Motor Trend

the magazine about the automobile industry

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Miles per gallon: automatic vs manual transmission.

Executive Summary

Questions

What type of transmission, automatic or manual, is better for Miles per Gallon (MPG)?

And quantify those differences.

Complications

Besides transmission type there are attributes like number of cylinders, horsepower, weight etc that can/will have an impact on the MPG. The significant ones will be taken into account.

Conclusion

Automatic transmission has a lower MPG than manual transmission. As a high MPG is prefered, one should choose manual transmission to get more miles per gallon.

Data exploration

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 aspects 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 (1000 lbs)
- [, 7] qsec 1/4 mile time
- [, 8] vs V/S (v-engine or straight engine, https://en.wikipedia.org/wiki/V_engine)
- [, 9] am Transmission (0 = automatic, 1 = manual)
- [,10] gear Number of forward gears
- [,11] carb Number of carburetors

A first impression of the relationship between the aspects can be seen in appendix 1 (pair plot and boxplot), the code is below.

```
pairs(mtcars)
```

```
g <- ggplot(mtcars, aes(factor(am), mpg)) + geom_boxplot() +
       xlab("transmission: 0 = automatic, 1 = manual") + ylab("miles per gallon")
g
```

Prelimenary conclusion of the mpg - am relation is that MPG seems higher for am = 1 (manual)

A basic t-test confirms this (hypothesis: mpg is equal for both transmissions).

```
##
##  Welch Two Sample t-test
##
## data:  subset(mtcars$mpg, mtcars$am == 0) and subset(mtcars$mpg, mtcars$am == 1)
## 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
```

Just checking that a linear model fit gives the same output:

```
summary(lm(mpg ~ am, mtcars))$coef
```

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

Yes it does, intercept is equal to mean of "auto", intercept + am is equal to mean of "man".

Some more analysis

Let's try ot find some aspects that might influence this apparent relationship between MPG en transmission type.

In appendix 2 some graphs have been assembled in which a third aspect is thrown in the mix.

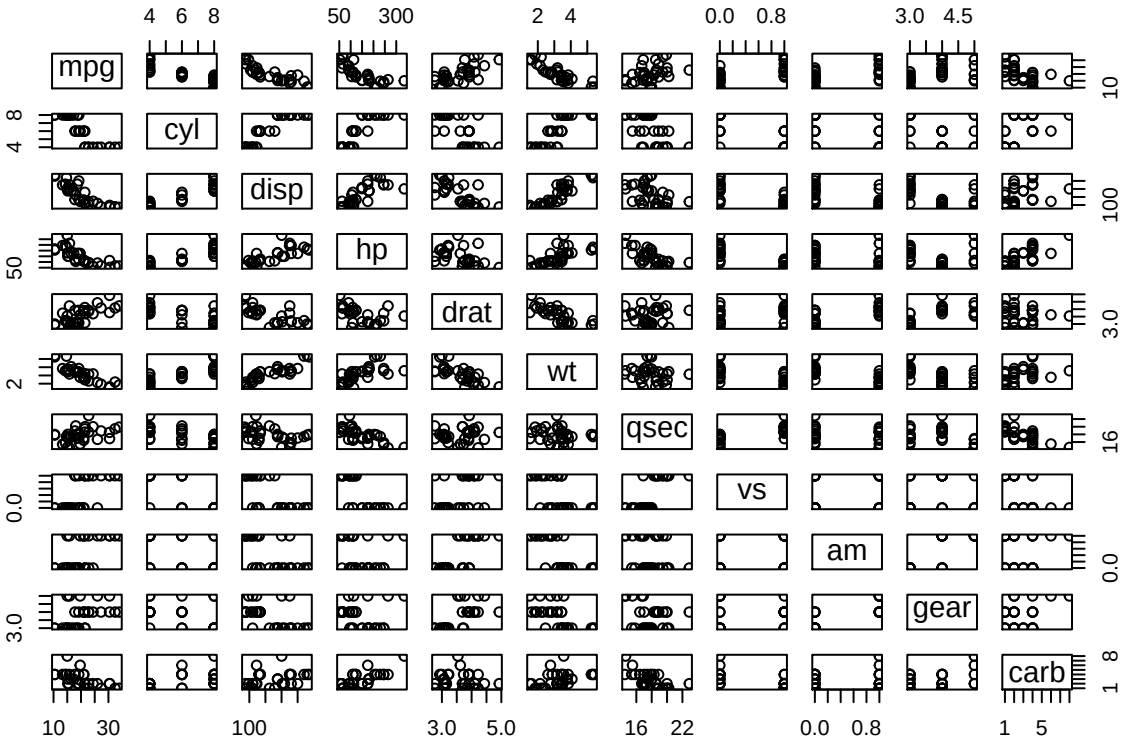
It turns out that for a car that has 8 cylinders there is no difference in MPG between automatic and manual transmission. For 6 cylinders there is a difference, but a t-test on that difference shows that it's not possible to reject the null-hypothesis that they're equal.

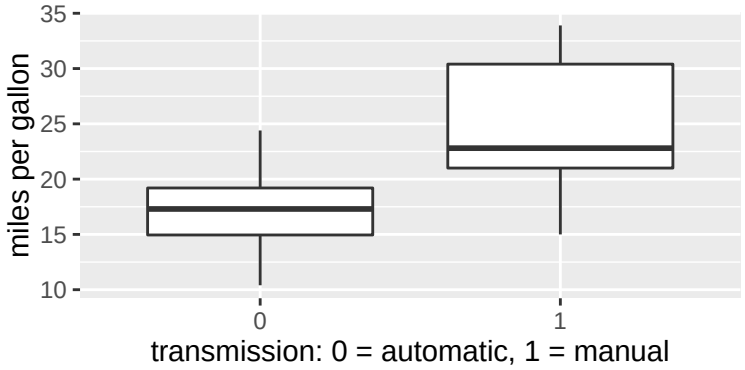
Final analysis

In appendix 3 the plots associated with a logistic regression model, that confirm the conclusion that manual transmission has higher MPG than automatic transmission.

