Alternative Approaches to Forecasting Highway Related Revenues in Virginia

by

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(ABSTRACT)

The highway related revenues for the Commonwealth of Virginia from three major tax sources; fuel tax, registration fee, and sales and use tax are estimated under three scenarios. Each scenario assumes different economic conditions for the future. The base case expects normal or moderate situations for future economy, where the optimistic case expects lower inflation rates and the pessimistic case assumes higher inflation rates.

Two modeling approaches have been used in forecasting the fuel tax revenue. One is based on travel, and the other is basesd on gasoline demand. The sales and use tax revenue has also been forecasted using two different approaches. One method depends on the demand for vehicle, and the other on the historical amount of revenues generated. Registration fee revenue for five types of vehicles are forecasted using number of registered vehicles and the average registration fees.

A comparison of the developed model with other existing state revenue forecasting models are also presented.

## ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

Appendix page

## LIST OF TABLES

## LIST OF FIGURES

# Chapter I

# INTRODUCTION

## 1.1 BACKGROUND OF THE PROBLEM

The high inflation during the 1970's for highway construction, operation and maintenance costs have outpaced the available state funding level needed for transportation improvements. This adverse financial situation was compounded by proposed energy conservation policies resulting from the 1973-74 Arab's oil embargo and the 1979 Iranian oil export cutoff. Among the examples of the conservation policies that have significant impacts on gas tax revenue, a major source of highway program funding, are federal automobile fuel economy standards, 55 mph speed limit, promotion of greater transit usage and high occupancy vehicles.

The impact of energy conservation policies and future economic conditions on state transportation financing are of increasing importance in all the states. Because of declining revenues, many states have been forced to reduce the magnitude of programs and level of services, and at the same time forced to raise taxes. According to Virginia Highway Commissioner Harold King in August 1981, the state of Virginia during the 1981-82 fiscal year awarded the smallest dollar volume of highway construction contracts in 20 years, and probably by the mid 1980's there will not be any contracts awarded for new construction. He added that the highway department would be also losing its ability to qualify for federal matching funds, one of the major non-local sources of revenues [1]. The need for federal funds may become even greater since proposals have been offered to increase the state's responsibility for funding urban and secondary roads. That places a burden on Virginia which has more than 42,000 miles of secondary roads.

The solution carried in by Virginia to generate more local revenues effective july 1, 1982 was to increase the registration fees for passenger and commercial vehicles and also levy a 3 percent tax on the wholesale price of motor fuels (Excise tax). In addition to increasing the highway-related taxes, an accurate forecast of the state revenues is also deemed necessary. To achieve this goal, a methodology was developed which the state can use to update its year-by-year or longer term forecasts of transportation revenues on the basis of changes in energy and economic conditions.

## 1.2 RESEARCH OBJECTIVES

The major objective of this research is to forecast Virginia Division of Motor Vehicles (DMV) highway related revenues in the eighties under the energy and economic conditions the state is likely to face in this decade. presently there is a model that was developed by the researchers at VPI & SU which forecasts the highway related revenues from three major sources; fuel tax, registration fee, and sales and use tax [2]. The above model and other forecasting models of highway related revenues have several shortcomings in terms of projecting fuel consumption and sales and use tax revenues. The purpose of this research is as follow:

1. To update the last year's DMV model using the 1981 data and analyzing the results in light of past trends and the new data points;

2. To develop new submodels for forecasting fuel consumption and sales and use tax revenues;

3. To compare the DMV model with two recent models developed for the Commonwealth of Virginia.

Subobjectives of this study is to revise and project new estimates for the population, economy, fuel price, and vehicle fuel efficiency variables.

The above objectives are carried in the following six chapters which are described next.

## 1.3 OUTLINE OF THE REMAINING CHAPTERS

The background of the problem and the purpose of the study were discussed in this chapter. In Chapter 2 a broad review on literature relevant to fuel consumption forecasting approaches and the vehicle demand models which respectively are the determining factors in estimating the fuel tax, registration fee, and sales and use tax revenues is given. Also the DMV revenue models, both updated and refined, are introduced. Since the continuous monitoring of results and updating of the model are imperative if the usefulness of the model is to be sustained, in Chapter 3 the last year's DMV model is updated using the 1981 data and the results are analyzed in light of past trends and new data points. In Chapter 4 the fuel tax revenue submodel and the sales and use tax revenue submodel are refined. In the refined model for forecasting fuel tax revenue, the total gallons of motor fuels were used as the dependent variable instead of the vehicle miles of travel used by the updated DMV model. Using directly the gallons of fuel as a dependent variable, the probable deficiencies of vehicle miles of travel data are eliminated. Sales and use tax refined submodel uses consumer price of all items instead of the mean price of new vehicles and mean price of used vehicles, which are unrealistic independent variables as long as all vehicle types are aggregated into one type only. In Chapter 5 the DMV model is compared with two recent models developed for the Commonwealth of Virginia. These two models are the ones developed by the Joint Legislative Audit and Review Commission (JLARC) and the Chase Econometrics model (CHASE). Forecasts of revenues under three economic conditions: Moderate, Optimistic, and Pessimistic using DMV model are given in Chapter 6. This chapter clearly shows the sensitivity of the two modeling approaches used by DMV model in forecasting the gasoline and sales and use tax revenues. Finally, in Chapter 7 the results of the forecasts are discussed and the recommendations for future research work are given.

# Chapter II

# LITERATURE REVIEW

## 2.1 INTRODUCTION

The goal of tranportation revenue forecasting is to produce reliable estimates of the funds that will be available to an agency in a future period. Transportation revenue forecast procedures are generally dependent on some general economic and demographic factors, such as population growth, economic growth, and price and availability of fuel, which are themselves quite uncertain. A degree of uncertainty is therefore inevitable and unavoidable. The forecast of transportation revenues can not have less uncertainty than the forecasts of economic, demographic, and energy variables that are used as input to the revenue forecast procedures. In order to develop a practical methodology for forecasting state transportation revenue under the energy condition of the 1980's , a synthesis is needed of forecast procedures, previous research results, and information sources. A general procedure for revenue forecasting is needed to incorporate previous research and data into an overall methodology that would be appropriate for forecasting state revenue under changing socio-economic conditions. The decision of the general procedure for revenue forecasting should involve a careful structuring of forecast porcedures to take advantage of all available data sources.

## 2.2 REVENUE FORECASTING METHODOLOGIES

There are a wide variety of forecasting methodologies available for use by researchers today, and the list is steadily growing. One reason for the increasing variety is the realization by public officials responsible for making decisions that sound, accurate forecasting techniques are a necessary part of the decision-making process. Forecasts can serve many purposes, but the most important is the use of forecasts to shape and direct current and future policies.

Since the technique chosen for use in a given forecasting situation is a function of the time frame involved in the analysis, it was decided to classify forecasting attempts by temporal requirements. Specifically, there are three classification according to time: yearly forecasts, short-term forecasts (3-5 years), and long-term forecasts (10- 20 years).

An annual revenue forecast adequatly fulfills the need of many states and local departments. And in fact, revenue collections rarely experience sudden variations on a year-to-year basis. For this reason, simple projection techniques such as trend analysis and extrapolation can be easily and accurately employed.

Short-term forecasting usually means revenue projection for 3-5 years into the future. This technique is characterized by the general introduction of economic considerations. It is recognized that economic conditions are intimately related to consumer decisions (such as travel behavior, vehicle purchase, etc.) , and subsequently to revenues. However, short-term forecasting still assumes that technological and socio-political conditions and behavior will remain relatively constant. Three classes of techniques could be used for purpose of short-term forecasting: trend analysis, regression analysis, and simple econometric models.

Long-term forecasting involves revenue projection over an extended period of time and, hence, demands a higher degree of sophistification than shorter term forecasts. The forecasting methodology must be more flexible in its application and must be able to incorporate the testing of a variety of alternative future scenarios. Because of the relative ability of the econometric models to capture real world complexities, and of their flexibility in considering a wide range of economic and policy questions, this approach is commonly used for long-term forecasting [3].

in the following pages, the common models used for forecasting national and state level fuel consumption, registration, and sales and use tax revenues are presented and their significance are discussed. Also, a brief introduction of the DMV model is given.

## 2.3 NATIONAL AND STATE LEVEL GASOLINE CONSUMPTION MODELS

Reflecting the economic conditions of the time, mathematical modeling of the transportation sector began in the late depression era, not with gasoline forecasting, but with automobile forecasting . These early efforts were largely inspired by the private sector's need for marketing information and are found in the work of DeWolff (1938). As was the case with state and local government finance studies, interest did not shift from the capital goods side of the budget to that of operating costs until the early 1970's. The efforts were directed at developing models capable of evaluating the impact of government policies on the demand for gasoline for highway use. This change in focus was brought about by the recognition of an impeding petroluem shortage by the year 2000 and by the petroluem crisis of 1973- 74. It was clear that national interests required the conservation of petroluem. Because of transportation large appetite (54% of all petroluem was consumed in the U.S. in 1976), the transportation sector was a primary target [4].

Two types of models exist for forecasting gasoline consumption. Both types relate to the short-and-long run responses in the consumption of gasoline to changes in factors affecting consumer demand. The two types of models are identified as direct and indirect estimating models. The direct estimation type of models take the form:

$$\text{Gallons of Gasoline Consumed} = f(\text{gasoline price, income, price of transportation alternatives, etc.}) \quad (2.1)$$

The disadvantage of the direct type of model is that available data permit only statewide aggregate gasoline consumption behavior to be estimated. Thus, an overlook of the significant substate variation in consumption patterns is possible. This problem can currently be addressed only through the use of the indirect modeling approach.

The indirect type of model uses the vehicle-miles of travel (VMT) as the dependent variable. The vehicle miles of travel can be estimated using standard economic assumptions such as: consumer price index of all items, price of gasoline, income, population, etc. Then the gasoline consumption is calculated by taking the estimated value of total vehicle miles of travel and dividing it by the average vehicle's mile per gallon fuel efficiency. The indirect gasoline estimation models are usually found in reports whose purpose was to develop travel demand forecasts as a means of estimating gasoline consumption. The benefit of using the indirect approach is that the availability of vehicle miles of travel on county level in most states could determine the needed gasoline supply in that area [5]. It should be recognized that data deficiencies on travel do exist because of the absence of a comprehensive count of vehicle miles of travel.

David L. Green (1978) developed a national direct gasoline demand model. The theoretical basis of the model lies in the household production theory of consumer demand. In this framework, households are viewed as purchasing goods in the market place, which they transform, in conjunction with available technology, into commodities whose consumption directly yields certain utility to the purchaser. Thus, gasoline, or even travel, is not necessarily desired for its own sake but is rather an input to the production of something else. That is, in this context the aggregate demand for gasoline is viewed as being conditional on the size, composition, and technology of the vehicle fleet, in addition to the traditional socio-economic indicators.

In Green's model, the gasoline consumption per household (GASPHH) is defined as a linear function of gasoline price (PRICE), personal disposable income (INC), registered vehicles per household (OWN), household size (SIZE), drivers per household (DRHH), and gasoline powered trucks as a percentage of gasoline powered vehicles registered within a state (PCTRUCK). Explicitly assumed constant is the vehicle stock and fleet efficiency level.

Using a pooled, cross-sectional, longitudinal state data base, with state dummy variables for the year 1966 to 1975, the following log-linear equation was estimated [5]:

$$Ln(GASPHH)=2.5-0.33*Ln(PRICE)+0.31*Ln(INC)+0.49*Ln(OWN)-0.47*Ln(SIZE)+0.11*Ln(DRHH)+0.04*Ln(PCTRUCK) \quad (R^2=0.981) \tag{2.2}$$

Another model at national level was developed by the System Design Concepts,Inc.[6]. The model uses the following procedure for forecasting gasoline consumption:

Base Year Gasoline Consumption by Vehicle Class * Predicted Relataive Number of Vehicles (Future Year/Base Year) *

Predicted Fleet Fuel Efficiency (Future Year/Base Year) * Predicted Relative Miles per Vehicle of Each Type (Future Year/Base Year) =

Predicted Future Year Gasoline Consumption by Vehicle Type

The forecast procedure begins with an allocation of gasoline consumption in base year to vehicles in a particular class, then predicts the number of vehicles in each class relative to the base year. The fuel efficiency of vehicles in each class relative to the base year are also determined. The product of multiplying these four factors together is the predicted forecst year consumption of gasoline by each class of vehicle.

In a survey of forecasting models in use by state agencies performed by Beaton, Weyland, and Neuman [5], many examples of gasoline consumption models were found. The most common form for these modeling efforts was the indirect modeling technique. Examples of this type of model have been found by Oregon and Minnesota state agencies which are discussed here. Also, examples of direct form of gasoline modeling used by Minnesota and Indiana states will be presented .

The base equations of the Oregon DOE gasoline forecasting model are:

Gallons of gasoline=Vehicle Miles of Travel/MPG (2.3)

Vehicle Miles of Travel=f(Gasoline Prices, Income, etc.) (2.4)

The value for vehicle-miles traveled is the product of the annual gasoline sales volume times an estimate of the passenger automobile fleet's MPG. Separate equations were estimated for the aggregate fleet of motor vehicles and for VMT generated by passenger vehicles. Coefficients of the equation for VMT are given in table 1.

Gasoline modeling by the Minnessota Energy Agency has taken two separate forms: first, an indirect estimation procedure similar in form to Oregon; and second, a direct gasoline estimation equation. Minnesota's first model indirectly estimates gasoline consumption through use of a recursive system of equations where vehicle miles traveled is estimated first using regression techniques.

$$Ln(V_t)=Ln(S_0)+S_1*Ln(Y_t)+S_2*Ln(P_t)+S_3*Ln(U_t)+ S_4*Ln(V_{t-1})+e_t \qquad (2.5)$$

where $S_0 ... S_4$ are estimated equation parameters;

Y=Per capita Real Income;

P=Retail Real Gasoline Price;

U=Average State Unemployment Rate;

t=Year;

$e_t$=Error Term; and

$V_t$=Vehicle-Miles Traveled.

TABLE 1

Oregon Gasoline Demand MOdel

| Dependent Variable | Coefficients of the Regression Equation for Estimating VMT (all vehicles) | (passenger cars) |
|---|---|---|
| Independent Variables: | | |
| Gasoline Price | -0.106 | -0.102 |
| Personal Income | 0.695 | 0.769 |
| Population | 1.135 | 0.947 |
| Constant | -8.736 | -7.77 |
| $R^2$ | 0.996 | 0.993 |
| n | 17 | 17 |

The gallons of gasoline needed to satisfy the desired travel through the distribution of vehicles in the two size classes (large and small) is defined as:

$$\text{Gallons} = \text{VMT} * \sum_{i=1}^{2} \frac{Ri(t)}{MPGi(t)} \qquad (2.6)$$

where R is the automobile registration by type and year.

The second Minnesota model is an example of the direct form of gasoline modeling. The actual change in gallons of gasoline consumed is assumed to lag the desired change following a given change in the independent causal variables. The equation to be estimated is:

$$X_t = C_0 + C_1 * P + C_2 * Y + C_3 * X_{t-1} + e_t \qquad (2.7)$$

where C1 and C2 are the estimates of the short-run elasticities of price and income respectively, and

X=Gallons of gasoline;

P=Price of gasoline;

Y=Per capita income;

t=Year;

C3=(1-Z);

Z=Elasticity coefficient;

e=Error term; and

the long-run adjusted elasticities (a1,a2) are computed through the formula :

$$ai = \frac{C1}{Z} \quad (2.8)$$

In the generalized least squares solution for this equation, the following parameters were estimated:

C1=-0.39, C2=0.47, Z=0.83, a1=-0.46, and a2=0.57

As in the case of the Oregon model, all fixed factors that influenced gasoline consumption over the span of years covered by the data base are forced to be reflected as either price or income effects or are placed in the error term.

The Indiana Deparment of Commerce has developed a direct state model for the determination of gasoline consumption. the model is unique in comparison to other estimating models in several ways. First, consumption is scaled on a per licensed-driver basis, and second, first differences between years are used as the basic unit of observation instead of the commonly used annual value series. Lastly, the number of consumption units (automobiles) is scaled by the number of licensed drivers.

$$\Delta\ GAST/DRILIC = -0.31128 + 1304.6 * \Delta\ GASUNITS/DRIVLIC - 24.054 * \Delta\ CPGL/CPIU \quad (2.9)$$

Where:

GAST= Gasoline consumption in millions of BTUs;

DRIVLIC= Number of licensed drivers in Indiana;

GASUNITS= Number of vehicles using gasoline as a fuel, divided by the average miles per gallon;

CPGL= Consumer price index for gasoline;

CPIU= Consumer price index; and

$\Delta$ = First differences (the incremental differences in variables' values between each time period).

In conclusion, it should be mentioned that the past decade clearly brought a new awareness to state governments of the limitations or at least the costs of developing the natural resources. The planning process, whether it be directed toward issues of land use, environment, or energy has gained strength in many agencies. The use of mathematical models as aids in this process appears to be increasing. The models reviewed are examples of a set of techniques that are being modified, expanded, and discarded dailey. Both the indirect and direct forms of gasoline consumption modeling can be used as valuable tools within the overall agency planning process.

Since the number of registered vehicles plays a significant role in determining the registration fee revenue and sales and use tax revenue, a brief discussion of most common existing national and state models is presented next.

## 2.4 VEHICLE REGISTRATION MODELS

It would be indeed difficult to overstate the significance of the automobile in the American economy and way of life. More than four out of five American households own at least one motor vehicle, and almost half of them own two or more vehicles [7]. More than 20 million new and used passenger cars purchased in 1974 accounted for almost 50 billion dollars on consumer expenditures [8]. It is only surprising that the extensive literature in economics concerning the demand for automobiles is not larger than it is.

Most recently, with increasing interest in the influence of the size, composition, and efficiency of the vehicle stock on gasoline consumption, models have been developed for forecasting vehicle demand by vehicle types. There are essentially two varieties of these model: (1) market shares models, which first forecast total demand for new cars and then use the shares equations to split the total into individual classes; and (2) class demand models, which separately specify demand equations for each vehicle type . In the following pages some examples of each modeling approach are presented.

The Rand Corporation [4] equation for new car demand per capita is a static one that includes current new and used car prices, the change in permanent income per household, and a strike dummy variable. The used car ownership is a function of real price of new cars, real price of used cars, real price of gasoline , income per household, and auto strike dummy variable. The used car price is expressed as a function of lagged stock (sum of used and new cars in previous year), new car prices, the price of gasoline, consumer income, and a strike dummy.

The Rand model departs from the customary approach of specifying an equation for the demand for the total stock. Instead, it completes the automobile submodel with an equation for the demand for used cars and an identity (lagged stock) relating total fleet to new and used car demand.

Sweeny's new car demand model is a stock adjustment model with modifications. First, new car price does not appear in the equation, whereas the rate of unemployment (a cyclical variable) does. Automobile VMT appears also, expressing the desired level of stock as a function of vehicle travel. Real disposable income also enters as does lagged stock. The sweeney's model uses the following formula:

$$Ln(A)=a_0+a_1*Ln(S-1)+a_2*Ln(V)+a_3*Ln(Y)+a_4*U \qquad (2.10)$$

where:

A=New car demand;

S-1=Lagged stock;

V=VMT;

Y=Real disposable income;

U=Unemployment rate.

Lagged stock is computed as last year's stock times the estimated survival rate times a weighting factor expressing the relative miles driven by cars of different ages, B=0.92

$$S=A+0.93*B*S-1 \quad (2.11)$$

Sweeney aggregates cars by relative usage, which intuitively would seem to be a more appropriate measure of transportation services available. The model lacks the ability to deal with some of the policy options readily dealt with by the market shares models (such as taxes on gas guzzlers) and is probably most appropriate for modeling at the aggregate national level.

All of the models described thus far are national models and were estimated either entirely or substantially using aggregate national data. Springer (1978) developed a national automobile demand model estimated entirely on a quarterly time series of cross-sectional state data. All of the new automobile class demand equations are identical in form. Demand for cars of class i (Ai) is a function of population (N), income (Y), the price of new cars in general (PA), the fuel cost per mile measure VMT (C), lagged total stock of automobiles (S-1), and lagged stock of class of i vehicles (Si-1):

$$Ai_t = Ai\,(N_t, Y_t, PA_t, C_t, S_{t-1}, Si_{t-1}) \qquad (2.12)$$

The five vehicle classes used are based on vehicle size and price: (1) Luxury, (2) Standard, (3) Intermediate, (4) Compact, and (5) Subcompact.

Springer's model is one of the few to estimate direct demand equations for automobiles by class. The quarterly U.S. state data were used in the above equation [4].

Wong et al. (1977) developed a market shares automobile demand model for the State of Minnesota that used only two car classes-large and small. First, registration of new vehicles (R) were predicted using per capita real income (Y), retail real gasoline price (P), average state unemployment rate (U), and the lagged stock (R-1).

$$Ln(R_t)=a_0+a_1*Ln(P_t)+a_3*Ln(U_t)+a_4*Ln(R_{t-1}) \qquad (2.13)$$

Since there are only two vehicle classes, the authors were able to formulate the market shares submodel as a system of two equations. The first predicts the ratio of small to large cars (D1/D2) as a linear function of income (Y), gasoline price (P), and the unemployment rate (U),

$$D1/D2=C_0+C_1*P_t+C_2*Y_t+C_3*U_t, \qquad (2.14)$$

while the second constrains the market shares to sum to one,

$$D1_t + D2_t = 1.0 \qquad (2.15)$$

This formulation has the advantage that a solution automatically produces market shares which divide new auto sales between small and large cars. The annual Minnesota state data from 1953 to 1974 were used in developing the above equation [5].

Nearly all state agencies which forecast vehicle registration use some measure of income, either total personal income or per capita income. Another important variable which is normally incorporated in the state's population over the age of which an individual can recieve a driver's license. For example, the state of Wisconsin determines the number of autos registered as a function of total population over 18 years of age. Also, it expresses the light truck and heavy truck registration as two separate equations using Wisconsin real per capita income. The state of Arizona projects number of vehicles registration using the Arizona personal income as an independent variable.

Generally the indicators used in models forecasting demand for vehicles could be divided into three parts.

1. Economic
   a. Income (disposable personal)
   b. Consumer Price Index

c. Unemployment Rate

d. Gasoline Price

e. New Car Price

f. Used Car Price

g. Strike (auto workers; steel workers)

2. Demographic

a. Population

b. Households

c. Number of Family Units of a Given Size

3. Transportation

a. Total Automobile Stock

b. Vehicle Miles Traveled

c. Automobile Scrappage Rate

d. Fuel Efficiency of a Size Class

Knowing the number of registered vehicles, the registration fee revenue could be simply determined by applying the appropriate fee rate. Likewise, the sales and use tax revenue which usually is a function of vehicle demand (either new, used or both) and economic variables such as personal income or consumer price index could be projected.

In the last part of this chapter, the DMV model which projects the local revenue from three sources: fuel tax, registration fee, and sales and use tax for the Commonwealth of Virginia is described. The emphasis is placed on major approaches and methodologies used in the model, not the specific equations which will be explained completely in the following chapters.

## 2.5 THE VIRGINIA DMV MODEL

This model is a continuation of the efforts conducted by Dr. A. G. Hobeika and his colleagues at Virginia Polytehnic Institute and State University for forecasting revenues of the Virginia Division of Motor Vehicles. The model is designed to predict future revenues under different socio-economic conditions that may occur in years ahead. The DMV revenue model clearly shows that primary factors influencing highway-related revenues are economic conditions in terms of inflation, gasoline prices, state economic growth, and vehicle fuel efficiencies.

The forecasting model is an econometric one which was developed under the assumption that population and economic factors are the major forces that affect travel behavior, vehicle ownership and use, and in turn influence the tax revenue potentials. Major tax revenues are determined by three sources:

1. Sales and use tax revenues are determined by applying the 2% tax rate to the total sales value of the vehicles.

2. Registration tax revenues are determined by multiplying the number of vehicles registered in each class (automobile, bus, truck, motorcycle, and trailer) by their respective average fees.

3. Fuel tax revenues in addition to excise and road tax revenues.

This year in addition to the updating of the old DMV model, a refined model which determines fuel consumption and sales and use tax revenues using different approaches has been added to the DMV model.

The updated DMV model, which is completely explained in chapter three, is divided into five basic submodels: economy, population, vehicle miles of travel, vehicle registration, and new and used vehicle purchaces. The basic components of the model are shown in figure 1.

Both population and economy are directly or indirectly related to each of the model's components. Both affect travel and automobile purchases. New car purchases affect the age distribution of the total auto fleet, which subsequently determines the overall gallons per mile of fuel

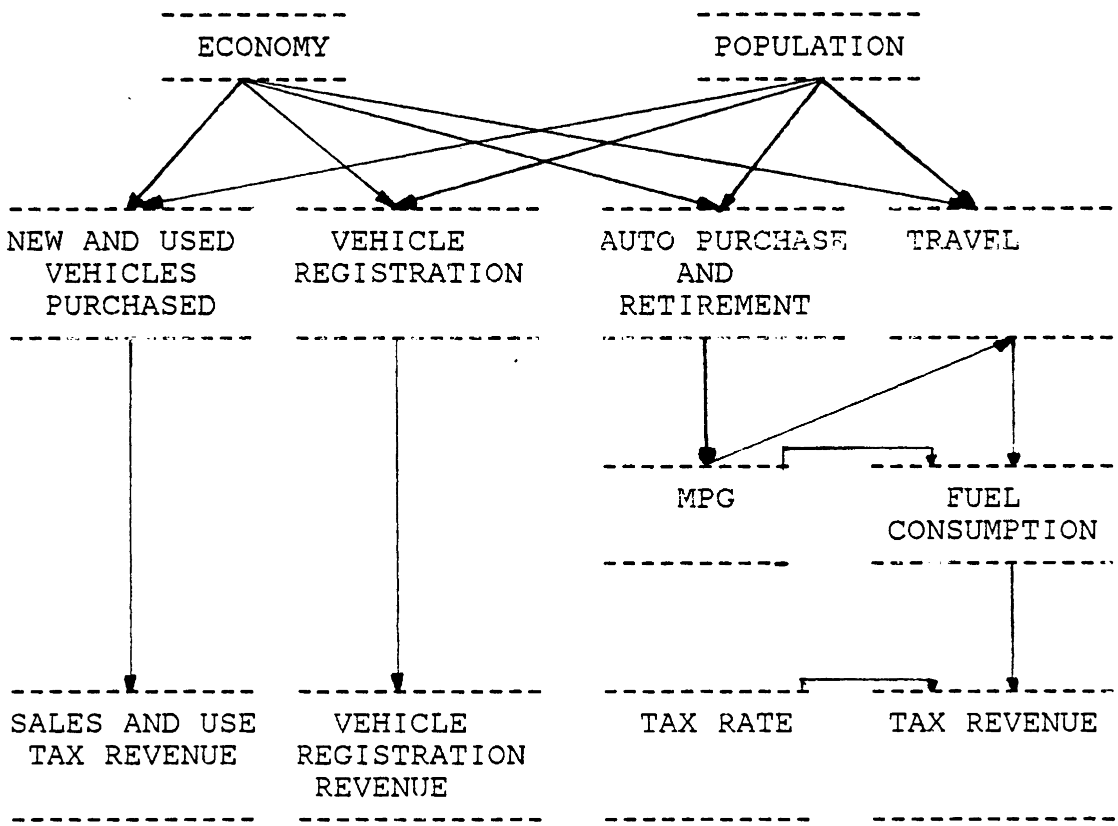


Figure 1: General Relationships in the Updated DMV Model

usage. Multiplying this figure by the amount of yearly vehicle miles of travel gives the total automobile fuel consumption. This consumption, when multiplied by the tax rate, gives the annual fuel tax revenue. In addition, population and economy affect the number of vehicles registered in the state, and new and used vehicle purchased, by influencing the driving age population (DPOP) - those persons 16 years of age and older- who can afford to own and operate a car. Sales and use tax revenues are determined by applying the 2% tax rate to the total sales value of the vehicles, where revenues from registrations are determined by multiplying the number of vehicles registered in each class (automobile, bus, truck, motorcycle, and trailer) by their respective fees.

The refined DMV model presented in chapter four uses gasoline demand (direct) approach instead of travel based (indirect) approach used by the updated DMV in determining the fuel tax revenues. Total gasoline consumption rather than total vehicle miles of travel is used as the dependent variable. Here again the economic and population variables in addition to automobile fuel efficiency are the influencing factors and are used as the independent variables. The refined sales and use tax submodel directly uses the dollar volume of sales of new and used vehicles as the dependent variable and the number of new car purchases, and consumer price index of all items as the three independent variables. The general relationships of the refined model are shown in figure 2.

