Efficient Fuel Consumption Analysis

Executive Summary

Based in the data gathered by *Motor Trend US* magazine in 1974, this study concludes than manual transmission is more efficient than automatic transmission, with 7.25 ($\pm$ 1.75) more miles per gallon, but only the 36% of variations of yield in terms of mpg are explained by transmission type. A more accuracy model must include variables such as weight, 1/4 mille time, displacement (cubic inch) and horse power, additional to transmission type.

Exploratory Data Analysis

Looking at a data set of a collection of cars, *Motor Trend*, a magazine about the automobile industry, is interested in exploring the relationship between a set of variables and miles per gallon (MPG). 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"

The data was extracted from the 1974 *Motor Trend US* magazine, and comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (1973-74 models). The detail of all aspects included can be found here. See Figure 1 in appendix for a matrix plot of `mtcars` dataset.

```
head(mtcars)
```

```
##                   mpg cyl disp  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
```

Data Analysis

The first aspect to be evaluated: "Is an automatic or manual transmission better for MPG?", suggest a hypothesis test:

- H_0 (null hypothesis): There is no differerence between automatic and manual transmission in terms of MPG
- H_a (alternative hypothesis): There are differences between automatic and manual transmission in terms of MPG

After executing a Student's t-test with a confidence level of 95%, the resulting p-value, 0.14%, less than 5% (or even 1%), allow us to reject H_0, indicating that there are differences between automatic and manual transmission, in terms of MPG. Now, we have to quantify this difference.

Regression Model

Lets generate a linear model with *mpg* as output and *transmission type* as predictor:

```
fit <- lm(mpg ~ factor(am), data=mtcars)
```

Results indicate the following:

- Mean of automatic transmission is 17.147 ± 1.125 mpg
- Mean of manual transmission is 24.392 ± 1.36 mpg
- Manual transmission vehicles have a yield of 7.245 ± 1.764 mpg more in relation to vehicles with automatic transmission
- Only the 36% of variations of yield in terms of mpg are explained by the transmission type, so we have to find a more accurate model.

Model Selection

After using a *brut-force approach*, evaluating all possible combinations of predictors and selecting the combination which maximizes adjusted R^2 (see Figure 3), we get the following model:

```
## lm(formula = mpg ~ disp + hp + wt + qsec + am, data = mtcars)
```

Figure 4 shows the residual plots of the selected model, which we can observe the following:

- The points in *Residuals vs Fitted* plot are randomly scattered with no particular pattern, but regression line indicates other predictors not included in the original data influence fuel consumption (way of driving, city or highway driving, etc.)
- The points in *Normal Q-Q* plot are quite aligned, indicating that the residuals follow a normal distribution.
- In both, *Scale-Location* and *Residuals vs Leverage* plots, the points are in a group with none too far from the center.

Conclusion

- Manual transmission is more efficient than automatic transmission, with 7.245 (± 1.764) more miles per gallon.
- Transmission type is not the only variable which explains gas comsumption (just 36% of variations)
- Selected model (transmission type, weight, 1/4 mille time, displacement and horse power) explains 86.4% of variations.
- There are other predictors not included in the original data influence fuel consumption.

