Regression Models - Course Project

Pier Lorenzo Paracchini, 18.12.2015

Executive Summary

According to the selected linear regression model **automatic** models are better for `mpg`. Actually **automatic** models have an estimated mpg of 26.585 (miles per gallon) with a 95% confidence interval included in [23.67 - 29.5] while **manual** models have an increased estimated mpg of 5.277 (miles per gallon).

Data Analysis

The `mtcars` dataset include 32 observations of 11 features. Each onservations comprises some information for a specific automobiles (1973 - 1974 model). The focus of this investigation is two specific features **mpg** (miles per gallon) and **am** (type of transmission - 0: automatic, 1: manual).

The available datase contains 19 automatic car models and 13 manual car models. The observed `mpg` by type of transmission `am` can be seen in the provided hystogram (see **Appendix, Figure 1**).

From the hystogram we can see that `am` (predictor) is visibly related to `mpg` (outcome) as we can see from the sample mean of each group. The "automatic" group has a lower sample mean (17.147 Miles/ Gallon) than the "manual" group (24.392 Miles/ Gallon).

Regression Model

A Simple Model

The simpler linear model, we can build, uses `mpg` (as outcome) with `am` as predictor (`mpg ~ am`). The coefficients of the fitted model are

```
##              Estimate Std. Error   t value     Pr(>|t|)
## (Intercept) 17.147368   1.124603 15.247492 1.133983e-15
## am1          7.244939   1.764422  4.106127 2.850207e-04
```

From the Residual vs Fitted plot (see **Appendix, Figure 2**) we can see that the model is just able to predict two possible values for the estimated `mpg` based on the predictor - **17.147 mpg for automatic models** and **24.392 mpg for manual models** with an estimated residuals standard error of **4.902 mpg**. While the Q-Q plot (see **Appendix, Figure 2**) confirms the normality of the errors (assumption). A more detailed interpration of the simple model can be found in **Appendix, Simple Model Interpretation**.

Extending the Model adding new features

The simple model is quite limited. Looking at the available features, other possible features could be used to identify a "better" model. A possible feature that may be valuable investigating is `hp` (**gross horse power** in hp). The relationship between `mpg` vs. `hp` by `am` can be seen in **Appendix, Figure 3**.

Using the **nested model testing technique** for the following nested models we can see that, **added feature of model 2 are necessary over model 1** (P-value < 0.05).

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ am + hp
##   Res.Df    RSS Df Sum of Sq      F   Pr(>F)
## 1     30 720.90
## 2     29 245.44  1    475.46 56.178 2.92e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model 2 (**`mpg ~ am + hp`**) seems to provide a better "description" of the response and it will be used to answer the original questions. See the Residual vs Fitted plot and Q-Q plot (see **Appendix, Figure 4**).

Note!! The same process can be executed adding other features to the model in a nested fashion - investigating the overall effect of the new features on the model in an incremental way.

Findings & Interpretation

Model 2 (**`mpg ~ am + hp`**) has the following coefficients

```
##               Estimate  Std. Error   t value     Pr(>|t|)
## (Intercept) 26.5849137 1.425094292 18.654845 1.073954e-17
## am1          5.2770853 1.079540576  4.888270 3.460318e-05
## hp          -0.0588878 0.007856745 -7.495191 2.920375e-08
```

- **automatic** models (reference group - `am = 0`) have an estimated mpg of 26.585 (miles per gallon) with a standard error of 1.425 (miles per gallon).
- **manual** models (`am = 1`) have an increased estimated mpg of 5.277 (miles per gallon) (over the reference group) with a standard error of 1.08 (miles per gallon). The P-value of 0 is statistically significant, reject the **null hypothersis** (having an increase/ decrease over the reference group null).

According to this very simple linear model, **automatic** transmission is better for **mpg** than **manual** transmission.

Based on the linear model previosly created we can state that

- **automatic** models use an estimated mpg of 26.585 (miles per gallon) with a 95% confidence interval included in [23.67 - 29.5] miles per gallon.
- **manual** models use an increased estimated mpg of 5.277 (miles per gallon) over the reference group with a 95% confidence interval included in [3.069 - 7.485] miles per gallon.

Appendix

Figure1: Hystogram of observed `mpg` by `am` (type of transmission)

Note the *blue* line represent the sample mean for each of the type of transmission (0: automatic, 1: manual).

