Estimating Motor Fuel Demand in South Carolina

The Dunbar-Martin Demand Model

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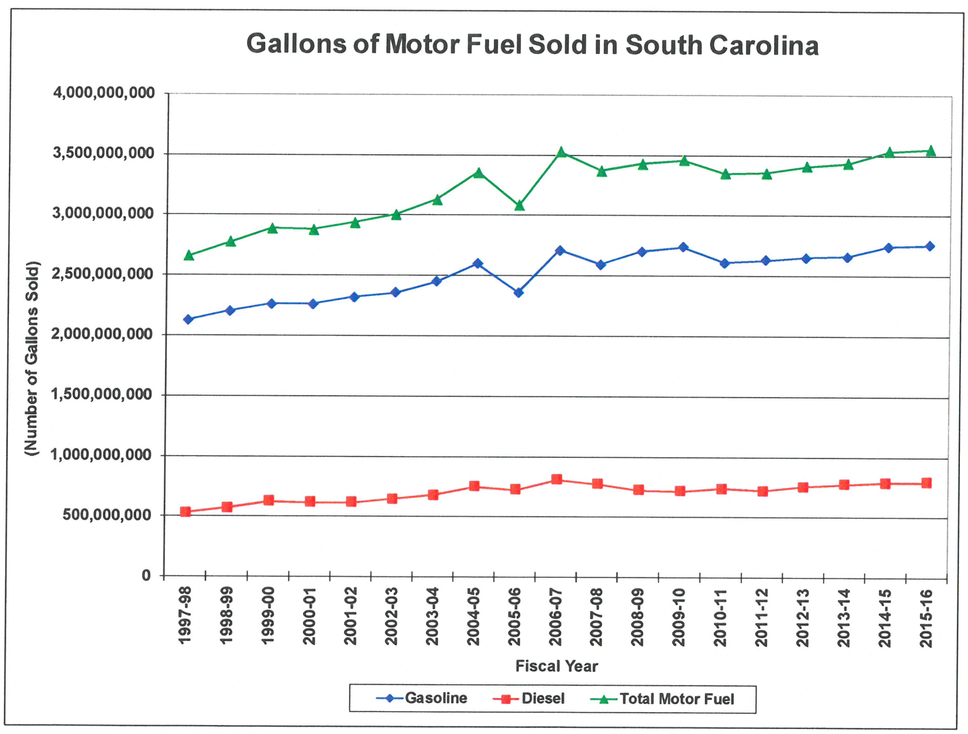
I. Introduction

Each year, over four million registered vehicles travel a combined forty-nine billion miles along the state's more than 68,300 miles of public primary and secondary highways. In doing so, motorists consumed more than three and one-half billion gallons of motor fuel as shown in the graph below. Gasoline is consumed at a rate of 3.5 to 1.0 more than diesel fuel. Total motor fuel collections yielded over $590,000,000 in FY2015-16. The majority of these funds are allocated to the State Non-Federal Aid Highway Trust Fund for use in repairing the state's roads and bridges.



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This report is organized in the following manner. After a brief introduction, Section II of the report provides a short background of the state excise tax on gasoline and diesel fuel in the State of South Carolina. Section III derives and specifies the equations used to determine the forecast levels and growth rates of gasoline and diesel fuel revenue collections. Section IV discusses the research findings of the motor fuel demand model results, while Section V provides a conclusion.

II. Background of State Excise Tax on Motor Fuel

In South Carolina, the excise tax on gasoline was adopted in 1922 and fixed at two-cents per gallon of gasoline. This was ten years before the enactment of the gasoline excise tax by the federal government. Since then, the excise tax has been raised eleven times and was last increased in 1989 where it currently resides at sixteen-cents per gallon of motor fuel. The excise tax rate is the same for gasoline, diesel fuel, and alternative fuels, either for on-highway or off-highway use.

