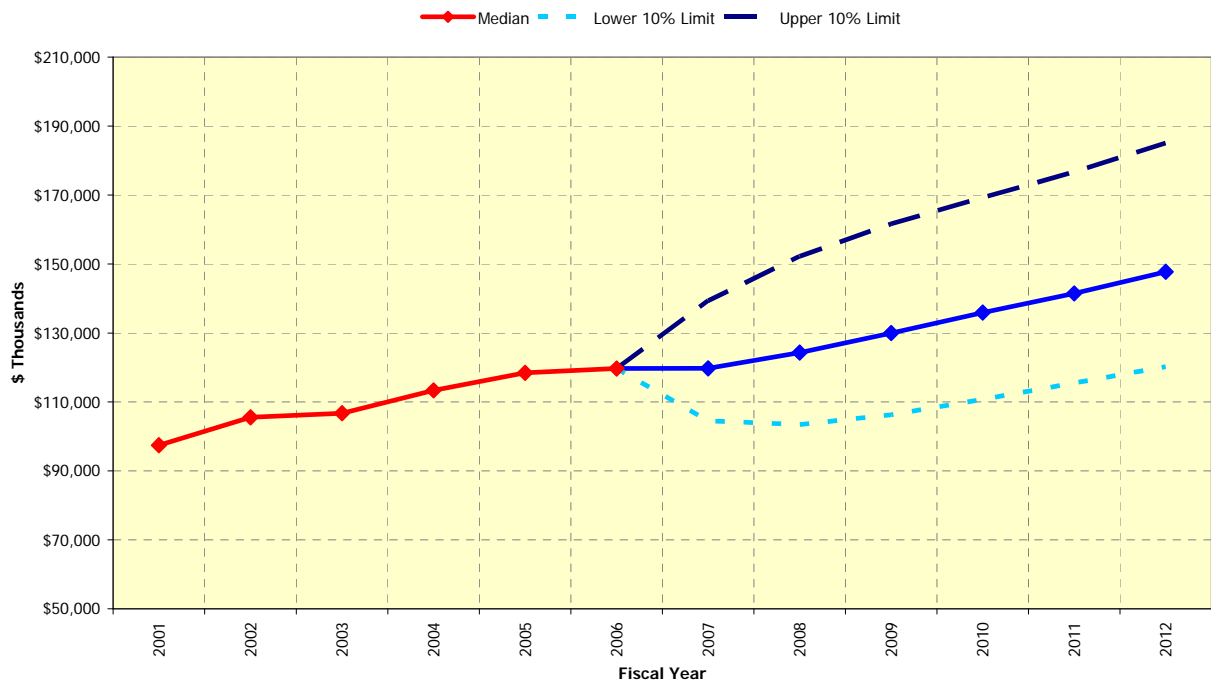


Table 19: Net Driver's License Fee Projections (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit	Upper 10% Limit
2007	\$17,778	\$16,174	\$19,792
2008	\$18,288	\$15,637	\$21,673
2009	\$18,703	\$15,516	\$23,180
2010	\$19,150	\$15,493	\$24,222
2011	\$19,650	\$15,687	\$25,230
2012	\$20,115	\$15,950	\$26,017

Note: All amounts are in thousands of dollars.

Table 20: Net Motor Vehicle Fee Projections (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit	Upper 10% Limit
2007	\$256,408	\$234,979	\$278,232
2008	\$262,822	\$241,427	\$286,876
2009	\$270,511	\$246,684	\$295,318
2010	\$278,929	\$253,431	\$305,238
2011	\$286,126	\$260,697	\$314,485
2012	\$294,683	\$266,997	\$325,723

Note: All amounts are in thousands of dollars.

Table 21: Net Motor Vehicle Sales Tax Revenue Projections (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit	Upper 10% Limit
2007	\$160,142	\$152,182	\$170,059
2008	\$196,801	\$178,567	\$217,273
2009	\$239,607	\$210,714	\$272,470
2010	\$253,641	\$220,215	\$296,686
2011	\$263,411	\$225,117	\$317,528
2012	\$276,016	\$228,585	\$334,223

Note: All amounts are in thousands of dollars.

Table 22: Net Motor Vehicle Use Tax Revenue Projections (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit	Upper 10% Limit
2007	\$42,665	\$38,603	\$46,062
2008	\$61,723	\$53,051	\$71,012
2009	\$64,127	\$53,357	\$75,477
2010	\$66,943	\$54,499	\$80,083
2011	\$70,348	\$56,368	\$84,424
2012	\$73,750	\$57,846	\$89,034

Note: All amounts are in thousands of dollars.

Table 23: Net Gasoline Tax Revenue Projections (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit	Upper 10% Limit
2007	\$393,044	\$378,188	\$408,182
2008	\$399,425	\$373,373	\$427,941
2009	\$407,941	\$374,516	\$447,199
2010	\$417,945	\$376,037	\$463,939
2011	\$423,348	\$377,761	\$476,346
2012	\$430,093	\$379,729	\$490,971

Note: All amounts are in thousands of dollars.

Table 24: Net Diesel Fuel Tax Revenue Projections (FY 2007 – FY 2012)

Fiscal Year	Median	Lower 10% Limit	Upper 10% Limit
2007	\$119,722	\$104,521	\$139,352
2008	\$124,305	\$103,417	\$152,230
2009	\$129,950	\$106,264	\$161,589
2010	\$135,914	\$110,736	\$169,257
2011	\$141,434	\$115,456	\$176,638
2012	\$147,753	\$120,243	\$185,013

Note: All amounts are in thousands of dollars.

7.2 Monthly Fuel Tax Revenue Projections

Table 25 and Table 26 below show net fuel tax revenue projections (gasoline and diesel fuel separately) from July 2007 to June 2012. Monthly projections were derived from annual projections by interpolation with a seasonal adjustment based on historical patterns. Note that the following estimates are for the month they are collected and reported by the Missouri Department of Revenue (i.e., one month after the actual sale and one month before the distribution to MoDOT).

Table 25: Net Gasoline Tax Revenue Projections, Median Estimates (July 2007 – June 2012)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
July	\$34,486	\$35,222	\$36,085	\$36,552	\$37,134
August	\$35,105	\$35,854	\$36,733	\$37,208	\$37,801
September	\$36,377	\$37,153	\$38,064	\$38,556	\$39,170
October	\$32,327	\$33,016	\$33,826	\$34,263	\$34,809
November	\$34,012	\$34,737	\$35,589	\$36,049	\$36,624
December	\$32,399	\$33,089	\$33,901	\$34,339	\$34,886
January	\$32,574	\$33,268	\$34,084	\$34,525	\$35,075
February	\$31,953	\$32,634	\$33,434	\$33,866	\$34,406
March	\$29,001	\$29,619	\$30,346	\$30,738	\$31,228
April	\$32,852	\$33,553	\$34,375	\$34,820	\$35,375
May	\$33,322	\$34,033	\$34,867	\$35,318	\$35,881
June	\$35,016	\$35,763	\$36,640	\$37,114	\$37,705

Note: All amounts are in thousands of dollars.

Table 26: Net Diesel Fuel Tax Revenue Projections, Median Estimates (July 2007 – June 2012)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
July	\$10,246	\$10,711	\$11,202	\$11,657	\$12,178
August	\$10,124	\$10,583	\$11,069	\$11,519	\$12,033
September	\$10,188	\$10,651	\$11,139	\$11,592	\$12,110
October	\$10,439	\$10,913	\$11,414	\$11,878	\$12,409
November	\$11,579	\$12,105	\$12,661	\$13,175	\$13,763
December	\$10,075	\$10,533	\$11,016	\$11,463	\$11,976
January	\$9,742	\$10,185	\$10,652	\$11,085	\$11,580
February	\$10,690	\$11,175	\$11,688	\$12,163	\$12,706
March	\$8,874	\$9,277	\$9,703	\$10,097	\$10,548
April	\$11,108	\$11,613	\$12,146	\$12,639	\$13,204
May	\$10,773	\$11,262	\$11,779	\$12,258	\$12,805
June	\$10,467	\$10,942	\$11,444	\$11,909	\$12,441

Note: All amounts are in thousands of dollars.

7.3 Comparison of Revenue Projections

Table 27 below compares HDR|HLB's annual median projections (level and percentage change) with the revenue forecasts developed by MoDOT in 2006. HDR|HLB's estimates for FY 2007 are somewhat similar to MoDOT's. Over the long term, however, HDR|HLB's revenue projections are higher than MoDOT's, with the exception of net driver's license fees. The most striking difference in the two sets of projections is for net motor vehicle use tax revenue: HDR|HLB's estimates are significantly higher than MoDOT's because it was assumed that the tax collection problems experienced by DOR over the last two fiscal years would not affect revenues after FY 2007. In other words, a level shift is highly expected for this revenue category in FY 2008.

Table 27: Comparison of HDR|HLB's Median Projections with MoDOT's Projections (FY 2007 – FY 2012)

		FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	
Net Driver's License Fees	MoDOT	\$17,995 4.1%	\$18,727 4.1%	\$19,489 4.1%	\$20,282 4.1%	\$21,107 4.1%	\$21,966 4.1%	
	HDR HLB	\$17,778 2.8%	\$18,288 2.9%	\$18,703 2.3%	\$19,150 2.4%	\$19,650 2.6%	\$20,115 2.4%	
Net Motor Vehicle Fees	MoDOT	\$256,201 -3.4%	\$262,412 2.4%	\$268,775 2.4%	\$275,291 2.4%	\$281,966 2.4%	\$288,803 2.4%	
	HDR HLB	\$256,408 -3.3%	\$262,822 2.5%	\$270,511 2.9%	\$278,929 3.1%	\$286,126 2.6%	\$294,683 3.0%	
Net Motor Vehicle Sales Tax Revenue	MoDOT	SRF	\$100,891	\$105,158	\$108,244	\$111,846	\$114,858	\$117,235
		Amend. 3	\$51,827	\$81,029	\$111,210	\$114,911	\$118,005	\$120,447
Total		\$152,718 19.5%	\$186,187 21.9%	\$219,454 17.9%	\$226,757 3.3%	\$232,863 2.7%	\$237,682 2.1%	
HDR HLB		\$160,142 25.3%	\$196,801 22.9%	\$239,607 21.8%	\$253,641 5.9%	\$263,411 3.9%	\$276,016 4.8%	
Net Motor Vehicle Use Tax Revenue	MoDOT	\$41,776 -0.5%	\$42,853 2.6%	\$43,621 1.8%	\$44,508 2.0%	\$45,240 1.6%	\$45,813 1.3%	
	HDR HLB	\$42,665 1.6%	\$61,723 44.7%	\$64,127 3.9%	\$66,943 4.4%	\$70,348 5.1%	\$73,750 4.8%	
Net Fuel Tax Revenue	MoDOT	\$512,470 N/A	\$514,633 0.4%	\$520,029 1.0%	\$526,024 1.2%	\$531,799 1.1%	\$536,999 1.0%	
	HDR HLB	\$512,766 0.9%	\$523,730 2.1%	\$537,891 2.7%	\$553,859 3.0%	\$564,781 2.0%	\$577,846 2.3%	

Notes: (a) All amounts are in thousands of dollars.

(b) Net Fuel Tax Revenue is the sum of Net Gasoline Tax Revenue and Net Diesel Fuel Tax Revenue and does not include Miscellaneous Fees. Therefore, HDR|HLB's estimate for Net Fuel Tax Revenue is the sum of the median values and not the median strictly speaking.

APPENDIX A: MODOT SAS OUTPUTS

This appendix provides the complete equation output and correlograms of residuals for each equation estimated in SAS by MoDOT.

Motor Vehicle Fee Model

Table 28 below presents the SAS output for the motor vehicle fee model. The original data were log transformed and first differenced. The table shows that: all model parameters (constant and dummy variables) have significant t values (p-value of less than 0.05) and are not correlated (correlation coefficient of less than 0.5 in absolute value); the model fits well the data (the standard error of the model is only 0.026); as evidenced by the χ^2 statistics, the no-autocorrelation hypothesis cannot be rejected (p-value is 0.5689 for the first six lags), suggesting that the residuals are uncorrelated.

Table 28: Motor Vehicle Fee Model – Equation Output

The ARIMA Procedure									
Maximum Likelihood Estimation									
Parameter	Estimate	Standard Error	t Value	Approx Pr > t	Lag	Variable	Shift		
MU	0.02396	0.0060716	3.95	<.0001	0	lmv_fees	0		
NUM1	0.09554	0.02715	3.52	0.0004	0	dum2001	0		
NUM2	-0.10481	0.02715	-3.86	0.0001	0	dum2002	0		
				Constant Estimate	0.023956				
				Variance Estimate	0.0007				
				Std Error Estimate	0.026466				
				AIC	-90.1818				
				SBC	-87.0482				
				Number of Residuals	21				
Correlations of Parameter Estimates									
		Variable							
		Parameter	lmv_fees MU	dum2001 NUM1	dum2002 NUM2				
		lmv_fees	MU	1.000	-0.224	-0.224			
		dum2001	NUM1	-0.224	1.000	0.050			
		dum2002	NUM2	-0.224	0.050	1.000			
Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	-----Autocorrelations-----					
6	4.81	6	0.5689	-0.058	0.101	-0.351	-0.149	-0.131	-0.008
12	9.40	12	0.6686	0.193	-0.078	0.194	-0.174	-0.011	-0.067
18	15.44	18	0.6317	0.195	0.103	-0.025	-0.103	-0.076	-0.088

The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the first-differenced, log-transformed data are presented in Table 29 on the next page. The plots indicate a significant autocorrelation at lag 3.