Appendix

Figure 1. Matrix of plots of mtcars dataset

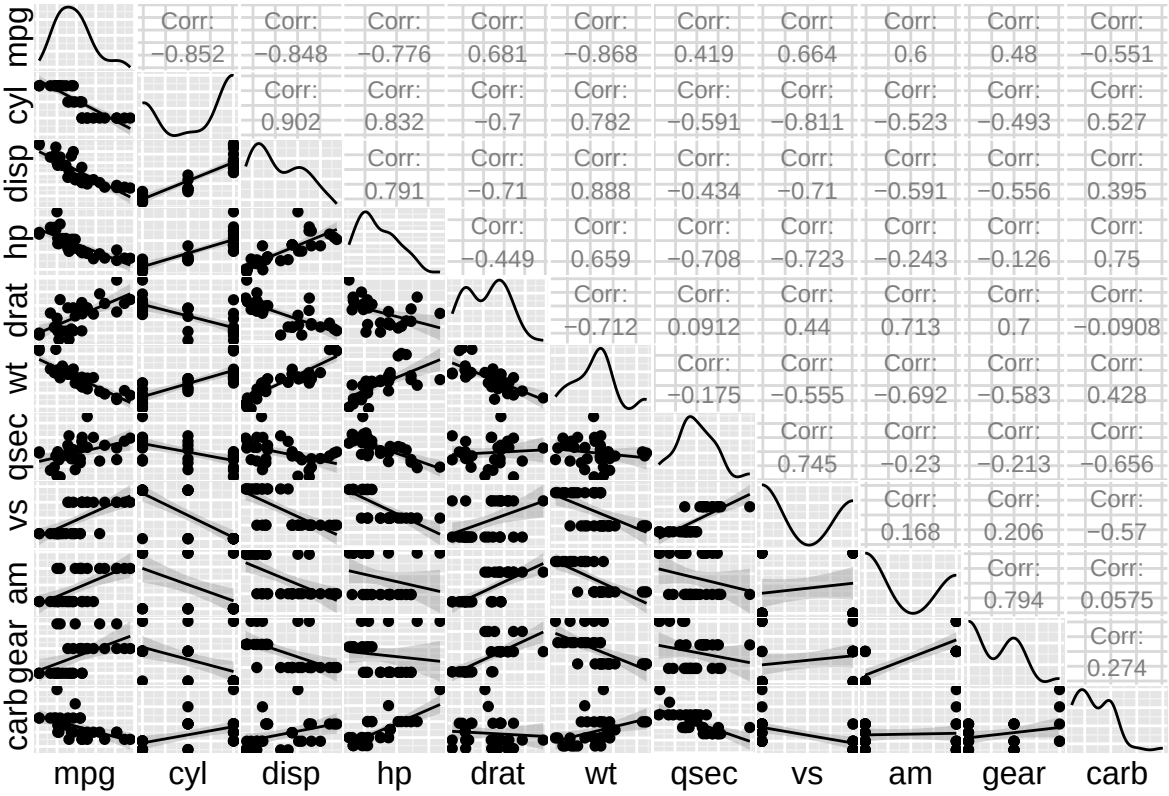


Figure 2. MPG according to Transmission type

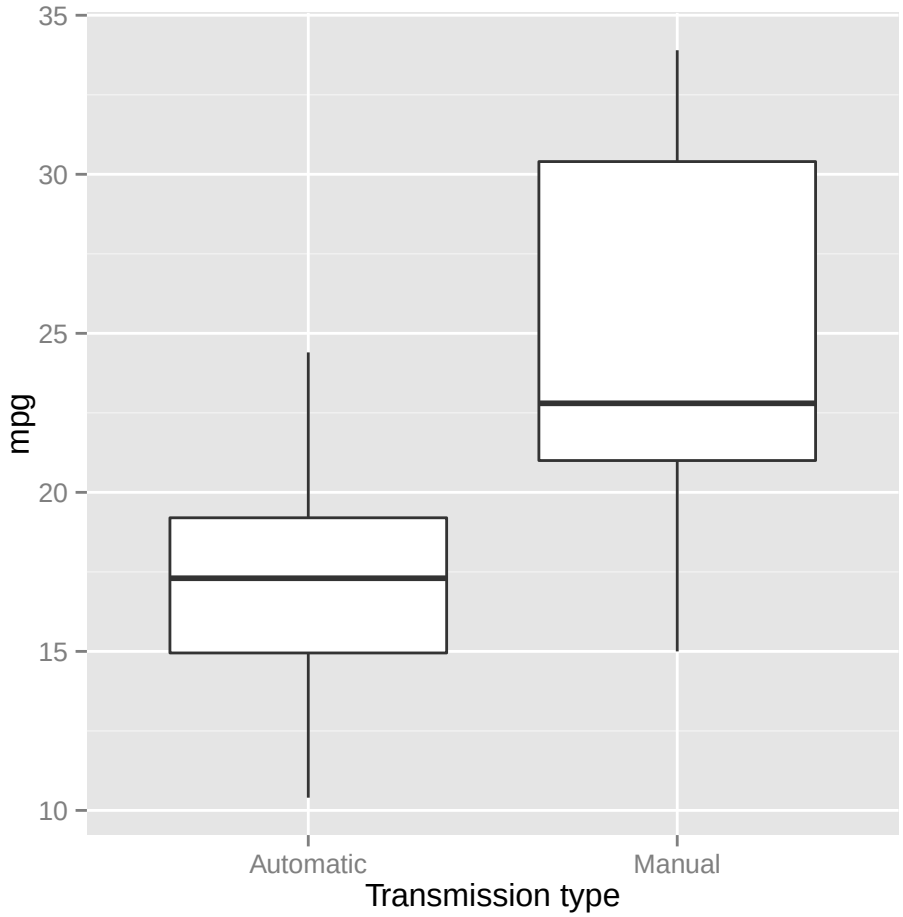


