STAT 526 HW 1

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Summary

Analysis

Appendix

Library import

```
library("tidyverse")
library("dplyr")
library("car")
library("ggplot2")
library("reshape2")
library("caTools")
library("Rcmdr")
library("MASS")
```

data import

```
data(Cars93, package = "MASS")
```

data display

```
View(Cars93)
# number of rows
nrow(Cars93)
```

```
## [1] 93
```

```
# data type of each column
str(Cars93)
```

```
## 'data.frame':    93 obs. of  27 variables:
##  $ Manufacturer      : Factor w/ 32 levels "Acura","Audi",..: 1 1 2 2 3 4 4 4 4 5 ...
##  $ Model             : Factor w/ 93 levels "100","190E","240",..: 49 56 9 1 6 24 54 74 73 35 ...
##  $ Type              : Factor w/ 6 levels "Compact","Large",..: 4 3 1 3 3 3 2 2 3 2 ...
##  $ Min.Price         : num  12.9 29.2 25.9 30.8 23.7 14.2 19.9 22.6 26.3 33 ...
```

```
##  $ Price             : num  15.9 33.9 29.1 37.7 30 15.7 20.8 23.7 26.3 34.7 ...
##  $ Max.Price         : num  18.8 38.7 32.3 44.6 36.2 17.3 21.7 24.9 26.3 36.3 ...
##  $ MPG.city          : int  25 18 20 19 22 22 19 16 19 16 ...
##  $ MPG.highway       : int  31 25 26 26 30 31 28 25 27 25 ...
##  $ AirBags           : Factor w/ 3 levels "Driver & Passenger",..: 3 1 2 1 2 2 2 2 2 2 ...
##  $ DriveTrain        : Factor w/ 3 levels "4WD","Front",..: 2 2 2 2 3 2 2 3 2 2 ...
##  $ Cylinders         : Factor w/ 6 levels "3","4","5","6",..: 2 4 4 4 2 2 4 4 4 5 ...
##  $ EngineSize        : num  1.8 3.2 2.8 2.8 3.5 2.2 3.8 5.7 3.8 4.9 ...
##  $ Horsepower        : int  140 200 172 172 208 110 170 180 170 200 ...
##  $ RPM               : int  6300 5500 5500 5500 5700 5200 4800 4000 4800 4100 ...
##  $ Rev.per.mile      : int  2890 2335 2280 2535 2545 2565 1570 1320 1690 1510 ...
##  $ Man.trans.avail   : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 1 1 1 1 1 ...
##  $ Fuel.tank.capacity: num  13.2 18 16.9 21.1 21.1 16.4 18 23 18.8 18 ...
##  $ Passengers        : int  5 5 5 6 4 6 6 6 5 6 ...
##  $ Length            : int  177 195 180 193 186 189 200 216 198 206 ...
##  $ Wheelbase         : int  102 115 102 106 109 105 111 116 108 114 ...
##  $ Width             : int  68 71 67 70 69 69 74 78 73 73 ...
##  $ Turn.circle       : int  37 38 37 37 39 41 42 45 41 43 ...
##  $ Rear.seat.room    : num  26.5 30 28 31 27 28 30.5 30.5 26.5 35 ...
##  $ Luggage.room      : int  11 15 14 17 13 16 17 21 14 18 ...
##  $ Weight            : int  2705 3560 3375 3405 3640 2880 3470 4105 3495 3620 ...
##  $ Origin            : Factor w/ 2 levels "USA","non-USA": 2 2 2 2 2 1 1 1 1 1 ...
##  $ Make              : Factor w/ 93 levels "Acura Integra",..: 1 2 4 3 5 6 7 9 8 10 ...
```

```
# if there is null values in the dataset
# is.na(Cars93)
# name of the columns in the dataset
names(Cars93)
```

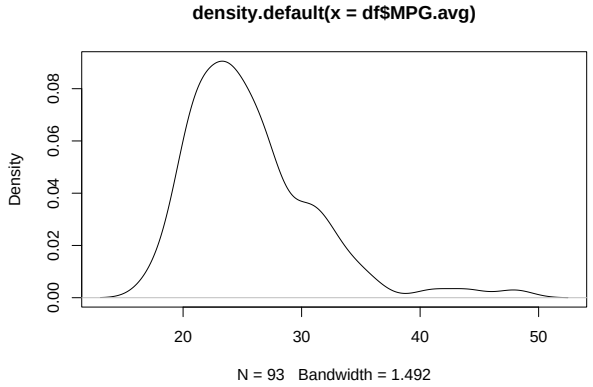
```
##  [1] "Manufacturer"       "Model"              "Type"
##  [4] "Min.Price"          "Price"              "Max.Price"
##  [7] "MPG.city"           "MPG.highway"        "AirBags"
## [10] "DriveTrain"         "Cylinders"          "EngineSize"
## [13] "Horsepower"         "RPM"                "Rev.per.mile"
## [16] "Man.trans.avail"    "Fuel.tank.capacity" "Passengers"
## [19] "Length"             "Wheelbase"          "Width"
## [22] "Turn.circle"        "Rear.seat.room"     "Luggage.room"
## [25] "Weight"             "Origin"             "Make"
```

create the response variable "MPG.avg" by averaging "MPG.city" and "MPG.highway"

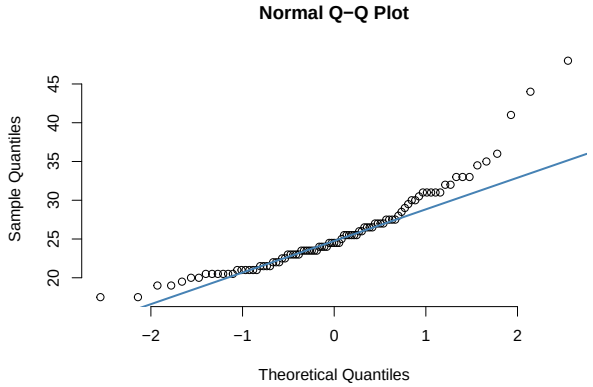
```
df <- Cars93 %>%
        mutate(MPG.avg = (Cars93$MPG.highway + Cars93$MPG.city) / 2)
```

check the distribution of response (histogram, qq-plot) → box-cox

```
plot(density(df$MPG.avg))
```




```
qqnorm(df$MPG.avg, pch = 1, frame = FALSE)
qqline(df$MPG.avg, col = "steelblue", lwd = 2)
```



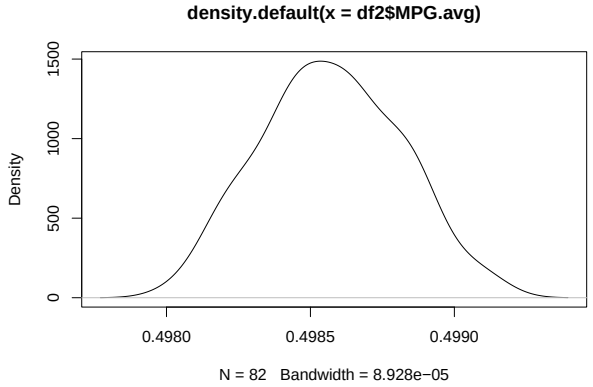
box-cox

```
## there is no 0 in MPG.avg
min(df$MPG.avg); max(df$MPG.avg)
```

