Regression Models Assignment

K H Chen

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Executive Summary

In this report, data gathered by Motor Trend US Magazine is explored and analyzed in order to determine the relationship between a set of variables and miles per gallon of automobiles. This report will try to answer the following two questions :

1) Is an automatic or manual transmission better for MPG?
2) What is the MPG difference between automatic and manual transmissions?

Based on the model created in this analysis, manual transmission has better MPG than auto. The MPG difference could be approximately quantified as: With weight and number of cylinders being equal, a car with manual transmission will have an improved MPG in the value of 11.9 minus 2.4 times the weight of car divided by 1,000, subtract the number of cylinders mutiplied by 1.2, further subtract 4.2 times the weight divided by 1,000, finally plus 34.3.

Exploratory Data Analysis

First, load the data and examine the data strucutre (Figure 1). Looks like among 32 observations, it is fairely an even split between two groups in question (19 auto, 13 manual). Now create a boxplot to examine which one has better MPG on average (Figure 2). The boxplot indicates that manual transmission has better MPG than auto.

Modelling

1st Modelling:

Forward-Selection model was used to create a basic model with a single variable: transmission type (am) (Figure 3). It produced the **p-value lower than 0.05** which indicated a linear correlation between type of transmission to MPG. Therefore, linear model was viable suitable model to be used.

2nd Modelling:

In 2nd modelling, **coefficients all have low p-values** has one more predictor, weight (wt) (Figure 4). The result has shown a better **Adjusted R-squared value**, which suggesting both predictors need to be included in the final model.

3rd Modelling:

In 3rd Modelling, the interaction between transmission type and weight (Figure 5) was tested. It shown a better **Ajusted R-squared value 0.815** while maintaining **low p-vlaues for all coefficients**.

4th Modelling:

In 4th Modelling, additional predictor, cylinder number (cyl), has beed added (Figure 6). The outcome was **Low p-values, better Adjusted R-squared value as 0.853**.

5th Modelling:

In 5th Modelling, the interaction between wt and cyl as well as between cyl and am were being tested. The outcomes shown there was no interaction between wt and cyl (Figure 7); but there was an interaction between cyl and am (Figure 8). However the **Adjusted R-squared value** is not as high as **0.853**.

Final Model

Our final model was from the 4th Modelling in Figure 6:

```
fit4 <- lm(mpg ~ am*wt + cyl, mtcars)
```

Residuals Examination

The test outcomes of the residuals vs. fitted values and standardized residuals theoretical quantiles were shown in Figure 9. This concluded that there was any significant outlier other than three instances.

Confidence Intervals

```
coef <- summary(fit4)$coef
coef <- data.frame(coef)
interval <- function(r) {
    r[1] + c(-1,1) * qt(.975, 27) * r[2]
}
t(apply(coef, 1, interval))
```

```
##                  [,1]       [,2]
## (Intercept) 28.545155 40.0208405
## am           4.048559 19.8284725
## wt          -4.060457 -0.6774023
## cyl         -1.961674 -0.4010575
## am:wt       -6.888512 -1.5063563
```

Conclusion

"Is an automatic or manual transmission better for MPG?" Manual transmission is better for MPG because the coefficient for am was positive (11.9385), and am took 1 as the value for manual.

"Quantify the MPG difference between automatic and manual transmissions?" A car with manual transmission will have an improved MPG in the value of 11.9385 minus 2.3689 times the weight of car divided by 1,000, subtract the number of cylinders mutiplied by 1.1814, further subtract 4.1974 times the weight divided by 1,000, finally plus 34.2830. This was with assumption of the weight and number of cylinders being equal.

Appendix

Figure 1

```r
head(mtcars, n=3)
```

```
##                mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4     21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag 21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710    22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
```

```r
## how many cobservations
nrow(mtcars)
```

```
## [1] 32
```

```r
## the distribution between two kinds of transmissions
table(mtcars$am)
```

```
##
##  0  1
## 19 13
```

Figure 2

```r
library(ggplot2)
ggplot(mtcars, aes(as.factor(am), mpg)) + geom_boxplot() + theme_bw() + labs(x="0=Auto, 1=Manual")
```

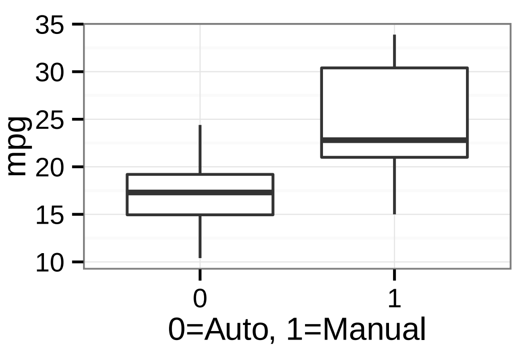


Figure 3

```r
fit1 <- lm(mpg ~ am, mtcars)
summary(fit1)$coef
```

```
##              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
```

```r
summary(fit1)$adj.r.squared
```

```
## [1] 0.3384589
```

Figure 4

```r
fit2 <- lm(mpg ~ am + wt, mtcars)
summary(fit2)$coef
```

```
##                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
```

```r
summary(fit2)$adj.r.squared
```

```
## [1] 0.7357889
```

