

# Automatic/ manual transmission and MPG

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## 1 Summary

In this document We'll investigating the relation between fuel consumption(mpg) and tranmission (automatic or manual).

The result show that we can conclude between automatic and manual which one is better because weight plays an importance role. The difference of MPG between automatic and manual transmission is not constant and depends on weight.

## 2 Exploratory analysis

### 2.1 The Data

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).

```
head(mtcars,2)
```

```
##           mpg cyl  disp  hp  drat   wt  qsec vs am gear carb
## Mazda RX4      21   6  160 110   3.9 2.620 16.46  0  1    4    4
## Mazda RX4 Wag  21   6  160 110   3.9 2.875 17.02  0  1    4    4
```

*mpg* (Miles/(US) gallon) is our output variable. The *am*(transmission 0=automatic, 1= manual) is our predictor. We'll investigating the relation of *mpg* and *am*. The *Mpg* is a continous variable and *am* is a dummy variable which takes 0 for automatic and 1 for manual.

We will check if we should include other variables in the database into our model. We do not want inflate our model nor exclude useful variable. Among theses variables, *cyl*, *vs*, *gear*, *carb* are dummies variables, and *disp*, *hp*, *drat*, *wt*, *qsec* are continous variable.

The dummies variables will be change to factor when fitting the model

### 2.2 Am and mpg

We can observe that there are group effect on mpg. We can suppose that the manual transmission (*am*=1) increasing fuel consumption. *see plot1*

### 2.3 am and other independent variables:

I made point plots for other variable and color it by *am*. I want to check the relation between automatic/ ùannual transmission with other variables. Nevertheless, I just show useful plots.*See plot2*

We can observe that the values of *wt*, *disp*, *drat* are related to *am*. When fitting the model, it suggest that we should create a variable of interaction between *am* and these variables.