Table 29: Motor Vehicle Fee Model – Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

Name of Variable = lmv_fees																								
Period(s) of Differencing										1														
Mean of Working Series										0.023515														
Standard Deviation										0.039471														
Number of Observations										21														
Observation(s) eliminated by differencing										1														
Autocorrelations																								
Lag	Covariance	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1	Std Error
0	0.0015579	1.00000	*****										0											
1	-0.0003379	-.21687	. ****										0.218218											
2	0.00010083	0.06472	. *										0.228251											
3	-0.0006991	-.44875	*****										0.229123											
4	0.00023016	0.14773	. ***										0.267724											
5	-0.0000594	-.03810	. *										0.271578											
Inverse Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	0.25076	. *****																						
2	0.17148	. ***																						
3	0.37485	. *****																						
4	0.04850	. *																						
5	0.02263	. .																						
Partial Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	-0.21687	. ****																						
2	0.01856	. .																						
3	-0.45237	*****																						
4	-0.04895	. *																						
5	-0.02898	. *																						

Driver’s License Fee Model

Table 30 below presents the SAS output for the driver’s license fee model. The original data were log transformed and first differenced. The table shows that: all model parameters (constant and dummy variables) have significant *t* values (p-value of less than 0.05) and are not correlated (correlation coefficient of less than 0.5 in absolute value); the model fits well the data (the standard error of the model is only 0.076); as evidenced by the χ^2 statistics, the no-autocorrelation hypothesis cannot be rejected (p-value is 0.2020 for the first six lags), suggesting that the residuals are uncorrelated.

Table 30: Driver's License Fee Model – Equation Output

Maximum Likelihood Estimation									
Parameter	Estimate	Standard Error	t Value	Approx Pr > t	Lag	Variable	Shift		
MU	0.03988	0.01749	2.28	0.0226	0	ldl_fees	0		
NUM1	0.19116	0.07821	2.44	0.0145	0	dum2001	0		
NUM2	-0.45998	0.07821	-5.88	<.0001	0	dum2004	0		
Constant Estimate				0.039884					
Variance Estimate				0.005811					
Std Error Estimate				0.076229					
AIC				-45.75					
SBC				-42.6165					
Number of Residuals				21					
Correlations of Parameter Estimates									
Variable Parameter	ldl_fees MU	dum2001 NUM1	dum2004 NUM2						
ldl_fees MU	1.000	-0.224	-0.224						
dum2001 NUM1	-0.224	1.000	0.050						
dum2004 NUM2	-0.224	0.050	1.000						
Autocorrelation Check of Residuals									
Lag	Square	DF	To ChiSq	Chi-	Pr >	-----Autocorrelations-----			
6	8.53	6	0.2020	-0.293	-0.217	0.220	-0.329	-0.060	0.155
12	13.47	12	0.3361	0.138	-0.120	0.173	-0.156	-0.134	0.106
18	15.77	18	0.6085	-0.024	0.115	-0.063	0.006	0.063	-0.059

The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the first-differenced, log-transformed data are presented in Table 31 on the next page. The plots show no evidence of autocorrelation, inverse autocorrelation or partial autocorrelation of the residuals (white noise).

Table 31: Driver's License Fee Model – Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

Name of Variable = ldl_fees																								
Period(s) of Differencing		1																						
Mean of Working Series		0.027083																						
Standard Deviation		0.128968																						
Number of Observations		21																						
Observation(s) eliminated by differencing		1																						
Autocorrelations																								
Lag	Covariance	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1	Std Error
0	0.016633	1.00000	*****																				0	
1	-0.0041558	-.24986	.*****																				0.218218	
2	-0.0018807	-.11307	.****																				0.231440	
3	-0.0022928	-.13785	.***																				0.234056	
4	0.0013570	0.08159	.****																				0.237891	
5	0.00035679	0.02145	.****																				0.239219	
Inverse Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	0.43711	*****																						
2	0.32268	.*****																						
3	0.24226	.*****																						
4	0.07163	.****																						
5	0.03029	.****																						
Partial Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	-0.24986	.*****																						
2	-0.18719	.****																						
3	-0.24113	.*****																						
4	-0.06457	.****																						
5	-0.03919	.****																						

Motor Vehicle Sales Tax Model

Table 32 below presents the SAS output for the motor vehicle sales tax model. The original data were log transformed and first differenced. The table shows that: all model parameters (employment, gasoline price and dummy variables) have significant *t* values (p-value of less than 0.05) and are not correlated (correlation coefficient of less than 0.5 in absolute value); the model fits well the data (the standard error of the model is only 0.046); as evidenced by the χ^2 statistics, the no-autocorrelation hypothesis cannot be rejected (p-value is 0.8467 for the first six lags), suggesting that the residuals are uncorrelated.

Table 32: Motor Vehicle Sales Tax Model – Equation Output

Maximum Likelihood Estimation									
Parameter	Estimate	Standard Error	t Value	Pr > t	Lag	Variable	Shift		
NUM1	0.13418	0.04973	2.70	0.0070	0	dum1994	0		
NUM2	0.29249	0.05520	5.30	<.0001	0	dum2000	0		
NUM3	1.51618	0.53490	2.83	0.0046	0	lemployment	0		
NUM4	-0.30527	0.06523	-4.68	<.0001	0	lgasoline_price	0		
Variance Estimate				0.002176					
Std Error Estimate				0.046644					
AIC				-68.8507					
SBC				-64.4866					
Number of Residuals				22					
Correlations of Parameter Estimates									
Variable Parameter		dum1994 NUM1	dum2000 NUM2	lemployment NUM3	lgasoline_price NUM4				
dum1994	NUM1	1.000	-0.020	-0.296	0.131				
dum2000	NUM2	-0.020	1.000	-0.228	-0.514				
lemployment	NUM3	-0.296	-0.228	1.000	0.158				
lgasoline_price	NUM4	0.131	-0.514	0.158	1.000				
Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	-----Autocorrelations-----					
6	2.69	6	0.8467	-0.104	-0.120	-0.014	-0.133	0.114	-0.183
12	3.72	12	0.9880	0.063	-0.093	0.106	-0.024	-0.040	-0.002
18	12.59	18	0.8151	-0.259	0.194	0.029	-0.022	-0.127	-0.070

The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the first-differenced, log-transformed data are presented in Table 33 on the next page. The plots show no evidence of autocorrelation, inverse autocorrelation or partial autocorrelation of the residuals (white noise).

Table 33: Motor Vehicle Sales Tax Model – Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

Name of Variable = lsales_revenue																								
Period(s) of Differencing		1																						
Mean of Working Series		0.038293																						
Standard Deviation		0.087484																						
Number of Observations		22																						
Observation(s) eliminated by differencing		1																						
Autocorrelations																								
Lag	Covariance	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1	Std Error
0	0.0076535	1.00000	*****											0										
1	0.00031972	0.04178	.											0.213201										
2	0.0011520	0.15053	.											0.213572										
3	-0.0010159	-.13274	. ***											0.218341										
4	-0.0004866	-.06358	. *											0.221979										
5	0.00084316	0.11017	. **											0.222806										
Inverse Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	-0.07268	. *											.											
2	-0.22210	. ****											.											
3	0.17972	. ****											.											
4	0.08529	. **											.											
5	-0.15256	. ***											.											
Partial Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	0.04178	. *											.											
2	0.14904	. ***											.											
3	-0.14785	. ***											.											
4	-0.07645	. **											.											
5	0.16851	. ***											.											

Motor Vehicle Use Tax Model

Table 34 below presents the SAS output for the motor vehicle use tax model. The original data were log transformed and first differenced. The table shows that: the model parameter (motor vehicle sales tax revenue) has a significant *t* value (p-value of less than 0.05); the model fits well the data (the standard error of the model is only 0.049); as evidenced by the χ^2 statistics, the no-autocorrelation hypothesis cannot be rejected (p-value is 0.4188 for the first six lags), suggesting that the residuals are uncorrelated.

Table 34: Motor Vehicle Use Tax Model – Equation Output

Maximum Likelihood Estimation									
Parameter	Estimate	Standard Error	t Value	Pr > t	Lag	Variable	Shift		
NUM1	0.61437	0.10997	5.59	<.0001	0	lsales_revenue	0		
Variance Estimate				0.002426					
Std Error Estimate				0.049256					
AIC				-69.0619					
SBC				-67.9708					
Number of Residuals				22					
Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	-----Autocorrelations-----					
6	6.04	6	0.4188	0.089	-0.301	-0.253	-0.164	-0.051	0.155
12	20.22	12	0.0631	0.313	0.110	-0.270	-0.205	-0.184	0.269
18	26.16	18	0.0962	0.114	0.019	-0.041	-0.071	-0.144	-0.135

The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the first-differenced, log-transformed data are presented in Table 35 on the next page. The plots show no evidence of autocorrelation, inverse autocorrelation or partial autocorrelation of the residuals (white noise).

Table 35: Motor Vehicle Use Tax Model – Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

Name of Variable = luse_revenue																								
Period(s) of Differencing		1																						
Mean of Working Series		0.019397																						
Standard Deviation		0.073362																						
Number of Observations		22																						
Observation(s) eliminated by differencing		1																						
Autocorrelations																								
Lag	Covariance	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1	Std Error
0	0.0053819	1.00000	*****											0										
1	0.00006790	0.01262	.											0.213201										
2	-0.0002470	-.04589	. *											0.213235										
3	0.00008535	0.01586	. .											0.213683										
4	-0.0003781	-.07026	. *											0.213737										
5	0.0011886	0.22085	. ****											0.214784										
Inverse Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	-0.05140	. *											.											
2	0.06163	. *											.											
3	-0.04137	. *											.											
4	0.07877	. **											.											
5	-0.21308	. ****											.											
Partial Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	0.01262	.											.											
2	-0.04606	. *											.											
3	0.01708	.											.											
4	-0.07300	. *											.											
5	0.22625	. *****											.											

Gasoline Tax Model

Table 36 below presents the SAS output for the gasoline tax model. The original data were log transformed and then differenced at lag 12 to account for seasonality in the data. The table shows that: the model parameters have significant *t* values (p-value of less than 0.05), except for two dummy variables (dum200108 and dum200208); the model parameters are not correlated (correlation coefficient of less than 0.5 in absolute value); the model fits well the data (the standard error of the model is only 0.034); as evidenced by the χ^2 statistics, the no-autocorrelation hypothesis cannot be rejected (p-value is 0.6151 for the first six lags), suggesting that the residuals are uncorrelated.

Table 36: Gasoline Tax Model – Equation Output

Maximum Likelihood Estimation									
Parameter	Estimate	Standard Error	t Value	Approx Pr > t	Lag	Variable	Shift		
MU	0.0096867	0.0047963	2.02	0.0434	0	lgasoline	0		
NUM1	-0.05499	0.01910	-2.88	0.0040	0	lprice	0		
NUM2	-0.02684	0.03485	-0.77	0.4411	0	dum200108	0		
NUM3	0.04614	0.03431	1.34	0.1787	0	dum200208	0		
NUM4	0.14547	0.03472	4.19	<.0001	0	dum200302	0		
NUM5	0.11255	0.03431	3.28	0.0010	0	dum200401	0		
NUM6	-0.15162	0.03431	-4.42	<.0001	0	dum200402	0		
Constant Estimate				0.009687					
Variance Estimate				0.001157					
Std Error Estimate				0.034021					
AIC				-244.53					
SBC				-229.418					
Number of Residuals				64					
Correlations of Parameter Estimates									
Variable	Parameter	lgasoline MU	lprice NUM1	dum200108 NUM2	dum200208 NUM3	dum200302 NUM4	dum200401 NUM5	dum200402 NUM6	
lgasoline	MU	1.000	-0.384	-0.185	-0.127	-0.059	-0.126	-0.121	
lprice	NUM1	-0.384	1.000	0.175	0.020	-0.153	0.017	0.005	
dum200108	NUM2	-0.185	0.175	1.000	0.020	-0.011	0.019	0.017	
dum200208	NUM3	-0.127	0.020	0.020	1.000	0.013	0.017	0.017	
dum200302	NUM4	-0.059	-0.153	-0.011	0.013	1.000	0.014	0.016	
dum200401	NUM5	-0.126	0.017	0.019	0.017	0.014	1.000	0.017	
dum200402	NUM6	-0.121	0.005	0.017	0.017	0.016	0.017	1.000	
Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	-----Autocorrelations-----					
6	4.46	6	0.6151	0.056	0.125	0.152	0.060	0.103	0.089
12	9.10	12	0.6940	0.073	-0.014	0.047	-0.119	0.040	-0.187
18	12.10	18	0.8421	0.017	0.062	-0.037	-0.054	-0.154	0.037
24	18.99	24	0.7526	-0.083	0.048	0.027	-0.074	-0.014	-0.226
30	25.16	30	0.7175	-0.045	0.029	-0.029	-0.079	0.096	-0.178
36	30.72	36	0.7176	-0.024	-0.046	-0.099	0.095	-0.123	-0.053

The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the differenced (at lag 12), log-transformed data are presented in Table 37 on the next page. The plots show no evidence of autocorrelation, inverse autocorrelation or partial autocorrelation of the residuals (white noise).