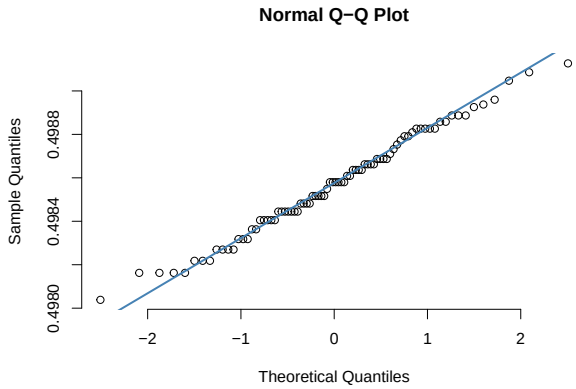
```
## [1] 17.5
```

```
## [1] 48
```

```
df2 <- df %>%
        na.omit() %>%
        mutate(Cylinders = as.numeric(.$Cylinders)) %>%
        subset(select = -c(MPG.city, MPG.highway, Min.Price, Max.Price, Manufacturer, Model, Make))

# boxcox
p1 <- powerTransform(df2$MPG.avg)
df2$MPG.avg <- bcPower(df2$MPG.avg, p1$lambda)

# ggplot(data = df2, aes(x = (MPG.avg^lambda -1)/lambda)) + geom_histogram(fill = "blue", bins = 15)

# plot again
plot(density(df2$MPG.avg))
```

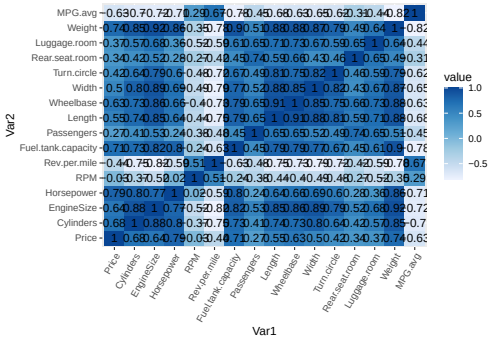



```
qqnorm(df2$MPG.avg, pch = 1, frame = FALSE)
qqline(df2$MPG.avg, col = "steelblue", lwd = 2)
```



check the Pairwise Pearson Correlations From the Person Correlation matrix, there appears to be a significant amount of correlated relations between the predictor variables. It will thus be necessary to ensure that multicollinearity can be a concern later in my model.

```
df %>%
    na.omit() %>%
    mutate(Cylinders = as.numeric(.$Cylinders)) %>%
    subset(select = -c(MPG.city, MPG.highway, Min.Price, Max.Price, Manufacturer, Model, Make)) %>%
    # remove the non-numerical variables
    # https://bit.ly/3ZXRAMH
    .[, colnames(.)[!grepl("factor|logical|character", sapply(., class))]] %>%
    cor(., ) %>%
    round(., 2) %>%
    melt() %>%
    ggplot(., aes(x = Var1, y = Var2, fill = value)) +
        geom_tile() +
        scale_fill_distiller(direction = +1) +
        geom_text(aes(Var2, Var1, label = value), color = "black", size = 4) +
        theme(axis.text.x = element_text(angle = 60, hjust = 1))
```