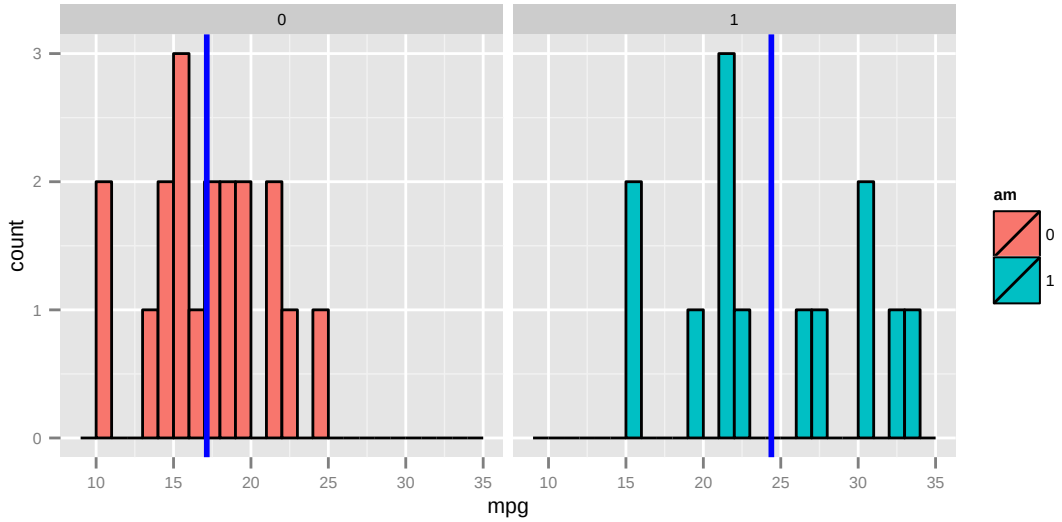


Figure2: Residual Plots for (*`mpg ~ am`*) model

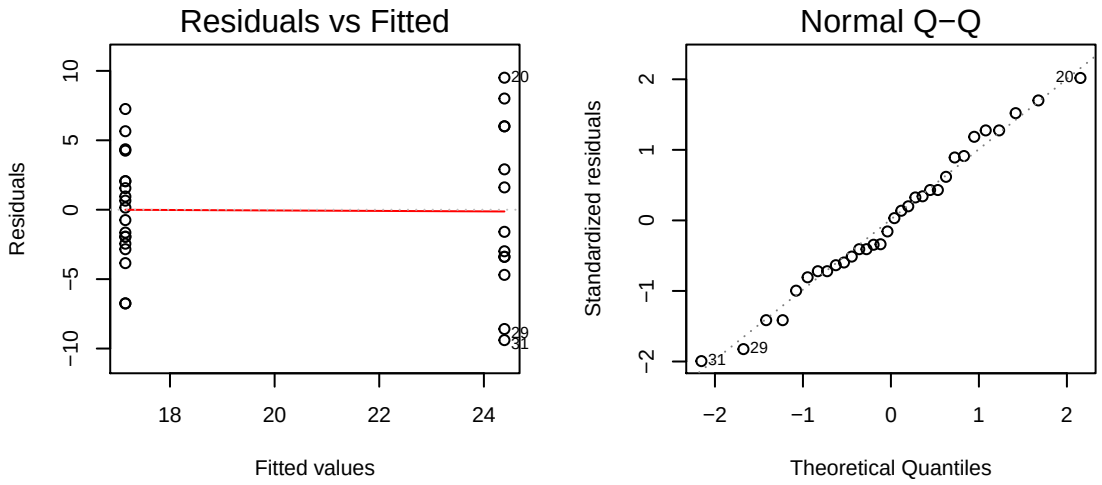


Figure3: (*`mpg vs. hp`*) by `am` (transmission type) plots

For each type of transmission the **unadjusted** line (black), **adjusted** lines (lightblue for automatic, salmon for manual) and sample averages (horizontal) lines (lightblue for automatic, salmon for manual) are plot.

