

Regression Models Project

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January 28, 2017

In this analysis, we will be exploring the “mtcars” dataset to determine what variables are associated with increased or decreased mileage per gallon. Precisely, we will be investigating what relationship (if any) the transmission, automatic or manual, has on the miles per gallon.

Per ?mtcars documentation:

A data frame with 32 observations on 11 variables.

- [, 1] mpg Miles/(US) gallon
- [, 2] cyl Number of cylinders
- [, 3] disp Displacement (cu.in.)
- [, 4] hp Gross horsepower
- [, 5] drat Rear axle ratio
- [, 6] wt Weight (lb/1000)
- [, 7] qsec 1/4 mile time
- [, 8] vs V/S
- [, 9] am Transmission (0 = automatic, 1 = manual)
- [,10] gear Number of forward gears
- [,11] carb Number of carburetors

Exploratory Data Analysis

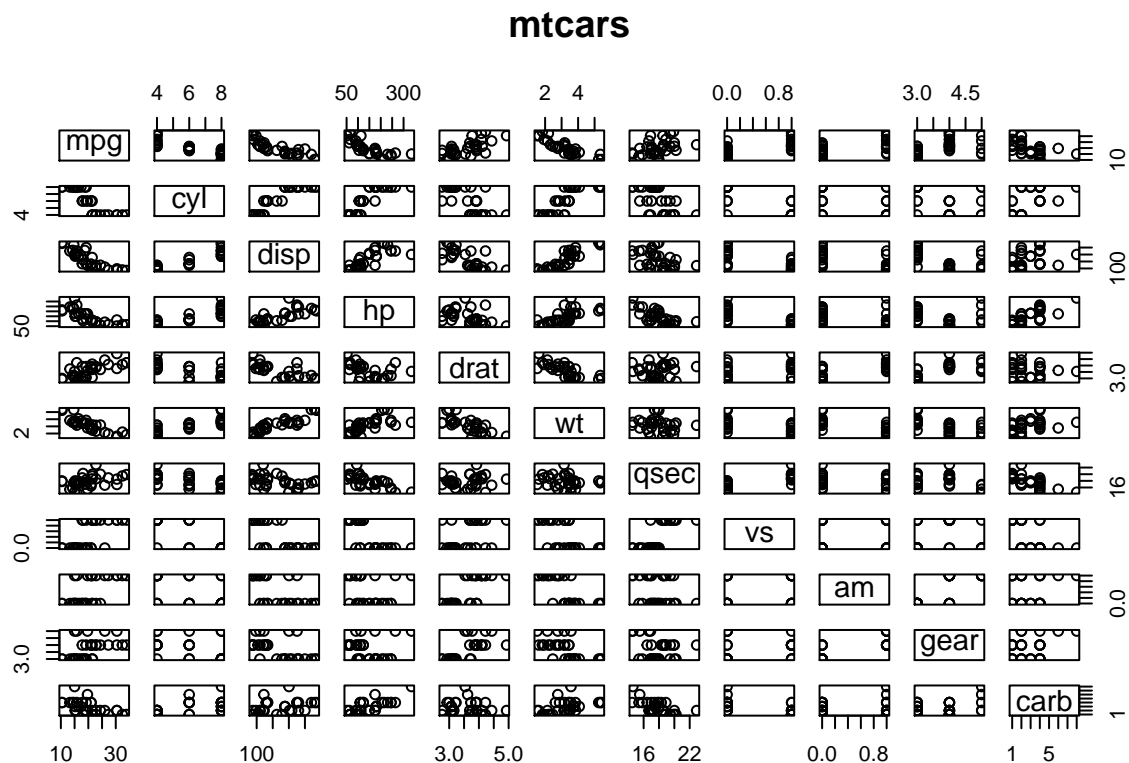
```
attach(mtcars) #Load data  
  
summary(mtcars)
```

