Motor Trend Car Road Analysis

Executive Summary

You work for Motor Trend, a magazine about the automobile industry. Looking at a data set of a collection of cars, they are interested in exploring the relationship between a set of variables and miles per gallon (MPG) (outcome). They are particularly interested in the following two questions:

1. “Is an automatic or manual transmission better for MPG”
2. “Quantify the MPG difference between automatic and manual transmissions”

Data Processing

The data was extracted from the 1974 Motor Trend US magazine, and comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (1973–74 models).

```
library(datasets)

data(mtcars)
```

It consists of 32 observations on 11 variables.

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

Is an automatic or manual transmission better for MPG?

For automatic:

```
summary(mtcars[mtcars$am==0,])
```

```
##       mpg             cyl             disp           hp           drat
##  Min.   :10.4   Min.   :4.00   Min.   :120   Min.   : 62   Min.   :2.76
##  1st Qu.:14.9   1st Qu.:6.00   1st Qu.:196   1st Qu.:116   1st Qu.:3.07
##  Median :17.3   Median :8.00   Median :276   Median :175   Median :3.15
##  Mean   :17.1   Mean   :6.95   Mean   :290   Mean   :160   Mean   :3.29
##  3rd Qu.:19.2   3rd Qu.:8.00   3rd Qu.:360   3rd Qu.:192   3rd Qu.:3.69
##  Max.   :24.4   Max.   :8.00   Max.   :472   Max.   :245   Max.   :3.92
```

```
##        wt             qsec             vs               am         gear
##  Min.   :2.46   Min.   :15.4   Min.   :0.000   Min.   :0   Min.   :3.00
##  1st Qu.:3.44   1st Qu.:17.2   1st Qu.:0.000   1st Qu.:0   1st Qu.:3.00
##  Median :3.52   Median :17.8   Median :0.000   Median :0   Median :3.00
##  Mean   :3.77   Mean   :18.2   Mean   :0.368   Mean   :0   Mean   :3.21
##  3rd Qu.:3.84   3rd Qu.:19.2   3rd Qu.:1.000   3rd Qu.:0   3rd Qu.:3.00
##  Max.   :5.42   Max.   :22.9   Max.   :1.000   Max.   :0   Max.   :4.00
##       carb
##  Min.   :1.00
##  1st Qu.:2.00
##  Median :3.00
##  Mean   :2.74
##  3rd Qu.:4.00
##  Max.   :4.00
```

For manual:

```
summary(mtcars[mtcars$am==1,])
```

```
##       mpg             cyl             disp             hp
##  Min.   :15.0   Min.   :4.00   Min.   : 71.1   Min.   : 52
##  1st Qu.:21.0   1st Qu.:4.00   1st Qu.: 79.0   1st Qu.: 66
##  Median :22.8   Median :4.00   Median :120.3   Median :109
##  Mean   :24.4   Mean   :5.08   Mean   :143.5   Mean   :127
##  3rd Qu.:30.4   3rd Qu.:6.00   3rd Qu.:160.0   3rd Qu.:113
##  Max.   :33.9   Max.   :8.00   Max.   :351.0   Max.   :335
##       drat             wt             qsec             vs               am
##  Min.   :3.54   Min.   :1.51   Min.   :14.5   Min.   :0.000   Min.   :1
##  1st Qu.:3.85   1st Qu.:1.94   1st Qu.:16.5   1st Qu.:0.000   1st Qu.:1
##  Median :4.08   Median :2.32   Median :17.0   Median :1.000   Median :1
##  Mean   :4.05   Mean   :2.41   Mean   :17.4   Mean   :0.538   Mean   :1
##  3rd Qu.:4.22   3rd Qu.:2.78   3rd Qu.:18.6   3rd Qu.:1.000   3rd Qu.:1
##  Max.   :4.93   Max.   :3.57   Max.   :19.9   Max.   :1.000   Max.   :1
##       gear            carb
##  Min.   :4.00   Min.   :1.00
```

