Regression Models - Transmission and MPG

Ryan Wissman

Saturday, March 21, 2015

Executive Summary

Fuel efficiency and transmission type are both very important and greatly debated factors when selecting a new car. This report examines the relationship between transmission type and fuel economy to determine if there is any MPG benefit to purchasing a car of either type transmission. The data used in this report is from the 1974 Motor Trend US magazine.

Key Findings:

- According to the following analysis a manual transmission does show slightly better fuel economy than an automatic transmission.
- The difference in fuel economy is 1.8 MPG, favoring manual transmission.
- Additional considerations for fuel economy are: number of cylinders, car weight, and horsepower.

Exploring the Data

First the mtcars data is loaded, variables set as factors (cylinders, v/s (v or straight engine), transmission, number of gears, number of carburetors), and some brief exploratory statistics are discovered.

```r
data(mtcars); attach(mtcars)

#set relevant variables to factors
mtcars$cyl <- factor(mtcars$cyl); mtcars$vs <- factor(mtcars$vs); mtcars$am <- factor(mtcars$am)
mtcars$gear <- factor(mtcars$gear); mtcars$carb <- factor(mtcars$carb)

mean(mpg[am=="0"]) #Automatic Transmission mean
mean(mpg[am=="1"]) #Manual Transmission mean
```

Quickly examining the data to determine the means we find that the average fuel economy among automatic cars is 17.14 MPG whereas the average among manual transmissions is 24.39 MPG. Furthermore, according to a boxplot of the data (*see* **Figure 1**) we could guess that the fuel efficiency of a manual transmission is greater than that of an automatic transmission. The average and median is MPG for manual transmission is distinctly higher than that of automatic transmissions. However, we cannot yet make a conclusion on based on this chart alone. First we will need to determine if a relationship does exist by using regression.

Regression Models

First we try a linear model using mpg as the outcome and transmission type (variable am, "0" denotes automatic whereas "1" denotes manual) as the predictor.

Regression Model: Transmission Type Only

```r
model_am <- lm(mpg ~ am)
summary(model_am)$adj.r.squared #result not shown to save space
```

Using this model we can determine that this model can only explain about 34% (Adjusted R-squared value of 0.3384) of the variance in MPG. Transmission alone does not look like it accounts for enough of the variation to be significant by itself. Therefore we should try another model to examine the other variables in the mtcars dataset.

Regression Model: All Variables

```r
model_full <- lm(mpg ~ ., mtcars)
summary(model_full)$adj.r.squared #result not shown to save space
```

Fitting all the variables can explain about 78% (Adjusted R-squared 0.7790) of the variance in MPG. According to the matrix scatterplot of all the variables in mtcars (*see* **Figure 2**) the there are a number of other variables that show significant correlation with MPG. Therefore we can probably create a better model using only the most significant variables.

Regression Model: Best Fit

Using R step function to step through the iterations of variables to determine which model would be the best.

```r
model_best <- step(model_full, trace=0)
summary(model_best)
```

This model now accounts for about 84% of the MPG variance (Adjusted R-squared 0.8401) which is better than our model that accounts for all the variables. The final model included four variables (number of cylinders, horsepower, weight, and transmission).

```r
summary(model_best)$coef
```

```
##                Estimate Std. Error   t value     Pr(>|t|)
## (Intercept) 33.70832390 2.60488618 12.940421 7.733392e-13
## cyl6        -3.03134449 1.40728351 -2.154040 4.068272e-02
## cyl8        -2.16367532 2.28425172 -0.947214 3.522509e-01
## hp          -0.03210943 0.01369257 -2.345025 2.693461e-02
## wt          -2.49682942 0.88558779 -2.819404 9.081408e-03
## am1          1.80921138 1.39630450  1.295714 2.064597e-01
```

Thus, we can determine that a manual transmission shows about 1.8 MPG better fuel economy than an automatic transmission.

Residuals

Residuals plots are shown in the Appendix (*see* **Figure 3**).

1. According to the Normal Q-Q plot we see that the residuals appear to be normally distributed as the data points fit quite closely to the line.
2. We can conclude that our model fits as the residuals vs fitted plot does not show a discernible pattern.
3. We also notice that there are no outliers by looking at the residuals vs leverage plot.

Appendix

Data and figures that accompany the report.

