# Motor Trend MPG Data Analysis

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**Executive Summary** This report analyzed the relationship between transmission type (manual or automatic) and miles per gallon (MPG). The report set out to determine which transmission type produces a higher MPG. The `mtcars` dataset was used for this analysis. A t-test between automatic and manual transmission vehicles shows that manual transmission vehicles have a 7.245 greater MPG than automatic transmission vehicles. After fitting multiple linear regressions, analysis showed that the manual transmission contributed less significantly to MPG, only an improvement of 1.81 MPG. Other variables, weight, horsepower, and number of cylinders contributed more significantly to the overall MPG of vehicles.

**Exploratory Data Analysis, Load Data** Load the dataset and convert categorical variables to factors.

```
data(mtcars)
head(mtcars, n=10)
dim(mtcars)
mtcars$cyl <- as.factor(mtcars$cyl)
mtcars$vs <- as.factor(mtcars$vs)
mtcars$am <- factor(mtcars$am)
mtcars$gear <- factor(mtcars$gear)
mtcars$carb <- factor(mtcars$carb)
attach(mtcars)
```

**Exploratory Analysis** **See Appendix Figure I** Exploratory Box graph that compares Automatic and Manual transmission MPG. The graph leads us to believe that there is a significant increase in MPG when vehicles with a manual transmission vs automatic.

**Statistical Inference** T-Test transmission type and MPG

```
testResults <- t.test(mpg ~ am)
testResults$p.value
```

```
## [1] 0.001373638
```

The T-Test rejects the null hypothesis that the difference between transmission types is 0.

```
testResults$estimate
```

```
## mean in group 0 mean in group 1
##        17.14737        24.39231
```

To get an initial feel for the relationships between the variables - and, in particular, between **mpg** and **am** - it is interesting to observe the scatterplots produced by plotting each variable against all others, as well as the specific distribution of **mpg** values within each level of **am**. The plots are shown in the Appendix, figures 1 and 2.

Two facts are immediately clear from the plots: first, **mpg** tends to correlate well with many of the other variables, most intensely with **drat** (positively) and **wt** (negatively). It is also clear that many of the variables are highly correlated (e.g., **wt** and **disp**). Second, it seems like manual transmission models present larger values of **mpg** than the automatic ones. In the next section a linear model will be fit to the data in order to investigate the significance and magnitude of this possible effect.

The difference estimate between the 2 transmissions is 7.24494 MPG in favor of manual.

**Regression Analysis** Fit the full model of the data

```
fullModelFit <- lm(mpg ~ ., data = mtcars)
summary(fullModelFit)
summary(fullModelFit)$coeff
```

Since none of the coefficients have a p-value less than 0.05 we cannot conclude which variables are more statistically significant.

Backward selection to determine which variables are most statistically significant

```
stepFit <- step(fullModelFit)
summary(stepFit)
summary(stepFit)$coeff
```

The new model has 4 variables (cylinders, horsepower, weight, transmission). The R-squared value of 0.8659 confirms that this model explains about 87% of the variance in MPG. The p-values also are statistically significantly because they have a p-value less than 0.05. The coefficients conclude that increasing the number of cylinders from 4 to 6 will decrease the MPG by 3.03. Further increasing the cylinders to 8 with decrease the MPG by 2.16. Increasing the horsepower is decreases MPG 3.21 for every 100 horsepower. Weight decreases the MPG by 2.5 for each 1000 lbs increase. A Manual transmission improves the MPG by 1.81.

**Residuals & Diagnostics** To verify whether the assumption of i.i.d. Gaussian residuals is violated, a graphical examination of the residual plots is often suggested. These plots are shown in the Appendix, figure 3. From these plots we can infer two characteristics:

(i) the residuals do appear to be approximately normal, but deviate from normality at the tails; and

(ii) there does not seem to be any large violation of homoscedasticity. Given the linear model relative robustness to these two assumptions, it is safe to assume that the obtained model is relatively sound.

Residual Plot **See Appendix Figure II**

The plots conclude:

