

Regression Models Course Project

majusus

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Executive Summary

Motor Trend is the top automobile magazine in the United States for producing accurate automobile data to the public. Following is a data analysis which will answer one question and support the answer with quantifiable data.

- 1) Is an automatic or manual transmission better for MPG (miles per gallon)?
- 2) Quantify the MPG difference between automatic and manual transmissions.

The following analysis will show the answers are:

- 1) The automatic or manual transmission as compared to MPG for this data set is not statistically significant.
- 2) The MPG difference is 1.8 for automatic transmission vs. manual transmissions.

Loading and Preprocessing the Data

A description of the data can be found at <https://stat.ethz.ch/R-manual/R-patched/library/datasets/html/mtcars.html> Let's get an idea of what the data within the data frame looks like.

```
head(mtcars)
```

	mpg	cyl	displacement	hp	drat	wt	qsec	vs	am	gear	carb
## Mazda RX4	21.0	6	160	110	3.90	2.620	16.46	0	1	4	4
## Mazda RX4 Wag	21.0	6	160	110	3.90	2.875	17.02	0	1	4	4
## Datsun 710	22.8	4	108	93	3.85	2.320	18.61	1	1	4	1
## Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44	1	0	3	1
## Hornet Sportabout	18.7	8	360	175	3.15	3.440	17.02	0	0	3	2
## Valiant	18.1	6	225	105	2.76	3.460	20.22	1	0	3	1

It is shown that there is a row for each make and model of automobile.

Let's look at the actual attributes of the data.

```
data("mtcars")
str(mtcars)
```

```
## 'data.frame':   32 obs. of  11 variables:
## $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 ...
## $ cyl : num  6 6 4 6 8 6 8 4 4 6 ...
```

```
## $ disp: num 160 160 108 258 360 ...
## $ hp : num 110 110 93 110 175 105 245 62 95 123 ...
## $ drat: num 3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.92 ...
## $ wt : num 2.62 2.88 2.32 3.21 3.44 ...
## $ qsec: num 16.5 17 18.6 19.4 17 ...
## $ vs : num 0 0 1 1 0 1 0 1 1 1 ...
## $ am : num 1 1 1 0 0 0 0 0 0 0 ...
## $ gear: num 4 4 4 3 3 3 3 4 4 4 ...
## $ carb: num 4 4 1 1 2 1 4 2 2 4 ...
```

We can now see that `mtcars` is a `data.frame` with 32 observations and 11 variables. All of the variables have a type of numbers

Data Cleansing

Since all of the variables are type of number and we need to use them for analysis, some variables need to be converted to factors so that they are not treated as numerics.

```
mtcars$cyl <- as.factor(mtcars$cyl)
mtcars$vs <- as.factor(mtcars$vs)
mtcars$am <- as.factor(mtcars$am)
mtcars$gear <- as.factor(mtcars$gear)
mtcars$carb <- as.factor(mtcars$carb)
```

Exploratory Analysis

Let's just begin with a simple linear regression of MPG vs automatic/manual transmissions. The assumptions are that the linear model is appropriate for the mean value of y_i , and the error distribution should be normally distributed and independent.

```
fit_linear <- lm(mpg ~ am, mtcars)
```

Refer to Figure 1 of the Appendix.

```
summary(fit_linear)

##
## 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 ***
## am1           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
```

Reviewing the coefficients from the summary data, we can look for the confidence interval using the formula $\text{betahat} \pm t \cdot \text{SE}(\text{betahat})$.

```
betahat <- .7245
SE <- 1.764
tstar <- qt(1-0.05/2, df = length(mtcars$mpg) - 2)
c(betahat - tstar*SE, betahat + tstar *SE)

## [1] -2.878069  4.327069
```

From both the plots in Figure one, the results of our coefficient summary, small p-value, and inclusion of 0 in the confidence interval, we reject the null hypothesis that transmission affects MPG.

Multivariate Analysis

While we are exploring MPG for manual vs automatic transmissions, we know that including new variables will increase standard errors of coefficient estimates of other correlated regressors. However, we need to be cautious not to omit variables because that will result in bias in coefficients of regressors which are correlated to the omitted variables.

First create a fit for all of the variables in reference to mpg.

```
fit_all <- lm(mpg ~ . , mtcars)
```

Next, determine which variables are necessary for the correlation can be done by using the stepAIC function in R. Details can be found here: <https://stat.ethz.ch/R-manual/R-devel/library/MASS/html/stepAIC.html>

```
library("MASS")
step <- stepAIC(fit_all, direction="both", trace=FALSE)
summary(step)

##
## 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 **
## am1          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
```

According to this summary, the significant variables in relation to the mpg are cyl(cylinders), hp(horsepower) and wt(weight)

Comparison of the two models.