##	mpg	cyl	disp	hp
##	Min. :10.40	Min. :4.000	Min. : 71.1	Min. : 52.0
##	1st Qu.:15.43	1st Qu.:4.000	1st Qu.:120.8	1st Qu.: 96.5
##	Median :19.20	Median :6.000	Median :196.3	Median :123.0
##	Mean :20.09	Mean :6.188	Mean :230.7	Mean :146.7
##	3rd Qu.:22.80	3rd Qu.:8.000	3rd Qu.:326.0	3rd Qu.:180.0
##	Max. :33.90	Max. :8.000	Max. :472.0	Max. :335.0
##	drat	wt	qsec	vs
##	Min. :2.760	Min. :1.513	Min. :14.50	Min. :0.0000
##	1st Qu.:3.080	1st Qu.:2.581	1st Qu.:16.89	1st Qu.:0.0000
##	Median :3.695	Median :3.325	Median :17.71	Median :0.0000
##	Mean :3.597	Mean :3.217	Mean :17.85	Mean :0.4375
##	3rd Qu.:3.920	3rd Qu.:3.610	3rd Qu.:18.90	3rd Qu.:1.0000
##	Max. :4.930	Max. :5.424	Max. :22.90	Max. :1.0000

```
##           am           gear           carb
##  Min.    :0.0000   Min.    :3.000   Min.    :1.000
## 1st Qu.:0.0000   1st Qu.:3.000   1st Qu.:2.000
##  Median :0.0000   Median :4.000   Median :2.000
##   Mean  :0.4062   Mean    :3.688   Mean    :2.812
## 3rd Qu.:1.0000   3rd Qu.:4.000   3rd Qu.:4.000
##   Max.   :1.0000   Max.     :5.000   Max.     :8.000
```

We will plot all variables against all others to look for any obvious relationships.

```
pairs(mtcars, main = "mtcars")
```



Let's see if there may be a relationship between miles per gallon and transmission:

```
auto <- mtcars[(mtcars$am == 0),] #0 = automatic
manu <- mtcars[(mtcars$am == 1),] #1 = manual
summary(auto$mpg)
```

```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 10.40   14.95   17.30   17.15   19.20   24.40
```

```
summary(manu$mpg)
```

```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 15.00   21.00   22.80   24.39   30.40   33.90
```

Manual transmissions have higher Median and Mean mileage per gallon, with Medians of 22.80 vs 17.30 (manual vs automatic) and Means of 24.39 vs 17.15.

Fitting Multiple Models

We can run a linear regression with mpg predicted by transmission type to determine if the relationship has statistical significance.

```
fit <- lm(mpg ~ am, data = mtcars)
summary(fit)$coefficients
```

```
##           Estimate Std. Error  t value    Pr(>|t|)
## (Intercept) 17.147368   1.124603 15.247492 1.133983e-15
## am           7.244939   1.764422  4.106127 2.850207e-04
```

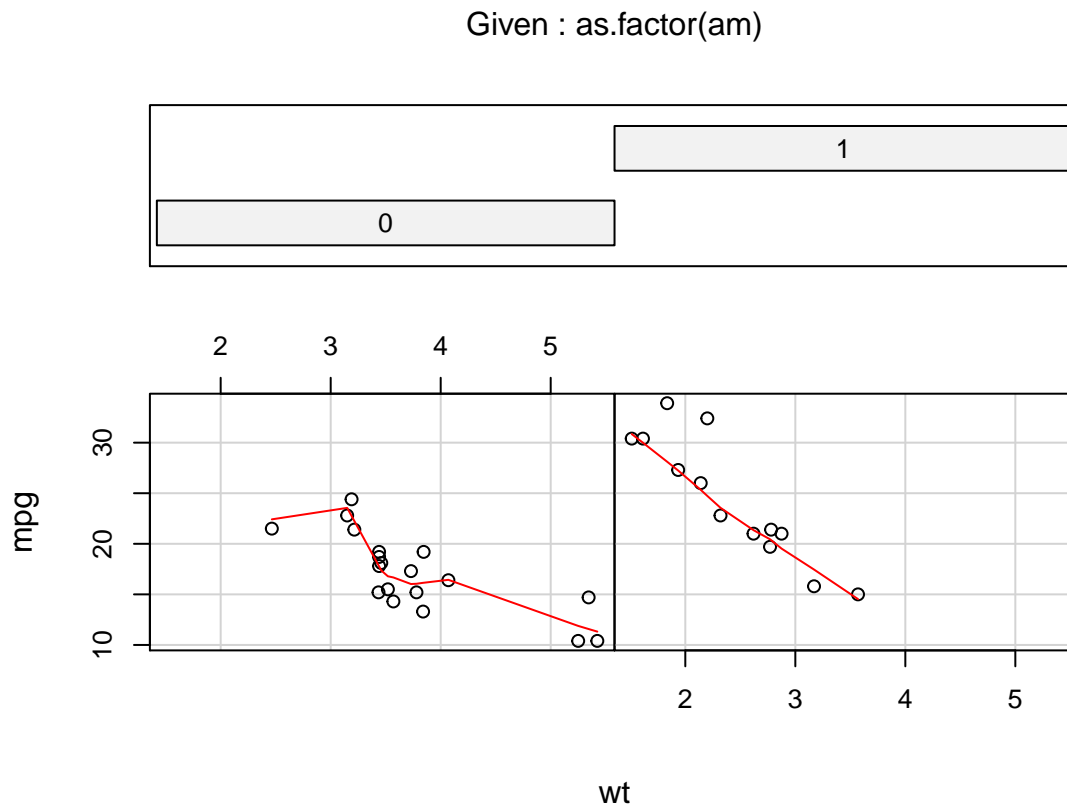
The probability that the transmission is not significant to mileage per gallon is 2.85×10^{-4} , which is much less than zero. Furthermore, we see that the slope of this model, 7.245 (the difference in mileage associated with a manual vs an automatic transmission) is precisely identical to the difference in means of both respective data:

```
mean(manu$mpg) - mean(auto$mpg)
```

```
## [1] 7.244939
```

