Introduction to statistical learning

NAME : SAI NIVAS PALADUGU
STUDENT ID : 16316008

8)

a) Use the `read.csv()` function to read the data into R. Call the loaded data `college`. Make sure that you have the directory set to the correct location for the data.

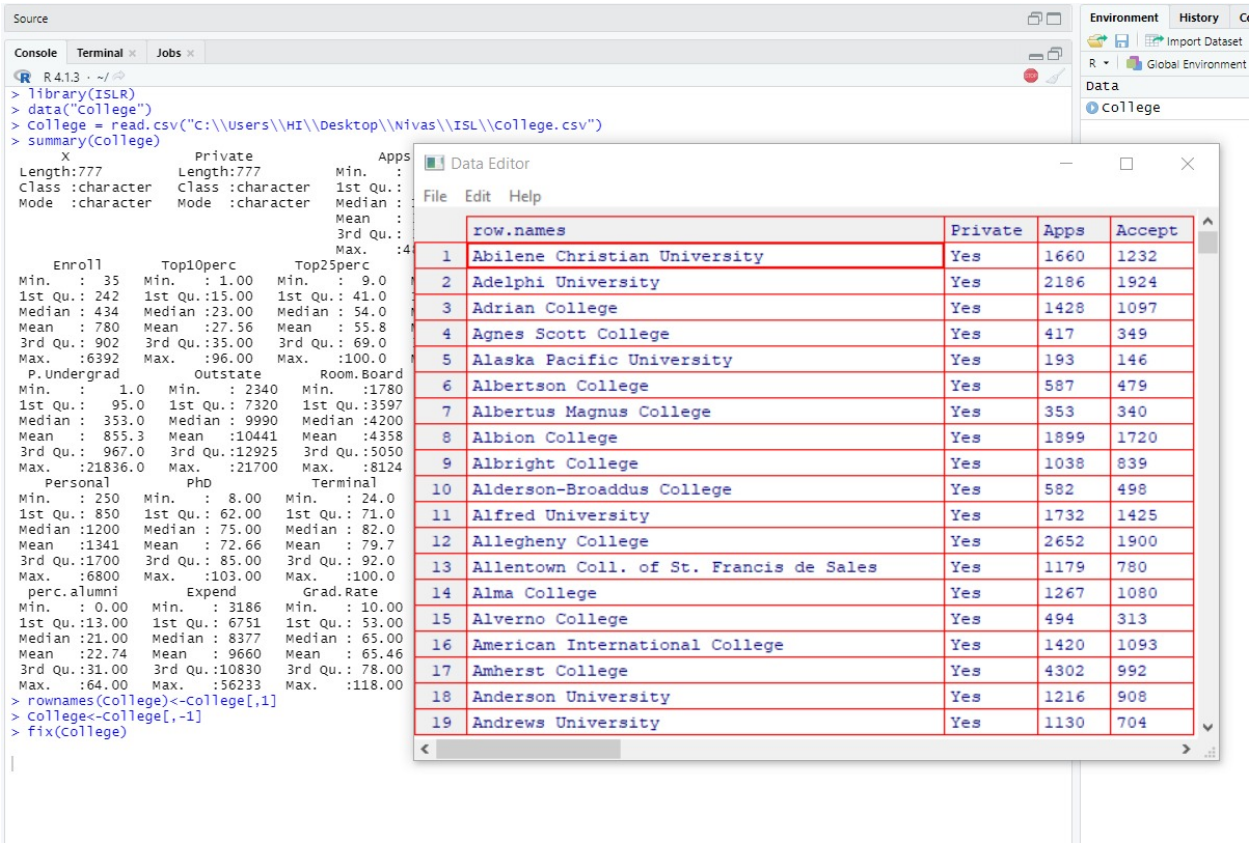
Source

Console Terminal Jobs

R 4.1.3 · ~/

```
> library(ISLR)
> data("College")
> College = read.csv("C:\\Users\\HI\\Desktop\\Nivas\\ISL\\College.csv")
> summary(College)
      X               Private               Apps           Accept       
 Length:777         Length:777         Min.   :   81   Min.   :   72  
 Class :character   Class :character   1st Qu.:  776   1st Qu.:  604  
 Mode  :character   Mode  :character   Median : 1558   Median : 1110  
                                       Mean   : 3002   Mean   : 2019  
                                       3rd Qu.: 3624   3rd Qu.: 2424  
                                       Max.   :48094   Max.   :26330  
     Enroll       Top10perc       Top25perc      F.Undergrad     
 Min.   :  35   Min.   : 1.00   Min.   :  9.0   Min.   :  139  
 1st Qu.: 242   1st Qu.:15.00   1st Qu.: 41.0   1st Qu.:  992  
 Median : 434   Median :23.00   Median : 54.0   Median : 1707  
 Mean   : 780   Mean   :27.56   Mean   : 55.8   Mean   : 3700  
 3rd Qu.: 902   3rd Qu.:35.00   3rd Qu.: 69.0   3rd Qu.: 4005  
 Max.   :6392   Max.   :96.00   Max.   :100.0   Max.   :31643  
  P.Undergrad         Outstate       Room.Board       Books      
 Min.   :    1.0   Min.   : 2340   Min.   :1780   Min.   :  96.0  
 1st Qu.:   95.0   1st Qu.: 7320   1st Qu.:3597   1st Qu.: 470.0  
 Median :  353.0   Median : 9990   Median :4200   Median : 500.0  
 Mean   :  855.3   Mean   :10441   Mean   :4358   Mean   : 549.4  
 3rd Qu.:  967.0   3rd Qu.:12925   3rd Qu.:5050   3rd Qu.: 600.0  
 Max.   :21836.0   Max.   :21700   Max.   :8124   Max.   :2340.0  
    Personal         PhD            Terminal       S.F.Ratio    
 Min.   : 250   Min.   :  8.00   Min.   : 24.0   Min.   : 2.50  
 1st Qu.: 850   1st Qu.: 62.00   1st Qu.: 71.0   1st Qu.:11.50  
 Median :1200   Median : 75.00   Median : 82.0   Median :13.60  
 Mean   :1341   Mean   : 72.66   Mean   : 79.7   Mean   :14.09  
 3rd Qu.:1700   3rd Qu.: 85.00   3rd Qu.: 92.0   3rd Qu.:16.50  
 Max.   :6800   Max.   :103.00   Max.   :100.0   Max.   :39.80  
  perc.alumni        Expend        Grad.Rate     
 Min.   : 0.00   Min.   : 3186   Min.   : 10.00  
 1st Qu.:13.00   1st Qu.: 6751   1st Qu.: 53.00  
 Median :21.00   Median : 8377   Median : 65.00  
 Mean   :22.74   Mean   : 9660   Mean   : 65.46  
 3rd Qu.:31.00   3rd Qu.:10830   3rd Qu.: 78.00  
 Max.   :64.00   Max.   :56233   Max.   :118.00  
> |
```

b) Look at the data using the `fix()` function. You should notice that the first column is just the name of each university. We don't really want R to treat this as data. However, it may be handy to have these names for later. Try the following commands:



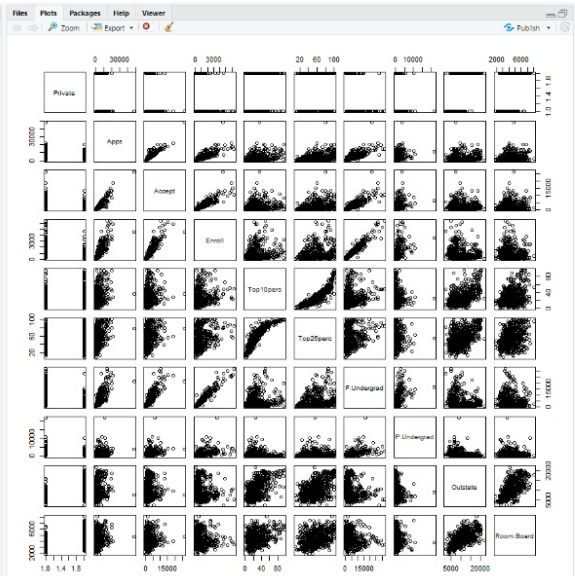
	row.names	Private	Apps	Accept
1	Abilene Christian University	Yes	1660	1232
2	Adelphi University	Yes	2186	1924
3	Adrian College	Yes	1428	1097
4	Agnes Scott College	Yes	417	349
5	Alaska Pacific University	Yes	193	146
6	Albertson College	Yes	587	479
7	Albertus Magnus College	Yes	353	340
8	Albion College	Yes	1899	1720
9	Albright College	Yes	1038	839
10	Alderson-Broaddus College	Yes	582	498
11	Alfred University	Yes	1732	1425
12	Allegheny College	Yes	2652	1900
13	Allentown Coll. of St. Francis de Sales	Yes	1179	780
14	Alma College	Yes	1267	1080
15	Alverno College	Yes	494	313
16	American International College	Yes	1420	1093
17	Amherst College	Yes	4302	992
18	Anderson University	Yes	1216	908
19	Andrews University	Yes	1130	704

C) Use the summary() function to produce a numerical summary of the variables in the data set.

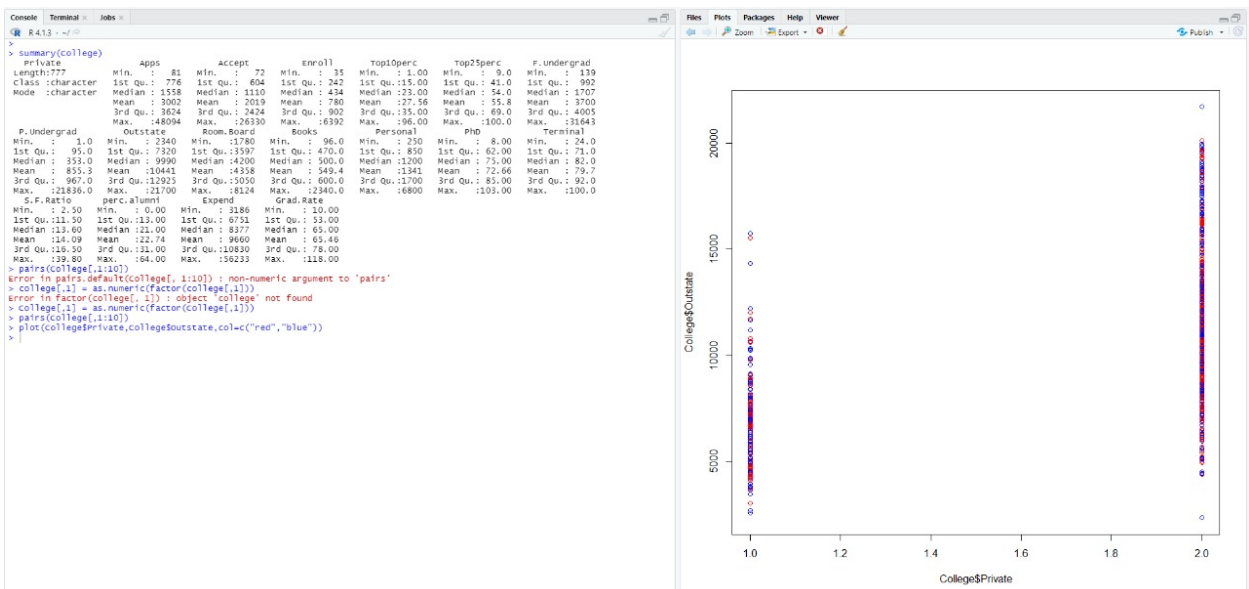
```
Source

Console   Terminal ×   Jobs ×
R 4.1.3 · ~/
>
> summary(college)
   Private                Apps           Accept          Enroll       Top10perc       Top25perc      F.Undergrad
 Length:777         Min.   :   81   Min.   :   72   Min.   :  35   Min.   : 1.00   Min.   :  9.0   Min.   :  139
 Class :character   1st Qu.:  776   1st Qu.:  604   1st Qu.: 242   1st Qu.:15.00   1st Qu.: 41.0   1st Qu.:  992
 Mode  :character   Median : 1558   Median : 1110   Median : 434   Median :23.00   Median : 54.0   Median : 1707
                    Mean   : 3002   Mean   : 2019   Mean   : 780   Mean   :27.56   Mean   : 55.8   Mean   : 3700
                    3rd Qu.: 3624   3rd Qu.: 2424   3rd Qu.: 902   3rd Qu.:35.00   3rd Qu.: 69.0   3rd Qu.: 4005
                    Max.   :48094   Max.   :26330   Max.   :6392   Max.   :96.00   Max.   :100.0   Max.   :31643
  P.Undergrad         Outstate       Room.Board       Books           Personal         PhD            Terminal
 Min.   :    1.0   Min.   : 2340   Min.   :1780   Min.   :  96.0   Min.   : 250   Min.   :  8.00   Min.   : 24.0
 1st Qu.:   95.0   1st Qu.: 7320   1st Qu.:3597   1st Qu.: 470.0   1st Qu.: 850   1st Qu.: 62.00   1st Qu.: 71.0
 Median :  353.0   Median : 9990   Median :4200   Median : 500.0   Median :1200   Median : 75.00   Median : 82.0
 Mean   :  855.3   Mean   :10441   Mean   :4358   Mean   : 549.4   Mean   :1341   Mean   : 72.66   Mean   : 79.7
 3rd Qu.:  967.0   3rd Qu.:12925   3rd Qu.:5050   3rd Qu.: 600.0   3rd Qu.:1700   3rd Qu.: 85.00   3rd Qu.: 92.0
 Max.   :21836.0   Max.   :21700   Max.   :8124   Max.   :2340.0   Max.   :6800   Max.   :103.00   Max.   :100.0
   S.F.Ratio      perc.alumni        Expend        Grad.Rate
 Min.   : 2.50   Min.   : 0.00   Min.   : 3186   Min.   : 10.00
 1st Qu.:11.50   1st Qu.:13.00   1st Qu.: 6751   1st Qu.: 53.00
 Median :13.60   Median :21.00   Median : 8377   Median : 65.00
 Mean   :14.09   Mean   :22.74   Mean   : 9660   Mean   : 65.46
 3rd Qu.:16.50   3rd Qu.:31.00   3rd Qu.:10830   3rd Qu.: 78.00
 Max.   :39.80   Max.   :64.00   Max.   :56233   Max.   :118.00
>
```