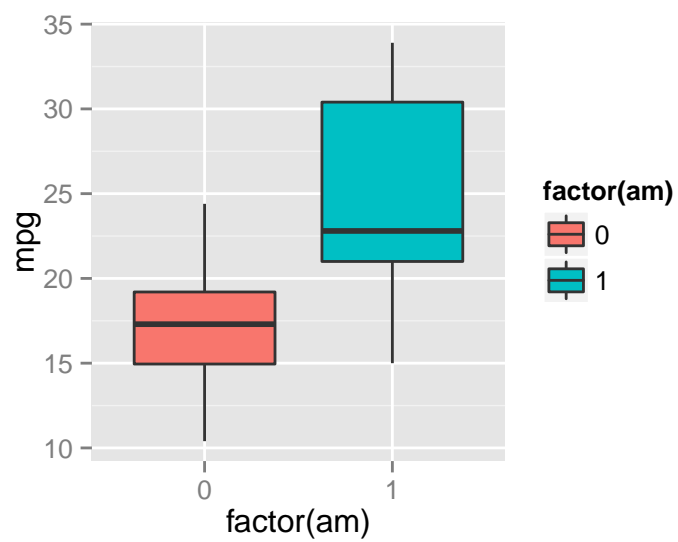


Figure 1: plot1: mpg vs am

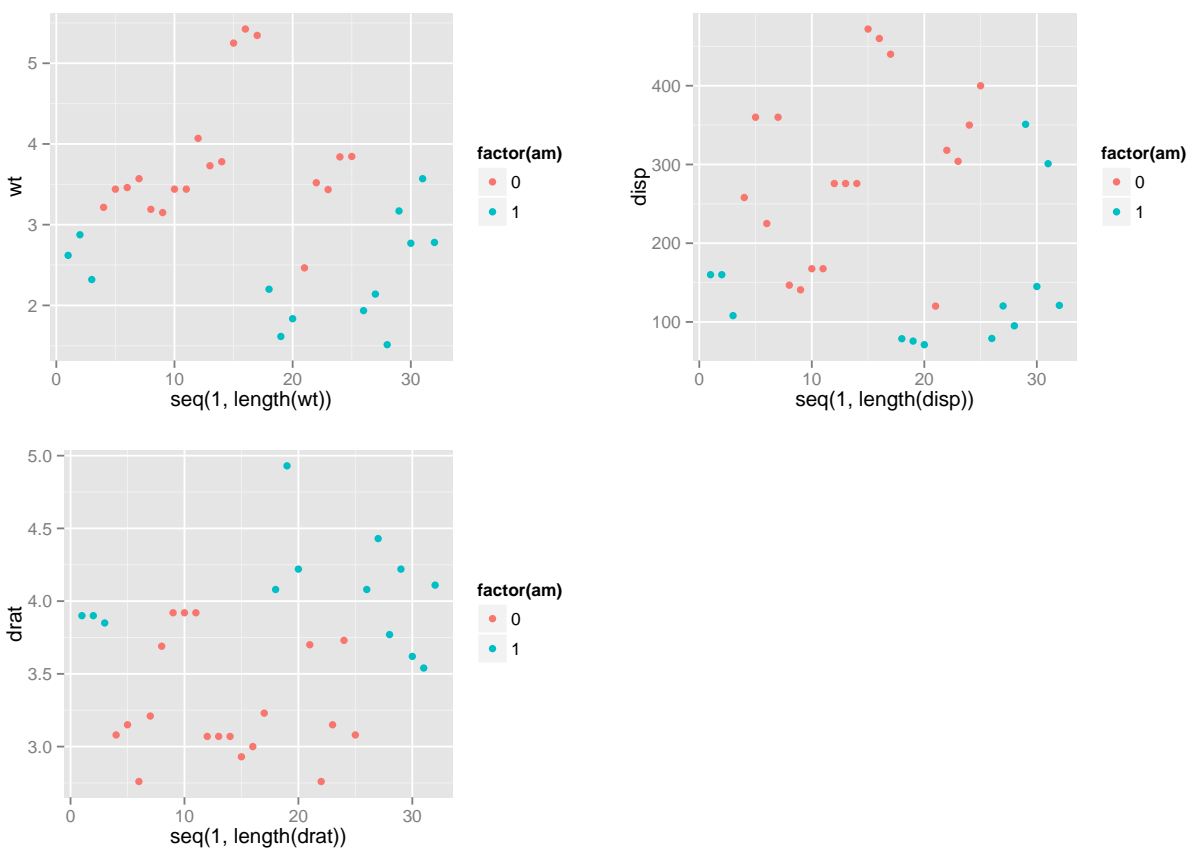


Figure 2: Plot2: am versus wt, disp, drat

### 3 Choosing the right model

```
##           Estimate Std. Error  t value    Pr(>|t|)
## (Intercept) 17.147368   1.124603 15.247492 1.133983e-15
## factor(am)1  7.244939   1.764422  4.106127 2.850207e-04
```

We will adding variable into our model one by one and use `{r anova}` to check if it worths to adding this variable. The order is defined by the absolute value of the correlation of mpg with the variable. I'll put the variable with strongest value first.

```
sort(abs(cor(mtcars)[,1]), decreasing=TRUE)
```

```
##      mpg      wt      cyl      disp      hp      drat      vs
## 1.0000000 0.8676594 0.8521620 0.8475514 0.7761684 0.6811719 0.6640389
##      am      carb      gear      qsec
## 0.5998324 0.5509251 0.4802848 0.4186840
```

The criteria of choosing the model passing the `{r anova}` test (p value <5%). Then I also look at the adjusted  $R^2$  value. I'll show just the useful models that passed the `{r anova}` test.

the p\_value of these model are inferior than 5% thus passed the `{r anova}` test. There are three models that passed the tests. Looking at their adjusted  $R^2$ , the int9 model has highest value.

```
anova(fit, int1, int2, int9)
```

```
## Analysis of Variance Table
##
## Model 1: mpg ~ factor(am)
## Model 2: mpg ~ factor(am) + wt + wt * factor(am)
## Model 3: mpg ~ factor(am) + wt + wt * factor(am) + factor(cyl)
## Model 4: mpg ~ factor(am) + wt + wt * factor(am) + factor(cyl) + qsec
##   Res.Df    RSS Df Sum of Sq    F    Pr(>F)
## 1      30 720.90
## 2      28 188.01  2    532.89 57.1536 4.727e-10 ***
## 3      26 137.99  2     50.02  5.3643  0.01152 *
## 4      25 116.55  1     21.44  4.5999  0.04188 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
rbind(summary(fit)$adj.r.squared, summary(int1)$adj.r.squared, summary(int2)$adj.r.squared, summary(int9)$adj.r.squared)
```

```
##           [,1]
## [1,] 0.3384589
## [2,] 0.8151486
## [3,] 0.8538884
## [4,] 0.8716582
```

I choose int9 to interpret the effect of am on mpg. We can notice than the p\_value of am and the interaction term am\*wt are lower than 5% thus their coefficients are different from 0

	Estimate	Std. Error	t value	Pr(> t )
## (Intercept)	10.7883482	9.2441804	1.1670422	0.254204858
## factor(am)1	13.5062777	3.9362244	3.4312773	0.002096746
## wt	-2.9148171	0.8267962	-3.5254360	0.001656303
## factor(cyl)6	-0.5447303	1.6239960	-0.3354259	0.740102358
## factor(cyl)8	-0.3643287	2.5214242	-0.1444932	0.886269543
## qsec	0.9728476	0.4535978	2.1447362	0.041881821
## factor(am)1:wt	-3.9741065	1.3104167	-3.0327044	0.005581111

