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United States Gasoline Consumption: An Econometric Model

ABSTRACT

This paper is about the United States consumption of gasoline per year. Its purpose is to econometrically model how the general public consumes gasoline. This is accomplished by using time series data obtained from various sources including general documents, online data, and other resources readily available to the general public. The importance of this paper is to show petroleum gasoline consumption patterns of the United States.

I. Introduction

How far will $30 of gasoline take you? If you are one of the lucky owners driving the hybrid electric, gasoline car you can travel for weeks on $30. If you are driving the thirsty two-ton SUV $30 will take you to work for a couple of days. What does this have to do with this paper? This paper attempts to model how the consumption of gasoline has changed over the years in the United States.

Increased gasoline consumption in the United States has led to dependency on foreign oil and is a contributing factor in global warming. The study contained in this paper will be a helpful tool in determining the way that assortments of variables affect the consumption patterns of gasoline. This paper will estimate petroleum gasoline consumption using econometric analysis. A possible prediction for the short-run future is also a goal for this paper. Predictions on future gasoline consumption rates in the United States can lead to a better understanding of the scarcity of valuable crude oil; it can also lead to the search for alternative fuels and can create environmental awareness of gasoline consumption.
II. Theory

Gasoline consumption rates are dependent on a number of variables. To explain the relationship between the variables and consumption, the following general model has been set forth:

\[
\text{Gasoline Consumption (GAS)} = \beta_1 \text{INCOME} + \beta_M \text{MILES} + \beta_T \text{TAX} + \beta_D \text{DRIVERS} + \beta_{\text{MPG}} \text{MPG} + \beta_C \text{CRUDE} + \beta_W \text{WAR} + \beta_S \text{SPEED} + \epsilon_0
\]

Gasoline Consumption (GAS) is defined in billions of gallons of petroleum gasoline consumed per year.

The independent variables are defined as:

- \( \text{INCOME} \) = per capita income per year in 1999 dollars.
- \( \text{MILES} \) = the total number of municipal and rural highway miles.
- \( \text{TAX} \) = the federal tax on gasoline per year (cents per gallon).
- \( \text{DRIVERS} \) = the number of drivers licenses in a given year (in thousands).
- \( \text{MPG} \) = the average miles per gallon per vehicle for each given year.
- \( \text{CRUDE} \) = Domestic first purchase prices of crude oil per year (dollars per Barrel).
- \( \text{WAR} \) = Dummy variable: 1 in times of war, 0 otherwise.
- \( \text{SPEED} \) = Dummy variable: 1 with federal speed limit laws (55 mph speed limit), 0 otherwise.
- \( \epsilon \) = the stochastic error of the model.

The models’ variables are expected to show relevant relationships to gasoline consumption. The variables will be assigned a coefficient. The purpose of each coefficient will be to show how each variable is related to the total consumption of gasoline.

Table 1 is a guide to the expected signs for each of the variables and the type of test that will be used to determine the variables’ significance.
Table 1: Expected Coefficient Signs, Hypothesis, and Decision rule.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Expected Sign</th>
<th>Hypothesis</th>
<th>Decision Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME</td>
<td>?</td>
<td>$H_0: \beta_3 = 0 \quad H_a: \beta_3 = 0$</td>
<td>Reject $H_0$ if $t &gt; t_{a/2}$</td>
</tr>
<tr>
<td>MILES</td>
<td>+</td>
<td>$H_0: \beta_4 \leq 0 \quad H_a: \beta_4 &gt; 0$</td>
<td>Reject $H_0$ if $t &gt; t_a$</td>
</tr>
<tr>
<td>TAX</td>
<td>-</td>
<td>$H_0: \beta_5 \geq 0 \quad H_a: \beta_5 &lt; 0$</td>
<td>Reject $H_0$ if $t &lt; t_a$</td>
</tr>
<tr>
<td>Drivers</td>
<td>+</td>
<td>$H_0: \beta_1 \leq 0 \quad H_a: \beta_1 &gt; 0$</td>
<td>Reject $H_0$ if $t &gt; t_a$</td>
</tr>
<tr>
<td>MPG</td>
<td>-</td>
<td>$H_0: \beta_2 \geq 0 \quad H_a: \beta_2 &lt; 0$</td>
<td>Reject $H_0$ if $t &lt; t_a$</td>
</tr>
<tr>
<td>CRUDE</td>
<td>-</td>
<td>$H_0: \beta_6 \geq 0 \quad H_a: \beta_6 &lt; 0$</td>
<td>Reject $H_0$ if $t &lt; t_a$</td>
</tr>
<tr>
<td>WAR</td>
<td>-</td>
<td>$H_0: \beta_7 \geq 0 \quad H_a: \beta_7 &lt; 0$</td>
<td>Reject $H_0$ if $t &lt; t_a$</td>
</tr>
<tr>
<td>SPEED</td>
<td>-</td>
<td>$H_0: \beta_8 \geq 0 \quad H_a: \beta_8 &lt; 0$</td>
<td>Reject $H_0$ if $t &lt; t_a$</td>
</tr>
</tbody>
</table>