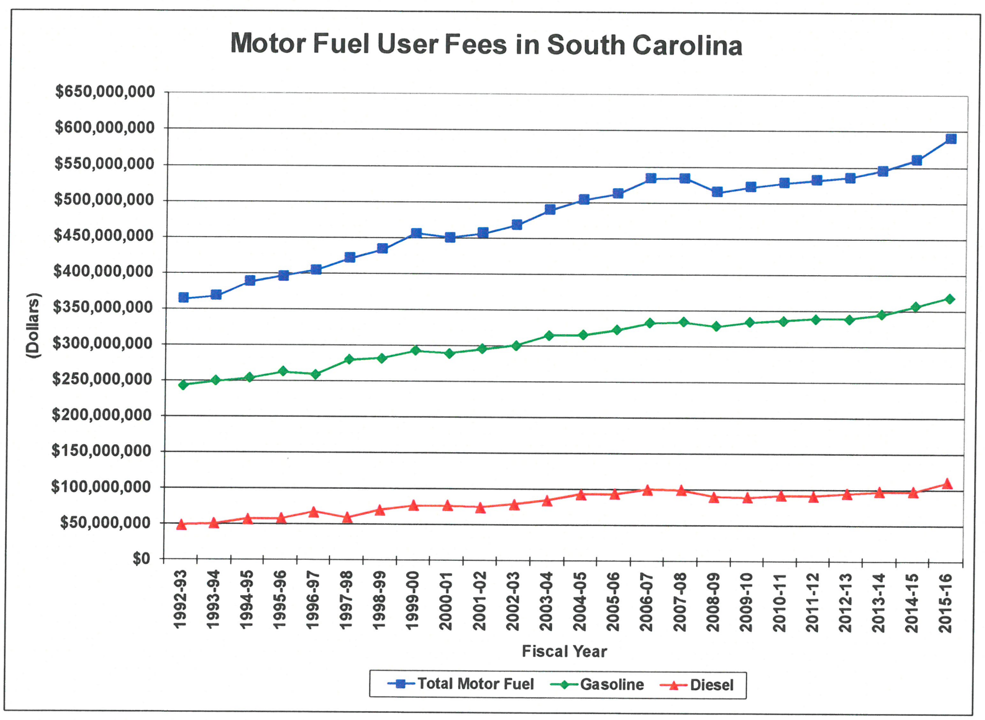
South Carolina Motor Fuels Tax Rates
By Date of Tax Rate Change
(Cents Per Gallon)

Year	Tax Rate	Legislative Enactment
1922	2 cents	Act 494 of 1922
1923	3 cents	Act 146 to 1923
1925	5 cents	Act 34 of 1925
1929	6 cents	Act 102 of 1929
1958	7 cents	Act 855 of 1958
1972	8 cents	Act 1575 of 1972
1977	9 cents	Act 141 of 1977
1979	10 cents	Act 197 of 1979
1980	11 cents	Act 506 of 1980
1981	13 cents	Act 177 of 1981
1987	15 cents	Act 197 of 1987
1989 1/	16 cents	1/

Note: 1/ Increase tax rate on gasoline and special fuels to 15 cents per gallon on July 1,1987. Tax rate increased to 16 cents per gallon on January 1, 1989.