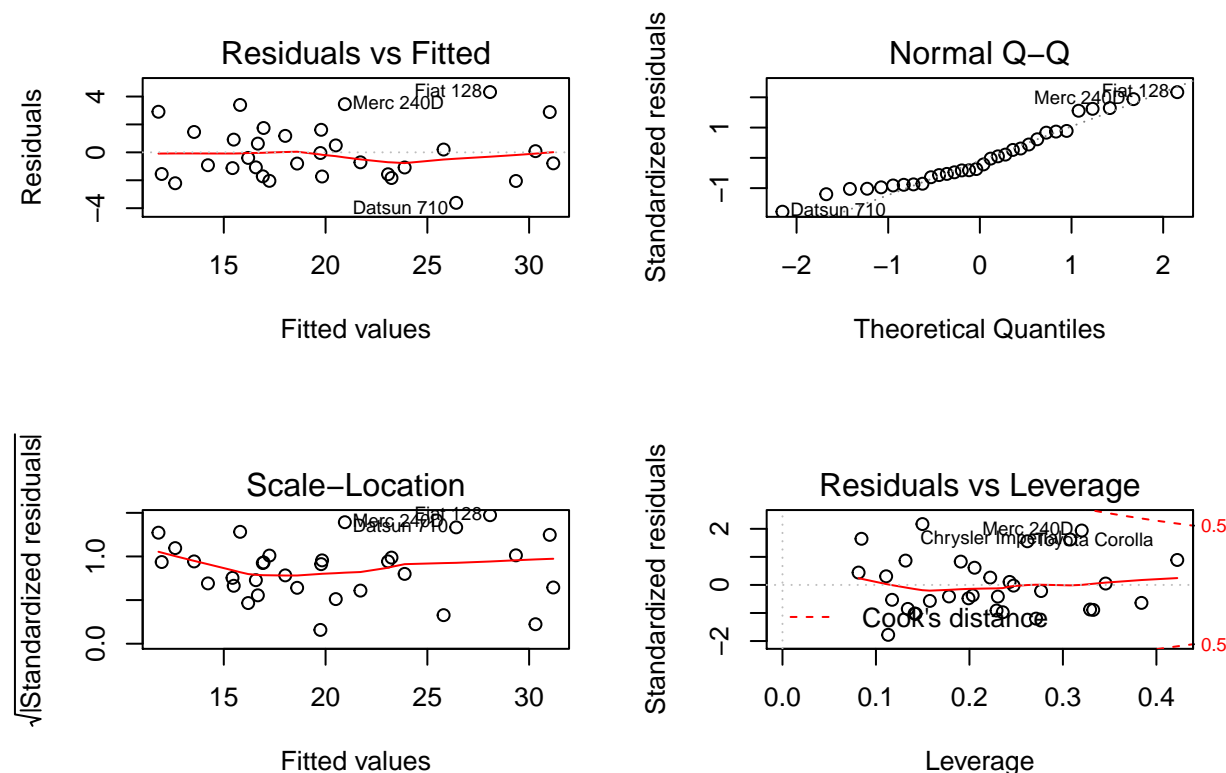


Figure 3:

The residual vs fitted plot suggests homoscedasticity QQ plot investigates the normality of the error The residual vs leverage suggests that some points (Merc 240D, Toyota Corolla) have high leverage and high standardized residuals. #Interpreting the effect

### 3.1 The effect of am on mpg

Our model:  $mpg_i = \beta_0 + \beta_1 * am_{i1} + \beta_2 * cyl_{i2} + \beta_3 * cyl_{i3} + \beta_4 * qsec_{i4} + \beta_5 * wt * am_{i5} + \beta_6 * wt_{i6} + \epsilon_i$

$am_{i1}$  is 1 for manual and 0 automatic transmission.  $wt * am_{i5}$  is the interaction term between weight and transmission  $\beta_1$ : when all else are constant, in comparison with am transmission, the manual transmission's effect on mpg is higher than the am's effect by  $\beta_1 = 13.506$  miles/(US) gallon.  $\beta_5$ : with an increase by 1 unit of weight, the effect of manual transmission on mpg in comparison with the am transmission is reduced by  $\beta_5 = -3.974$ .

So the manual transmission did increase the mpg but its effect reduces when weight increases. “Is an automatic or manual transmission better for MPG?” The answer is its depend on weight. For light weight, the automatic is better but for higher weight, the manual is better.

### 3.2 Quantify the MPG difference between automatic and manual transmissions?

The difference of the expected of value of mpg between automatic and manual transmission holding all other variables constant is:  $E[mpg_i | am_i = 1, all - else - constant] - E[mpg_i | am_i = 0, all - else - constant] = \beta_1 + \beta_5 * wt_i$  This difference depends on weight and not constant.

## 4 Conclusion

We can not say the automatic or manual is better because its effect depends on weight. The difference of mpg is not constant and also depends on weight. In this regression, we can not conlude any causal relation between transmission and mpg. Perhaps, it is weight that determine the kind of transmission and weight has most important influence on mpg.