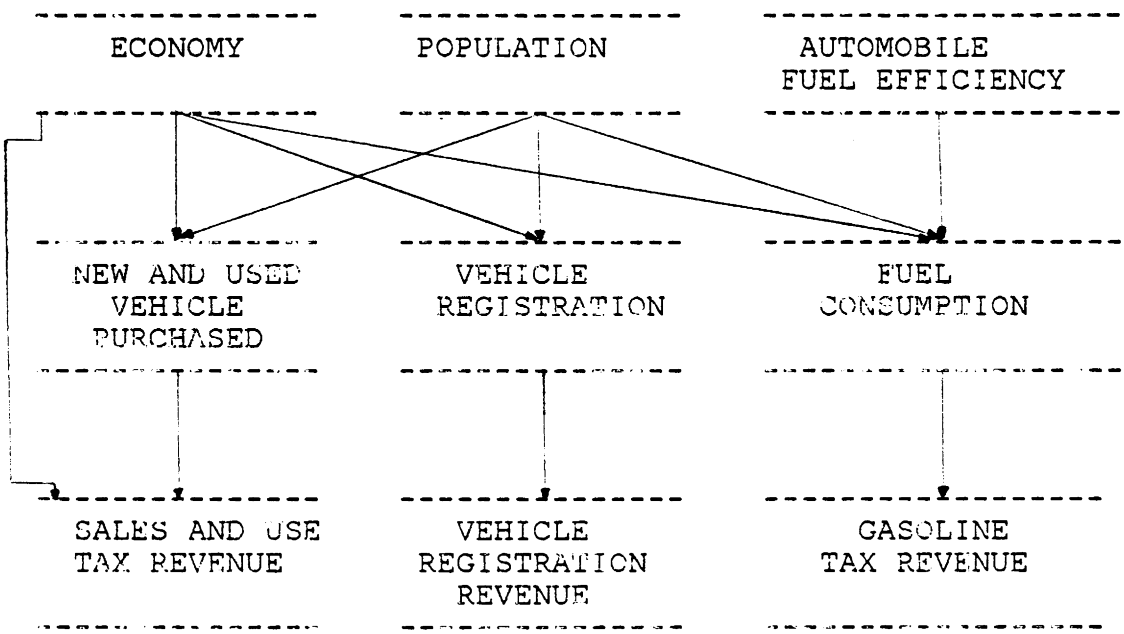


Figure 2: General Relationship of the Refined DMV Model

# Chapter III

# UPDATING AND RECALIBRATING THE DMV MODEL

## 3.1 INTRODUCTION

In order to improve the reliability and the stability of the DMV model and make it more useful as a forecasting tool, a continous updating of the data base and recalibration of the previous equations are necessary. The updated data set helps to identify any changes in the nature of the relationships between economic and demographic factors overtime. It also allows for more accurate evaluation of the interrelationships among the variables. All the equations in the DMV model were recalibrated by means of the Ordinary Least Square (OLS) method. In general, the higher the $R^2$ (coefficient of determination), the better the estimated equation fits the data used.

In this chapter, a comparison between the new recalibrated equations with those of the previous DMV model is first presented to see whether the structure and the relationship among variables have changed or not. Then the projected revenues of the recalibrated model is examined and compared against the results of the previous old DMV model and suggested recommendations are made to improve any existing equations which appear to predict unreasonable estimates.

## 3.2 COMPUTATION OF THREE MAJOR VARIABLES

Before going any further, it is essential to introduce the three major independent variables which influence almost every equation in the model. These variables are number of households in Virginia (HH), average household income (AHHI), and average cost per mile for auto (ACPM).

The total number of the households in Virginia is calculated by the following equations:

$$HH_t = POP_t / PPH_t \qquad (3.1)$$

where POP and PPH are Virginia total population and persons per household respectively. Subscript t is for the specified year. Table 2 shows the estimates of Virginia population and persons per household as adopted from last year's research [2]. No new estimates are deemed necessary for this year's work, since most of the estimates were revised and adjusted according to the 1980 census data in the previous DMV model. The annual growth rate for population is estimated to be 1.2 percent for period 1981-1990.

Since the average household income is dependent upon number of households and total personal income in Virginia(PI) as shown in Equation 3.2, the only way for increase of average household income in the future is that the personal income annual growth rate be much greater than the growth rate for number of households. The growth rate for number of households in Virginia was estimated to be about 2 percent using Table 2 and Equation 3.1. Assuming that personal income growth rate in Virginia will be about 10 percent, the annual growth rate for average household income comes to be about 5 percent, which means average household income will double after a period of ten years.

$$AHHI_t = PI_t / HH_t \qquad (3.2)$$

The last of the three variables, average cost per mile is dependent upon consumer price index for gasoline (CPIGC), auto mile per gallon fuel efficiency (AMPG), and consumer price index for parking (CPIPC). It is obvious that both high gasoline price and parking charges have direct effect on avreage auto cost per mile. But automobiles with better fuel efficiency will reduce the cost per mile.
Consumer price index for gasoline and auto mile per gallon fuel efficiency will be discussed later in this chapter.
Since after 1977, the Federal Bureau of Labor Statistics stopped generating new values for consumer price index of parking, past trends has been used for estimating new values.

$$ACPM_t = (4.1\ CPIGC_t * AMPG_{1970}) / (CPIGC_{1970} * AMPG_t) \qquad (3.3)$$
$$+ 2.0\ CPIPC_t / CPIPC_{1970}$$

where:

TABLE 2

Population and Persons Per Household Projections

| Year | Population | Persons Per Household |
|---|---|---|
| 1970 | 4,648,494* | 3.27* |
| 1971 | 4,736,000 | 3.23 |
| 1972 | 4,799,000 | 3.19 |
| 1973 | 4,865,000 | 3.15 |
| 1974 | 4,924,000 | 3.11 |
| 1975 | 4,989,000 | 3.06 |
| 1976 | 5,052,000 | 3.01 |
| 1977 | 5,122,000 | 2.96 |
| 1978 | 5,199,000 | 2.90 |
| 1979 | 5,272,000 | 2.84 |
| 1980 | 5,346,279* | 2.78* |
| 1981 | 5,410,000 | 2.73 |
| 1982 | 5,475,000 | 2.69 |
| 1983 | 5,541,000 | 2.67 |
| 1984 | 5,608,000 | 2.65 |
| 1985 | 5,675,000 | 2.63 |
| 1986 | 5,743,000 | 2.62 |
| 1987 | 5,812,000 | 2.61 |
| 1988 | 5,882,000 | 2.60 |
| 1989 | 5,952,000 | 2.59 |
| 1990 | 6,024,000 | 2.59 |

*Actual Census Data

4.1 and 2.0 figures are the average cents per mile for gasoline and parking in 1970.

### 3.3 PERSONAL INCOME(PI)

This variable influences nine out of eleven equations in DMV model and, therefore, more attention should be given to its estimation procedure. Currently the estimation of personal income in Virginia is based on one variable only, Total Discounted Capital Stock in Manufacturing (TDCSM), which is in turn obtained using Manufacturing Capital Expenditures (MFGINV) via the formula below:

$$TDCSM_t = [(SLM-1)/SLM]\ TDCSM_{t-1} + MFGINV_t * 100/CPIAI_t \qquad (3.4)$$

where
CPIAI=Consumer Price Index of All Items and SLM is the service life of manufacturing and is considered to be 14 years in this model. Previous research works[9] have shown that TDCSM is the best indicator for estimating personal income in Virginia.

The recalibrated equation for personal income and the one from last year are given below:

$$PI = 3.9141\ e^{0.5291*TDCSM} \qquad (3.5\ old)$$
$$(R^2=0.998)$$

$$PI = 4.9745\ e^{0.4652*TDCSM} \qquad (3.5\ new)$$
$$(R^2=0.998)$$

The $R^2$ for recalibrated equation remained the same as previous year. This high $R^2$ indicates the strength and consistency of the equation. Smaller coefficient for TDCSM results in lower growth rate for personal income projections.

## 3.4 VEHICLE MILES OF TRAVEL SUBMODEL

This submodel is based on four equations which estimate vehicle miles of travel by in-state automobiles (AVMISH), out-of-state automobiles (AVMOSH), total trucks (TTKVM), and heavy trucks (HTKVM) which pay an extra two cents tax per gallon (this equation has been added to the submodel this year). Using the above four equations, the total vehicle miles of travel and subsequently the total fuel consumption and gasoline tax revenue can be determined.

### 3.4.1 Travel by In-State Automobiles(AVMISH)

$$AVMISH=[2.696*10^{-6} +1.1932*10^{-9}\ AHHI67- 5.4813*10^{-7} *(ACPM*100/CPIAI)]\ HH \quad (3.6\ old)$$

$(R^2=0.8399)$

$$AVMISH=[1.7814*10^{-10} *(ACPM*100/CPIAI)^{-0.2135} * (AHHI67)^{1.2403}]\ HH \quad (3.6\ new)$$

$(R^2=0.939)$

where AHHI67 is the average household income in 1967 constant dollars.

The new equation appears to have improved the estimation of in-state vehicle miles of travel. The exponential nature of the equation seems to overestimate the travel in the future as it has done in past years. However, because of lower estimation of AHHI67, the projected values are lower than last year's predictiopn of travel by in-state automobiles. The high $R^2$ indicates stronger relationship of the dependent and independent variables. The above $R^2$ is the highest value this model has ever had.

### 3.4.2 Travel by Out-of-State Automobiles(AVMOSH)

$$AVMOSH=9.953-11091.581(ACPM/AHHI)+0.3069*TDCSM \quad (R^2=0.878) \qquad (3.7\ old)$$

$$AVMOSH=10.122-11279.262(ACPM/AHHI)+0.2584*TDCSM \quad (R^2=0.825) \qquad (3.7\ new)$$

The new equation projects lower travel for future by out-of-state automobiles and this is because of lower coefficient of capital stock in manufacturing which itself is related to investment in business, a source of providing more travel by out-of-state automobiles. Also the negative sign of the independent variable, average cost per mile, indicates the logical decrease in travel by out-of-state automobiles as the price of gasoline goes up. The lower $R^2$ is the continuation of a trend from past years which shows a weak strength among the related variables.

### 3.4.3 Travel by Trucks(TTKVM)

This equation estimates the travel by all trucks regardless of the number of their axles or their gross weight:

$$TTKVM=-5.655+0.783(PI*100/CPIAI) \quad (R^2=0.9805) \qquad (3.8\ old)$$

$$TTKVM=-5.7376+0.7782(PI*100/CPIAI) \quad (R^2=0.987) \qquad (3.8\ new)$$

The equation continues to show strong relationship between dependent and independent variables and this has resulted in even higher $R^2$ for the recalibrated equation. Since the estimation of personal income has been reduced from last year, the recalibrated equation projects lower miles of travel by trucks.

### 3.4.4 Travel by Heavy Trucks(HTKVM)

The term heavy trucks here applies to straight trucks with more than two axles and to all tractors. As has been mentioned before, this change in DMV model is because of the difference in tax rate paid by heavy trucks, which is an additional two cents per gallon.

$$HTKVM=-593.212+98.277(PI*100/CPIAI) \quad (R^2=0.941) \qquad (3.9)$$

The structure of this equation is similar to the one which estimates the total miles of travel. The data for constructing the above equation was taken from State

Corporation Commission (SCC) of Virginia. The owners of heavy trucks are required to fill the motor fuel road tax report which should indicate the total miles they traveled in Virginia and the total fuel consumed for this purpose. This report also specifies the total motor fuel used and purchased in Virginia.

The total fuel purchased in Virginia by heavy trucks (TFPIVA) is related to vehicle miles of travel by heavy trucks.

$$TFPIVA=66.05+0.1462*HTKVM \quad (R^2=0.948) \tag{3.10}$$

The above equation is needed for determining the total fuel tax revenue and also the road tax revenue. The heavy trucks' road tax revenue is obtained using the following equation:

$$ROAD\ TAX=(TFPIVA*0.02+(HTKFC-TFPIVA)*(HVFTXR+0.02)) \tag{3.11}$$

where HVFTXR is the heavy trucks tax rate.

Where heavy truck fuel consumption (HTKFC) is obtained simply with dividing heavy trucks vehicle miles by their fuel efficiency. Automobiles and light trucks fuel efficiencies are taken from last year's DMV report [2]. Heavy trucks fuel efficiency is obtained using motor fuel road tax report data. On the average the heavy trucks fuel efficiency came to be about 4.8 mile per gallon of fuel, except the year 1975, which as a result of increase in new trucks purchases, the fuel efficiency became higher. Since the heavy trucks fuel efficiency remained the same over the past years, a major change is unlikely possible. Therefore, the same fuel efficiency (4.8 mpg) is assumed for future years. This assumption becomes realistic, when considering that methods to increase fuel efficiency like reducing the weight and the size of the vehicle, is not going to be practical in case of heavy trucks. Fuel efficiency estimates for all three types of vehicles are given in table 3.

Fuel consumption of in-state and out-of-state automobiles is obtained after dividing their total miles of travel by automobile fuel efficiency. Light trucks miles of travel (total travel by all trucks minus total travel by heavy trucks), when divided by light truck fuel efficiency results in fuel consumption by these types of trucks. Finally, adding the total fuel purchased by heavy trucks to the above sum will result in the total fuel consumption in Virginia.

Knowing the total gallons of fuel consumed by all vehicles, the fuel tax revenue will be obtained after multiplying this figure by appropriate fuel tax rate.

## 3.5 VEHICLE REGISTRATION SUBMODEL

Five different vehicle types are considered in obtaining the vehicle registration revenue. These types include automobiles, buses, trucks, motorcycles, and trailers. Three equations are used to estimate the total vehicle registration. The first one, Vehicle registration (ABTREG), predicts registration of the autos, buses, and trucks combined. It is then broken down into separate estimates for each vehicle type. The other two equations estimate the motorcycle (moto) and trailer ( TRAIL) registrations.

### 3.5.1 Vehicle Registration(ABTREG)

ABTREG=-217,682+180,191*(PI*100/CPIAI) (3.12 old)
($R^2$=0.9654)

ABTREG=-934,484+220,189.81*(PI*100/CPIAI) (3.12 new)
($R^2$=0.961)

The change in $R^2$ is of an almost negligible magnitude. The structure of new equation is the same as the previous year, but it predicts higher number of vehicle registration. The growing number of vehicle registration in the past year explaines the behavior of the new equation.

Two of three equations used for determining the number of registered automobiles (auto), buses (BUS), and trucks (TRUCK) have changed completely. The only unchanged

TABLE 3

Vehicle Fuel Efficiencies Projection

| Year | Automobile(MPG) | Light Truck(MPG) | Heavy Truck(MPG) |
|---|---|---|---|
| 1976 | 13.93 | 10.52 | 4.66 |
| 1977 | 14.15 | 10.83 | 4.73 |
| 1978 | 14.06 | 11.01 | 4.75 |
| 1979 | 14.49 | 11.25 | 4.79 |
| 1980 | 15.50 | 11.70 | 4.76 |
| 1981 | 16.40 | 11.95 | 4.82 |
| 1982 | 17.20 | 12.24 | 4.80 |
| 1983 | 18.10 | 12.60 | 4.80 |
| 1984 | 19.00 | 12.99 | 4.80 |
| 1985 | 19.80 | 13.38 | 4.80 |
| 1986 | 20.80 | 13.77 | 4.80 |
| 1987 | 22.00 | 14.10 | 4.80 |
| 1988 | 23.20 | 14.45 | 4.80 |
| 1989 | 24.40 | 14.66 | 4.80 |
| 1990 | 25.60 | 14.79 | 4.80 |

equation is the one which determines the number of registered trucks.

TRUCK=ABTREG-(AUTO+BUS) (3.13)

The data for the past five years given in table 4 shows that the percentage of autos being registered has been greater than the one obtained from Equation 3.14-old. So, the updating of Equation 3.14 was really necessary.

AUTO=0.83876*ABTREG (3.14 old)

AUTO=0.842932*ABTREG (3.14 new)

The Equation 3.15-old which determines the number of registered buses is based on a compound rate of decline which has been underestimating bus registration. The old equation could not be used, since the number of registered buses has been growing over the past years. The new equation is dependent upon population, saying that as the population in an area increases the number of buses also increases accordingly. The new equation predicts a low growth rate for bus registration in the future.

$$BUS=0.0034*(1-0.01954)^{n}*ABTREG \qquad (3.15\ old)$$

$$BUS=-16759+0.0055386*POP \qquad (3.15\ new)$$

where n is the number of years beyond 1975.

### 3.5.2 Motorcycle Registration(MOTO)

$$MOTO=3.9542*10^{-32} *DPOP^{3.229479} *AHHI67^{3.709611} \quad (3.16\ old)$$
$$(R^2=0.8618)$$

$$MOTO=1.27344*10^{-35} *DPOP^{3.92207} *AHHI67^{3.4486} \quad (3.16\ new)$$
$$(R^2=0.871)$$

where DPOP is the driving age population.

Although the number of motorcycles registered during last year remained the same, the new equation projects higher motorcycle registration in the future. This is as a result of increase in projected average household income. The recalibrated equation displays stronger relationship among dependent and independent variables than the old one. This is apparent from the higher $R^2$ of the new equation.

### 3.5.3 Trailer Registration(TRAIL)

$$TRAIL=-261,565+0.155079*HH+16.5699*AHHI67 \quad (3.17\ old)$$
$$(R^2=0.977)$$

$$TRAIL=-291,295+0.157*HH+18.9361*AHHI67 \quad (3.17\ new)$$
$$(R^2=0.987)$$

The equations imply that trailer purchases will increase with income rather than with the number of potential buyers. AHHI67 now have stronger relationship than previously had. The linear structure of both equations seem to project more reasonable future trailer registrations. The new

TABLE 4

(Automobiles/Total Vehicle Registered*)X100%

| Year | Percentage |
|---|---|
| 1960 | 84.00 |
| 1961 | 84.14 |
| 1962 | 84.35 |
| 1963 | 84.41 |
| 1964 | 84.53 |
| 1965 | 84.47 |
| 1966 | 84.42 |
| 1967 | 84.29 |
| 1968 | 84.22 |
| 1969 | 84.06 |
| 1970 | 83.73 |
| 1971 | 83.54 |
| 1972 | 83.27 |
| 1973 | 82.11 |
| 1974 | 83.74 |
| 1975 | 83.35 |
| 1976 | 83.71 |
| 1977 | 84.98 |
| 1978 | 85.37 |
| 1979 | 85.51 |
| 1980 | 84.71 |
| 1981 | 84.69 |

*Total Vehicle Registered include automobiles, buses, and trucks only.

TABLE 5

(Buses/Total Vehicle Registered*)X100%

| Year | Percentage |
| --- | --- |
| 1960 | 0.457 |
| 1961 | 0.475 |
| 1962 | 0.444 |
| 1963 | 0.444 |
| 1964 | 0.450 |
| 1965 | 0.436 |
| 1966 | 0.428 |
| 1967 | 0.431 |
| 1968 | 0.431 |
| 1969 | 0.408 |
| 1970 | 0.402 |
| 1971 | 0.387 |
| 1972 | 0.377 |
| 1973 | 0.367 |
| 1974 | 0.344 |
| 1975 | 0.340 |
| 1976 | 0.335 |
| 1977 | 0.339 |
| 1978 | 0.333 |
| 1979 | 0.345 |
| 1980 | 0.366 |
| 1981 | ** |

*Total Vehicles Registered include automobiles, buses, and trucks only.
**1981 Preliminary estimates for buses is combined with trucks which is shown in table 6.

TABLE 6

(Trucks/Total Vehicle Registered*)X100%

| Year | Percentage |
|---|---|
| 1960 | 15.543 |
| 1961 | 15.385 |
| 1962 | 15.206 |
| 1963 | 15.116 |
| 1964 | 15.020 |
| 1965 | 15.090 |
| 1966 | 15.152 |
| 1967 | 15.278 |
| 1968 | 15.249 |
| 1969 | 15.532 |
| 1970 | 15.868 |
| 1971 | 16.072 |
| 1972 | 17.523 |
| 1973 | 16.916 |
| 1974 | 16.310 |
| 1975 | 16.405 |
| 1976 | 14.685 |
| 1977 | 14.291 |
| 1978 | 14.245 |
| 1979 | 14.920 |
| 1980 | 15.31** |
| 1981 | |

*Total Vehicles Regisered include automobiles, buses, and trucks only.
**Preliminary estimates for trucks and buses combined.

recalibrated equation predicts a lower growth rate for trailer purchases. This result is more consistent with today's era of high fuel prices and less new trailer purchases.

## 3.6 NEW AND USED VEHICLE PURCHASES SUBMODEL

This submodel is composed of four separate equations, representing the four factors which directly influence the sales and use tax revenue. These four variables are the mean price of new vehicles (PRNEW), the mean price of used vehicles (PRUSED), the number of new vehicles purchased (NEWCP), and the number of used vehicles purchased (USEDCP). Total sales and use revenue (SUTXRV) then is obtained using the following formula:

SUTXRV=$0.02[(PRNEW*NEWCP)+(PRUSED*USEDCP)] (3.18)

The recalibration of this submodel proved to be more encouraging. Since all the new equations are either stronger than before or only slightly weaker. Sales and use tax revenue projections as a result of these improvements appear to be more reliable and logical.

### 3.6.1 Mean Price of New Vehicles (PRNEW)

PRNEW=-424.8+33.73*CPIAI (3.19 old)
($R^2$=0.9819)

PRNEW=-643.75+35.336*CPIAI (3.19 new)
($R^2$=0.985)

The new equation displays a slightly stronger relationship than the original equation. This equation has been one of the more stable equations in the submodel. The positive relationship between PRNEW and CPIAI appears to be strenghthening after each recalibration. The new updated equation projects lower prices for new autos, because of a reduction in estimation of consumer price index of all items.

### 3.6.2 Mean Price of Used Vehicles (PRUSED)

PRUSED=6.473+0.2795*PRNEW (3.20 old)
($R^2$=0.9368)

PRUSED=-64.306+0.2962*PRNEW (3.20 new)
($R^2$=0.960)

The recalibrated equation for PRUSED is statistically superior with a higher $R^2$ value. This equation, like the one for PRNEW, has been relatively stable over the years. The new equation projects 3% increase in price of used cars compared to that of the previous DMV model in 1990.

### 3.6.3 Number of New Vehicles Purchased(NEWCP)

NEWCP=110,279+17862.83*(PI*100/CPIAI)+357.4 (3.21 old)
*(PRUSED*100/CPIAI)-219,244*(CPIGC/CPIAI)
($R^2$=0.8438)

NEWCP=-64,033+17866.69*(PI*100/CPIAI)+301.6 (3.21 new)
*(PRUSED*100/CPIAI)-221,396.74*(CPIGC/CPIAI)
($R^2$=0.818)

As one can readily see, the recalibrated equation has a lower $R^2$, but the structure and independent variables remained the same as before. In 1981, for the second year, the purchase of new automobiles dropped considerably compared to those of previous years. This noticeable change influenced the projected number of new cars purchased, and resulted in a reduction of estimated values by the new recalibrated equation.

### 3.6.4 Number of Used Vehicles Purchased(USEDCP)

USEDCP=-2,203,695+133.85*AHHI67+369.9* (PRNEW*100/CPIAI)+312,958*(CPIGC/CPIAI) ($R^2$=0.8665) (3.22 old)

USEDCP=-2,256,144+170.759*AHHI67+265.054* (PRNEW*100/CPIAI)+273,278.58*(CPIGC/CPIAI) ($R^2$=0.874) (3.22 new)

The new version exhibits a slightly improved $R^2$, and stronger relationship between used auto purchases and average household income. On the other hand, the relationship between dependent variable and independent variables PRNEW and CPIGC have weakend. The predicted number of purchased used cars seems to be slightly higher, however, the difference in this equation is not likely to result in major changes in the output from the submodel.

## 3.7 READJUSTMENT OF FUTURE ECONOMIC CONDITIONS

For making a better judgement on the two models the result of recalibrated model is compared to last year's DMV model without reflecting any changes that has been made in registration fees policy and the addition of gasoline wholesale price tax levied on the wholesalers.

There have been significant differences in estimation of revenues by the recalibrated version and that of the old DMV model. Except for the last four years of projection period, 1987-1990, total revenue predicted by the recalibrated model has been on the average about 2% greater than the old DMV model. After substantial investigation, it was found that the main driving force behind all these changes is the personal income estimated values. Personal income and its substantial influence on average household income is clearly understandable. These two independent variables are present almost in every equation of the model. Actually, the annual growth rate of personal income for revised model was 8.31 percent, compared to 9.3 percent of the old model. Personal income is highly dependent on Total Discounted Capital Stock in Manufacturing (TDCSM) which itself is obtained using Investment in Manufacturing (MFGINV) and equation 3.4. This year's estimated values for investment in manufacturing is compared with that of the last year in table 9.

The decision to reduce the growth rate of manufacturing investment is because of the future outlook in economy which appears to be in recession as a result of high interest rates and their subsequent influence on reducing business investments.

Before running the recalibrated model, assumptions for future economic conditions reflected in Consumer Price Index of All Items (CPIAI) and Consumer Price Index for Gasoline(CPIGC) under three economic situations, base, pessimistic, and optimistic are made. In estimating the consumer price index of all items, past trends and future expectation of economic conditions have been taken into account. Until 1984 the CPIAI's growth rates are expected to drop slightly every year,and by the 1990 (the end of projection period), it still stays below the 1981 growth rates even though it will experience ups and downs along the way. The graphic presentation of CPIAI's growth rates are shown in figure 3.

In estimating the consumer price index for gasolin, the pump price of gasoline projected by Energy Information Administration (EIA) has been used [10]. Since the EIA's estimates are in 1980 constant dollars, the estimated CPIAI's were used to change them into current dollars. Then having the nominal price of gasoline in current dollars and

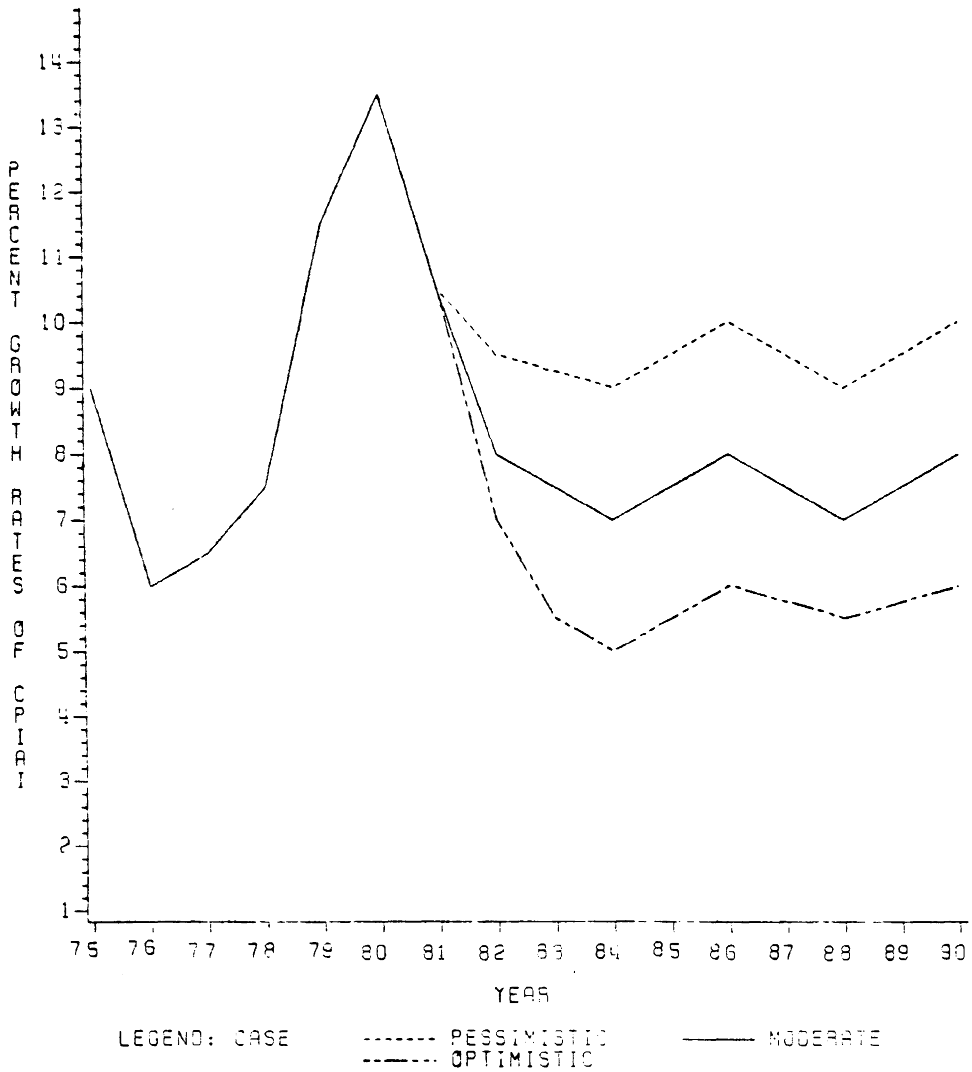


Figure 3: Percent Growth Rates of CPIAI

TABLE 7

Vehicle Miles of Travel and Registration Equations

| | | |
|---|---|---|
| Personal Income | $PI=4.9745\ e^{0.4652*TDCSM}$<br>[5465] | $R^2=0.998$ |
| Vehicle Miles of Travel | $AVMISH=[1.7814*10^{-10}*(ACPM*100/CPIAI)^{-.2135}$<br>[7.52]<br>$*(AHHI67)^{1.2403}]*HH$<br>[183.60] | $R^2=0.939$ |
| | $AVMOSH=10.122-11279.262*(ACPM/AHHI)+0.2584*TDCSM$<br>[54.22] [13.23] | $R^2=0.825$ |
| | $TTKVM=-5.7376+0.7782*(PI*100/CPIAI)$<br>[1031] | $R^2=0.987$ |
| | $HTKVM=-593.212+98.277*(PI*100/CPIAI)$<br>[127.92] | $R^2=0.941$ |
| | $TFPIVA=66.05+0.1462*HTKVM$<br>[146.07] | $R^2=0.948$ |
| Registration submodel | $ABTREG=-934484+220189.81*(PI*100/CPIAI)$<br>[297.96] | $R^2=0.961$ |
| | $MOTO=1.27344*10^{-35}*DPOP^{3.92207}*AHHI67^{3.4486}$<br>[25.75] [9.52] | $R^2=0.871$ |
| | $TRAIL=-291,295+18.9361*AHHI67+0.157*HH$<br>[58.76] [304] | $R^2=0.987$ |
| | $AUTO=0.842932*ABTREG$<br>[97447] | $R^2=0.999$ |
| | $BUS=-16759+0.0055386*POP$<br>[246.43] | $R^2=0.954$ |
| | $TRUCK=ABTREG-(AUTO+BUS)$ | |

TABLE 8

Sales and Use Tax Equations

| | | |
|---|---|---|
| Sales | PRNEW=-643.75+35.336*CPIAI | $R^2$=0.985 |
| and | [856] | |
| Use Tax | | |
| Submodel | PRUSED=-64.306+0.2962*PRNEW | $R^2$=0.960 |
| | [315] | |
| | NEWCP=-64033+17866.69*(PI*100/CPIAI)+ | $R^2$=0.818 |
| | [39.60] | |
| | 301.595*(PRUSED*100/CPIAI)-221396.74 | |
| | [5.83] | |
| | *(CPIGC/CPIAI) | |
| | [24.96] | |
| | USEDCP=-2,256,144+170.759*(AHHI67)+ | $R^2$=0.874 |
| | [39.09] | |
| | 265.054*(PRNEW*100/CPIAI)+ | |
| | [4.71] | |
| | 273,278.58*(CPIGC/CPIAI) | |
| | [7.76] | |

TABLE 9

Original and Revised Manufacturing Investment Projection*

| Year | Original MFGINV*** | New MFGINV**** |
| --- | --- | --- |
| 1979 | 1.377** | 1.377** |
| 1980 | 1.275 | 1.500 |
| 1981 | 1.415 | 1.635 |
| 1982 | 1.571 | 1.774 |
| 1983 | 1.744 | 1.925 |
| 1984 | 1.944 | 2.079 |
| 1985 | 2.167 | 2.245 |
| 1986 | 2.416 | 2.425 |
| 1987 | 2.693 | 2.643 |
| 1988 | 3.002 | 2.881 |
| 1989 | 3.347 | 3.140 |
| 1990 | 3.731 | 3.423 |

*In billions of dollars
**Actual
***Based on 11.0% growth rate for 1980-83 and 11.5% growth rate for 1984-90.
****Growth rates are 9.0% for 1980-81, 8.5% for 1982-83,8.0% for 1984-86, and 9.0% for 1987-90.

making use of the following formula the future CPIGC's were predicted.

$$CPIGC_t = (\text{Nominal Price})_t * 100/\text{Nominal Price in 1967} \quad (3.23)$$

Results of the two models, new recalibrated and the old DMV, which are shown in the following pages, reflects only the base economic condition.