Table 37: Gasoline Tax Model – Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

		Name of Variable = lgasoline			
		Period(s) of Differencing		12	
		Mean of Working Series		0.006452	
		Standard Deviation		0.045161	
		Number of Observations		64	
		Observation(s) eliminated by differencing		12	

Lag	Covariance	Correlation	Autocorrelations																	Std Error					
			-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6		7	8	9	1	
0	0.0020395	1.00000																							0
1	-0.0003221	-0.15791																							0.125000
2	0.00006074	0.02978																							0.128079
3	0.00031857	0.15620																							0.128187
4	-0.0001036	-0.05078																							0.131128
5	0.00010866	0.05328																							0.131434
6	0.00030089	0.14753																							0.131771
7	-0.0001325	-0.06496																							0.134328
8	0.00012787	0.06270																							0.134818
9	0.00001430	0.00701																							0.135272
10	-0.0003725	-0.18267																							0.135278
11	0.00035156	0.17238																							0.139079
12	-0.0004603	-0.22571																							0.142378
13	-0.0001144	-0.05610																							0.147863
14	0.00020127	0.09869																							0.148195
15	0.00014455	0.07088																							0.149218
16	-0.0001654	-0.08111																							0.149744

Lag	Correlation	Inverse Autocorrelations																							
		-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1			
1	0.15803																								
2	-0.02258																								
3	-0.13176																								
4	-0.05315																								
5	-0.13615																								
6	-0.19744																								
7	-0.07382																								
8	0.00723																								
9	0.06906																								
10	0.13235																								
11	0.00060																								
12	0.23394																								
13	0.05793																								
14	-0.08701																								
15	-0.16614																								
16	-0.00433																								

Lag	Correlation	Partial Autocorrelations																							
		-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1			
1	-0.15791																								
2	0.00497																								
3	0.16580																								
4	-0.00089																								
5	0.03727																								
6	0.14494																								
7	-0.01527																								
8	0.02710																								
9	-0.01825																								
10	-0.18576																								
11	0.09674																								
12	-0.21080																								
13	-0.08102																								
14	0.04905																								
15	0.20343																								
16	0.00535																								

Diesel Tax Model

Table 38 below presents the SAS output for the diesel tax model. The original data was differenced (at lag 1 and again at lag 12 to account for seasonality in the data) and transformed in log. The table shows that: the model parameter (first-order moving average) has a significant t value (p-value of less than 0.05); the model fits well the data (the standard error of the model is only 0.039); as evidenced by the χ^2 statistics, the no-autocorrelation hypothesis cannot be rejected (p-value is 0.349 for the first six lags), suggesting that the residuals are uncorrelated.

Table 38: Diesel Tax Model – Equation Output

Maximum Likelihood Estimation									
Parameter	Estimate		Standard Error	t Value	Approx Pr > t	Lag			
MA1,1	0.69792		0.15132	4.61	<.0001	1			
			Variance Estimate	0.001546					
			Std Error Estimate	0.039315					
			AIC	-89.2129					
			SBC	-87.994					
			Number of Residuals	25					
Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	-----Autocorrelations-----					
6	5.58	5	0.3490	-0.141	-0.142	0.281	0.048	0.060	0.226
12	8.47	11	0.6703	-0.092	-0.126	0.054	-0.010	0.123	-0.145
18	12.55	17	0.7655	-0.020	0.068	-0.110	0.080	0.100	-0.130
24	15.62	23	0.8710	-0.027	0.114	-0.078	0.028	-0.006	-0.002

The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the differenced (at lag 1 and lag 12), log-transformed data are presented in Table 39 on the next page. The plots show no evidence of autocorrelation, inverse autocorrelation or partial autocorrelation of the residuals (white noise).

Table 39: Diesel Tax Model – Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

Name of Variable = ldiesel																								
Period(s) of Differencing											1,12													
Mean of Working Series											-0.00253													
Standard Deviation											0.049971													
Number of Observations											25													
Observation(s) eliminated by differencing											13													
The ARIMA Procedure																								
Autocorrelations																								
Lag	Covariance	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1	Std Error
0	0.0024971	1.00000												*****										0
1	-0.0012180	-.48776								*****														0.200000
2	-0.0004440	-.17782								.	****													0.242966
3	0.00070243	0.28130								.				*****										0.248117
4	-0.0002673	-.10705								.	**													0.260562
5	-0.0001484	-.05944								.	*													0.262315
6	0.00052442	0.21001								.				****										0.262854
7	-0.0003275	-.13114								.	***													0.269482
8	-0.0002404	-.09629								.	**													0.272022
9	0.00024581	0.09844								.				**										0.273382
10	-0.0002181	-.08732								.	**													0.274796
11	0.00043068	0.17247								.				***										0.275904
12	-0.0004353	-.17434								.	***													0.280184
13	0.00004155	0.01664								.														0.284490
Inverse Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	0.77572												*****											
2	0.41343									.			*****											
3	0.02632									.			*											
4	-0.16909									.	***													
5	-0.15039									.	***													
6	0.02403									.														
7	0.25608									.			*****											
8	0.38860									.			*****											
9	0.36804									.			*****											
10	0.26498									.			*****											
11	0.12352									.			**											
12	0.05163									.			*											
13	0.11678									.			**											
Partial Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	-0.48776									*****														
2	-0.54551									*****														
3	-0.22197									.	****													
4	-0.18856									.	****													
5	-0.16304									.	***													
6	0.13461									.			***											
7	0.17727									.			****											
8	0.05890									.			*											
9	-0.08918									.	**													
10	-0.34247									.	*****													
11	-0.08001									.	**													
12	-0.22939									.	*****													
13	-0.12159									.	**													

Total Refund Model

Table 40 below presents the SAS output for the total refund model. The original data were log transformed and first differenced. The table shows that: all model parameters (fuel tax rate, first-order autoregressive term and two dummy variables) have significant t values (p-value of less than 0.05); the model fits well the data (the standard error of the model is only 0.088); as evidenced by the χ^2 statistics, the no-autocorrelation hypothesis cannot be rejected (p-value is 0.8343 for the first six lags), suggesting that the residuals are uncorrelated.

Table 40: Total Refund Model – Equation Output

Maximum Likelihood Estimation									
Parameter	Estimate	Standard Error	t Value	Approx Pr > t	Lag	Variable	Shift		
AR1,1	-0.68263	0.16005	-4.27	<.0001	1	lrefunds	0		
NUM1	1.07191	0.13940	7.69	<.0001	0	lrate	0		
NUM2	0.66712	0.07402	9.01	<.0001	0	dum1990	0		
NUM3	-0.24660	0.07227	-3.41	0.0006	0	dum2002	0		
Variance Estimate				0.007844					
Std Error Estimate				0.088565					
AIC				-43.9923					
SBC				-39.2801					
Number of Residuals				24					
Correlations of Parameter Estimates									
Variable Parameter	lrefunds AR1,1	lrate NUM1	dum1990 NUM2	dum2002 NUM3					
lrefunds	AR1,1	1.000	0.012	-0.220	-0.043				
lrate	NUM1	0.012	1.000	-0.003	-0.001				
dum1990	NUM2	-0.220	-0.003	1.000	0.010				
dum2002	NUM3	-0.043	-0.001	0.010	1.000				
The ARIMA Procedure									
Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	-----Autocorrelations-----					
6	2.11	5	0.8343	-0.076	0.081	0.201	-0.122	0.040	-0.033
12	4.06	11	0.9682	0.082	-0.157	0.099	0.022	0.055	-0.057
18	9.00	17	0.9403	-0.046	0.176	-0.058	0.114	0.102	0.083

The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the first-differenced, log-transformed data are presented in Table 41 on the next page. The plots show no evidence of autocorrelation, inverse autocorrelation or partial autocorrelation of the residuals (white noise).

Table 41: Total Refund Model – Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

Name of Variable = lrefunds																								
Period(s) of Differencing	1																							
Mean of Working Series	0.071181																							
Standard Deviation	0.153835																							
Number of Observations	24																							
Observation(s) eliminated by differencing	1																							
REFUNDS	10:24 Wednesday, February 9, 2000 4																							
The ARIMA Procedure																								
Autocorrelations																								
Lag	Covariance	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1	Std Error
0	0.023665	1.00000												*****										0
1	0.0049424	0.20885												****	.									0.204124
2	0.0052632	0.22240						.						****	.									0.212842
3	0.0032686	0.13812						.						***	.									0.222314
4	-0.0030417	-.12853						.		***					.									0.225861
5	-0.0003080	-.01302						.							.									0.228888
Inverse Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	-0.12107									.	**													
2	-0.21489									.	****													
3	-0.12161									.	**													
4	0.19593									.			****	.										
5	-0.00317									.				.										
Partial Autocorrelations																								
Lag	Correlation	-1	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	1		
1	0.20885												****	.										
2	0.18694												****	.										
3	0.06643												*	.										
4	-0.22115									.	****			.										
5	0.00360									.				.										

APPENDIX B: AUGMENTED DICKEY-FULLER UNIT ROOT TEST RESULTS

To ensure that time series variables are cointegrated the augmented Dickey-Fuller unit root test was performed on the residual series of each model. If the augmented Dickey-Fuller test statistic is smaller than the critical values (at the 1 percent, 5 percent or 10 percent significance levels) we can reject the null hypothesis that the residual series has a unit root. In other words, the residual series is stationary, and therefore the model variables are cointegrated.

Table 42: Augmented Dickey-Fuller Unit Root Test on Residuals for Net Driver's License Fee Equation

Null Hypothesis: Residual series has a unit root
 Exogenous: None
 Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.836475	0.0006
Test critical values: 1% level	-2.692358	
5% level	-1.960171	
10% level	-1.607051	

*MacKinnon (1996) one-sided p-values.

Table 43: Augmented Dickey-Fuller Unit Root Test on Residuals for Net Motor Vehicle Fee Equation

Null Hypothesis: Residual series has a unit root
 Exogenous: None
 Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.387831	0.0018
Test critical values: 1% level	-2.685718	
5% level	-1.959071	
10% level	-1.607456	

*MacKinnon (1996) one-sided p-values.

Table 44: Augmented Dickey-Fuller Unit Root Test on Residuals for Net Motor Vehicle Sales Tax Revenue Equation

Null Hypothesis: Residual series has a unit root
 Exogenous: None
 Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.648792	0.001
Test critical values: 1% level	-2.685718	
5% level	-1.959071	
10% level	-1.607456	

*MacKinnon (1996) one-sided p-values.

Table 45: Augmented Dickey-Fuller Unit Root Test on Residuals for Net Motor Vehicle Use Tax Revenue Equation

Null Hypothesis: Residual series has a unit root
 Exogenous: None
 Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.651055	0.0000
Test critical values: 1% level	-2.685718	
5% level	-1.959071	
10% level	-1.607456	

*MacKinnon (1996) one-sided p-values.

Table 46: Augmented Dickey-Fuller Unit Root Test on Residuals for Net Gasoline Consumption Equation

Null Hypothesis: Residual series has a unit root
 Exogenous: None
 Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.463659	0.0001
Test critical values: 1% level	-2.634731	
5% level	-1.951000	
10% level	-1.610907	

*MacKinnon (1996) one-sided p-values.

Table 47: Augmented Dickey-Fuller Unit Root Test on Residuals for Net Diesel Fuel Consumption Equation

Null Hypothesis: Residual series has a unit root

Exogenous: None

Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.218358	0.0000
Test critical values:		
1% level	-2.634731	
5% level	-1.951000	
10% level	-1.610907	

*MacKinnon (1996) one-sided p-values.

APPENDIX C: CORRELOGRAMS

A common problem in time series regression analysis is that the residuals are correlated with their lagged values. As a consequence, the OLS regression coefficients are biased. HDR|HLB tested for the presence of serial correlation in each model by means of correlograms and Ljung-Box Q statistics. If there is no serial correlation in the residuals, all Q statistics should be insignificant at all lags with large p -values. Each correlogram displays the autocorrelation and partial autocorrelation functions (ACF and PACF) up to the highest order of lag. The dotted lines in the ACF and PACF plots are the approximate two standard error bounds. If the autocorrelation or partial autocorrelation is within these bounds it is not significantly different from zero at the 5 percent significance level.

Figure 24 through Figure 29 below display the correlograms and associated Q statistics for all six equations.