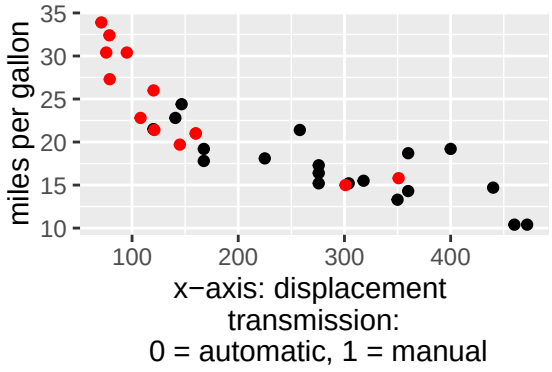
```
fit <- glm(am ~ mpg, data=mtcars, family = "binomial")
par(mfrow = c(2,2))
plot(fit)
par(mfrow = c(1,1))
```

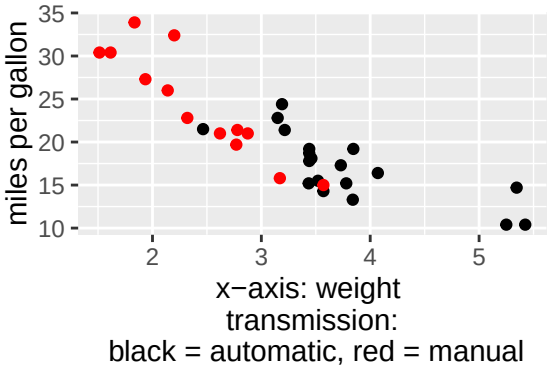
Appendix 1 - Pair and box plot

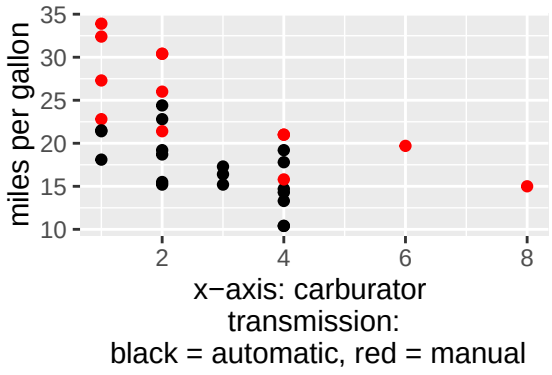


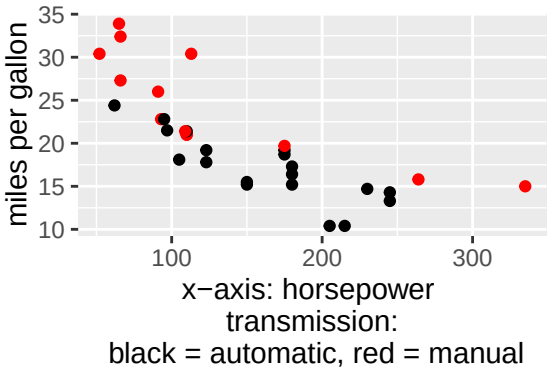


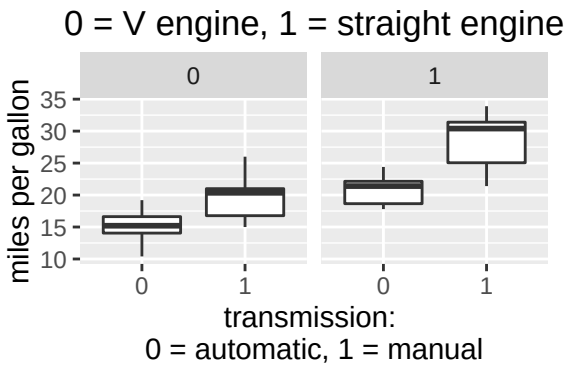
Appendix 2 - other variables in the mix

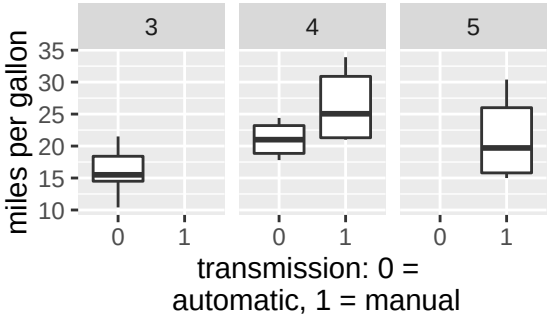


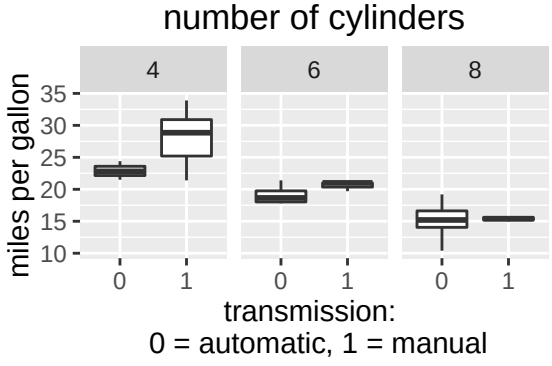












Appendix 3: Model Plots