Each variable has been assigned a sign; the purpose of this is to show how the variable relates to the total consumption of gasoline. If the sign is positive, it is assumed to have a positive influence on the total consumption of gasoline, and visa versa for a negative sign. The coefficient on income is a questionable value. The income variable is one that needs to be looked at closely. Gasoline may be classified differently in each household; it can be classified as either an inferior or a normal good, and this is dependent on individual consumer’s demand. The actual population classification of gasoline is unknown and a questionable sign will be assigned to the variable. As the number of miles of highway increases, people begin traveling to more places, or begin moving away from the city into more rural areas. As a result, the total consumption of gasoline should increase. Thus, a positive sign is given to the MILES coefficient. Tax will be treated much like an extra cost to the consumer, with the law of demand we have to conclude that the sign for the coefficient on TAX will be negative. The coefficient
on DRIVERS has been assigned a positive sign, as the number of licensed drivers increases, we expect to see an increase in total gasoline consumption. The coefficient on fuel efficiency of motor vehicles (MPG) is assigned a negative sign. As the fuel efficiency of vehicles increases, the total consumption of gasoline should decrease. The coefficient is, however, under close investigation because the increased fuel efficiency has a tendency to lead to an increase in automobile travel. The variable assigned to the price of crude oil is treated much like the tax variable. The additional cost of rising crude oil prices are passed on to the consumer and a negative sign is given to this coefficient. War is going to be used as a dummy variable. In times of war the country seems to become uncertain with the future and with gasoline supply, so prices generally rise. This leads to a fall in total gasoline consumption. We will assume that the WAR coefficient has a negative relationship with consumption. SPEED will also be used in the model as a dummy variable. In the late 70’s the United States put into law a required 55-mph. speed limit. The purpose of this regulation was to reduce the amount of gasoline consumed. For this reason we must place a negative sign with the coefficient and assume that consumption decreased with imposed speed limits.

T-tests will be run for each coefficient. The test will show the statistical relevance of each variable, and help to determine the reliability of assumptions made while creating the model. Other statistical tests include the “special F-test.” This will be run to test the overall significance of the model.

**III Literature Review**

Richard Schmalensee and Thomas Stoker’s “Household Gasoline Demand in the United States” is a study on the consumption of data using household-level data (645). The purpose of their paper is to report findings on the price elasticity of high-income families and see if they
show similar income elasticity in comparison to other households (645). Schmalensee and
Stoker also model the effects on gasoline consumption for the changing demographic
characteristics (646) of the United States. They have chosen to create a model at the household
level even with little work done in this area of study.

The framework for the study is set forth in section 2. In this section Schmalensee and
Stoker discuss the data collection process--where it comes from, why it is theoretically relevant
to the planned study, how the data was obtained and why they are using the data obtained.
Discussions include data used from the Department of Energy’s household surveys, observations
on odometer readings, how data is separated into sections for economic research and “location
effects (647).” The section also discusses the modeling framework and assumptions made for
the analysis of their model.