Figure 1: Boxplot summarizing both automatic and manual transmission types relative to MPG

```
boxplot(mpg ~ am, xlab="Transmission Type", ylab="Miles per Gallon (MPG)", xaxt="n",
        main="Transmission and MPG",
        col=c("green", "red"))
axis(1, at=1:2, labels=c("Automatic", "Manual"))
```

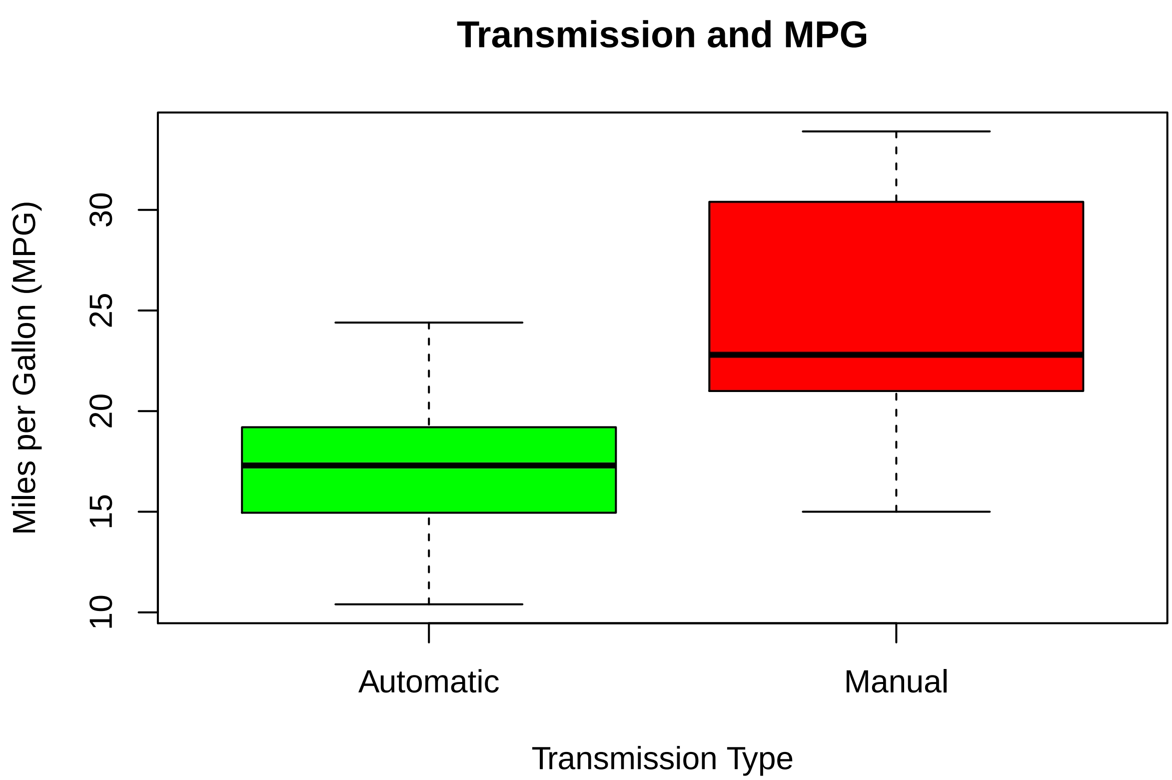


Figure 2: Matrix Scatterplot of all Variables

Matrix scatterplot covering the variances between many different variables in the mtcars dataset.

```
pairs(mtcars, main="Matrix Scatterplot of all Variables", panel=function(x,y){
  points(x,y)
  abline(lm(y~x), col="red")
})
```