Linear Models to grasp the trend

```
# simple linear model
# I use my intuition for now. Simply, I suppose the size of a car and engine and fuel tank are correlat
simple <- lm(MPG.avg ~ Weight + Width + Length +
                     Fuel.tank.capacity + Horsepower,
                     data = df2
                     )
# Only weight is significant
summary(simple)
```

```
##
## Call:
## lm(formula = MPG.avg ~ Weight + Width + Length + Fuel.tank.capacity +
##     Horsepower, data = df2)
##
## Residuals:
##        Min          1Q      Median          3Q         Max
## -2.840e-04 -7.125e-05  5.640e-06  6.970e-05  3.739e-04
##
## Coefficients:
##                       Estimate Std. Error  t value Pr(>|t|)
## (Intercept)          4.991e-01  3.568e-04 1398.637  < 2e-16 ***
## Weight              -3.337e-07  8.790e-08   -3.797 0.000293 ***
## Width                7.138e-06  7.763e-06    0.920 0.360736
## Length               2.018e-06  2.150e-06    0.938 0.351016
## Fuel.tank.capacity -1.808e-05  9.370e-06   -1.930 0.057356 .
## Horsepower         -5.212e-07  5.308e-07   -0.982 0.329205
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0001096 on 76 degrees of freedom
## Multiple R-squared:  0.8035, Adjusted R-squared:  0.7906
## F-statistic: 62.17 on 5 and 76 DF,  p-value: < 2.2e-16
```

```
# Regression Diagnostics
simple.infl <- influence.measures(simple)
print(simple.infl)
```

```
## Influence measures of
##   lm(formula = MPG.avg ~ Weight + Width + Length + Fuel.tank.capacity +      Horsepower, data = df2)
```

```
##
##      dfb.1_  dfb.Wght  dfb.Wdth  dfb.Lngt  dfb.Fl..  dfb.Hrsp     dffit cov.r
## 1  -0.00291 -0.003981  0.003231  4.16e-03 -1.35e-02  0.011878  0.021061 1.139
## 2  -0.03922 -0.038322  0.057077 -3.42e-02  6.75e-02 -0.057516 -0.161980 1.074
## 3   0.03401  0.033043 -0.024501 -1.26e-02 -1.21e-02 -0.010293  0.042694 1.203
## 4   0.00406 -0.006395 -0.006880  1.71e-03  2.37e-02 -0.002894  0.028336 1.188
## 5   0.78121  0.396986 -0.541030 -4.45e-01  6.48e-01 -0.143391  1.385759 0.392
## 6  -0.00207 -0.003273 -0.001105  4.77e-03  3.65e-03 -0.002295  0.009910 1.123
## 7  -0.01873 -0.004127  0.014293  1.91e-03 -3.73e-03  0.001326  0.025551 1.130
## 8   0.04453 -0.007155 -0.035364  1.76e-02 -3.79e-02  0.045426 -0.090020 1.261
## 9  -0.00604 -0.000409  0.004426 -4.55e-04  1.99e-03 -0.001805  0.011987 1.115
## 10  0.12551  0.098639  0.089963 -3.50e-01  2.39e-01 -0.269171 -0.551171 0.850
## 11  0.01316  0.038438  0.003277 -3.46e-02  2.35e-02 -0.090958 -0.105044 1.351
## 12 -0.00401 -0.128965 -0.059613  1.35e-01  6.31e-02  0.071275  0.180989 1.152
## 13 -0.00763 -0.044712 -0.032713  7.44e-02  4.09e-02 -0.028448  0.165135 1.018
## 14  0.21283  0.025240 -0.214811  3.19e-02  1.46e-01 -0.048817 -0.302083 1.107
## 15  0.00288 -0.004340  0.001808 -5.20e-03  2.65e-03  0.009416 -0.016841 1.150
## 18 -0.05522 -0.015812  0.037774 -6.30e-03  6.40e-02 -0.042587  0.106168 1.266
## 20 -0.06130  0.012670  0.038467  1.04e-02 -1.99e-02 -0.033584  0.106821 1.120
## 21  0.04087  0.040997 -0.035246 -3.68e-03 -2.05e-02 -0.018772  0.067589 1.095
## 22 -0.02616 -0.033028  0.038500 -2.20e-02  3.27e-02  0.013261 -0.057258 1.341
## 23  0.01353  0.040009 -0.002818 -2.90e-02 -7.32e-03 -0.021792 -0.054630 1.145
## 24 -0.03978 -0.102669 -0.022474  9.83e-02  2.90e-02  0.119374 -0.180079 1.058
## 25 -0.05438 -0.107221  0.026804  6.05e-02 -1.35e-02  0.141296 -0.165121 1.103
## 27 -0.04536 -0.112456  0.089273 -5.21e-02  3.32e-02  0.163849 -0.244047 1.074
## 28  0.02801 -0.004328  0.058439 -1.24e-01 -2.73e-02  0.184171  0.320464 1.405
## 29  0.00719  0.022748 -0.001068 -1.71e-02 -3.42e-03 -0.012099 -0.032969 1.139
## 30 -0.13203 -0.132708  0.068526  1.04e-01 -5.01e-02  0.175198  0.237000 1.150
## 31 -0.04109 -0.087678 -0.224677  3.66e-01  4.20e-02  0.078692 -0.499691 1.144
## 32  0.02825  0.068342 -0.057731 -3.19e-03  7.19e-02 -0.109626 -0.204869 1.037
## 33  0.04428  0.027770 -0.087017  9.34e-02 -1.84e-01  0.166242 -0.314834 0.938
## 34 -0.01590 -0.037753  0.004192  2.24e-02 -4.54e-03  0.060782 -0.085406 1.089
## 35  0.03659  0.025100 -0.042326  1.32e-02 -1.77e-02  0.001586 -0.055038 1.134
## 37  0.00555  0.123312 -0.001764 -2.44e-02 -1.09e-01 -0.083723  0.180788 1.082
## 38 -0.09474  0.010512  0.082074 -1.97e-02 -1.68e-02 -0.027066  0.132236 1.194
## 39 -0.03907 -0.128010  0.102475 -4.38e-02  5.09e-02  0.046904  0.272119 1.136
## 40 -0.01082  0.104918  0.130948 -1.84e-01 -8.58e-02 -0.096168  0.267816 1.080
## 41 -0.09301 -0.080777  0.151456 -9.08e-02  2.81e-02  0.081506  0.212342 1.090
## 42 -0.19224 -0.245876  0.162961  1.74e-01 -2.54e-01  0.255109  0.584130 0.761
## 43  0.19143  0.037186 -0.238638  1.10e-01  6.93e-02 -0.027578  0.305135 0.948
## 44  0.00944  0.004398 -0.009244  3.75e-03 -5.69e-03 -0.001617  0.014284 1.159
## 45 -0.07479 -0.006332  0.046265 -1.19e-02  7.23e-02 -0.056255 -0.185670 1.002
## 46 -0.03707  0.000785  0.029003 -1.82e-02  3.51e-02 -0.016597 -0.090614 1.114
## 47  0.06520  0.137368 -0.038727 -3.13e-02 -1.93e-01  0.012431 -0.262830 0.958
## 48 -0.05888  0.052775  0.079567 -3.88e-02 -6.68e-02 -0.147677 -0.255823 1.221
## 49 -0.12884 -0.152085  0.078798  9.46e-02  9.61e-03  0.045969 -0.254044 1.004
## 50 -0.00638  0.172268  0.017242 -1.85e-02 -2.03e-01 -0.216989 -0.393119 1.025
## 51  0.00542 -0.112712  0.037354 -2.88e-02  7.00e-02  0.098381 -0.211357 1.093
## 52 -0.12219 -0.002253  0.033426  9.65e-02 -8.42e-02  0.028096  0.246257 1.145
## 53 -0.00990 -0.002280  0.063162 -7.42e-02  2.41e-02 -0.042432  0.142242 1.096
## 54 -0.00175 -0.095501  0.002503  3.07e-02  7.50e-02  0.029414  0.167762 1.048
## 55 -0.04334 -0.157084 -0.004913  1.52e-01 -1.25e-01  0.284481  0.377052 0.817
## 58 -0.09066 -0.117612  0.042082  6.07e-02  8.06e-02  0.048424 -0.158141 1.077
## 59  0.00032  0.000132 -0.000278 -6.29e-06 -7.29e-05  0.000221  0.000562 1.163
```

```