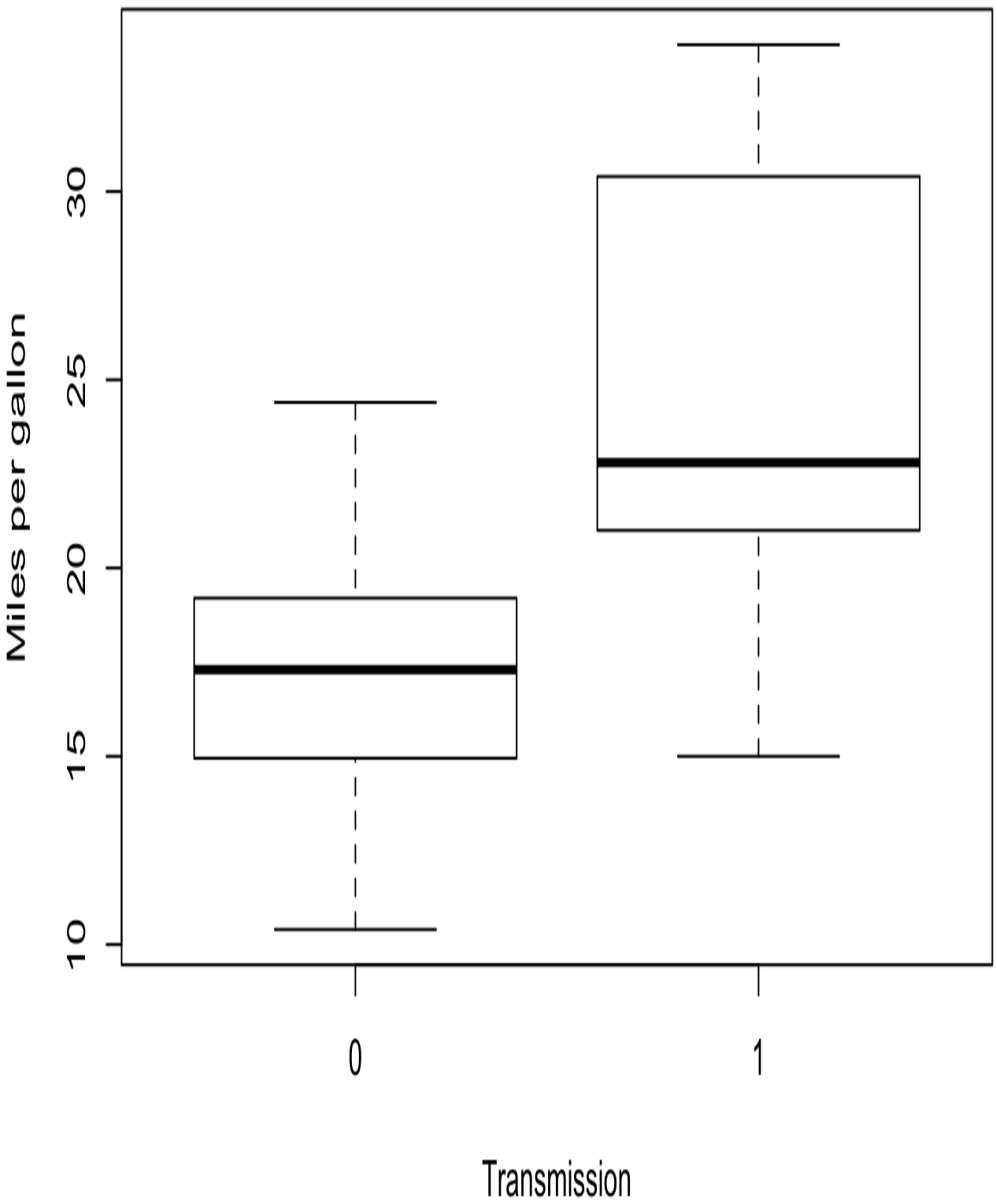
```
##  1st Qu.:4.00   1st Qu.:1.00
##  Median :4.00   Median :2.00
##  Mean   :4.38   Mean   :2.92
##  3rd Qu.:5.00   3rd Qu.:4.00
##  Max.   :5.00   Max.   :8.00
```

Hence, the mean of mpg is greater for manual (at 24.4) than automatic (at 17.1).