Original and updated personal income estimates are given in table 13. Although the new revised model predicts higher personal income in early years, 1982-1986,its growth rates in the last 4 years drops significantly and estimates 127.26 billion dollars for personal income in 1990 compared to 140.04 billion dollars of the old DMV model.

TABLE 10

Revision of Economic Variables Under Base Economic Conditions

| Year | CPIAI | EIA Price | Nominal Price | CPIGC |
|---|---|---|---|---|
| 1979 | 217.4* | .92* | .81* | 265.6* |
| 1980 | 246.8* | 1.125 | 1.13* | 369.1* |
| 1981 | 272.4* | 1.13 | 1.25* | 410.9* |
| 1982 | 294.2 | 1.14 | 1.36 | 445.6 |
| 1983 | 316.0 | 1.15 | 1.47 | 482.8 |
| 1984 | 338.1 | 1.16 | 1.59 | 521.1 |
| 1985 | 363.4 | 1.17 | 1.72 | 564.9 |
| 1986 | 392.5 | 1.19 | 1.89 | 620.6 |
| 1987 | 422.3 | 1.21 | 2.07 | 678.9 |
| 1988 | 452.7 | 1.23 | 2.26 | 739.8 |
| 1989 | 487.2 | 1.25 | 2.47 | 809.1 |
| 1990 | 526.1 | 1.27 | 2.71 | 887.7 |

*Actual

TABLE 11

Revision of Economic Variables Under Optimistic Conditions

| Year | CPIAI | EIA Price | Nominal Price | CPIGC |
|---|---|---|---|---|
| 1979 | 217.4* | .92* | .81* | 365.6* |
| 1980 | 246.8* | 1.125 | 1.13* | 369.1* |
| 1981 | 272.4* | 1.13 | 1.25* | 410.9* |
| 1982 | 291.5 | 1.14 | 1.35 | 441.5 |
| 1983 | 307.8 | 1.15 | 1.43 | 470.3 |
| 1984 | 323.2 | 1.16 | 1.52 | 498.1 |
| 1985 | 341.0 | 1.17 | 1.62 | 530.1 |
| 1986 | 361.4 | 1.19 | 1.74 | 571.4 |
| 1987 | 382.0 | 1.21 | 1.87 | 614.1 |
| 1988 | 402.6 | 1.23 | 2.01 | 657.9 |
| 1989 | 425.6 | 1.25 | 2.16 | 706.8 |
| 1990 | 451.1 | 1.27 | 2.32 | 761.2 |

*Actual

TABLE 12

Revision of Economic Variables Under Pessimistic Conditions

| Year | CPIAI | EIA Price | Nominal Price | CPIGC |
|---|---|---|---|---|
| 1979 | 217.4* | .92* | .81* | 265.6* |
| 1980 | 246.8* | 1.125 | 1.13* | 369.1* |
| 1981 | 272.4* | 1.13 | 1.25* | 410.9* |
| 1982 | 298.3 | 1.14 | 1.38 | 451.8 |
| 1983 | 325.9 | 1.15 | 1.52 | 497.9 |
| 1984 | 355.2 | 1.16 | 1.67 | 547.4 |
| 1985 | 388.9 | 1.17 | 1.84 | 604.5 |
| 1986 | 427.8 | 1.19 | 2.06 | 676.4 |
| 1987 | 468.8 | 1.21 | 2.30 | 753.7 |
| 1988 | 512.0 | 1.23 | 2.55 | 836.7 |
| 1989 | 561.2 | 1.25 | 2.84 | 932.0 |
| 1990 | 617.3 | 1.27 | 3.17 | 1041.6 |

*Actual

TABLE 13

Original and Updated Personal Income Estimates*

| Year | Original | New |
|---|---|---|
| 1982 | 63.08 | 63.59 |
| 1983 | 69.03 | 70.38 |
| 1984 | 75.84 | 77.53 |
| 1985 | 83.47 | 84.93 |
| 1986 | 91.94 | 92.44 |
| 1987 | 101.59 | 100.38 |
| 1988 | 112.77 | 108.89 |
| 1989 | 125.62 | 117.89 |
| 1990 | 140.04 | 127.26 |

*In billions of dollars

The new recalibrated model shows on the average a decrease of 1.3% in the travel by in-state autos, a 6.8% reduction of travel by out-of-state autos, and a 0.4 percent increase in travel by all trucks. Because of the reduction in travel by autos, the total fuel consumed is predicted to be lower than the previous year's estimation. This is as a result of using different fuel efficiencies for light autos, light trucks, and heavy trucks. On the average the fuel consumption has decreased by 3.6 percent in comparison to the old DMV model.

The registration submodel has been performing quite well and this year is not an exception. Despite a very slight higher estimate for all types of vehicles, the results of new recalibrated submodel appears to be reliable and consistent. The growth rate for total vehicle registered dropped to 1.34 percent compared to its previous value of 1.96 percent.

Over estimation of sales and use tax submodel has always been noticeable, but this year's model might put an end to it. Except average price of used vehicles and used vehicle purchases, all other equations predicted lower values compared to the old DMV model.

Automobile fuel tax revenue projected by last year's DMV model had a decreasing trend. The new recalibrated model,

TABLE 14

Original Estimates For Travel and Fuel Consumption

| Year | Travel by In-State Autos* | Travel by Out-of-States AUTOS* | Travel by trucks* | Total Vehicle Miles of Travel* | Total Fuel Consumed ** |
|---|---|---|---|---|---|
| 1982 | 24.47 | 5.44 | 11.04 | 40.94 | 2.82 |
| 1983 | 24.98 | 5.64 | 11.26 | 41.65 | 2.78 |
| 1984 | 25.71 | 5.88 | 11.62 | 43.21 | 2.77 |
| 1985 | 26.23 | 6.03 | 11.88 | 44.14 | 2.75 |
| 1986 | 26.78 | 6.27 | 12.10 | 45.14 | 2.71 |
| 1987 | 27.62 | 6.56 | 12.51 | 46.69 | 2.70 |
| 1988 | 28.71 | 6.88 | 13.08 | 48.67 | 2.72 |
| 1989 | 29.81 | 7.18 | 13.67 | 50.66 | 2.73 |
| 1990 | 30.74 | 7.47 | 14.15 | 52.35 | 2.74 |

*In billion miles

**In billion gallons

TABLE 15

New Estimates for Travel and Fuel Consumption

| Year | Travel by In-State Autos* | Travel by Out-of-State AUTOS* | Travel by Light Trucks* | Travel by Heavy Trucks* | Total Fuel Consumed ** |
|---|---|---|---|---|---|
| 1982 | 24.24 | 5.00 | 9.549 | 1.531 | 2.75 |
| 1983 | 25.22 | 5.34 | 9.995 | 1.595 | 2.76 |
| 1984 | 26.19 | 5.64 | 10.450 | 1.660 | 2.77 |
| 1985 | 26.84 | 5.84 | 10.746 | 1.704 | 2.75 |
| 1987 | 27.54 | 6.18 | 11.017 | 1.743 | 2.61 |
| 1988 | 28.01 | 6.36 | 11.209 | 1.771 | 2.56 |
| 1989 | 28.27 | 6.49 | 11.305 | 1.785 | 2.50 |
| 1990 | 28.34 | 6.61 | 11.306 | 1.784 | 2.44 |

*In billion miles

**In billion gallons

on the other hand, predicted lower revenue from the fuel tax. The reason behind all these is that the trucks were divided into light and heavy classes, and therefore, different fuel efficiencies were used which resulted in more accurate fuel consumption estimates and subsequently reliable fuel tax revenues. This year's total fuel consumption has been reduced by 0.825 percent ( the total refunded gallons of fuel).

The new recalibrated submodel for registration predicts more revenue from this source. The basic reason is the increase in prediction of total number of vehicle registrations.

Sales and use tax revenue is projected to be higher by the recalibrated model in the earlier years, 1982-1987. But as the year 1990 is reached, the total sales and use tax revenue becomes 199.09 million dollars compared to that of 220.74 million dollars projected by the previous DMV model. The estimation of sales and use tax revenue by the new submodel appears to be more logical and accurate, especially when remembering the over estimation of the previous models.

Overall this year's recalibrated DMV model estimates higher revenue for the future and its increase is more apparent in the first five years of projection period 1982-1986. The reason, as mentioned before, is a reflection of slightly higher estimates of personal income and its subsequent impact on average household income in Virginia.

Since the performance of gasoline tax and sales and use tax submodels are not satisfactory, in the next chapter, it is tried to improve these two submodels in order to make better and consistent estimates of the above revenue sources which together provide almost 83 percent of the total local vehicle related revenues.

TABLE 16

Original Estimates for Vehicle Registration

| Year | Automobile | Bus | Truck | Motorcycle | Trailer | Total |
|---|---|---|---|---|---|---|
| 1982 | 3,039,496 | 10732 | 573569 | 79,810 | 227,641 | 3931246 |
| 1983 | 3,082,017 | 10670 | 581806 | 81,559 | 232,735 | 3988785 |
| 1984 | 3,150,664 | 10694 | 594978 | 85,754 | 239,290 | 4081379 |
| 1985 | 3,201,519 | 10655 | 604793 | 88,215 | 245,002 | 4150182 |
| 1986 | 3,243,308 | 10583 | 612899 | 91,062 | 249,715 | 4207565 |
| 1987 | 3,322,998 | 10631 | 628170 | 97,748 | 256,358 | 4315903 |
| 1988 | 3,433,891 | 10771 | 649347 | 108,153 | 264,520 | 4466680 |
| 1989 | 3,531,940 | 10863 | 668104 | 119,484 | 272,772 | 4603161 |
| 1990 | 2,581,503 | 10800 | 677695 | 130,875 | 279,271 | 4680143 |

TABLE 17

New Estimates for Vehicle Registration

| Year | Automobile | Bus | Truck | Motorcycle | Trailer | Total |
|---|---|---|---|---|---|---|
| 1982 | 3,223,830 | 13567 | 587147 | 93,128 | 229,362 | 4147034 |
| 1983 | 3,269,041 | 13931 | 595208 | 101,971 | 237,735 | 4217886 |
| 1984 | 3,315,019 | 14299 | 603407 | 111,384 | 246,118 | 4290227 |
| 1985 | 3,360,998 | 14672 | 611601 | 117,391 | 252,572 | 4357234 |
| 1986 | 3,407,742 | 15049 | 619934 | 120,521 | 256,296 | 4419542 |
| 1987 | 3,454,487 | 15431 | 628262 | 124,306 | 260,436 | 4482922 |
| 1988 | 3,501,998 | 15817 | 636729 | 129,408 | 265,211 | 4549163 |
| 1989 | 3,549,508 | 16208 | 645191 | 131,879 | 268,889 | 4611675 |
| 1990 | 3,559,317 | 16603 | 654078 | 133,545 | 270,800 | 4674343 |

TABLE 18

Original Estimates for Vehicle Purchases

| Year | New Vehicle Purchased | Used Vehicle Purchased | Average Price of New Cars$ | Average Price of Used Cars$ |
|---|---|---|---|---|
| 1982 | 285,699 | 839,511 | 9,556 | 2,664 |
| 1983 | 287,697 | 841,252 | 10,356 | 2,888 |
| 1984 | 294,026 | 850,788 | 11,175 | 3,117 |
| 1985 | 295,245 | 857,187 | 12,150 | 3,389 |
| 1986 | 298,822 | 859,527 | 13,257 | 3,699 |
| 1987 | 305,575 | 877,375 | 14,349 | 4,004 |
| 1988 | 317,075 | 904,327 | 15,473 | 4,318 |
| 1989 | 328,879 | 931,170 | 16,744 | 4,674 |
| 1990 | 338,119 | 954,567 | 18,255 | 5,096 |

TABLE 19

New Estimates for Vehicle Purchases

| Year | New Vehicle Purchased | Used Vehicle Purchased | Average Price of New Cars$ | Average Price of Used Cars$ |
|---|---|---|---|---|
| 1982 | 276,358 | 849,738 | 9,752 | 2,824 |
| 1983 | 286,939 | 876,434 | 10,522 | 3,052 |
| 1984 | 297,334 | 901,525 | 11,303 | 3,284 |
| 1985 | 303,877 | 907,849 | 12,197 | 3,549 |
| 1986 | 302,754 | 903,735 | 13,226 | 3,853 |
| 1987 | 302,173 | 902,101 | 14,279 | 4,165 |
| 1988 | 302,596 | 905,034 | 15,353 | 4,483 |
| 1989 | 300,489 | 897,172 | 16,572 | 4,844 |
| 1990 | 295,644 | 885,214 | 17,947 | 5,251 |

TABLE 20

Original Forecasted Revenues*

| Year | Automotive Fuel Tax Revenue | Registration Revenue | Sales and Use Tax Revenue | Total Revenue |
|---|---|---|---|---|
| 1982 | 310.28 | 77.78 | 99.34 | 487.40 |
| 1983 | 305.86 | 78.90 | 108.18 | 492.94 |
| 1984 | 304.81 | 80.70 | 118.76 | 504.27 |
| 1985 | 302.28 | 82.05 | 129.85 | 514.18 |
| 1986 | 298.42 | 83.16 | 142.81 | 524.38 |
| 1987 | 297.03 | 85.25 | 157.96 | 540.24 |
| 1988 | 298.98 | 88.15 | 176.22 | 563.35 |
| 1989 | 301.05 | 90.74 | 197.17 | 588.96 |
| 1990 | 301.27 | 92.13 | 220.74 | 614.14 |

*In million of dollars

TABLE 21

New Forecasted Revenues*

| Year | Automotive Fuel Tax Revenue | Registration Revenue | Sales and Use Tax Revenue | Total Revenue |
|---|---|---|---|---|
| 1982 | 302.23 | 81.63 | 101.90 | 485.76 |
| 1983 | 303.37 | 82.89 | 113.89 | 500.15 |
| 1984 | 304.16 | 84.18 | 126.43 | 514.77 |
| 1985 | 302.05 | 85.42 | 138.56 | 526.03 |
| 1986 | 294.59 | 86.62 | 149.73 | 530.94 |
| 1987 | 287.43 | 87.82 | 161.44 | 536.69 |
| 1988 | 281.67 | 89.07 | 174.06 | 544.80 |
| 1989 | 275.24 | 90.27 | 186.52 | 552.03 |
| 1990 | 267.95 | 91.51 | 199.09 | 558.55 |

*In million of dollars

# Chapter IV

# REFINEMENT OF THE DMV REVENUE MODEL

## 4.1 INTRODUCTION

The major purpose of refining the model is to improve its reliability and eliminate some weaknesses in the structure of the model in order to provide more stable forecasts.

Since the registration submodel has been performing quite well in predicting the registration revenues over the past years, it will be kept unchanged. The fuel tax revenue submodel was based on the concept that both population and economy affect travel and automobile purchases, and new car purchases affect the age distribution of the total auto fleet, which subsequently determines the total gallons of fuel consumed per mile. Multiplying this figure by the amount of yearly vehicle miles of travel would give the total vehicle fuel consumption in a year. Finally, the gasoline tax revenue is obtained after multiplying the total fuel consumed by the tax rate. The above structure is very logical and reasonable, but the problem is that the accuracy and reliability of the data on vehicle miles of travel by three types of vehicles used in the submodel, in-state automobiles, out-of-state automobiles, and by all trucks are questionable. Instead, it was tried to eliminate the vehicle miles of travel from the submodel. The refined gasoline tax revenue submodel is primarily dependent on population, economy, and average auto mile per gallon (AMPG). The concept behind the new submodel comes from the fact that population and economy represented by number of household (HH), and average household income (AHHI), in addition to average auto mile per gallon fuel efficiency of vehicles all together determine the demand for total gasoline consumption.

The sales and use tax submodel has been using four equations, mean price of new cars (PRNEW), mean price of used cars (PRUSED), number of new vehicles purchased (NEWCP), and number of used vehicles purchased (USEDCP ). The sales and use tax revenue obtained by applying two percent tax to sum of (NEWCP*PRNEW) and (USEDCP*PRUSED) has been always overestimating the revenue. Using a mean price for new and used cars purchased, seems to be the main contributing factor for inaccuracy of the submodel. Because a small variation in the mean price would result in a sizable tax difference when muliplied by car purchases. The refined submodel uses two new equations in predicting the number of used and new vehicle purchases, and then directly finds the sales and use tax revenue using results of the above equations and also the consumer price index for all items, which substitutes for the mean price of new and used vehicles.

## 4.2 GASOLINE DEMAND SUBMODEL

The submodel is divided into two parts, the first part determines the total fuel consumed by all vehicles except the heavy trucks (straight trucks with more than 2 axles ), using the gasoline demand concept stated earlier. The second part finds fuel consumed by heavy trucks using their total annual miles of travel and their fuel efficiency. The reason for making use of miles of travel again is that these heavy trucks are required to fill the motor fuel road tax report every year, which shows their annual miles of travel and the total gallons of fuel used in one year. Whether the information given in these reports are totally accurate or not does not matter, since the DMV is collecting the road tax revenue based on these reports. Of course, the main purpose of dividing the whole submodel into two parts is because of the difference in tax rate charged on a gallon of fuel for these two types of vehicles.

### 4.2.1 Fuel Consumption by Automobiles (CLTFC)

In the previous chapter three equations were used to determine the total gasoline consumed by predicting the total travel by in-state automobiles, by out-of-state automobiles, and by all trucks. The refined equation given below determines directly the fuel consumption by all vehicles excluding heavy trucks.

$$CLTFC=-2616.021+0.354747*AHHI67+0.0015358*HH -97.29116*AMPG \quad (R^2=0.867) \qquad (4.1)$$

where CLTFC=Car and Light Trucks Fuel Consumption

The $R^2$ of refined equation is high enough to predict reliable and accurate forecasts of fuel consumption by cars and light trucks. The positive coefficients of average household income and number of households indicate the fact that gasoline demand increases with an increase in value of these two independent variables. Average household income was used as an economic variable to explain the increase in the demand for gasoline as the real household income increases. The number of households on the other hand is used to represent the size of the demand and as a substitute variable for number of vehicles. Average auto fleet efficiency has a negative effect on gasoline consumption. In other words, more fuel efficient vehicles reduce the demand for gasoline.

4.2.2 <u>Fuel Consumption by Heavy Trucks</u> (<u>HTKFC</u>)

Travel by three and more axle trucks is highly correlated with personal income as shown in the equation below:

$$HTKVM=-593.212+98.2776518*(PI*100/CPIAI) \qquad (4.2)$$
$$(R^2=0.941)$$

The above equation indicates that the better the economy of the state is, the more travel by heavy trucks is generated.

The results of the above equation are used to determine the total fuel purchased in Virginia by heavy trucks (TFPIVA).

$$TFPIVA=66.05+0.1462*HTKVM \qquad (4.3)$$
$$(R^2=0.948)$$

the high $R^2$ explains the strong relationship of HTKVM and TFPIVA. and it appears to estimate reliable and accurate forecasts.

Actually the total fuel used in Virginia by heavy trucks has been more than the amount of fuel purchased in Virginia. Road tax revenue has been calculated by applying 13 cents tax to each gallon of fuel bought outside Virginia plus two cents tax for each gallon of fuel purchased in Virginia by heavy trucks.

Heavy truck fuel efficiency which will be used to estimate future fuel usage in Virginia is obtained by dividing total heavy truck vehicle miles by total fuel used in Virginia which is given in Table 3 of the previous chapter.

## 4.3 SALES AND USE TAX SUBMODEL

The refined submodel is based on three equations, instead of five which have been used in the previous years. These three equations determine the number of used vehicle purchases, the number of new vehicle purchases, and total sales and use tax revenues.

### 4.3.1 Used Vehicle Purchases (XUSED)

$$XUSED=-465996.151+53.4816527*AHHI67-2491.30566*CPIGC+6468.463414*CPIAI \quad (R^2=0.912) \tag{4.4}$$

The refined equation has higher $R^2$, and as a result more satbility and strength exists among variables. The independent variable, mean price of new cars (PRNEW), has not been used in this equation because of its insignificant role in the previous DMV model. The linear structure of the refined equation appears to estimate more used vehicle purchases in the future rather than the old equation. The increase in purchase of used vehicles will become more logical if the economic outlook of the future which shows a reduction in average household income or in other words, less availability of money for purchase of expensive new cars is considered. Also the negative coefficient of CPIGC indicates that higher gasoline prices encourages people to buy more new cars rather than used cars which will consume more gasoline.

### 4.3.2 New Vehicle Purchases (XNEW)

$$XNEW=-377893.756648+60.21*AHHI67+3820.66717*CPIGC/CPIAI \quad (R^2=0.688) \tag{4.5}$$

However, the $R^2$ of the refined model is lower than the recalibrated DMV model, it is still acceptable and does not indicate that the equation is inaccurate. Unlike the recalibrated equaion, the mean price of used vehicles was dropped because of its low correlation with the dependent variable. The most significant phase of the new equation is the reliance on CPIGC/CPIAI which shows higher new car purchases as a result of increase in gasoline prices.

### 4.3.3 Sales and Use Tax Revenue (SUTXRV)

$$\frac{SUTXRV}{0.02}=8.946*(XNEW)^{0.49673}*(XUSED)^{0.69612}*CPIAI^{0.73714} \quad (R^2=0.980) \tag{4.6}$$

where 0.02 =sales and use tax rate

The above equation estimates the sales and use tax revenue without using mean price of new and used vehicles. Actually, the CPIAI which has been used to estimate PRNEW and PRUSED is substituted here instead of those variables. The very high $R^2$ is an indication of strength and stability of the equation, and the results presented in the following pages will support this notation as well. The values of XUSED and XNEW are taken from the results of equations 4.4 and 4.5.

## 4.4 RESULTS OF THE REFINED MODEL

In order to run the gasoline consumption submodel, it is needed to estimate future values of four independent variables used in the refined equations, which are average household income (AHHI), number of households (HH), average auto mile per gallon (AMPG), and heavy trucks mile per gallon fuel efficiency (HTKMPG). Since used and new car purchases are a function of consumer price index for gasoline (CPIGC) and average household income (AHHI), a future prediction of the above variables are necessary. Projection of consumer price index for gasoline has been made in chapter two. The average household income is obtained after dividing personal income by number of households, the same as equation 3.2.

In constant dollars the average household income for the year 1990 is actually 1.82 percent lower than the 1981 values, because the growth rate for population is estimated

TABLE 22

Refined DMV Equations

| | | |
|---|---|---|
| Gasoline Tax Submodel | CLTFC=-2616.021+0.354747*AHHI67 [6.69]<br>+0.0015358*HH-97.29116*AMPG [7.06] [0.71] | $R^2$=0.867 |
| | HTKVM=-593.212+98.27765*(PI*100/CPIAI) [14.15] | $R^2$=0.941 |
| | TFPIVA=66.05+0.1462*HTKVM [146.07] | $R^2$=0.948 |
| Sales and Use Tax Submodel | XUSED=-465996.151+53.48165*AHHI67 [1.57]<br>-2491.30566*CPIGC+6468.463414*CPIAI [5.10] [9.23] | $R^2$=0.912 |
| | XNEW=-377893.756648+60.21*AHHI67+ [26.42]<br>3820.66717*CPIGC/CPIAI [0.01] | $R^2$=0.688 |
| | $\frac{SUTXRV}{0.02}=8.946*NEW^{0.49673}*USED^{0.69612}*CPIAI^{0.73714}$<br>NEW [4.96], USED [6.21], CPIAI [27.52] | $R^2$=0.980 |

TABLE 23

Households Number and Income Estimates

| Year | Number of Households | Average Household Income* |
|---|---|---|
| 1982 | 2,035,449 | 31,243 |
| 1983 | 2,075,304 | 33,911 |
| 1984 | 2,116,059 | 36,637 |
| 1985 | 2,157,736 | 39,361 |
| 1986 | 2,191,963 | 42,171 |
| 1987 | 2,226,766 | 45,077 |
| 1988 | 2,262,154 | 48,136 |
| 1989 | 2,298,139 | 51,297 |
| 1990 | 2,325,717 | 54,720 |

*Average Household Income is in Current Dollars.

to be much greater than the one for personal income in Virginia.

The heavy truck average mile per gallon is assumed to remain unchanged, since over the past ten years, the heavy truck fuel efficiency has been very close to 4.8 value. The justification for future fuel efficiency value is that unlike the automobiles, any weight reduction of heavy trucks in order to increase their fuel efficiency is not expected. Heavy trucks fuel efficiency is needed for determining the heavy truck fuel consumption which will be used to estimate the road tax revenue.

Comparing the results predicted by recalibrated model and table 25 , it is concluded that about 3 percent of total travel by all trucks are made by heavy trucks. Because of having very low fuel efficiency, the heavy trucks use considerable fuel regarding their total miles of travel.

The total gasoline consumed by all vehicles except heavy trucks shows a decrease in fuel after 1984, or the last six years of projection period. The total fuel used in 1990 is about 7 percent lower than the 1982 prediction. This surprising reduction is predicted to be a result of decreasing average household income in the future which appears to change the travel habits of car owners and make them to drive less often. Also, the effort to produce more

TABLE 24

Average Automobile and Heavy Truck MPG Estimates

| Year | Auto MPG | Heavy Truck MPG |
|---|---|---|
| 1982 | 17.20 | 4.8 |
| 1983 | 18.10 | 4.8 |
| 1984 | 19.00 | 4.8 |
| 1985 | 19.80 | 4.8 |
| 1986 | 20.80 | 4.8 |
| 1987 | 22.00 | 4.8 |
| 1988 | 23.20 | 4.8 |
| 1989 | 24.40 | 4.8 |
| 1990 | 25.60 | 4.8 |

TABLE 25

Heavy Trucks Miles of Travel and Fuel Consumption

| Year | Miles of Travel* | Fuel Consumed** |
| --- | --- | --- |
| 1982 | 1531 | 319 |
| 1983 | 1595 | 332 |
| 1984 | 1660 | 346 |
| 1985 | 1704 | 355 |
| 1986 | 1721 | 359 |
| 1987 | 1743 | 363 |
| 1988 | 1771 | 369 |
| 1989 | 1785 | 372 |
| 1990 | 1784 | 372 |

*In Million Miles

**In Million Gallons

small and fuel efficient cars by manufactures might be the other contributing factor in reducing the consumption of fuels.

The past data indicates that the fuel tax of about 1.5 percent of the total gallons of fuels consumed in Virginia will be refunded. So for calculating the total fuel tax revenues, the total fuel consumption has been reduced by 1.5 percent before applying the appropriate tax rate. Road tax was calculated by multiplying 13 cents by total fuel used in Virginia minus 11 cents times the total fuel purchased in Virginia by heavy trucks. There is about 5 percent difference in fuel revenues estimated by recalibrated and above refined submodel. Since the refined model directly uses total fuel consumption as a dependent variable and major contributing factors such as AHHI, HH, and AMPG for the independent variables, the predicted results appear to be more reliable and reasonable than those estimated by recalibrated submodel.

