Relationship between Transmission type and MPG?

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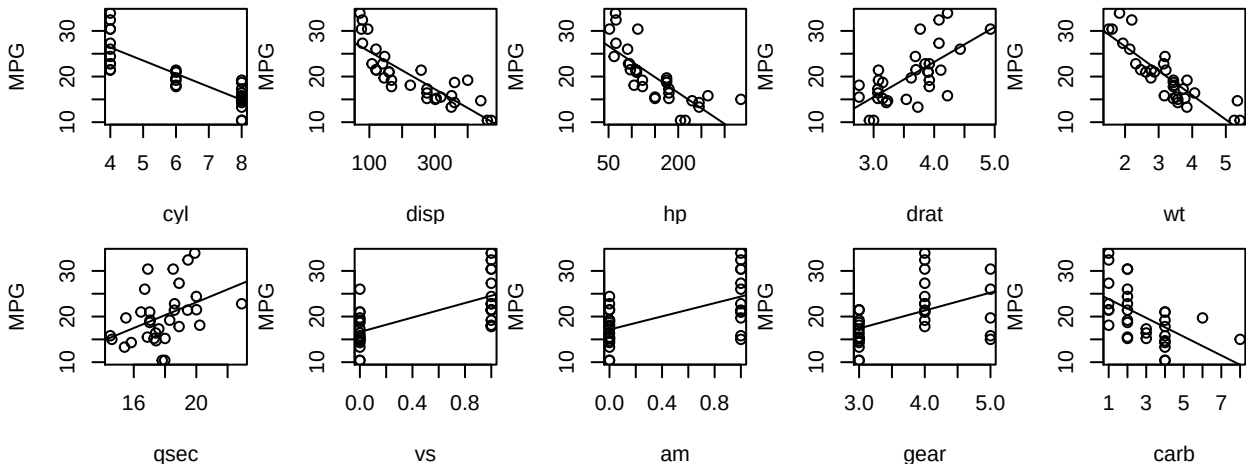
We look here at the Mtcars data set to explore the effect of transmission type on miles per gallon (MPG).Here we wish to answer two questions: **(1) Is an automatic or manual transmission better for MPG? (2) Quantify the MPG difference between automatic and manual transmissions.**

Variables include: MPG - Miles/(US) gallon, CYL - Number of cylinders, DISP - Displacement (cu.in.), HP - Gross horsepower, DRAT - Rear axle ratio, WT - Weight (1000 lbs), QSEC - Acceleration (1/4 mile time), VS - V/S, AM - Transmission , GEAR- Number of forward gears, CARB- Number of carburetors.

Exploratory Analysis

Here we first want to explore the relationships between MPG and all the car attributes.

```
par(mfrow=c(2,5),mar=c(3.90, 4.25, 1, 0))
for (variables in 2:11){thisvar = mtcars[,variables]
  plot(thisvar, mtcars$mpg, xlab = names(mtcars[variables]), ylab='MPG')
  abline(lm(mtcars$mpg ~ thisvar))}
```



We can see that Rear axle ratio, Accelearation, V/S, Transmission and No.Gears were positivly associated with MPG while No.Cylinders, Displacement, HP, Weight and No.Carburetors are negatively related.

Is an automatic or manual transmission better for MPG?

Here we first want to analyse which transmission type (Automatic or Manua) shows the higher MPG rating, without considering any other variables. This will be done using a simple linear model between the 2 variable.

```
basicmodel <- lm(mpg ~ factor(am), data=mtcars)
summary(basicmodel)$coef;summary(basicmodel)$r.squared
```

```
##             Estimate Std. Error t value             Pr(>|t|)
## (Intercept)  17.1474     1.1246 15.2475 0.000000000000001134
## factor(am)1   7.2449     1.7644  4.1061 0.000285020743935068
```

```
## [1] 0.3598
```

From the above, when just examining the relationship between Transmission and MPG, automatics have an avergae MPG of 17.15 while manuals have an extra 7.25 MPG with an average of 24.392. We can therefore say Manual transmissions are better for MPG (Appendix Figure.1). However, the R^2 value shows Tramsission only explains 33.85% of the MPG variance, suggesting other motor attributes are involved.

Quantify the MPG difference between transmissions types

There is a clear relationship between transmission type and MPG, however we now want to investigate whether this relationship changes when other car attributes are taken into consideration. Here we conduct a backwards step-wise analysis where we start by modelling all variables and gradually remove one at each step to find a model with a smaller AIC value; suggesting a better model fit.

```
fullmodel <- lm(mpg ~ ., data=mtcars); idealmodel <- step(fullmodel, direction = "backward")
```

```
summary(fullmodel)$coef;summary(fullmodel)$r.squared
```

```
##              Estimate Std. Error  t value Pr(>|t|)
## (Intercept) 12.303374  18.717884  0.65731 0.518124
## cyl         -0.111440   1.045023 -0.10664 0.916087
## disp         0.013335   0.017858  0.74676 0.463489
## hp          -0.021482   0.021769 -0.98684 0.334955
## drat         0.787111   1.635373  0.48130 0.635278
## wt          -3.715304   1.894414 -1.96119 0.063252
## qsec         0.821041   0.730845  1.12341 0.273941
## vs           0.317763   2.104509  0.15099 0.881423
## am           2.520227   2.056651  1.22540 0.233990
## gear         0.655413   1.493260  0.43891 0.665206
## carb        -0.199419   0.828752 -0.24063 0.812179
```

```
## [1] 0.86902
```

```
summary(idealmodel)$coef;summary(idealmodel)$r.squared
```

```
##             Estimate Std. Error t value     Pr(>|t|)
## (Intercept)   9.6178    6.95959  1.3819 0.1779151655
## wt           -3.9165    0.71120 -5.5069 0.0000069527
## qsec          1.2259    0.28867  4.2467 0.0002161737
## am            2.9358    1.41090  2.0808 0.0467155099
```

```
## [1] 0.84966
```

From the above we can see the full model with all variable can explain 86.90% of the data, however the model has a higher AIC value compared to the ideal model suggesting a worse fit. Whilst the ideal model explains slight less variance at 85.00%, it only contains 3 variables so is less likely to have problems with variable inflation. residual plots for this model can be seen in Appendix Figure2. From this ideal model, we can see that transmission continues to significantly predict ($p<.05$) MPG when weight and accelearation is taken into consideration, however there is a smaller difference. Here manual cars have an extra 2.94 MPG compared to automatic cars.