“The basic household demand model” is presented in section 3. Schmalensee and
Stokers basic model is “Log Gallons = F (Income, demographics, Location)(648).” The theory
had little evidence of a correct functional form for estimation. The model variables and
estimations are explained. Tables are provided for the β estimations and plots are provided to
show these findings. The end result of their analysis “on gasoline demand primary reflect
systematic differences in driving patterns, rather than in vehicle characteristics (653).”
Coefficients were tested for statistical significance and the final results were posted in table II
(653). The same methods were used to estimate the 1988 model.

Section 4 is the (ATTEMPTED) ESTIMATION OF THE PRICE EFFECTS. The price elasticity
of gasoline was computed using various OLS estimates (656). Schmalensee and Stoker discuss
the problems that occurred during this analysis and reported the estimates in table III. They also
set forth some observations that may useful in future estimations.
The concluding remarks are found in section 5 of the text. They report that household structure has a strong effect on gasoline consumption (659). The income elasticity and age effects are discussed as well. The goodness of fit of the model is then reported to have an $R^2 = .40$ (659). They also remind the reader of the importance of the modeling framework.

The article provided many helpful hints in setup and framework for the model to be estimated in this paper. For example for fear of correlation between the number of drivers and the number of cars in the estimated model of this paper lead to the decision to only keep the number of drivers in the model. The authors also showed the importance of income as a variable and remind the reader the difficulties in finding data on such subjects as gasoline consumption.

**IV Data and Empirical Methodology**

The data collected will be in time series form. A total of 30 observations will be made. Eight independent variables are taken as yearly data from the time period containing the years 1969 to 1998. Data for the variables has been collected for each year. The model uses a 30-year span to reach a reliable outcome with predictive possibilities. Therefore with 30 observations (n) and 8 independent variables (k) the degrees of freedom is 21 (n-(k+1)).

The data will be collected from various reliable resources such as the *Statistical Abstract* and various government agencies. The dependent variable Gasoline consumption can be found in the *Statistical Abstract* under the table of Motor Fuel Consumptions, by use: 19xx to 19xx (xx’s are variable for each years data point). The data is in billions of gallons.

As for the independent variables, income will be measured per capita and in real dollars, the data for nominal income comes from the *Statistical Abstract of the United States*. The data can be found in the Personal Income-Per Square Mile and Per Capita table located in the Income Expenditures and Wealth section. The data needed for the variable observations was obtained
from the same table of the *Statistical Abstract*, the years of publication included 1971 to 2000. The income data was originally obtained in nominal dollars. The data was then converted into real 1999 dollars. The conversation was made using the CPI, the past and current (1999) CPI’s were found on the U.S. department of Labor’s web site (http://data.bls.gov/servlet/SurveyOutputServlet).

Miles data was found in the *Statistical Abstract*. The data was found using printed versions of the *Statistical Abstract*. Each data point found comes from a different printed version. The years for the data points span 1971 to 2001. The table used for the data remains the same throughout the years. Although the table number may vary, the table title remains the same. The table title containing the miles data is “Municipal and Rural Highway Mileage – States.” This table can be found in the Transportation—Land section. For most years the total miles of highway were given in the table, but for the following years small calculations needed to be made. For miles in 1980 (*Statistical Abstract* 1982-1983) to miles in 1986 (*Statistical Abstract* 1989) the municipal and rural miles were added together and multiplied by 1000 to get the total miles. For the data in years 1987 (*Statistical Abstract* 1990) to 1991 (*Statistical Abstract* 1995) the municipal and rural miles were added together. The values are reported in actual miles.

The Federal level of Tax on gasoline is found in the *Statistical Abstract* under the Federal and State Gasoline Tax – States table. Gasoline taxes are measured in cents per gallon. The *Statistical Abstract’s* from the years of 1970 to 1997 were used to find the tax data for the years 1969 to 1995. After 1995 the tax data is not available in the above table. The tax rates have remained at a constant rate of 18.4 cents per gallon. This information was found online on 12/11/2002 at http://www.ahtd.state.ar.us/planning/F%20&%20E/Biennial%20Report/federal%20tax%…
The number of drivers data is found in the Transportation-Land section of the Statistical Abstract of the United States. The values of the variable are found in the Motor-Vehicle Registrations, 19xx to 19xx, and Drivers Licenses, 19xx, by state (xx’s are variable for each years data point). The values given for drivers are measured in thousands. The total number of drivers licenses needed to interpolated for the following years (assumed linear growth in the number of drivers), 1976, 1984,1987 and 1988

The MPG data is found in the Statistical Abstract, miles per gallon are given as a national average per vehicle. The data can be found in the Motor Fuel Consumptions, by use: 19xx to 19xx table. The actual measurement of MPG is for the average mileage per gallon, per vehicle. The total average was used and the mileage per gallon of passenger cars, busses, truck and combinations were left out of the model.

