Report on Fuel Consumption of automobiles

May 22, 2015

Introduction

We investigate data that extracted from the 1974 *Motor Trend* US magazine. They comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (1973-74 models). We are particularly interested in the following questions:

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

The boxplot on Figure 1 suggests that manual transmission is better for mpg. However, Figure 2 shows that actually weight or number of gears can be a most important factor. Let's see.

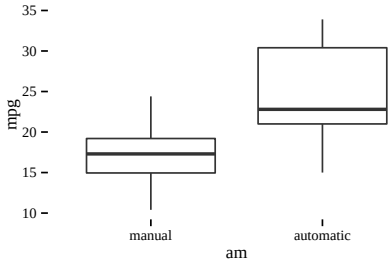


Figure 1: Automatic vs. manual transmission.

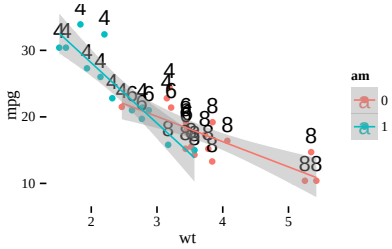


Figure 2: Impact of weight, transmission and number of cylinders on fuel consumption.

Model Selection

Let us try to identify the subset of the predictors that can be related to the mpg response. For that we use `regsubsets` function from `leaps` library which select the best model with n predictors, for $n = 1 \ldots 8$. This way we can choose from quite large amount of models. Additionally in Appendix we show plots of few models with different sets of predictors.

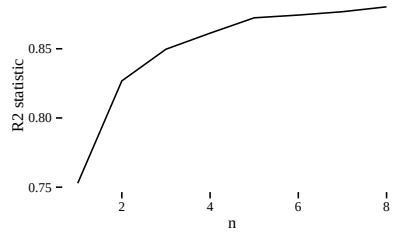


Figure 3: R^2 statistic for the best model with $n = 1, \ldots, 8$.

	cyl6	cyl8	disp	hp	drat	wt	qsec	vs1	am1	gear4	gear5	carb2	carb3	carb4	carb6	carb8
1 (1)						*										
2 (1)				*		*										
3 (1)						*	*		*							
4 (1)	*			*		*			*							
5 (1)	*			*		*		*	*							
6 (1)	*			*		*		*	*		*					
7 (1)		*		*		*	*	*	*		*					
8 (1)	*		*	*		*				*	*	*				*

If we take a look at Figure 3 where we plot R^2 statistic for the best model with $n = 1, ..., 8$ predictors, we see that $n = 5$ would be the best choice. Therefore our regression model is the following has predictors horsepower (hp), weight (wt), manual transmission (am=1), six cylindes (cyl=6) and V/S (vs=1).

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	31.2824	3.1902	9.8058	0.0000
hp	-0.0339	0.0104	-3.2504	0.0032
wt	-2.3678	0.8686	-2.7262	0.0113
am1	2.6211	1.3000	2.0163	0.0542
I(cyl == 6)TRUE	-2.2052	1.0321	-2.1365	0.0422
I(vs == 1)TRUE	1.8774	1.2481	1.5042	0.1446

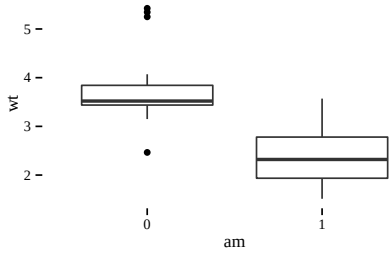


Figure 4: Boxplots of weight

Conclusion

Is an automatic or manual transmission better for MPG?

In my opinion the results are not conclusive. This regression model suggest that actually the most significant is characteristics are horsepower and weight. One can clearly see that the more heavy cars have automatic transmission (Figure 4). This could be an effect of that economic car (in the sense of price) are smaller and tends to have manual transmission while luxury cars are bigger and its transmission is automatic.