ii) Use the pairs() function to produce a scatterplot matrix of the first ten columns or variables of the data. Recall that you can reference the first ten columns of a matrix A using A[,1:10].

```
Console   Terminal ×   Jobs ×
R 4.1.3 · ~/
>
> summary(college)
   Private                Apps           Accept          Enroll       Top10perc       Top25perc      F.Undergrad
 Length:777         Min.   :   81   Min.   :   72   Min.   :  35   Min.   : 1.00   Min.   :  9.0   Min.   :  139
 Class :character   1st Qu.:  776   1st Qu.:  604   1st Qu.: 242   1st Qu.:15.00   1st Qu.: 41.0   1st Qu.:  992
 Mode  :character   Median : 1558   Median : 1110   Median : 434   Median :23.00   Median : 54.0   Median : 1707
                    Mean   : 3002   Mean   : 2019   Mean   : 780   Mean   :27.56   Mean   : 55.8   Mean   : 3700
                    3rd Qu.: 3624   3rd Qu.: 2424   3rd Qu.: 902   3rd Qu.:35.00   3rd Qu.: 69.0   3rd Qu.: 4005
                    Max.   :48094   Max.   :26330   Max.   :6392   Max.   :96.00   Max.   :100.0   Max.   :31643
  P.Undergrad         Outstate       Room.Board       Books           Personal         PhD            Terminal
 Min.   :    1.0   Min.   : 2340   Min.   :1780   Min.   :  96.0   Min.   : 250   Min.   :  8.00   Min.   : 24.0
 1st Qu.:   95.0   1st Qu.: 7320   1st Qu.:3597   1st Qu.: 470.0   1st Qu.: 850   1st Qu.: 62.00   1st Qu.: 71.0
 Median :  353.0   Median : 9990   Median :4200   Median : 500.0   Median :1200   Median : 75.00   Median : 82.0
 Mean   :  855.3   Mean   :10441   Mean   :4358   Mean   : 549.4   Mean   :1341   Mean   : 72.66   Mean   : 79.7
 3rd Qu.:  967.0   3rd Qu.:12925   3rd Qu.:5050   3rd Qu.: 600.0   3rd Qu.:1700   3rd Qu.: 85.00   3rd Qu.: 92.0
 Max.   :21836.0   Max.   :21700   Max.   :8124   Max.   :2340.0   Max.   :6800   Max.   :103.00   Max.   :100.0
   S.F.Ratio      perc.alumni        Expend        Grad.Rate
 Min.   : 2.50   Min.   : 0.00   Min.   : 3186   Min.   : 10.00
 1st Qu.:11.50   1st Qu.:13.00   1st Qu.: 6751   1st Qu.: 53.00
 Median :13.60   Median :21.00   Median : 8377   Median : 65.00
 Mean   :14.09   Mean   :22.74   Mean   : 9660   Mean   : 65.46
 3rd Qu.:16.50   3rd Qu.:31.00   3rd Qu.:10830   3rd Qu.: 78.00
 Max.   :39.80   Max.   :64.00   Max.   :56233   Max.   :118.00
> pairs(college[,1:10])
Error in pairs.default(college[, 1:10]) : non-numeric argument to 'pairs'
> college[,1] = as.numeric(factor(college[,1]))
Error in factor(college[, 1]) : object 'college' not found
> College[,1] = as.numeric(factor(College[,1]))
> pairs(College[,1:10])
>
```



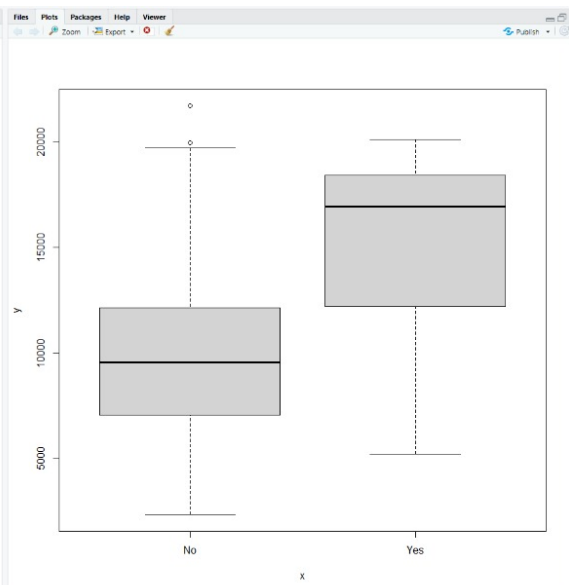
iii) use the plot() function to produce side-by-side boxplots of Outstate versus Private.



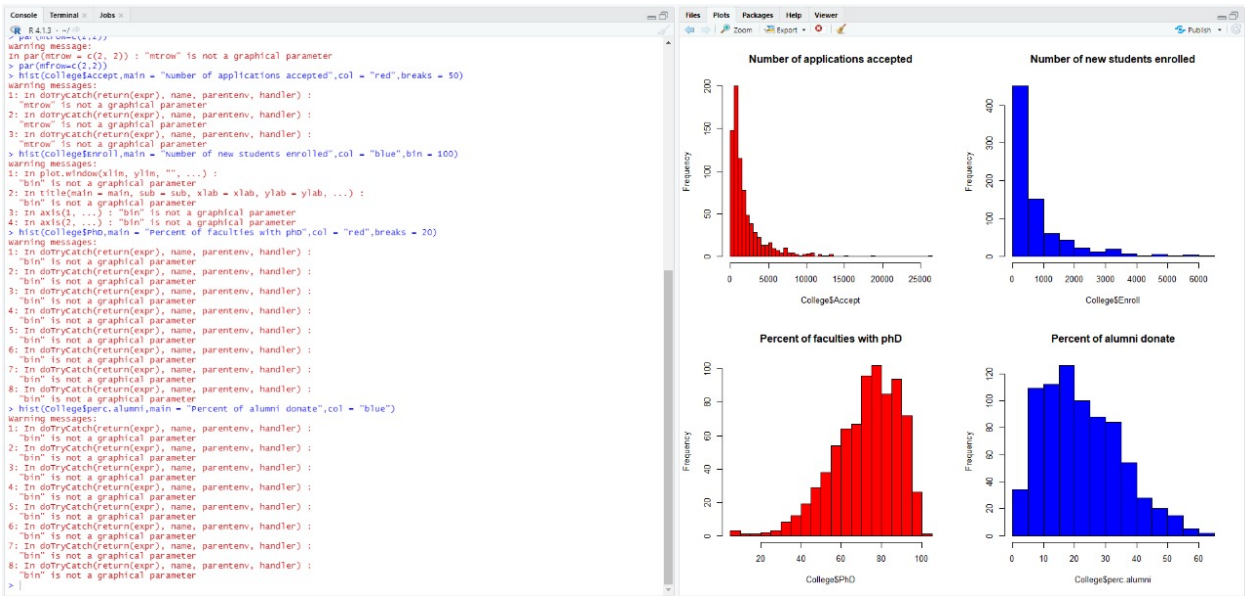
iv) Create a new qualitative variable, called Elite, by binning the Top10perc variable. We are going to divide universities into two groups based on whether or not the proportion of students coming from the top 10 % of their high school classes exceeds 50 %.

```
> College[,1] = as.numeric(factor(College[,1]))
> pairs(College[,1:10])
> plot(College$Private,College$Outstate,col=c("red","blue"))
> Elite=rep("No",nrow(College))
> Elite[College$Top10perc > 50]="Yes"
> Elite = as.factor(Elite)
> College=data.frame(College,Elite)
> summary(College$Elite)
 No Yes
699  78
> |
```

```
Console   Terminal ×   Jobs ×
R 4.1.3 · ~/
>
> summary(College)
   Private             Apps           Accept          Enroll       Top10perc       Top25perc      F.Undergrad
 Length:777         Min.   :   81   Min.   :   72   Min.   :  35   Min.   :  1.00   Min.   :  9.0   Min.   :  139
 Class :character   1st Qu.:  776   1st Qu.:  604   1st Qu.: 242   1st Qu.:15.00   1st Qu.: 41.0   1st Qu.:  992
 Mode  :character   Median : 1558   Median : 1110   Median : 434   Median :23.00   Median : 54.0   Median : 1707
                    Mean   : 3002   Mean   : 2019   Mean   : 780   Mean   :27.56   Mean   : 55.8   Mean   : 3700
                    3rd Qu.: 3624   3rd Qu.: 2424   3rd Qu.: 902   3rd Qu.:35.00   3rd Qu.: 69.0   3rd Qu.: 4005
                    Max.   :48094   Max.   :26330   Max.   :6392   Max.   :96.00   Max.   :100.0   Max.   :31643
 P.Undergrad         Outstate       Room.Board       Books           Personal         PhD            Terminal
 Min.   :    1.0   Min.   : 2340   Min.   :1780   Min.   :  96.0   Min.   : 250   Min.   :  8.00   Min.   : 24.0
 1st Qu.:   95.0   1st Qu.: 7320   1st Qu.:3597   1st Qu.: 470.0   1st Qu.: 850   1st Qu.: 62.00   1st Qu.: 71.0
 Median :  353.0   Median : 9990   Median :4200   Median : 500.0   Median :1200   Median : 75.00   Median : 82.0
 Mean   :  855.3   Mean   :10441   Mean   :4358   Mean   : 549.4   Mean   :1341   Mean   : 72.66   Mean   : 79.7
 3rd Qu.:  967.0   3rd Qu.:12925   3rd Qu.:5050   3rd Qu.: 600.0   3rd Qu.:1700   3rd Qu.: 85.00   3rd Qu.: 92.0
 Max.   :21836.0   Max.   :21700   Max.   :8124   Max.   :2340.0   Max.   :6800   Max.   :103.00   Max.   :100.0
   S.F.Ratio      perc.alumni        Expend        Grad.Rate
 Min.   : 2.50   Min.   : 0.00   Min.   : 3186   Min.   : 10.00
 1st Qu.:11.50   1st Qu.:13.00   1st Qu.: 6751   1st Qu.: 53.00
 Median :13.60   Median :21.00   Median : 8377   Median : 65.00
 Mean   :14.09   Mean   :22.74   Mean   : 9660   Mean   : 65.46
 3rd Qu.:16.50   3rd Qu.:31.00   3rd Qu.:10830   3rd Qu.: 78.00
 Max.   :39.80   Max.   :64.00   Max.   :56233   Max.   :118.00
> pairs(College[,1:10])
Error in pairs.default(College[, 1:10]) : non-numeric argument to 'pairs'
> College[,1] = as.numeric(factor(College[,1]))
Error in factor(College[, 1]) : object 'College' not found
> College[,1] = as.numeric(factor(College[,1]))
> pairs(College[,1:10])
> plot(College$Private,College$Outstate,col=c("red","blue"))
> Elite=rep("No",nrow(College))
> Elite[College$Top10perc > 50]="Yes"
> Elite = as.factor(Elite)
> College=data.frame(College,Elite)
> summary(College$Elite)
 No Yes
699  78
> plot(College$Elite,College$Outstate,col=c("red","blue"))
> plot(College$Elite,College$Outstate,col=c("red","blue"))
> plot(College$Elite,College$Outstate,col=c("red","blue"))
>
```