CRUDE price is found on the Energy Information Administration web site (accessed through the Department of Energy web page). The table of prices can be found at http://www.eia.doe.gov/emeu/aer/pdf/pages/sec5-195.pdf (found on 12/11/2002). Nominal prices were taken from the table for the years of 1969 to 1999. Then using the same CPI data used to figure real income, real First Purchase Prices of crude oil were transformed into 1999 dollars. The price is the US average in Dollars per barrel.

Data on the wartime periods of the United States during the years explained by the model were found in the World Book encyclopedia. In this model, war is used a dummy variable. It holds a value of 1 if in wartime periods and 0 otherwise. The war-time periods include 1969 to 1973, during this time the United States was involved in the Vietnam War. The other year that will be assigned a value of 1 is 1991 during this time the United States was involved in the Persian Gulf War.
The 55 speed limit data was found in a journal article found on Expanded Academia ASAP. “Don’t brake for big government. (Federal speed limit repeal)” by Tyce Palmaffy appeared in Policy Review Sept-Oct 1996 n79 p11 (3). The National Maximum Speed Limit was originally put into place in 1974 to help reduce gasoline consumption. It was a reaction to the OPEC oil embargo of 1974. The model will assign a 1 for the years in which this legislation was in place. The speed limit law was repealed in 1995.

Table 2 reports the descriptive statistics of the independent variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Means</th>
<th>Standard Deviations</th>
<th>Minimum</th>
<th>Maximums</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>21,284</td>
<td>3,084.4</td>
<td>16,787</td>
<td>26,995</td>
</tr>
<tr>
<td>Miles</td>
<td>3,866,300</td>
<td>62,932</td>
<td>3,710,300</td>
<td>4,000,000</td>
</tr>
<tr>
<td>Tax</td>
<td>0.0906</td>
<td>0.057367</td>
<td>0.04</td>
<td>0.184</td>
</tr>
<tr>
<td>Drive</td>
<td>150,950,000</td>
<td>22,681,000</td>
<td>108,300,000</td>
<td>184,980,000</td>
</tr>
<tr>
<td>MPG</td>
<td>14.366</td>
<td>1.9776</td>
<td>11.85</td>
<td>17</td>
</tr>
<tr>
<td>Crude</td>
<td>24.41</td>
<td>11.928</td>
<td>11.11</td>
<td>58.228</td>
</tr>
<tr>
<td>War</td>
<td>0.2</td>
<td>0.40684</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Speed</td>
<td>0.733</td>
<td>0.44978</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

All of the descriptive statistics were calculated in SHAZAM for the 30-observation sample. The data in the table are held to the same parameters as above and the units remain the same. From looking at the minimum and maximum values the general pattern of growth shows a positive relationship with time. Over time real income, the number of miles, tax, and the number of drivers are increasing. On the other hand the miles per gallon although generally increasing over time seem to be falling towards the end of the sample. Crude oil prices have showed no real constancy over time and the price peaked in 1981. The standard deviations for the sample seem to be small relative to their mean, the exceptions are CRUDE, WAR and SPEED. The data in the table will be used in future sample calculations.