The MPG difference between automatic and manual transmissions

The difference is clearly visible on Figure 1. Let us do however *t-test* to test if the difference in mean is significant.

```
##
##  Welch Two Sample t-test
##
## data:  mtcars[mtcars$am == 0, 1] and mtcars[mtcars$am == 1, 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
```

Hence the difference in mean is significant, however *correlation does not imply causation*, and as we have mentioned above it is likely to be caused by other factors like weight and horsepower. For example, on Figure 5 we presented how mpg depends on weight and on Figure 6 the residual plot for the linear regression. And on the next figures we did the same for horsepower. These relations definitely make sense.

The code of this file is available on my github:
`https://github.com/sbartek/mpg_report`

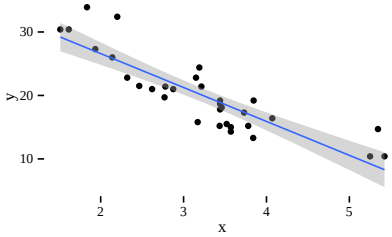


Figure 5: Relation beteewn mpg and weight

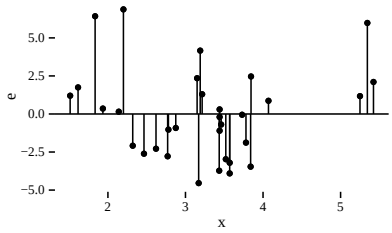


Figure 6: Residual plot for regresion beteewn mpg and weight

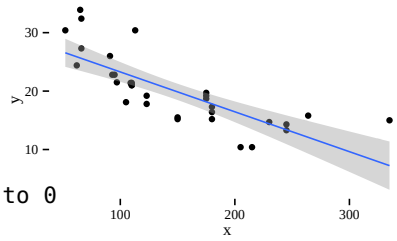


Figure 7: Relation beteewn mpg and horsepower

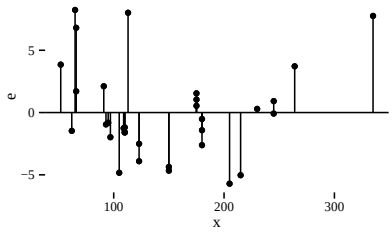


Figure 8: Residual plot for regresion beteewn mpg and horsepower

Appendix

```
pairs(mtcars.dt[, .(mpg, cyl, disp, hp, drat,
    wt, qsec, vs, am, gear, carb)], panel = panel.smooth)
```