The refined submodel predicts less NEW and more USED vehicle purchases in the future, however, it follows the same trend as the recalibrated model, which is a decrease in purchases of new vehicles after 1985. The growth rate for USED vehicle purchases is about 4.6 percent annually.

TABLE 26

Gasoline Consumption by Autos and Heavy trucks*

| Year | Fuel Consumed by Automobiles | Total Gasoline Purchased in VA. | Fuel Purchased by Heavy Trucks in VA. |
|---|---|---|---|
| 1982 | 2,604 | 2,894 | 290 |
| 1983 | 2,617 | 2,916 | 299 |
| 1984 | 2,629 | 2,938 | 309 |
| 1985 | 2,614 | 2,929 | 315 |
| 1986 | 2,538 | 2,856 | 318 |
| 1987 | 2,450 | 2,771 | 321 |
| 1988 | 2,373 | 2,698 | 325 |
| 1989 | 2,275 | 2,602 | 327 |
| 1990 | 2,155 | 2,482 | 327 |

*In Million of Gallons

TABLE 27

Estimates of Fuel and Road Tax Revenue*

| Year | Fuel Tax Revenue | Road Tax Revenue |
|---|---|---|
| 1982 | 313.54 | 9.579 |
| 1983 | 315.99 | 10.287 |
| 1984 | 318.34 | 11.000 |
| 1985 | 317.35 | 11.477 |
| 1986 | 309.44 | 11.671 |
| 1987 | 300.23 | 11.907 |
| 1988 | 292.33 | 12.215 |
| 1989 | 281.89 | 12.370 |
| 1990 | 268.91 | 12.362 |

*In Million of Dollars

It has been noticed that almost one out of every 3 cars (actually 3.15) registered in Virginia will be involved in transaction. It means that the total of new and used vehicles purchased are about 1/3 of total vehicles registered. The above relation has been used to check and choose one of the two submodels, recalibrated or refined, which gives better estimation of new and used purchases. For this purpose, the registration submodel of chapter three was used and its future estimates of total registered vehicles were divided by 3.15 to get an approximation of total new and used vehicle purchases. The results of refined model even though still low, proved to give better projection of future new and used vehicle purchases.

There is no doubt about overestimation of sales and use tax submodel in the previous years. The refined submodel predicts much lower sales and use tax revenue. The estimated revenue of refined submodel for year 1990 is about 156.917 million dollars compared to 199.089 million dollars of recalibrated one or actually about 27 percent reduction of projected revenue. The results of refined submodel matches the previous data and the estimated revenues appear to be very logical and reliable. As yet, this submodel seems to be the best one that gives stable and accurate prediction of the sales and use tax revenue.

TABLE 28

Estimated New and Used Vehicle Purchases

| Year | New Vehicle Purchased | Used Vehicle Purchased |
|---|---|---|
| 1982 | 267,293 | 894,847 |
| 1983 | 274,071 | 949,160 |
| 1984 | 280,432 | 1,002,301 |
| 1985 | 280,199 | 1,056,581 |
| 1986 | 275,054 | 1,101,387 |
| 1987 | 270,946 | 1,145,166 |
| 1988 | 268,565 | 1,187,880 |
| 1989 | 262,397 | 1,232,826 |
| 1990 | 254,806 | 1,281,801 |

TABLE 29

Estimated of Sales and Use Tax Revenue*

| Year | Sales and Use Tax Revenue |
|---|---|
| 1982 | 81.522 |
| 1983 | 90.651 |
| 1984 | 100.100 |
| 1985 | 109.471 |
| 1986 | 118.173 |
| 1987 | 127.199 |
| 1988 | 136.743 |
| 1989 | 146.431 |
| 1990 | 156.917 |

*In millions of Dollars

## Chapter V

## COMPARISON OF ALTERNATIVE REVENUE MODELS

### 5.1 INTRODUCTION

In this chapter, three recent revenue models developed for the Commonwealth of Virginia were discussed and compared. The focus was basically on accuracy of forecasts and stability and reliability of the models' equations over time. These three models are referred to as the Division of Motor Vehicles model (DMV), the Joint Legislative and Audit Review Commission model (JLARC), and the Chase Econometrics model (CHASE).

All three models compared here are of econometric type models. These forecasting models rely on statistical techniques and past data to predict the future revenues. The main advantage of econometric models lies in their ability to deal with a wide variety of variables. Econometric models are a valuable tool for testing and evaluating alternative future scenarios and policies. It is very important that these models are well constructed, and are periodically tested and adjusted.

The JLARC model is used as a short-range forecasting model to project revenues up to the year 1986. But the DMV and the CHASE are long-range models and the projection period is up to the year 1990. It should be kept in mind that longer time periods cause more uncertain predictions.

It is necessary to mention here that the three models are compared under the taxation policies prior to July 1, 1982. That is before the increase in registration fees and the three percent tax on the wholesale price of motor fuel by the wholesale dealers.

In previous chapters, sufficient background about the DMV model was given. Here, JLARC and CHASE models are briefly explained.

Joint Legislative Audit and Review Commission (JLARC) was assigned by Senate Joint Resolution 50 of the General Assembly of Virginia to review the programs and activities of the Department of Highway and Transportation (DHT). One section of the report prepared by JLARC [11] presents estimates of future revenues to be generated by current taxes. The emphasis was basically on revenues collected from three major sources: motor fuel tax, sales and use tax, and registration fee. The above sources generally will account for more than 90 percent of state-generated revenues. The method used in JLARC model for forecasting was a time series regression model. It statistically computes the past revenues using economic or environmental variables. Then using the future expectations of the economy the estimated revenues are projected.

The other revenue forecasting model was developed by Chase Econometrics, a private forecasting firm. The model was available at the end of winter 1982. In addition to vehicle-related revenues, it forecasts the general fund revenues such as corporate income tax, insurance company premium tax and etc.

In the following pages the above three models are briefly discussed for each of the three major taxes and their forecasted revenues are presented.

## 5.2 MOTOR FUEL TAX SUBMODELS

The motor fuel consumption in Virginia has become increasingly unstable in the last ten years. The reason could be the high fuel prices and the shift to small cars which resulted in a reduction in motor fuel consumption and consequently a decline in fuel tax revenue.

The fuel tax submodels presented here mainly are grouped into two modeling approaches, the indirect travel based approach and the direct gasoline demand approach. The DMV model uses both approaches in determining the fuel tax revenue. The updated DMV presented in Chapter Three is based on forecasting travel and indirectly the fuel tax revenue, while the refined DMV model mentioned in Chapter Four directly uses a gasoline demand model to predict the total fuel tax revenue. The JLARC model follows the indirect travel-based approach and the CHASE model uses the gasoline demand route.

The JALRC motor fuel tax submodel uses Virginia's total vehicle miles of travel, real household income, and vehicle cost per mile as the independent variables. The vehicle miles of travel used in the submodel is the sum of travel by four classes of vehicles [11].

Class I. All passenger cars, pick up trucks, panel trucks motorcycles.

Class II. Two-axle, six tire trucks.

Class III. All three-axles, single-unit trucks.

Class IV. Three-, four-, and five-axle tractor-trailer combinations.

The concept used is similar to the travel-based DMV model, which relates the fuel consumption directly to vehicle miles of travel. Then using the fuel efficiency of vehicles the travel is translated into gallons of fuel consumed. Applying the fuel tax rate to the total gallons of fuel consumption would produce the motor fuel tax revenues.

Dividing the vehicles into four classes proved to be unnecessary, since an aggregate value for vehicle miles of travel by all classes was used, as well as an aggregate value for fuel efficiency.

The equation used for determining vehicle miles of travel (VMT) is given below:

$$\text{Ln(VMT)} = 0.705799 + 210.947(\text{Real Household Income}) - 1.57188(\text{Vehicle Cost Per Mile}) \quad (5.1)$$
$$(R^2 = 0.9916)$$

Real household income variable was used as a measure of economy which indicates the better the state's economy, the more travel is produced. The vehicle cost per mile as shown in the above equation has a negative effect on travel. It indicates that high gasoline prices and less fuel efficient cars reduce the travel. Vehicle cost per mile is derived using the following formula:

$$\text{Vehicle Cost Per Mile} = (\text{Gasoline Price}/\text{GNP Deflator})/\text{Fuel Efficiency} \quad (5.2)$$

Where GNP is the gross national product.

Here again one figure for fuel efficiency for all vehicles is used and the vehicle cost is restricted only to the real price of gasoline per mile, irrespective of maintenance costs and their variations among the different classes of vehicles.

The CHASE model uses the direct gasoline-demand approach for projecting fuel consumption and cosequently fuel tax revenues [12]. It uses the total net motor fuel tax collections (NMFVA) as a dependent variable. The independent variable is the quarterly net taxable gallons of gasoline and special fuels (TGALVA) which enters the equation in the form of a two quarter moving average because there is some lag between the sale of the fuels and the reciept of the tax revenue.

$$Log(NMFVA/MFTR)=6.17937+0.7161*Log[TGALVA+TGALVA(-1)/2] \quad (R^2=0.764) \qquad (5.3)$$

where MFTR is the motor fuels tax rate.

In the equation for estimating the quarterly net taxable gallons of gasoline and special fuels, the independent variables are number of passenger vehicles registered in Virginia (AUTOVA), consumer price index for gasoline (PCIGOS), consumer price index of all items (PCIUS), dummy variables for the first three quarters (QD), and dummy variable for oil embargo (DEMB).

$$Log(TGALVA)=-4.55907+1.21757*Log(AUTOVA)-0.48973*Log(PCIGOS/PCIUS)-0.08047*QD1+0.0334*QD2+0.05066*QD3-0.09084*DEMB \quad (R^2=0.960) \qquad (5.4)$$

where AUTOVA is a function of new passenger cars registered in Virginia (XCARSVA):

$$AUTOVA_t=0.92352*XCARSVA_t+0.98911*AUTOVA_{(t-1)} \quad (R^2=0.999) \qquad (5.5)$$

The number of new passenger cars (XCARSVA) is modeled as a function of disposable personal income in Virginia (RDPIVA), implicit deflator of new cars consumption expenditures (PCANN), dummy variables for strike (DASTR) and oil embargo (DEMB), consumer price index for gasoline (PCIGOS) and for all items (PCIUS).

$$\text{Log(XCARSVA)} = 8.11345 + 0.53534 * \text{Log}[(\text{RDPIVA/PCANN} + \text{RDPIVA}(-1)/\text{PCANN}(-1)/2] + 0.09396 * \text{DASTR} - 0.11704 * \text{Log}[\text{PCIGOS}(-1)/\text{PCIUS}(-1)] - 0.222 * \text{DEMB} \quad (R^2 = 0.555) \qquad (5.6)$$

The model is directly based on the demand for gasoline instead on the vehicle miles of travel translated into fuel consumption. However, it takes as input the passenger cars only without considering or accounting for other types of vehicles. The impact of increased fuel efficiency in passenger cars is lacking and this will reflect on the total demand for gasoline. Inflationary pressures in the economy are introduced into the model by using consumer price indices for gasoline and for all goods. oil embargo dummy variable explaines the change in supply of fuel and provide a better fit of the model to the previous data.

Actual fuel tax revenue for the year 1981 given in the motor fuel tax report which is published yearly by the Division of Motor Vehicles of Virginia was about 304.277 million dollars. Fuel tax revenues estimated by CHASE, JLARC, gasoline-demand DMV, and travel-based DMV showed respectively 5.4, 4.6, 2.2, and 1.2 percent error in their projections.

The above models which used economic, demographic and fuel efficiency factors to forecast motor fuel consumption show that there is a declining trend in fuel consumption, except for the CHASE model that shows a small upward trend.

In comparing the two modeling approaches, the travel based models provided comparable results to the gasoline demand models. From the results it can also be concluded that the reliability of fuel consumption forecasts is more dependent on the accuracy of economic projections rather than on the modeling approach. The forecasted fuel tax revenues established by the above models are given in table 30. Also the structure of each model's equations are presented in table 31.

The JLARC model had provided fuel tax revenue forecasts up to the year 1986 only. It is also necessary to point out that JLARC's estimates of fuel tax revenue are for the fiscal year, not the calendar year used as the basis of forecasting by the CHASE and DMV models.

## 5.3 REGISTRATION FEE REVENUE SUBMODELS

Most stable of the major sources of revenues over the past years has been the registration fee revenues. despite a small decreases in a few years, the revenues have risen very slightly in most years.

JLARC registration fee submodel uses number of registered cars as a dependent variable and number of registered vehicles in pervious year and real household income as the two independent variables. In addition to the number of new

TABLE 30

Total Fuel Tax Revenue Estimates*

| Year | CHASE | JLARC | Travel-based DMV | Gasoline-demand DMV |
|---|---|---|---|---|
| 1981 | 322.3 | 318.9 | 300.5 | 311.1 |
| 1982 | 318.4 | 295.0 | 302.2 | 313.5 |
| 1983 | 330.8 | 281.2 | 303.4 | 316.0 |
| 1984 | 337.1 | 273.4 | 304.2 | 318.3 |
| 1985 | 342.3 | 273.6 | 302.1 | 317.3 |
| 1986 | 344.9 | 275.4 | 294.6 | 309.4 |
| 1987 | 346.6 | N/A | 287.4 | 300.2 |
| 1988 | 348.2 | N/A | 281.7 | 292.3 |
| 1989 | 350.0 | N/A | 275.2 | 281.9 |
| 1990 | 350.7 | N/A | 267.9 | 268.9 |

N/A=Not Available

*In Million of Dollars

TABLE 31

Structure of Motor Fuel Tax Submodels

| Model | Dependent Variable | Independent Variable |
|---|---|---|
| JLARC | Total Vehicle Miles of Travel | *Real Household Income<br>*Vehicle Cost Per Mile |
| CHASE | Total Net Motor Fuel Tax Collections | *Quarterly Net Taxable Gallon of Gasoline and Special Fuel |
| | Quarterly Net Taxable Gallons of Gasoline and Special Fuels | *Number of Passenger Cars Registered in Virginia<br>*Consumer Price Index for Gasoline<br>*Consumer Price Index of All Items<br>*Quarterly Dummy Variables<br>*Oil Embargo Dummy Variable |
| Gasoline Demand DMV | Cars and Light Trucks Fuel Consumption | *Average Household Income<br>*Number of Households<br>*Average Auto fuel Efficiency |
| | Total Fuel Purchased by Heavy Trucks in VA. | *Heavy Trucks Vehicle Miles of Travel |
| Travel Based DMV | Total Vehicle Miles of Travel Excluding Heavy Trucks | *Travel by in-state Autos<br>*Travel by out-of-state Autos<br>*Travel by Light Trucks |
| | Total Fuel Purchased by Heavy Trucks in VA. | *Heavy Trucks Vehicle Miles of Travel |

car purchases which is accounted by using real household income, the number of cars registered in previous year is used as the second independent variable in order to predict the total number of registered vehicles in Virginia.

Number of registered vehicles includes passenger, tractor, trailer, and truck registrations. Also, single unit truck registrations are obtained using a proportion of the original licenses sold. The real household income was used for the reason of taking into account the economic conditions too, which influence the registration of vehicles.

Chase Econometrics registration fee submodel is divided into three equations. The first equation determines the motor vehicle registration fee revenues (FTMVLFVA).

$$Log(FTMVLFVA)=C_0+C_1*Log(AUTOVA) \quad (5.7)$$
$$(R^2=0.937)$$

Where the number of passenger cars registered in Virginia (AUTOVA) is estimated by using the new passenger cars registered in Virginia(XCARSVA) and the number of passenger cars in previous year as the two independent variables, as shown in the equation 5.5.

The structure and reasoning of the submodel is very poor, since it is saying that the total number of passenger cars registered in Virginia will be always equal to the sum of passenger cars registered in previous year and the new cars regisration. The above statement is a fact and there is no need to prove it with the help of statistical model. That's why the coefficients of the independent variables are very close to one (0.92 and 0.99) and the $R^2$ is very high.

The number of new cars registration is obtained using the equation 5.6 mentioned previously in this chapter.

The low $R^2$ of the equation 5.6 clearly indicates the weakness and instability of the equation. However, most logical variables that influence the new passenger cars registration were used. Since no similar equations were used for the other types of vehicles such as buses, trucks, motorcycles and trailers the results of registration revenue would be misleading and incorrect. Considering only the passenger cars which form only 75 percent of the total vehicles is not very sensible. It is possible that projected revenues will underestimate the actual figures simply because of above inaccurate approach in determining total number of registered vehicles.

The DMV submodel for registration fee revenue are mentioned in chapter two.

The actual registration fee revenue for the past years when divided by the number of registered vehicles does not correspond to the registration fees set by the state government. The reason could be explained by the fact that all passenger cars with less than 4000 pounds and those with greater than 4000 pounds which pay different registration fees ($15 and $20), are combined together in the model. The average registration fee for passenger cars regardless of their weight was about 15 dollars in past years.

Trucks registration fee are based on more complicated structure. Since heavy trucks contribute more to the pavement and bridge destruction, they pay more registration fee. In fact, truck registration fee increases with the increaes of their weight and the number of axles. The average truck registration fee even not stable over the past decade came to be very close to 50 dollars in the last ten years.

Following registration fees were used in determining refined DMV revenues from registered vehicles (as shown in table 32 ).

Actual Registrtion fee for the year 1981 was about 85,821 thousand dollars. The percent error for DMV, JLARC, and CHASE were -8.3, -10.95, and -9.75 respectively. Chase Econometrics underestimation of the revenue was predictable since they considered only the registered passenger vehicles in their submodel. It is not known what the percent erroes would have been if JLARC estimates were in the calendar year

TABLE 32

Average Registration Fees for Vehicles

| | |
|---|---|
| Automobile | $15.00 |
| Bus | $5.25 |
| Truck | $50.00 |
| Motorcycle | $8.00 |
| Trailer | $13.50 |

TABLE 33

Structure of Registration Fee Submodels

| Model | Dependent Variable | Independent Variable |
|---|---|---|
| JLARC | Number of Registered Vehicles in Virginia | *Number of registered Vehicles in Previous Year<br>*Real Household Income |
| CHASE | Motor Vehicle Registration Fee | *Nmber of Passenger Cars Registered |
| | Number of Passenger cars Registered in VA. | *Number of Registered Passenger Cars in Previous Year<br>*Number of New Passenger Cars Registered |
| | Number of New Passenger Cars Registration | *Disposable Personal Income in Virginia<br>*Implicit Deflator of New Cars Consumption Expenditures 1972=100<br>*Auto Strikes Dummy Variable<br>*Oil Embargo Dummy Variable<br>*Consumer Price Index for Gasoline<br>*Consumer Price Index for All goods |
| DMV | Number of Registered Autos, Buses, and Trucks | *Personal Income in VA.<br>*Consumer Price Index for All Items |
| | Motorcycle Registration | *Driving Age Population<br>*Average Household Income in 1967 Cinstant Dollars |
| | Trailer Registration | *Number of Households<br>*Average Household Income in 1967 constant Dollars |

instead of fiscal year. But similarity of JLARC and CHASE submodels might indicate that JLARC registration submodel is under estimating the revenues too.

The registration fee revenues growth rate for the past years have been about 6 percent annually. Now, assuming even half of the past growth rate for future years, by 1986 the registration fee revenues would be about 99,500 thousand dollars.

Considering all the above facts, the DMV registration submodel appears to predict more reasonable and logical estimates. Concept and structure of the submodel is more stable and it also fits not only the past registered cars data but also the registration fee revenues more consistent than the other two models.

## 5.4 SALES AND USE TAX REVENUE SUBMODEL

Collection of revenue from sales and use tax is dependent upon selling price of motor vehicles, therefore, revenues are very sensitive and difficult to forecast accurately. As the price of sold motor vehicles increases, sales and use tax revenue increases accordingly. The better the state of economy the more vehicles, either new or used, are purchased which in turn contribute to increases in sales and use tax revenues.

TABLE 34

Total Registration Fee Revenue Estimates*

| Year | CHASE | JLARC | DMV |
|---|---|---|---|
| 1981 | 78.2 | 77.3 | 81.8 |
| 1982 | 77.3 | 77.3 | 84.9 |
| 1983 | 79.2 | 79.8 | 86.2 |
| 1984 | 81.0 | 81.2 | 87.3 |
| 1985 | 82.7 | 83.1 | 88.4 |
| 1986 | 84.4 | 84.7 | 89.5 |
| 1987 | 85.8 | N/A | 90.6 |
| 1988 | 87.2 | N/A | 91.7 |
| 1989 | 88.5 | N/A | 92.8 |
| 1990 | 89.7 | N/A | 93.8 |

N/A=Not Available

*In Million of Dollars

JLARC's submodel for sales and use tax revenue uses two independent variables nominal household income (NHI) and auto loan interest rate (NINTA). It is assuming that increases in household income result in increases of total expenditures on motor vehicles purchases. Also the reason for using auto interest rate is explained because of its effect on revenues, the higher the rate the lower the volume of sales is going to result. Dollar volume of sales of new and used vehicles (RSV) was used as dependent variable. Total sales and use tax revenues (SUR) then is estimated by applying the two percent tax rate to the total dollar volume of sales.

$$Log(RSV)=21.9506+1.35198*Log(NHI)-0.713609*Log(NINTA) \quad (R^2=0.9322) \qquad (5.8)$$

Other than economic variables that have been used in the submodel, it would have helped the accuracy of the equation in forecasting the future revenues if an independent variable representing the number of registered vehicles in past years was present in the equation. Number of registered vehicles usually has a positive effect on total volume of sales.

CHASE sales and use tax submodel is almost similar to JLARC's model. The dependent variable used is the same, but instead here number of registered new passenger vehicles in Virginia (XCARSVA) and average montly payment on new cars

(PCAMPS) in addition to three quarterly dummy variables have been used as the independent variables.

$$Log(TMVSLVA/MVSTR)=C_0+C_1*Log(XCARSVA)+C_2*Log(PCAMPS)$$

$$+C_3*QD_1+C_4*QD_2+C_5*QD_3 \qquad (5.9)$$

$(R^2=0.943)$

where TMVSLVA is the sales and use tax revenue and MVSTR is the tax rate.

Number of new registered passenger vehicles (XCARSVA) has been used in all the submodels of the Chase Econometrics. As mentioned previously, the total number of registered vehicles, not only the registered new passenger cars, would have been more effective in predicting reliable forecasts. Average montly payment on new cars has very important influence on decision to buy a new car. Lower montly payment will encourage people in purchasing a vehicle.

The DMV model used two approaches in determining the sales and use tax revenue. The first appraoch which is completely explained in chapter two makes the use of four equation: number of new car purchases (NEWCP), number of used car purchases (USEDCP), mean price of new cars (PRNEW), and mean price of used cars (PRUSED). This approach indirectly determines the total sales and use tax revenue.

The second approach directly uses the dollar volume of sales of new and used vehicles as the dependent variable and the number of new car purchases, number of used car purchases, and consumer price index of all items as the three independent variables. This approach is presented in chapter three.

Actual revenues for sales and use tax were about 68,687 thousand dollars in 1981. After comparing the estimated revenues of the three models with 1981 data the percent errors were 7.3, 7.5, 6.5, and 24.6 respectively for JLARC, CHASE, direct DMV, and indirect DMV models. This indicates that at least for the year 1981, all the models are overestimating the revenue.

JLARC indicates in their report that if the economic downturn is not reversed, their forecast may be optimistic especially in the later years. As one can see the economic downturn is even getting worse than before.

The past growth rate for sales and use tax revenues was about 8.2 percent annually. Assuming the same rate of growth for the future sales and use tax revenue and applying it to 1981 data, for the year 1986 the total revenues will amount to 110 million dollars. Looking at table 36 which gives estimates of sales and use tax revenues and considering the above fact, there is a possibility that

TABLE 35

Structure of Sales and Use Tax Submodels

| Model | Dependent Variable | Independent Variable |
|---|---|---|
| JLARC | Dollar Volume of Sales of New and Used Cars | *Nominal Household income<br>*Auto Loan Interest Rate |
| CHASE | Dollar Volume of Sales of New and Used Cars | *Registered New Passenger Cars in Virginia<br>*Average Montly Payment on New Cars<br>*Three Quarterly Dummy Variables |
| Direct DMV | Dollar Volume of Sales of New and Used Cars | *Number of New Car Purchases<br>*Number of Used Car Purchases<br>*Consumer Price Index of All Items |
| | Number of Used Cars Purchased | *Average Household Income in 1967 Constant Dollars<br>*Consumer Price Index of All Items<br>*Consumer Price Index of Gasoline |
| | Number of New Cars Purchased | *Average Household Income in 1967 Constant Dollars<br>*Consumer Price Index of All Items<br>*Consumer Price Index of Gasoline |

JLARC, indirect DMV, and CHASE are over estimating the revenues. The direct DMV model with the estimated growth rate of 8.8 percent is more likely to give better projections of sales and use tax revenue rather than JLARC, indirect DMV, and CHASE models which are assming 12.7, 9.1 and 10.4 annual growth rates.

Accuracy and reliability of a model should not be judged only by its equations, $R^2$ or other statistical information. The model's structure and reasoning in using each single independent and dependent variable is also very important. Of course, if a model's equations have both the logical structure and the high $R^2$ with significant F-statistics it would be perfect but still the accuracy and reliability of projections can not be guranteed.

In the next chapter, using the DMV model and the new registration fees and addition of excise tax on motor fuel, the vehicle related revenues are forecasted under three economic conditions.

TABLE 36

Sales and Use Tax Revenue Estimates*

| Year | CHASE | JLARC | Direct-DMV | Indirect-DMV |
|---|---|---|---|---|
| 1981 | 73.2 | 73.0 | 73.4 | 91.1 |
| 1982 | 90.4 | 77.5 | 81.5 | 101.9 |
| 1983 | 104.7 | 86.5 | 90.7 | 113.9 |
| 1984 | 112.9 | 99.3 | 100.1 | 126.4 |
| 1985 | 124.0 | 115.2 | 109.5 | 138.6 |
| 1986 | 133.1 | 132.8 | 118.2 | 149.7 |
| 1987 | 143.0 | N/A | 127.2 | 161.4 |
| 1988 | 154.0 | N/A | 136.4 | 174.1 |
| 1989 | 166.3 | N/A | 146.4 | 186.5 |
| 1990 | 177.7 | N/A | 157.0 | 199.1 |

N/A=Not Available

*In MIllion of Dollars

## Chapter VI

## FORECASTING REVENUES UNDER FUTURE SCENARIOS

### 6.1 INTRODUCTION

In this chapter vehicle-related revenues are forecasted under three different scenarios: base, optimistic, and pessimistic. The base case is reflective of future conditions given recent trends. This base (Moderate) case expects normal and moderate situations for future economy. The optimistic (Low) scenario assumes lower inflattion rate for future economic conditions. This case implies that economy improves and as a result personal income and average household income in constant dollars will increase, which subsequently causes the increase in vehicle-related revenues. On the other hand, pessimistic (High) scenario assumes higher inflation rates for economy or in constant dollars lower personal income and average household income which results in lower revenues from DMV sources.

The DMV model discussed in chapter two and three are used for the purpose of forecasting. The sensitivity of the two different approaches in estimating the fuel tax revenue and sales and use tax revenue under different scenarios are discussed and compared.

In forecasting the future revenues the increase of registration fees and addition of oil franchise tax on the sale of motor fuel by wholesale dealers are considered.

## 6.2 ASSUMPTIONS FOR FUTURE ECONOMIC CONDITIONS

Each economic condition includes assumptions for the Consumer Price Index of All Items (CPIAI), Consumer Price Index of Gasoline (CPIGC), Wholesale Gasoline Price (WSGP), and Wholesale Diesel Price (WSDP).

The rates of growth of CPIAI and CPIGC under three scenarios are assumed to fluctuate over the rest of the decade as it did fluctuate in the past decade. The CPIAC growth rates vary between 5% to 6%, 7% to 8%, and 9% to 10% under optimistic, base, and pessimistic economic conditions respectively, as shown in figure 3

The gasoline price is assumed to increase from $1.13 in 1981 to $1.27 in 1990 in 1980 constant dollars. The inflated prices for gasoline for the three scenarios will depend on the assumed values for CPIAI.

The future wholesale gasoline prices were estimated by using the nominal pump price which in turn were predicted using the Energy Information Administration (EIA) estimates which are explained in chapter three. After subtracting the Federal and States taxes ($0.11 & $0.04) from nominal pump prices, the results give the price of gasoline with mark-up and excise tax. Assuming that retailers mark-up 11.132 percent of price of gasoline and considering the 3 percent excise tax, the wholesale price of gasoline is determined for future years.

Since about 12 percent of the total fuel used by motor vehicles is diesel fuel instead of gasoline and this ratio is increasing by 5.7 percent every year as a result of more production of diesel fuel cars by manufactures, the diesel fuel price were also estimated for the three scenarios. From past trend information on gasoline and diesel prices it was found that the ratio of price of diesel to price of gasoline is about 91.84 percent. This ratio was used in estimating wholesale price of diesel fuels.

Future estimated values of CPIAI, CPIGC, WSGP, and WSDP for three scenarios are given in table 37 through table 39 .

## 6.3 FUEL TAX REVENUE PROJECTIONS

Both versions of the DMV models were tested against three different scenarios: Moderate (base), Optimistic (low), and Pessimistic (high) conditions. These tests are presented here to indicate the sensitivity of the two approaches travel-based and gasoline demand based to the economic conditions under the same set of input data.