Figure 3. Adjusted R^2 for all evaluated models

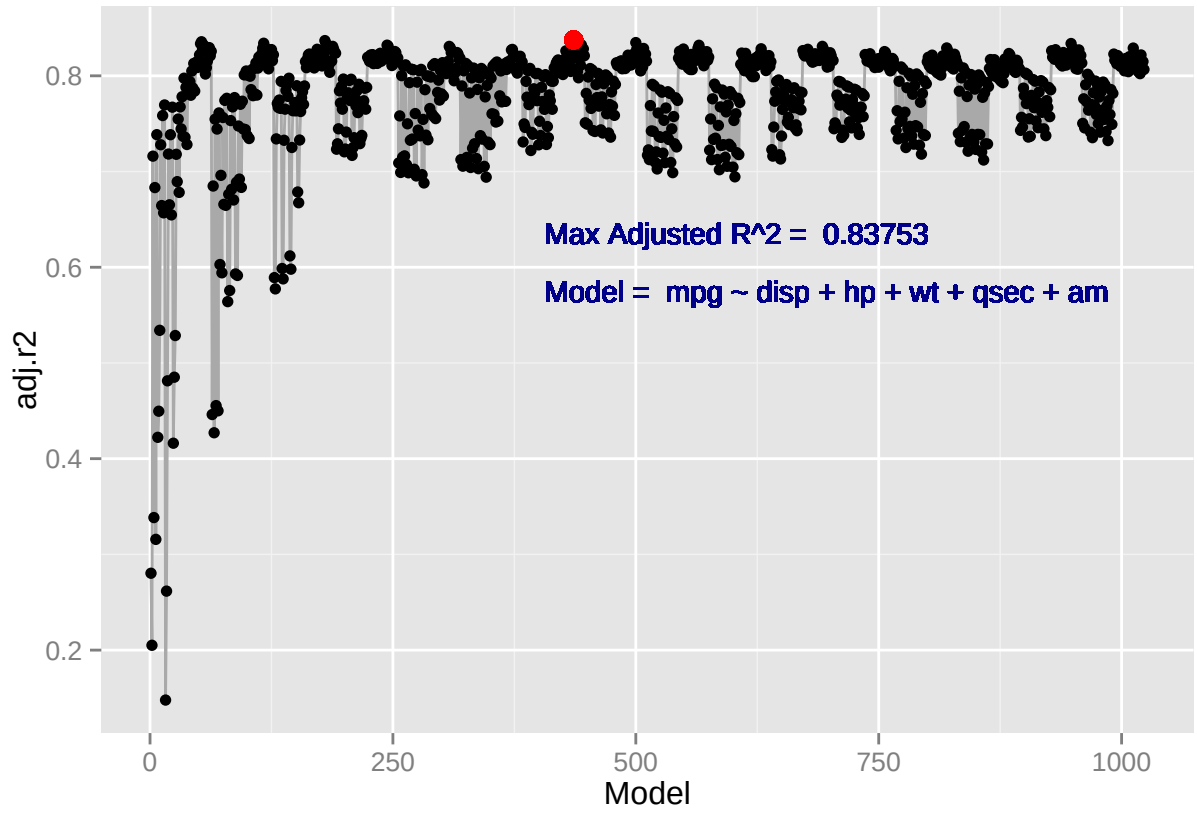
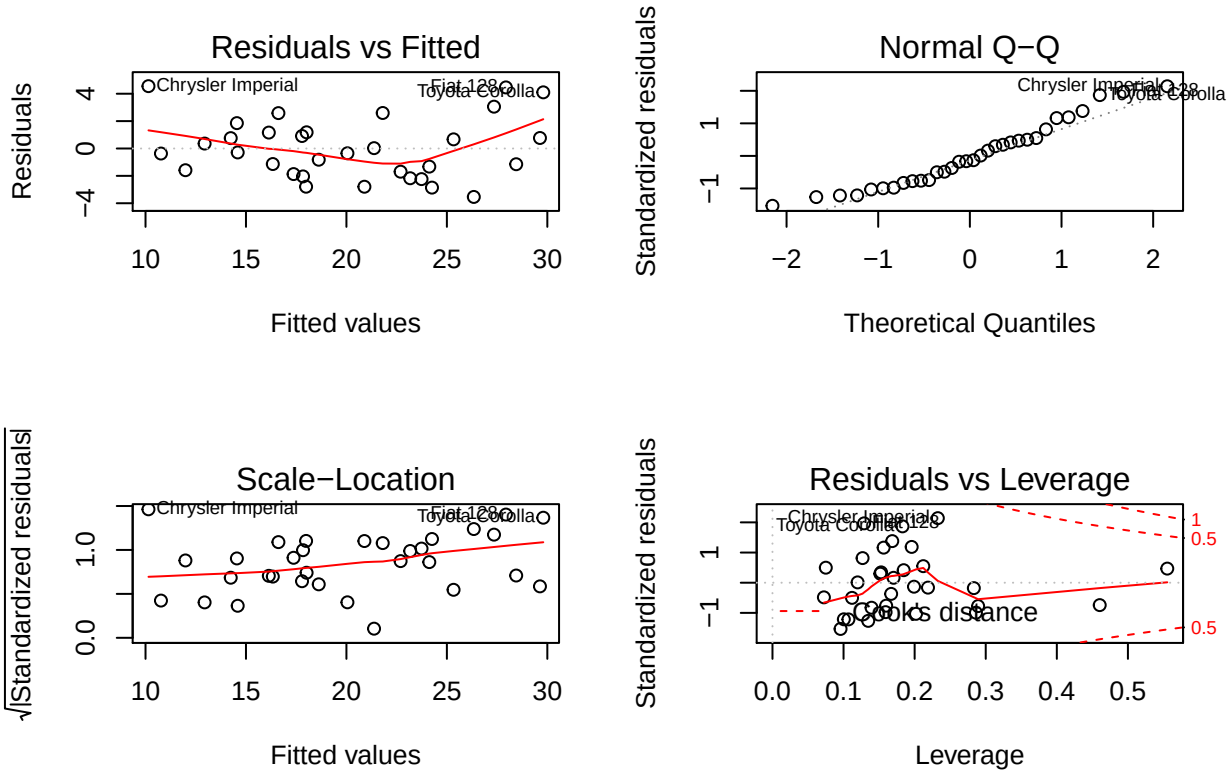


Figure 4. Residuals plots of selected model



Aditional information

See GitHub repository for source file of this report and the worksheet used to build linear models combinations.