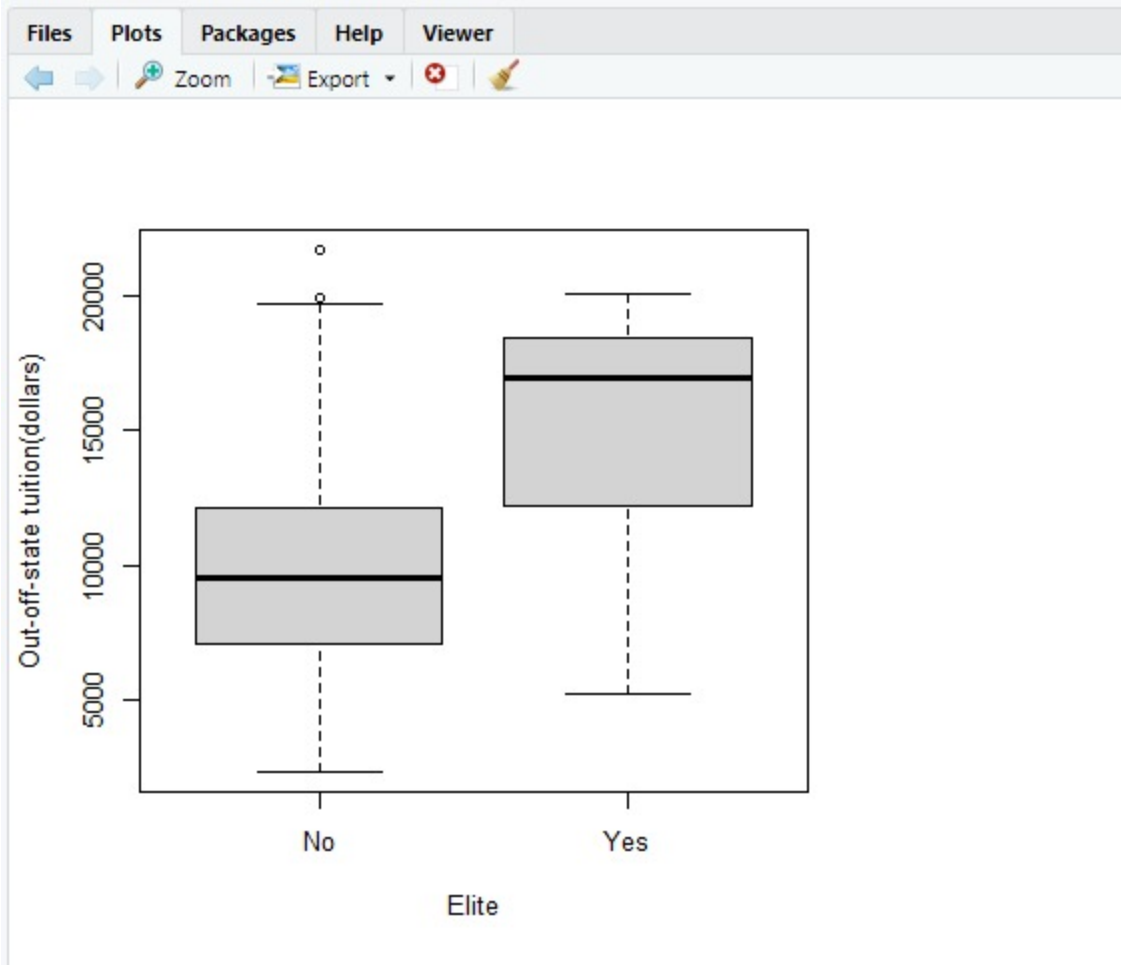
v) use the hist() function to produce some histograms with differing numbers of bins for a few of the quantitative variables. You may find the command par(mfrow=c(2,2)) useful: it will divide the print window into four regions so that four plots can be made simultaneously. Modifying the arguments to this function will divide the screen in other ways.



