

Analysis of MPG vs Transmission type

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Executive summary

We are trying to answer the following questions:

“Is an automatic or manual transmission better for MPG”

“Quantify the MPG difference between automatic and manual transmissions”

Based on the given (mtcars) data set, all else being equal, cars with manual transmissions are more efficient than the ones with automatic transmissions. The difference is, on average, 7.24 mpg. This value has a 95% confidence interval of [3.21 , 11.28], in other words we are 95% confident that the savings is 7.24 ± 4.03 mpg.

Analysis

Summary of the data

The data was extracted from the 1974 Motor Trend US magazine, and comprises fuel consumption and other aspects of automobile design and performance for 32 automobiles (1973–74 models). We will only be using the mpg & am (transmission type, 0 = Automatic, 1 = Manual) features.

Initial Exploration

If we visualize how mpg changes with transmission type (see Figure 1 in Appendix), then we see that there is clearly a difference (~7 mpg). However we need to check the significance of this hypothesis.

Although transmission type is a categorical variable, because it has only two values, we can treat it as numerical. So let's check the correlation between mpg and the transmission type:

```
cor.test(mtcars$mpg, mtcars$am)

##
## Pearson's product-moment correlation
##
## data:  mtcars$mpg and mtcars$am
## t = 4.1061, df = 30, p-value = 0.000285
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.3175583 0.7844520
## sample estimates:
##      cor
## 0.5998324
```

Based on the p value (0.000285) from the above result, we can confidently say that there is a direct correlation. So, let's try linear regression to model the relation between MPG and the transmission type:

```
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 ***
## am              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
```

This model tells us that we can formulate the mpg-am relation by the following formula (see Figure 2 for more details) :

$$\text{mpg} = 17.147 + 7.245 * \text{am}$$

7.245, the coefficient of am in the above formula, is the mpg difference between cars with automatic and manual transmissions (with automatic transmissions consuming more gallons of gas per mile).

Let's also check the significance of this with a t-test:

```
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 0 mean in group 1
##      17.14737      24.39231
```

From the result of the above t-test, we see that mpg values of the cars with manual and automatic transmission are 17.14737 and 24.39231, respectively, hence the difference is: 7.24494. From the p-value ($0.001374 < 0.05$), we can confidently say that this difference is significant, i.e. not happening by chance. Also from the 95% confidence interval, we can say that this difference varies between 3.209684 and 11.280194. Note that the result of this test agrees exactly with the result of the regression model.

Conclusion.

As seen from both of the results above, cars with manual transmission provide a savings of, on average, 7.24494 mpg over cars with automatic transmission, with a 95% confidence interval of [3.21 , 11.28].

