Motor Trend Assignment

Alan C Bonnici

Tuesday, October 21, 2014

Assignment

You work for Motor Trend, a magazine about the automobile industry. Looking at a data set of a collection of cars, they are interested in exploring the relationship between a set of variables and miles per gallon (MPG) (outcome). They are particularly interested in the following two questions:

- "Is an automatic or manual transmission better for MPG"
- "Quantify the MPG difference between automatic and manual transmissions"

Data

The data source for this assignment comes from the **mtcars** dataset which is bundled with R. The dataset can be loaded into R by typing . The effect of this command is to load into the environment **mtcars**. The resulting dataset consists of **32** rows, each row made up of **11** columns.

The columns making up this dataset are:

1 mpg Miles/(US) gallon
2 cyl Number of cylinders
3 disp Displacement (cu.in.)
4 hp Gross horsepower
5 drat Rear axle ratio
6 wt Weight (lb/1000)
7 qsec 1/4 mile time
8 vs V/S
9 am Transmission (0 = automatic, 1 = manual)
10 gear Number of forward gears
11 carb Number of carburetors

The information provided here was sourced from the R documentation page. This, together with addition information can be called up by typing *?mtcars* at the R prompt. A link to the online version of the page is available at (https://stat.ethz.ch/R-manual/R-devel/library/datasets/html/mtcars.html).

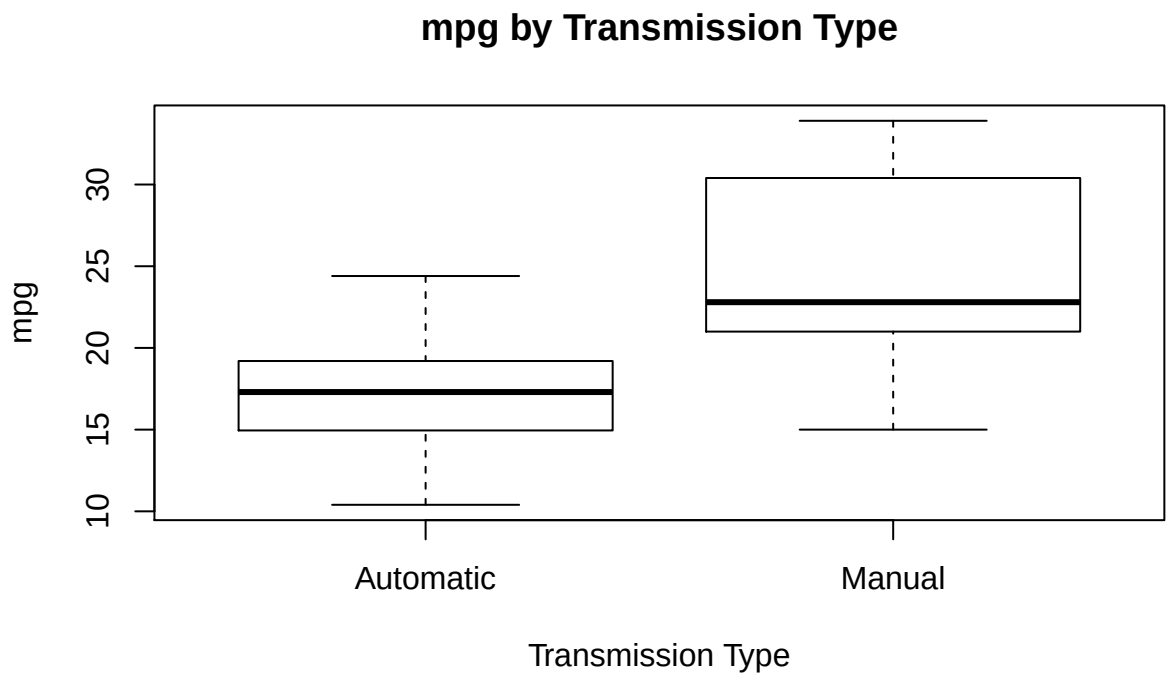
Project Requirement

The two columns we will be dealing with are *mpg* and *am*. The data type of these two properties are:

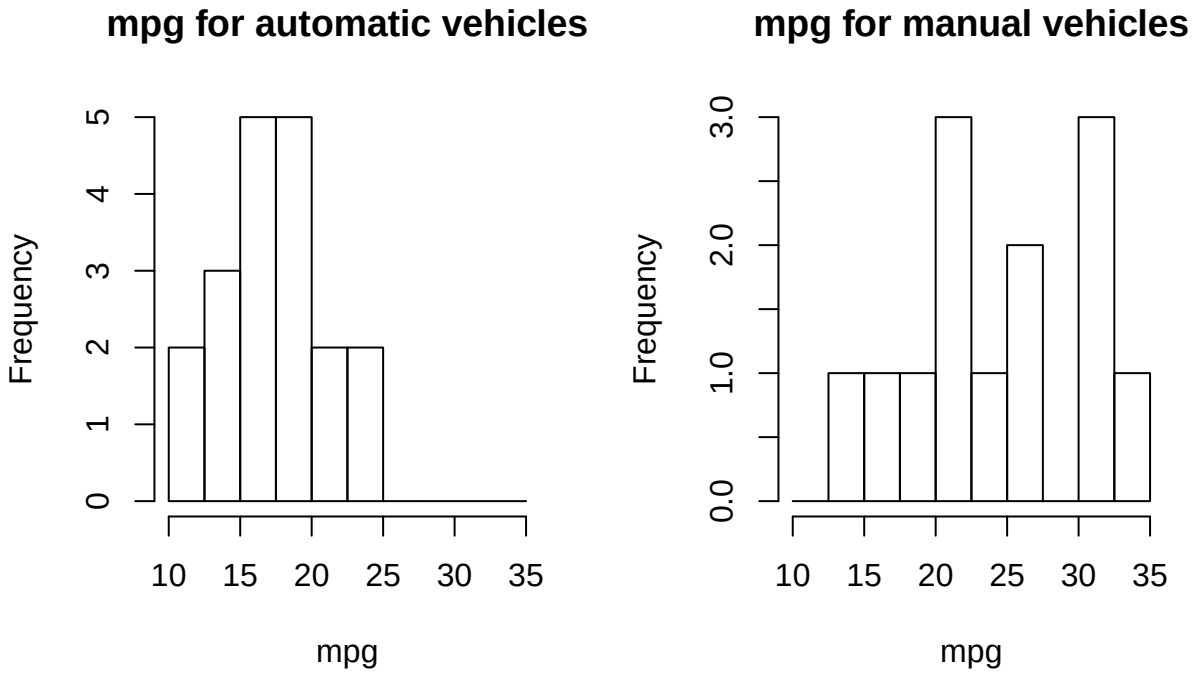
- mpg '{r class(mtcars$mpg)}'
- am '{r class(mtcars$am)}'

am will be converted into a factor variable.

```
mtcars$am <- as.factor(mtcars$am)
levels(mtcars$am) <-c("Automatic", "Manual")
```



The boxplot above examples the different transmission types with respect to the mpg. From this chart, it seems that manual transmission have a higher mpg than automatic transmissions. One could also not that neither have any outliers and the whiskers of the box plot are balanced.



The histogram above compares the mpg of the two types of transmissions.

Data Analysis of mpg for automatic vs manual tranmssions

```
cars.Auto <- mtcars[mtcars$am == "Automatic",]
cars.Man <- mtcars[mtcars$am == "Manual",]
```

The average mpg for vehicles with automatic transmission is **17.15**. The average mpg for vehicles with manual transmission is **24.39**.

```
t.test(cars.Auto$mpg, cars.Man$mpg)
```

```
##
##  Welch Two Sample t-test
##
## data:  cars.Auto$mpg and cars.Man$mpg
## 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 of x mean of y
##  17.14737  24.39231
```

From the information presented in the Welch Two Sample t-test, it is clear that at a 95% confidence interval the difference between the mpg means of the automatic and petrol vehicles is always negative implying that manual will always be 3.21 mpg more efficient than automatic.

From the information presented above, the *null hypothesis: true difference in means is equal to 0* will be rejected at the 99% confidence level.

Even though the information shown above indicates that manual is more efficient than automatic, one needs to ensure that other factors are not confounding the results. For example, if automatic cars analysed here are heavier than manual ones than weight could be "upsetting" the results. Likewise if one category of vehicle have higher, hp or cylinder values this could be a factor and not the transmission.

A correlation analysis can help show the relationship of the various properties with respect to mpg shows that an increase in cylinders, displacement, hp, weight and number of carburetors all negativly impact mpg while rear axle ratio, 1/4 mile time and number of forward gears all contribute to higher mpgs.

```
x <- head(cor(sapply(mtcars, as.numeric)),1)
x <- x[, order(x)]
x[-11]
```

```
##         wt        cyl       disp         hp       carb       qsec
## -0.8676594 -0.8521620 -0.8475514 -0.7761684 -0.5509251  0.4186840
##       gear         am         vs       drat
##  0.4802848  0.5998324  0.6640389  0.6811719
```

In a simple regression analysis from mpg given transmission

```
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
```

From the above data we can infer that, on average, manual transmission vehicle give 7.25 mpgs more than then automatic transmission. A value of R^2 of 35.98% means that the model does not explain all of the variance and further investigation is required.