To verify that the multivariate model from step is the better fit, use ANOVA to compare the two models.

```
anova(fit_linear, step)

## 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
```

Upon comparing the two models, the difference is significant, leading us to rule out the simpler model.

Visually, it may be easier to see if we plot this best fit model. This is done in Figure 2 in the Appendix.

Determining the Significance of the transmission type on mpg

Let's summarize the coefficients of this best model:

```
coefficients(summary(step))

##              Estimate Std. Error  t value    Pr(>|t|)
## (Intercept) 33.70832390 2.60488618 12.940421 7.733392e-13
## cyl6        -3.03134449 1.40728351 -2.154040 4.068272e-02
## cyl8        -2.16367532 2.28425172 -0.947214 3.522509e-01
```

```
## hp          -0.03210943  0.01369257 -2.345025  2.693461e-02
## wt          -2.49682942  0.88558779 -2.819404  9.081408e-03
## am1         1.80921138  1.39630450  1.295714  2.064597e-01
```

Reviewing the p-values in the summary data, we can see that the p-value for am (automatic vs. manual transmission) is not significant in the measurement of mpg. This can be proven with the confidence interval formula as done previously in the Exploratory analysis section.

```
betahat1 <- 1.80921138 #From the summary for am
SE1 <- 1.39630450      #From the summary for am
tstar1 <- qt(1-0.05/2, df = length(mtcars$mpg) - 2)
c(betahat1 - tstar1*SE1, betahat1 + tstar1 *SE1)

## [1] -1.042423  4.660846
```

Since the confidence interval includes 0 and the p-value is greater than .05, the difference between an automatic transmission and a manual transmission does not significantly impact mpg(miles per gallon). It does however show that an automatic transmission is 1.8 greater than a manual transmission.

Conclusion

Upon review of the the models, the best fit in Figure 2, it is shown that the Normal Q-Q graph is normally distributed and the Scale-Location graph has a steady variance. This is improved from Figure 1 where only am(transmission type) was compared with mpg. Upon further review, it was determined that am did not have a significant impact on mpg.

Appendix

Figure 1:

```
par(mfrow=c(2,2))
plot(fit_linear);
abline(fit_linear)
```

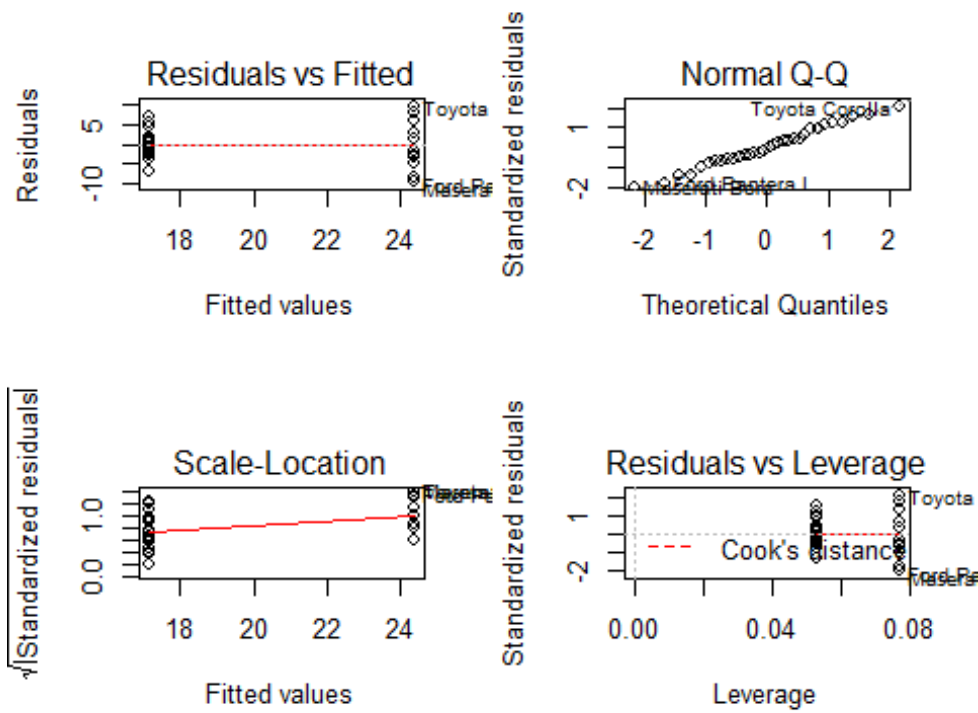


Figure 2:

```
par(mfrow=c(2,2))
plot(step);
abline(step)
```

```
## Warning in abline(step): only using the first two of 6 regression
## coefficients
```

