Automatic vs Manual: Influence in Fuel Autonomy

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Executive Summary

This report explores the relationship and differences of fuel efficiency for cars with automatic and manual transmission. A data set with 10 specifications for 32 different cars has been used for this analysis. To explain the difference in mileage between automatic and manual transmission this document also takes into account a few more car properties. A predictive model is formulated from the existing information to explain overall vehicles' fuel autonomy.

Data Analysis

The data set contains information about 32 different cars. This is a sample of 5 cars out of the data set:

```
##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
```

To get an initial sense of the relationship between transmission type and fuel consumption, in **Figure 1** it is shown that cars with manual transmission tend to have better performance, with an average consumption of **24.3923077** MPG for manual transmission cars and **17.1473684** MPG for cars running on automatic transmission. Although the figure shows a tendency of better fuel autonomy on models with manual transmission, we can also find some cars with manual transmission which perform worse than the average consumption for automatic cars. This criterion applies the other way around as well, meaning, we can find some models with automatic transmission with a better MPG rate than the average for manual ones. Given this information, we can not conclude that manual transmission will always guarantee better performance in terms of fuel consumption. We'll perform a more detailed analysis including other indicators to explore this relationship more in depth.

Model

By doing an analysis of relationships between the features in the data set (see **Figure 3** in the Appendix), we can determine that Number of Cylinders (cyl), Displacement (disp), Horsepower (hp) and Weight (wt) are the factors most related to the MPG measurement. Since cyl, disp and hp are heavily correlated to each other as well, we will leave cyl and disp out when creating the linear model. Fitting the linear model with the aforementioned regressors we get the following outcome:

```r
trlm <- lm(mpg~wt+hp,mtcars)
trlm2 <- update(trlm,mpg~wt+hp+am,mtcars)
summary(trlm2)$coefficients
```

```
##                Estimate  Std. Error   t value     Pr(>|t|)
## (Intercept) 34.00287512 2.642659337 12.866916 2.824030e-13
## wt          -2.87857541 0.904970538 -3.180850 3.574031e-03
## hp          -0.03747873 0.009605422 -3.901830 5.464023e-04
## am1          2.08371013 1.376420152  1.513862 1.412682e-01
```

The linear model summary shows an average difference of **2 MPG** between automatic and manual transmission vehicles, but we can also see a high p-value (0.14) for the transmission type property, which means transmission type is not significant for predicting MPG for a car. Furthermore, we can also see the same by doing an analysis of variance between a linear model without a transmission specification and a model with it included.

```
anova(trlm,trlm2)
```

```
## Analysis of Variance Table
##
## Model 1: mpg ~ wt + hp
## Model 2: mpg ~ wt + hp + am
##   Res.Df    RSS Df Sum of Sq      F Pr(>F)
## 1     29 195.05
## 2     28 180.29  1    14.757 2.2918 0.1413
```

The high p-value for the F-Statistic shows that including am is not important for the prediction model.

We can also see in **Figure 2**. the importance of weight and power and their relationship with the transmission type and mpg.

```
coefs <- summary(trlm)$coefficients
cii <- coefs[1,1] + c(-1,1) * qt(.975,df=trlm$df) * coefs[1,2]
ciwt <- coefs[2,1] + c(-1,1) * qt(.975,df=trlm$df) * coefs[2,2]
cihp <- (coefs[3,1] + c(-1,1) * qt(.975,df=trlm$df) * coefs[3,2]) * 100
```

After calculating the confidence intervals for the regressor variables, we can say with 95% confidence that fuel autonomy will drop between **2.6** and **5.2** MPG for each extra lb the car gets, and it will also decrease between **1.3** and **5** MPG every 100 hp increase in gross power.

To finish with the formulation of the linear model, an analysis of residuals is performed and displayed on **Figure 4**. We can see on the residuals and standardized residuals plots that there's no particular pattern on the distribution suggesting heteroskedasticity or any abnormal behavior. The Normal Q-Q plot also suggests normality of the error terms.

Conclusions

Even though there is a clear trend which shows that cars using automatic transmission have lower efficiency in fuel consumption, it cannot be stated that it's solely and directly related to transmission type. The variation in MPG can be better explained in relation to vehicles' weight and power.