Investigating further..

Quantify the MPG difference between automatic and manual transmissions.

```
boxplot(mpg ~ am, data = mtcars, xlab = "Transmission", ylab = "Miles per gallon", main="Miles per gallon by Transmission Type")
```


Miles per gallon by Transmission Type
Miles per gallon
10
15
20
25
30
0
1
Transmission

Manual (represented by 1) has a higher mean for mpg than automatic (represented by 0).

Hypothesis Testing

```
aggregate(mpg~am, data = mtcars, mean)
```

```
##   am   mpg
## 1  0 17.15
## 2  1 24.39
```

The mean transmission for manual is 7.24mpg higher than automatic. Let alpha=0.5.

```
auto <- mtcars[mtcars$am == 0,]
manual <- mtcars[mtcars$am == 1,]
t.test(auto$mpg, manual$mpg)
```

```
##
##  Welch Two Sample t-test
##
## data:  auto$mpg and manual$mpg
## t = -3.767, df = 18.33, p-value = 0.001374
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -11.28  -3.21
## sample estimates:
## mean of x mean of y
##     17.15     24.39
```

Since p-value = 0.001374, we reject the null hypothesis. There is a major difference between mpg of manual and automatic transmissions.

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

```
##
## Call:
## lm(formula = mpg ~ am, data = mtcars)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -9.392 -3.092 -0.297  3.244  9.508
##
```

```
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)    17.15       1.12   15.25  1.1e-15 ***
## am              7.24       1.76    4.11  0.00029 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.9 on 30 degrees of freedom
## Multiple R-squared:  0.36,   Adjusted R-squared:  0.338
## F-statistic: 16.9 on 1 and 30 DF,  p-value: 0.000285
```

From the above, we may conclude that automatic run at 17.15mpg, while manual have 7.24 more mpg.

Also, R^2 is 0.36, hence the model only accounts for 36% variance.

Performing multivariate linear regression:

```
model <- lm(mpg~am + wt + hp + cyl, data = mtcars)
anova(m,model)
```

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ am + wt + hp + cyl
##   Res.Df RSS Df Sum of Sq    F  Pr(>F)
## 1     30 721
## 2     27 170  3       551 29.2 1.3e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The final model is below:

```
summary(model)
```

```
##
## Call:
## lm(formula = mpg ~ am + wt + hp + cyl, data = mtcars)
##
## Residuals:
##    Min     1Q Median     3Q    Max
```