TABLE 37

Estimates of Future Economic Conditions (base)

| Year | CPIAI | CPIGC | WSGP | WSDP |
|---|---|---|---|---|
| 1982 | 294.2 | 445.6 | 1.078* | 0.990 |
| 1983 | 316.0 | 482.8 | 1.157 | 1.063 |
| 1984 | 338.1 | 521.1 | 1.262 | 1.159 |
| 1985 | 363.4 | 564.9 | 1.376 | 1.264 |
| 1986 | 392.5 | 620.6 | 1.525 | 1.401 |
| 1987 | 422.3 | 678.9 | 1.682 | 1.545 |
| 1988 | 452.7 | 739.8 | 1.849 | 1.698 |
| 1989 | 487.2 | 809.1 | 2.033 | 1.867 |
| 1990 | 526.1 | 887.7 | 2.243 | 2.060 |

*A mark-up of $0.10 is used due to competition

TABLE 38

Estimates of Future Economic Conditions (Low)

| Year | CPIAI | CPIGC | WSGP | WSDP |
|---|---|---|---|---|
| 1982 | 291.5 | 441.5 | 1.068* | 0.981 |
| 1983 | 307.8 | 470.3 | 1.122 | 1.030 |
| 1984 | 323.2 | 498.1 | 1.200 | 1.102 |
| 1985 | 341.0 | 530.1 | 1.288 | 1.183 |
| 1986 | 361.4 | 571.4 | 1.393 | 1.279 |
| 1987 | 382.0 | 614.1 | 1.507 | 1.384 |
| 1988 | 402.6 | 657.9 | 1.630 | 1.497 |
| 1989 | 425.6 | 706.8 | 1.761 | 1.617 |
| 1990 | 451.1 | 761.2 | 1.901 | 1.746 |

*A mark-up of $0.10 is used due to competition

TABLE 39

Estimates of Future Economic Conditions (High)

| Year | CPIAI | CPIGC | WSGP | WSDP |
|---|---|---|---|---|
| 1982 | 298.3 | 451.8 | 1.097* | 1.007 |
| 1983 | 325.9 | 497.9 | 1.200 | 1.102 |
| 1984 | 355.2 | 547.4 | 1.332 | 1.233 |
| 1985 | 388.9 | 604.5 | 1.481 | 1.360 |
| 1986 | 427.8 | 676.4 | 1.674 | 1.537 |
| 1987 | 468.8 | 753.7 | 1.884 | 1.730 |
| 1988 | 512.0 | 836.7 | 2.103 | 1.931 |
| 1989 | 561.2 | 930.2 | 2.357 | 2.165 |
| 1990 | 617.3 | 1041.6 | 2.646 | 2.430 |

*A mark-up of $0.10 is used due to competition

The fuel consumption forecasts by the two models as shown in table 40 and table 41 in addition to figure 2 and figure 4 which present their similarity under different economic conditions. Both models show their sensitivity to the economic variations under optimistic and pessimistic scenarios. The growth rate of fuel revenue estimated by travel-based model is about -6.9, -1.5, and +3.5 percent under high, base, and low economic conditions respectively, where the gasoline demand model estimates the fuel revenue growth rates to be -10, -1.9, and +4.4 percent under the same economic conditions. The highest fuel tax revenue is projected by the gasoline-demand DMV under low economic conditions of the year 1990 (about 450.1 million dollars), and the lowest fuel tax revenue is projected by the same model under high economic conditions of the year 1990 (about 142.6 million dollars). The spread of the fuel revenue forecasts from the base case is much smaller in the travel-based model compared to the gasoline-demand model, reflecting better consistency and reliability. The percent share of fuel tax revenue out of the total vehicle-related revenue forecasted by the DMV model has a decreasing trend. For the travel-based model it drops from 54% in 1982 to 43% in 1986 and finally to 35% in 1990, where for the gasoline-demand model it drops from 57% in 1982 to 45% in

1986 and finally to 37% in 1990 as shown in figure 14 and figure 15 . The above result indicates that in the future the vehicles fuel efficiency and high gasoline price and other economic factors will reduce the gasoline consumption and subsequently will lower the fuel tax revenues.

## 6.4 EXCISE TAX REVENUE PROJECTIONS

On July 1, 1982 an excise tax of 3 percent on wholesale price of motor fuels went into effect in Virginia. Since the fuel consumption estimates of both DMV models are on yearly basis, for the year 1982 the excise tax was applied to 1/2 of total gallons of fuels. Except the pessimistic case of gasoline-demand DMV, the revenue from this source is predicted to grow annually because of higher price of gasoline and diesel fuels in the future. Forecasted revenues by the travel-based model show growth rates of 7.9, 15.8, and 11.4 percent under base, optimistic, and pessimistic conditions, where the gasoline-demand DMV projects 7.3 , 12.5, and 0.7 percent growth rates under base, optimistic, and pessimistic economic conditions. As shown in figure 14 and figure 15 the excise tax revenues form about 17 to 22 percent of the total vehicle-related revenues forecasted by the DMV models.

TABLE 40

Fuel Tax Revenue Forecasted by Travel-Based DMV*

| Year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 302.2 | 295.5 | 306.8 |
| 1983 | 303.4 | 287.3 | 317.4 |
| 1984 | 304.2 | 277.0 | 330.5 |
| 1985 | 302.1 | 263.1 | 342.5 |
| 1986 | 294.6 | 244.2 | 350.7 |
| 1987 | 287.4 | 225.7 | 360.3 |
| 1988 | 281.7 | 208.3 | 373.0 |
| 1989 | 275.2 | 190.7 | 387.4 |
| 1990 | 268.0 | 172.9 | 403.2 |

*In millions of dollars

TABLE 41

Fuel Tax Revenues by Gasoline Demand DMV*

| Year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 313.5 | 305.8 | 318.8 |
| 1983 | 316.0 | 247.2 | 332.5 |
| 1984 | 318.3 | 285.9 | 349.9 |
| 1985 | 317.4 | 270.2 | 366.6 |
| 1986 | 309.4 | 247.2 | 379.2 |
| 1987 | 300.2 | 222.2 | 392.9 |
| 1988 | 292.3 | 197.7 | 410.9 |
| 1989 | 281.9 | 171.2 | 429.9 |
| 1990 | 268.9 | 142.6 | 450.1 |

*In millions of dollars

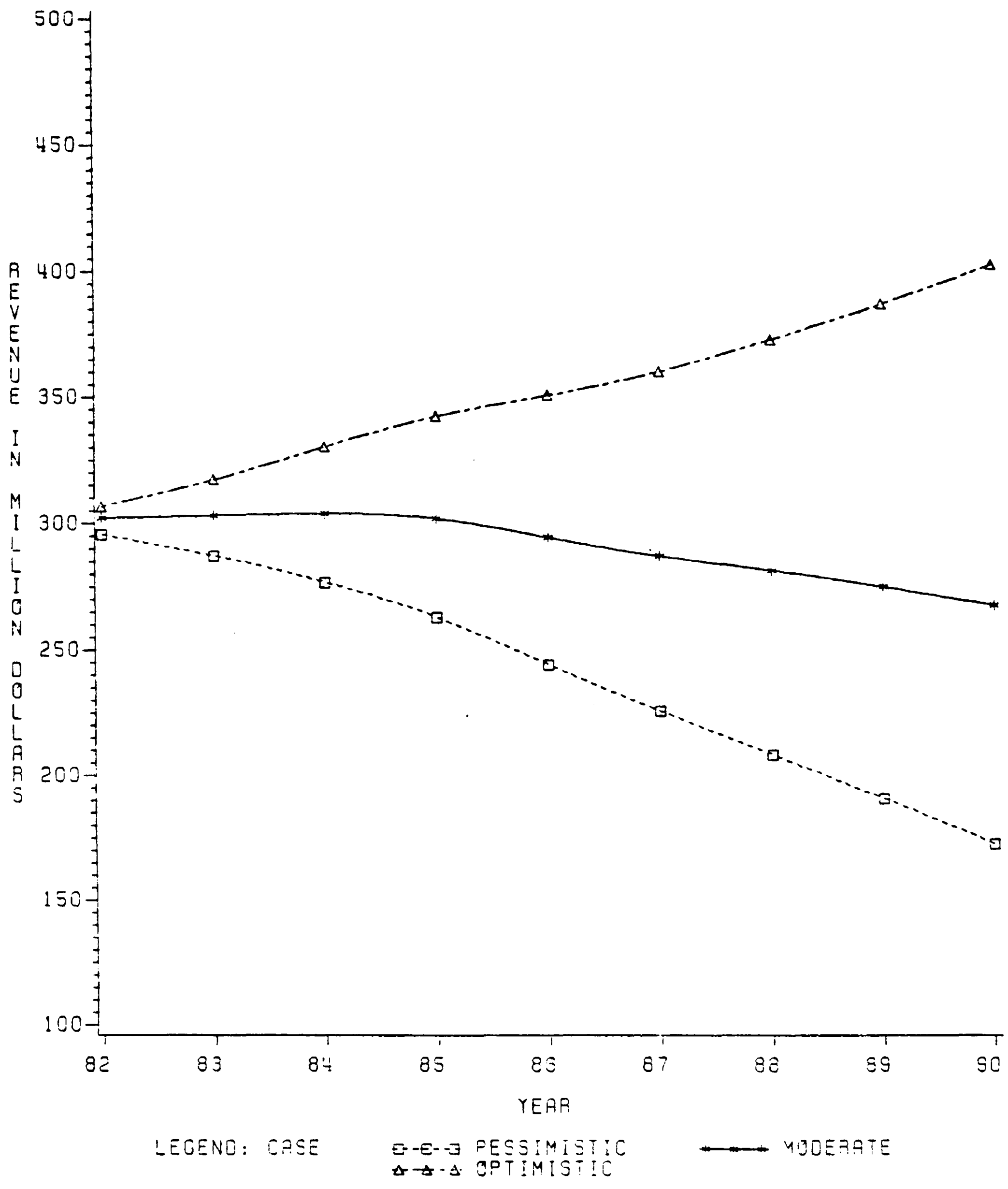


Figure 4: Fuel Tax Revenues Estimated by Travel-based DMV

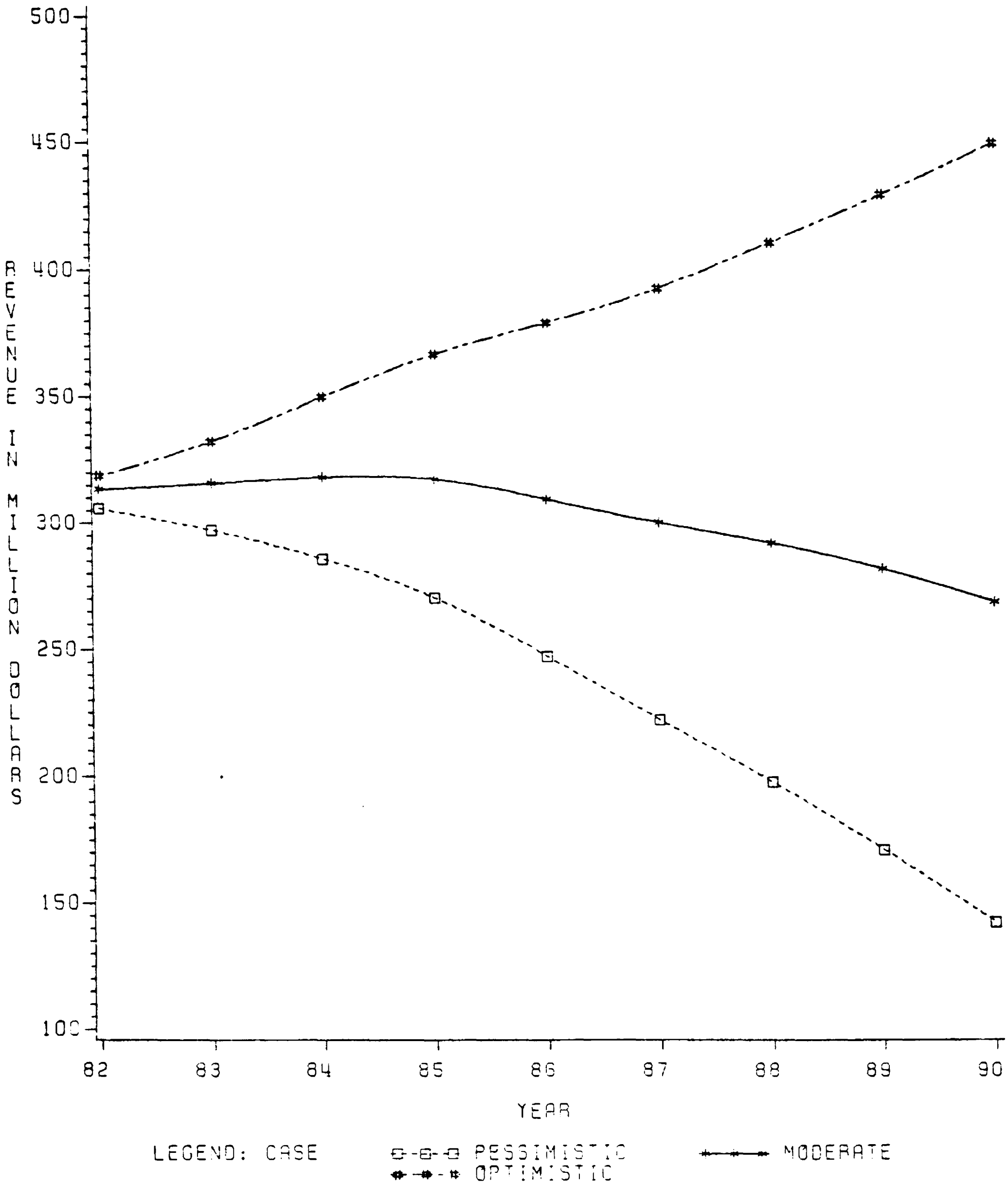


Figure 5: Fuel Tax Revenue by Gasoline-Demand DMV

TABLE 42

Excise Tax Revenue Forecasts by Travel-based DMV*

| Year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 44.0 | 43.7 | 44.2 |
| 1983 | 94.7 | 93.0 | 96.0 |
| 1984 | 103.5 | 99.5 | 106.9 |
| 1985 | 112.0 | 105.0 | 118.8 |
| 1986 | 120.9 | 110.0 | 131.5 |
| 1987 | 130.0 | 114.3 | 146.0 |
| 1988 | 140.0 | 117.7 | 163.4 |
| 1989 | 150.2 | 120.7 | 183.2 |
| 1990 | 161.2 | 122.7 | 205.6 |

*In millions of dollars

TABLE 43

Excise tax Revenues by Gasoline-Demand DMV*

| Year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 45.6 | 45.3 | 45.9 |
| 1983 | 98.63 | 96.2 | 100.6 |
| 1984 | 108.3 | 107.0 | 113.2 |
| 1985 | 117.6 | 107.8 | 127.2 |
| 1986 | 127.0 | 111.4 | 142.2 |
| 1987 | 135.8 | 112.6 | 159.2 |
| 1988 | 145.3 | 111.7 | 180.0 |
| 1989 | 153.9 | 108.4 | 203.3 |
| 1990 | 161.8 | 101.2 | 229.6 |

*In millions of dollars

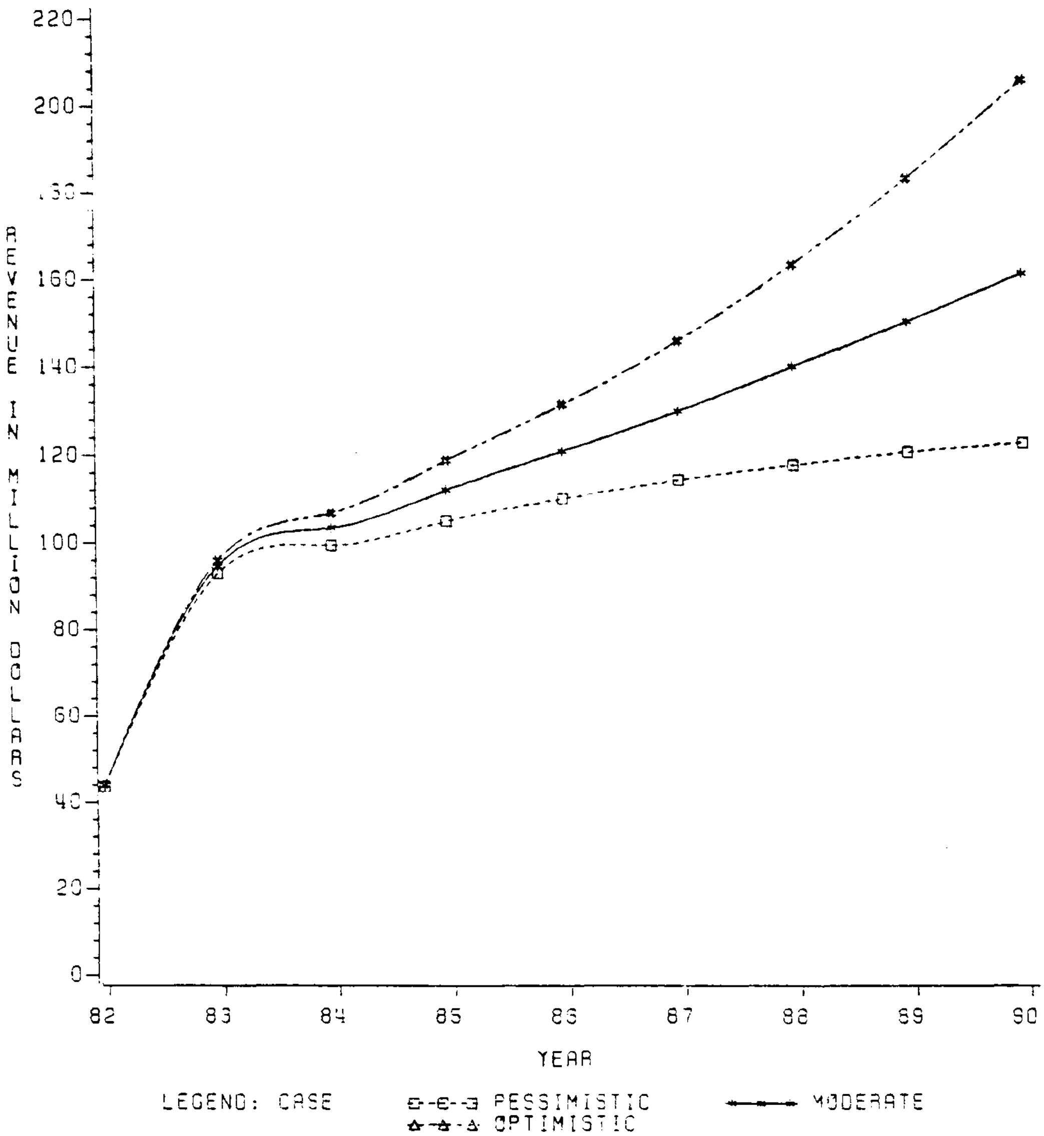


Figure 6: Excise Tax Revenues by Travel-based DMV

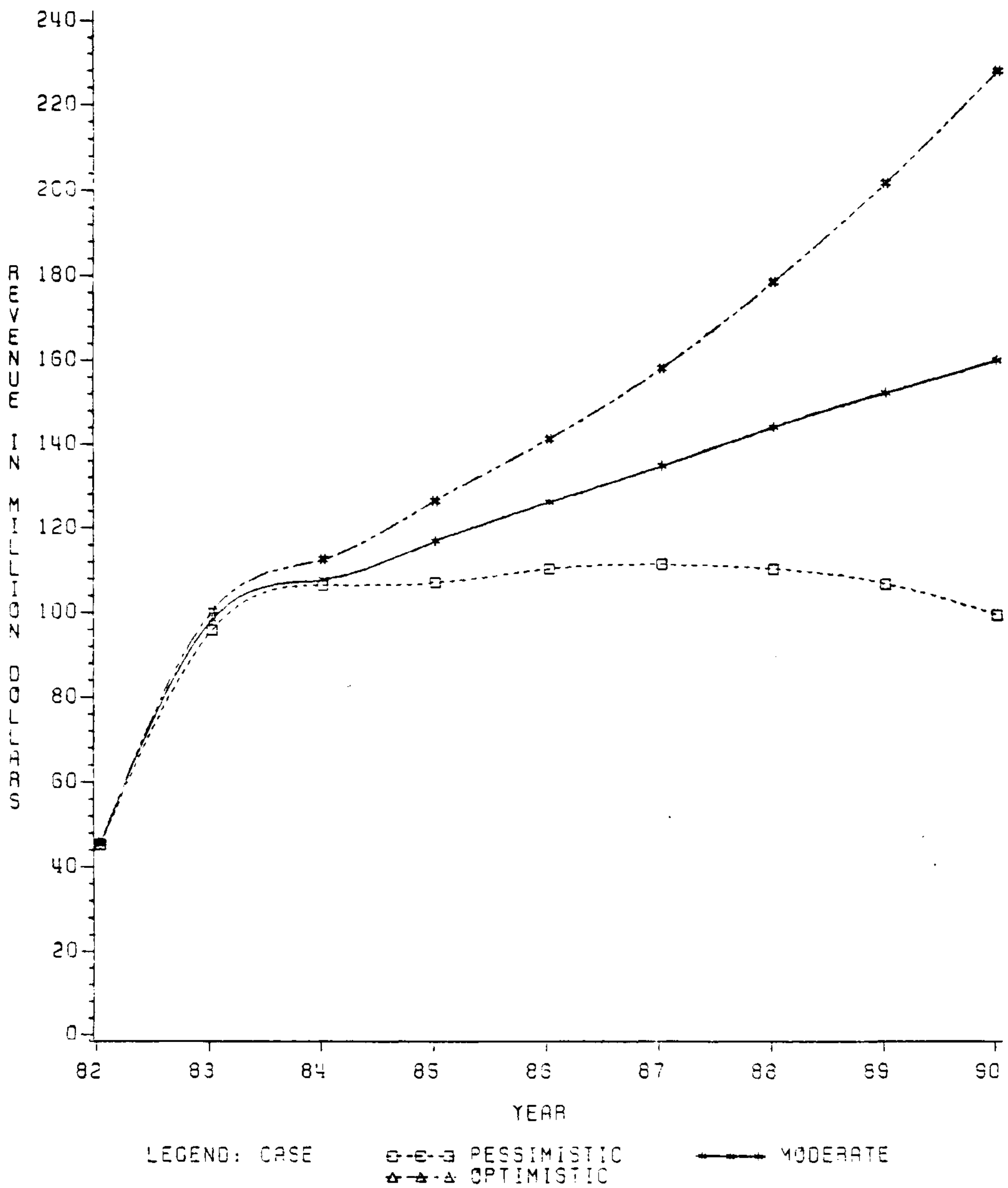


Figure 7: Excise Tax Revenues by Gasoline-Demand DMV

## 6.5 ROAD TAX REVENUE PROJECTIONS

Road tax revenue is based on the extra tax that heavy trucks pay on each gallon of fuel used in Virginia. On each gallon of fuel purchased in Virginia 2 cents is collected for road tax. Also, for those gallons of fuel bought outside Virginia but used inside state, 13 cents plus three percent of wholesale price of fuel is obtained from heavy trucks. Since a large percentage of heavy trucks use diesel fuel, it is assumed that all the gallons of fuel purchased outside the state but used in Virginia will be diesel fuels.

Under three scenarios, the road tax revenue which is directly related to heavy trucks fuel consumption, behaves exactly like the fuel tax revenue estimates. For moderate and optimistic cases the growth rates are 5.72 and 14.7 percent ammually. The pessimistic case experiences ups and downs along the projection period. The road tax revenue for 1990 is estimated to be 1/2 of the 1982 projected value. The road tax revenues are presented in table 44 . Also, the road tax is predicted to form about 2 percent of the total revenue in future years as shown in figure 14 through 16.

TABLE 44

Road Tax Revenue Projections*

| Year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 10.0 | 9.6 | 10.3 |
| 1983 | 11.3 | 10.2 | 12.4 |
| 1984 | 12.3 | 10.2 | 14.3 |
| 1985 | 13.0 | 9.9 | 16.2 |
| 1986 | 13.4 | 9.1 | 18.0 |
| 1987 | 13.9 | 8.3 | 20.2 |
| 1988 | 14.5 | 7.4 | 22.9 |
| 1989 | 14.9 | 6.3 | 25.7 |
| 1990 | 15.1 | 5.0 | 28.7 |

*In millions of dollars

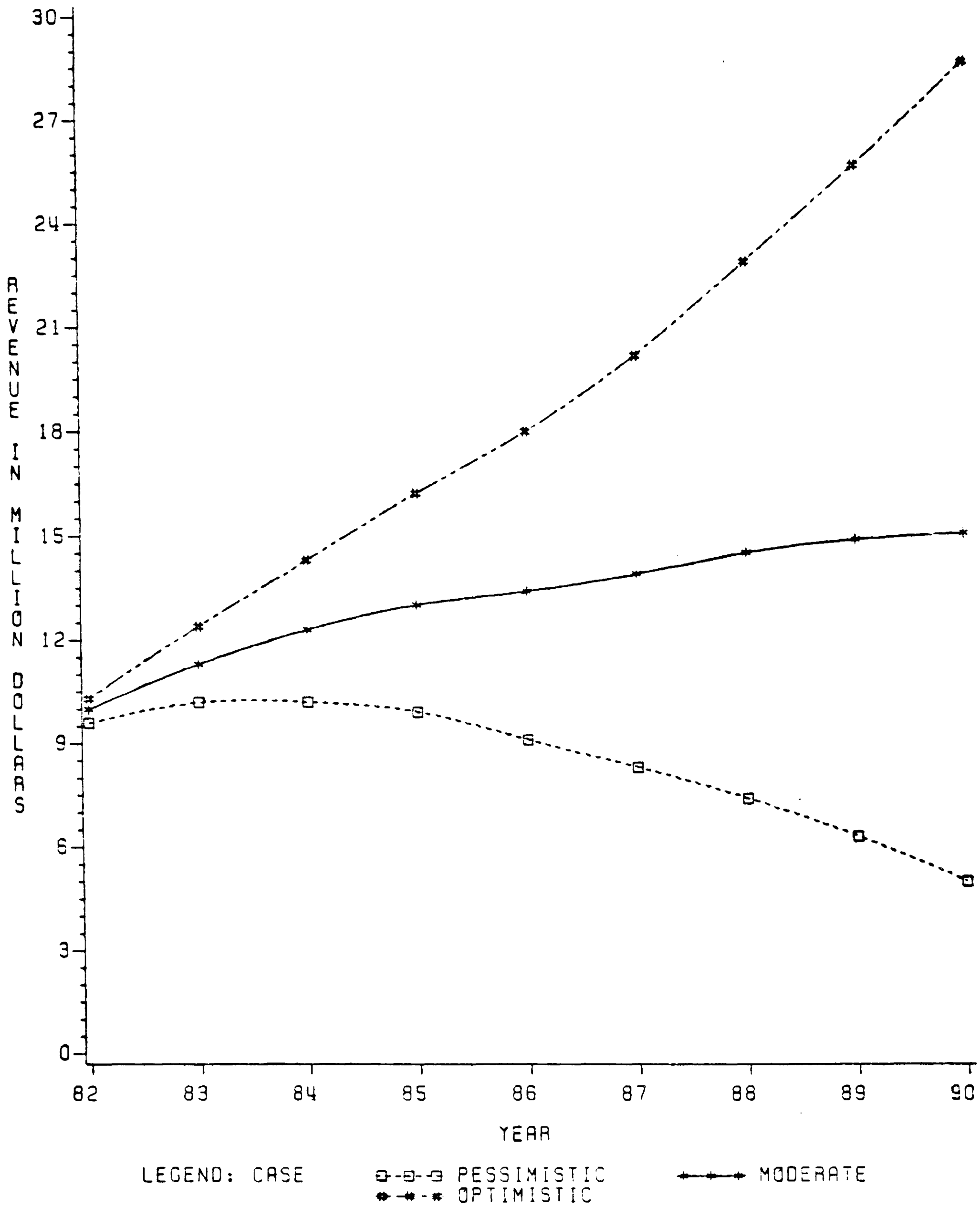


Figure 8: Road Tax Revenue Forecasts

## 6.6 REGISTRATION FEE REVENUE PROJECTIONS

On July 1, 1982 new registrtion fees for different types of vehicles went into effect. Since the number of vehicles registered in Virginia is projected annually by the DMV model, half of the new increase in registration fee was applied to the total registered vehicles of each type. The new and previous fees are shown in table 45 . The estimated registration revenue is growing at the rates of 3.1 and 3.7 percent under base and optimistic conditions. Under pessimistic (high) economic condition the revenues grow up to the year 1985 and then drop to the point where 1990 estimates of registration revenues (81.4 million dollars) becomes about 13 percent lower than 1982 (93.8 million dollars). Over the future years the registration revenue forms about 17 percent of the total vehicle-related revenues projected by DMV model.