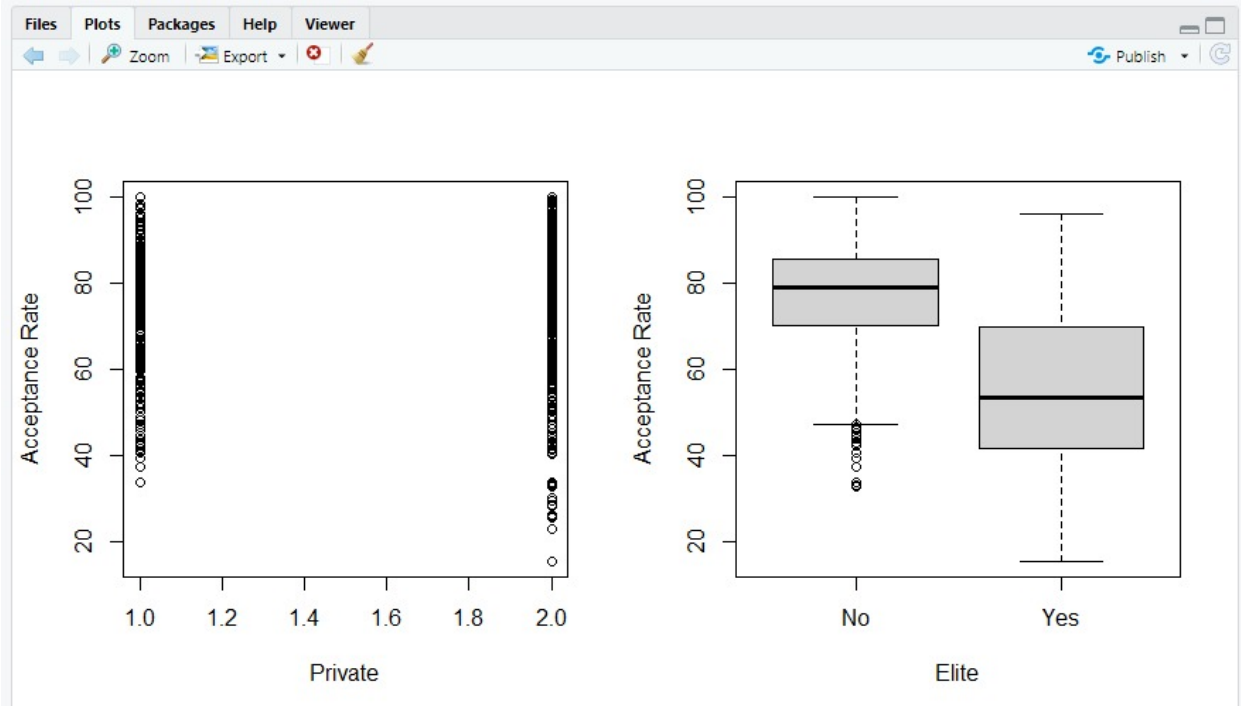

```
> summary(College$PhD)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   8.00   62.00   75.00   72.66   85.00  103.00
```

```
> summary(College$Enroll)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
     35     242     434     780     902    6392
```

```
> plot(College$Elite,College$Outstate,xlab = "Elite", ylab = "Out-off-state tuition(dollars)")
>
```



```
> AcceptPerc = College$Accept / College$Apps * 100
> College = data.frame(College, AcceptPerc)
> par(mfrow = c(1, 2))
> plot(College$Private, College$AcceptPerc, xlab = "Private", ylab = "Acceptance Rate")
> plot(College$Elite, College$AcceptPerc, xlab = "Elite", ylab = "Acceptance Rate")
>
```



9)

a) Which of the predictors are quantitative, and which are qualitative?

```
Console   Terminal ×   Jobs ×
R 4.1.3 · ~/
> data("Auto")
> summary(Auto)
      mpg          cylinders      displacement     horsepower        weight      acceleration        year
 Min.   : 9.00   Min.   :3.000   Min.   : 68.0   Min.   : 46.0   Min.   :1613   Min.   : 8.00   Min.   :70.00
 1st Qu.:17.00   1st Qu.:4.000   1st Qu.:105.0   1st Qu.: 75.0   1st Qu.:2225   1st Qu.:13.78   1st Qu.:73.00
 Median :22.75   Median :4.000   Median :151.0   Median : 93.5   Median :2804   Median :15.50   Median :76.00
 Mean   :23.45   Mean   :5.472   Mean   :194.4   Mean   :104.5   Mean   :2978   Mean   :15.54   Mean   :75.98
 3rd Qu.:29.00   3rd Qu.:8.000   3rd Qu.:275.8   3rd Qu.:126.0   3rd Qu.:3615   3rd Qu.:17.02   3rd Qu.:79.00
 Max.   :46.60   Max.   :8.000   Max.   :455.0   Max.   :230.0   Max.   :5140   Max.   :24.80   Max.   :82.00

     origin                      name
 Min.   :1.000   amc matador       :  5
 1st Qu.:1.000   ford pinto        :  5
 Median :1.000   toyota corolla    :  5
 Mean   :1.577   amc gremlin       :  4
 3rd Qu.:2.000   amc hornet        :  4
 Max.   :3.000   chevrolet chevette:  4
                 (Other)           :365
>
```

Quantitative variables: mpg, cylinders, displacement, horsepower, weight, acceleration.

Qualitative variables: Year, origin, name.

b) What is the range of each quantitative predictor? You can answer this using the range() function.

```
> range(Auto$mpg)
[1]  9.0 46.6
> range(Auto$cylinders)
[1] 3 8
> range(Auto$displacement)
[1]  68 455
> range(Auto$horsepower)
[1]  46 230
> range(Auto$weight)
[1] 1613 5140
> range(Auto$acceleration)
[1]  8.0 24.8
> range(Auto$year)
[1] 70 82
>
```

c) What is the mean and standard deviation of each quantitative predictor?

```
> sapply(Auto[,c(1:6),],mean)
         mpg    cylinders displacement   horsepower       weight acceleration
   23.445918     5.471939   194.411990   104.469388  2977.584184    15.541327
> sapply(Auto[,c(1:6),],sd)
         mpg    cylinders displacement   horsepower       weight acceleration
    7.805007     1.705783   104.644004    38.491160   849.402560     2.758864
>
```

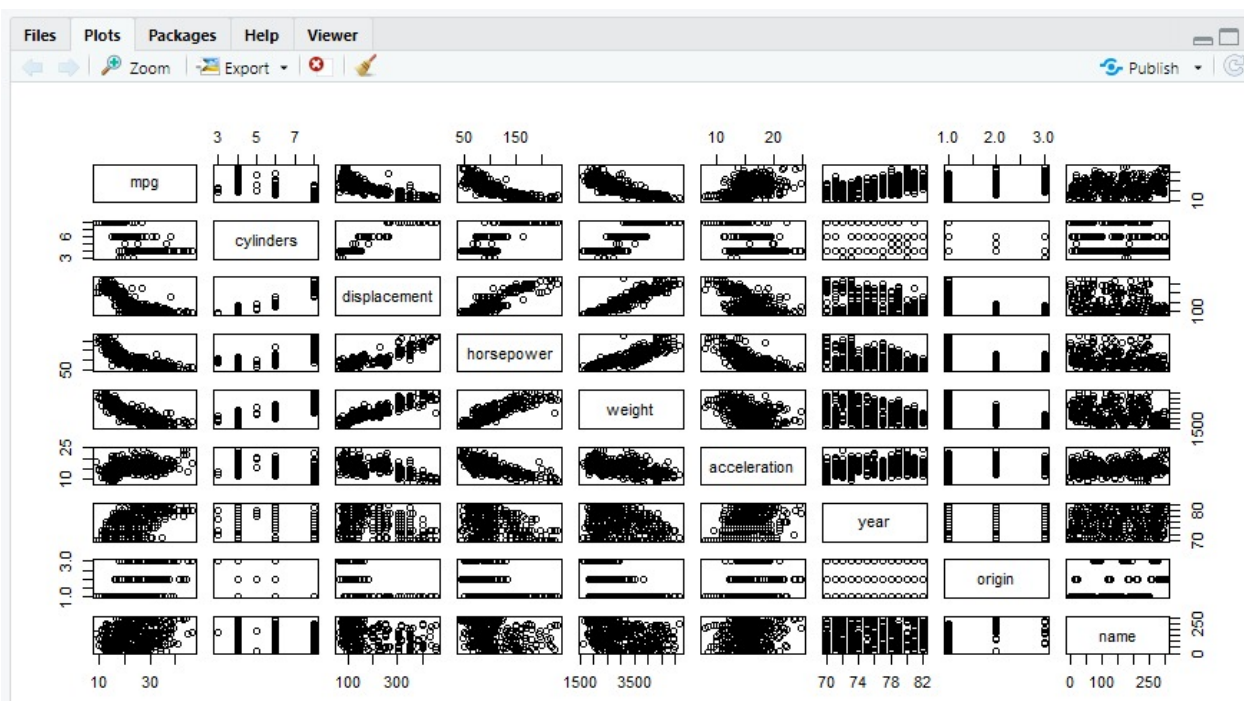
d) Now remove the 10th through 85th observations. What is the range, mean, and standard deviation of each predictor in the subset of the data that remains?

```
> new.auto= subset(Auto[-c(10:85),])
> sapply(new.auto[,-c(9)],range)
      mpg cylinders displacement horsepower weight acceleration year origin
[1,] 11.0         3           68         46   1649          8.5   70      1
[2,] 46.6         8          455        230   4997         24.8   82      3
> |
```