It is safe to reject the null hypothesis and investigate further. We will also begin to explore if weight affects gas mileage:

```
coplot(mpg ~ wt | as.factor(am), data = mtcars, panel = panel.smooth, rows = 1)
```



Visually, it would appear that, for both manual and automatic transmissions, weight affects fuel mileage.

We will investigate briefly if weight is a factor by adding it to our regression model and seeing if it improves the fit.

```
fit2 <- lm(mpg ~ am + wt, data = mtcars)
summary(fit2)$coefficients
```

```
##              Estimate Std. Error    t value    Pr(>|t|)
## (Intercept) 37.32155131  3.0546385 12.21799285 5.843477e-13
## am          -0.02361522  1.5456453 -0.01527855 9.879146e-01
## wt          -5.35281145  0.7882438 -6.79080719 1.867415e-07
```

Here, weight seems to be more predictive of mileage per gallon than does the transmission type, with P-values of 1.87e-07 and 9.88e-01, respectively.

Executive Summary

In this analysis, we generated two models to explain differences in mileage per gallon using the mtcars data set. Our first linear model included only the transmission to predict mileage per gallon. Our second linear fit included weight in addition to the transmission type.

We can now test to determine if these two models are distinct.

```
anova(fit, fit2, test="Chisq")
```

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ am + wt
##   Res.Df    RSS Df Sum of Sq  Pr(>Chi)
## 1      30 720.90
## 2      29 278.32  1    442.58 1.115e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