Appendix

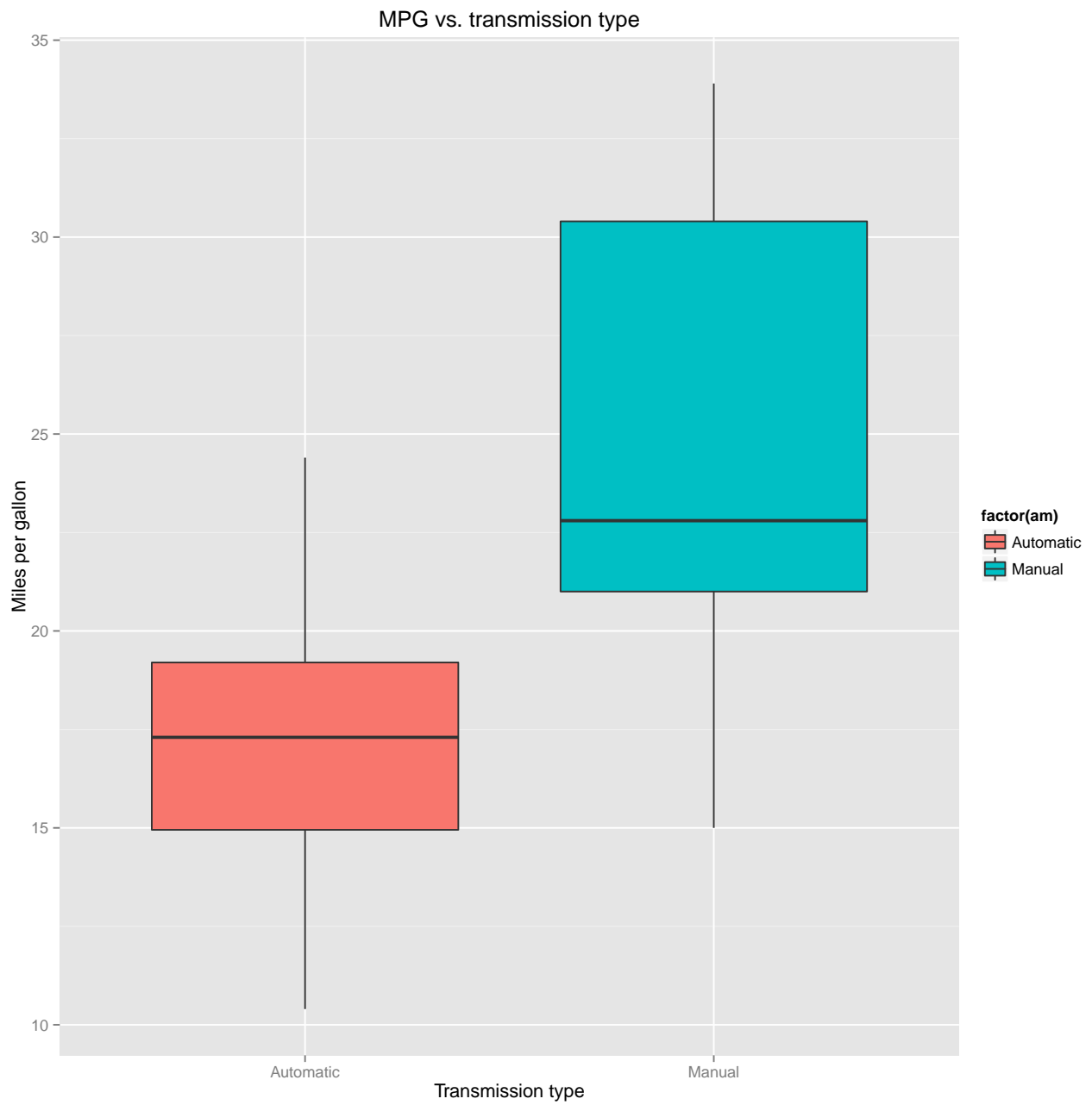


Figure 1: How mpg changes with transmission type

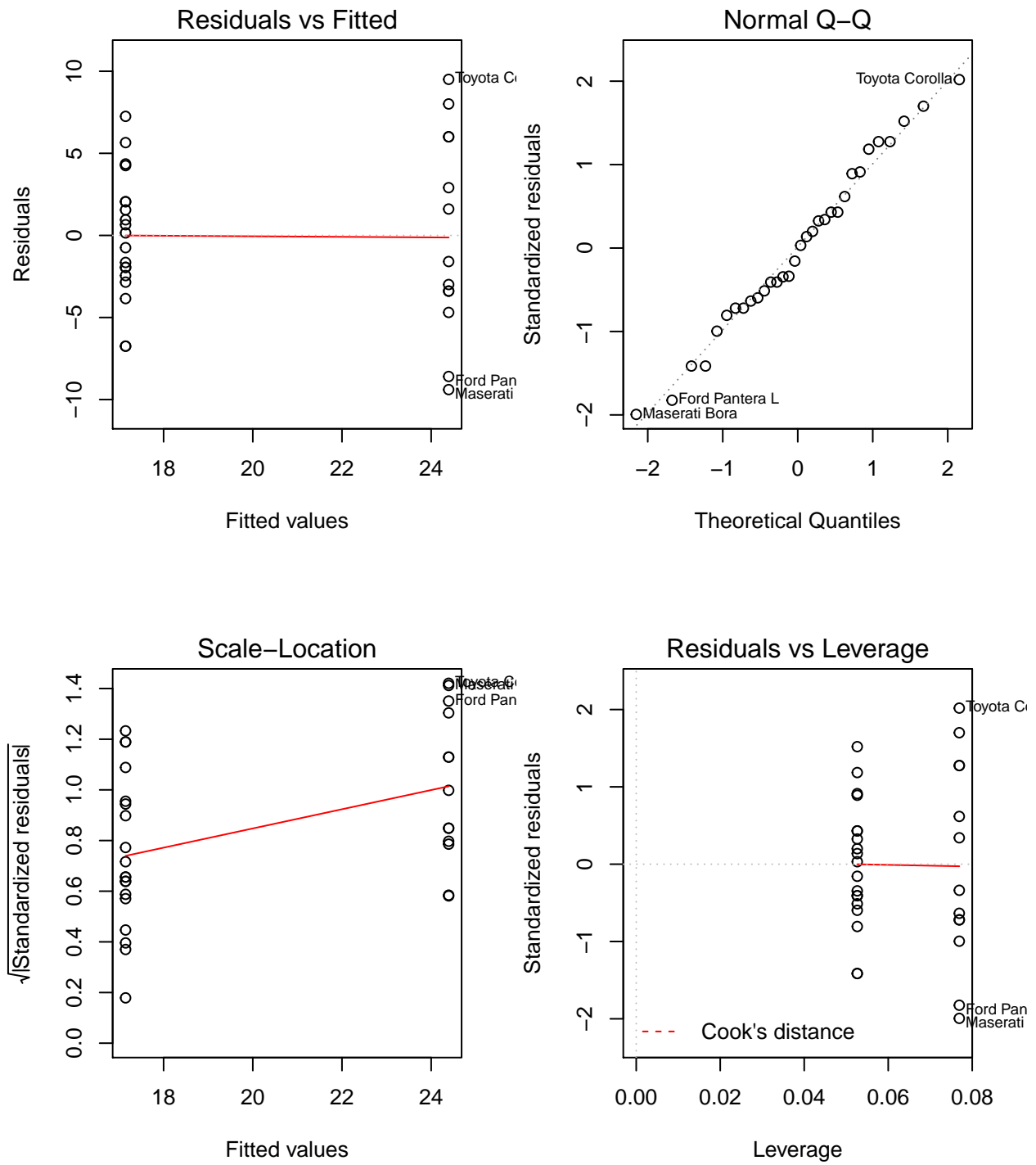


Figure 2: Details of model “fit”