Figure 24: Correlogram for Net Driver's License Fee Equation

Sample: 1987 2006

Included observations: 20

Q-statistic probabilities adjusted for 1 ARMA term(s)

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.105	0.105	0.2559	
		2	-0.298	-0.313	2.4329	0.119
		3	0.048	0.136	2.4914	0.288
		4	0.088	-0.038	2.7061	0.439
		5	-0.149	-0.117	3.3550	0.500
		6	-0.187	-0.149	4.4527	0.486
		7	-0.049	-0.102	4.5355	0.605
		8	0.017	-0.048	4.5465	0.715
		9	0.049	0.043	4.6444	0.795
		10	-0.096	-0.146	5.0475	0.830
		11	-0.231	-0.257	7.6668	0.661
		12	-0.057	-0.156	7.8428	0.727
		13	0.187	0.045	10.037	0.613
		14	0.064	0.001	10.336	0.666
		15	-0.220	-0.237	14.596	0.406
		16	0.153	0.111	17.157	0.310
		17	0.140	-0.205	20.035	0.219
		18	-0.043	0.037	20.443	0.252

Figure 25: Correlogram for Net Motor Vehicle Fee Equation

Sample: 1986 2006

Included observations: 21

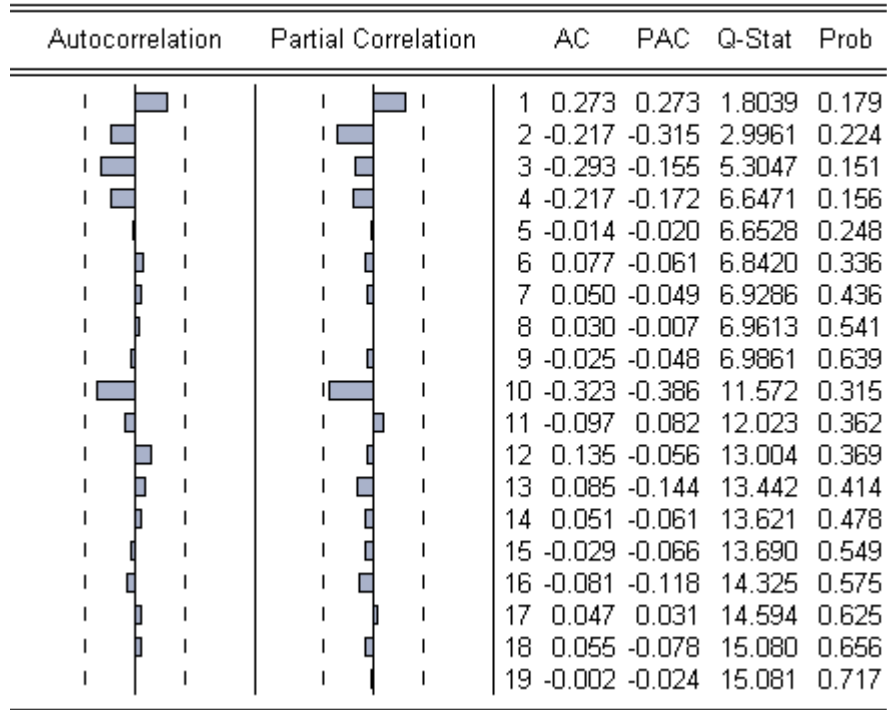


Figure 26: Correlogram for Net Motor Vehicle Sales Tax Revenue Equation

Sample: 1986 2006

Included observations: 21

Q-statistic probabilities adjusted for 1 ARMA term(s)

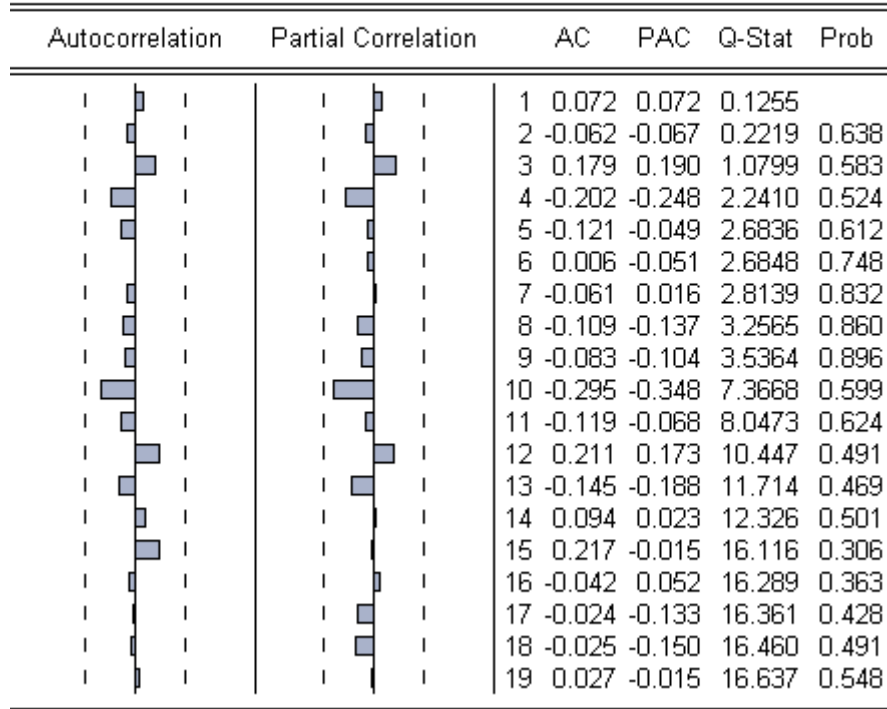


Figure 27: Correlogram for Net Motor Vehicle Use Tax Revenue Equation

Sample: 1986 2006

Included observations: 21

Q-statistic probabilities adjusted for 1 ARMA term(s)

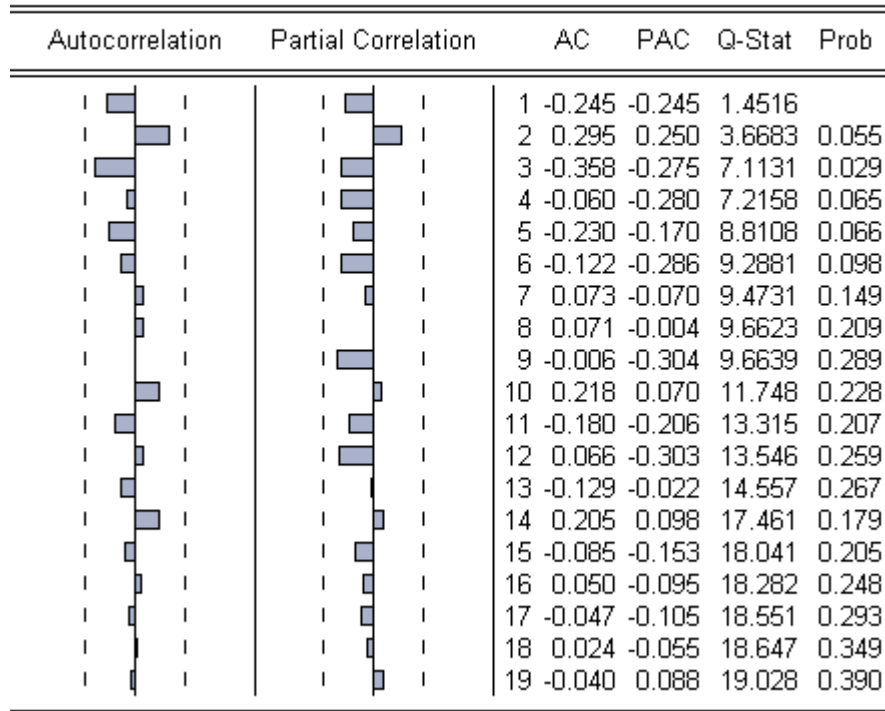


Figure 28: Correlogram for Net Gasoline Consumption Equation

Sample: 1972 2006

Included observations: 35

Q-statistic probabilities adjusted for 1 ARMA term(s)

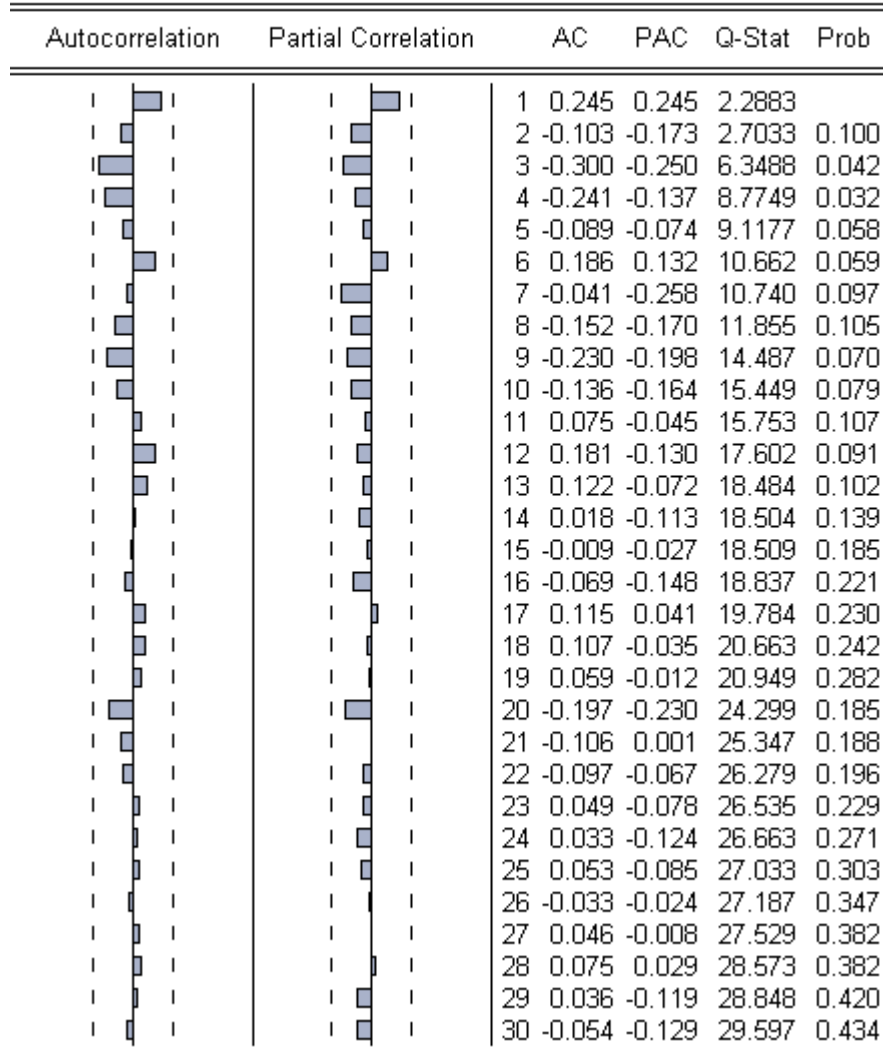
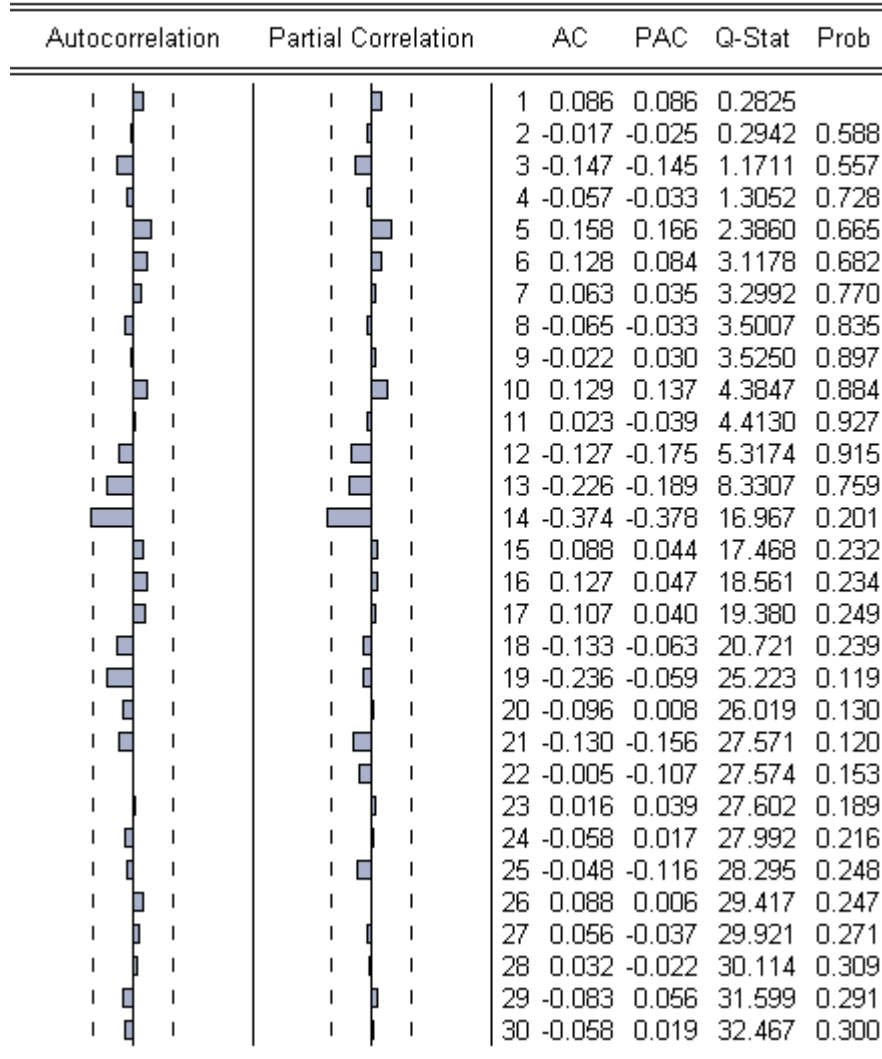


Figure 29: Correlogram for Net Diesel Fuel Consumption Equation

Sample: 1972 2006

Included observations: 35

Q-statistic probabilities adjusted for 1 ARMA term(s)



APPENDIX D: RESPONSES TO PANEL COMMENTS

A risk analysis workshop with MoDOT staff was held in Jefferson City, MO on May 3rd, 2007 to scrutinize HDR|HLB's approach to state highway user revenue forecasting. The forecasting models along with the model assumptions were reviewed by an independent panel of experts. Responses to key comments and recommendations made by panel experts during the workshop are provided below.