Appendix

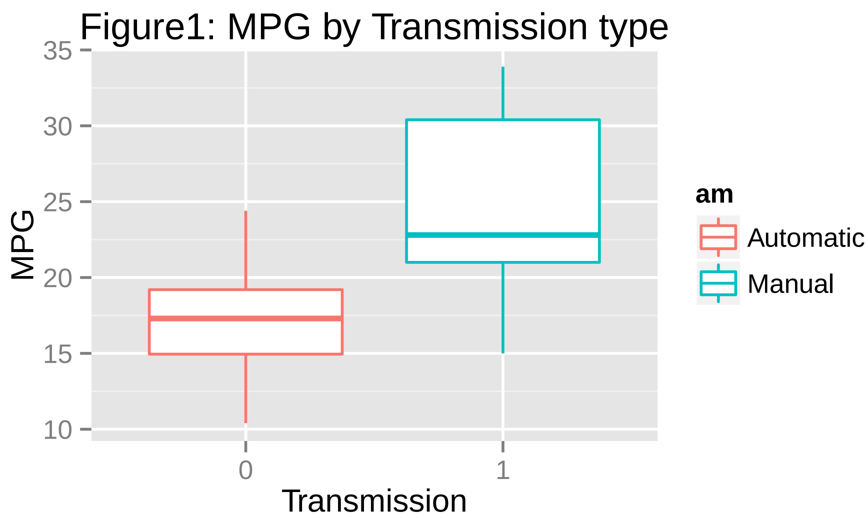

Figure 1. Distribution of mileage by transmission type

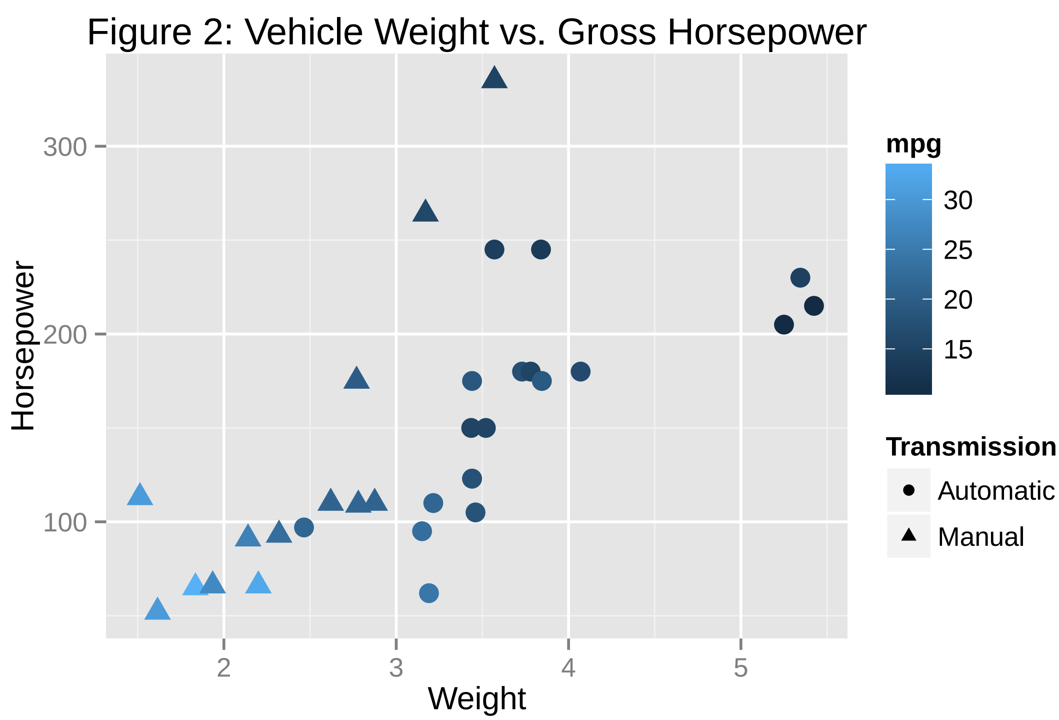

Figure 2. Vehicle Weight vs. Gross Horsepower and relation with Transmission type and MPG