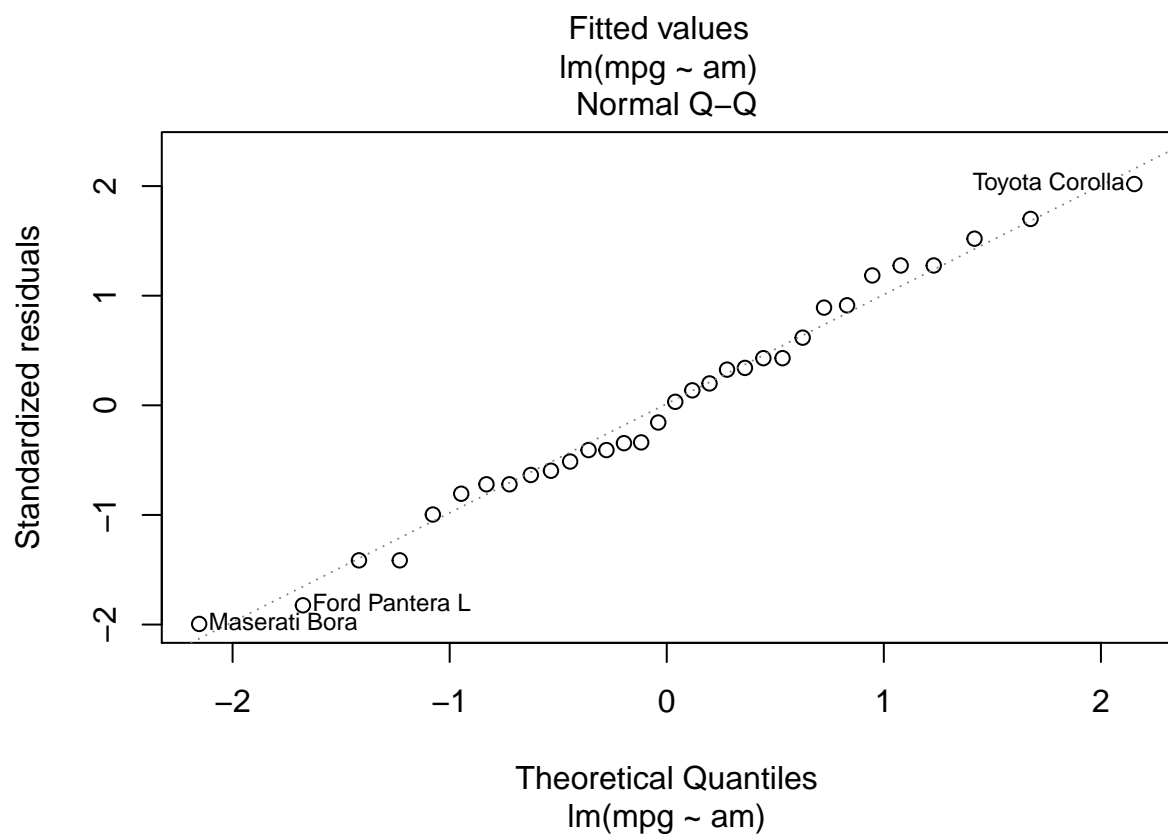
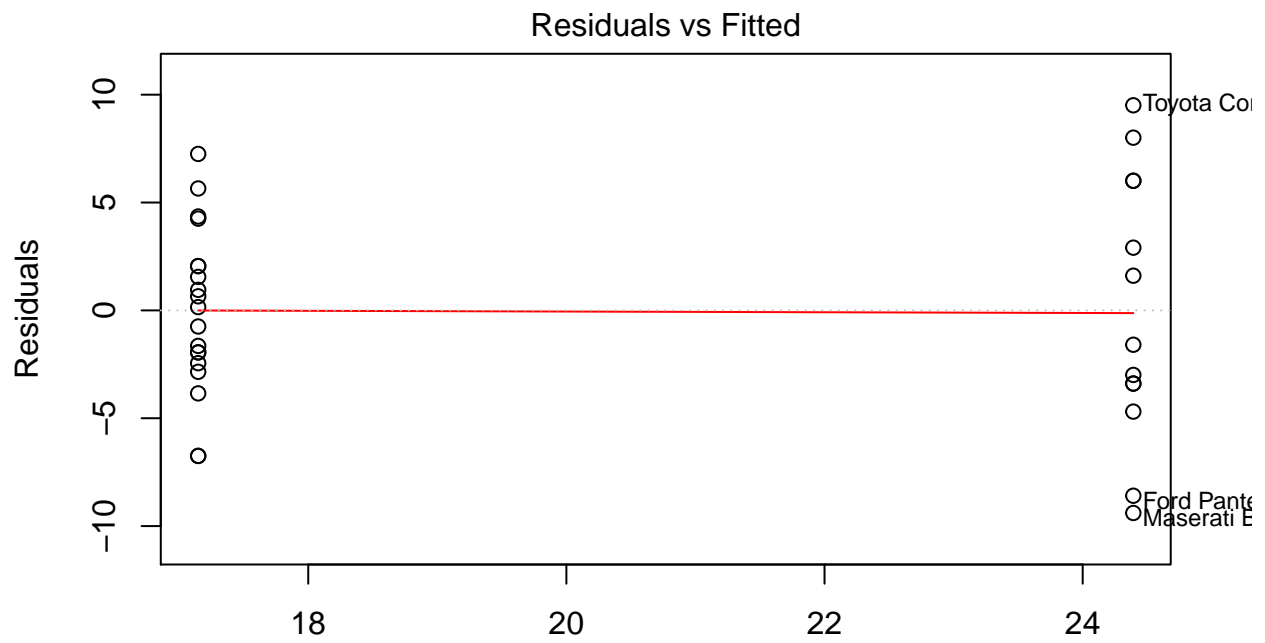
In this case, with the addition of wt to the model, the probability that the variation in predictions in either model is due only to chance is 1.12e-11, which is insignificant.