## 60 -0.27439 -0.342477  0.097393  1.04e-01  6.00e-01  0.005835 -0.778073 0.640
## 61  0.00469 -0.056035 -0.007856  2.46e-02  1.82e-02  0.059919 -0.080343 1.173
## 62  0.01825  0.027136 -0.016957 -7.91e-03 -5.53e-03 -0.011487 -0.040102 1.140
## 63 -0.07561 -0.088653  0.053435  4.00e-02  2.36e-02  0.024292 -0.122930 1.164
## 64  0.03905  0.021743 -0.006342 -1.91e-02 -5.40e-02  0.006436  0.128945 1.058
## 65  0.17065  0.100589 -0.159846  2.28e-02 -6.26e-02  0.003920  0.227726 0.997
## 67 -0.00616  0.003841  0.008647 -3.77e-03 -1.38e-02 -0.000423 -0.022464 1.117
## 68  0.05899 -0.073698 -0.141176  1.89e-01 -6.36e-02  0.136827  0.235429 1.119
## 69 -0.02481 -0.022337  0.010106  1.89e-02  2.02e-02 -0.011155  0.052264 1.123
## 71 -0.01601 -0.004509  0.011127  3.66e-03 -3.33e-03  0.001983  0.021863 1.131
## 72 -0.00797 -0.005133 -0.014326  4.14e-02 -6.21e-02  0.058536 -0.100522 1.124
## 73 -0.02418 -0.098882 -0.035046  1.37e-01  1.08e-02 -0.009041  0.254159 1.027
## 74 -0.01570  0.068428  0.054705 -8.64e-02 -3.88e-02 -0.033047 -0.122861 1.122
## 75  0.32390  0.085261 -0.303094  7.34e-03  1.72e-01 -0.085180 -0.411218 1.119
## 76  0.00868  0.000486 -0.002707 -1.26e-02  3.32e-02 -0.027966 -0.050081 1.155
## 77 -0.08457  0.171206  0.262331 -3.62e-01  6.29e-04 -0.155811  0.398281 1.370
## 78 -0.02491  0.426112  0.175351 -2.98e-01 -4.46e-01 -0.198513 -0.624783 0.914
## 79 -0.06264 -0.011342  0.069471 -5.79e-04 -5.59e-02 -0.028272  0.161485 1.078
## 80  0.08874  0.074018 -0.041082 -4.48e-02 -6.34e-02 -0.020277  0.126750 1.278
## 81 -0.02526  0.030985  0.034984 -2.46e-02 -6.51e-02  0.016288 -0.095313 1.153
## 82  0.17813  0.203239 -0.123686 -8.01e-02 -5.10e-02 -0.136226  0.251225 1.054
## 83  0.03332 -0.061187 -0.025304  5.66e-02 -5.09e-02  0.056942  0.204440 1.098
## 84 -0.00354 -0.008512  0.005693  4.05e-05  1.16e-03  0.004695  0.015581 1.152
## 85  0.00262  0.122713  0.150298 -2.69e-01  2.17e-02 -0.118753  0.319176 0.950
## 86 -0.02456 -0.037214  0.015700  1.42e-03  7.81e-02 -0.022465  0.094853 1.131
## 88 -0.10503 -0.019959  0.076670 -5.89e-03  1.13e-02  0.016863 -0.169276 1.080
## 90  0.06918 -0.005309 -0.059826 -1.80e-02  1.35e-01 -0.049302  0.173795 1.128
## 91 -0.26427  0.167941 -0.170541  6.57e-01 -7.27e-01 -0.149748 -1.164180 0.860
## 92 -0.08819 -0.042607  0.145795 -1.10e-01  2.33e-02  0.046123 -0.191806 1.114
## 93  0.04010 -0.006531 -0.023482 -3.51e-02  1.04e-01 -0.013898  0.141331 1.107
##      cook.d    hat inf
## 1  7.49e-05 0.0500
## 2  4.39e-03 0.0407
## 3  3.08e-04 0.1009
## 4  1.36e-04 0.0894
## 5  2.69e-01 0.1097   *
## 6  1.66e-05 0.0360
## 7  1.10e-04 0.0429
## 8  1.37e-03 0.1446   *
## 9  2.43e-05 0.0290
## 10 4.87e-02 0.0699
## 11 1.86e-03 0.2015   *
## 12 5.51e-03 0.0857
## 13 4.54e-03 0.0244
## 14 1.52e-02 0.0907
## 15 4.79e-05 0.0590
## 18 1.90e-03 0.1492   *
## 20 1.92e-03 0.0497
## 21 7.70e-04 0.0252
## 22 5.54e-04 0.1934   *
## 23 5.04e-04 0.0579
## 24 5.42e-03 0.0394
## 25 4.58e-03 0.0545
## 27 9.94e-03 0.0619
```

```
## 28 1.73e-02 0.2482   *
## 29 1.84e-04 0.0512
## 30 9.42e-03 0.0968
## 31 4.14e-02 0.1522
## 32 6.99e-03 0.0387
## 33 1.62e-02 0.0406
## 34 1.23e-03 0.0264
## 35 5.11e-04 0.0495
## 37 5.47e-03 0.0486
## 38 2.95e-03 0.1043
## 39 1.24e-02 0.0974
## 40 1.20e-02 0.0703
## 41 7.54e-03 0.0605
## 42 5.38e-02 0.0598   *
## 43 1.53e-02 0.0405
## 44 3.45e-05 0.0661
## 45 5.72e-03 0.0257
## 46 1.38e-03 0.0421
## 47 1.14e-02 0.0337
## 48 1.10e-02 0.1410
## 49 1.07e-02 0.0415
## 50 2.55e-02 0.0806
## 51 7.48e-03 0.0617
## 52 1.02e-02 0.0961
## 53 3.40e-03 0.0451
## 54 4.70e-03 0.0329
## 55 2.28e-02 0.0339
## 58 4.19e-03 0.0408
## 59 5.34e-08 0.0693
## 60 9.25e-02 0.0713   *
## 61 1.09e-03 0.0824
## 62 2.71e-04 0.0522
## 63 2.55e-03 0.0826
## 64 2.78e-03 0.0260
## 65 8.59e-03 0.0340
## 67 8.52e-05 0.0322
## 68 9.28e-03 0.0802
## 69 4.61e-04 0.0406
## 71 8.07e-05 0.0439
## 72 1.70e-03 0.0513
## 73 1.07e-02 0.0479
## 74 2.54e-03 0.0551
## 75 2.81e-02 0.1218
## 76 4.23e-04 0.0651
## 77 2.66e-02 0.2407   *
## 78 6.30e-02 0.0999
## 79 4.37e-03 0.0420
## 80 2.71e-03 0.1587   *
## 81 1.53e-03 0.0702
## 82 1.05e-02 0.0560
## 83 7.00e-03 0.0621
## 84 4.10e-05 0.0602
## 85 1.67e-02 0.0437
## 86 1.52e-03 0.0543
```

```
## 88 4.80e-03 0.0450
## 90 5.07e-03 0.0703
## 91 2.13e-01 0.1911   *
## 92 6.17e-03 0.0672
## 93 3.36e-03 0.0509
```

```
# check the vif. In fact, Weight has the highest vif (16.69)
vif(simple)
```

```
##             Weight              Width             Length Fuel.tank.capacity
##          16.692146           5.546023           7.275453           5.366428
##         Horsepower
##           4.953250
```

```
# get rid of the weight parameter
simple_v2 <- lm(MPG.avg ~ Width + Length +
                    Fuel.tank.capacity + Horsepower,
                    data = df2
                    )
# Indeed, Fuel.tank.capacity and Horsepower became significant. Yet, this model is not preferrable in t
summary(simple_v2)
```

```
##
## Call:
## lm(formula = MPG.avg ~ Width + Length + Fuel.tank.capacity +
##     Horsepower, data = df2)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -3.329e-04 -8.941e-05  1.314e-05  7.026e-05  3.344e-04
##
## Coefficients:
##                      Estimate Std. Error  t value Pr(>|t|)
## (Intercept)         4.998e-01  3.323e-04 1503.792  < 2e-16 ***
## Width              -3.313e-07  8.137e-06   -0.041 0.967632
## Length             -2.040e-06  2.022e-06   -1.009 0.316263
## Fuel.tank.capacity -3.361e-05  9.135e-06   -3.680 0.000431 ***
## Horsepower         -1.820e-06  4.398e-07   -4.137 8.89e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0001187 on 77 degrees of freedom
## Multiple R-squared:  0.7663, Adjusted R-squared:  0.7541
## F-statistic: 63.11 on 4 and 77 DF,  p-value: < 2.2e-16
```

```
# check the vif. There are none high vif variables
vif(simple_v2)
```

```
##             Width             Length Fuel.tank.capacity         Horsepower
##          5.189839           5.478482           4.343808           2.896575
```

