Analysis of MPG for Automatic vs. Manual Transmission

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January 25, 2016

Regression Models - Course Project

Executive Summary

We will analyze the mtcars dataset collected by the magazine "Motor Trend". This report will leverage methods of exploratory and regression analysis. The analysis will focus on the relationship between miles per gallon (MPG) and transmission type.

"Is an automatic or manual transmission better for MPG"

"Quantify the MPG difference between automatic and manual transmissions"

Manual transmissions get more miles per gallon mpg.

The ratio of this is 1.8 adjusted by hp, cyl, and wt.

Multivariable Regression

Regression will all available variables.

```
full_fit <- lm(mpg ~ . ,data=mtcars)
best_fit <- step(full_fit, direction = "both", trace = FALSE)
```

Step method runs lm multiple times to build multiple regression models and select the best variables from them using both forward selection and backward elimination methods by the AIC algorithm.

```
summary(best_fit)
```

```
##
## Call:
## lm(formula = mpg ~ cyl + hp + wt + am, data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.9387 -1.2560 -0.4013  1.1253  5.0513
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 33.70832    2.60489  12.940 7.73e-13 ***
## cyl6        -3.03134    1.40728  -2.154  0.04068 *
## cyl8        -2.16368    2.28425  -0.947  0.35225
## hp          -0.03211    0.01369  -2.345  0.02693 *
## wt          -2.49683    0.88559  -2.819  0.00908 **
## amManual     1.80921    1.39630   1.296  0.20646
```

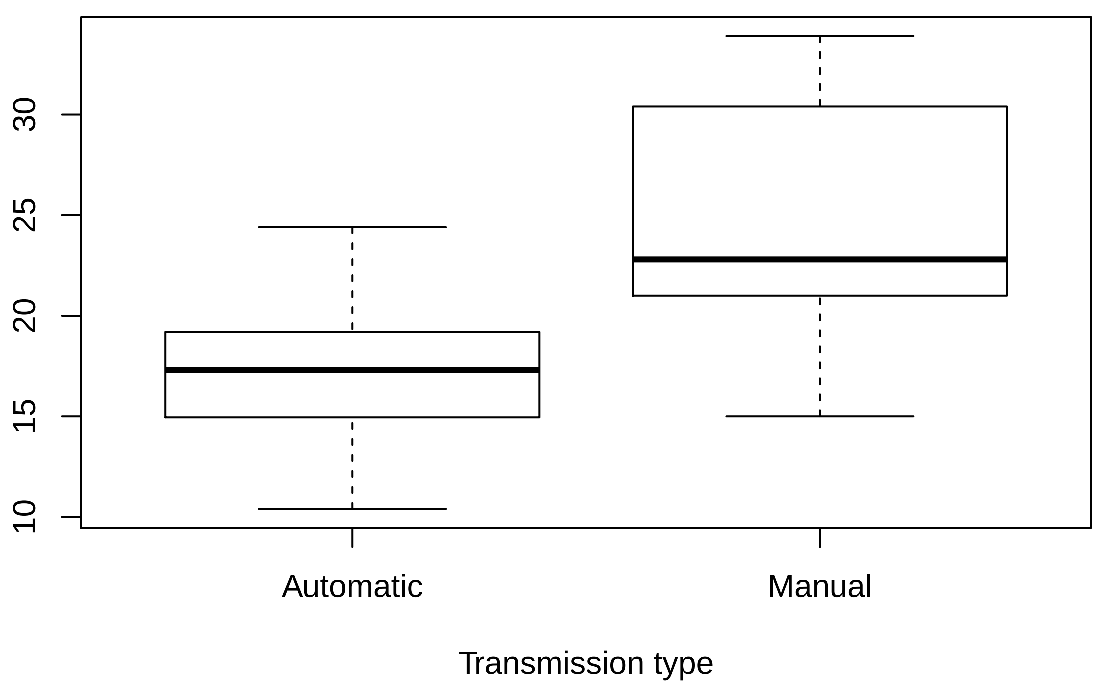
```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.41 on 26 degrees of freedom
## Multiple R-squared:  0.8659, Adjusted R-squared:  0.8401
## F-statistic: 33.57 on 5 and 26 DF,  p-value: 1.506e-10
```

We conclude that hp, wt, and cylare confounding variables in the relationship between 'am and 'mpg'. With 84% of the variance covered by this model its a good fit (see analysis in appendix for further validation)

Appendix

Exploratory analysis

```r
boxplot(mpg ~ am, data = mtcars, xlab = "Transmission type")
```



Clear seperation of means between Automatic and Manual transmissions.

