Automatic Transmission Cars Aren't Worse Than Manual Cars In Terms of MPG

Chi Lam

November 20, 2015

Executive Summary

Motor Trend Road Car Road Tests Data was used to determined that automatic transmission cars are not worse than manual transmission cars in terms of fuel economy. It was deteremined that only the *number of cylinders*, and *weight* are significant determinants of a car's *fuel economy*. Forcing *transmission type* into a model doesn't improve the *fuel economy* prediction power of the model; and just using *transmission type* alone to model *fuel economy* is inadequate. The MPG Difference between an automatic car and a manual car is therefore not quantifiable.

Exploratory Data Analysis: Fitting a Good Model

We fit a linear model that encompasses all the variable, then use anova to filter out those variables that are not useful. To contrast the result, we will later on try to force *transmission type* into our model, and try to use just *transmission type* to model *fuel economy*.

```
cars <- mtcars
cars$am <- factor(cars$am)
cars$vs <- factor(cars$vs)
carAllFit <- lm(mpg ~ ., data=cars)
anova(carAllFit)
```

```
## Analysis of Variance Table
##
## Response: mpg
##           Df Sum Sq Mean Sq  F value    Pr(>F)
## cyl        1 817.71  817.71 116.4245 5.034e-10 ***
## disp       1  37.59   37.59   5.3526  0.030911 *
## hp         1   9.37    9.37   1.3342  0.261031
## drat       1  16.47   16.47   2.3446  0.140644
## wt         1  77.48   77.48  11.0309  0.003244 **
## qsec       1   3.95    3.95   0.5623  0.461656
## vs         1   0.13    0.13   0.0185  0.893173
## am         1  14.47   14.47   2.0608  0.165858
## gear       1   0.97    0.97   0.1384  0.713653
## carb       1   0.41    0.41   0.0579  0.812179
## Residuals 21 147.49    7.02
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the data, it looks like only the *number of cylinders*(cyl), and the *weight*(wt) are significant predictors for the cars' MPG at a two-sided 95% confidence level using the dataset. *Displacement*(disp) fails the two-sided 95% confidence level test by a small margin.

Therefore the best model balancing between bias and over-modeling is:

`mpg = B0 + B1*cyl + B2*wt`

Note that the *transmission type*(am) is not a factor of the model.

Best Fit Model Coefficients

```
carBestFit <- lm(mpg ~ cyl + wt, data=cars)
bestFitCoeff <- summary(carBestFit)$coefficients
row.names( bestFitCoeff ) <- c("B0", "B1", "B2")
bestFitCoeffEst <- bestFitCoeff[,1]
bestFitCoeffEst
```

```
##        B0        B1        B2
## 39.686261 -1.507795 -3.190972
```

Therefore, the average *fuel economy*(mpg) of the cars is 39.6862615; and for each unit increase in *number of cylinder*(cyl), a change of -1.507795 mpg of *fuel economy*(mpg) is expected; and for each 1000 lbs increase in *weight*(wt), a change of -3.1909721 mpg of *fuel economy*(mpg) is expected.

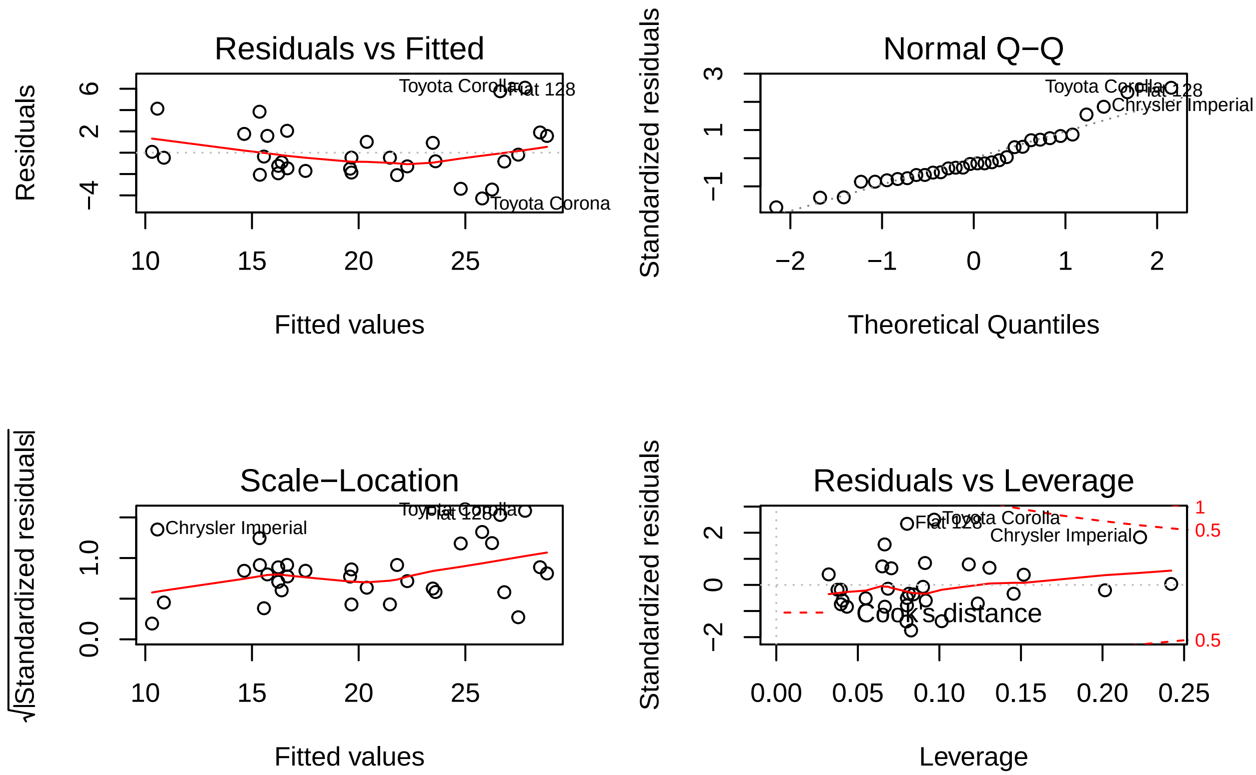
The 95% confidence intervals for the parameters can be calculated with the following code:

```
bestFitCoeffConInt <- qt(.975, df = carBestFit$df)* bestFitCoeff[,2]
bestFitCoeffLB <- bestFitCoeffEst - bestFitCoeffConInt
bestFitCoeffUB <- bestFitCoeffEst + bestFitCoeffConInt
bestFitCoeffBounds <- data.frame(lowerBound=bestFitCoeffLB, upperBound=bestFitCoeffUB)
bestFitCoeffBounds
```

```
##    lowerBound upperBound
## B0  36.178725 43.1937976
## B1  -2.355928 -0.6596622
## B2  -4.739020 -1.6429245
```

Residual Plot of the Best Fit Model

```
par(mfrow = c(2, 2))
plot(carBestFit)
```



The residual plots look normal, and there doesn't seem to be a pattern in the residual; therefore the best fit model is an acceptable model.

Forcing Transmission Type As a Predictor

Transmission type(am) is added to the best fit model to investigate further if *transmission type* can affect *fuel economy*.

```
cylWtAmFit <- lm(mpg ~ cyl + wt + am, data=cars)
anova(carBestFit, cylWtAmFit)
```

```
## Analysis of Variance Table
##
## Model 1: mpg ~ cyl + wt
## Model 2: mpg ~ cyl + wt + am
##   Res.Df    RSS Df Sum of Sq      F Pr(>F)
## 1     29 191.17
## 2     28 191.05  1   0.12491 0.0183 0.8933
```

Note that the p value is huge(0.89) compared to our threshold of 0.025 for a 95% confidence level. The 95% confidence interval for the slope of *transmission type* is given by the following

```
cylWtAmFitCoeff <- summary(cylWtAmFit)$coefficients
amCoeffBounds <- cylWtAmFitCoeff[4,1]+ c(-1, 1) * qt(.975, df = cylWtAmFit$df)* cylWtAmFitCoeff[4,2]
amCoeffBounds
```

```
## [1] -2.495555  2.848541
```

Note that the interval includes 0, therefore further confirming that the *transmission type* is not a good predictor for a car's *fuel economy*(mpg).

Using Transmission Type As The Sole Predictor

The following code calculates the R-squared of just using *transmission type* to model *fuel economy*

```
amFit <- lm(mpg ~ am, data=cars)
amFitRS <- summary(amFit)$r.squared
amFitRS
```

```
## [1] 0.3597989
```

Note that the R-squared is only 0.3597989, so the model can't even account for half the variations of the *fuel economy*. In contrast, R-squared for the best fit model is 0.8302274. Using *transmission type* alone is inadequate.

Conclusion

Using ANOVA, it was deteremined that only the *number of cylinders*, and *weight* are significant determinants of a car's *fuel economy*, not *transmission type*. Forcing *transmission type* into a model doesn't improve the *fuel economy* prediction power of the model; and just using *transmission type* alone to model *fuel economy* is inadequate. Therefore, we can conclude that automatic transmission cars are not statistically different from manual transmission cars in terms of *fuel economy*.