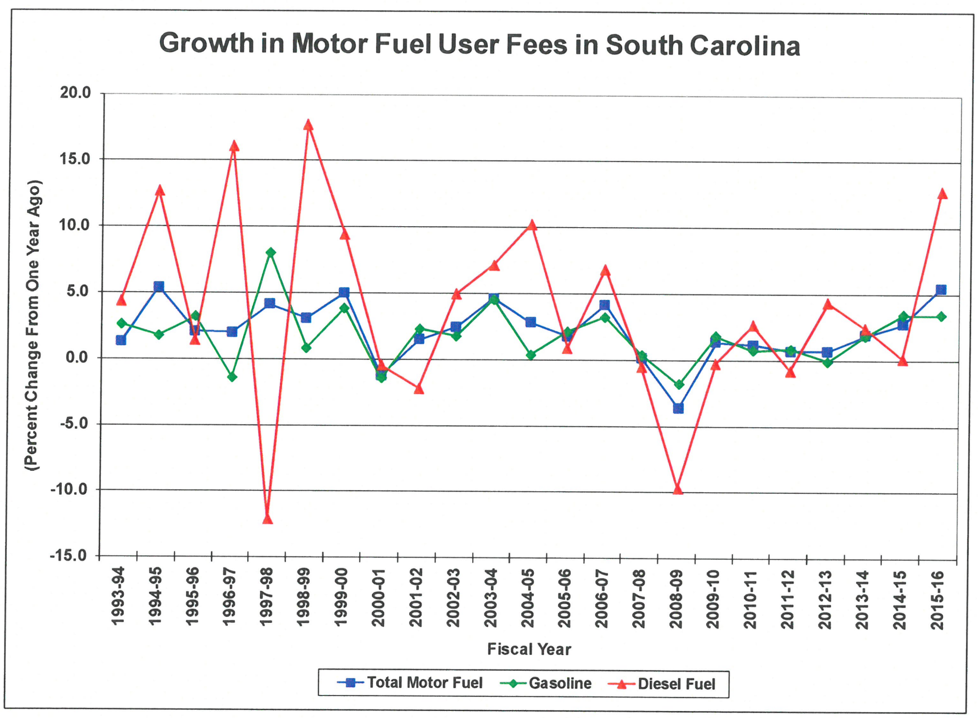
Sources: South Carolina Department of Revenue; U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information, Washington, D.C.

In 1995, two additional fees were added to the motor fuel excise tax rate. A fee of one-fourth cent a gallon was added for the purpose of providing funds for inspecting, testing, and analyzing petroleum products. The fee is divided as ten percent to the Department of Agriculture for use in inspecting and calibrating motor fuel pumps at service stations, and ninety percent is transferred to the State Non-federal Aid Highway Fund within the Department of Transportation. Also, a fee of one-half cent a gallon was imposed as an environmental impact fee to fund the Department of Health and Environmental Control's program of inspecting and monitoring motor fuel storage tanks for leaks or contamination. Collectively, these fees added an additional seventy-five one hundredths of one-cent per gallon to the excise tax rate of sixteen cents per gallon for a combined state motor fuel excise tax rate of $0.1675 per gallon of motor fuel.



The table above shows the amount of revenue collected from the state excise tax on gasoline and diesel fuel. During this time period, the state motor fuel excise tax rate per gallon has been fixed at $0.16 per gallon of fuel. In FY2015-16, gasoline tax revenue reached nearly $369,000,000 and the diesel fuel revenue yielded an additional $111,100,000 from the 13-cent component of the motor fuel tax. The additional 3.75-cents per gallon are earmarked for designated purposes other than the construction of and repair of roads and bridges. The effects of the national recessions in 2000-01 and 2007 through 2009 can clearly be seen in the graph above.

The graph below shows the growth in motor fuel user fees over time. The rate of growth of gasoline appears to be more stable than the rate of growth of diesel fuel. While each is subject to changing economic conditions, diesel fuel is subject to wider swings in the rate of growth than is gasoline. This may suggest that diesel fuel is subject to different economic factors than gasoline. Since FY1993-94, the average rate of growth of all motor fuel was 1.23 percent. Gasoline averaged an annual compound growth rate of 1.20 percent and diesel fuel averaged 1.42 percent rate of growth.



III. The Dunbar-Martin Motor Fuel Demand Model

The demand for motor fuel is dependent on many factors and conditions. Most are quantifiable, but some are not. State economic growth, fluctuating motor fuel prices, increases in the fuel efficiency of vehicles, global crude oil supply and refinery costs, changing motor vehicle preferences of drivers, changing driving habits of drivers, as well as the level of motor fuel tax rates all affect motor fuel consumption.