In order to investigate further a multivariate regression analysis is performed. In this case we adopt a stepwise linear regression. Stepwise regression is a semi-automated process of building a model by successively removing variables based solely on the t-statistics of their estimated coefficients.

```
fit2 <- lm(mpg ~ ., data=mtcars)
summary(fit2)
```

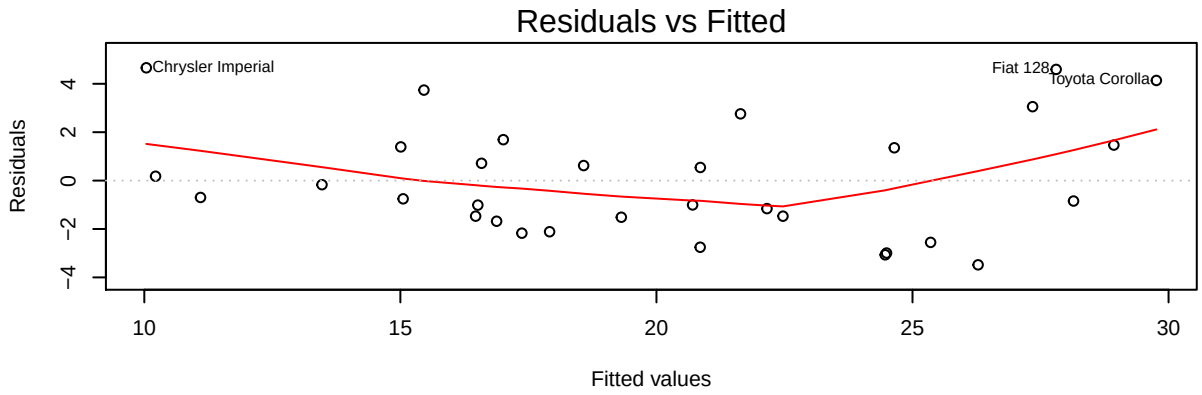
```
##
## Call:
## lm(formula = mpg ~ ., data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.4506 -1.6044 -0.1196  1.2193  4.6271
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 12.30337   18.71788   0.657   0.5181
## cyl         -0.11144    1.04502  -0.107   0.9161
## disp         0.01334    0.01786   0.747   0.4635
## hp          -0.02148    0.02177  -0.987   0.3350
## drat         0.78711    1.63537   0.481   0.6353
## wt          -3.71530    1.89441  -1.961   0.0633 .
## qsec         0.82104    0.73084   1.123   0.2739
## vs           0.31776    2.10451   0.151   0.8814
## amManual     2.52023    2.05665   1.225   0.2340
## gear         0.65541    1.49326   0.439   0.6652
## carb        -0.19942    0.82875  -0.241   0.8122
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

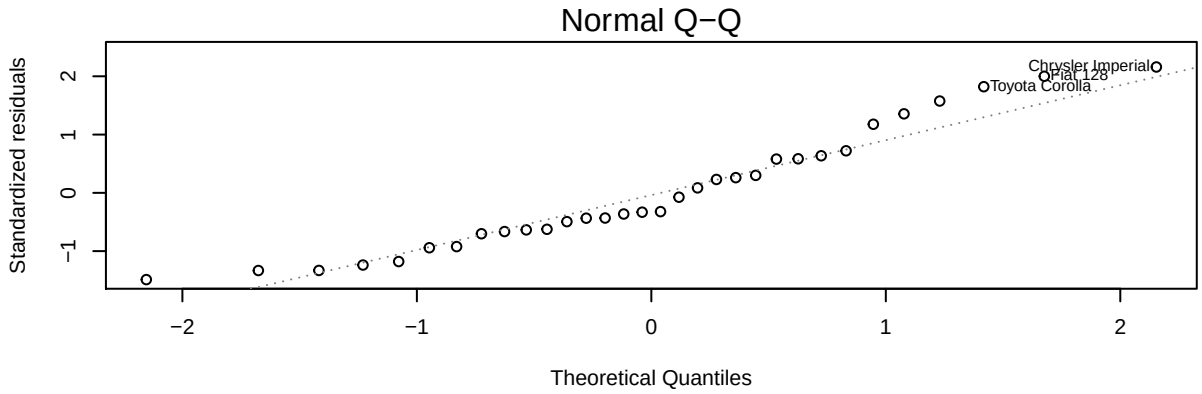
```
## Residual standard error: 2.65 on 21 degrees of freedom
## Multiple R-squared:  0.869,  Adjusted R-squared:  0.8066
## F-statistic: 13.93 on 10 and 21 DF,  p-value: 3.793e-07
```

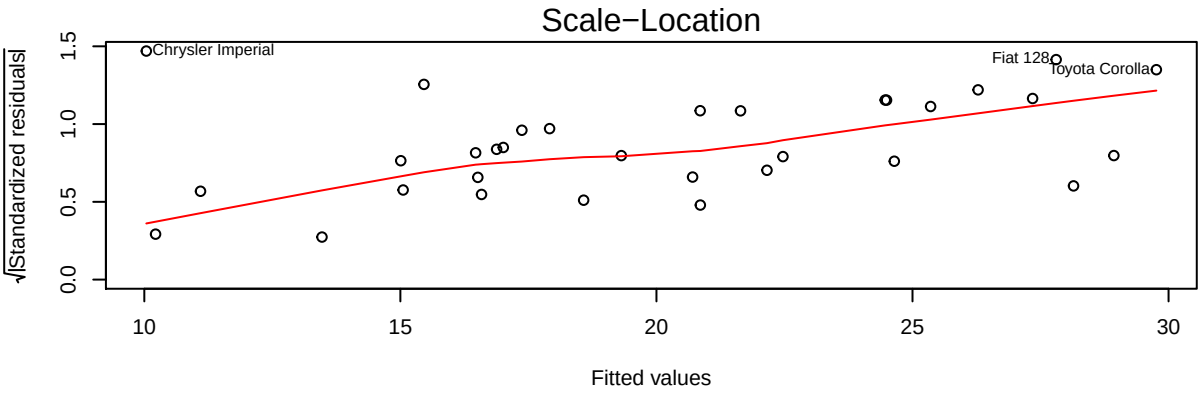