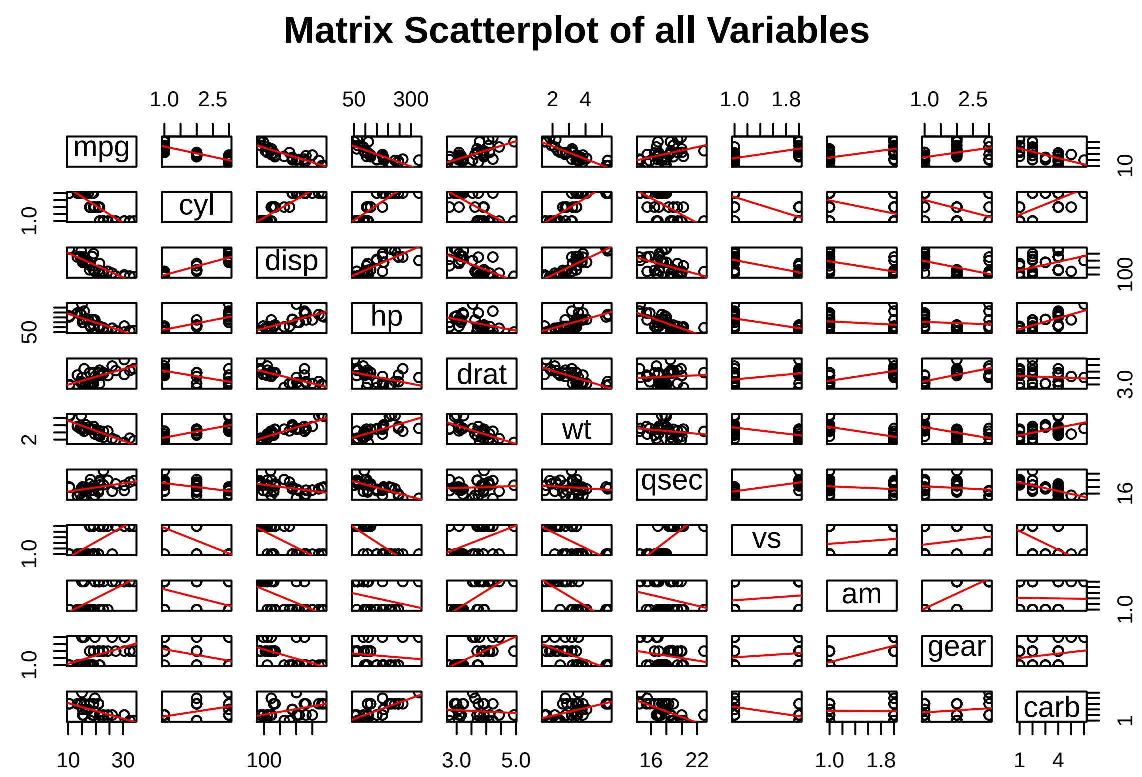
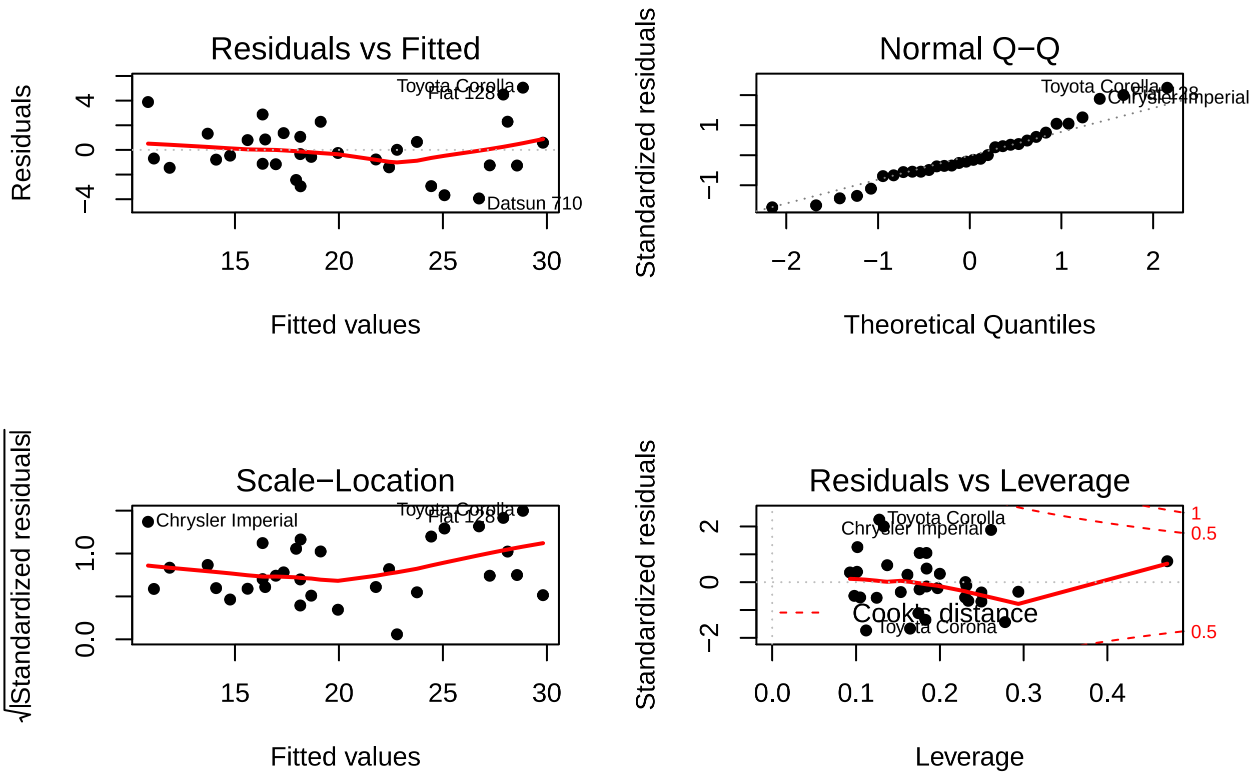


Figure 3: Residual Plots

Residuals plots for the best fit model.

```
par(mfrow=c(2,2))
plot(model_best, pch=16, lwd=2)
```


Residuals vs Fitted
Residuals
Fitted values
Toyota Corolla
Fiat 128
Datsun 710
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Toyota Corolla
Fiat 128
Chrysler Imperial
Scale−Location
√|Standardized residuals|
Fitted values
Chrysler Imperial
Toyota Corolla
Fiat 128
Residuals vs Leverage
Standardized residuals
Leverage
Toyota Corolla
Chrysler Imperial
Toyota Corona
Cook's distance
1
0.5
0.5