The data for the empirical models was obtained from state and federal government sources believed to be reliable and timely at the time of model specification. All of the data is subject to strict reporting requirements and is subject to periodic review and revision schedules. The motor fuel demand models are specified as ordinary least squares (OLS) models with each variable converted to natural logarithms before each equation is regressed.

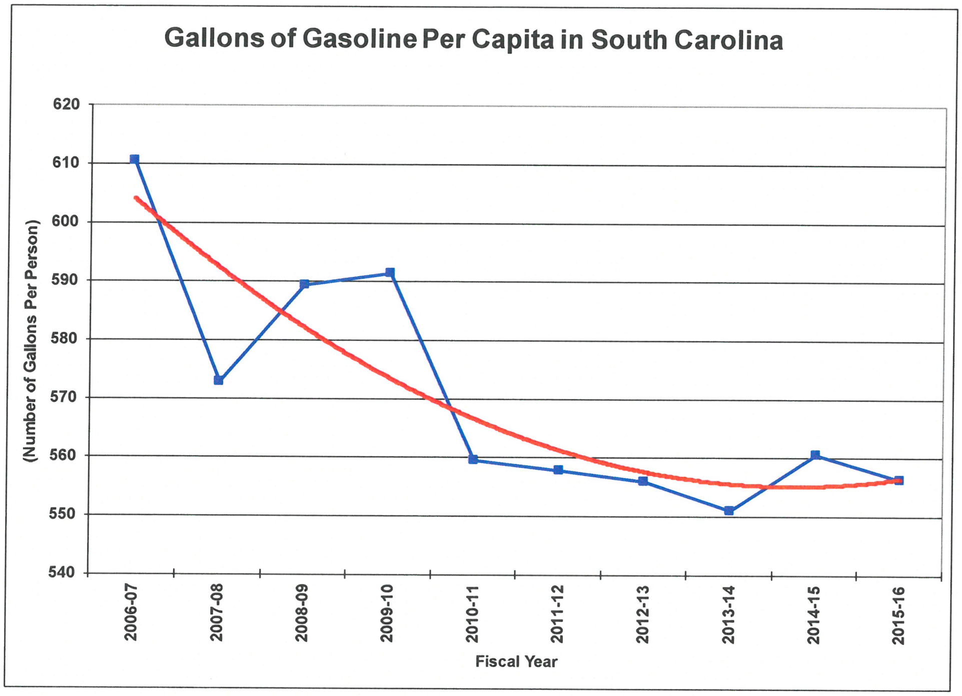
A. The Gasoline Demand Equation

The demand for motor fuel is divided into two separate econometric models – the demand for gasoline and the demand for diesel, or special fuels. The demand for gasoline may be written in the functional form as,

(Equation 1.1) $G_t = f(P_t, Yd_t)$,

where:
G_t is the level of gasoline consumption per capita at time t,
P_t is the price of gasoline per gallon at time t,
Yd_t is the level of personal disposable income per capita at time t,
t is any period or observation within the range of observed values in period t.

Many times the relationship between an explanatory variable (x) and the dependent variable (y) is nonlinear. After examining a scatterplot of the explanatory variables (x) and the dependent variable (y), there may be nonlinear relationships between them. Then the residuals of the linear model were examined to check for collinearity between the variables. There was no discernable pattern among the residuals. There are several ways to correct for nonlinearity. The most common one is to add the quadratic version of a continuous variable to the model.