Conclusion

Transmission type shows a significant effect on MPG where manual cars have an extra 2.94 MPG compared to automatics. However, this relationship also depends on weight and acceleration which also influence MPG.

Appendix Figures

```
plot(mtcars$mpg ~ factor(mtcars$am), ylab = "Miles Per Gallon (MPG)", xlab = "Transmission Type",
    names = c("Automatic", "Manual"), col = c("lightcoral", "lightblue"))
```

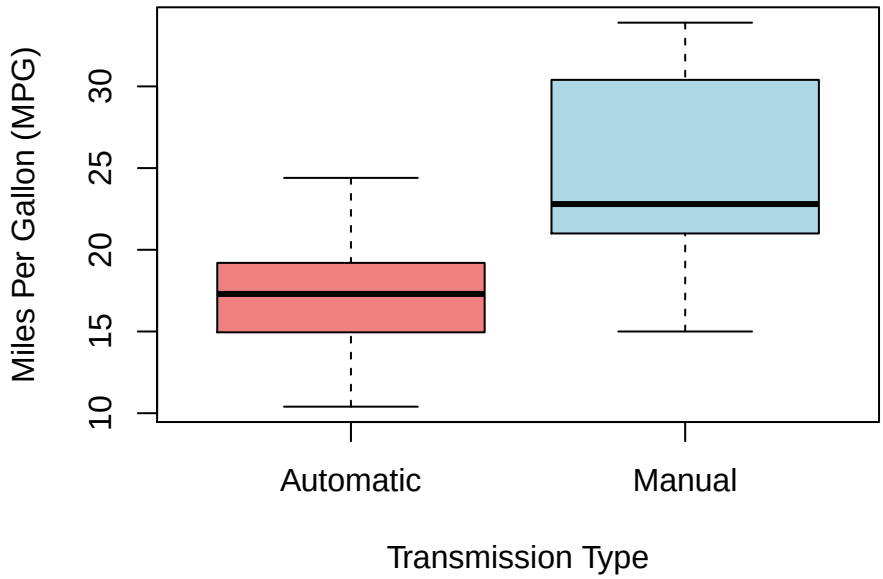


Figure 1: Box plot showing differences in MPG ratings for both automatic and manual transmission cars.

```
par(mfrow=c(2,2),mar=c(4, 4.5, 2, 2))
plot(idealmodel)
```

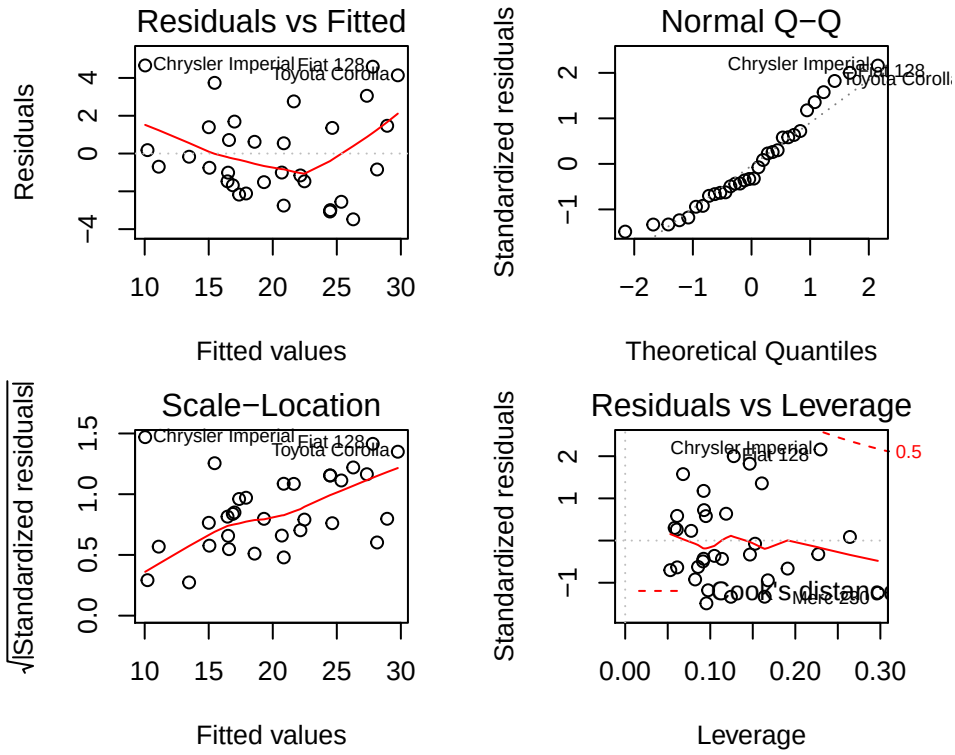


Figure 2: Residual plots of the Ideal model; modelling Transmission type, Acceleration adn Weight to predict MPG.