Regression Coefficient on Population

Experts at the risk analysis workshop expressed some concern about the magnitude of the regression coefficient on population²¹ in the Driver's License Fee equation, and reckoned that it should not be much different from one.²² It is our belief, however, that the coefficient should be significantly higher than unity for the following reasons:

- Driver's license fees include a wide array of fees and not merely personal driver's license fees.²³ For instance, people who lose their driver's licenses have to pay renewal fees to obtain new ones.
- One person may be driving more than one type of motor vehicle (e.g., passenger car and motorcycle).
- Average annual population estimates are used in the regression analysis. Each estimate only reflects the incremental growth in population over a twelve-month period. It is a (somewhat low) approximation of the total number of individuals who are residing in Missouri at some point over that period, and is used as a proxy for the number of Missouri residents who are licensed to drive a motor vehicle.

To some extent, the coefficient on population is capturing all these effects. Ideally, specific explanatory variables should be included in the model to account for each effect and each sub-category of fees, separately. For instance, reinstatement fees could be explained by the number of major traffic violations. However, data availability is a major constraint in regression analysis, especially when using time series. In the end, we consider that population is the best available predictor of all driver's license fees.

Non-Stationary Time Series and OLS Estimation

Experts at the risk analysis workshop raised the concern that performing linear regressions on non-stationary²⁴ time series data using the OLS method was a dangerous approach that could produce spurious regressions and biased coefficient estimates.²⁵

²¹ Natural Log of Population = 3.11.

²² The rationale being that one person pays for one driver's license only.

²³ In addition to fees related to the various types of driver's licenses (operator, chauffeur, commercial and motorcycle), this revenue category includes the following: commercial driver's license road/written test fee; non-driver identification card fee; instruction permit fee; organ donor contribution; processing fee for the issuance of licenses and other documents; reinstatement fee; and miscellaneous fees.

The usual procedure for testing hypotheses concerning the relationship between non-stationary variables is to run OLS regressions on data that have been (first) differenced. However, Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary.²⁶ If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated.²⁷ Stock (1987) went further and suggested that OLS coefficients are super-consistent when time series are cointegrated.²⁸

Accordingly, to ensure that time series are cointegrated and that OLS coefficients are not biased (and thus valid for forecasting purposes), HDR|HLB proceeded as follows:

- For each equation, the augmented Dickey-Fuller unit root test was performed on the residuals to ensure that time series variables are cointegrated;²⁹ and
- Subsequently, each equation was estimated using the OLS method.

Note that this two-stage approach was employed in other studies. For instance, Ghouri (2006) used the Johansen and Juselius cointegration technique to establish a long-run correlation between oil prices and natural gas prices, and used the OLS method to forecast individual natural gas prices.³⁰ The excerpt below is taken from the paper's abstract:

“This paper uses Augmented Dickey-Fuller and Phillips-Perron technique for determining whether individual crude oil prices (West Texas Intermediate, Brent, Japan crude cocktail) and natural gas prices- Henry Hub (HH), National Balancing Point (NBP), European and Japanese liquefied natural gas (LNG) prices are stationary or non-stationary. It then applies Johansen and Juselius cointegration technique for establishing long-run correlation between respective oil prices and natural gas prices. The paper concludes that all individual series pertaining to oil and natural gas prices are non-stationary and indeed having long-run relationship, despite short term drift. Ordinary least square method was used to forecast individual natural gas prices in various markets, assuming of course, that historical relationship continues to hold with respective oil prices throughout the forecasting period.”

²⁴ A time series is called non-stationary when the mean and the variance of the series are not constant over time.

²⁵ A spurious regression is one that tends to accept a false relation or reject a true relation by flawed regression techniques. In other words, it refers to a regression that does not make any sense though the results are seemingly acceptable (high R-squared and significant t-statistics). For example: U.S. military expenditures regressed on population of South Africa.

²⁶ Engle, Robert F., and Clive W. J. Granger, “Co-integration and Error Correction: Representation, Estimation and Testing”, *Econometrica*, Vol. 55, No. 2, March 1987, pp. 251-276.

²⁷ Cointegration is an econometric technique for testing the correlation between non-stationary time series variables. For a non-technical discussion on cointegration, read the speech that Professor Clive W.J. Granger gave at the Nobel Prize Award Ceremony on December 8th, 2003: http://nobelprize.org/nobel_prizes/economics/laureates/2003/granger-lecture.pdf

²⁸ Stock, James H., “Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors,” *Econometrica*, Vol. 55, No. 5, September 1987, pp. 1035-1056.

²⁹ See Appendix B.

³⁰ Ghouri, Salman Saif, “Forecasting Natural Gas Prices Using Cointegration Technique,” *OPEC Review*, Vol. 30, No. 4, December 2006, pp. 249-269.

Regression of Nominal/Real Variables

Experts at the workshop recommended against using explanatory variables in real terms because all dependent variables are expressed in nominal terms.

Accordingly, HDR|HLB re-estimated the motor vehicle sales tax revenue equation and the motor vehicle use tax revenue equation: real gasoline price index was replaced by nominal gasoline price index in the motor vehicle sales tax revenue equation; and real per capita personal income in the region was replaced by nominal per capita personal income in the region in the motor vehicle sales tax revenue equation. The revised regression results are presented in Section 5.3.

However, the other four equations were not revised for the following reasons:

- Two dependent variables are not expressed in dollars (gasoline consumption and diesel fuel consumption are expressed in gallons); and
- Driver's license fees and motor vehicle unit fees did not change during the estimation period (FY 1985 – FY 2006). Therefore, inflation is not a plausible predictor and all dollar explanatory variables should be deflated.

APPENDIX E: RAP PRIMER

Economic forecasts traditionally take the form of a single “expected outcome” supplemented with alternative scenarios. The limitation of a forecast with a single expected outcome is clear: while it may provide the single best statistical estimate, it offers no information about the range of other possible outcomes and their associated probabilities. The problem becomes acute when uncertainty surrounding the forecast’s underlying assumptions is material.

A common approach is to create “high case” and “low case” scenarios to bracket the central estimate. This scenario approach can exacerbate the problem of dealing with risk because it gives no indication of likelihood associated with the alternative outcomes. The commonly reported “high case” may assume that most underlying assumptions deviate in the same direction from their expected value, and likewise for the “low case.” In reality, the likelihood that all underlying factors shift in the same direction simultaneously is just as remote as that of everything turning out as expected.

Another common approach to providing added perspective on reality is “sensitivity analysis.” Key forecast assumptions are varied one at a time in order to assess their relative impact on the expected outcome. A problem here is that the assumptions are often varied by arbitrary amounts. A more serious concern with this approach is that, in the real world, assumptions do not veer from actual outcomes one at a time. It is the impact of simultaneous differences between assumptions and actual outcomes that is needed to provide a realistic perspective on the risk levels of a forecast.

Risk Analysis provides a way around the problems outlined above. It helps avoid the lack of perspective in “high” and “low” cases by measuring the probability or “odds” that an outcome will actually materialize. This is accomplished by attaching ranges (probability distributions) to the forecasts of each input variable. The approach allows all inputs to be varied simultaneously within their distributions, thus avoiding the problems inherent in conventional sensitivity analysis. The approach also recognizes interrelationships between variables and their associated probability distributions.

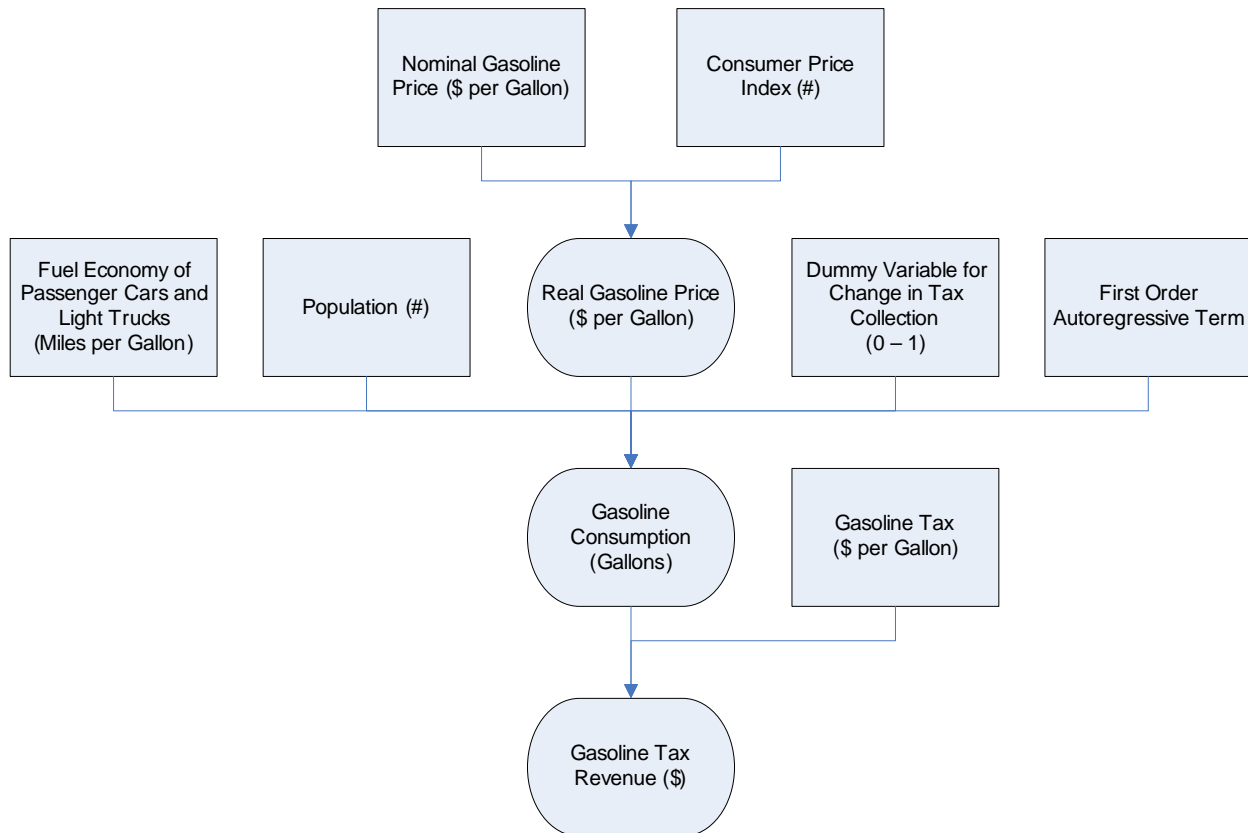
The Risk Analysis Process involves four steps:

1. Defining the structure and logic of the forecasting problem;
2. Assigning estimates and ranges (probability distributions) to each variable and forecasting coefficient in the forecasting structure and logic;
3. Engaging experts and stakeholders in assessment of model and assumption risks (the “RAP Session”); and
4. Issuing forecast risk analysis.

Step 1. Define Structure and Logic of the Forecasting Problem

A “structure and logic model” depicts the variables and cause and effect relationships that underpin the forecasting problem at-hand. Although the structure and logic model is conventionally written down in mathematical form to facilitate analysis, it can also be presented diagrammatically in order to permit stakeholder scrutiny and modification in Step 3 of the process (see Figure 30 below).

Figure 30: Example of Structure and Logic Model, an Illustration



Step 2. Assign Central Estimates and Conduct Probability Analysis

Each variable is then assigned a central estimate and a range (a probability distribution) to represent the degree of uncertainty. Special data sheets are used to record the estimates. The first column gives an initial median while the second and third columns define an uncertainty range representing an 80 percent confidence interval (see Table 48 below). This is the range within which the actual outcome will fall, with an 80 percent probability. The greater the uncertainty associated with a forecast variable, the wider the range.

Table 48: Data Sheet for Population Growth, an Illustration

Year	Median	Lower 10% Limit	Upper 10% Limit
2007	2.45%	1.80%	3.10%
2008	2.45%	1.80%	3.10%
2009	2.35%	1.60%	3.10%
2010	2.30%	1.50%	3.10%

Probability ranges are established on the basis of both statistical analysis and subjective probability. Probability ranges need not be normal or symmetrical – that is, there is no need to assume the bell shaped normal probability curve. The bell curve assumes an equal likelihood of being too low and being too high in forecasting a particular value. For example, it might well be that, if a projected growth rate deviates from expectations, circumstances are such that it is more likely to be higher than the median expected outcome than lower.

The risk analysis computer program transforms the ranges as depicted above into formal probability distributions (or “probability density functions”). This liberates the non-statistician from the need to appreciate the abstract statistical depiction of probability and thus enables stakeholders to understand and participate in the process whether or not they possess statistical training.

From where do the central estimates and probability ranges for each assumption in the forecasting structure and logic framework come? There are two sources. The first is an historical analysis of statistical uncertainty in all variables and an error analysis of the forecasting “coefficients.” Coefficients are numbers that represent the measured impact of one variable (say, population) on another (such as gasoline consumption). While these coefficients can only be known with uncertainty, statistical methods help uncover the magnitude of such error (using diagnostic statistics such as “standard deviation,” “standard error,” “confidence intervals” and so on).