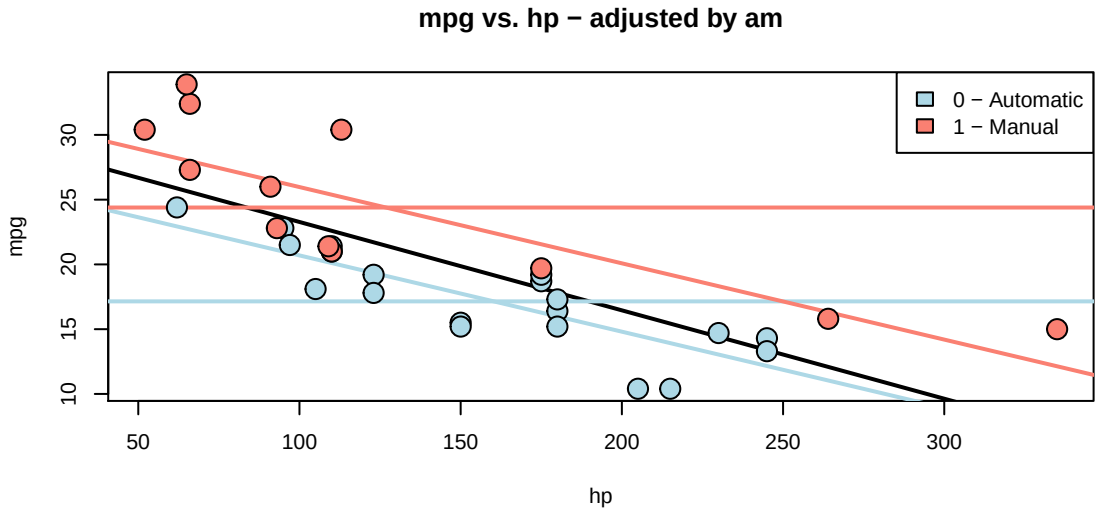
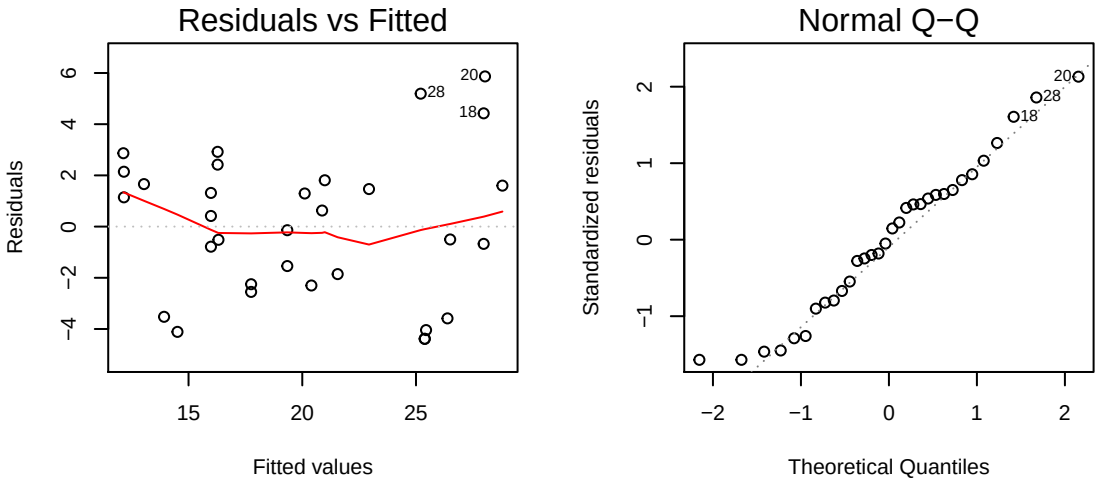


Figure4: Residual Plots for (`mpg ~ am + hp`) model



Simple Model Interpretation

Looking at the coefficients of the simple model (`mpg ~ am`)

```
##              Estimate Std. Error   t value     Pr(>|t|)
## (Intercept) 17.147368   1.124603 15.247492 1.133983e-15
## am1          7.244939   1.764422  4.106127 2.850207e-04
```

- **automatic** models (reference group) have an estimated mpg of 17.147 (miles per gallon) with a standard error of 1.125 (miles per gallon).

- **manual** models have an increased estimated mpg of 7.245 (miles per gallon) (over the reference group) with a standard error of 1.764 (miles per gallon). The P-value of 0 (statistically significant) confirms that the **null hypothersis** (having an increase/ decrease over the reference group null) can be rejected.

Based on the linear model previosly created we can state that

- **automatic** models use an estimated mpg of 17.147 (miles per gallon) with a 95% confidence interval included in [14.851 - 19.444] miles per gallon.
- **manual** models use an increased estimated mpg of 7.245 (miles per gallon) over the reference group with a 95% confidence interval included in [3.642 - 10.848] miles per gallon.