MPGTransmissionStudy.Rmd

Jim Callahan

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Executive Summary

This project is intended to answer the following two questions:

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

2. "Quantify the MPG difference between automatic and manual transmissions?"

using statistical regression analysis in **R** on the **"Motor Trend"**, **"mtcars"** data set included with the **R** system.

Data Vintage

It should be noted the **"mtcars"** data set is vintage **1981** and is therefore unlikely to be representative of the contemporary state of the art.

The source of the **"mtcars"** data set (as described in the documentation "help(mtcars)") is Henderson and Velleman (1981), **Building multiple regression models interactively.** Biometrics, 37, 391–411.

Exploratory Data Analysis

```
data(mtcars)
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 : num  6 6 4 6 8 6 8 4 4 6 ...
##  $ 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  : num  0 0 1 1 0 1 0 1 1 1 ...
##  $ am  : num  1 1 1 0 0 0 0 0 0 0 ...
##  $ gear: num  4 4 4 3 3 3 3 4 4 4 ...
##  $ carb: num  4 4 1 1 2 1 4 2 2 4 ...
```

Preliminary Analysis

On the surface the minimum requirements of this project are trivially simple:
1. Convert the zero-one transmission indicator variable, **"am"** to an **R "factor"**.
2. Run a regression with mpg = f(am) or in **R** notation **lm(mpg ~ am))**

```
# MPG Model zero "000" -- our "quick and dirty" literal regression
MPGmod000 <- lm(mtcars$mpg ~ as.factor(mtcars$am))
MPGmod000
```

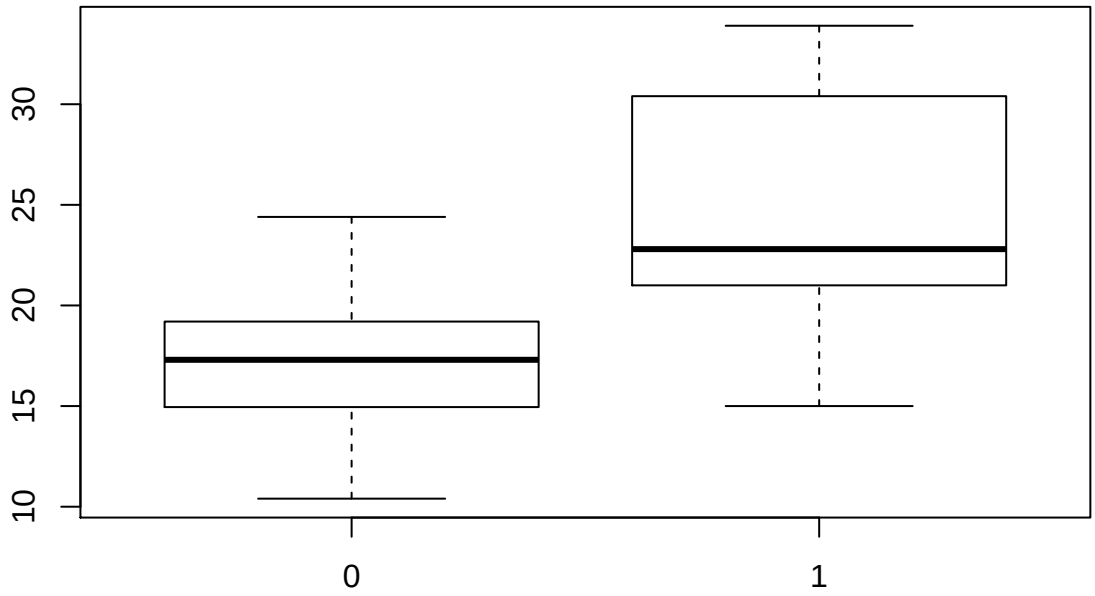
```
##
## Call:
## lm(formula = mtcars$mpg ~ as.factor(mtcars$am))
##
## Coefficients:
##           (Intercept)  as.factor(mtcars$am)1
##                17.147                  7.245
```

According to the documention (help(mtcars)) the coding for **"am"** variable is
zero(0) = automatic transmission and one(1) = manual transmission.

So, the "quick and dirty" interpretation our base model zero, would be that
the average 1980 vintage car with automatic transmission gets 17 miles per gallon while the average 1980 vintage car with manual transmisson gets an additional 7 miles per gallon for a total of 24 miles per gallon.

We can picture this with a box plot.

```
plot(as.factor(mtcars$am), mtcars$mpg)
abline(mtcars$mpg ~ as.factor(mtcars$am))
```



Of course to accept this analysis at face value, one would have to invoke the economist's assumption of "***ceteris paribus***" (all other things being equal).

Of course we know all other things are **NOT EQUAL**. There are **confounding variables**. For instance, the cars vary in weight, number of cylinders in their engines and the size of their engines measured in cubic inch displacement.

```
# wt = Weight (lb/1000)
summary( mtcars$wt )
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.513   2.581   3.325   3.217   3.610   5.424
```

```
# cyl = Number of cylinders
summary( as.factor(mtcars$cyl) )
```

```
##  4  6  8
## 11  7 14
```

```
# disp = Displacement (cu.in.)
summary( mtcars$disp )
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    71.1   120.8   196.3   230.7   326.0   472.0
```

Historical Context

Moreover, keep in mind the historical context, this is the late 1970s/early 1980s when there was still a huge difference between American, European and Japanese auto technology.

> "In the mid-1980s, Toyota took over the Fremont [,California] plant, one of GM's worst, a factory known for sex, drugs and defective vehicles. And as part of an historic joint venture [NUMMI], Toyota turned the plant into one of GM's best, practically overnight.
> Along the way — remarkably — Toyota even shared its production secrets. . . . In 1985, after NUMMI opened, Car and Driver magazine ran the following
> headline: **'Hell Freezes Over.'**"
> **"The End Of The Line For GM-Toyota Joint Venture"** by Frank Langfitt,
> National Public Radio (NPR), MARCH 26, 2010 3:00 PM ET
> http://www.npr.org/templates/story/story.php?storyId=125229157

GM's Saturn was not introduced until the 1991 model year, ten years after the 1981 vintage of the "mtcars" data set.
https://en.wikipedia.org/wiki/Saturn_Corporation

Electric vehicle hybrids, such as Toyota's Prius NHW11, were not introduced to the US market until the 2001 model year.
https://en.wikipedia.org/wiki/Toyota_Prius