The uncertainty analysis outlined above is known in the textbooks as “frequentist” probability. The second line of uncertainty analysis employed in risk analysis is called “subjective probability” (also called “Bayesian” statistics, for the mathematician Bayes who developed it). Whereas a frequentist probability represents the measured frequency with which different outcomes occur (i.e., the number of heads and tails after thousands of coin tosses), the Bayesian probability of an event occurring is the degree of belief held by an informed person or group that it will occur. Obtaining subjective probabilities is the subject of Step 3.

Step 3. Conduct Expert Evaluation: The RAP Session

Step 3 involves the formation of an expert panel and the use of facilitation techniques to elicit, from the panel, risk and probability beliefs about:

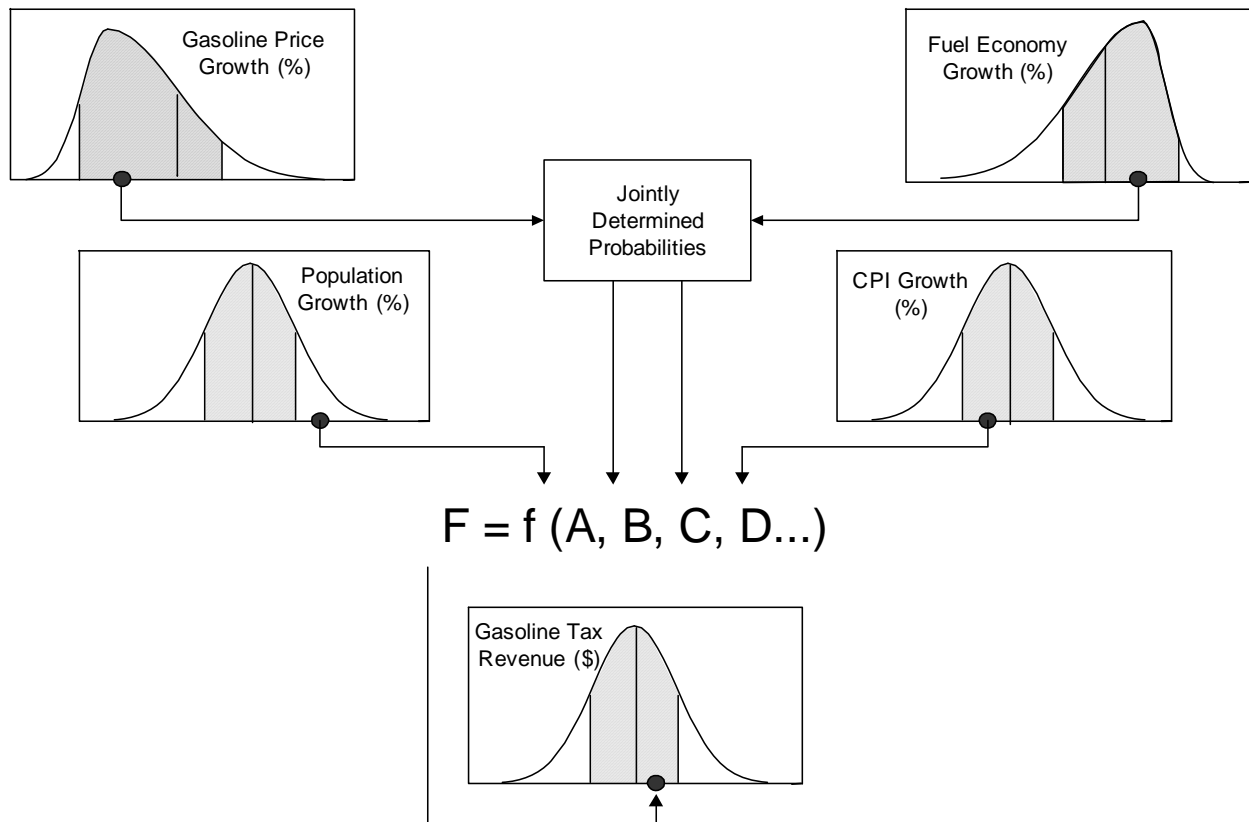
1. The structure of the forecasting framework; and
2. Uncertainty attaching to each variable and forecasting coefficient within the framework.

In (1), experts are invited to add variables and hypothesized causal relationships that may be material, yet missing from the model. In (2), panelists are engaged in a discursive protocol during which the frequentist-based central estimates and ranges, provided to panelists in advance of the session, are modified according to subjective expert beliefs. This process is aided with an interactive “groupware” computer tool that permits the visualization of probability ranges under alternative belief systems.

Step 4. Issue Risk Analysis

The final probability distributions are formulated by the risk analyst (HDR|HLB) and represent a combination of “frequentist” and subjective probability information drawn from Step 3. These are combined using a simulation technique (Monte Carlo analysis) that allows each variable and forecasting coefficient to vary simultaneously according to its associated probability distribution (see Figure 31 below).

Figure 31: Combining Probability Distributions



The end result is a central forecast, together with estimates of the probability of achieving alternative outcomes given uncertainties in underlying variables and coefficients (see Figure 32 and Table 49 below).

Figure 32: Risk Analysis of Gasoline Tax Revenue, an Illustration

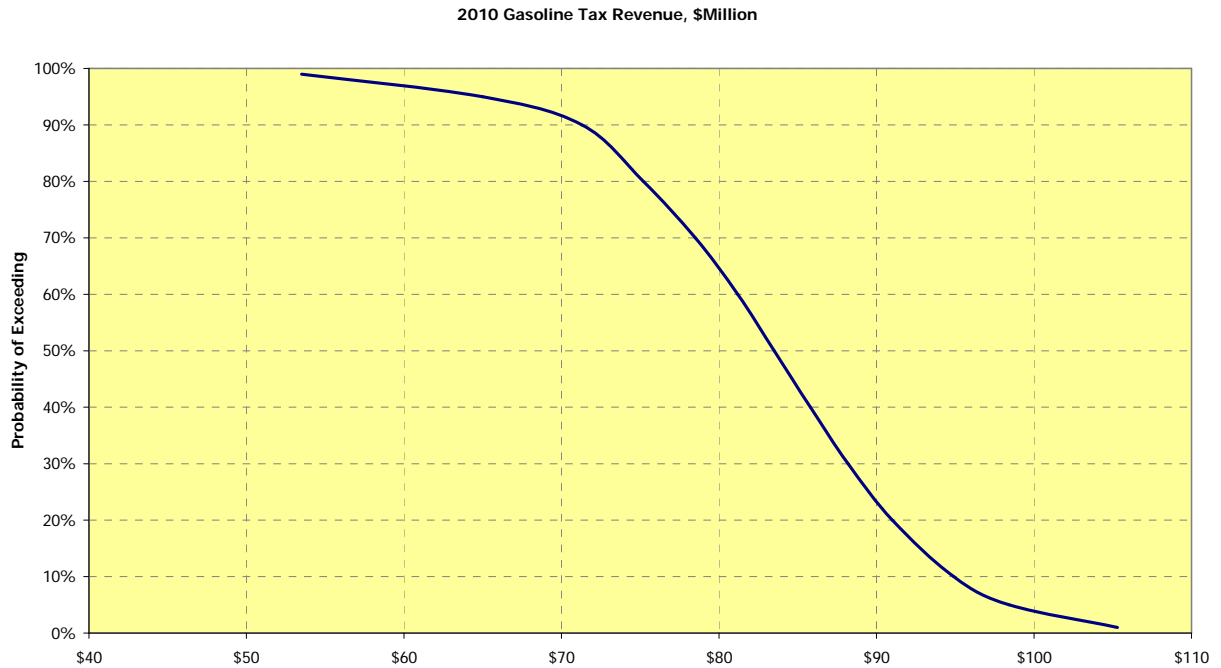


Table 49: Risk Analysis of Annual Gasoline Tax Revenue, an Illustration

Projected Gasoline Tax Revenue in 2010 (In Millions of Dollars)	Probability of Exceeding Value Shown at Left
105.3	1%
98.4	5%
94.9	10%
91.0	20%
88.2	30%
85.8	40%
83.5	50%
81.2	60%
78.5	70%
75.2	80%
71.3	90%
65.0	95%
53.5	99%
82.9	Mean Expected Outcome

APPENDIX F: DATA SHEETS

Data sheets were used during the risk analysis workshop to describe the model variables and record a range (or probability distribution) for each variable within the model.

Annual Growth in Gasoline Price in Missouri

Variable Description: This variable is the annual growth in gasoline price (inclusive of federal and state taxes) in Missouri, in dollars per gallon. It is used in conjunction with other variables to forecast gasoline consumption and motor vehicle sales tax revenue in Missouri.

How the Variable Affects the Model: Other things being equal, an increase in gasoline price is expected to reduce the demand for gasoline and motor vehicles, leading to lower gasoline and motor vehicle sales tax revenues.

Data Source: U.S. Department of Energy, Energy Information Administration. The data for the period 1971 – 2003 is from *State Energy Consumption, Price, and Expenditure Estimates (SEDS)*. Estimates from 2004 onward are derived from *Monthly Products Price Surveys*.

Historical Data

FY	\$ per gallon	Change	FY	\$ per gallon	Change	FY	\$ per gallon	Change	FY	\$ per gallon	Change
1970	N/A	N/A	1980	\$1.02	36.18%	1990	\$1.00	12.58%	2000	\$1.24	21.44%
1971	\$0.35	N/A	1981	\$1.22	19.81%	1991	\$1.06	5.29%	2001	\$1.39	11.77%
1972	\$0.36	2.34%	1982	\$1.25	2.84%	1992	\$1.03	-2.99%	2002	\$1.33	-4.30%
1973	\$0.37	4.22%	1983	\$1.16	-7.02%	1993	\$1.00	-2.30%	2003	\$1.38	3.80%
1974	\$0.47	24.38%	1984	\$1.08	-7.54%	1994	\$1.01	0.51%	2004	\$1.53	11.01%
1975	\$0.55	19.00%	1985	\$1.07	-1.04%	1995	\$1.03	2.30%	2005	\$1.83	19.67%
1976	\$0.58	4.87%	1986	\$0.92	-13.89%	1996	\$1.10	6.63%	2006	\$2.36	28.48%
1977	\$0.61	5.23%	1987	\$0.81	-11.97%	1997	\$1.16	5.28%			
1978	\$0.63	2.59%	1988	\$0.85	5.51%	1998	\$1.07	-7.93%			
1979	\$0.75	18.83%	1989	\$0.89	4.73%	1999	\$1.02	-3.90%			

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	11.14%	-4.30%	28.48%	-1.06%	24.95%
10 Years	7.92%	-7.93%	28.48%	-4.66%	22.14%
Full Period	5.59%	-13.89%	36.18%	-7.33%	20.78%

Note: CAGR is the compound annual growth rate.

Annual Growth in Diesel Fuel Price in the Midwest

Variable Description: This variable is the annual growth in diesel fuel price (inclusive of federal and state taxes) in Petroleum Administration for Defense District (PADD) 2, in dollars per gallon. It is used in conjunction with other variables to forecast diesel fuel consumption.

How the Variable Affects the Model: Other things being equal, an increase in diesel fuel price is expected to reduce the demand for diesel fuel, leading to fewer taxable gallons of diesel fuel and lower diesel fuel tax revenue.

Data Source: U.S. Department of Energy, Energy Information Administration. The data for the period 1971 – 2003 is from *State Energy Consumption, Price, and Expenditure Estimates (SEDS)*. Estimates from 2004 onward are derived from *Monthly Products Price Surveys*.

Historical Data

FY	\$ per gallon	Change	FY	\$ per gallon	Change	FY	\$ per gallon	Change	FY	\$ per gallon	Change
1970	N/A	N/A	1980	\$0.87	44.00%	1990	\$1.04	14.00%	2000	\$1.29	21.97%
1971	\$0.18	N/A	1981	\$1.10	27.22%	1991	\$1.10	6.07%	2001	\$1.42	10.62%
1972	\$0.18	2.01%	1982	\$1.17	6.48%	1992	\$1.06	-3.65%	2002	\$1.34	-5.62%
1973	\$0.20	11.14%	1983	\$1.09	-6.83%	1993	\$1.05	-1.06%	2003	\$1.39	3.37%
1974	\$0.29	43.66%	1984	\$1.04	-4.40%	1994	\$1.05	0.14%	2004	\$1.46	5.40%
1975	\$0.38	28.54%	1985	\$1.03	-0.92%	1995	\$1.05	-0.02%	2005	\$1.93	31.77%
1976	\$0.40	6.86%	1986	\$0.92	-10.79%	1996	\$1.13	6.84%	2006	\$2.50	29.60%
1977	\$0.44	7.68%	1987	\$0.87	-5.56%	1997	\$1.19	5.80%			
1978	\$0.47	7.04%	1988	\$0.90	2.93%	1998	\$1.09	-8.67%			
1979	\$0.60	29.01%	1989	\$0.91	1.72%	1999	\$1.05	-3.05%			

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	11.92%	-5.62%	31.77%	-2.03%	30.90%
10 Years	8.30%	-8.67%	31.77%	-5.93%	29.82%
Full Period	7.79%	-10.79%	44.00%	-5.60%	29.37%

Note: CAGR is the compound annual growth rate.