V Findings
The model of this paper will use an Ordinary Least Squares (OLS) method of estimation. The values of the coefficients are found in the Econometrics program SHAZAM. Using Gasoline Consumption as the dependent variable and the eight theoretical independent variables (defined above), INCOME, MILES TAX, DRIVERS MPG, CRUDE, WAR AND SPEED, the estimated OLS model looks as fallow:

\[
\text{GAS} = 11.221 + 0.0024355 \times \text{INCOME} + 0.0000093822 \times \text{MILES} + 58.577 \times \text{TAX} + 0.00089599 \\
\text{(0.0006959)} + 0.00001464 \times \text{DRIVERS} - 7.8856 \times \text{MPG} - 0.15532 \times \text{CRUDE} + 1.7723 \times \text{WAR} - 1.1333 \times \text{SPEED} \\
\text{(28.72)} + 0.0001504 \times \text{(1.267)} + 0.06944 \times \text{(2.066)} + 1.496 \times \text{(1.496)}
\]

The overall goodness of fit of the model is defined as

\[
R^2 = 0.9889 \quad R^2 = 0.9847 \quad \text{F-stat} = 233.694
\]

The model variables were tested for multi-co-linearity. Table 3 is the Correlation Matrix of the Coefficients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>INCOME</th>
<th>MILES</th>
<th>TAX</th>
<th>DRIVE</th>
<th>MPG</th>
<th>CRUDE</th>
<th>WAR</th>
<th>SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME</td>
<td>1.00000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MILES</td>
<td>-0.03756</td>
<td>1.00000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAX</td>
<td>0.47549</td>
<td>-0.01304</td>
<td></td>
<td>1.00000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRIVE</td>
<td>-0.57905</td>
<td>-0.53356</td>
<td>-0.30321</td>
<td>1.00000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPG</td>
<td>-0.29063</td>
<td>0.54059</td>
<td>-0.53696</td>
<td>-0.48162</td>
<td>1.00000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRUDE</td>
<td>0.76423</td>
<td>-0.06604</td>
<td>0.64166</td>
<td>-0.50286</td>
<td>-0.27774</td>
<td>1.00000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAR</td>
<td>0.25047</td>
<td>-0.09152</td>
<td>0.22161</td>
<td>0.30322</td>
<td>-0.58389</td>
<td>0.25839</td>
<td>1.00000</td>
<td></td>
</tr>
<tr>
<td>SPEED</td>
<td>0.52694</td>
<td>-0.02120</td>
<td>0.53907</td>
<td>-0.27253</td>
<td>-0.35442</td>
<td>0.36316</td>
<td>0.50549</td>
<td>1.00000</td>
</tr>
</tbody>
</table>

From looking at the table the only a few correlation raise question. The Price of crude and the income seem to be highly correlated as well as crude prices and taxes. The correlation between CRUDE and INCOME come as a surprise due to irregular price changes in CRUDE. Looking the correlation between tax and crude come a little should be explained by the cost of extracting crude oil and the stricter environmental regulations of the government.
Table 3 and appendix A contain findings that suspect multi-collinearity between the independent variables INCOME, TAX, DRIVERS, MPG, AND CRUDE and the other included variables in each of stated OLS equations.

The model was tested for Auto Correlation. An RSTAT option was run in respect to the original OLS model, the command reported a Durban-Watson test result of 1.3337 the corresponding $\rho$ is .31090. The output was put to the Durban-Watson hypothesis test for positive auto correlation.

At the 5% level of significance and a degree of freedom of 21, a one sided Durban-Watson test has the lower limit ($d_L$) of 1.22 and an upper limit ($d_u$) of 1.42. An inconclusive decision is made about auto correlation in the original model.

The inconclusive test led to a plot of residuals against time, the plot found in Appendix C. The graph of the residuals over time will show positive auto correlation if the data points show a snake type pattern over the x-axis. The plot seems to provide little evidence of positive auto correlation.

A plot of the two error terms was added to ensure no positive auto correlation. The plot found in Appendix D. In the case of positive auto correlation, the error terms would be bunched in quadrants I and III of the graph. For this plot of the model, that is not the case. Therefore, we still have little evidence of positive auto correlation.

As a result of these findings the OLS model originally stated will be used to estimate gasoline consumption patterns of the United States.

The overall significance of the model is tested using the special F-test (See appendix E). The critical value of the F-test is 2.42. The F-stat form the SHAZAM output is 233.694. Since
233.694 is greater than 2.42, we can reject the null hypothesis and conclude the model is statistically significant at the 5% level of significance.

Table 4 will set forth the critical values for statistical significance of the OLS model coefficients, and their standard errors. The t-statistics for each coefficient are calculated in a manner that is consistent to the t-tests given in Table 1, and entered in Table 7. The t-test will determine the statistical significance of each variable at the 5% level of significance.