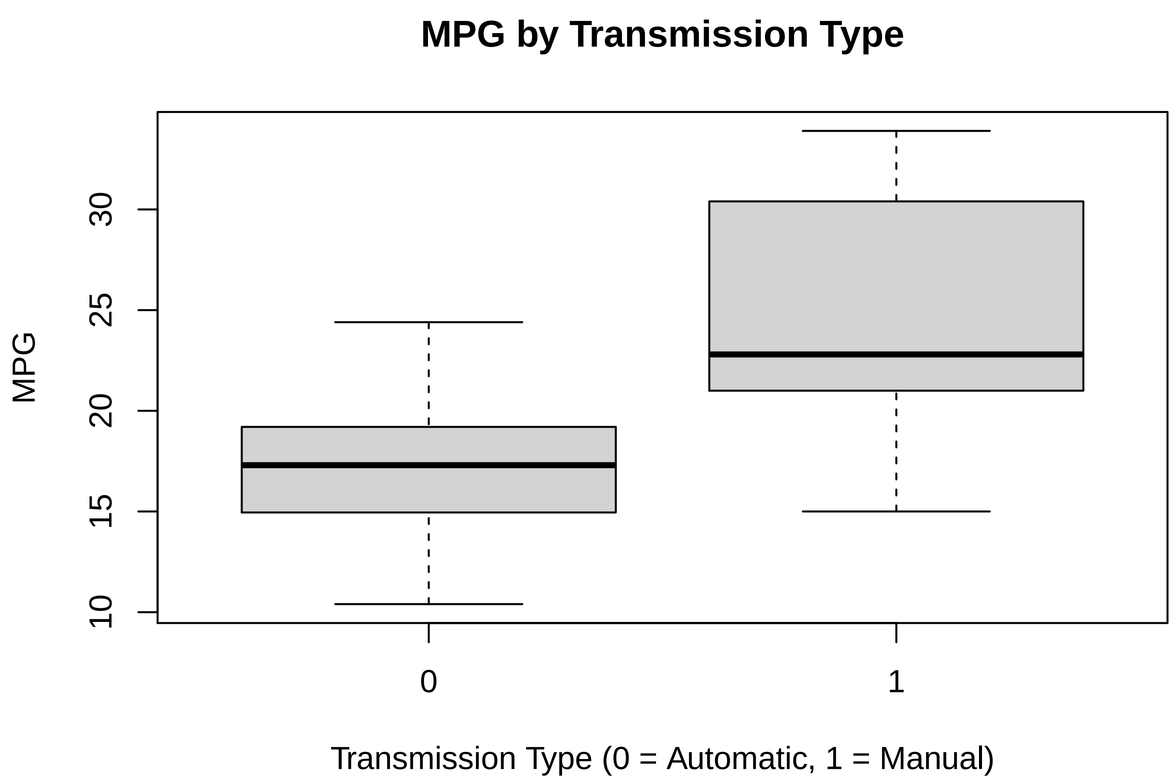
1. The randomness of the Residuals vs. Fitted plot supports the assumption of independence
2. The points of the Normal Q-Q plot following closely to the line conclude that the distribution of residuals is normal
3. The Scale-Location plot random distribution confirms the constant variance assumption
4. Since all points are within the 0.05 lines, the Residuals vs. Leverage concludes that there are no outliers

```r
sum((abs(dfbetas(stepFit)))>1)
```

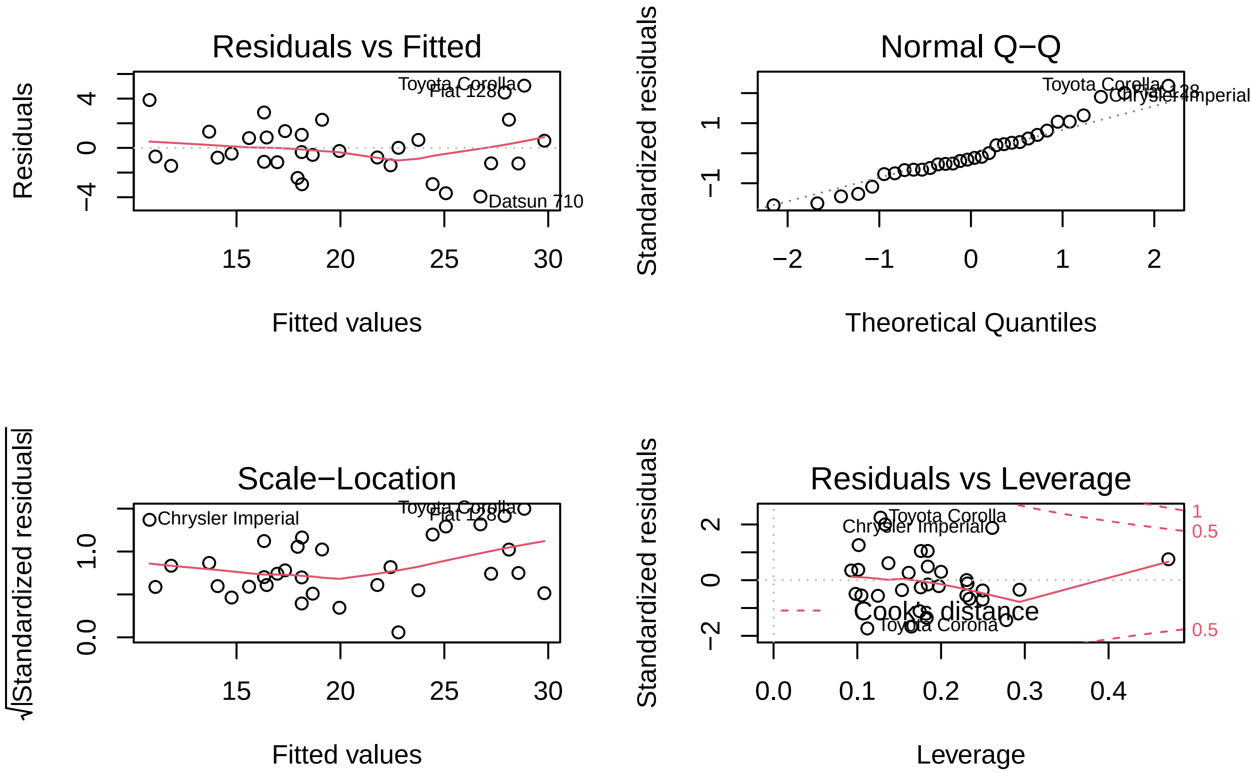
```
## [1] 0
```

**Conclusion** There is a difference in MPG based on transmission type. A manual transmission will have a slight MPG boost. However, it seems that weight, horsepower, & number of cylinders are more statistically significant when determining MPG.

**Appendix Figures**




**I**


Residuals vs Fitted
Residuals
Fitted values
Toyota Corolla
Fiat 128
Datsun 710
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Chrysler Imperial
Scale−Location
√|Standardized residuals|
Residuals vs Leverage
Leverage
Cook's distance
Toyota Corona

**II**