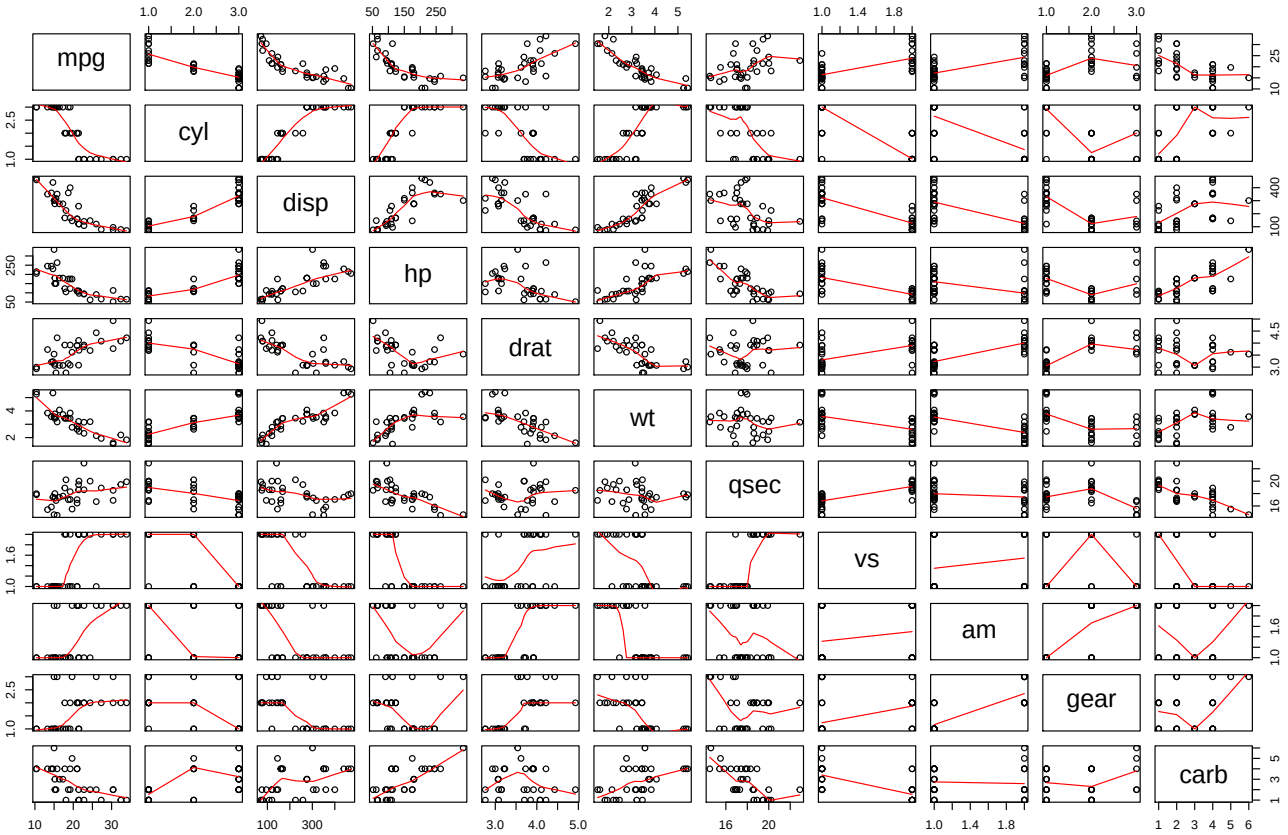
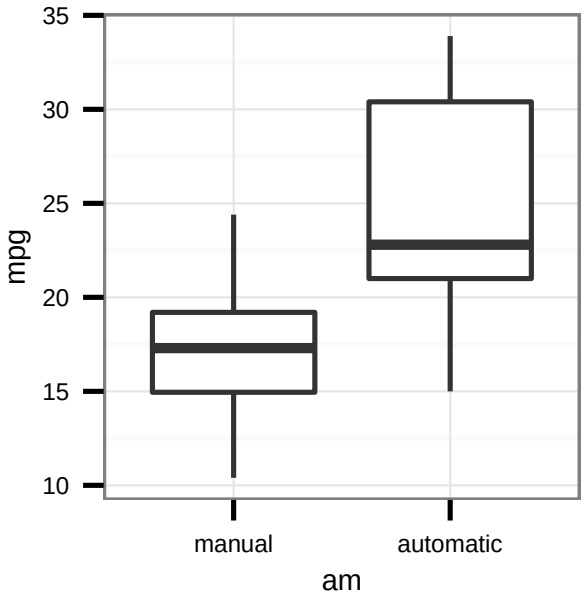


Figure 9: Pairs figure.

```
p1 <- ggplot(mtcars.dt, aes(am, mpg)) + geom_boxplot() +
    theme.bartek + scale_x_discrete(labels = c("manual",
    "automatic"))
p2 <- ggplot(mtcars.dt, aes(wt, mpg, colour = am)) +
    geom_point() + theme.bartek + theme(legend.position = "none") +
    geom_text(aes(label = cyl, colour = NULL),
        vjust = -0.6, size = 2) + geom_smooth(method = "lm")
grid.arrange(p1, p2, ncol = 2)
```

```
ggplot(mtcars.dt, aes(hp, mpg, colour = am)) +
    geom_point() + geom_text(aes(label = cyl,
    colour = NULL), vjust = -0.6) + theme.bartek +
    geom_smooth(method = "lm")
```



