Motor Trend Car Road Tests - Effects of automatic and manual transmission on MPG

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Abstract

Motor Trend, the auto magazine, has gathered data with the intent of comparing miles per gallon (MPG) for various vehicles, and especially comparing automatic and manual transmissions.

Using a combination of hypothesis testing and linear regression, we'll compare average MPG from automatic and manual transmission vehicles. The results will show that manual transmission cars do get better gas mileage than automatic transmission cars. In fact, they get approximately _____ additional miles per gallon.

Data Loading and Processing

First, install necessary packages ggplot2 and bestglm, load the libraries into the session, load mtcars data set and check the structures.

```
#install.packages("ggplot2")
library(ggplot2)
#install.packages("bestglm")
library(bestglm)
data(mtcars)
str(mtcars)
```

See Appendix for output of str(mtcars). Make sure all columns that *should* be factors, are factors.

Number of Cylinders, V or Straight engine block, number of forward gears and number of carburetors should not be considered multiplicative, and so should be treated as factors.

Test the population mean MPG between automatic and manual transmissions

Create two different datasets, one for manual transmissions and one for automatic. From the help section of mtcars, am==0 is automatic transmissions and am==1 is manual transmission.

Manual transmission cars averaged 24.39 MPG, while automatic transmission cars averaged 17.15 MPG.

Based on this data, it looks like manual cars average more MPG than Automatic. Test this hypothesis using a t test and store the information under object 'test'. Use test

$$H_0 : \mu_{manual} = \mu_{automatic}$$

with alternative hypothesis

$$H_a : \mu_{manual} \neq \mu_{automatic}$$

```
test <- t.test(manualtrans$mpg, autotrans$mpg)
```

The p-value for this test is 0.001. The 95% confidence interval is (3.21,11.28).

Both of these indicate that there is, in fact, a difference in means between automatic and manual transmissions. Not only that, the data suggests that manual transmissions have a higher fuel economy.

Regression Analysis

To quantify the difference between automatic and manual transmissions, look at some regression models that predict MPG from the mtcars data set. To start, fit a base model only using field AM to predict MPG. Call it fit1.

```
fit1 <- lm(mpg~am,data = mtcars)
```

This model has an R square of 0.3597989.

Now that the baseline has been set, use library bestglm to automatically find the best model features to use to predict MPG. To do so, move the 'MPG' column to the final column and rename the column as 'y'.

```
col_idx <- grep("mpg",names(mtcars))
new_cols <- c(2:length(mtcars),col_idx)

mtcars.Xmpg <- subset(mtcars, select = new_cols)

colnames(mtcars.Xmpg)[colnames(mtcars.Xmpg)=='mpg'] <- 'y'
mtcars.Xy <- mtcars.Xmpg

fit3 <- bestglm(mtcars.Xy, IC = 'AIC', method = 'exhaustive')
```

```
formula(fit3$BestModel)
```

```
## y ~ wt + qsec + am
## <environment: 0x7fa1d7396ea8>
```

The model gives us features wt, qsec and am, name it our best fitting model, bestFit, and compare the three models with an ANOVA.

```
bestFit <- lm(mpg ~ wt + qsec + am, data = mtcars)
```

Using the best fitting model (R square of 0.8496636), the difference between manual and automatic transmissions is 2.94.

Conclusion

In revisiting the problem at hand, we were posed with two questions. Answers are provided in the bullet below each question.

1. Is an automatic or manual transmission better for MPG?

- With 95% confidence, there is a difference between automatic and manual transmissions in fuel economy.