Figure 5

```r
fit3 <- lm(mpg ~ am*wt, mtcars)
summary(fit3)$coef
```

```
##              Estimate Std. Error   t value     Pr(>|t|)
## (Intercept) 31.416055  3.0201093 10.402291 4.001043e-11
## am          14.878423  4.2640422  3.489277 1.621034e-03
## wt          -3.785908  0.7856478 -4.818836 4.551182e-05
## am:wt       -5.298360  1.4446993 -3.667449 1.017148e-03
```

```r
summary(fit3)$adj.r.squared
```

```
## [1] 0.8151486
```

Figure 6 - FINAL MODEL

```r
fit4 <- lm(mpg ~ am*wt + cyl, mtcars)
summary(fit4)$coef
```

```
##              Estimate Std. Error   t value     Pr(>|t|)
## (Intercept) 34.282998  2.7964507 12.259468 1.518742e-12
## am          11.938516  3.8453256  3.104683 4.438319e-03
## wt          -2.368930  0.8243992 -2.873523 7.815636e-03
## cyl         -1.181366  0.3802985 -3.106417 4.419268e-03
## am:wt       -4.197434  1.3115498 -3.200362 3.496375e-03
```

```r
summary(fit4)$adj.r.squared
```

```
## [1] 0.8587759
```

Figure 7

```r
fit5 <- lm(mpg ~ am*wt + cyl*wt, mtcars)
summary(fit5)$coef
```

```
##                Estimate Std. Error    t value   Pr(>|t|)
## (Intercept) 31.93034090 16.1464125  1.9775502 0.05867096
## am          12.98800292  8.0997757  1.6035016 0.12090441
## wt          -1.60442842  5.2323464 -0.3066365 0.76156235
## cyl         -0.87890918  2.0796154 -0.4226306 0.67603965
## am:wt       -4.53101524  2.6197284 -1.7295744 0.09556325
## wt:cyl      -0.09787432  0.6611812 -0.1480295 0.88346154
```

```r
summary(fit5)$adj.r.squared
```

```
## [1] 0.8534677
```

Figure 8

```r
fit6 <- lm(mpg ~ am*wt + cyl*am, mtcars)
summary(fit6)$coef
```

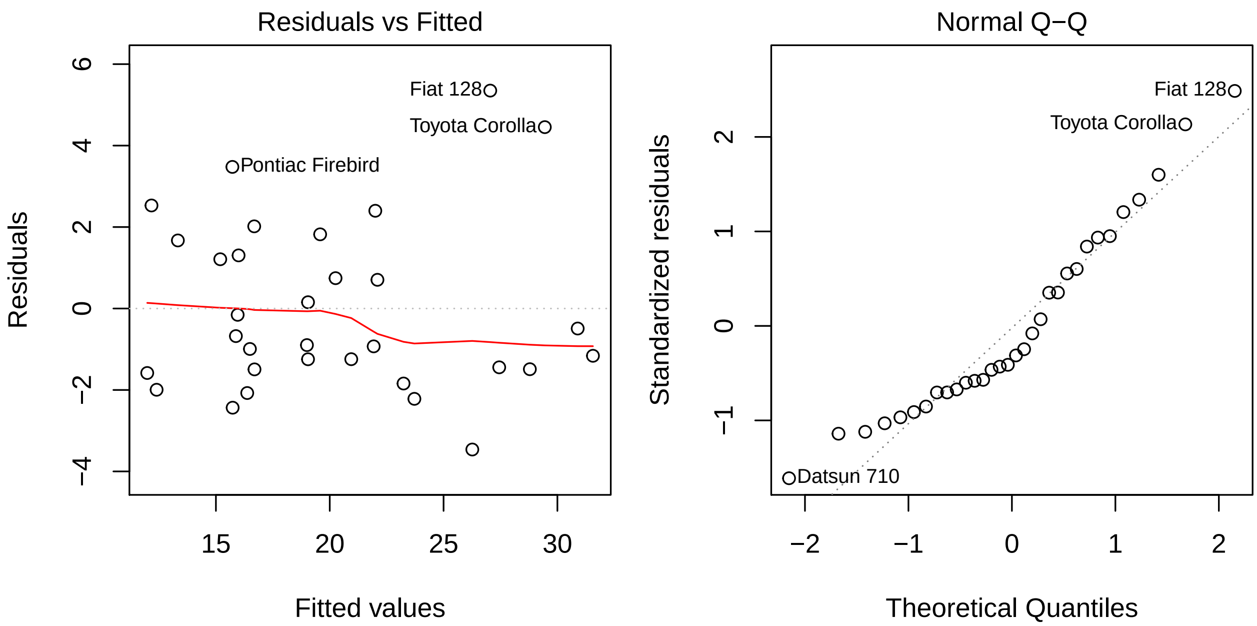
```
##               Estimate Std. Error    t value     Pr(>|t|)
## (Intercept) 34.5680688  2.8786700 12.0083470 4.127484e-12
## am          11.6776786  3.9234021  2.9764165 6.231780e-03
## wt          -2.2280342  0.8725637 -2.5534344 1.687769e-02
## cyl         -1.2988334  0.4391468 -2.9576290 6.521476e-03
## am:wt       -5.1746064  2.2000002 -2.3520936 2.651858e-02
## am:cyl       0.5098372  0.9148842  0.5572696 5.821095e-01
```

```r
summary(fit6)$adj.r.squared
```

```
## [1] 0.8550752
```

Figure 9

```r
par(mfrow = c(1,2), mar = c(4, 4, 2, 1))
plot(fit4, which=1)
plot(fit4, which=2)
```



Residuals vs Fitted
Residuals
Fitted values
Fiat 128
Toyota Corolla
Pontiac Firebird
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Fiat 128
Toyota Corolla
Datsun 710