Annual Growth in Consumer Price Index in the Midwest

Variable Description: This variable is the annual growth in the consumer price index (CPI) for all items in the Midwest. It is used in all equations (except for the driver's license fee equation) to express certain variables (e.g., personal income and fuel prices) in real terms (or constant dollars).

How the Variable Affects the Model: An increase in the consumer price index for all items lowers the relative (or inflation adjusted) price of gasoline, and thus increases gasoline gallons consumed and gasoline tax revenues.

Data Source: U.S. Department of Labor, Bureau of Labor Statistics.

Historical Data

FY	CPI	Change	FY	CPI	Change	FY	CPI	Change	FY	CPI	Change
1970	37.98	N/A	1980	78.07	13.77%	1990	124.13	4.34%	2000	165.48	3.00%
1971	39.73	4.61%	1981	86.72	11.08%	1991	130.36	5.02%	2001	171.18	3.44%
1972	40.95	3.08%	1982	93.57	7.90%	1992	134.18	2.93%	2002	173.34	1.27%
1973	42.58	3.97%	1983	98.77	5.56%	1993	138.15	2.96%	2003	176.81	2.00%
1974	46.55	9.34%	1984	101.97	3.24%	1994	141.82	2.65%	2004	180.09	1.86%
1975	51.43	10.47%	1985	105.40	3.37%	1995	146.43	3.25%	2005	185.14	2.80%
1976	54.85	6.66%	1986	107.62	2.10%	1996	150.53	2.80%	2006	191.41	3.38%
1977	58.23	6.15%	1987	109.92	2.14%	1997	155.14	3.07%			
1978	62.52	7.38%	1988	113.93	3.64%	1998	157.99	1.84%			
1979	68.62	9.75%	1989	118.97	4.43%	1999	160.67	1.69%			

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	2.26%	1.27%	3.38%	1.50%	3.15%
10 Years	2.43%	1.27%	3.44%	1.65%	3.39%
Full Period	4.60%	1.27%	13.77%	1.93%	9.54%

Note: CAGR is the compound annual growth rate.

Annual Growth in Motor Vehicle Fuel Economy

Variable Description: This variable is the annual growth in the fuel economy of the stock of cars and light trucks (vans, pickup trucks, sport utility vehicles, etc.) expressed in miles per gallon (MPG). It is used in conjunction with other variables to forecast gasoline consumption.

How the Variable Affects the Model: Other things being equal, an increase in motor vehicle fuel economy will lead to a decrease in gasoline consumption.

Data Source: U.S. Department of Energy, Energy Information Administration.

Historical Data

FY	MPG	Change	FY	MPG	Change	FY	MPG	Change	FY	MPG	Change
1970	11.61	N/A	1980	13.36	3.94%	1990	17.59	2.96%	2000	19.22	0.84%
1971	11.70	0.76%	1981	13.89	3.97%	1991	18.24	3.70%	2001	19.56	1.77%
1972	11.76	0.49%	1982	14.49	4.32%	1992	18.75	2.80%	2002	19.61	0.28%
1973	11.77	0.13%	1983	14.99	3.42%	1993	18.78	0.14%	2003	19.20	-2.08%
1974	11.96	1.60%	1984	15.23	1.57%	1994	18.76	-0.12%	2004	18.92	-1.45%
1975	12.05	0.75%	1985	15.51	1.89%	1995	18.88	0.67%	2005	19.01	0.48%
1976	12.04	-0.13%	1986	15.72	1.35%	1996	18.98	0.51%	2006	19.04	0.17%
1977	12.25	1.79%	1987	16.02	1.87%	1997	19.03	0.28%			
1978	12.54	2.39%	1988	16.52	3.15%	1998	19.10	0.38%			
1979	12.86	2.50%	1989	17.09	3.43%	1999	19.06	-0.25%			

Note: 2005 and 2006 estimates calculated by HDR|HLB, based on preliminary data.

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	-0.53%	-2.08%	0.48%	-1.83%	0.40%
10 Years	0.04%	-2.08%	1.77%	-1.52%	0.93%
Full Period	1.38%	-2.08%	4.32%	-0.12%	3.56%

Note: CAGR is the compound annual growth rate.

Annual Population Growth in Missouri

Variable Description: This variable is the annual population growth in Missouri. It is used in conjunction with other variables to forecast driver's license fees, motor vehicle sales tax revenue and gasoline consumption.

How the Variable Affects the Model: Other things being equal, an increase in population is expected to lead to an increase in all three variables.

Data Source: U.S. Census Bureau.

Historical Data

FY	Population	Change	FY	Population	Change	FY	Population	Change	FY	Population	Change
1970	4,658,812	N/A	1980	4,914,558	0.28%	1990	5,112,355	0.46%	2000	5,584,240	0.76%
1971	4,701,695	0.92%	1981	4,924,375	0.20%	1991	5,149,840	0.73%	2001	5,624,882	0.73%
1972	4,742,273	0.86%	1982	4,930,758	0.13%	1992	5,193,951	0.86%	2002	5,661,746	0.66%
1973	4,770,712	0.60%	1983	4,936,592	0.12%	1993	5,244,138	0.97%	2003	5,696,307	0.61%
1974	4,789,289	0.39%	1984	4,959,506	0.46%	1994	5,297,836	1.02%	2004	5,732,608	0.64%
1975	4,802,121	0.27%	1985	4,987,773	0.57%	1995	5,351,372	1.01%	2005	5,775,282	0.74%
1976	4,823,668	0.45%	1986	5,011,668	0.48%	1996	5,404,900	1.00%	2006	5,820,208	0.78%
1977	4,851,102	0.57%	1987	5,039,882	0.56%	1997	5,456,373	0.95%			
1978	4,876,288	0.52%	1988	5,069,216	0.58%	1998	5,501,479	0.83%			
1979	4,900,915	0.51%	1989	5,088,783	0.39%	1999	5,541,857	0.73%			

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	0.69%	0.61%	0.78%	0.62%	0.76%
10 Years	0.74%	0.61%	0.95%	0.63%	0.84%
Full Period	0.62%	0.12%	1.02%	0.27%	0.96%

Note: CAGR is the compound annual growth rate.

Annual Population Growth in the Region

Variable Description: This variable is the annual population growth in the region, which encompasses the states of Missouri, Illinois, Arkansas, Kansas, and Iowa. It is used in conjunction with other variables to forecast motor vehicle use tax revenue.

How the Variable Affects the Model: Other things being equal, an increase in population is expected to lead to an increase in the demand for motor vehicles, leading to higher motor vehicle use tax revenue.

Data Source: U.S. Census Bureau.

Historical Data

FY	Population	Change	FY	Population	Change	FY	Population	Change	FY	Population	Change
1970	22,709,335	N/A	1980	23,877,186	0.23%	1990	24,148,280	0.32%	2000	26,258,281	0.70%
1971	22,892,225	0.81%	1981	23,934,341	0.24%	1991	24,310,196	0.67%	2001	26,416,658	0.60%
1972	23,072,404	0.79%	1982	23,949,033	0.06%	1992	24,548,654	0.98%	2002	26,552,822	0.52%
1973	23,184,307	0.49%	1983	23,940,449	-0.04%	1993	24,804,320	1.04%	2003	26,685,808	0.50%
1974	23,259,548	0.32%	1984	23,967,134	0.11%	1994	25,046,468	0.98%	2004	26,824,914	0.52%
1975	23,358,756	0.43%	1985	23,987,046	0.08%	1995	25,276,412	0.92%	2005	26,973,052	0.55%
1976	23,488,564	0.56%	1986	23,975,554	-0.05%	1996	25,495,338	0.87%	2006	27,139,759	0.62%
1977	23,624,423	0.58%	1987	23,984,753	0.04%	1997	25,697,311	0.79%			
1978	23,745,768	0.51%	1988	24,023,783	0.16%	1998	25,888,890	0.75%			
1979	23,823,030	0.33%	1989	24,070,185	0.19%	1999	26,076,086	0.72%			

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	0.54%	0.50%	0.62%	0.51%	0.59%
10 Years	0.63%	0.50%	0.79%	0.51%	0.75%
Full Period	0.50%	-0.05%	1.04%	0.07%	0.89%

Note: CAGR is the compound annual growth rate.

Annual Growth in Personal Income in Missouri

Variable Description: This variable is the annual growth in personal income of Missouri residents. Faster personal income growth indicates a healthy, growing economy. The variable is used in conjunction with other variables to forecast motor vehicle fees.

How the Variable Affects the Model: Other things being equal, an increase in personal income is expected to lead to an increase in the demand for motor vehicles, leading to higher motor vehicle fee revenues.

Data Source: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Accounts.

Historical Data

FY	Personal Income	Change	FY	Personal Income	Change	FY	Personal Income	Change	FY	Personal Income	Change
1970	\$17,329	N/A	1980	\$43,939	10.04%	1990	\$88,483	5.23%	2000	\$147,811	5.21%
1971	\$18,754	8.23%	1981	\$48,629	10.67%	1991	\$92,541	4.59%	2001	\$155,275	5.05%
1972	\$20,164	7.52%	1982	\$53,339	9.69%	1992	\$97,761	5.64%	2002	\$158,894	2.33%
1973	\$22,304	10.62%	1983	\$56,476	5.88%	1993	\$103,009	5.37%	2003	\$163,374	2.82%
1974	\$24,437	9.56%	1984	\$61,797	9.42%	1994	\$107,411	4.27%	2004	\$169,012	3.45%
1975	\$26,267	7.49%	1985	\$67,744	9.62%	1995	\$114,023	6.16%	2005	\$177,150	4.81%
1976	\$29,053	10.61%	1986	\$71,593	5.68%	1996	\$118,857	4.24%	2006	\$186,387	5.21%
1977	\$31,962	10.01%	1987	\$75,118	4.92%	1997	\$126,225	6.20%			
1978	\$35,804	12.02%	1988	\$79,078	5.27%	1998	\$133,648	5.88%			
1979	\$39,930	11.52%	1989	\$84,086	6.33%	1999	\$140,486	5.12%			

Note: Personal income data are expressed in millions of dollars.

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	3.72%	2.33%	5.21%	2.53%	5.05%
10 Years	4.60%	2.33%	6.20%	2.77%	5.91%
Full Period	6.82%	2.33%	12.02%	4.26%	10.61%

Note: CAGR is the compound annual growth rate.

Annual Growth in Personal Income in the Region

Variable Description: This variable is the annual growth in personal income of residents of Missouri, Illinois, Arkansas, Kansas and Iowa. Faster personal income growth indicates a healthy, growing economy. The variable is used in conjunction with other variables to forecast motor vehicle use tax revenue.

How the Variable Affects the Model: Other things being equal, an increase in personal income is expected to lead to an increase in the demand for motor vehicles, leading to higher motor vehicle use tax revenue.

Data Source: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Accounts.

Historical Data

FY	Personal Income	Change	FY	Personal Income	Change	FY	Personal Income	Change	FY	Personal Income	Change
1970	\$90,911	N/A	1980	\$230,979	9.45%	1990	\$443,860	5.76%	2000	\$739,891	5.04%
1971	\$97,223	6.94%	1981	\$254,407	10.14%	1991	\$464,232	4.59%	2001	\$776,965	5.01%
1972	\$105,048	8.05%	1982	\$278,090	9.31%	1992	\$488,652	5.26%	2002	\$790,259	1.71%
1973	\$117,389	11.75%	1983	\$289,944	4.26%	1993	\$515,047	5.40%	2003	\$809,548	2.44%
1974	\$131,221	11.78%	1984	\$312,946	7.93%	1994	\$535,033	3.88%	2004	\$841,577	3.96%
1975	\$142,302	8.44%	1985	\$340,210	8.71%	1995	\$567,917	6.15%	2005	\$882,778	4.90%
1976	\$156,079	9.68%	1986	\$355,256	4.42%	1996	\$596,380	5.01%	2006	\$929,893	5.34%
1977	\$170,504	9.24%	1987	\$372,240	4.78%	1997	\$632,253	6.02%			
1978	\$190,090	11.49%	1988	\$394,622	6.01%	1998	\$670,559	6.06%			
1979	\$211,035	11.02%	1989	\$419,688	6.35%	1999	\$704,370	5.04%			

Note: Personal income data are expressed in millions of dollars.

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	3.66%	1.71%	5.34%	2.00%	5.16%
10 Years	4.54%	1.71%	6.06%	2.37%	6.02%
Full Period	6.67%	1.71%	11.78%	4.11%	10.58%

Note: CAGR is the compound annual growth rate.

Annual Growth in Gross State Product in the Region

Variable Description: This variable is the annual growth in the gross state product (GSP) in the region, which encompasses the states of Missouri, Illinois, Arkansas, Kansas, and Iowa. It is used in conjunction with other variables to forecast diesel fuel consumption.

How the Variable Affects the Model: Other things being equal, an increase in the gross state product will lead to an increase in the demand for diesel fuel.

Data Source: U.S. Department of Commerce, Bureau of Economic Analysis.