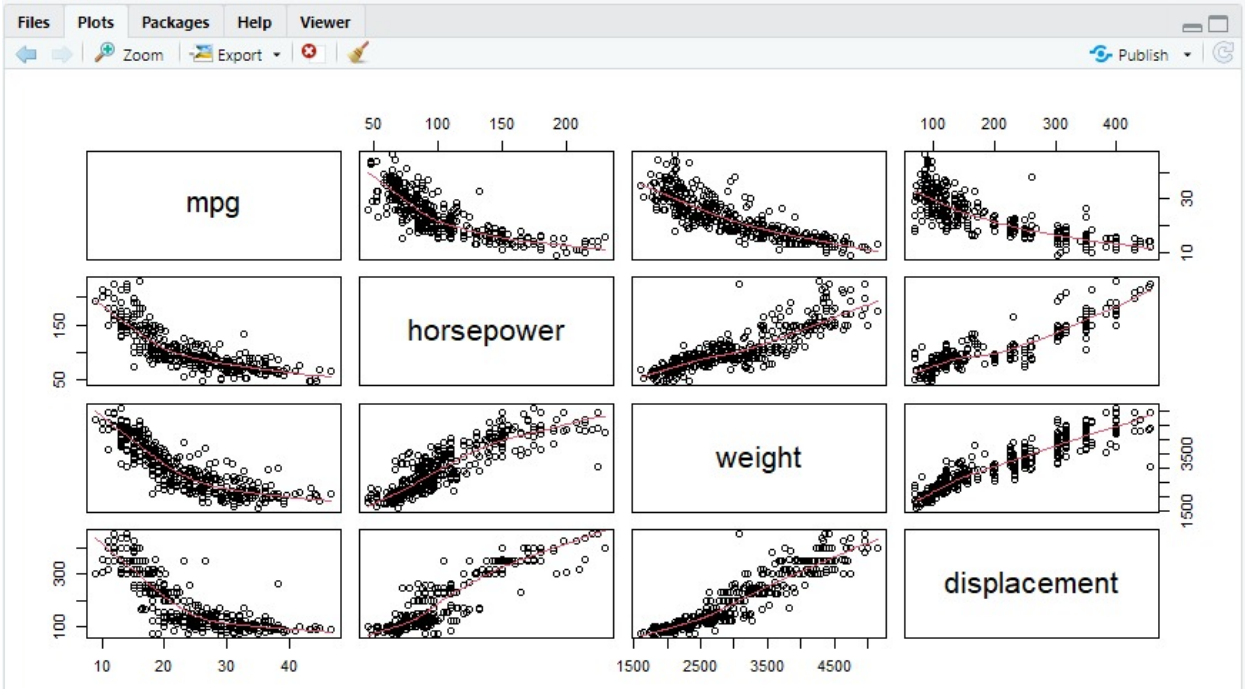
```
> sapply(new.auto[,-c(9)],mean)
        mpg    cylinders displacement   horsepower       weight acceleration         year       origin
  24.404430     5.373418   187.240506   100.721519  2935.971519    15.726899    77.145570     1.601266
> sapply(new.auto[,-c(9)],sd)
        mpg    cylinders displacement   horsepower       weight acceleration         year       origin
   7.867283     1.654179    99.678367    35.708853   811.300208     2.693721     3.106217     0.819910
> |
```

e) Using the full data set, investigate the predictors graphically, using scatterplots or other tools of your choice. Create some plots highlighting the relationships among the predictors. Comment on your findings

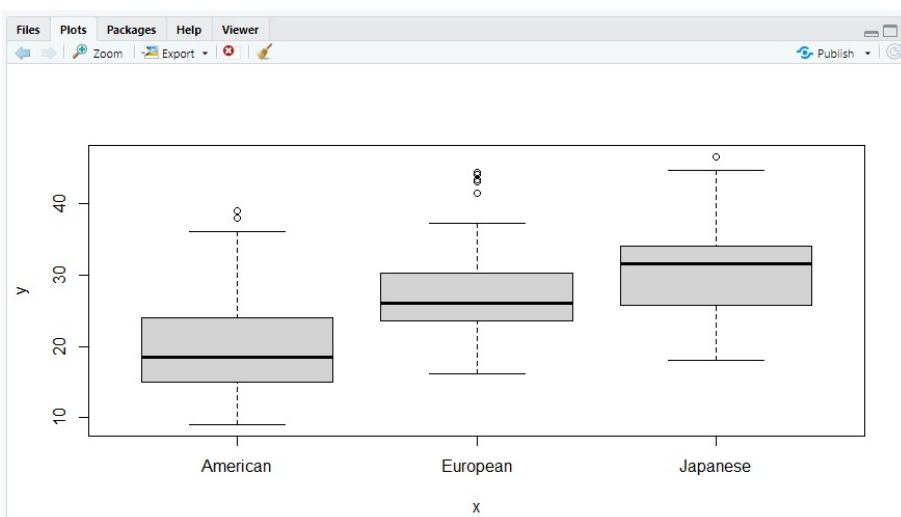
```
> pairs(Auto)
> |
```



```
> pairs(~mpg+ horsepower +weight + displacement, data=Auto, panel = panel.smooth)
>
```



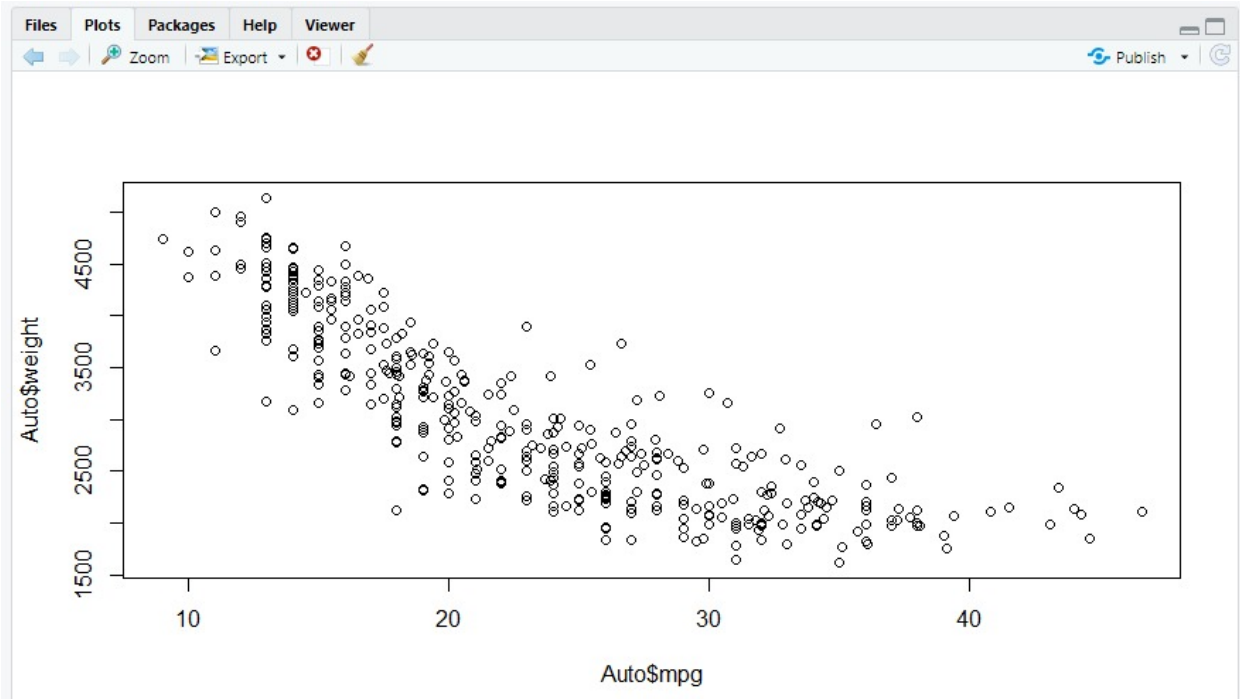
This mpg is inversely proportional to weight, horsepower, and displacement. Weight, horsepower and displacement are directly proportional to each other.