The functional relationship above resembles the trend of a quadratic or polynomial expression. The red trend line portrays a polynomial expression of degree two and shows a trend that is decreasing at a decreasing rate. This functional relationship is incorporated into the gasoline model structure. Generally, the functional relationship may be rewritten and expressed for any period or observations t as:

(Equation 1.2) $\ln G_t = f(\beta_o, \ln P_t, \ln Yd_t, \ln P^2{}_t, \ln Yd^2{}_t, u_t)$,

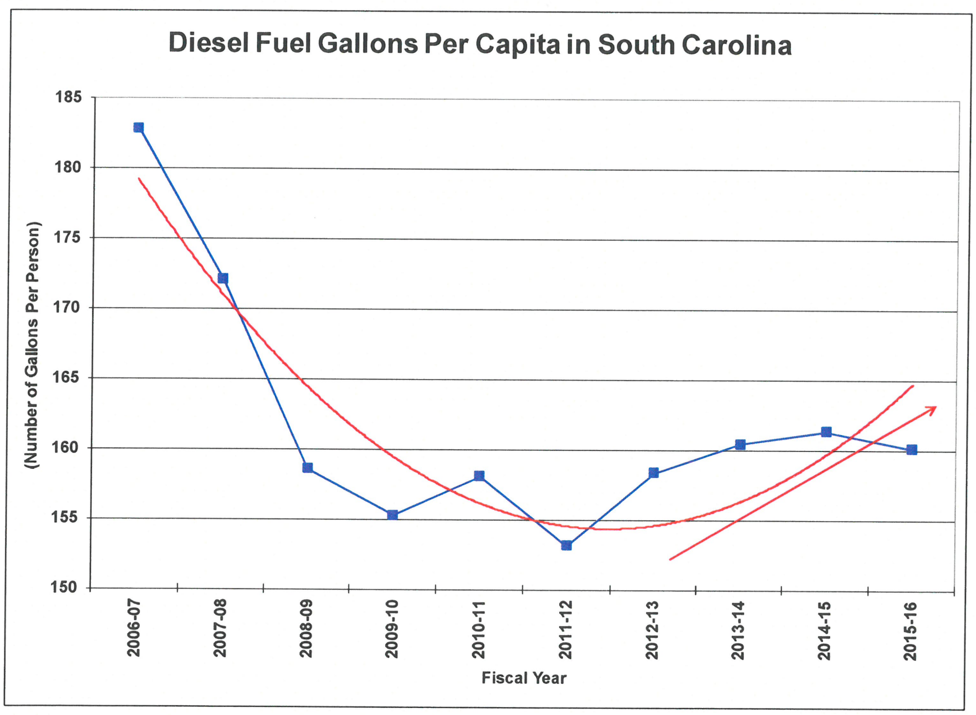
where each independent variable also is expressed as a polynomial term of degree two, an intercept term, β_o, and an error term, u_t, that is randomly distributed around a mean of zero.

The final gasoline demand specification is a log-log model structure where gasoline demand is a function of the price of gasoline, state personal disposable income, and their quadratic terms. The functional equation above may now be rewritten as:

(Equation 1.3) $\ln G_t = \beta_o + \beta_1 \ln P_t + \beta_2 \ln Yd_t + \beta_3 (\ln P)^2_t + \beta_4 (\ln Yd)^2_t + \mu_t$

B. The Diesel Fuel Demand Equation

The variables that affect the demand for diesel fuel, or special fuels, behave differently than the variables for gasoline. The same estimation method used in the gasoline model was attempted in the diesel fuel demand model. The model specifications yielded statistically insignificant results for most of the variables selected. The pattern of diesel fuel demand appears to be more linear in recent fiscal years than quadratic in nature as shown in the graph below.



The demand for diesel fuel may be written in the functional form as,

(Equation 2.1) $\ln D_t = f(\ln SCGDP_t, \ln TTU_t)$

where:
D_t is the level of diesel fuel consumption in gallons at time t,
$SCGDP_t$ is the level of gross domestic product in South Carolina at time t,
TTU_t is the level of employment in the trade, transportation, and utilities sector in South Carolina at time t,
t is any period or observation within the range of observed values in period t.

