# Effect of Transmissions Mode to Fuel MPG

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## Executive Summary

This analysis aims to answer two questions in particular:

1. Is an automatic or manual transmission better for MPG?
2. What is the MPG difference (if any) between manual and automatic transmission?

The analysis starts with some exploratory data analysis, followed by model selection and interpretations. Finally it attempts to try to answer the posed questions above.

## Exploratory Data Analysis

The dataset contains 32 observations of 11 variables. Variables like vs, am, and cyl are distinct values, so we can convert them to factors so ggplot can handle them better. There seems to be a distinct difference in mpg distributions between automatic and manual transmissions as shown in Figure 1 (Appendix).

The table below shows the correlations of each variable in mtcars dataset.

```
##             mpg        cyl       disp         hp        drat         wt
## mpg   1.0000000 -0.8521620 -0.8475514 -0.7761684  0.68117191 -0.8676594
## cyl  -0.8521620  1.0000000  0.9020329  0.8324475 -0.69993811  0.7824958
## disp -0.8475514  0.9020329  1.0000000  0.7909486 -0.71021393  0.8879799
## hp   -0.7761684  0.8324475  0.7909486  1.0000000 -0.44875912  0.6587479
## drat  0.6811719 -0.6999381 -0.7102139 -0.4487591  1.00000000 -0.7124406
## wt   -0.8676594  0.7824958  0.8879799  0.6587479 -0.71244065  1.0000000
## qsec  0.4186840 -0.5912421 -0.4336979 -0.7082234  0.09120476 -0.1747159
## vs    0.6640389 -0.8108118 -0.7104159 -0.7230967  0.44027846 -0.5549157
## am    0.5998324 -0.5226070 -0.5912270 -0.2432043  0.71271113 -0.6924953
## gear  0.4802848 -0.4926866 -0.5555692 -0.1257043  0.69961013 -0.5832870
## carb -0.5509251  0.5269883  0.3949769  0.7498125 -0.09078980  0.4276059
##             qsec         vs          am       gear        carb
## mpg   0.41868403  0.6640389  0.59983243  0.4802848 -0.55092507
## cyl  -0.59124207 -0.8108118 -0.52260705 -0.4926866  0.52698829
## disp -0.43369788 -0.7104159 -0.59122704 -0.5555692  0.39497686
## hp   -0.70822339 -0.7230967 -0.24320426 -0.1257043  0.74981247
## drat  0.09120476  0.4402785  0.71271113  0.6996101 -0.09078980
## wt   -0.17471588 -0.5549157 -0.69249526 -0.5832870  0.42760594
## qsec  1.00000000  0.7445354 -0.22986086 -0.2126822 -0.65624923
## vs    0.74453544  1.0000000  0.16834512  0.2060233 -0.56960714
## am   -0.22986086  0.1683451  1.00000000  0.7940588  0.05753435
## gear -0.21268223  0.2060233  0.79405876  1.0000000  0.27407284
## carb -0.65624923 -0.5696071  0.05753435  0.2740728  1.00000000
```

## Model Selection and Interpretations

We will consider our model by starting with a variable (our variable of interest, "am"), and we will add variables having |correlation with mpg| greater than 0.8 using nested model technique. After variables are added, we run ANOVA function to test if the variable should be added.

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ am + wt
## Model 3: mpg ~ am + wt + cyl
## Model 4: mpg ~ am + wt + cyl + disp
##   Res.Df    RSS Df Sum of Sq       F    Pr(>F)
## 1     30 720.90
## 2     29 278.32  1    442.58 62.9247 2.073e-08 ***
## 3     27 182.97  2     95.35  6.7784  0.004273 **
## 4     26 182.87  1      0.10  0.0141  0.906470
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

- [fit2] First variable to be added is weight (wt), with correlation value to MPG -0.8676594. Which should make sense. As a car gets heavier, it should take more fuel to travel the same distance, thus it should mean worse MPG.
- [fit3] Next to be added is number of cylinders (corr value to MPG of -0.8521620), which impacts how fast power can be generated in a car, so it should have an effect to MPG.
- [fit4] Next is displacement (corr value to MPG of -0.8475514). Displacement is also related to the car's power output.

From the Anova table, we should not add displacement as the p-value is above 5%. So we will use Model 3 in the anova table, which is based on am, wt, and cyl. The coefficients of the selected model is as follows:

```
##               Estimate Std. Error    t value     Pr(>|t|)
## (Intercept) 33.7535920  2.8134831 11.9970836 2.495549e-12
## amManual     0.1501031  1.3002231  0.1154441 9.089474e-01
## wt          -3.1495978  0.9080495 -3.4685309 1.770987e-03
## cyl6        -4.2573185  1.4112394 -3.0167231 5.514697e-03
## cyl8        -6.0791189  1.6837131 -3.6105432 1.227964e-03
```

The base of reference for this model is am = "Automatic", which is a factor, so the intercept is the predicted MPG for automatic transmission, while other variables are not present (zero for continuous variable, or in case of factor, the reference, which is 4 cylinders for cylinder variable). The coefficients for wt represents the change in MPG for each unit of change in wt, while holding other variables constants. The coefficients for amManual represents the change in MPG if the mode of transmission change to Manual from Automatic, while holding other variables constant.

Figure 3 (Appendix) shows the residuals of the data for the 32 observations in the data set. There does not seem to be any clear pattern to suggest abnormality (e.g. heteroskesdacity).

Figure 4 (Appendix) shows QQ Plot of the residuals. It does not seem to have obvious abnormality.

## Conclusion

The coefficients for amManual, which represent the change in MPG by changing mode of transmission from automatic to manual, is positive 0.1501031. That means manual transmission seems to result in more MPG (which means more efficient cars).