Inferance

```r
alpha <- 0.05
fit <- lm(mpg ~ am, data = mtcars)
summary(fit)
```

```
##
## Call:
## lm(formula = mpg ~ am, data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.3923 -3.0923 -0.2974  3.2439  9.5077
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   17.147      1.125  15.247 1.13e-15 ***
## amManual       7.245      1.764   4.106 0.000285 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.902 on 30 degrees of freedom
## Multiple R-squared:  0.3598, Adjusted R-squared:  0.3385
## F-statistic: 16.86 on 1 and 30 DF,  p-value: 0.000285
```

Simple Linear Regression: Adjusted R squared value is only 0.338 (or 33.8%) of the regression variance can be explained by our model. This indicates we should look into the other variables in a multivariate regression and potential confounding relationships.

```
analysis <- aov(mpg ~ ., data = mtcars)
summary(analysis)
```

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## cyl          2  824.8   412.4  51.377 1.94e-07 ***
## disp         1   57.6    57.6   7.181   0.0171 *
## hp           1   18.5    18.5   2.305   0.1497
## drat         1   11.9    11.9   1.484   0.2419
## wt           1   55.8    55.8   6.950   0.0187 *
## qsec         1    1.5     1.5   0.190   0.6692
## vs           1    0.3     0.3   0.038   0.8488
## am           1   16.6    16.6   2.064   0.1714
## gear         2    5.0     2.5   0.313   0.7361
## carb         5   13.6     2.7   0.339   0.8814
## Residuals   15  120.4     8.0
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Using analysis of variance we see potential impact on mpg from am but higher on a number of other varibles.

```
t.test(mpg ~ am, data = mtcars)
```

```
##
##  Welch Two Sample t-test
##
## data:  mpg by am
## t = -3.7671, df = 18.332, p-value = 0.001374
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
```

```
##  -11.280194  -3.209684
## sample estimates:
## mean in group Automatic    mean in group Manual
##                17.14737                24.39231
```

Transmission types are clearly differnt with respect the thier relationship to mpg.

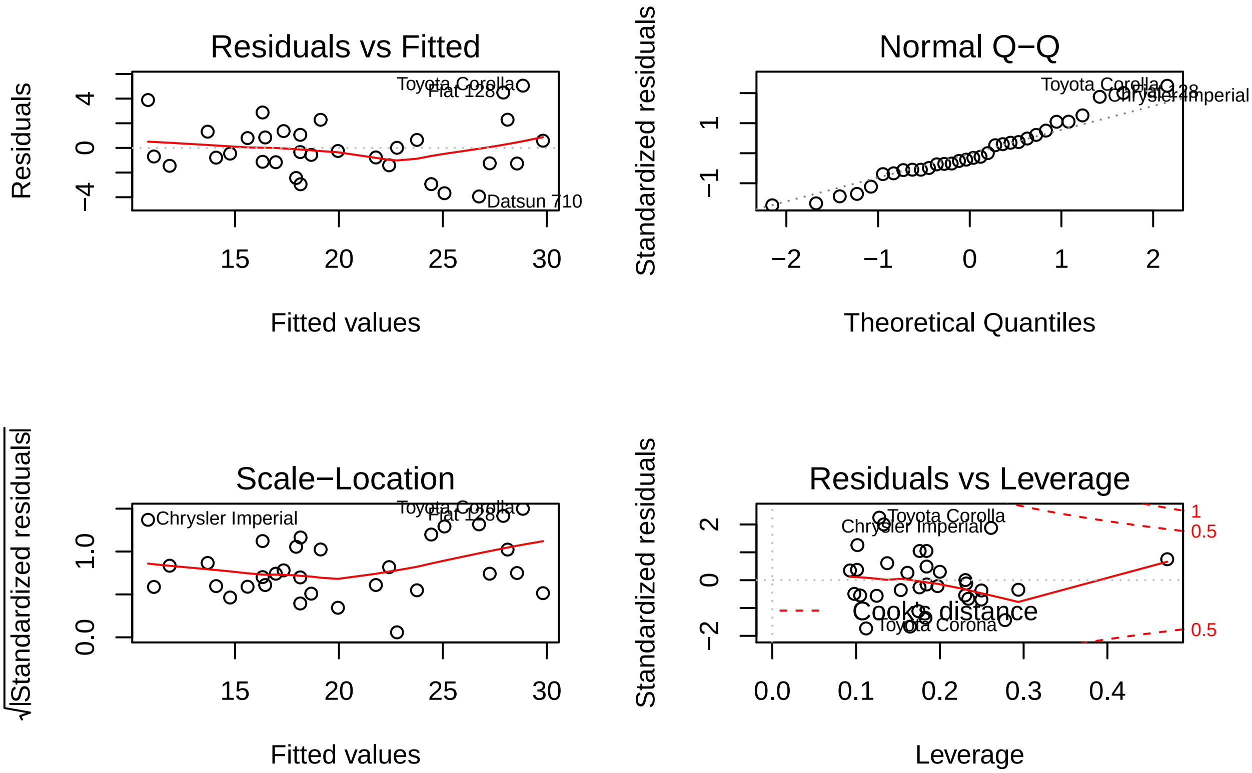
Residual Analysis and Diagnosis

The p-value analysis between simple regression and best allow us to reject the null hypothsis that confounding variable impact the relation between am and mpg. The residual analysis plots below validate the model as well.

```r
anova(fit, best_fit)
```

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ cyl + hp + wt + am
##   Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1     30 720.90
## 2     26 151.03  4    569.87 24.527 1.688e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
par(mfrow = c(2, 2))
plot(best_fit)
```


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
1
0.5