```
fit2.best <- step(fit2, trace=0)
summary(fit2.best)
```

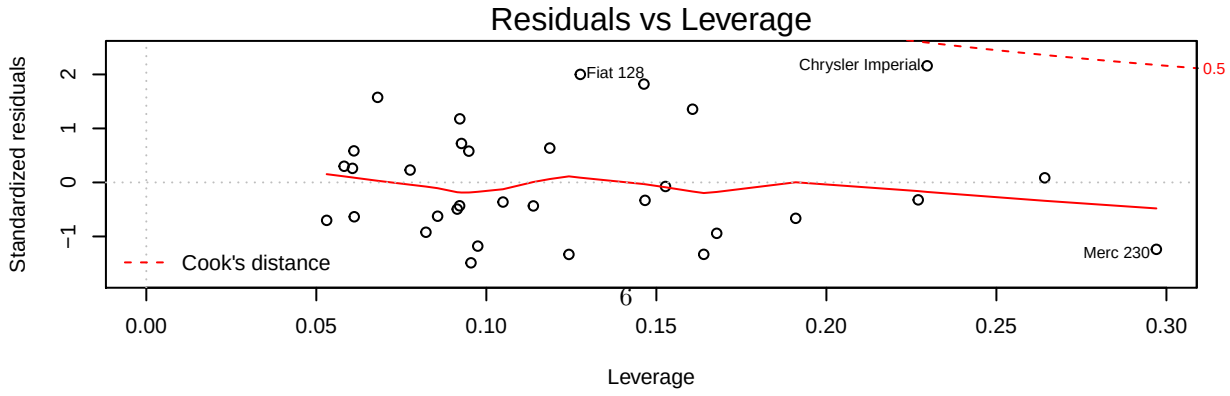
```
##
## Call:
## lm(formula = mpg ~ wt + qsec + am, data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.4811 -1.5555 -0.7257  1.4110  4.6610
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   9.6178     6.9596   1.382 0.177915
## wt           -3.9165     0.7112  -5.507 6.95e-06 ***
## qsec          1.2259     0.2887   4.247 0.000216 ***
## amManual      2.9358     1.4109   2.081 0.046716 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.459 on 28 degrees of freedom
## Multiple R-squared:  0.8497, Adjusted R-squared:  0.8336
## F-statistic: 52.75 on 3 and 28 DF,  p-value: 1.21e-11
```

From the information presented above we can conclude that manual transmission contributes 2.94 mpg over automatic. This is far less than the value reported using the linear regression of mpg given transmission on its own or the t-test and can be explained by the weight and 0.25 mile time that play an important role in overall mpg value.


Residuals vs Fitted
Chrysler Imperial
Fiat 128
Toyota Corolla
Residuals
Fitted values


Normal Q−Q
Chrysler Imperial
Fiat 128
Toyota Corolla
Standardized residuals
Theoretical Quantiles


Scale−Location
Chrysler Imperial
Fiat 128
Toyota Corolla
√|Standardized residuals|
Fitted values


Residuals vs Leverage
Fiat 128
Chrysler Imperial
0.5
Cook's distance
Merc 230
Standardized residuals
Leverage