stepwise with AIC and BIC

```r
# use stepwise methods based on AIC and BIC
m1 <- lm(data = df2, MPG.avg ~ .)
M1_BIC <- stepwise(m1, direction = "forward/backward", criterion = "BIC")
```

```
##
## Direction:  forward/backward
## Criterion:  BIC
##
## Start:  AIC=-1363.87
## MPG.avg ~ 1
##
##                       Df  Sum of Sq        RSS     AIC
## + Weight               1 3.5969e-06 1.0487e-06 -1481.5
## + Fuel.tank.capacity   1 3.2658e-06 1.3799e-06 -1459.0
## + Cylinders            1 3.1450e-06 1.5006e-06 -1452.1
## + EngineSize           1 3.1017e-06 1.5439e-06 -1449.8
## + Horsepower           1 3.0577e-06 1.5879e-06 -1447.5
## + Price                1 2.6052e-06 2.0404e-06 -1426.9
## + Type                 4 2.7563e-06 1.8893e-06 -1420.0
## + Length               1 2.4066e-06 2.2390e-06 -1419.3
## + Width                1 2.3643e-06 2.2814e-06 -1417.8
## + Wheelbase            1 2.2472e-06 2.3985e-06 -1413.7
## + Rev.per.mile         1 2.1306e-06 2.5150e-06 -1409.8
## + Turn.circle          1 1.9762e-06 2.6695e-06 -1404.9
## + Man.trans.avail      1 1.1600e-06 3.4856e-06 -1383.0
## + Luggage.room         1 1.0447e-06 3.6010e-06 -1380.3
## + AirBags              2 1.0519e-06 3.5937e-06 -1376.1
## + Passengers           1 8.2490e-07 3.8207e-06 -1375.5
## + Rear.seat.room       1 6.5460e-07 3.9910e-06 -1371.9
## + DriveTrain           2 7.4690e-07 3.8987e-06 -1369.4
## + RPM                  1 3.6850e-07 4.2771e-06 -1366.2
## <none>                              4.6456e-06 -1363.9
## + Origin               1 1.7970e-07 4.4659e-06 -1362.7
##
## Step:  AIC=-1481.51
## MPG.avg ~ Weight
##
##                       Df  Sum of Sq        RSS     AIC
## + Wheelbase            1 1.2320e-07 9.2550e-07 -1487.3
## + Price                1 1.0170e-07 9.4700e-07 -1485.5
## + Cylinders            1 1.0160e-07 9.4720e-07 -1485.5
## + Length               1 6.0600e-08 9.8820e-07 -1482.0
## + Luggage.room         1 5.8500e-08 9.9020e-07 -1481.8
## <none>                              1.0487e-06 -1481.5
## + Horsepower           1 5.3700e-08 9.9500e-07 -1481.4
## + Fuel.tank.capacity   1 5.2700e-08 9.9600e-07 -1481.3
## + Width                1 4.9900e-08 9.9890e-07 -1481.1
## + Man.trans.avail      1 2.2700e-08 1.0261e-06 -1478.9
## + Turn.circle          1 1.9700e-08 1.0291e-06 -1478.7
## + Rear.seat.room       1 1.6600e-08 1.0321e-06 -1478.4
## + Passengers           1 4.7000e-09 1.0440e-06 -1477.5
## + RPM                  1 3.3000e-09 1.0455e-06 -1477.4
## + EngineSize           1 3.2000e-09 1.0456e-06 -1477.3
```

```
## + Rev.per.mile        1 1.9000e-09 1.0468e-06 -1477.2
## + Origin              1 1.4000e-09 1.0473e-06 -1477.2
## + AirBags             2 3.7300e-08 1.0114e-06 -1475.7
## + DriveTrain          2 1.8000e-09 1.0470e-06 -1472.8
## + Type                4 7.6100e-08 9.7260e-07 -1470.1
## - Weight              1 3.5969e-06 4.6456e-06 -1363.9
##
## Step:  AIC=-1487.35
## MPG.avg ~ Weight + Wheelbase
##
##                       Df  Sum of Sq        RSS     AIC
## + Cylinders            1 9.2680e-08 8.3282e-07 -1491.6
## + Price                1 8.8800e-08 8.3670e-07 -1491.2
## + Fuel.tank.capacity   1 5.4600e-08 8.7090e-07 -1487.9
## <none>                              9.2550e-07 -1487.3
## + EngineSize           1 2.6110e-08 8.9939e-07 -1485.3
## + Passengers           1 1.4050e-08 9.1145e-07 -1484.2
## + Horsepower           1 1.1400e-08 9.1409e-07 -1484.0
## + Width                1 1.0420e-08 9.1508e-07 -1483.9
## + Luggage.room         1 7.3800e-09 9.1811e-07 -1483.6
## + Rear.seat.room       1 6.5800e-09 9.1892e-07 -1483.5
## + Turn.circle          1 5.8900e-09 9.1961e-07 -1483.5
## + Length               1 1.6900e-09 9.2381e-07 -1483.1
## + Origin               1 1.4700e-09 9.2402e-07 -1483.1
## + RPM                  1 4.2000e-10 9.2508e-07 -1483.0
## + Rev.per.mile         1 4.0000e-11 9.2546e-07 -1483.0
## + Man.trans.avail      1 2.0000e-11 9.2548e-07 -1483.0
## + AirBags              2 4.2190e-08 8.8331e-07 -1482.4
## - Wheelbase            1 1.2325e-07 1.0487e-06 -1481.5
## + DriveTrain           2 1.5190e-08 9.1031e-07 -1479.9
## + Type                 4 4.6120e-08 8.7938e-07 -1473.9
## - Weight               1 1.4730e-06 2.3985e-06 -1413.7
##
## Step:  AIC=-1491.6
## MPG.avg ~ Weight + Wheelbase + Cylinders
##
##                       Df  Sum of Sq        RSS     AIC
## + Fuel.tank.capacity   1 7.4610e-08 7.5821e-07 -1494.9
## + Price                1 6.4180e-08 7.6864e-07 -1493.8
## <none>                              8.3282e-07 -1491.6
## + Width                1 4.0150e-08 7.9267e-07 -1491.2
## + Passengers           1 1.5610e-08 8.1721e-07 -1488.7
## + Luggage.room         1 1.5240e-08 8.1758e-07 -1488.7
## + Rev.per.mile         1 6.5300e-09 8.2629e-07 -1487.8
## + Rear.seat.room       1 4.4400e-09 8.2838e-07 -1487.6
## + Man.trans.avail      1 4.2100e-09 8.2861e-07 -1487.6
## + Turn.circle          1 3.5500e-09 8.2926e-07 -1487.5
## - Cylinders            1 9.2680e-08 9.2550e-07 -1487.3
## + Length               1 1.4500e-09 8.3137e-07 -1487.3
## + RPM                  1 8.6000e-10 8.3195e-07 -1487.3
## + Horsepower           1 8.4000e-10 8.3198e-07 -1487.3
## + EngineSize           1 2.0000e-11 8.3280e-07 -1487.2
## + Origin               1 0.0000e+00 8.3282e-07 -1487.2
## - Wheelbase            1 1.1436e-07 9.4718e-07 -1485.5
```

```
## + AirBags             2 2.6390e-08 8.0643e-07 -1485.4
## + Type                4 9.2140e-08 7.4067e-07 -1483.6
## + DriveTrain          2 6.6300e-09 8.2619e-07 -1483.4
## - Weight              1 5.8118e-07 1.4140e-06 -1452.6
##
## Step:  AIC=-1494.89
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity
##
##                       Df  Sum of Sq        RSS     AIC
## + Price                1 4.3942e-08 7.1427e-07 -1495.4
## <none>                              7.5821e-07 -1494.9
## + Width                1 3.7818e-08 7.2039e-07 -1494.7
## + Luggage.room         1 2.7203e-08 7.3101e-07 -1493.5
## + Passengers           1 1.8140e-08 7.4007e-07 -1492.5
## - Fuel.tank.capacity   1 7.4605e-08 8.3282e-07 -1491.6
## + Origin               1 4.9060e-09 7.5330e-07 -1491.0
## + Rear.seat.room       1 3.6240e-09 7.5459e-07 -1490.9
## + Length               1 1.5500e-09 7.5666e-07 -1490.7
## + Turn.circle          1 4.7100e-10 7.5774e-07 -1490.5
## + RPM                  1 2.0900e-10 7.5800e-07 -1490.5
## + Horsepower           1 1.4100e-10 7.5807e-07 -1490.5
## + Man.trans.avail      1 1.3500e-10 7.5808e-07 -1490.5
## + Rev.per.mile         1 1.2200e-10 7.5809e-07 -1490.5
## + EngineSize           1 6.3000e-11 7.5815e-07 -1490.5
## - Cylinders            1 1.1269e-07 8.7090e-07 -1487.9
## + AirBags              2 1.5281e-08 7.4293e-07 -1487.7
## - Wheelbase            1 1.1557e-07 8.7378e-07 -1487.7
## + DriveTrain           2 6.2620e-09 7.5195e-07 -1486.8
## + Type                 4 6.0867e-08 6.9734e-07 -1484.1
## - Weight               1 1.6390e-07 9.2211e-07 -1483.2
##
## Step:  AIC=-1495.38
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price