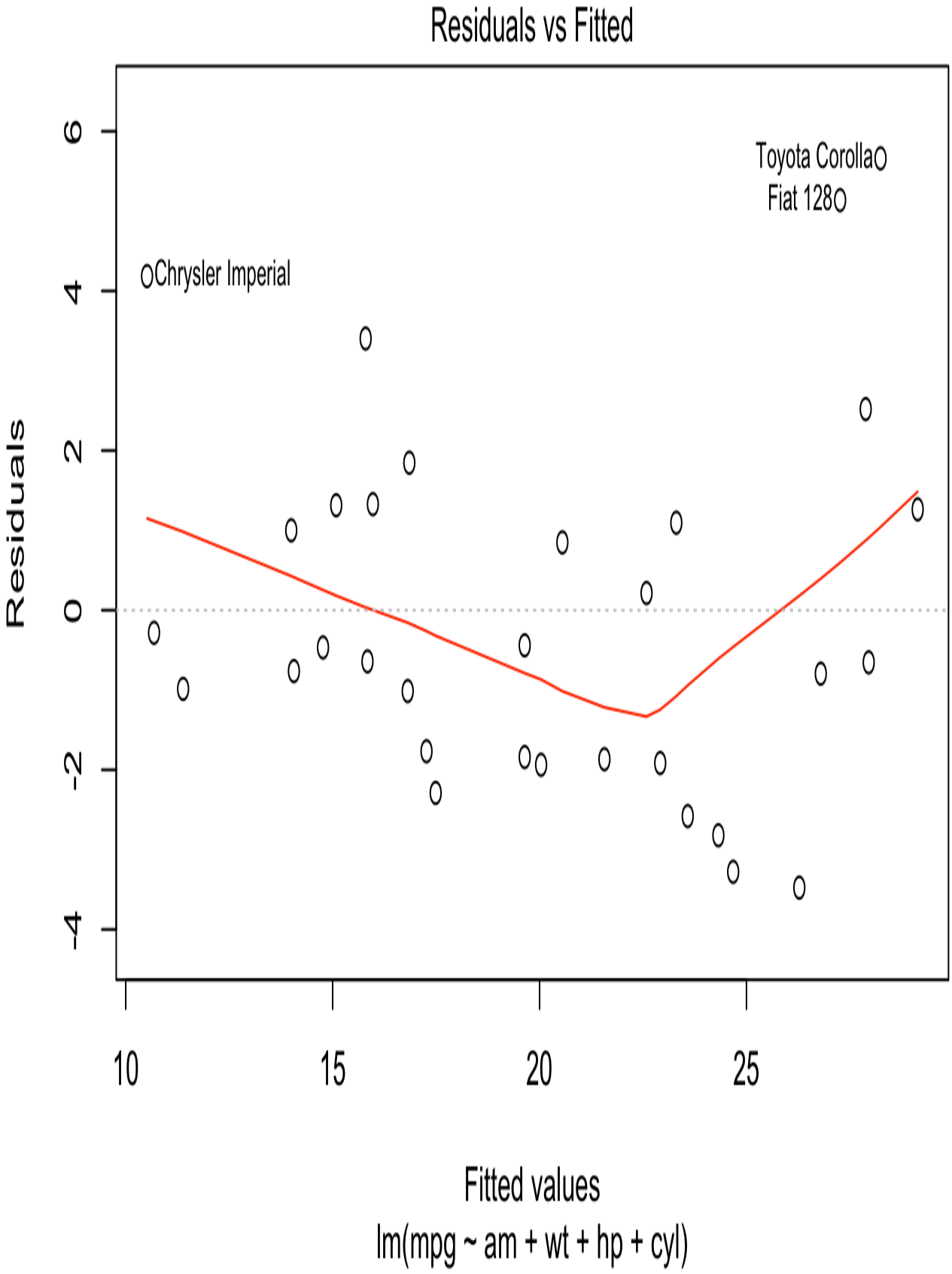
```
## -3.476 -1.847 -0.554  1.276  5.661

##

## Coefficients:

##             Estimate Std. Error t value Pr(>|t|)

## (Intercept)  36.1465     3.1048   11.64  4.9e-12 ***

## am            1.4780     1.4411    1.03   0.3142

## wt           -2.6065     0.9198   -2.83   0.0086 **

## hp           -0.0250     0.0136   -1.83   0.0786 .

## cyl          -0.7452     0.5828   -1.28   0.2119

## ---

## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##

## Residual standard error: 2.51 on 27 degrees of freedom

## Multiple R-squared:  0.849,  Adjusted R-squared:  0.827

## F-statistic:   38 on 4 and 27 DF,  p-value: 1.02e-10
```

