Regression Models Course Project

Executive Summary

The following requested analysis is offered for the exclusive use by Motor Trend Magazine and is intended to explore the availability of statistical evidence of the relationship between a set of variables and miles per gallon (MPG) in a representative sample of vehicles. Given the increasing percentage of the world's economy devoted to energy for logistics, this issue has significant implications that can help guide the future optimal use of resources.
This paper particularly addresses the following two questions:

- "Is an automatic or manual transmission better for MPG"
- "Quantifying how different is the MPG between automatic and manual transmissions?"

As presented below, the available evidence strongly supports the hypothesis of a difference in miles per gallon (mpg) for cars with manual versus automatic transmissions– even with other covariates or interactions (weight, etc) that may affect mpg concurrently considered. Summary findings include the observation that, in general, vehicle millage is higher in cars with manual transmissions. This is true despite the gross horsepower, cylinders, and number of carburetors. However, there is a confounding effect with the weigh of the vehicle. Vehicles with a weight less than three tons have higher miles per gallon while vehicles more than 3000 lbs have lower average miles per gallon with manual transmissions.

The Data

The R-cran project web site has kindly provided a data.frame composed of indicator values for a range of cars that may statistically represent the miles per gallon (*mpg*) of vehicles currently in use. This 1974 data on thirty-two 1973-1974 model cars additionally includes measures of the motors cylinders (*cyl*), motor displacement (*disp*), horse power (*hp*), rear axle ratio (*drat*), weight (*wt*), quarter mile time (*qsec*), V/S (*vs*), manual or automatic (*am*), number of gears(*gear*), and the number of carburetors (*carb*) for each of thirty-two cars. The following table presents basic details on the available data. The coding for transmission utilizes "0" for automatic and "1". We have 19 cars with automatic transmission and 13 with manual transmissions. The following plots presents an overview of the relationship between miles per gallon and the available variables. Transmission type is included as a factor variable for the analysis.

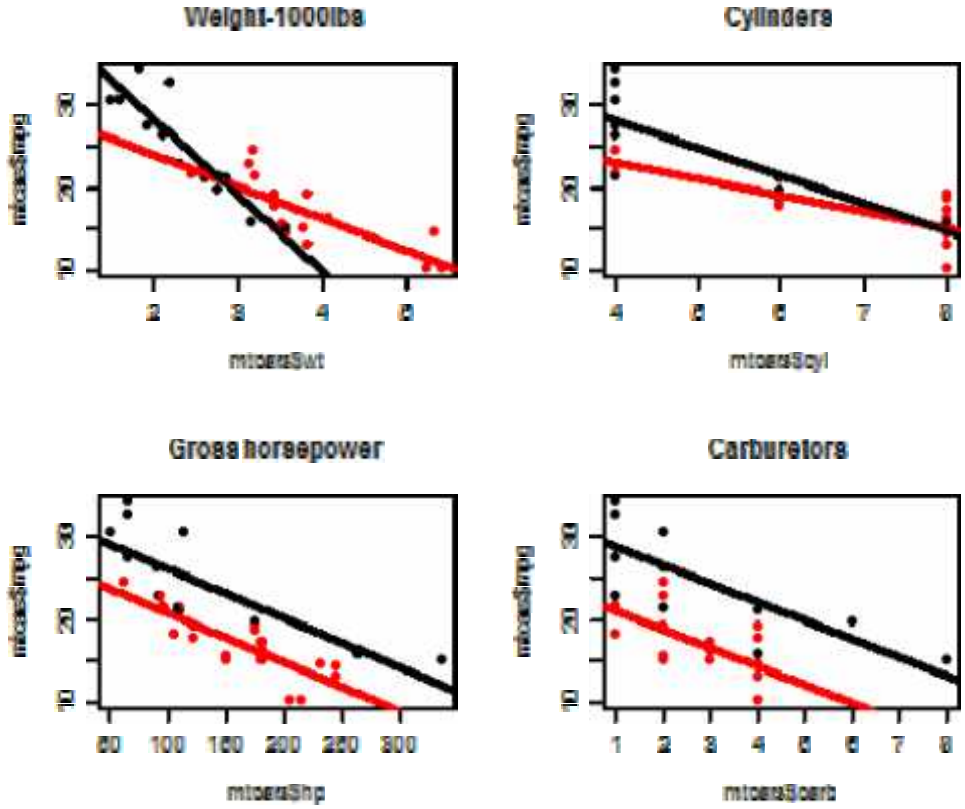
Analysis

Version 3.1 or the **R** package from CRAN is utilized for this analysis. Only basic packages are employed. Transmission type is included as a factor variable for the analysis. The overall average miles per gallon for the sampled automatic and manual transmission cars is:

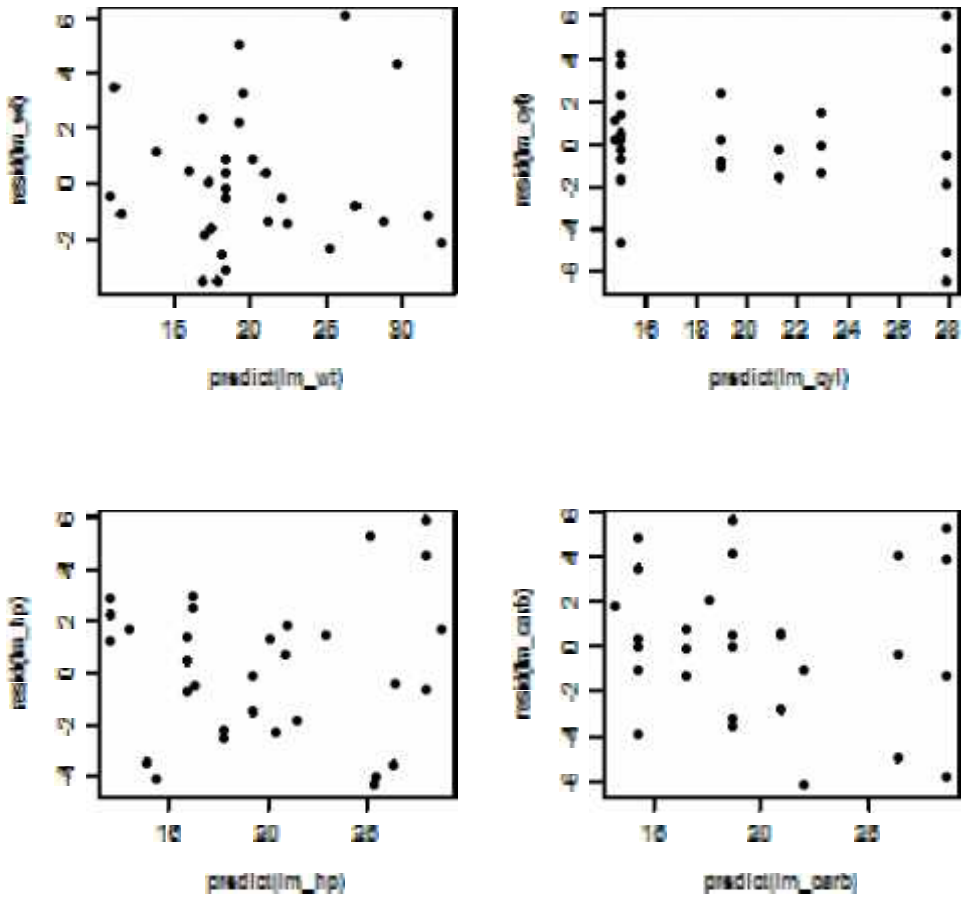
17.1474, 24.3923 In general, manual transmissions provide the following mean increase in miles per gallon:7.2449. The general regresson model **lm(mpg ~ am)** yields the basic estimate:

```
##             Estimate Std. Error t value  Pr(>|t|)
## (Intercept)   17.147      1.125  15.247 1.134e-15
## am             7.245      1.764   4.106 2.850e-04
```

A multiple linear regression model with implied dummy variables for transmission (*am*) will be utilized to explore possible contributions to any differences in the reported average miles per gallon for vehicles with automatic versus manual transmissions. Covariates or interactions will be examined for their possible significant contribution to miles per gallon. The following plots graphically depict interactions or confounders which affect the reported miles per gallon for cars with automatic and manual transmissions. Black depicts manual transmissions. The number of cylinders, gross horsepower and number of carburetors does not have a significant interaction effect on miles per gallon. However, the weight of the vehicle appears to have a significant confounding affect. It may be useful to note that this confounding effect increases the miles per gallon for the lower weight cars.
Vehicle millage appears to be a function of gear type and weight.



An examination of the residuals, Normal Q-Q plot,dfbetas and hatvalues does not raise concerns.



Findings

The principal findings of this analysis are provided in the notes below:

```
##
## Call:
## lm(formula = mtcars$mpg ~ mtcars$wt + mtcars$am + mtcars$am
*
##     mtcars$wt)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -3.600 -1.545 -0.533  0.901  6.091
##
## Coefficients:
##                      Estimate Std. Error t value Pr
(>|t|)
## (Intercept)            31.416      3.020   10.40  4.0e-11
***
## mtcars$wt              -3.786      0.786   -4.82  4.6e-05
***
## mtcars$am              14.878      4.264    3.49   0.0016
**
## mtcars$wt:mtcars$am    -5.298      1.445   -3.67   0.0010
**
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '
' 1
##
## Residual standard error: 2.59 on 28 degrees of freedom
## Multiple R-squared:  0.833,  Adjusted R-squared:  0.815
## F-statistic: 46.6 on 3 and 28 DF,  p-value: 5.21e-11
```

In brief, manual transmissions tend to increase miles per gallon by approximately 7.24 miles with a standard error of 1.76 miles. The weight of the car has a confounding effect– increasing the millage gain for lower weight manual transmission cars and decreasing the millage gain for heaver manual transsission cars over that of automatic transmission cars.