Historical Data

FY	GSP	Change	FY	GSP	Change	FY	GSP	Change	FY	GSP	Change
1970	\$112,006	N/A	1980	\$275,760	7.03%	1990	\$515,753	5.03%	2000	\$854,505	4.30%
1971	\$118,891	6.15%	1981	\$297,097	7.74%	1991	\$537,350	4.19%	2001	\$885,727	3.65%
1972	\$129,641	9.04%	1982	\$316,281	6.46%	1992	\$564,508	5.05%	2002	\$912,461	3.02%
1973	\$144,347	11.34%	1983	\$328,885	3.99%	1993	\$591,843	4.84%	2003	\$947,016	3.79%
1974	\$158,242	9.63%	1984	\$357,758	8.78%	1994	\$627,871	6.09%	2004	\$995,037	5.07%
1975	\$171,626	8.46%	1985	\$388,198	8.51%	1995	\$669,564	6.64%	2005	\$1,047,706	5.29%
1976	\$189,556	10.45%	1986	\$408,303	5.18%	1996	\$705,069	5.30%	2006	\$1,091,371	4.17%
1977	\$209,349	10.44%	1987	\$430,018	5.32%	1997	\$746,321	5.85%			
1978	\$232,571	11.09%	1988	\$459,400	6.83%	1998	\$785,667	5.27%			
1979	\$257,638	10.78%	1989	\$491,076	6.89%	1999	\$819,273	4.28%			

Note: GSP data are expressed in millions of dollars.

Historical Data Analysis

Period	CAGR	Minimum	Maximum	80% Range	
				Lower 10%	Upper 10%
5 Years	4.26%	3.02%	5.29%	3.33%	5.20%
10 Years	4.47%	3.02%	5.85%	3.59%	5.35%
Full Period	6.53%	3.02%	11.34%	4.08%	10.44%

Note: CAGR is the compound annual growth rate.

APPENDIX G: COMPLETE RISK ANALYSIS RESULTS

Table 50: Net Driver's License Fees, Risk Analysis Results

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
5%	\$20,361	\$22,660	\$24,436	\$25,739	\$26,806	\$27,844
10%	\$19,792	\$21,673	\$23,180	\$24,222	\$25,230	\$26,017
15%	\$19,436	\$21,034	\$22,298	\$23,215	\$24,131	\$24,815
20%	\$19,094	\$20,459	\$21,552	\$22,386	\$23,140	\$23,793
25%	\$18,818	\$20,006	\$20,917	\$21,726	\$22,419	\$23,041
30%	\$18,600	\$19,622	\$20,464	\$21,169	\$21,800	\$22,373
35%	\$18,400	\$19,290	\$19,984	\$20,625	\$21,156	\$21,744
40%	\$18,132	\$18,878	\$19,463	\$20,031	\$20,579	\$21,141
45%	\$17,986	\$18,577	\$19,131	\$19,622	\$20,152	\$20,567
50%	\$17,778	\$18,288	\$18,703	\$19,150	\$19,650	\$20,115
55%	\$17,575	\$17,925	\$18,267	\$18,678	\$19,074	\$19,493
60%	\$17,399	\$17,616	\$17,904	\$18,221	\$18,620	\$19,022
65%	\$17,230	\$17,344	\$17,583	\$17,899	\$18,266	\$18,646
70%	\$17,022	\$17,015	\$17,175	\$17,423	\$17,778	\$18,131
75%	\$16,833	\$16,730	\$16,824	\$17,001	\$17,266	\$17,605
80%	\$16,646	\$16,416	\$16,431	\$16,553	\$16,783	\$17,110
85%	\$16,411	\$16,049	\$15,966	\$16,065	\$16,327	\$16,546
90%	\$16,174	\$15,637	\$15,516	\$15,493	\$15,687	\$15,950
95%	\$15,716	\$14,989	\$14,656	\$14,625	\$14,760	\$14,962

Table 51: Net Motor Vehicle Fees, Risk Analysis Results

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
5%	\$285,814	\$294,341	\$303,492	\$314,972	\$325,267	\$335,948
10%	\$278,232	\$286,876	\$295,318	\$305,238	\$314,485	\$325,723
15%	\$274,867	\$281,735	\$291,177	\$299,442	\$309,072	\$318,698
20%	\$271,339	\$278,626	\$287,276	\$295,394	\$304,235	\$314,189
25%	\$268,434	\$275,877	\$284,289	\$291,860	\$300,514	\$309,824
30%	\$265,990	\$273,089	\$281,690	\$288,997	\$297,474	\$306,856
35%	\$263,334	\$270,205	\$278,323	\$286,693	\$295,043	\$303,212
40%	\$260,506	\$267,439	\$275,384	\$284,271	\$292,305	\$300,140
45%	\$258,388	\$265,260	\$272,806	\$281,257	\$288,818	\$297,387
50%	\$256,408	\$262,822	\$270,511	\$278,929	\$286,126	\$294,683
55%	\$254,020	\$260,888	\$268,365	\$275,858	\$283,339	\$292,114
60%	\$252,077	\$258,670	\$266,239	\$273,492	\$281,563	\$288,824
65%	\$250,353	\$256,377	\$263,872	\$270,768	\$278,556	\$285,227
70%	\$248,458	\$254,630	\$260,959	\$267,959	\$275,281	\$282,316
75%	\$245,583	\$251,832	\$258,468	\$265,042	\$272,352	\$278,754
80%	\$242,280	\$248,131	\$255,241	\$261,878	\$268,947	\$274,866
85%	\$239,230	\$244,566	\$251,481	\$258,659	\$264,575	\$271,203
90%	\$234,979	\$241,427	\$246,684	\$253,431	\$260,697	\$266,997
95%	\$230,536	\$236,114	\$241,493	\$247,059	\$252,755	\$260,003

Table 52: Net Motor Vehicle Sales Tax Revenue, Risk Analysis Results

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
5%	\$172,634	\$223,946	\$282,067	\$308,797	\$331,039	\$353,102
10%	\$170,059	\$217,273	\$272,470	\$296,686	\$317,528	\$334,223
15%	\$167,825	\$212,476	\$266,028	\$287,728	\$305,650	\$321,859
20%	\$166,533	\$209,832	\$260,571	\$281,365	\$298,112	\$311,543
25%	\$165,064	\$207,283	\$256,432	\$274,925	\$289,129	\$305,430
30%	\$163,743	\$204,805	\$252,139	\$270,220	\$283,411	\$298,722
35%	\$162,875	\$202,594	\$248,571	\$266,391	\$279,208	\$292,656
40%	\$161,801	\$200,304	\$245,751	\$261,277	\$273,482	\$286,436
45%	\$160,882	\$198,436	\$242,755	\$256,907	\$268,858	\$280,739
50%	\$160,142	\$196,801	\$239,607	\$253,641	\$263,411	\$276,016
55%	\$159,356	\$195,129	\$236,722	\$249,763	\$259,984	\$272,174
60%	\$158,687	\$193,151	\$234,320	\$246,347	\$255,777	\$267,150
65%	\$158,002	\$191,604	\$230,776	\$242,919	\$251,794	\$262,270
70%	\$157,086	\$189,710	\$227,451	\$239,622	\$246,325	\$256,250
75%	\$156,400	\$187,522	\$224,246	\$235,723	\$241,854	\$248,715
80%	\$155,276	\$184,588	\$220,739	\$231,198	\$237,075	\$243,703
85%	\$154,055	\$182,386	\$216,051	\$226,761	\$231,765	\$237,386
90%	\$152,182	\$178,567	\$210,714	\$220,215	\$225,117	\$228,585
95%	\$149,970	\$172,287	\$201,719	\$210,773	\$211,099	\$217,161

Table 53: Net Motor Vehicle Use Tax Revenue, Risk Analysis Results

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
5%	\$47,224	\$73,392	\$78,378	\$82,831	\$87,956	\$92,767
10%	\$46,062	\$71,012	\$75,477	\$80,083	\$84,424	\$89,034
15%	\$45,477	\$69,248	\$73,155	\$77,012	\$81,663	\$85,675
20%	\$44,904	\$68,086	\$71,395	\$75,301	\$79,141	\$83,290
25%	\$44,440	\$66,912	\$70,205	\$73,525	\$77,454	\$81,152
30%	\$44,050	\$65,662	\$68,935	\$72,267	\$76,011	\$79,780
35%	\$43,696	\$64,733	\$67,736	\$70,888	\$74,035	\$78,002
40%	\$43,362	\$63,699	\$66,443	\$69,520	\$72,643	\$76,444
45%	\$43,039	\$62,845	\$65,299	\$68,191	\$71,548	\$74,982
50%	\$42,665	\$61,723	\$64,127	\$66,943	\$70,348	\$73,750
55%	\$42,282	\$61,105	\$63,252	\$65,761	\$68,459	\$71,765
60%	\$41,894	\$60,151	\$62,084	\$64,259	\$66,931	\$69,915
65%	\$41,518	\$59,331	\$60,876	\$63,195	\$65,343	\$68,018
70%	\$41,056	\$58,323	\$59,598	\$61,555	\$63,984	\$66,460
75%	\$40,517	\$57,428	\$58,570	\$60,105	\$62,147	\$64,621
80%	\$40,190	\$56,264	\$57,406	\$58,519	\$60,408	\$62,904
85%	\$39,502	\$54,930	\$55,492	\$57,109	\$58,804	\$60,553
90%	\$38,603	\$53,051	\$53,357	\$54,499	\$56,368	\$57,846
95%	\$37,574	\$50,802	\$50,827	\$51,493	\$52,999	\$54,735

Table 54: Net Gasoline Tax Revenue, Risk Analysis Results

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
5%	\$412,511	\$435,689	\$457,552	\$478,174	\$493,031	\$506,618
10%	\$408,182	\$427,941	\$447,199	\$463,939	\$476,346	\$490,971
15%	\$405,272	\$422,346	\$439,920	\$454,003	\$468,243	\$477,440
20%	\$402,777	\$418,562	\$434,786	\$448,084	\$458,545	\$467,657
25%	\$401,162	\$415,011	\$429,563	\$441,691	\$450,762	\$459,671
30%	\$399,078	\$411,642	\$425,356	\$436,536	\$444,518	\$452,756
35%	\$397,700	\$408,592	\$420,227	\$432,038	\$440,001	\$447,163
40%	\$395,861	\$405,467	\$415,698	\$426,485	\$433,662	\$441,354
45%	\$394,465	\$402,525	\$412,110	\$422,403	\$428,977	\$435,062
50%	\$393,044	\$399,425	\$407,941	\$417,945	\$423,348	\$430,093
55%	\$391,304	\$396,118	\$404,764	\$413,015	\$417,715	\$425,182
60%	\$390,081	\$392,733	\$399,872	\$407,936	\$412,216	\$419,172
65%	\$388,528	\$390,485	\$395,840	\$403,816	\$408,153	\$412,630
70%	\$386,810	\$387,713	\$392,849	\$399,477	\$403,274	\$407,152
75%	\$384,768	\$384,899	\$388,717	\$394,192	\$397,649	\$401,785
80%	\$382,821	\$381,334	\$383,454	\$390,290	\$392,813	\$395,842
85%	\$380,857	\$377,905	\$378,836	\$383,406	\$385,818	\$387,713
90%	\$378,188	\$373,373	\$374,516	\$376,037	\$377,761	\$379,729
95%	\$374,187	\$366,557	\$365,896	\$366,553	\$364,928	\$367,938

Table 55: Net Diesel Fuel Tax Revenue, Risk Analysis Results

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
5%	\$144,598	\$158,769	\$169,967	\$178,204	\$187,202	\$196,210
10%	\$139,352	\$152,230	\$161,589	\$169,257	\$176,638	\$185,013
15%	\$135,407	\$146,340	\$155,604	\$162,466	\$170,101	\$177,808
20%	\$132,611	\$141,721	\$149,859	\$158,215	\$164,272	\$171,855
25%	\$129,614	\$138,043	\$145,983	\$153,165	\$159,530	\$166,092
30%	\$127,264	\$134,809	\$142,037	\$148,323	\$154,633	\$161,691
35%	\$125,458	\$131,408	\$138,271	\$144,453	\$151,112	\$157,586
40%	\$123,772	\$129,256	\$135,607	\$141,551	\$147,961	\$154,690
45%	\$121,721	\$126,762	\$133,373	\$139,124	\$144,807	\$151,508
50%	\$119,722	\$124,305	\$129,950	\$135,914	\$141,434	\$147,753
55%	\$118,098	\$121,604	\$127,187	\$133,004	\$138,510	\$143,882
60%	\$116,579	\$119,637	\$124,720	\$130,017	\$135,572	\$141,155
65%	\$115,115	\$117,333	\$122,454	\$127,604	\$133,081	\$138,900
70%	\$113,364	\$114,915	\$119,711	\$124,530	\$130,130	\$136,002
75%	\$111,708	\$112,579	\$116,729	\$121,204	\$126,450	\$132,044
80%	\$109,102	\$109,732	\$113,365	\$117,893	\$123,139	\$128,545
85%	\$106,960	\$106,811	\$110,196	\$114,758	\$119,409	\$124,542
90%	\$104,521	\$103,417	\$106,264	\$110,736	\$115,456	\$120,243
95%	\$101,057	\$99,325	\$102,099	\$105,203	\$109,445	\$114,406

APPENDIX H: LIST OF PANEL EXPERTS

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APPENDIX I: REFERENCES AND DATA SOURCES

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