##
##                       Df  Sum of Sq        RSS     AIC
## <none>                              7.1427e-07 -1495.4
## - Price                1 4.3942e-08 7.5821e-07 -1494.9
## + Origin               1 3.2587e-08 6.8168e-07 -1494.8
## + Passengers           1 2.9341e-08 6.8493e-07 -1494.4
## - Fuel.tank.capacity   1 5.4371e-08 7.6864e-07 -1493.8
## + Luggage.room         1 1.3624e-08 7.0065e-07 -1492.5
## + Horsepower           1 1.2159e-08 7.0211e-07 -1492.4
## + Width                1 9.8340e-09 7.0444e-07 -1492.1
## + RPM                  1 9.5100e-09 7.0476e-07 -1492.1
## + Rev.per.mile         1 5.0770e-09 7.0919e-07 -1491.5
## + Rear.seat.room       1 3.7200e-09 7.1055e-07 -1491.4
## + Turn.circle          1 3.0280e-09 7.1124e-07 -1491.3
## + EngineSize           1 1.9850e-09 7.1228e-07 -1491.2
## + Length               1 1.1750e-09 7.1309e-07 -1491.1
## + Man.trans.avail      1 5.2000e-11 7.1422e-07 -1491.0
## + AirBags              2 3.5308e-08 6.7896e-07 -1490.7
## - Cylinders            1 8.5761e-08 8.0003e-07 -1490.5
## - Wheelbase            1 1.0719e-07 8.2146e-07 -1488.3
```

```
## + DriveTrain          2 4.1200e-09 7.1015e-07 -1487.0
## - Weight              1 1.3345e-07 8.4772e-07 -1485.7
## + Type                4 4.2409e-08 6.7186e-07 -1482.8
```

```
M1_AIC <- stepwise(m1, direction = "forward/backward", criterion = "AIC")
```

```
##
## Direction:  forward/backward
## Criterion:  AIC
##
## Start:  AIC=-1366.28
## MPG.avg ~ 1
##
##                       Df  Sum of Sq        RSS     AIC
## + Weight               1 3.5969e-06 1.0487e-06 -1486.3
## + Fuel.tank.capacity   1 3.2658e-06 1.3799e-06 -1463.8
## + Cylinders            1 3.1450e-06 1.5006e-06 -1456.9
## + EngineSize           1 3.1017e-06 1.5439e-06 -1454.6
## + Horsepower           1 3.0577e-06 1.5879e-06 -1452.3
## + Type                 4 2.7563e-06 1.8893e-06 -1432.1
## + Price                1 2.6052e-06 2.0404e-06 -1431.7
## + Length               1 2.4066e-06 2.2390e-06 -1424.1
## + Width                1 2.3643e-06 2.2814e-06 -1422.6
## + Wheelbase            1 2.2472e-06 2.3985e-06 -1418.5
## + Rev.per.mile         1 2.1306e-06 2.5150e-06 -1414.6
## + Turn.circle          1 1.9762e-06 2.6695e-06 -1409.7
## + Man.trans.avail      1 1.1600e-06 3.4856e-06 -1387.8
## + Luggage.room         1 1.0447e-06 3.6010e-06 -1385.2
## + AirBags              2 1.0519e-06 3.5937e-06 -1383.3
## + Passengers           1 8.2490e-07 3.8207e-06 -1380.3
## + Rear.seat.room       1 6.5460e-07 3.9910e-06 -1376.7
## + DriveTrain           2 7.4690e-07 3.8987e-06 -1376.7
## + RPM                  1 3.6850e-07 4.2771e-06 -1371.0
## + Origin               1 1.7970e-07 4.4659e-06 -1367.5
## <none>                              4.6456e-06 -1366.3
##
## Step:  AIC=-1486.32
## MPG.avg ~ Weight
##
##                       Df  Sum of Sq        RSS     AIC
## + Wheelbase            1 1.2320e-07 9.2550e-07 -1494.6
## + Price                1 1.0170e-07 9.4700e-07 -1492.7
## + Cylinders            1 1.0160e-07 9.4720e-07 -1492.7
## + Length               1 6.0600e-08 9.8820e-07 -1489.2
## + Luggage.room         1 5.8500e-08 9.9020e-07 -1489.0
## + Horsepower           1 5.3700e-08 9.9500e-07 -1488.6
## + Fuel.tank.capacity   1 5.2700e-08 9.9600e-07 -1488.5
## + Width                1 4.9900e-08 9.9890e-07 -1488.3
## <none>                              1.0487e-06 -1486.3
## + Man.trans.avail      1 2.2700e-08 1.0261e-06 -1486.1
## + Turn.circle          1 1.9700e-08 1.0291e-06 -1485.9
## + Rear.seat.room       1 1.6600e-08 1.0321e-06 -1485.6
## + AirBags              2 3.7300e-08 1.0114e-06 -1485.3
## + Passengers           1 4.7000e-09 1.0440e-06 -1484.7
```

```
## + RPM                 1 3.3000e-09 1.0455e-06 -1484.6
## + EngineSize          1 3.2000e-09 1.0456e-06 -1484.6
## + Type                4 7.6100e-08 9.7260e-07 -1484.5
## + Rev.per.mile        1 1.9000e-09 1.0468e-06 -1484.5
## + Origin              1 1.4000e-09 1.0473e-06 -1484.4
## + DriveTrain          2 1.8000e-09 1.0470e-06 -1482.5
## - Weight              1 3.5969e-06 4.6456e-06 -1366.3
##
## Step:  AIC=-1494.57
## MPG.avg ~ Weight + Wheelbase
##
##                       Df  Sum of Sq        RSS     AIC
## + Cylinders           1 9.2680e-08 8.3282e-07 -1501.2
## + Price               1 8.8800e-08 8.3670e-07 -1500.8
## + Fuel.tank.capacity  1 5.4600e-08 8.7090e-07 -1497.6
## + EngineSize          1 2.6110e-08 8.9939e-07 -1494.9
## <none>                             9.2550e-07 -1494.6
## + AirBags             2 4.2190e-08 8.8331e-07 -1494.4
## + Passengers          1 1.4050e-08 9.1145e-07 -1493.8
## + Horsepower          1 1.1400e-08 9.1409e-07 -1493.6
## + Width               1 1.0420e-08 9.1508e-07 -1493.5
## + Luggage.room        1 7.3800e-09 9.1811e-07 -1493.2
## + Rear.seat.room      1 6.5800e-09 9.1892e-07 -1493.2
## + Turn.circle         1 5.8900e-09 9.1961e-07 -1493.1
## + Length              1 1.6900e-09 9.2381e-07 -1492.7
## + Origin              1 1.4700e-09 9.2402e-07 -1492.7
## + RPM                 1 4.2000e-10 9.2508e-07 -1492.6
## + Rev.per.mile        1 4.0000e-11 9.2546e-07 -1492.6
## + Man.trans.avail     1 2.0000e-11 9.2548e-07 -1492.6
## + DriveTrain          2 1.5190e-08 9.1031e-07 -1491.9
## + Type                4 4.6120e-08 8.7938e-07 -1490.8
## - Wheelbase           1 1.2325e-07 1.0487e-06 -1486.3
## - Weight              1 1.4730e-06 2.3985e-06 -1418.5
##
## Step:  AIC=-1501.22
## MPG.avg ~ Weight + Wheelbase + Cylinders
##
##                       Df  Sum of Sq        RSS     AIC
## + Fuel.tank.capacity  1 7.4610e-08 7.5821e-07 -1506.9
## + Price               1 6.4180e-08 7.6864e-07 -1505.8
## + Width               1 4.0150e-08 7.9267e-07 -1503.3
## + Type                4 9.2140e-08 7.4067e-07 -1502.8
## <none>                             8.3282e-07 -1501.2
## + Passengers          1 1.5610e-08 8.1721e-07 -1500.8
## + Luggage.room        1 1.5240e-08 8.1758e-07 -1500.7
## + Rev.per.mile        1 6.5300e-09 8.2629e-07 -1499.9
## + AirBags             2 2.6390e-08 8.0643e-07 -1499.9
## + Rear.seat.room      1 4.4400e-09 8.2838e-07 -1499.7
## + Man.trans.avail     1 4.2100e-09 8.2861e-07 -1499.6
## + Turn.circle         1 3.5500e-09 8.2926e-07 -1499.6
## + Length              1 1.4500e-09 8.3137e-07 -1499.4
## + RPM                 1 8.6000e-10 8.3195e-07 -1499.3
## + Horsepower          1 8.4000e-10 8.3198e-07 -1499.3
## + EngineSize          1 2.0000e-11 8.3280e-07 -1499.2
```

```
## + Origin              1 0.0000e+00 8.3282e-07 -1499.2
## + DriveTrain          2 6.6300e-09 8.2619e-07 -1497.9
## - Cylinders           1 9.2680e-08 9.2550e-07 -1494.6
## - Wheelbase           1 1.1436e-07 9.4718e-07 -1492.7
## - Weight              1 5.8118e-07 1.4140e-06 -1459.8
##
## Step:  AIC=-1506.92
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity
##
##                       Df  Sum of Sq        RSS     AIC
## + Price                1 4.3942e-08 7.1427e-07 -1509.8
## + Width                1 3.7818e-08 7.2039e-07 -1509.1
## + Luggage.room         1 2.7203e-08 7.3101e-07 -1507.9
## <none>                              7.5821e-07 -1506.9
## + Passengers           1 1.8140e-08 7.4007e-07 -1506.9
## + Type                 4 6.0867e-08 6.9734e-07 -1505.8
## + Origin               1 4.9060e-09 7.5330e-07 -1505.5
## + Rear.seat.room       1 3.6240e-09 7.5459e-07 -1505.3
## + Length               1 1.5500e-09 7.5666e-07 -1505.1
## + Turn.circle          1 4.7100e-10 7.5774e-07 -1505.0
## + RPM                  1 2.0900e-10 7.5800e-07 -1504.9
## + Horsepower           1 1.4100e-10 7.5807e-07 -1504.9
## + Man.trans.avail      1 1.3500e-10 7.5808e-07 -1504.9
## + Rev.per.mile         1 1.2200e-10 7.5809e-07 -1504.9
## + EngineSize           1 6.3000e-11 7.5815e-07 -1504.9
## + AirBags              2 1.5281e-08 7.4293e-07 -1504.6
## + DriveTrain           2 6.2620e-09 7.5195e-07 -1503.6
## - Fuel.tank.capacity   1 7.4605e-08 8.3282e-07 -1501.2
## - Cylinders            1 1.1269e-07 8.7090e-07 -1497.6
## - Wheelbase            1 1.1557e-07 8.7378e-07 -1497.3
## - Weight               1 1.6390e-07 9.2211e-07 -1492.9
##
## Step:  AIC=-1509.82
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price
##
##                       Df  Sum of Sq        RSS     AIC
## + Origin               1 3.2587e-08 6.8168e-07 -1511.6
## + Passengers           1 2.9341e-08 6.8493e-07 -1511.3
## + AirBags              2 3.5308e-08 6.7896e-07 -1510.0
## <none>                              7.1427e-07 -1509.8
## + Luggage.room         1 1.3624e-08 7.0065e-07 -1509.4
## + Horsepower           1 1.2159e-08 7.0211e-07 -1509.2
## + Width                1 9.8340e-09 7.0444e-07 -1509.0
## + RPM                  1 9.5100e-09 7.0476e-07 -1508.9
## + Rev.per.mile         1 5.0770e-09 7.0919e-07 -1508.4
## + Rear.seat.room       1 3.7200e-09 7.1055e-07 -1508.2
## + Turn.circle          1 3.0280e-09 7.1124e-07 -1508.2
## + EngineSize           1 1.9850e-09 7.1228e-07 -1508.0
## + Length               1 1.1750e-09 7.1309e-07 -1508.0
## + Man.trans.avail      1 5.2000e-11 7.1422e-07 -1507.8
## - Price                1 4.3942e-08 7.5821e-07 -1506.9
## + Type                 4 4.2409e-08 6.7186e-07 -1506.8
## + DriveTrain           2 4.1200e-09 7.1015e-07 -1506.3
```

```
## - Fuel.tank.capacity  1 5.4371e-08 7.6864e-07 -1505.8
## - Cylinders           1 8.5761e-08 8.0003e-07 -1502.5
## - Wheelbase           1 1.0719e-07 8.2146e-07 -1500.3
## - Weight              1 1.3345e-07 8.4772e-07 -1497.8
##
## Step:  AIC=-1511.64
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price + Origin
##
##                       Df  Sum of Sq        RSS     AIC
## + Width                1 2.6144e-08 6.5554e-07 -1512.8
## + Passengers           1 2.0480e-08 6.6120e-07 -1512.2
## + AirBags              2 3.4964e-08 6.4672e-07 -1512.0
## + Luggage.room         1 1.8816e-08 6.6287e-07 -1511.9
## <none>                              6.8168e-07 -1511.6
## + Rear.seat.room       1 8.3430e-09 6.7334e-07 -1510.7
## + Horsepower           1 8.1790e-09 6.7350e-07 -1510.6
## + Man.trans.avail      1 2.3010e-09 6.7938e-07 -1509.9
## + Rev.per.mile         1 1.9250e-09 6.7976e-07 -1509.9
## + RPM                  1 1.6490e-09 6.8003e-07 -1509.8
## - Origin               1 3.2587e-08 7.1427e-07 -1509.8
## + Length               1 2.2100e-10 6.8146e-07 -1509.7
## + Turn.circle          1 5.7000e-11 6.8163e-07 -1509.7
## + EngineSize           1 0.0000e+00 6.8168e-07 -1509.6
## + DriveTrain           2 5.6270e-09 6.7606e-07 -1508.3
## + Type                 4 3.4725e-08 6.4696e-07 -1507.9
## - Cylinders            1 6.3835e-08 7.4552e-07 -1506.3
## - Fuel.tank.capacity   1 6.9588e-08 7.5127e-07 -1505.7
## - Price                1 7.1622e-08 7.5330e-07 -1505.5
## - Weight               1 1.1255e-07 7.9423e-07 -1501.1
## - Wheelbase            1 1.2947e-07 8.1115e-07 -1499.4
##
## Step:  AIC=-1512.85
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price + Origin + Width
##
##                       Df  Sum of Sq        RSS     AIC
## + Luggage.room         1 1.9303e-08 6.3623e-07 -1513.3
## <none>                              6.5554e-07 -1512.8
## + Passengers           1 1.3850e-08 6.4169e-07 -1512.6
## + Horsepower           1 6.3430e-09 6.4919e-07 -1511.7
## - Width                1 2.6144e-08 6.8168e-07 -1511.6
## + Man.trans.avail      1 4.8680e-09 6.5067e-07 -1511.5
## + AirBags              2 1.8781e-08 6.3676e-07 -1511.2
## + RPM                  1 2.8370e-09 6.5270e-07 -1511.2
## + Rev.per.mile         1 2.7150e-09 6.5282e-07 -1511.2
## + Rear.seat.room       1 2.1540e-09 6.5338e-07 -1511.1
## + Turn.circle          1 1.3180e-09 6.5422e-07 -1511.0
## + EngineSize           1 7.3100e-10 6.5481e-07 -1510.9
## - Price                1 3.2221e-08 6.8776e-07 -1510.9
## + Length               1 4.9900e-10 6.5504e-07 -1510.9
## + DriveTrain           2 1.1626e-08 6.4391e-07 -1510.3
## - Origin               1 4.8897e-08 7.0444e-07 -1509.0
## + Type                 4 2.6404e-08 6.2913e-07 -1508.2
```

```
## - Wheelbase           1 7.5177e-08 7.3072e-07 -1506.0
## - Fuel.tank.capacity  1 8.0802e-08 7.3634e-07 -1505.3
## - Cylinders           1 8.7154e-08 7.4269e-07 -1504.6
## - Weight              1 1.3596e-07 7.9150e-07 -1499.4
##
## Step:  AIC=-1513.3
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price + Origin + Width + Luggage.room
##
##                       Df  Sum of Sq        RSS     AIC
## + Passengers           1 2.9462e-08 6.0677e-07 -1515.2
## + Horsepower           1 2.0658e-08 6.1558e-07 -1514.0
## <none>                              6.3623e-07 -1513.3
## - Luggage.room         1 1.9303e-08 6.5554e-07 -1512.8
## + Rear.seat.room       1 1.1420e-08 6.2481e-07 -1512.8
## + RPM                  1 1.0403e-08 6.2583e-07 -1512.7
## - Price                1 2.3548e-08 6.5978e-07 -1512.3
## + AirBags              2 2.1390e-08 6.1484e-07 -1512.1
## - Width                1 2.6632e-08 6.6287e-07 -1511.9
## + Rev.per.mile         1 3.7590e-09 6.3248e-07 -1511.8
## + Man.trans.avail      1 2.1180e-09 6.3412e-07 -1511.6
## + EngineSize           1 1.7030e-09 6.3453e-07 -1511.5
## + Turn.circle          1 1.5090e-09 6.3473e-07 -1511.5
## + Length               1 1.2390e-09 6.3500e-07 -1511.5
## - Wheelbase            1 3.4682e-08 6.7092e-07 -1511.0
## + DriveTrain           2 1.0575e-08 6.2566e-07 -1510.7
## - Origin               1 5.5092e-08 6.9133e-07 -1508.5
## + Type                 4 2.1003e-08 6.1523e-07 -1508.0
## - Fuel.tank.capacity   1 9.4151e-08 7.3039e-07 -1504.0
## - Cylinders            1 9.8016e-08 7.3425e-07 -1503.5
## - Weight               1 1.2035e-07 7.5658e-07 -1501.1
##
## Step:  AIC=-1515.19
## MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price + Origin + Width + Luggage.room + Passengers
##
##                       Df  Sum of Sq        RSS     AIC
## <none>                              6.0677e-07 -1515.2
## + Horsepower           1 1.3481e-08 5.9329e-07 -1515.0
## - Width                1 1.7164e-08 6.2394e-07 -1514.9
## + RPM                  1 1.1195e-08 5.9558e-07 -1514.7
## + Man.trans.avail      1 1.0231e-08 5.9654e-07 -1514.6
## + AirBags              2 2.3228e-08 5.8354e-07 -1514.4
## + Rev.per.mile         1 3.5450e-09 6.0323e-07 -1513.7
## + DriveTrain           2 1.6993e-08 5.8978e-07 -1513.5
## + EngineSize           1 2.0910e-09 6.0468e-07 -1513.5
## - Price                1 2.8187e-08 6.3496e-07 -1513.5
## + Turn.circle          1 1.3750e-09 6.0540e-07 -1513.4
## - Passengers           1 2.9462e-08 6.3623e-07 -1513.3
## + Rear.seat.room       1 5.6900e-10 6.0620e-07 -1513.3
## + Length               1 1.2000e-11 6.0676e-07 -1513.2
## + Type                 4 4.1545e-08 5.6523e-07 -1513.0
## - Luggage.room         1 3.4915e-08 6.4169e-07 -1512.6
## - Origin               1 3.9418e-08 6.4619e-07 -1512.0
```

```
## - Wheelbase           1 5.4895e-08 6.6167e-07 -1510.1
## - Fuel.tank.capacity  1 9.6051e-08 7.0282e-07 -1505.1
## - Cylinders           1 9.9320e-08 7.0609e-07 -1504.8
## - Weight              1 1.1637e-07 7.2314e-07 -1502.8
```

```
# check the summary. M1_AIC has insignificant variable; hence, do not use M1_AIC this time. Interpret M
summary(M1_BIC)
```

```
##
## Call:
## lm(formula = MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price, data = df2)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -2.579e-04 -5.886e-05  1.269e-05  6.431e-05  2.312e-04
##
## Coefficients:
##                       Estimate Std. Error  t value Pr(>|t|)
## (Intercept)          4.987e-01  2.641e-04 1888.156  < 2e-16 ***
## Weight              -2.547e-07  6.760e-08   -3.768 0.000323 ***
## Wheelbase            1.182e-05  3.499e-06    3.377 0.001157 **
## Cylinders           -5.507e-05  1.823e-05   -3.021 0.003433 **
## Fuel.tank.capacity -2.021e-05  8.402e-06   -2.405 0.018595 *
## Price               -3.566e-06  1.649e-06   -2.162 0.033741 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.694e-05 on 76 degrees of freedom
## Multiple R-squared:  0.8462, Adjusted R-squared:  0.8361
## F-statistic: 83.66 on 5 and 76 DF,  p-value: < 2.2e-16
```

```
summary(M1_AIC)
```

```
##
## Call:
## lm(formula = MPG.avg ~ Weight + Wheelbase + Cylinders + Fuel.tank.capacity +
##     Price + Origin + Width + Luggage.room + Passengers, data = df2)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -2.312e-04 -5.271e-05  2.142e-05  6.387e-05  2.091e-04
##
## Coefficients:
##                       Estimate Std. Error  t value Pr(>|t|)
## (Intercept)          4.981e-01  4.225e-04 1178.954  < 2e-16 ***
## Weight              -2.547e-07  6.854e-08   -3.716 0.000397 ***
## Wheelbase            1.108e-05  4.341e-06    2.552 0.012826 *
## Cylinders           -6.612e-05  1.926e-05   -3.433 0.000993 ***
## Fuel.tank.capacity -2.828e-05  8.378e-06   -3.376 0.001188 **
## Price               -3.540e-06  1.935e-06   -1.829 0.071563 .
## Originnon-USA        5.764e-05  2.665e-05    2.163 0.033885 *
## Width                1.121e-05  7.858e-06    1.427 0.157861
```

```
## Luggage.room        1.139e-05  5.597e-06    2.035 0.045487 *
## Passengers         -3.956e-05  2.116e-05   -1.870 0.065583 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.18e-05 on 72 degrees of freedom
## Multiple R-squared:  0.8694, Adjusted R-squared:  0.8531
## F-statistic: 53.25 on 9 and 72 DF,  p-value: < 2.2e-16
```

```
# vif
vif(M1_BIC)
```

```
##             Weight          Wheelbase          Cylinders Fuel.tank.capacity
##          12.614474           4.412349           3.680002           5.513076
##              Price
##           2.324593
```

```
# since Weight's vif is higher than 10 so I will try to remove some of variables while maintaing R-squa
m2 <- lm(data = df2, MPG.avg ~ Price + Cylinders + Wheelbase + Weight)
M2_BIC <- stepwise(m2, direction = "forward/backward", criterion = "BIC")
```

```
##
## Direction:  forward/backward
## Criterion:  BIC
##
## Start:  AIC=-1363.87
## MPG.avg ~ 1
##
##             Df  Sum of Sq        RSS     AIC
## + Weight     1 3.5969e-06 1.0487e-06 -1481.5
## + Cylinders  1 3.1450e-06 1.5006e-06 -1452.1
## + Price      1 2.6052e-06 2.0404e-06 -1426.9
## + Wheelbase  1 2.2472e-06 2.3985e-06 -1413.7
## <none>                    4.6456e-06 -1363.9
##
## Step:  AIC=-1481.51
## MPG.avg ~ Weight
##
##             Df  Sum of Sq        RSS     AIC
## + Wheelbase  1 1.2320e-07 9.2550e-07 -1487.3
## + Price      1 1.0170e-07 9.4700e-07 -1485.5
## + Cylinders  1 1.0160e-07 9.4720e-07 -1485.5
## <none>                    1.0487e-06 -1481.5
## - Weight     1 3.5969e-06 4.6456e-06 -1363.9
##
## Step:  AIC=-1487.35
## MPG.avg ~ Weight + Wheelbase
##
##             Df  Sum of Sq        RSS     AIC
## + Cylinders  1 9.2680e-08 8.3282e-07 -1491.6
## + Price      1 8.8800e-08 8.3670e-07 -1491.2
## <none>                    9.2550e-07 -1487.3
## - Wheelbase  1 1.2325e-07 1.0487e-06 -1481.5
```

```
## - Weight     1 1.4730e-06 2.3985e-06 -1413.7
##
## Step:  AIC=-1491.6
## MPG.avg ~ Weight + Wheelbase + Cylinders
##
##             Df  Sum of Sq        RSS     AIC
## + Price      1 6.4180e-08 7.6864e-07 -1493.8
## <none>                    8.3282e-07 -1491.6
## - Cylinders  1 9.2680e-08 9.2550e-07 -1487.3
## - Wheelbase  1 1.1436e-07 9.4718e-07 -1485.5
## - Weight     1 5.8118e-07 1.4140e-06 -1452.6
##
## Step:  AIC=-1493.77
## MPG.avg ~ Weight + Wheelbase + Cylinders + Price
##
##             Df  Sum of Sq        RSS     AIC
## <none>                    7.6864e-07 -1493.8
## - Price      1 6.4180e-08 8.3282e-07 -1491.6
## - Cylinders  1 6.8060e-08 8.3670e-07 -1491.2
## - Wheelbase  1 1.0474e-07 8.7338e-07 -1487.7
## - Weight     1 3.9963e-07 1.1683e-06 -1463.8
```

```
# vif of Weight become under 10.
vif(M2_BIC)
```

```
##    Weight Wheelbase Cylinders     Price
##  8.062370  4.411181  3.597503  2.256325
```

```
summary(M2_BIC)
```

```
##
## Call:
## lm(formula = MPG.avg ~ Weight + Wheelbase + Cylinders + Price,
##     data = df2)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -2.330e-04 -6.264e-05  5.455e-06  6.208e-05  2.238e-04
##
## Coefficients:
##               Estimate Std. Error  t value Pr(>|t|)
## (Intercept)  4.986e-01  2.720e-04 1833.399  < 2e-16 ***
## Weight      -3.524e-07  5.570e-08   -6.327 1.51e-08 ***
## Wheelbase    1.168e-05  3.605e-06    3.239  0.00177 **
## Cylinders   -4.851e-05  1.858e-05   -2.611  0.01084 *
## Price       -4.245e-06  1.674e-06   -2.536  0.01325 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.991e-05 on 77 degrees of freedom
## Multiple R-squared:  0.8345, Adjusted R-squared:  0.8259
## F-statistic:  97.1 on 4 and 77 DF,  p-value: < 2.2e-16
```

ANOVA for Origin, Passengers, Type