Japanese vehicles have more mpg than American and European vehicles.

```
> plot(factor(Auto$origin),Auto$mpg,names = (c("American","European","Japanese")))
>
```

```
> plot(Auto$mpg,Auto$weight)
>
```



f. All of the predictors show correlation with mpg. The name predictor has too few observations per name though, so using this as a predictor is likely to result in overfitting the data and will not generalize well.

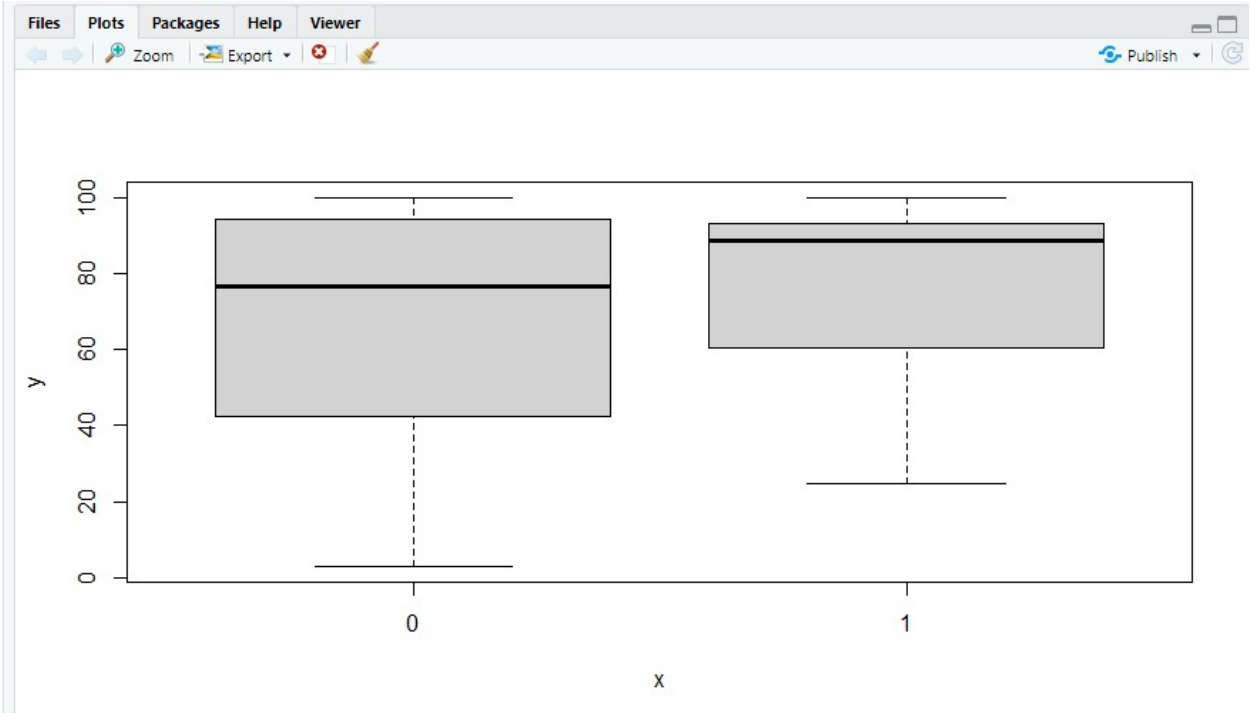
10)

a) To begin, load in the Boston data set. The Boston data set is part of the MASS library in R.

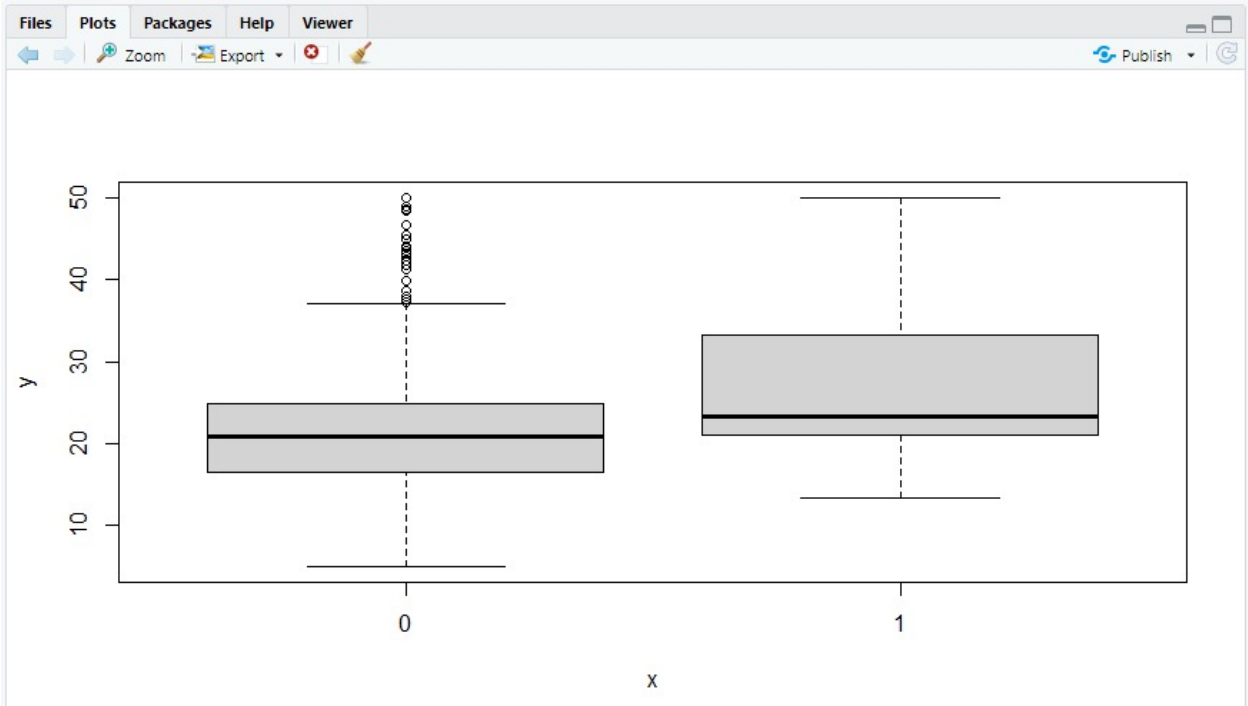
```
Console   Terminal ×   Jobs ×
R 4.1.3 · ~/
> library(MASS)
> data("Boston")
> summary(Boston)
      crim                zn             indus            chas              nox                rm             age
 Min.   : 0.00632   Min.   :  0.00   Min.   : 0.46   Min.   :0.00000   Min.   :0.3850   Min.   :3.561   Min.   :  2.90
 1st Qu.: 0.08205   1st Qu.:  0.00   1st Qu.: 5.19   1st Qu.:0.00000   1st Qu.:0.4490   1st Qu.:5.886   1st Qu.: 45.02
 Median : 0.25651   Median :  0.00   Median : 9.69   Median :0.00000   Median :0.5380   Median :6.208   Median : 77.50
 Mean   : 3.61352   Mean   : 11.36   Mean   :11.14   Mean   :0.06917   Mean   :0.5547   Mean   :6.285   Mean   : 68.57
 3rd Qu.: 3.67708   3rd Qu.: 12.50   3rd Qu.:18.10   3rd Qu.:0.00000   3rd Qu.:0.6240   3rd Qu.:6.623   3rd Qu.: 94.08
 Max.   :88.97620   Max.   :100.00   Max.   :27.74   Max.   :1.00000   Max.   :0.8710   Max.   :8.780   Max.   :100.00
      dis              rad              tax           ptratio          black             lstat            medv
 Min.   : 1.130   Min.   : 1.000   Min.   :187.0   Min.   :12.60   Min.   :  0.32   Min.   : 1.73   Min.   : 5.00
 1st Qu.: 2.100   1st Qu.: 4.000   1st Qu.:279.0   1st Qu.:17.40   1st Qu.:375.38   1st Qu.: 6.95   1st Qu.:17.02
 Median : 3.207   Median : 5.000   Median :330.0   Median :19.05   Median :391.44   Median :11.36   Median :21.20
 Mean   : 3.795   Mean   : 9.549   Mean   :408.2   Mean   :18.46   Mean   :356.67   Mean   :12.65   Mean   :22.53
 3rd Qu.: 5.188   3rd Qu.:24.000   3rd Qu.:666.0   3rd Qu.:20.20   3rd Qu.:396.23   3rd Qu.:16.95   3rd Qu.:25.00
 Max.   :12.127   Max.   :24.000   Max.   :711.0   Max.   :22.00   Max.   :396.90   Max.   :37.97   Max.   :50.00
> |
```