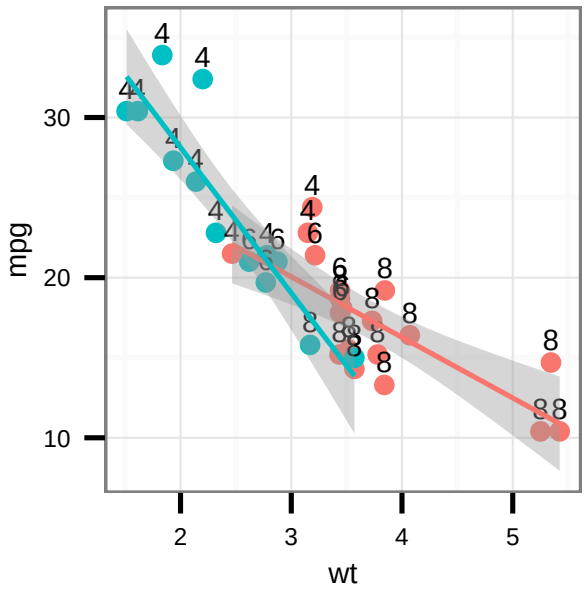


Figure 10: Fuel consumption. Automatic vs. manual transmission and impact of weight, transmission and number of cylinders.

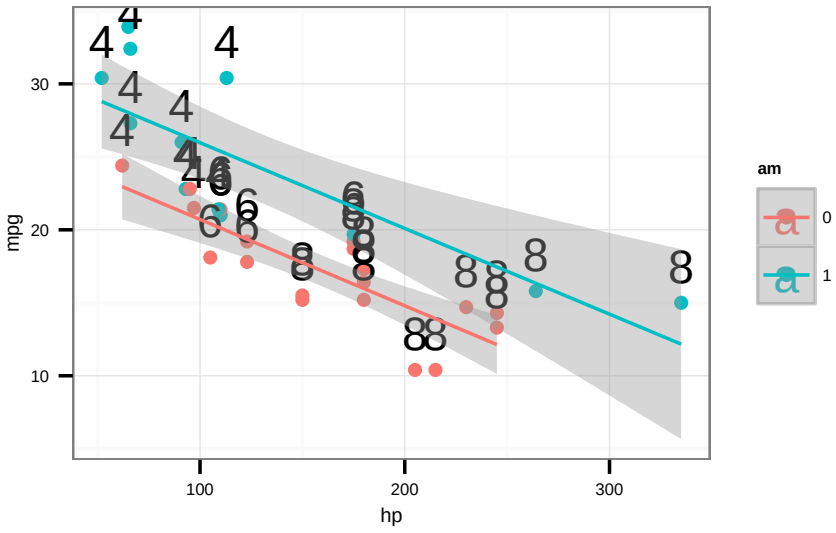


Figure 11: Horsepower vs. mpg

```
ggplot(mtcars.dt, aes(disp, mpg, colour = am)) +
    geom_point() + theme.bartek + geom_smooth(method = "lm")
```

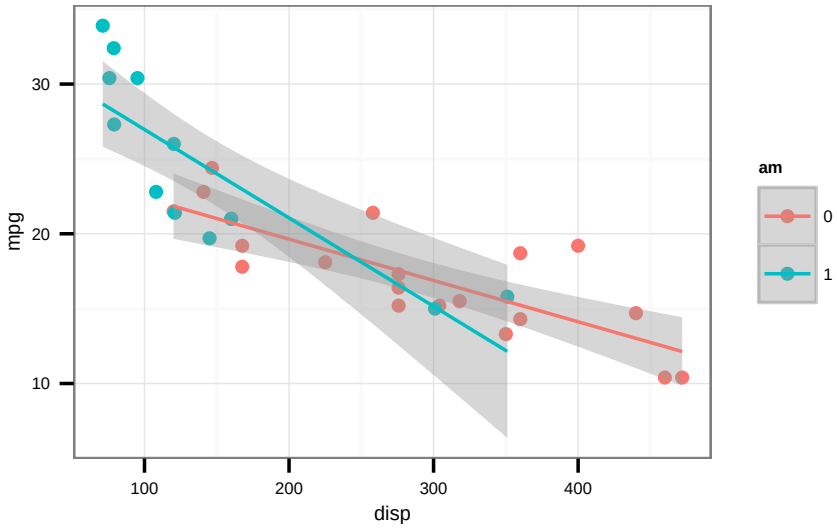


Figure 12: Displacement vs. mpg