## 6.7 SALES AND USE TAX REVENUE PROJECTIONS

Two approaches used in determining sales and use tax revenues estimated completely different results. The indirect approach which uses number of new car purchases, number of used car purchases, average price of new cars, and average price of used cars is very possible that over estimates the revenues. The growth rates of revenue

TABLE 45

Current and Previous Average Registration Fees

| | Current | Previous |
|---|---|---|
| Automobile | 20.0 | 15.0 |
| bus | 10.25 | 5.25 |
| Truck | 68.0 | 50.0 |
| Motorcycle | 15.0 | 8.0 |
| Trailer | 18.5 | 13.5 |

TABLE 46

Registration Revenue Projections*

| year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 95.9 | 93.8 | 96.0 |
| 1983 | 111.9 | 108.4 | 112.3 |
| 1984 | 113.5 | 107.9 | 114.2 |
| 1985 | 115.1 | 105.5 | 116.2 |
| 1986 | 116.5 | 101.3 | 118.3 |
| 1987 | 118.0 | 96.9 | 120.4 |
| 1988 | 119.5 | 92.5 | 122.9 |
| 1989 | 120.9 | 87.3 | 125.5 |
| 1990 | 122.4 | 81.4 | 128.5 |

*In millions of dollars

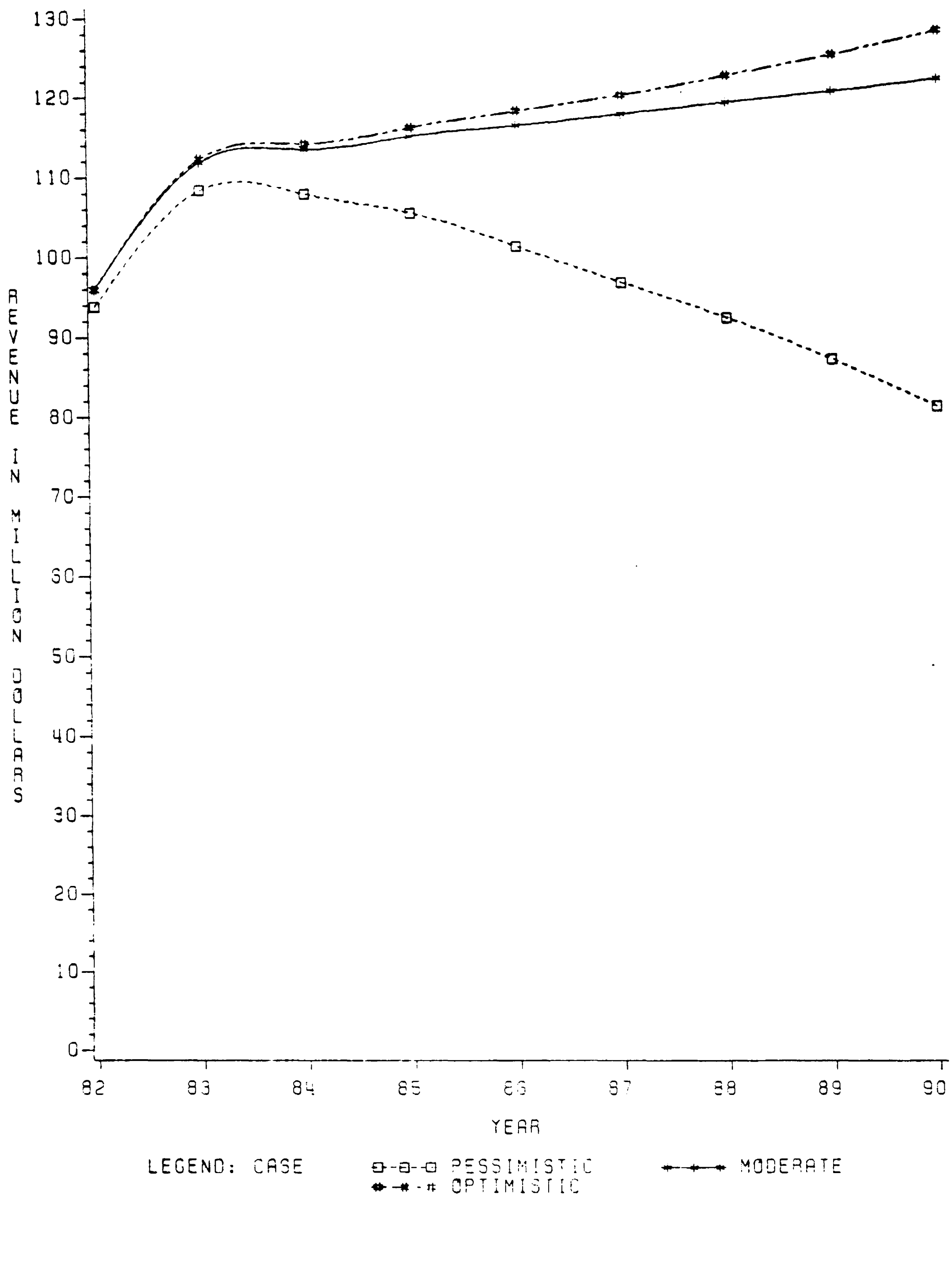


Figure 9: Registration Fee Revenue Forecasts

projected by indirect approach are 8.7, 2.3, and 13.8 under base, pessimistic, and optimistic scenarios. The direct approach which uses number of new car purchases (XNEW), number of used car purchases (XUSED), consumer price index of all items (CPIAI), and dollar volume of sales projects 8.5, 2.4, and 12.1 percent growth rates for base, pessimistic, and optimistic conditions. Highest projected revenue by direct approach is about 205 million dollars compared to 288.8 million dollars estimated by indirect approach. The percent of the total revenue by sales and use tax revenue is projected to be about 18, 21, and 26 percent for the year 1982, 1986, and 1990 respectively given by the indirect approach DMV, where the direct approach DMV predicts the percentages to be 15, 17, and 22 for the year 1982, 1986, and 1990 respectively.

TABLE 47

Sales and Use Tax Revenues by Indirect DMV*

| Year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 101.9 | 100.4 | 102.9 |
| 1983 | 113.9 | 109.5 | 117.5 |
| 1984 | 126.4 | 117.5 | 134.4 |
| 1985 | 138.6 | 123.4 | 152.7 |
| 1986 | 149.7 | 126.4 | 172.4 |
| 1987 | 161.4 | 127.9 | 195.3 |
| 1988 | 174.1 | 128.0 | 222.2 |
| 1989 | 186.5 | 125.4 | 252.9 |
| 1990 | 199.1 | 120.1 | 288.8 |

*In millions of dollars

TABLE 48

Sales and Use Tax Revenue by Direct DMV*

| year | Moderate(base) | Pessimistic(high) | Optimistic(low) |
|---|---|---|---|
| 1982 | 81.5 | 80.7 | 82.1 |
| 1983 | 90.7 | 88.2 | 92.6 |
| 1984 | 100.1 | 95.0 | 104.4 |
| 1985 | 109.5 | 100.7 | 117.2 |
| 1986 | 118.2 | 104.2 | 130.6 |
| 1987 | 127.2 | 106.3 | 145.7 |
| 1988 | 136.7 | 106.9 | 163.0 |
| 1989 | 146.4 | 104.3 | 182.4 |
| 1990 | 156.9 | 97.9 | 205.0 |

*In millions of dollars

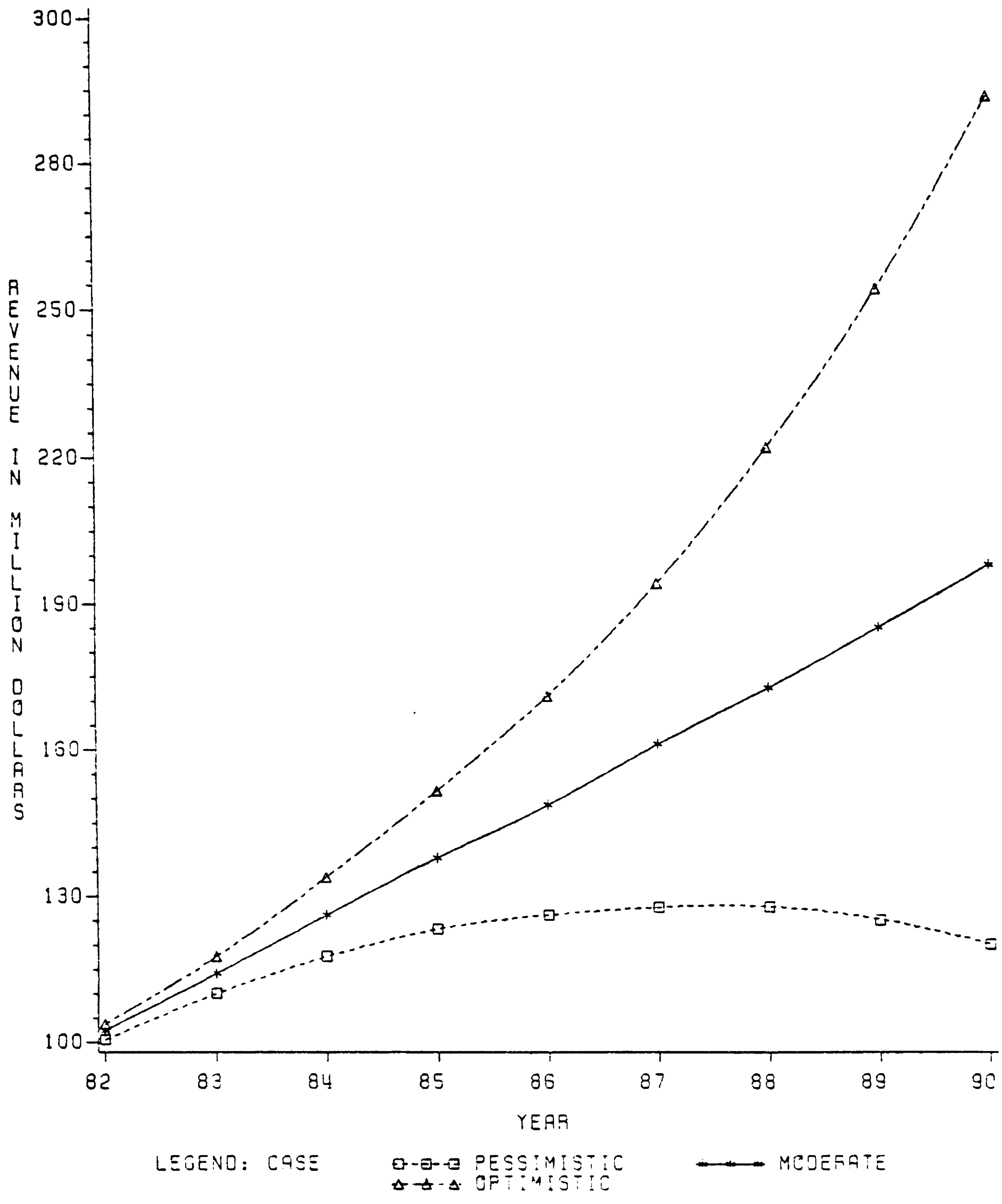


Figure 10: Sales and Use Tax Revenue by Indirect Approach

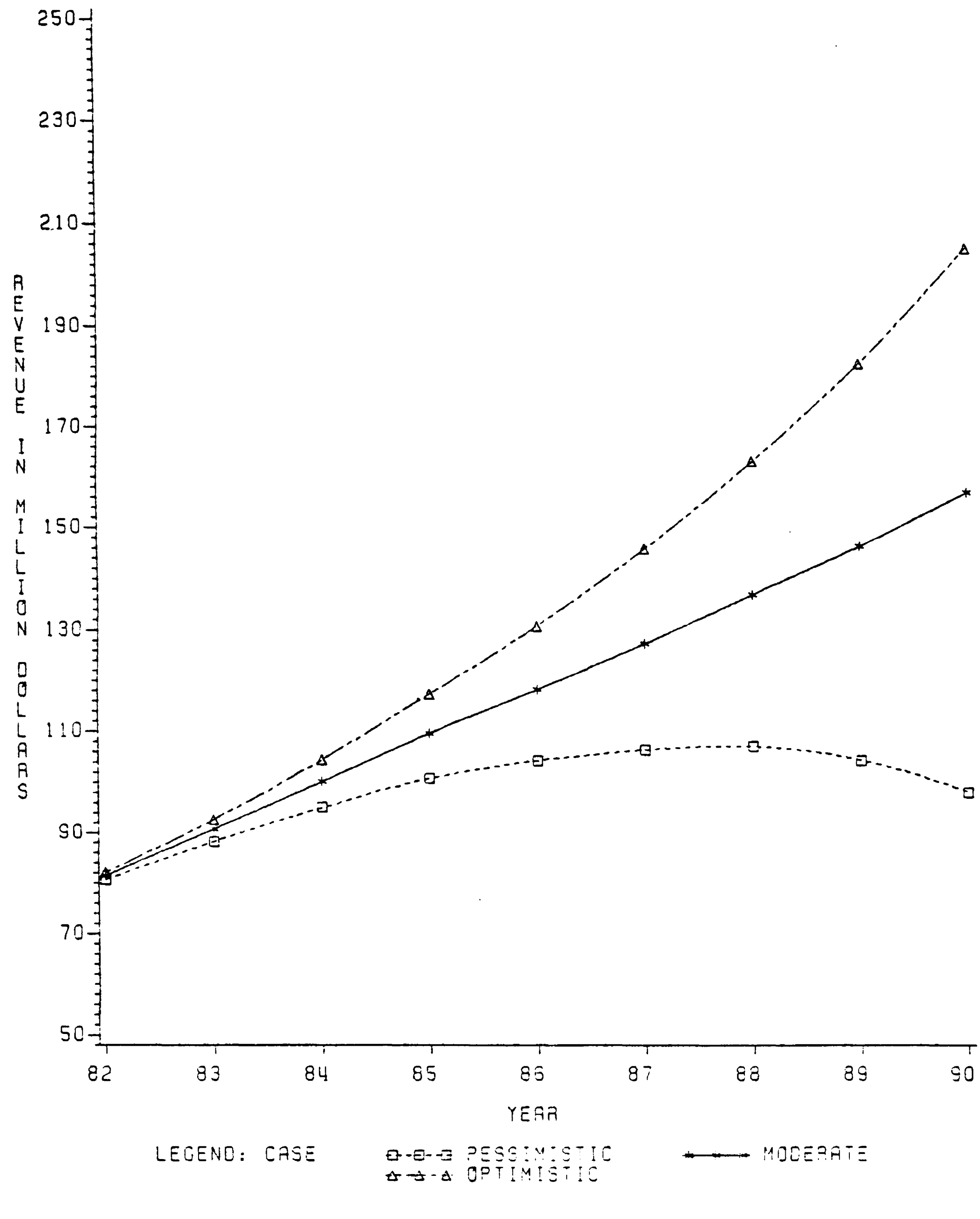


Figure 11: Sales and Use Tax Revenue by Direct Approach

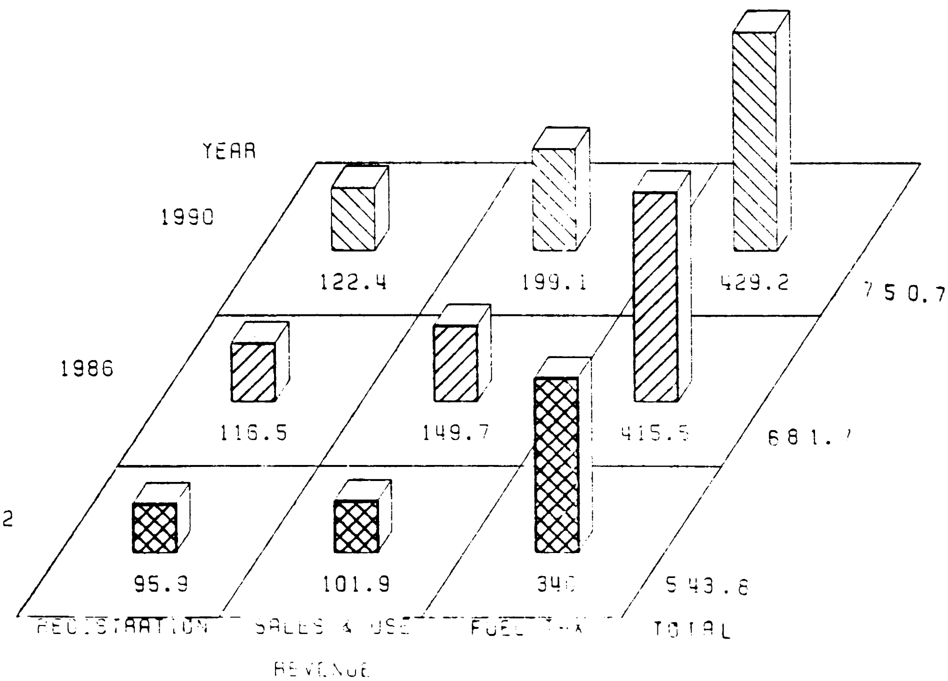


Figure 12: Forecasted revenues of Updated DMV (Million $)

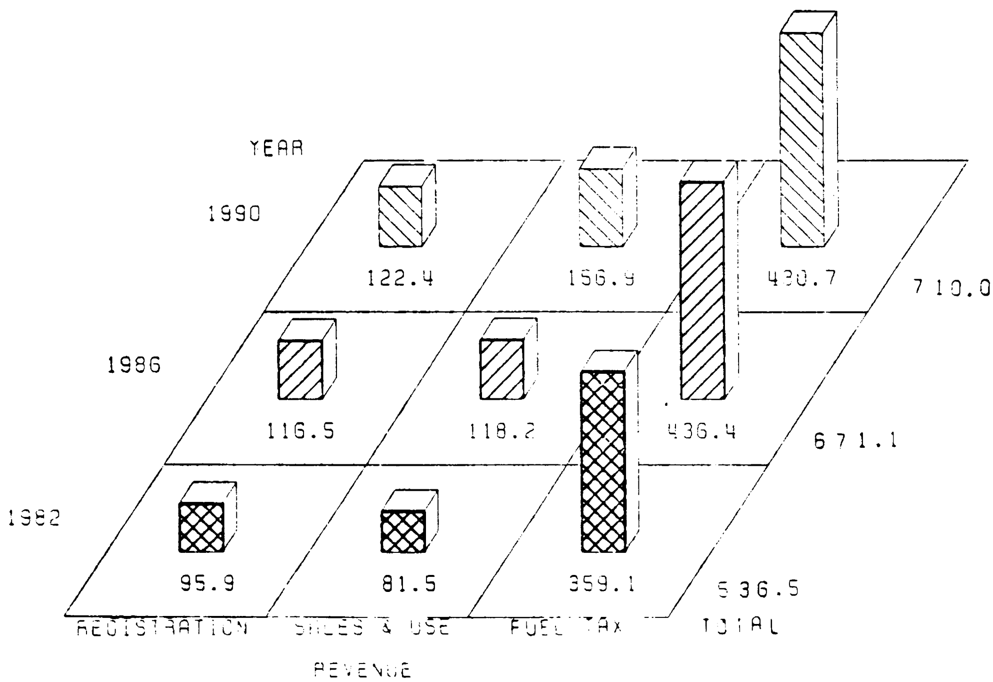


Figure 13: Forecasted Revenues of Refined DMV (Million $)