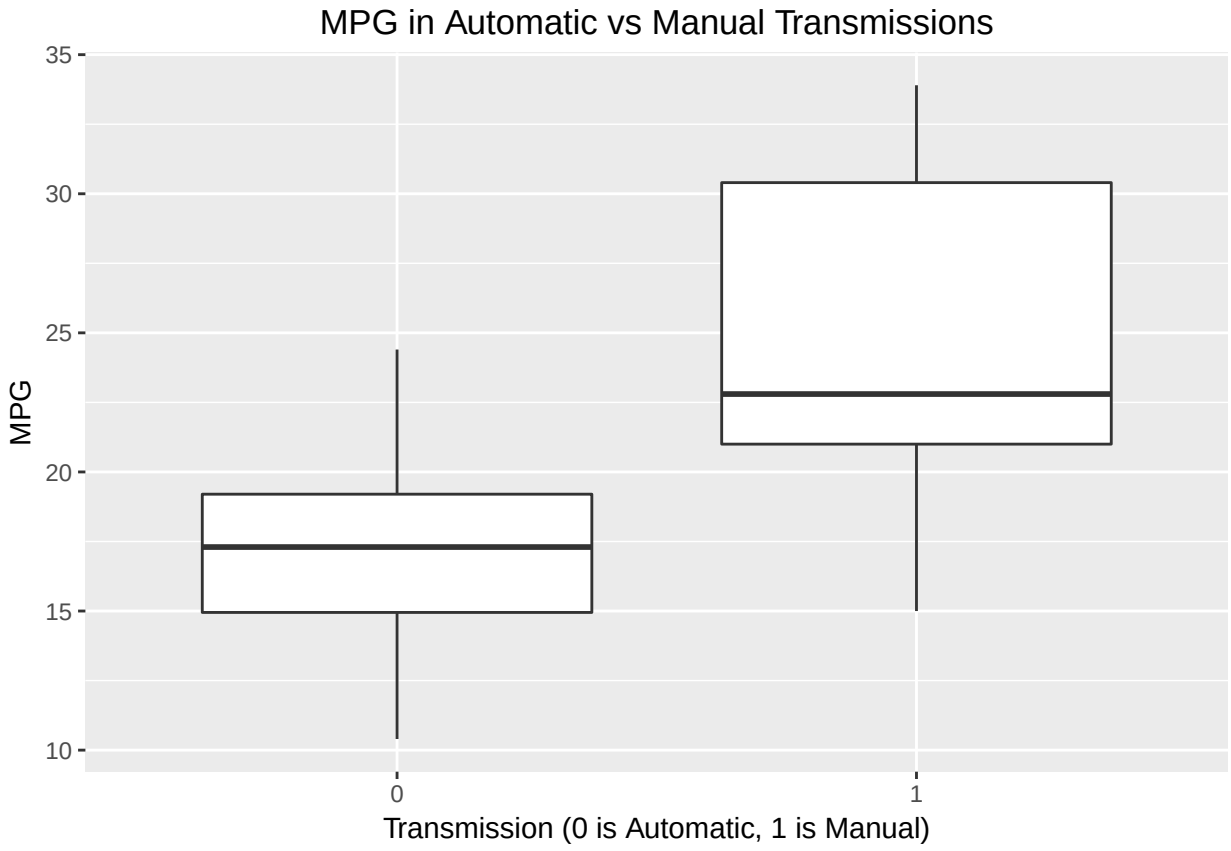
2. Quantify the MPG difference between automatic and manual transmissions

- The estimated mileage increase in switching from an automatic to a manual transmission is 2.94. This number is based on our best estimating model, and after accounting for other variables 1/4 mile time and weight.

Appendix

Look at a box-and-whisker plot of automatic vs manual transmission vs MPG.

```
g <- ggplot(data = mtcars, aes(x=factor(am),y=mpg)) +
  geom_boxplot() +
  xlab('Transmission (0 is Automatic, 1 is Manual)') +
  ylab('MPG') +
  ggtitle('MPG in Automatic vs Manual Transmissions') +
  theme(plot.title = element_text(hjust = 0.5))
g
```



Output of structure output

```
str(mtcars)
```

```
## 'data.frame':    32 obs. of  11 variables:
##  $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 ...
##  $ cyl : Factor w/ 3 levels "4","6","8": 2 2 1 2 3 2 3 1 1 2 ...
##  $ disp: num  160 160 108 258 360 ...
##  $ hp  : num  110 110 93 110 175 105 245 62 95 123 ...
##  $ drat: num  3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.92 ...
##  $ wt  : num  2.62 2.88 2.32 3.21 3.44 ...
##  $ qsec: num  16.5 17 18.6 19.4 17 ...
##  $ vs  : Factor w/ 2 levels "0","1": 1 1 2 2 1 2 1 2 2 2 ...
##  $ am  : num  1 1 1 0 0 0 0 0 0 0 ...
```

```
##  $ gear: Factor w/ 3 levels "3","4","5": 2 2 2 1 1 1 1 2 2 2 ...
##  $ carb: Factor w/ 6 levels "1","2","3","4",..: 4 4 1 1 2 1 4 2 2 4 ...
```

Model diagnostics

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