Table 7: t-critical values for the coefficients on specified independent variables, their standard errors and the t-statistic for each coefficient.

<table>
<thead>
<tr>
<th>Variables</th>
<th>t-critical</th>
<th>Standard errors</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME</td>
<td>2.08</td>
<td>0.006959</td>
<td>3.499784*</td>
</tr>
<tr>
<td>MILES</td>
<td>1.721</td>
<td>0.001464</td>
<td>0.64127</td>
</tr>
<tr>
<td>TAX</td>
<td>-1.7121</td>
<td>28.720000</td>
<td>2.039589</td>
</tr>
<tr>
<td>DRIVERS</td>
<td>1.7121</td>
<td>0.000150</td>
<td>5.95738*</td>
</tr>
<tr>
<td>MPG</td>
<td>-1.7121</td>
<td>1.267000</td>
<td>-6.22384*</td>
</tr>
<tr>
<td>CRUDE</td>
<td>-1.7121</td>
<td>0.069440</td>
<td>-2.23675*</td>
</tr>
<tr>
<td>WAR</td>
<td>-1.7121</td>
<td>2.066000</td>
<td>2.236751</td>
</tr>
<tr>
<td>SPEED</td>
<td>-1.7121</td>
<td>1.495000</td>
<td>-0.75806</td>
</tr>
</tbody>
</table>

* Indicates Statistical significance at the 5% level

The table concludes that the total number of highway miles, the federal gasoline tax rate, times of war and a federal speed limit are statistically insignificant factors in total gasoline consumption of the nation. On the other hand, the remaining variables show statistical evidence that is effective in explaining the theoretical model set forth.

Income has a positive effect on gasoline consumption; this is as predicted in the theoretical model. As the per capita income in real 1999 dollars rises by one dollar, the total gasoline consumption in the United States rises by a factor of 2.43550 million (.0024355 billion) gallons. A positive increase in drivers does create an increase in gasoline consumption. For every one unit increase (1000) of drivers the gasoline consumption of the U.S. increases by 0.00089599 billion gallons. When the national average miles of per gallon increases, the total
gasoline consumption will fall. The statistical tests provide evidence of this theory. A one-unit (mile per gallon) increase in the national average of miles per gallon will decrease the total gasoline consumption of the U.S. by 7.8856 billion gallons. Lastly, if the price of crude increased, it will have a negative effect on the consumption of gasoline. The statistical significance of crude oil prices can be found in Table 7. For a one dollar (real 1999 dollars) increase in the first purchase price of crude oil, total gasoline consumption falls by 0.15532 billion gallons.

The overall goodness to fit of the model is high. Factors that must not be overlooked when reviewing the model include the multi-co-linearity stated earlier. As concluded earlier, the model contains four statistically insignificant variables (table 4) and evidence of multi-co-linearity is present in the correlation matrix found in table 3. The variance inflation factor also shows some evidence of multi-co-linearity. Multi-co-linearity effects the variance of the expected $\beta_k$ by increasing the value, but he estimate still remains BLUE due to the fact that no other variable has smaller variance. Also with the assumptions made to deal with positive auto correlation, the model estimations are BLUE and the regression was run using OLS.

VI. Extensions and Conclusions

The estimation of total gasoline consumption proved to be closely related to the theoretical model. The model has concluded that with an increase in the number of drivers the total consumption of gasoline will rise. It also concludes that as the price of crude increases and the average miles per gallon increase, the total gasoline consumption will decrease. As theoretically set forth in the beginnings of this paper, the coefficients on all except tax followed the expected trend. As for tax, even though it is not a statistically significant variable, conversation with fellow students led to the conclusion that tax may have little effect on total
gasoline consumption. Few of these people even think about the federal tax rate on gasoline while at the pump. The answer to this reasoning, the pump says $1.49 per gallon and that is what you pay. The thought of actually paying the tax is forgotten when it is included in the price. This variable requires extensive evaluation. Overall the theory proved to be effective.

For future extension of this paper more time observations should be added. Quarterly data would have provided a more significant model as well as have better short-run predictive measurement. The first purchase price of crude, a statistically significant variable, changes as world markets change, More observations would create a model that can more accurately make adjustments for such price fluctuations.