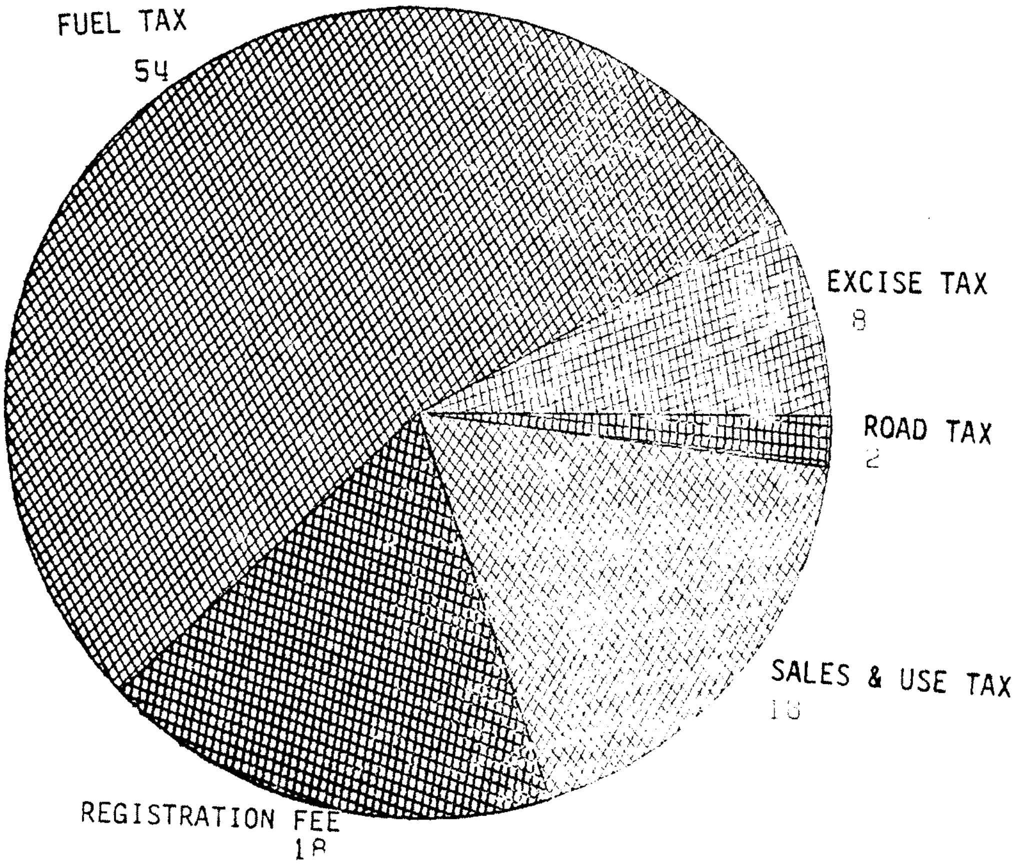


Figure 14: Percent Revenues by Type (Updated DMV) for 1982

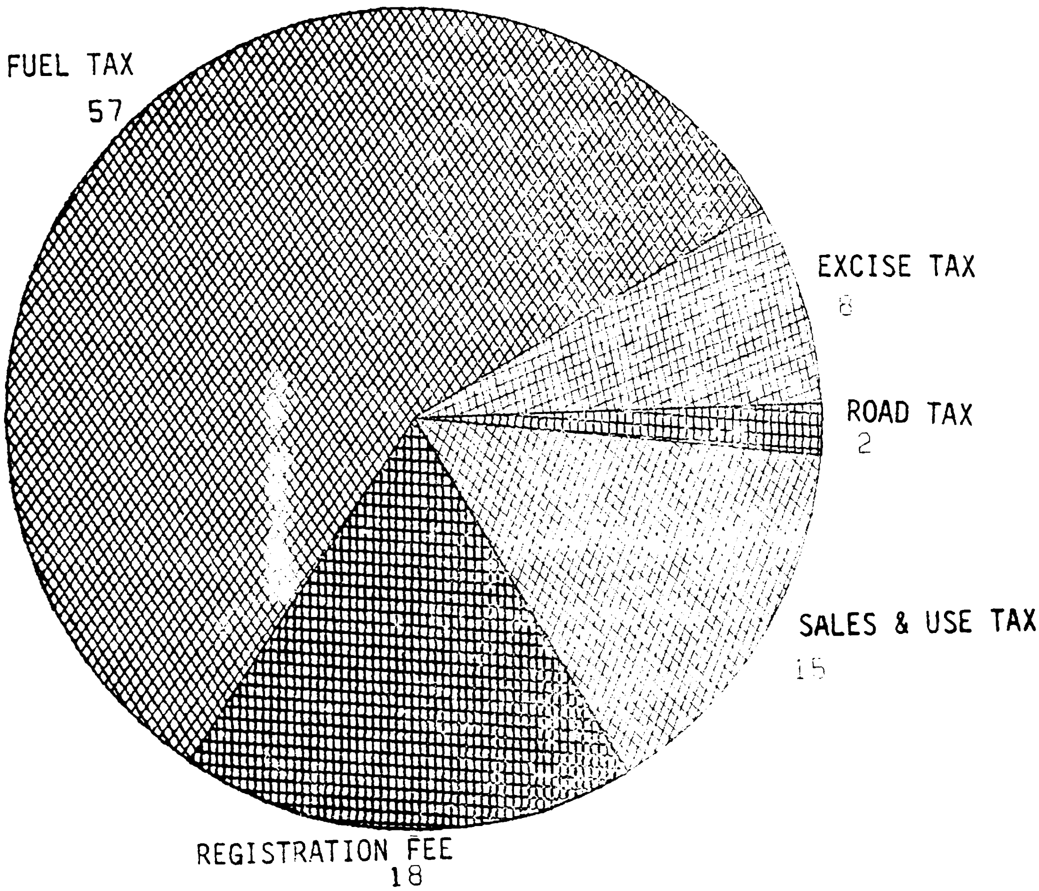


Figure 15: Percent Revenue by Type (Refined DMV) for 1982

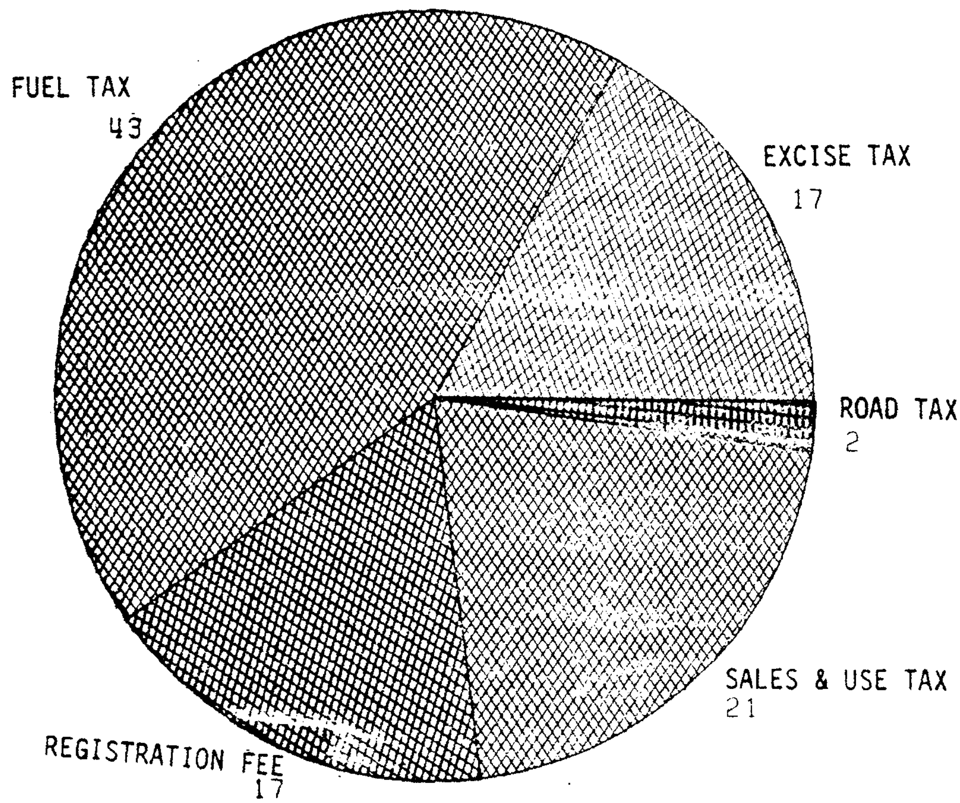


Figure 16: Percent Revenue by Type (updated DMV) for 1986

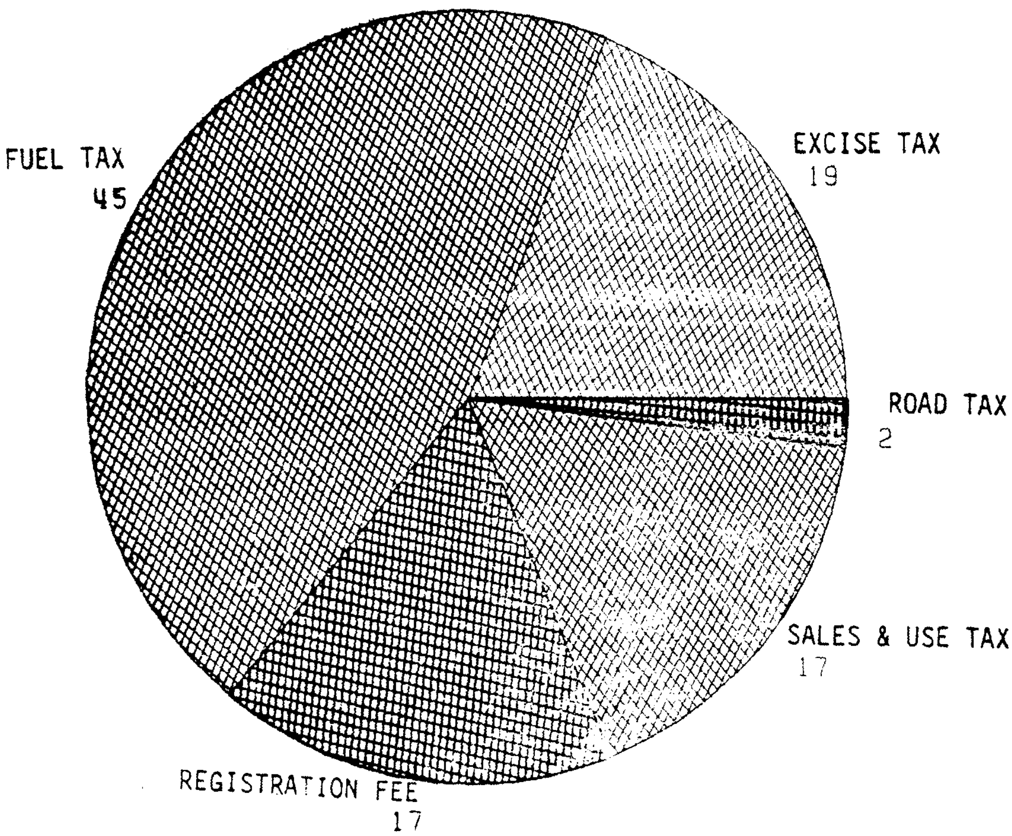


Figure 17: Percent Revenue by Type (Refined DMV) for 1986

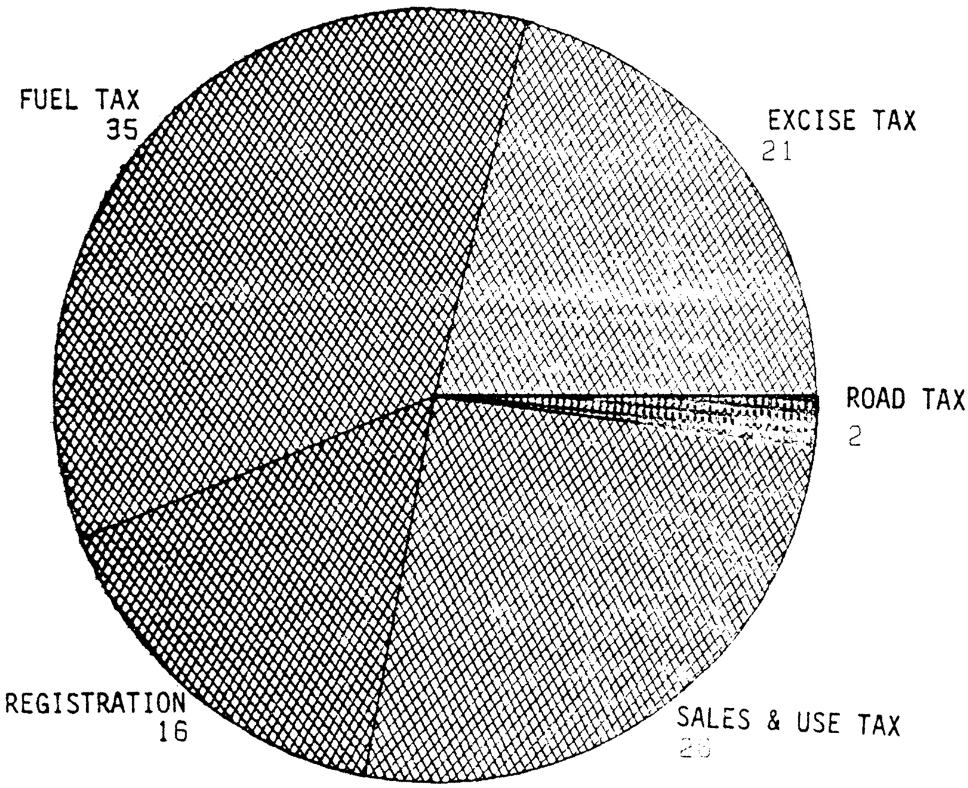


Figure 18: Percent Revenue by Type (Updated DMV) for 1990

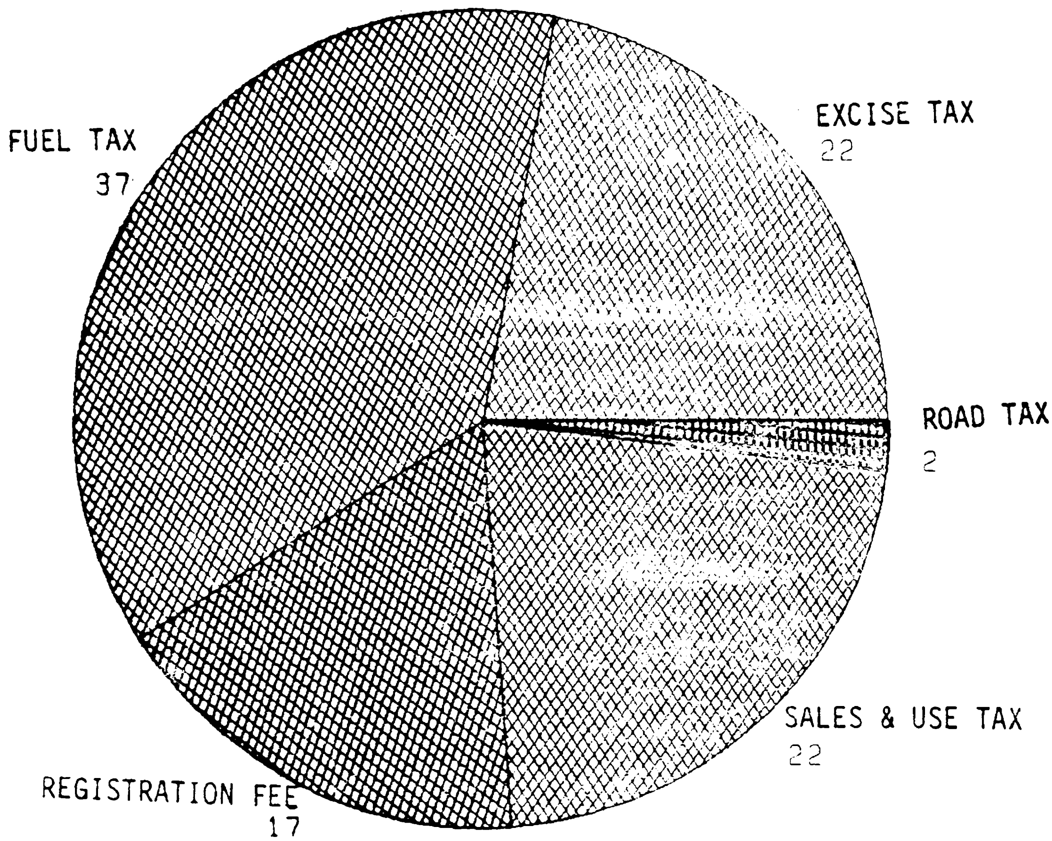


Figure 19: Percent Revenue by Type (Refined DMV) for 1990

## Chapter VII

## SUMMARY AND CONCLUSION

Total revenues from the three major sources: fuel tax, registration fee, and sales and use tax are estimated under base (Moderate) economic condition to grow using either the updated DMV (which uses travel-based concept for determining fuel tax revenue and indirect approach for estimating sales and use tax revenue) or the refined DMV (which uses the gasoline-demand concept for projecting fuel tax revenue and direct approach for predicting the sales and use tax revenue) model. The percent growths of the total revenues are 4.6 and 4.0 for the updated and the refined DMV models. Except the sales and use tax revenue estimated by updated model which overestimates this source of revenue, the updated and refined models predicted comparative results. Total revenues estimated by the updated model are 1.5, 1.3, and 5.4 percent greater than the refined model for the year 1982, 1986, and 1990 respectively.

Fuel tax revenue excluding the excise tax contributes, on the average of the two models, 55, 44, and 36 percent of the total revenues for the year 1982, 1986, and 1990. The reason for the decline of motor fuel tax revenue is that the motor vehicles fuel efficiencies are expected to increase which results in decrease of motor fuel purchases.

The excise tax which went into effect in Virginia on July 1, 1982 are expected to contribute 17 to 22 percent of the total revenues in future years. This source of revenue is sensitive to inflation and it generates more revenue if gasoline and diesel fuel prices will increase.

The registration fee and sales and use tax revenues are estimated to contribute separately between 17 to 20 percent of the total revenues. The increase of registration fees are predicted to generate about 30 to 35 million dollars of additional revenue.

The increase of sales and use tax from 2 to 3 percent is recommended, because an increase in this tax has the political advantage in that it is only paid once over the course of ownership of a vehicle. An increase in this tax would also provide a more stable long-term source of revenue and will generate between 30 to 50 million dollars additional revenue in future years.

The two modeling approaches used in determining the fuel tax revenue: travel-based and gasoline-demand provided comparable results. The criticism levied against the accuracy of the vehicle miles of travel data utilized by the travel-based model did not project unreasonable estimates of fuel consumption when compared to gasoline-demand model forecasts. Besides the travel-based DMV model showed better sensitivity for future economic scenarios than the gasoline-demand DMV model for the same input data. It is apparent that both approaches provide reasonable estimates of future fuel consumption in Virginia and the reliability of forecasts is more dependent on the accuracy of the projections of economic conditions rather than on the modeling approach.

The accuracy of sales and use tax revenue estimated by the updated and refined DMV models proved to be dependent on the reliability of the equations determining the new and used vehicle purchases in the future. The improvment of the refined model in forecasting better estimates of sales and use tax revenue relies basically on the two new equations which project the number of new and used vehicle purchases. Of course, using the actual dollar volume of sales of new and used vehicles as a dependent variable was another factor for success of the refined model in forecasting better and more reliable revenue from sales and use tax.

Using average price of new and used vehicles by the updated DMV model is the basic reason for overestimation of the sales and use tax revenue. The price of used vehicles are usually higher than the purchased price claimed by people who pay the sales tax. So, it is better not to use the average price of either new or used vehicles in the equations determining sales and use tax revenue. On the other hand, it is suggested that independent variables such as average montly payment on purchase of new cars or auto loan interest rate to be used instead. In conclusion, it is recommended that more emphsis be given in projecting population and economic variables which influence the entire estimates of the vehicle-related revenues.

## REFERENCES


1. Virginia Tech at the News, "Published by the Public Information Office," 315 Burres ,Vol. 5, No. 1.

2. Hobieka, a. g., and et al., "Future Virginia's Highway Revenues and expenditures:an Integrated Approach to Evaluating Highway Taxation Policies (Phase 1)." Department of Civil Engineering, Virginia polytechnique Institute and State University, September 1981.

3. Technical Memorandum, Task A ; "Review and Summary of Past Work," System Design Concepts, Inc., Washington, D.C., 1979.

4. David , L. Green, "The Aggregate Demand for Gasoline and Highway Passenger Vehicles in The United States: A Review of Literature 1938-1978," Oak Ridge National Laboratory, July, 1981.

5. Beaton, W. P., Weyland, J. H., and Numan, N. C., "Energy Forecasting for planners:Transportation Models," Center for Urban Policy Research, The State University of New Jersey, 1982.

6. Technical memorandum, Task C: "Identifying Revenue Impacts," System Design Inc., Wasshington, D.C., 1980.

7. Shonka, D. B., Loebl, A. S., and Patterson, P. D., "Transportation Energy Data Book ," Oak Ridge National Laboratory,k, N.Y., 1952. Oak Ridge, TN.,1977.

8. Motor Vehicle Manufacturers Association, "America Runs On Wheels," MVMA of the United States, Inc., Detroit, MI.,1978.

9. Hobeika, A. G., and Gordon, F., "Virginia Highway Related Revenues Under Different Taxation Policies ," Department of Civil Engineering, Virginia Tech., Blacksburg, Virginia, August 1980.

10. Energy Projections, "U.S. DOE, Energy Information Administration," Annual Report to Congress, Vol. 3, January 1982.

11. Joint Legislative Audit and Review Commission, "Highway Financing," Senate Document no. 14, Commonwealth of Virginia,Richmond, 1982.

12. Preliminary Report, "Department of Taxation," Commonwealth of Virginia Richmond, July 26, 1982.

# Appendix A

# INPUT DATA

TABLE 49

DEMOGRAPHIC DATA

| Calendar Year | (1) Population | (1) Population Age 16 and Over | (1) Persons Per Household |
|---|---|---|---|
| 1967 | 4,609,884 | 3,122,723 | 3.35 |
| 1968 | 4,555,255 | 3,188,831 | 3.32 |
| 1969 | 4,619,601 | 3,256,018 | 3.30 |
| 1970 | 4,648,494 | 3,525,161 | 3.27 |
| 1971 | 4,736,000 | 3,411,000 | 3.23 |
| 1972 | 4,799,000 | 3,477,000 | 3.19 |
| 1973 | 4,865,000 | 3,553,000 | 3.15 |
| 1974 | 4,924,000 | 3,621,000 | 3.11 |
| 1975 | 4,989,000 | 3,694,000 | 3.06 |
| 1976 | 5,052,000 | 3,767,000 | 3.01 |
| 1977 | 5,112,000 | 3,837,000 | 2.96 |
| 1978 | 5,177,000 | 3,911,000 | 2.90 |
| 1979 | 5,197,000 | 3,953,000 | 2.84 |
| 1980 | 5,346,279 | 4,068,000 | 2.78 |

TABLE 50

ECONOMIC DATA

| Calendar Year | (2) Manufacturing Capital Expenditures ($billion) | (2) Total Discounted** Capital Stock In Mfg. ($billion) | (1) Personal Income ($billion) |
|---|---|---|---|
| 1960 | 0.139 | 1.263 | 7.51 |
| 1961 | 0.171 | 1.350 | 7.95 |
| 1962 | 0.194 | 1.453 | 8.56 |
| 1963 | 0.214 | 1.560 | 9.15 |
| 1964 | 0.273 | 1.726 | 10.07 |
| 1965 | 0.308 | 1.905 | 10.90 |
| 1966 | 0.357 | 2.110 | 11.82 |
| 1967 | 0.334 | 2.270 | 12.90 |
| 1968 | 0.325 | 2.397 | 14.20 |
| 1969 | 0.425 | 2.585 | 15.87 |
| 1970 | 0.400 | 2.744 | 17.29 |
| 1971 | 0.386 | 2.866 | 18.97 |
| 1972 | 0.535 | 3.089 | 21.11 |
| 1973 | 0.613 | 3.329 | 23.76 |
| 1974 | 0.727 | 3.583 | 26.47 |
| 1975 | 0.738 | 3.785 | 28.99 |
| 1976 | 0.905 | 4.045 | 32.10 |
| 1977 | 0.855 | 4.227 | 35.82 |
| 1978 | 0.968 | 4.420 | 40.18 |
| 1979 | 1.377 | 4.606 | 44.98 |
| 1980 | 1.500* | 5.007* | 50.33 |

*Estimated
**Calculated using Equation (2) in "A Model for Forecasting Virginia Automotive Fuels Tax Revenues," John W. Dickey for the Virginia Division of Motor Vehicles, Richmond, Virginia.

TABLE 51

CONSUMER PRICE INDICES

| Calendar Year | (3) Overall | (3) Gasoline* | (3) Parking** | (4) Trucking Labor*** |
|---|---|---|---|---|
| 1960 | 88.7 | 92.5 | | |
| 1961 | 89.6 | 91.4 | | |
| 1962 | 90.6 | 91.9 | | |
| 1963 | 91.7 | 91.8 | | |
| 1964 | 92.9 | 91.4 | 94.0 | |
| 1965 | 94.5 | 94.9 | 95.6 | |
| 1966 | 97.2 | 97.0 | 96.6 | |
| 1967 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1968 | 104.2 | 101.4 | 104.8 | 105.8 |
| 1969 | 109.8 | 104.7 | 111.0 | 112.2 |
| 1970 | 116.3 | 105.6 | 124.0 | 118.8 |
| 1971 | 121.3 | 106.3 | 135.3 | 134.7 |
| 1972 | 125.3 | 107.6 | 144.5 | 149.5 |
| 1973 | 133.1 | 118.3 | 152.8 | 163.8 |
| 1974 | 147.7 | 159.9 | 158.9 | 176.0 |
| 1975 | 161.2 | 170.8 | 172.1 | 188.1 |
| 1976 | 170.5 | 180.8 | 183.9 | 199.7 |
| 1977 | 181.5 | 188.2 | 194.5 | 213.9 |
| 1978 | 195.4 | 196.3 | 206.6+ | 241.0 |
| 1979 | 217.4 | 265.6 | 226.5+ | 259.3 |
| 1980 | 246.8 | 369.1 | 241.8+ | N/A |
| 1981 | 272.4 | 410.9 | 258.1+ | N/A |

*Includes gas tax

**Consumer Price Index for Parking is no longer a separate index.

***Index of average hourly earnings for labor in SIC category 421,3 trucking and truck terminals.

+Projected by regression analysis.

TABLE 52

VEHICLE MILES OF TRAVEL

| Calendar Year | (5) Total Vehicle Miles of Travel* (billions) | (5) % of Travel by Virginia Passenger Cars | (5) % of Travel by Out-of-State Passenger Cars | (5) % of Travel by Trucks and buses |
|---|---|---|---|---|
| 1966 | 21.75 | 61.17 | 19.22 | 19.61 |
| 1967 | 22.64 | 62.26 | 18.36 | 19.38 |
| 1968 | 24.55 | 62.31 | 18.31 | 19.38 |
| 1969 | 26.95 | 62.76 | 17.70 | 19.54 |
| 1970 | 28.42 | 61.28 | 18.06 | 20.66 |
| 1971 | 30.50 | 61.10 | 17.78 | 21.12 |
| 1972 | 32.72 | 60.75 | 17.54 | 21.71 |
| 1973 | 34.66 | 60.67 | 16.92 | 22.41 |
| 1974 | 33.63 | 60.85 | 15.51 | 23.64 |
| 1975 | 34.64 | 60.83 | 15.93 | 23.24 |
| 1976 | 36.71 | 60.38 | 15.43 | 24.19 |
| 1977 | 38.10 | 59.41 | 15.04 | 25.55 |
| 1978 | 39.83 | 58.67 | 14.51 | 26.82 |
| 1979 | 38.48 | 59.79 | 12.36 | 27.85 |
| 1980 | 37.75 | 60.57 | 12.25 | 27.18 |
| 1981 | 38.44** | 60.58** | 12.66** | 26.76** |

*On Virginia roads by all travelers.
**Preliminary Estimates

TABLE 53

FUEL CONSUMPTION DATA

| Calendar Year | (7) National Auto MPG | (7) Light Trucks MPG | (8) Heavy Trucks MPG | (9) Net Gallons of Fuel Used (billions) |
|---|---|---|---|---|
| 1965 | 14.00 | | | 1.60 |
| 1966 | 13.96 | | | 1.67 |
| 1967 | 13.91 | | | 1.76 |
| 1968 | 13.77 | | | 1.91 |
| 1969 | 13.63 | | | 2.05 |
| 1970 | 13.58 | | | 2.17 |
| 1971 | 13.61 | | 4.92 | 2.33 |
| 1972 | 13.57 | | 4.87 | 2.51 |
| 1973 | 13.21 | | 4.78 | 2.67 |
| 1974 | 13.56 | | 4.76 | 2.59 |
| 1975 | 13.65 | | 5.83 | 2.65 |
| 1976 | 13.93 | 10.52 | 4.66 | 2.82 |
| 1977 | 14.15 | 10.83 | 4.73 | 2.94 |
| 1978 | 14.06 | 11.01 | 4.75 | 3.07 |
| 1979 | 14.49 | 11.25 | 4.79 | 2.96 |
| 1980 | 15.50+ | 11.70 | 4.76 | 2.81 |
| 1981 | 16.40+ | 11.95 | 4.82 | 2.77 |

+Estimates

TABLE 54

VEHICLE REGISTRATION

| Calendar Year | Auto (10) | Bus (10) | Truck (10) | Moto (10) | Trail (10) | Grand Total |
|---|---|---|---|---|---|---|
| 1960 | 1198043 | 6514 | 221614 | 6611 | 69579 | 1502361 |
| 1961 | 1247326 | 7035 | 228056 | 6485 | 73866 | 1562768 |
| 1962 | 1318171 | 6934 | 237497 | 6738 | 78325 | 1647665 |
| 1963 | 1389481 | 7307 | 249300 | 6855 | 84242 | 1737105 |
| 1964 | 1442978 | 7683 | 256415 | 7886 | 83688 | 1798650 |
| 1965 | 1520008 | 7848 | 271701 | 13732 | 92243 | 1905532 |
| 1966 | 1582609 | 8018 | 284152 | 20247 | 99227 | 1994253 |
| 1967 | 1628849 | 8322 | 245307 | 21277 | 104471 | 2058226 |
| 1968 | 1724400 | 8831 | 314326 | 25088 | 111671 | 2184316 |
| 1969 | 1816787 | 8822 | 335669 | 24622 | 119515 | 2305415 |
| 1970 | 1894532 | 9099 | 359090 | 32566 | 127904 | 2423191 |
| 1971 | 2013427 | 9325 | 387464 | 40984 | 139237 | 2590437 |
| 1972 | 2167217 | 9823 | 425733 | 52729 | 153264 | 2808766 |
| 1973 | 2293648 | 10255 | 489646 | 70362 | 170975 | 3034886 |
| 1974 | 2656125 | 10916 | 504703 | 89978 | 177063 | 3438785 |
| 1975 | 2709506 | 11051 | 530304 | 91151 | 184376 | 3526388 |
| 1976 | 2764444 | 11123 | 526685 | 72302 | 187624 | 3562178 |
| 1977 | 2767455 | 11045 | 478258 | 75688 | 193303 | 3332446 |
| 1978 | 2936000 | 11462 | 491493 | 72175 | 203935 | 3715132 |
| 1979 | 2998006 | 12136 | 500020 | 79942 | 206116 | 3795772 |
| 1980 | 3071878 | 13274 | 541128 | 85439 | 211431 | 3923150 |
| 1981 | 3137000+ | | 567000++ | 91000+ | | |

+Estimates
++Includes trucks and buses

TABLE 55

REGISTRATION REVENUES IN THOUSANDS OF DOLLARS

| Calendar Year | (10) Auto | (10) Bus | (10) Truck | (10) Moto | (10) Trail | Total |
|---|---|---|---|---|---|---|
| 1960 | 11749 | 157 | 8835 | 18 | 448 | 21207 |
| 1961 | 12223 | 167 | 9046 | 18 | 484 | 21938 |
| 1962 | 12893 | 168 | 9754 | 19 | 531 | 23365 |
| 1963 | 13592 | 177 | 10544 | 19 | 585 | 24917 |
| 1964 | 21706 | 240 | 13873 | 59 | 1139 | 37017 |
| 1965 | 22932 | 225 | 14431 | 103 | 1184 | 38875 |
| 1966 | 24079 | 217 | 15320 | 156 | 1276 | 41048 |
| 1967 | 24750 | 224 | 15652 | 164 | 1326 | 42116 |
| 1968 | 26130 | 224 | 16473 | 193 | 1384 | 44404 |
| 1969 | 27543 | 228 | 17451 | 189 | 1460 | 46871 |
| 1970 | 28826 | 238 | 18254 | 248 | 1526 | 49092 |
| 1971 | 30554 | 222 | 19606 | 312 | 1652 | 52346 |
| 1972 | 33805 | 228 | 21699 | 403 | 1834 | 57969 |
| 1973 | 42624 | 199 | 24041 | 525 | 2058 | 69447 |
| 1974 | 39308 | 164 | 19991 | 684 | 2214 | 62361 |
| 1975 | 41063 | 159 | 28037 | 656 | 2307 | 72151 |
| 1976 | 41835 | 115 | 27158 | 564 | 2550 | 72222 |
| 1977 | 43662 | 66 | 25187 | 601 | 2529 | 72045 |
| 1978 | 48768 | 61 | 23990 | 576 | 2731 | 76126 |
| 1979 | 50250 | 64 | 30682 | 636 | 2787 | 84419 |
| 1980 | 50035 | 62 | 32410 | 636 | 2678 | 85821 |

TABLE 56

SALES AND USE TAX DATA

| | (11) | (11) | (11) | (11) | |
|---|---|---|---|---|---|
| | Purchases* | | Average Price* | | |
| Calendar Year | NEWCP | USEDCP | PRNEW | PRUSED | REVSU |
| 1967 | 195107 | 448957 | 3005.8 | 791.7 | 18837188 |
| 1968 | 241949 | 512098 | 3195.2 | 870.6 | 24378157 |
| 1969 | 223610 | 501739 | 3340.9 | 976.2 | 24737829 |
| 1970 | 243691 | 577897 | 3372.8 | 1004.5 | 28048190 |
| 1971 | 288615 | 630611 | 3562.1 | 1076.6 | 34139290 |
| 1972 | 310544 | 658569 | 3754.4 | 1119.7 | 38065520 |
| 1973 | 354969 | 712805 | 3954.6 | 1178.5 | 44876520 |
| 1974 | 279706 | 700324 | 4310.6 | 1202.6 | 40958010 |
| 1975 | 239097 | 718441 | 4918.4 | 1301.6 | 42222230 |
| 1976 | 288175 | 806768 | 5423.1 | 1459.8 | 54810040 |
| 1977 | 288340 | 833356 | 5920.0 | 1512.3 | 62976307 |
| 1978 | 336279 | 864252 | 6574.0 | 1637.4 | 72516057 |
| 1979 | 348048 | 1023882 | 7094.0 | 2034.0 | 70228080 |
| 1980 | 256621 | 774561 | 7490.9 | 2350.9 | 66115600 |
| 1981 | 275778 | 783941 | 9355.8 | 2818.4 | 67686926 |

*Includes all types of vehicles: autos, buses, trucks, motorcycles, and trailers.

# DATA SOURCES

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10. Federal Highway Administration. Highway Statistics, U.S.G.P.O., Washington, D.C. (1979 estimates provided by Ms. Arlene Munday).