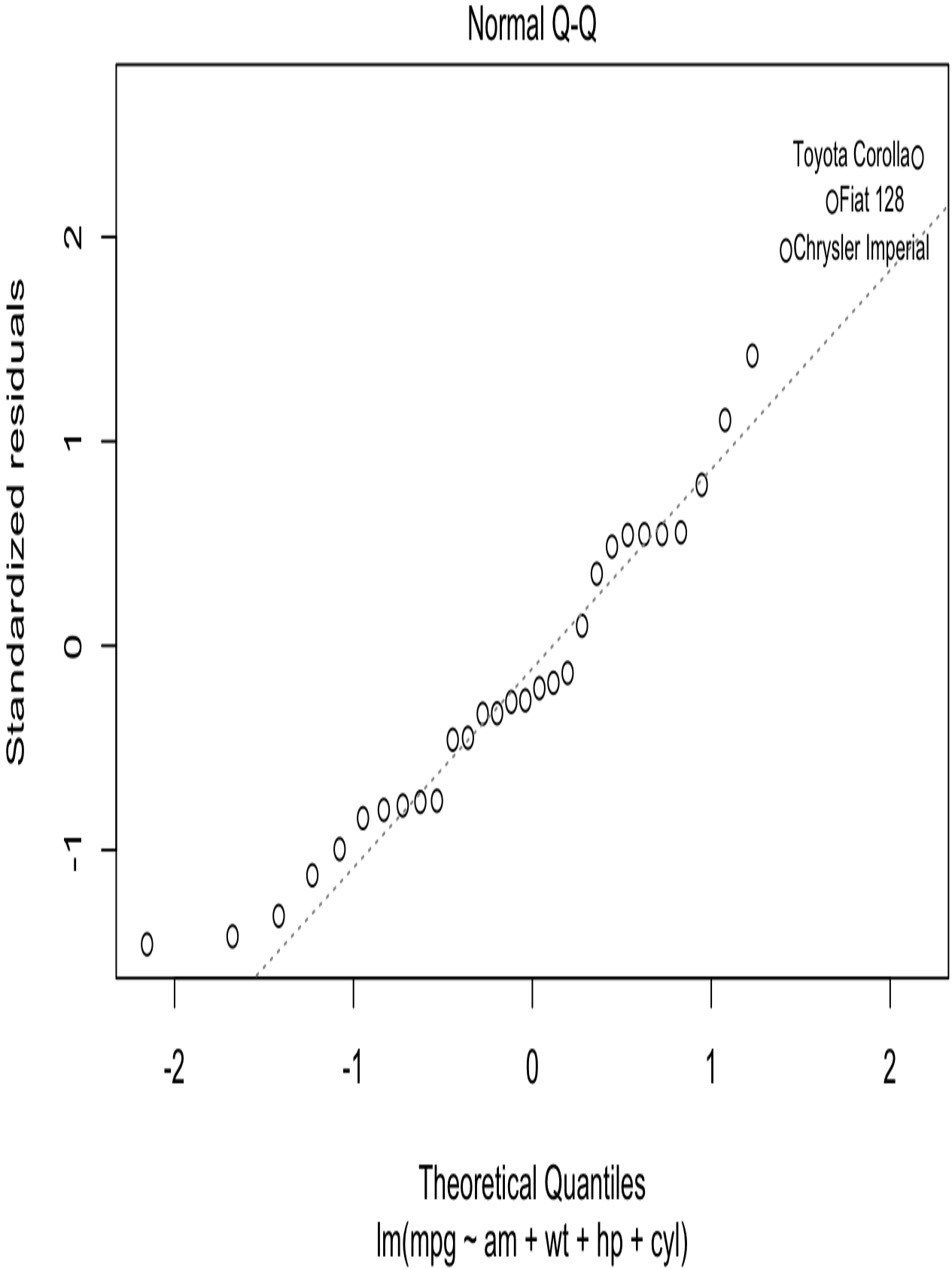
Conclusion

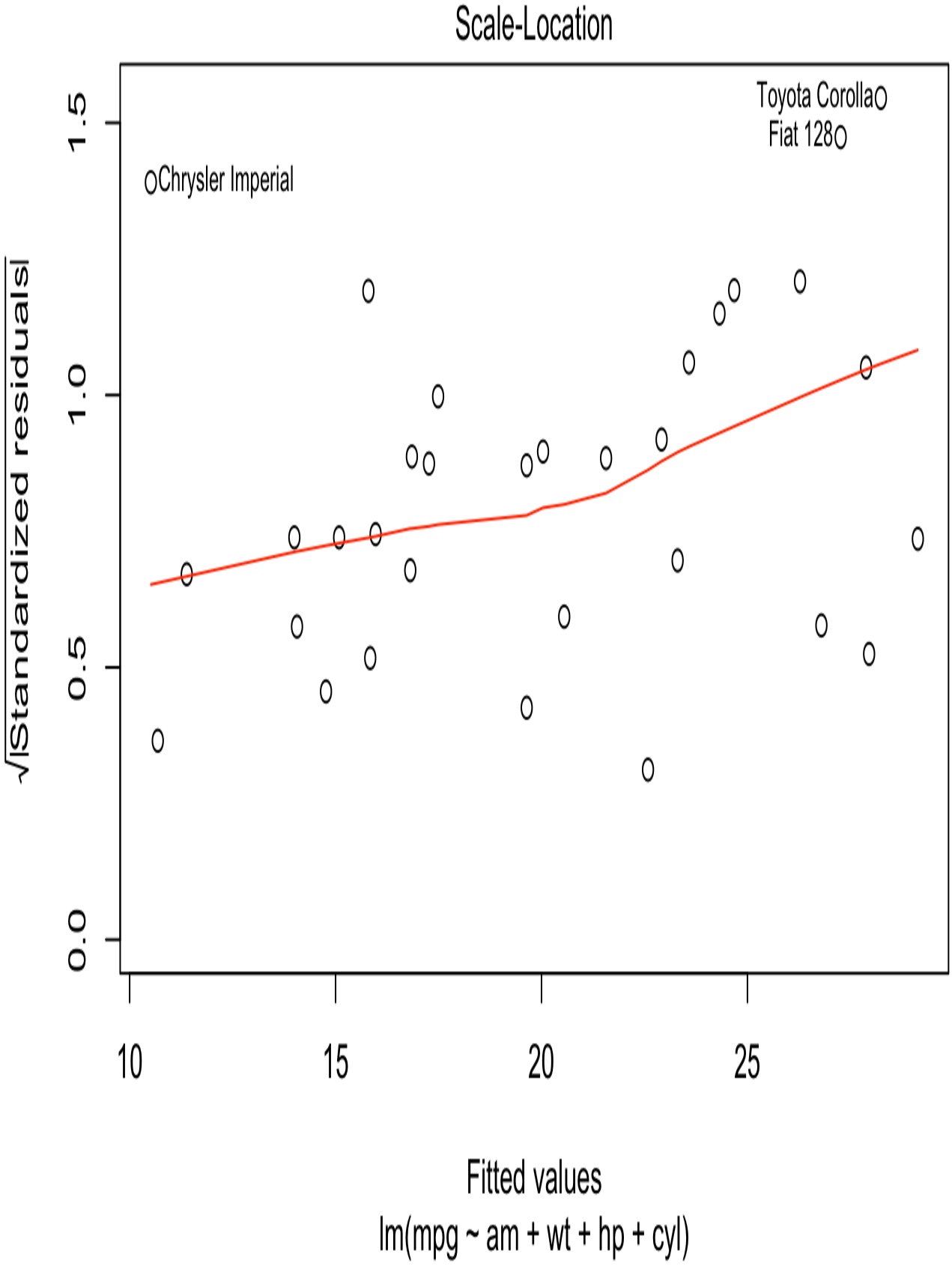
This model explains 84.9% of the variance. It may be concluded that on average, manual transmissions have 1.478 more mpg than automatic.