Generally, the functional relationship may be rewritten and expressed for any period or observations t as:

(Equation 2.2) $\ln D_t = f(\beta_o, \ln SCGDP_t, \ln TTU_t, u_t)$,

and includes an intercept term, β_o, and an error term, u_t, that is randomly distributed around a mean of zero. The diesel fuel demand model is a log-log model structure where diesel fuel demand is a function of the gross domestic product in South Carolina and the level of employment in the trade, transportation, and utilities industry in South Carolina. The functional equation above may now be rewritten as:

(Equation 2.3) $\ln D_t = \beta_o + \beta_1 \ln SCGDP_t + \beta_2 \ln TTU_t + \mu_t$

IV. Results

The final gasoline and diesel fuel models estimation equations are shown below. The gasoline demand model is,

(Equation 1.4) $\ln G_t = \beta_o + \beta_1 \ln P_t + \beta_2 \ln Yd_t + \beta_3 (\ln P)^2_t + \beta_4 (\ln Yd)^2_t + \mu_t$

The diesel fuel demand model is,

(Equation 2.4) $\ln D_t = \beta_o + \beta_1 \ln SCGDP_t + \beta_2 \ln TTU_t + \mu_t$

The log-log OLS gasoline and diesel fuel demand econometric models were each regressed separately and the results of each were summed to total motor fuel demand. The results of the forecast model simulation are shown in the tables below. The gasoline demand model had a multiple R statistic of ninety-five percent and the diesel fuel model had a multiple R statistic of ninety-seven percent. The multiple R statistics is a measure of the "goodness of fit" of the model equation with multiple regressors, or how well the equation explains changes in the model's dependent variable for changes in the independent variable(s). It is the coefficient of multiple correlation. For example, a ninety-five percent multiple R means that the model specification explains ninety-five percent of the variance in the dependent variable by changes in the model's independent variable(s). Only five percent of the change in the dependent variable is explained by something other than what is captured in the model. Also, all of the independent variables are significant at the ninety-five percent confidence interval as measured by the t-statistics shown below. In short, the gasoline demand and diesel fuel demand models are statistically significant specified economic models that can be used to forecast short term fluctuations in the demand for motor fuel.

Summary of Motor Fuel Demand Model Results

Gasoline		**Diesel**	
Multiple R	0.95	Multiple R	0.97
Variable	**t-stat**	**Variable**	**t-stat**
Intercept	(3.08)	Intercept	2.79
ln P	3.15	SCGDP	6.70
ln Yd	3.40	SCTTU	2.29
ln (P)^2	(3.28)		
ln (YD)^2	(3.25)		

Note: All variables are statistically significant at the 95 percent confidence level.

V. Conclusion

The demand for motor fuel was divided into two separate econometric models – the demand for gasoline and the demand for diesel fuel. Although the demand for each type of motor fuel is driven by different key variables, each model is statistically significant at the ninety-five percent confidence level and each variable in the respective models is statistically significant as well.

The individual economic models, gasoline and diesel fuel, were each regressed separately and the results were summed to provide a total motor fuel amount. A summary of the results is shown in the table below. Gasoline excise tax revenue benefited from falling gasoline prices in FY2015-16 as drivers consumed more gallons of gasoline. As gasoline prices begin to increase during the forecast period, the growth rate of gasoline excise taxes will be tempered. Diesel fuel demand was very strong in FY2015-16. As the state's economy performed well as measured the state's gross domestic product and consumer spending hit record highs, the movement and delivery of those goods resulted is strong diesel fuel demand by the trucking industry. As the general rate of growth in the state's economy slows during the forecast period, the rate of growth for diesel fuel will slow as well, as shown in the table below.

Projected Motor Fuel Revenue Collections
Fiscal Years 2016-17 to 2017-18

Fiscal Year	Gasoline Collections (Millions)	Gasoline Collections Growth	Special Fuel Collections (Millions)	Special Fuel Collections Growth	Total (Millions)
FY2015-16	$368.984	3.42%	$111.097	12.82%	$480.081
FY2016-17	$371.942	0.80%	$115.805	4.24%	$487.747
FY2017-18	$375.492	0.95%	$120.596	4.14%	$496.088

Source: Board of Economic Advisors

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National Highway Traffic Safety Administration, Washington, D.C.