However while the model used looks like a good fit, the p-value of the coefficient of is 9.089474e-01, which is outside typical 5% threshold we set for p-values. That means we are unable to reject the null hypothesis. So while the coefficient is non-zero, it is unlikely that the mode of transmission has an impact on the MPG. Thus this analysis is unable to answer the questions posed in the executive summary based on the data provided and model selected.

# Appendix

Figure 1. Comparison of Mode of Transmission Effect on MPG
(Red Point Represents the Mean)

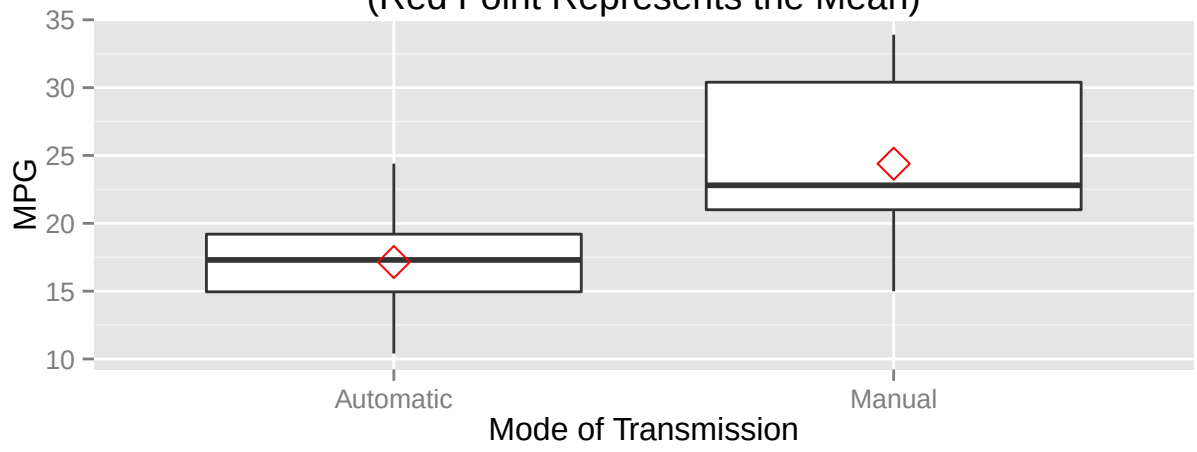
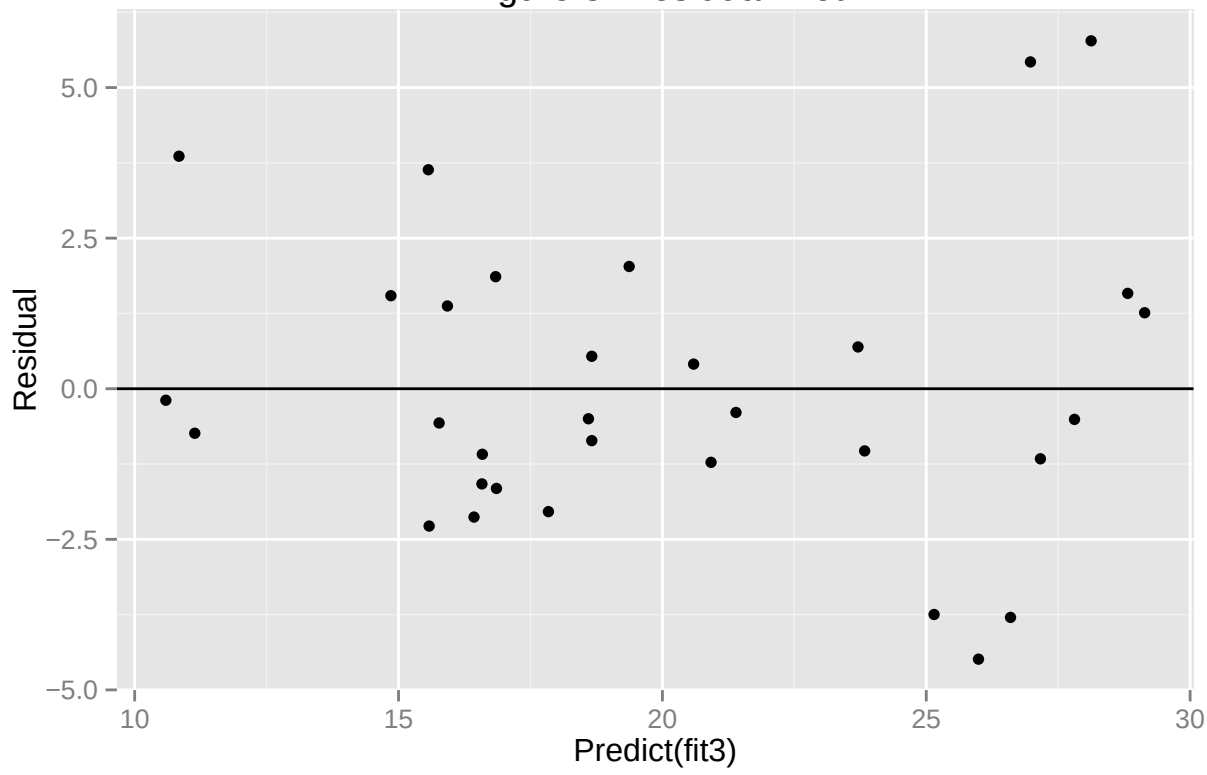



Figure 3. Residual Plot




```
## Warning in rlm.default(x, y, weights, method = method, wt.method =
## wt.method, : 'rlm' failed to converge in 20 steps
```

**Figure 4. QQ Plot**