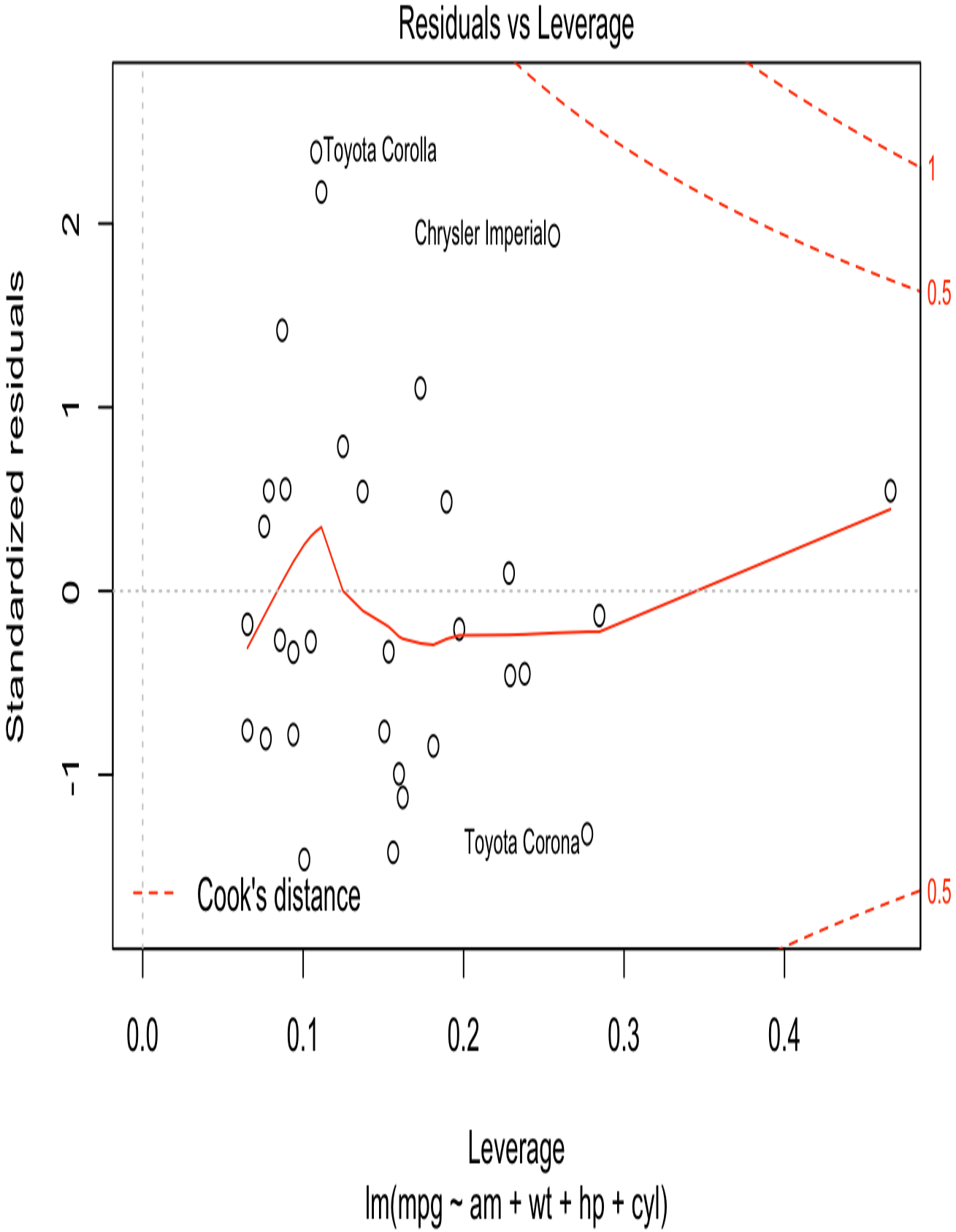
APPENDIX

```
plot(model)
```


Residuals vs Fitted
Toyota Corolla
Fiat 128
Chrysler Imperial
Residuals
6
4
2
0
-2
-4
10
15
20
25
Fitted values
lm(mpg ~ am + wt + hp + cyl)


Normal Q-Q
Toyota Corolla
Fiat 128
Chrysler Imperial
Standardized residuals
2
1
0
-1
-2
-1
0
1
2
Theoretical Quantiles
lm(mpg ~ am + wt + hp + cyl)


Scale-Location
Toyota Corolla
Fiat 128
Chrysler Imperial
√|Standardized residuals|
0.0
0.5
1.0
1.5
10
15
20
25
Fitted values
lm(mpg ~ am + wt + hp + cyl)


Residuals vs Leverage
Toyota Corolla
Chrysler Imperial
Toyota Corona
Cook's distance
1
0.5
0.5
Standardized residuals
2
1
0
-1
0.0
0.1
0.2
0.3
0.4
Leverage
lm(mpg ~ am + wt + hp + cyl)

Hence, the residuals are normally distributed, and homoskedastic.