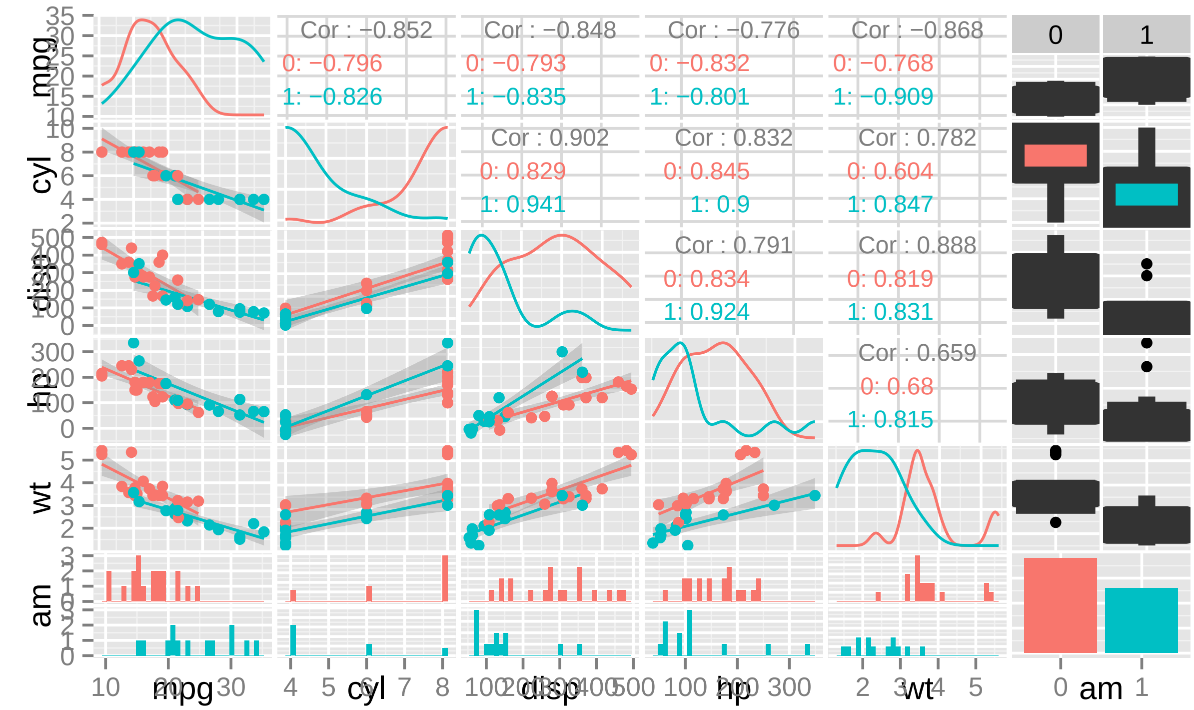

Figure 3. Relationships between data set features

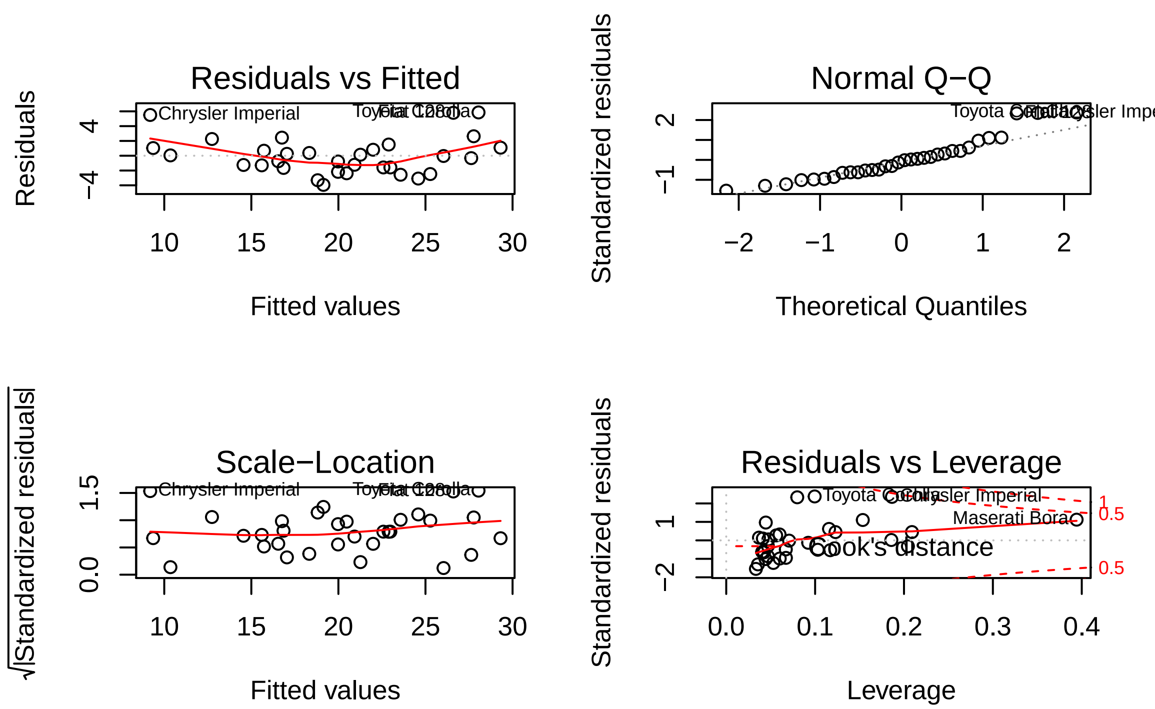

Figure 4. Analysis of residuals