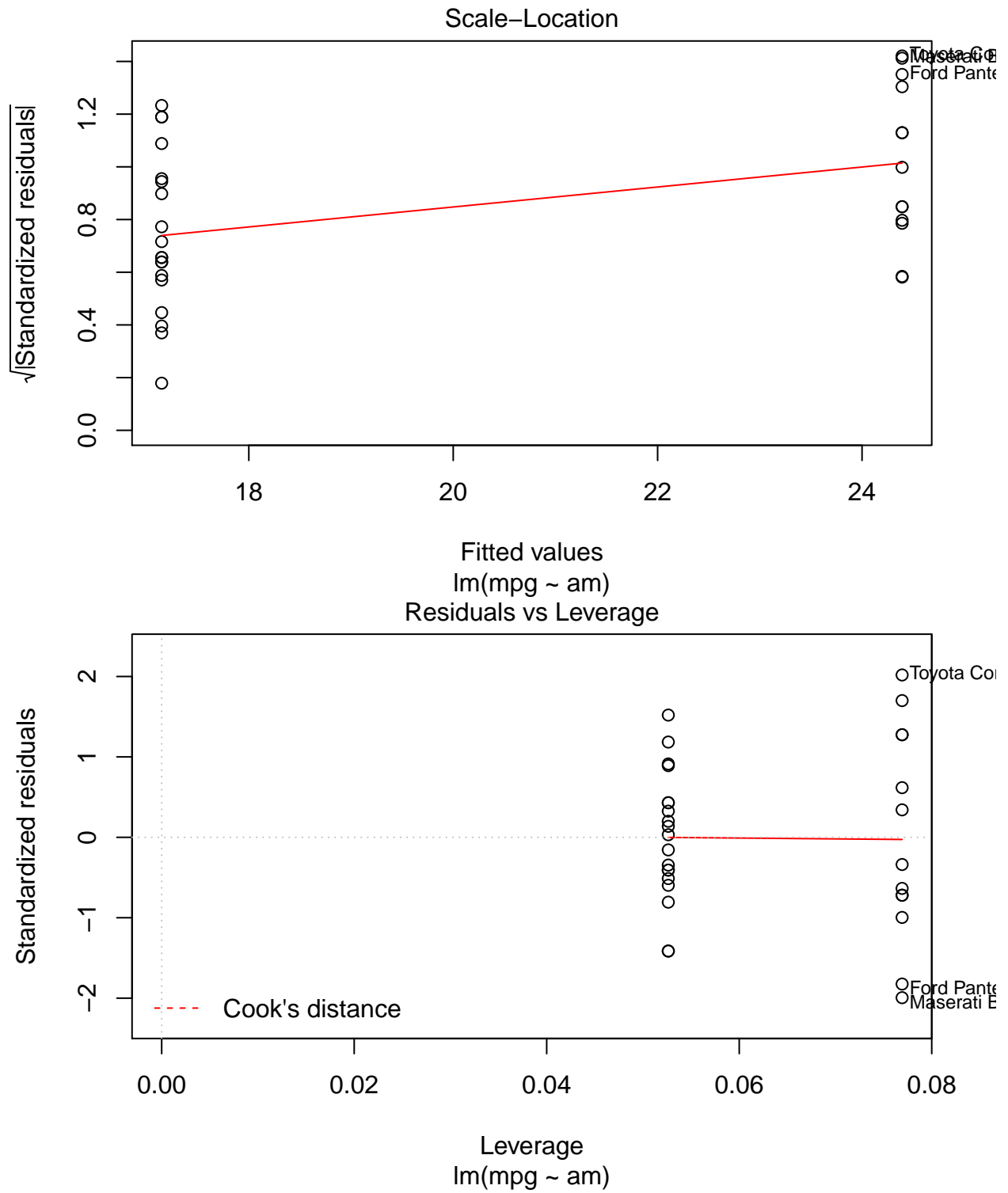
Furthermore, we have determined that a manual transmission is associated with an increase in gas mileage on average of 7.25 mpg (disregarding all other variables).

Appendix

Residual plots for fit (mpg ~ am) and fit2 (mpg ~ am + wt)

```
plot(fit)
```





```
plot(fit2)
```