As a closing measure, we see a great decline in total gasoline consumption with just one unit (mile per gallon) increase in the average miles per gallon. This is a goal that can be easily obtained by motor vehicle manufactures. If the manufactures of automobiles in the U.S. did this, the country could help to slow pollution and help save our precious oil reserves.
Appendix A: Auxiliary Regressions and corresponding Variance Inflation Factor

<table>
<thead>
<tr>
<th>Auxiliary Regressions</th>
<th>R square</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME = f (MILES, TAX, DRIVERS, MPG, CRUDE, WAR, SPEED)</td>
<td>0.9693</td>
<td>32.57329</td>
</tr>
<tr>
<td>MILES = f (INCOME, TAX, DRIVERS, MPG, CRUDE, WAR, SPEED)</td>
<td>0.8331</td>
<td>5.991612</td>
</tr>
<tr>
<td>TAX = f (INCOME, MILES, DRIVERS, MPG, CRUDE, WAR, SPEED)</td>
<td>0.9478</td>
<td>19.15709</td>
</tr>
<tr>
<td>DRIVERS = f (INCOME, MILES, TAX, MPG, CRUDE, WAR, SPEED)</td>
<td>0.9878</td>
<td>81.96721</td>
</tr>
<tr>
<td>MPG = f (INCOME, MILES, TAX, DRIVERS, CRUDE, WAR, SPEED)</td>
<td>0.9774</td>
<td>44.24779</td>
</tr>
<tr>
<td>CRUDE = f (INCOME, MILES, TAX, DRIVERS, MPG, WAR, SPEED)</td>
<td>0.7935</td>
<td>4.842615</td>
</tr>
<tr>
<td>WAR = f (INCOME, MILES, TAX, DRIVERS, MPG, CRUDE, SPEED)</td>
<td>0.7994</td>
<td>4.985045</td>
</tr>
<tr>
<td>SPEED = f (INCOME, MILES, TAX, DRIVERS, MPG, CRUDE, WAR)</td>
<td>0.6866</td>
<td>3.19081</td>
</tr>
</tbody>
</table>

*The OLS models for Auxiliary Regressions report the Variance Inflation Factors (VIF).

Appendix B: The Durban-Watson hypothesis test for positive auto correlation.

H₀: ρ ≤ 0 “no positive auto correlation”
Hₐ: ρ > 0 “positive auto correlation”

Decision Rule:
If d<d_L ⇒ Reject H₀
If d_L ≤ d < d_U ⇒ Inconclusive
If d > d_U ⇒ can not reject H₀

Reject H₀  Inconclusive  Can not reject H₀
<-----------------|------------------|------------------->
      d_L            d_U
Appendix C: Plot of OLS residuals over time.

```plaintext
6.0000 5.3684 4.7368 4.1053 3.4737 2.8421 2.2105 1.5789 0.94737 0.31579 -0.31579 -0.94737 -1.5789 -2.2105 -2.8421 -3.4737 -4.1053 -4.7368 -5.3684 -6.0000

1960.000 1970.000 1980.000 1990.000 2000.000
YEAR
```
Appendix D: plot of $e_t - e_{t-1}$

* = ERROR

$M = $MULTIPLE POINT

| 6.0000 | 5.3684 | 4.7368 | 4.1053 | 3.4737 | 2.8421 | 2.2105 | 1.5789 | 0.94737 | 0.31579 | -0.31579 | -0.94737 | -1.5789 | -2.2105 | -2.8421 | -3.4737 | -4.1053 | -4.7368 | -5.3684 | -6.0000 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|

ERROR2

Appendix E: Special F test.

$H_0$: $\beta_{\text{INCOME}} = \beta_{\text{MILES}} = \beta_{\text{TAX}} = \beta_{\text{DRIVERS}} = \beta_{\text{MPG}} = \beta_{\text{CRUDE}} = \beta_{\text{WAR}} = \beta_{\text{SPEED}} = 0$

$H_a$: $H_0$ NOT TRUE

Decision rule: If F-stat > F-critical reject the null hypothesis $H_0$. 