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Appendix B

COMPUTER PROGRAM

```
$JOB     WATFIV,KP=29
      INTEGER BYR,HYR
C     --BASE CASE ECONOMIC CONDITION------------------------------------
C     SOCIO-ECONOMIC VARIABLES
C
      REAL TDCSM(30),MIGR(30),CPIAI(30),PI(30),AHHI(30),
     $AHHI67(30),POP(30),PPH(30),HH(30),MFGINV
C     ------------------------------------------------------------------
C     TRAVEL AND FUEL TAX VARIABLES
C
      REAL AMPG(30),LTMPG(30),HTMPG(30),CPIGC(30),ACPM(30),TCPM(30),
     &FUELTX(30),WSGP(30),WSDP(30),BFTXR(30),CPIPC(30),CPILC(30)
C     ------------------------------------------------------------------
C     REGISTRATION VARIABLES:
      REAL DPOP(30)
C     ------------------------------------------------------------------
      REAL MATRIX(30,12),MTRX(30,12)
      COMMON/BLCK1/MATRIX,MTRX
      COMMON/BLCK2/TDCSM
      COMMON/BLCK3/PI,AHHI,AHHI67,HH
      COMMON/BLCK4/FUELTX,ACPM,TCPM
      COMMON/BLCK5/ BYR,HYR
C
C     BEGIN INPUTS:
C     ------------------------------------------------------------------
C
      READ,BYR,HYR
C
C     ------------------------------------------------------------------
C     END INPUT;
C
      M=HYR-BYR+1
      N=M+1
      CALL SOECON(MIGR,CPIAI,POP,DPOP,PPH,N,M)
      CALL GASTX(AMPG,LTMPG,HTMPG,CPIGC,CPIPC,CPILC,CPIAI,WSGP,WSDP,
     &BFTXR,M)
      CALL REGIS(DPOP,POP,CPIAI,M)
      CALL SALUSE(CPIAI,CPIGC,AMPG,M)
      STOP
      END
      SUBROUTINE SOECON(MIGR,CPIAI,POP,DPOP,PPH,N,M)
C *************************************************************
C
C                SOCIO-ECONOMIC FORECAST SUBROUTINE             *
C
C *************************************************************
C
      REAL TDCSM(30),PI(30),AHHI(30),AHHI67(30),HH(30),MFGINV,
     $MIGR(M),CPIAI(M),POP(M),DPOP(M),PPH(M),MATRIX(30,12),MTRX(30,12)
      COMMON/BLCK1/MATRIX,MTRX
      COMMON/BLCK2/TDCSM
      COMMON/BLCK3/PI,AHHI,AHHI67,HH
C
C     BEGIN INPUTS:
C     ------------------------------------------------------------------
```

```
C
      READ,TDCSM(1),MFGINV,SLM,
     &     MIGR,POP,PPH,CPIAI,DPOP
C
C     -----------------------------------------------------------------
C     END INPUT;
C
      DO 1 I=1,M
        HH(I)=POP(I)/PPH(I)
        IV=1
        CALL ASSIGN(POP(I),MATRIX,I,IV)
        CALL ASSIGN(PPH(I),MATRIX,I,IV)
        CALL ASSIGN(HH(I),MATRIX,I,IV)
        CALL ASSIGN(DPOP(I),MATRIX,I,IV)
1     CONTINUE
      IV=IV-1
      WRITE(6,100)
100   FORMAT('1',20X,'DEMOGRAPHIC PROJECTIONS',/,1X,'YEAR',8X,'POP',
     &2X,'% GROWTH',7X,'PPH',2X,'% GROWTH',8X,'HH',2X,'% GROWTH',6X,
     &'DPOP',2X,'% GROWTH',/)
      CALL PRINT(MATRIX,IV,M,1,1,1,0)
      WRITE(6,101)
101   FORMAT(//,' POP = POPULATION'//,' PPH = PERSONS PER HOUSEHOLD'//,
     &' HH = HOUSEHOLDS'//,' DPOP = DRIVING POPULATION (16 AND OLDER)')
      DO 2 K=1,M
        I=K+1
        MFGINV=MFGINV*(1.0+MIGR(K))
        TDCSM(I)=(TDCSM(K)*(SLM-1.0)/SLM)+MFGINV*100.0/CPIAI(K)
        TDCSM(K)=TDCSM(I)
C
C     REGRESSION EQUATION: PERSONAL INCOME
C
        PI(K)=4.9745*EXP(0.4652*TDCSM(I))
        PI67=PI(K)*100.0/CPIAI(K)
C
        AHHI(K)=1.0E9*PI(K)/HH(K)
        AHHI67(K)=AHHI(K)*100.0/CPIAI(K)
        CAHI=AHHI(K)/1000.; CAHI67=AHHI67(K)/1000.
        IV=1
        CALL ASSIGN(MFGINV,MATRIX,K,IV)
        CALL ASSIGN(TDCSM(K),MATRIX,K,IV)
        CALL ASSIGN(PI(K),MATRIX,K,IV)
        CALL ASSIGN(PI67,MATRIX,K,IV)
        CALL ASSIGN(CAHI,MATRIX,K,IV)
        CALL ASSIGN(CAHI67,MATRIX,K,IV)
2     CONTINUE
      IV=IV-1
      WRITE(6,102)
102   FORMAT('1',20X,'ECONOMIC PROJECTIONS',/,' YEAR',5X,'MFGINV',2X,
     &'% GROWTH',5X,'TDCSM',2X,'% GROWTH',8X,'PI',2X,'% GROWTH',6X,
     &'PI67',2X,'% GROWTH',6X,'AHHI',2X,'% GROWTH',4X,'AHHI67',2X,'%
     & GROWTH',/)
      CALL PRINT(MATRIX,IV,M,3,3,2,1)
      WRITE(6,103)
103   FORMAT(//,' MFGINV = MANUFACTURING INVESTMENT (BILL. DOLLARS)'//,
```

```
      &' TDCSM = TOTAL DISCOUNTED CAPITAL STOCK IN MANUFACTURING (BILL. D
      &OLLARS)'//,' PI = TOTAL STATE PERSONAL INCOME (BILL. DOLLARS)'//,
      &' PI67= TOTAL STATE PERSONAL INCOME IN 1967 CONSTANT DOLLARS '//,
      &' AHHI = AVG. HOUSEHOLD INCOME (THOUS. DOLLARS)'//,' AHHI67 = AVG.
      &HOUSEHOLD INCOME (THOUS. 1967 DOLLARS)')
       RETURN
       END
       SUBROUTINE GASTX(AMPG,LTMPG,HTMPG,CPIGC,CPIPC,CPILC,CPIAI,WSGP,
      &WSDP,BFTXR,M)
C     ****************************************************************
C
C                          FUEL TAX AND TRAVEL SUBROUTINE
C
C      ****************************************************************
C
       REAL AMPG(M),LTMPG(M),HTMPG(M),CPIGC(M),CPIAI(M),CPIPC(M),CPILC(M)
      &,WSGP(M),WSDP(M),BFTXR(M),
      &AHHI(30),AHHI67(30),HH(30),PI(30),ACPM(30),TCPM(30),TDCSM(30),
      &FUELTX(30),MATRIX(30,12),MTRX(30,12),LTKVM,LVFTXR,DGGR(30),DGR
       INTEGER BYR,HYR
       COMMON/BLCK1/MATRIX,MTRX
       COMMON/BLCK2/TDCSM
       COMMON/BLCK3/PI,AHHI,AHHI67,HH
       COMMON/BLCK4/FUELTX,ACPM,TCPM
       COMMON/BLCK5/ BYR,HYR
C
C      BEGIN INPUTS:
C      ----------------------------------------------------------------
C
       READ,CPIGC7,CPIPC7,CPILC7,AMPG7,TMPG7,DGR,
      &AMPG,LTMPG,HTMPG,CPIGC,CPIPC,CPILC,BFTXR,WSGP,WSDP,DGGR
C      ----------------------------------------------------------------
C      END INPUTS;
C
C      BGTXR = BASE GAS TAX RATE
C      BDTXR = BASE DIESEL TAX RATE
C
       DO 1 I=1,M
       DGR=DGR*(1.0+DGGR(I))
         ACPM(I)=(4.1*CPIGC(I)*AMPG7/(AMPG(I)*CPIGC7)) + 2.0*CPIPC(I)/
      $  CPIPC7
         TCPM(I)=(6.1*CPIGC(I)*TMPG7/(LTMPG(I)*CPIGC7)) + 9.7*CPILC(I)/
      $  CPILC7
C
C      REGRESSION EQUATION: IN-STATE HOUSEHOLD VMT
C
           AVMISH=1.7814E-10*((ACPM(I)*100.0/CPIAI(I))**(-0.2135))*
      &      (AHHI67(I)**1.2403)*HH(I)
C
         HVMLIM=25000.0*HH(I)/1.0E9
         IF(AVMISH.GT.HVMLIM) AVMISH=HVMLIM
C
C      REGRESSION EQUATIONS: TRUCK VMT & OUT-OF STATE VMT
C
         TTKVM=(0.7782*100.0*PI(I)/CPIAI(I)) - 5.7376
```

```
      HTKVM=(-593.212+98.277652*PI(I)*100.0/CPIAI(I))/1000.0
      LTKVM=TTKVM-HTKVM
C
      AVMOSH=10.122-(11279.262*ACPM(I)/AHHI(I))+0.2584*TDCSM(I)
C   -----------------------------------------------------------------
      TOTVM=AVMISH+AVMOSH+TTKVM
      CLTFC1=(AVMISH+AVMOSH)/AMPG(I) +
     &  LTKVM/LTMPG(I)
      CLTFC2=(-2616.0213+0.354747*AHHI67(I)+0.0015358*HH(I)-97.291161*
     & AMPG(I))/1000.0
      HTKFC=HTKVM/HTMPG(I)
      TFPIVA=66.05E-3+.1462*HTKVM
      TFC=CLTFC1+TFPIVA
      TFC1=CLTFC2+TFPIVA
      TFC=.99175*TFC
      TFC1=.985*TFC1
      IF((I+BYR-1).LT.1982) THEN DO
       LVFTXR=BFTXR(I)
       HVFTXR=BFTXR(I)
      ELSE DO
      N=(I+BYR)-1982
       DO CASE N
        CASE
         LVFTXR=BFTXR(I)+0.03*WSGP(I)*0.5
         HVFTXR=BFTXR(I)+0.03*WSDP(I)*0.5
        IF NONE DO
         LVFTXR=BFTXR(I)+0.03*WSGP(I)
         HVFTXR=BFTXR(I)+0.03*WSDP(I)
        END CASE
       END IF
      FTAX1=((TFC*DGR)*HVFTXR+(TFC*(1.0-DGR))*LVFTXR)*1000.0
      FTAX2=((TFC1*DGR)*HVFTXR+(TFC1*(1.0-DGR))*LVFTXR)*1000.0
      ROADTX=1000.*(TFPIVA*0.02+(HTKFC-TFPIVA)*(HVFTXR+0.02))
      IV1=1
      CALL ASSIGN(CLTFC2,MTRX,I,IV1)
      CALL ASSIGN(HTKVM,MTRX,I,IV1)
      CALL ASSIGN(HTKFC,MTRX,I,IV1)
      CALL ASSIGN(FTAX2,MTRX,I,IV1)
      CALL ASSIGN(TFPIVA,MTRX,I,IV1)
      CALL ASSIGN(ROADTX,MTRX,I,IV1)
      IV=1
      CALL ASSIGN(AVMISH,MATRIX,I,IV)
      CALL ASSIGN(AVMOSH,MATRIX,I,IV)
      CALL ASSIGN(TTKVM,MATRIX,I,IV)
      CALL ASSIGN(TOTVM,MATRIX,I,IV)
      CALL ASSIGN(CLTFC1,MATRIX,I,IV)
      CALL ASSIGN(FTAX1,MATRIX,I,IV)
1    CONTINUE
     IV1=IV1-1
     IV=IV-1
     WRITE(6,100)
100  FORMAT('1',20X,'TRAVEL - FUEL CONSUMPTION - FUELS TAX',//,
    &' YEAR',5X,'AVMISH',2X,'% GROWTH',4X,'AVMOSH',2X,'% GROWTH',6X,
    &'TKVM',2X,'% GROWTH',5X,'TOTVM',2X,'% GROWTH',4X,'CLTFC1',2X,
    &'% GROWTH',5X,'FTAX1',2X,'% GROWTH',/)
```

```
      CALL PRINT(MATRIX,IV,M,3,3,2,1)
      WRITE(6,101)
101   FORMAT(//,' AVMISH = AUTO VEH. MILES IN-STATE HOUSEHOLDS (BILL.)',
     &//,' AVMOSH = AUTO VEH. MILES OUT-OF-STATE HOUSEHOLDS (BILL.)'//,
     &' TKVM = TRUCK VEH. MILES (BILL.)'//,' TOTVM = TOTAL VEH. MILES OF
     &TRAVEL (BILL.)'//,' CLTFC1 = CAR & LIGHT TRUCK FUEL CONSUMPTION (B
     &ILL. GALL.)',//,' FTAX1 = FUELS TAX REVENUES (MILL. DOLLARS)')
      WRITE(6,106)
106   FORMAT('1',20X,'FUELS TAX USING DIRECT FUEL CONS. FORECAST',//,
     &' YEAR',5X,'CLTFC2',2X,'% GROWTH',5X,'HTKVM',2X,'% GROWTH',5X,'HTK
     &FC',2X,'% GROWTH',5X,'FTAX2',2X,'% GROWTH',4X,'TFPIVA',2X,'% GROWT
     &H',4X,'ROADTX',2X,'% GROWTH',/)
      CALL PRINT(MTRX,IV1,M,3,3,2,1)
      WRITE(6,108)
108   FORMAT(//,' CLTFC2=CAR & LIGHT TRUCK FUEL CONSUMPTION(BILL.GALL.)'
     &,//,' HTKVM=HEAVY TRUCK VEH. MILES(BILL.)'//,
     &' HTKFC=HEAVY TRUCK FUEL CONSUMPTION(BILL.GALL.)'//,' FTAX2=FUELS
     &TAX REVENUES(MILL.DOLLARS)'//,' TFPIVA=TOTAL FUEL PURCHASED VA'//,
     &' ROADTX=ROAD TAX FOR HEAVY TRUCKS(MILL.DOLLARS)')
      WRITE(6,107)
107   FORMAT(1H1)
      DO 2 I=1,M
      IV=1
        CALL ASSIGN(CPIAI(I),MATRIX,I,IV)
        CALL ASSIGN(CPIGC(I),MATRIX,I,IV)
        CALL ASSIGN(CPIPC(I),MATRIX,I,IV)
        CALL ASSIGN(CPILC(I),MATRIX,I,IV)
2     CONTINUE
      IV=IV-1
      WRITE(6,102)
102   FORMAT('1',20X,'CONSUMER PRICE INDICES',//,' YEAR',6X,'CPIAI',2X,'
     &% GROWTH',5X,'CPIGC',2X,'% GROWTH',5X,'CPIPC',2X,'% GROWTH',5X,
     &'CPILC',2X,'% GROWTH',/)
      CALL PRINT(MATRIX,IV,M,2,2,2,1)
      WRITE(6,103)
103   FORMAT(//,' CPIAI = CONSUMER PRICE INDEX OF ALL ITEMS'//,' CPIGC =
     &CONSUMER PRICE INDEX OF GASOLINE COST'//,' CPIPC = CONSUMER PRICE
     &INDEX OF PARKING COST'//,' CPILC = CONSUMER PRICE INDEX OF (TRUCKI
     &NG) LABOR COST')
      DO 3 I=1,M
      IV=1
        CALL ASSIGN(AMPG(I),MATRIX,I,IV)
        CALL ASSIGN(LTMPG(I),MATRIX,I,IV)
        CALL ASSIGN(HTMPG(I),MATRIX,I,IV)
        CALL ASSIGN(ACPM(I),MATRIX,I,IV)
        CALL ASSIGN(TCPM(I),MATRIX,I,IV)
3     CONTINUE
      IV=IV-1
      WRITE(6,104)
104   FORMAT('1',20X,'FUEL EFFICIENCY AND TRAVEL COSTS/MILE',//,
     &' YEAR',7X,'AMPG',2X,'% GROWTH',5X,'LTMPG',2X,'% GROWTH',5X,
     &'HTMPG',2X,'% GROWTH',6X,'ACPM',2X,'% GROWTH',6X,'TCPM',2X,'% GROW
     *TH',/)
      CALL PRINT(MATRIX,IV,M,2,2,2,1)
      WRITE(6,105)
```

```
105   FORMAT(//,' AMPG = AUTO MILES PER GALLON'//,' TMPG = TRUCK MILES P
     &ER GALLON'//,' ACPM = AUTO COST PER MILE'//,' TCPM = TRUCK COST PE
     &R MILE')
      RETURN
      END
      SUBROUTINE REGIS(DPOP,POP,CPIAI,M)
C  *******************************************************************
C
C                     REGISTRATION REVENUE SUBROUTINE
C
C  ******************************************************************
C
      REAL DPOP(M),POP(M),CPIAI(M),MOFEE,TOTRR(30),MOTO,MOTORR,
     &   PI(30),AHHI67(30),AHHI(30),HH(30),MATRIX(30,12),MTRX(30,12)
      INTEGER BYR,HYR
      COMMON/BLCK1/MATRIX,MTRX
      COMMON/BLCK3/PI,AHHI,AHHI67,HH
      COMMON/BLCK5/ BYR,HYR
C
C     BEGIN INPUTS:
C     -----------------------------------------------------------------
C
      READ,AFEE,BFEE,TRKFEE,MOFEE,TRLFEE
C
C     -----------------------------------------------------------------
C     END INPUT;
C
      DPTRVL=1.1
      DO 1 I=1,M
C
C     REGRESSION EQUATIONS: AUTOS, BUSES & TRUCKS REGISTERED
C
      ABTREG= -934484.0 + 220189.81*PI(I)*100.0/CPIAI(I)
C     -----------------------------------------------------------------
C
        DPTRV=DPOP(I)/ABTREG
        IF(DPTRV.LT.DPTRVL) ABTREG=DPOP(I)/DPTRVL
C
C     REGRESSION EQUATIONS: AUTO REGISTRATION & BUS REGISTRATION
C
        AUTO=0.842932 * ABTREG
        BUS=-16759.0 + 0.0055386 * POP(I)
C
        TRUCK=ABTREG-AUTO-BUS
C
C    REGRESSION EQUATIONS: MOTOCYCLE REGISTRATION & TRAILER REGISTRATION
C
        MOTO=1.27344E-35*(DPOP(I)**3.92207)*(AHHI67(I)**3.4486)
        TRAIL=-291295.0 + 0.157*HH(I) + 18.9361*AHHI67(I)
        TOTREG=AUTO+BUS+TRUCK+TRAIL+MOTO
        IV=1
        CALL ASSIGN(ABTREG,MATRIX,I,IV)
        CALL ASSIGN(AUTO,MATRIX,I,IV)
        CALL ASSIGN(BUS,MATRIX,I,IV)
        CALL ASSIGN(TRUCK,MATRIX,I,IV)
```

```
          CALL ASSIGN(MOTO,MATRIX,I,IV)
          CALL ASSIGN(TRAIL,MATRIX,I,IV)
C
        IF((I+BYR-1).GE.1982) THEN DO
         N=(I+BYR)-1982
         DO CASE N
          CASE
            AFEE=AFEE+2.5
            BFEE=BFEE+2.5
            TRKFEE=TRKFEE+9.0
            MOFEE=MOFEE+3.5
            TRLFEE=TRLFEE+2.5
            CASE
            AFEE=AFEE+2.5
            BFEE=BFEE+2.5
            TRKFEE=TRKFEE+9.0
            MOFEE=MOFEE+3.5
            TRLFEE=TRLFEE+2.5
           IF NONE DO
            AFEE=AFEE
           END CASE
         END IF
          AUTORR=AUTO*AFEE
          BUSRR=BUS*BFEE
          TRKRR=TRUCK*TRKFEE
          MOTORR=MOTO*MOFEE
          TRLRR=TRAIL*TRLFEE
          TOTRR(I)=AUTORR+BUSRR+TRKRR+TRLRR+MOTORR
          IV1=1
          CALL ASSIGN(AUTORR,MTRX,I,IV1)
          CALL ASSIGN(BUSRR,MTRX,I,IV1)
          CALL ASSIGN(TRKRR,MTRX,I,IV1)
          CALL ASSIGN(MOTORR,MTRX,I,IV1)
          CALL ASSIGN(TRLRR,MTRX,I,IV1)
          CALL ASSIGN(TOTRR(I),MTRX,I,IV1)
1       CONTINUE
        IV=IV-1
        IV1=IV1-1
        WRITE(6,100)
100     FORMAT('1',20X,'REGISTRATION PROJECTIONS',//,' YEAR',5X,'ABTREG',
     &2X,'% GROWTH',6X,'AUTO',2X,'% GROWTH',7X,'BUS',2X,'% GROWTH',5X,
     &'TRUCK',2X,'% GROWTH',6X,'MOTO',2X,'% GROWTH',5X,'TRAIL',2X,
     &'% GROWTH',/)
        CALL PRINT(MATRIX,IV,M,0,0,2,1)
        WRITE(6,101)
101     FORMAT(//,' ABTREG = TOTAL AUTOS, BUSES & TRUCKS REGISTERED'//,
     &' AUTO = AUTOS REGISTERED'//,' BUS = BUSES REGISTERED'//,' TRUCK =
     &TRUCKS REGISTERED'//,' MOTO = MOTOCYCLES REGISTERED'//,' TRAIL = T
     &RAILERS REGISTERED')
        WRITE(6,102)
102     FORMAT('1',20X,'REGISTRATION REVENUES',//,' YEAR',5X,'AUTORR',
     &2X,'% GROWTH',5X,'BUSRR',2X,'% GROWTH',5X,'TRKRR',2X,'% GROWTH',
     &4X,'MOTORR',2X,'% GROWTH',5X,'TRLRR',2X,'% GROWTH',5X,'TOTRR',2X,
     &'% GROWTH',/)
        CALL PRINT(MTRX,IV1,M,0,0,2,1)
```

```
      WRITE(6,103)
103   FORMAT(//,' AUTORR = AUTO REGISTRATION REVENUES '//,' BUSRR = BUS
     &REGISTRATION REVENUES'//,' TRKRR = TRUCK REGISTRATION REVENUES'//,
     &' MOTORR = MOTOCYCLE REGISTRATION REVENUES'//,' TRLRR = TRAILER RE
     &GISTRATION REVENUES'//,' TOTRR = TOTAL REGISTRATION REVENUES')
      RETURN
      END
      SUBROUTINE SALUSE(CPIAI,CPIGC,AMPG,M)
C    ******************************************************************
C
C                     SALES & USE TAX REVENUE SUBROUTINE
C
C   *******************************************************************
      REAL PI(30),AHHI(30),AHHI67(30),HH(30),CPIAI(M),CPIGC(M),AMPG(M),
     &     MATRIX(30,12),MTRX(30,12),SUTXRV(30),NEWCP
      COMMON/BLCK1/MATRIX,MTRX
      COMMON/BLCK3/PI,AHHI,AHHI67,HH
C
C     BEGIN INPUTS:
C     -----------------------------------------------------------------
C
      READ,SUTXRT
C
C     -----------------------------------------------------------------
C     END INPUT;
C
      DO 1 I=1,M
C
C     REGRESSION EQUATIONS: (1) PRICE OF NEW CAR
C                           (2) PRICE OF USED CAR
C                           (3) NEW VEHICLES PURCHASED
C                           (4) USED VEHICLES PURCHASED
C
        PRNEW=-643.75 + 35.336*CPIAI(I)
        PRUSED=-64.306 + 0.2962*PRNEW
        NEWCP=17866.69*PI(I)*100.0/CPIAI(I) - 221396.74*CPIGC(I)/
     &         CPIAI(I) + 301.595*PRUSED*100.0/CPIAI(I)-64033.0
        USEDCP=-2256144.0+170.759*AHHI67(I)+265.054*PRNEW*100.0/
     &      CPIAI(I)+273278.58*CPIGC(I)/CPIAI(I)
C
        SUTXRV(I)=SUTXRT*(PRNEW*NEWCP+PRUSED*USEDCP)
        IV=1
        CALL ASSIGN(PRNEW,MATRIX,I,IV)
        CALL ASSIGN(PRUSED,MATRIX,I,IV)
        CALL ASSIGN(NEWCP,MATRIX,I,IV)
        CALL ASSIGN(USEDCP,MATRIX,I,IV)
      SUT=SUTXRV(I)/1.0E6
        CALL ASSIGN(SUT,MATRIX,I,IV)
1     CONTINUE
      IV=IV-1
      WRITE(6,100)
100   FORMAT('1',20X,'SALES AND USE TAX REVENUES',//,' YEAR',6X,'PRNEW',
     &2X,'% GROWTH',4X,'PRUSED',2X,'% GROWTH',5X,'NEWCP',2X,'% GROWTH',4
     &X,'USEDCP',2X,'% GROWTH',4X,'SUTXRV',2X,'% GROWTH',/)
      CALL PRINT(MATRIX,IV,M,0,3,2,1)
```

```
      WRITE(6,101)
101   FORMAT(//,' PRNEW = AVG. PRICE OF NEW CARS'//,' PRUSED = AVG. PRIC
     &E OF USED CARS'//,' NEWCP = NEW CARS PURCHASED'//,' USEDCP = USED
     &CARS PURCHASED'//,' SUTXRV = SALES AND USE TAX REVENUES (MILL. DOL
     &LARS)')
      DO 2 I=1,M
      XNEW=-377893.756648+60.21*AHHI67(I)+3820.66717*(CPIGC(I)/CPIAI(I))
      XUSED=-465996.151+53.4816527*AHHI67(I)-2491.30566*CPIGC(I)+
     &6468.463414*CPIAI(I)
      SUTX2=.02*(8.946*XNEW**.49673)*(XUSED**0.69612)*
     &  (CPIAI(I)**.73714)/1.0E6
      IV=1
      CALL ASSIGN(XNEW,MATRIX,I,IV)
      CALL ASSIGN(XUSED,MATRIX,I,IV)
      CALL ASSIGN(SUTX2,MATRIX,I,IV)
2     CONTINUE
      IV=IV-1
      WRITE(6,102)
102   FORMAT('1',10X,' SALES AND USE TAX REVENUES USING DIRECT APPROACH'
     &,//,'YEAR',6X,'XNEW',2X,'% GROWTH',4X,'XUSED',2X,'% GROWTH',5X,
     &'SUTX2',2X,'% GROWTH',/)
      CALL PRINT(MATRIX,IV,M,0,3,2,1)
      WRITE(6,103)
103   FORMAT(//,' XNEW=NEW CARS PURCHASED'//,' XUSED=USED CARS PURCHASED
     &'//,' SUTX2=SALES AND USE TAX REVENUES(MILL.DOLLARS)')
      WRITE(6,107)
107   FORMAT(1H1)
      RETURN
      END
      SUBROUTINE ASSIGN(VAL,V,I,J)
      REAL V(30,12)
      V(I,J)=VAL
      IF(I.EQ.1) THEN DO
      V(I,J+1)=0.
      ELSE DO
      V(I,J+1)=(V(I,J)-V(I-1,J))*100.0/V(I-1,J)
      END IF
      J=J+2
      RETURN
      END
      SUBROUTINE PRINT(V,IV,M,SF1,SF2,NC,NN)
C    *********************************************************************
C
C                     PRINT SUBROUTINE
C
C    *********************************************************************
C
      INTEGER SF1,SF2,BYR,HYR
      REAL V(30,12)
      CHARACTER*43 FMT(1)
      CHARACTER*20 LINE(6)/6*'--------------------'/
      COMMON/BLCK5/ BYR,HYR
      K=BYR
      N=(IV/2)-NN
      WRITE(FMT,100) N,SF1,NN,SF2
```

```
100    FORMAT('(1X,I4,',I1,'(F11.',I1,',1X,F8.2),',I1,'(F11.',I1,',1X,F8.
     &2),/)')
       DO CASE NC
         CASE 1
          DO 1 I=1,M
           WRITE(6,101) K,(V(I,J),J=1,IV)
101        FORMAT(1X,I4,F11.0,F9.2,F11.2,F9.2,2(F11.0,F9.2),/)
           K=K+1
1         CONTINUE
         IF NONE DO
          DO 2 I=1,M
           WRITE(6,FMT) K,(V(I,J),J=1,IV)
           K=K+1
2         CONTINUE
       END CASE
       N1=IV/2
       WRITE(6,102)(LINE(J),J=1,N1)
102    FORMAT(/,1X,'----',6A20)
       RETURN
       END
$ENTRY
1981 1990
5.007 1.500 14.
.09 .085 .085 .08 .08 .08 .09 .09 .09 .09
 5410434. 5475359. 5541064. 5607557. 5674847.
5742945. 5811861. 5881603. 5952182. 6023609.
 2.73 2.69 2.67 2.65 2.63 2.62 2.61 2.60 2.59 2.59
272.4 294.2 316.0 338.1 363.4 392.5 422.3 452.7 487.2 526.1
4.150E6 4.207E6 4.266E6 4.326E6 4.386E6
4.447E6 4.508E6 4.570E6 4.632E6 4.697E6
105.6 124.0 118.8 13.58 8.38 .1146
16.40 17.20 18.10 19.00 19.80 20.80 22.00 23.20 24.40 25.60
11.95 12.24 12.60 12.99 13.38 13.77 14.10 14.45 14.66 14.79
4.8 4.8 4.8 4.8 4.8 4.8 4.8 4.8 4.8 4.8
410.9 445.6 482.8 521.1 564.9 620.6 678.9 739.8 809.1 887.7
258.1 275.5 294.1 314.0 335.2 357.8 382.0 407.7 435.3 464.7
305.3 331.2 359.4 389.9 423.0 459.0 498.0 540.3 586.3 639.1
.11 .11 .11 .11 .11 .11 .11 .11 .11 .11
1.0 1.078 1.157 1.262 1.376 1.525 1.682 1.849 2.033 2.243
0.92 0.990 1.063 1.159 1.264 1.401 1.545 1.698 1.867 2.060
.057 .057 .057 .057 .057 .057 .057 .057 .057 .057 .01 .01 .01 .01 .01
.01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01
15. 5.25 50. 8.0 13.5
.02
```

## Appendix C

## DEFINITION OF VARIABLES

| | |
|---|---|
| ABTREG | =Total of autos, buses, and trucks registered |
| ACPM | =Average auto cost per mile(cents per mile) |
| AFEE | =automobile registration fee(dollar) |
| AHHI | =Average household income(thousand dollar) |
| AHHI67 | =Average household income in 1967 constant dollars |
| AMPG | =Average auto mile per gallon |
| AMPG7 | =Average auto mile per gallon in 1970 |
| AVMISH | =Travel by in-state automobiles(billion miles) |
| AVMOSH | =Travel by out-of-state automobiles(billion miles) |
| AUTO | =Number of registered autos |
| AUTORR | =Automobile registration revenue(dollar) |
| BASE | =Base case economic condition |
| BFTXR | =Base fuel tax rate(dollar) |
| BUS | =Number of registered buses |
| BUSFEE | =Bus registration fee(dollar) |
| BUSRR | =Bus registration revenue(dollar) |
| CLTFC | =Cars and light trucks fuel consumption(billion) |
| CPIAI | =Consumer price index of all items |
| CPIGC | =Consumer price index of gasoline |
| CPIGC7 | =Consumer price index of gasoline in 1970 |
| CPILC | =Consumer price index of trucking labor |
| CPIPC | =Consumer price index for parking |
| CPIPC7 | =Consumer price index for parking in 1970 |
| DPOP | =Driving age population (16 and over) |
| FTAX | =Fuel tax revenue(million dollars) |

| | |
|---|---|
| HH | =Number of households |
| HTKVM | =Heavy trucks vehicle miles(billion miles) |
| HTMPG | =Heavy trucks mile per gallon |
| HTKFC | =Heavy trucks fuel consumption(billion gallons) |
| HVFTXR | =Heavy trucks fuel tax rate(dollar) |
| LTKVM | =Light trucks vehicle miles(billion miles) |
| LTKMPG | =Light trucks mile per gallon |
| LVFTXR | =Light vehicles fuel tax rate(dollar) |
| MFGINV | =Manufacturing investment(billion dollars) |
| MIGR | =manufacturing growth rate |
| MOTO | =number of registered motorcycles |
| MOTORR | =Motorcycles registration revenue(dollar) |
| NEWCP | =New car purchases |
| PI | =Personal income in virginia(billion dollars) |
| POP | =Popualtion of Virginia |
| PPH | =Persons per household in virginia |
| PRNEW | =Average price of new cars(dollar) |
| PRUSED | =Average price of used cars(dollar) |
| ROADTX | =Road tax revenue(million dollars) |
| SUTX | =Sales and use tax revenue(million dollars) |
| SUTXR | =sales and use tax revenue(million dollars) |
| SUTXRT | =Sales and use tax rate(dollar) |
| TCPM | =Truck average cost per mile(cents per mile) |
| TDCSM | =total discounted capital stock in manufacturing |
| TFC | =Total fuel consumption(billion gallons) |

| | |
|---|---|
| TFPIVA | =Total fuel purchased in virginia(billion gallons) |
| TKVM | =Truck vehicle Miles of Travel(billion miles) |
| TMPG | =Truck average mile per gallon |
| TOTRR | =total registration revenue(dollars) |
| TOTVM | =Total vehicle miles of travel(billion miles) |
| TRKFEE | =Truck registration fee(dollar) |
| TRKRR | =Truck registration revenue(dollar) |
| TRLFEE | =Trailer registration fee(dollar) |
| TRLRR | =Trailer registration revenue(dollar) |
| USEDCP | =Number of used car purchases |
| WSGP | =Wholesale gasoline price(dollar) |
| WSDP | =Wholesale diesel price(dollar) |
| XNEW | =Number of new car purchases |
| XUSED | =Number of used car purchases |

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