b) Make some pairwise scatterplots of the predictors (columns) in this data set. Describe your findings.

```
> plot(as.factor(Boston$chas),Boston$age)
>
```

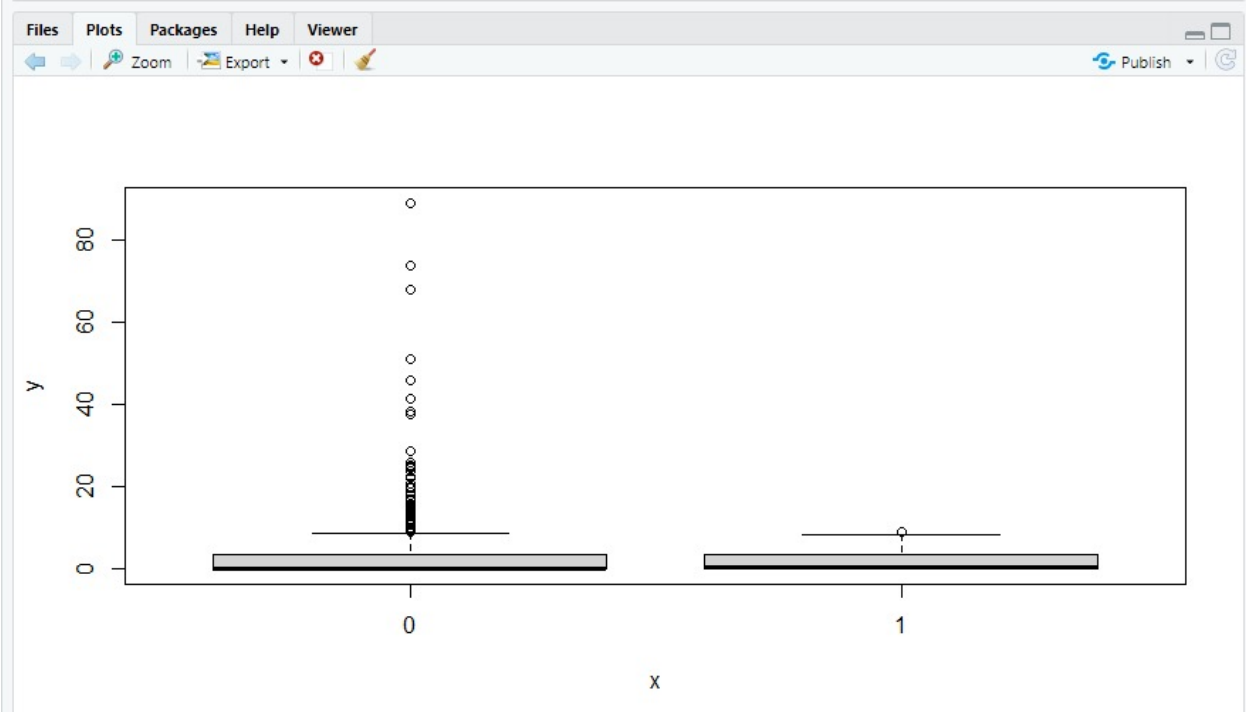



```
> plot(as.factor(Boston$chas),Boston$medv)
>
```

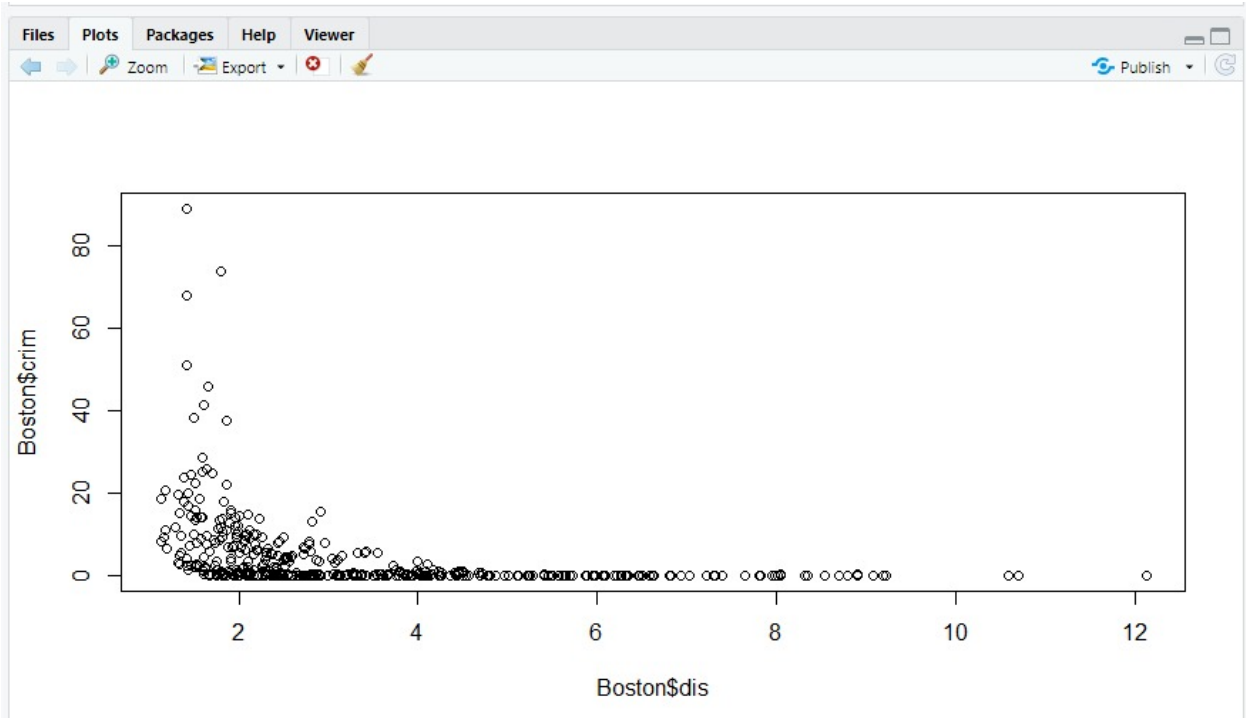


c. Are any of the predictors associated with per capita crime rate? If so, explain the relationship.

```
> plot(as.factor(Boston$chas),Boston$crim)
>
```

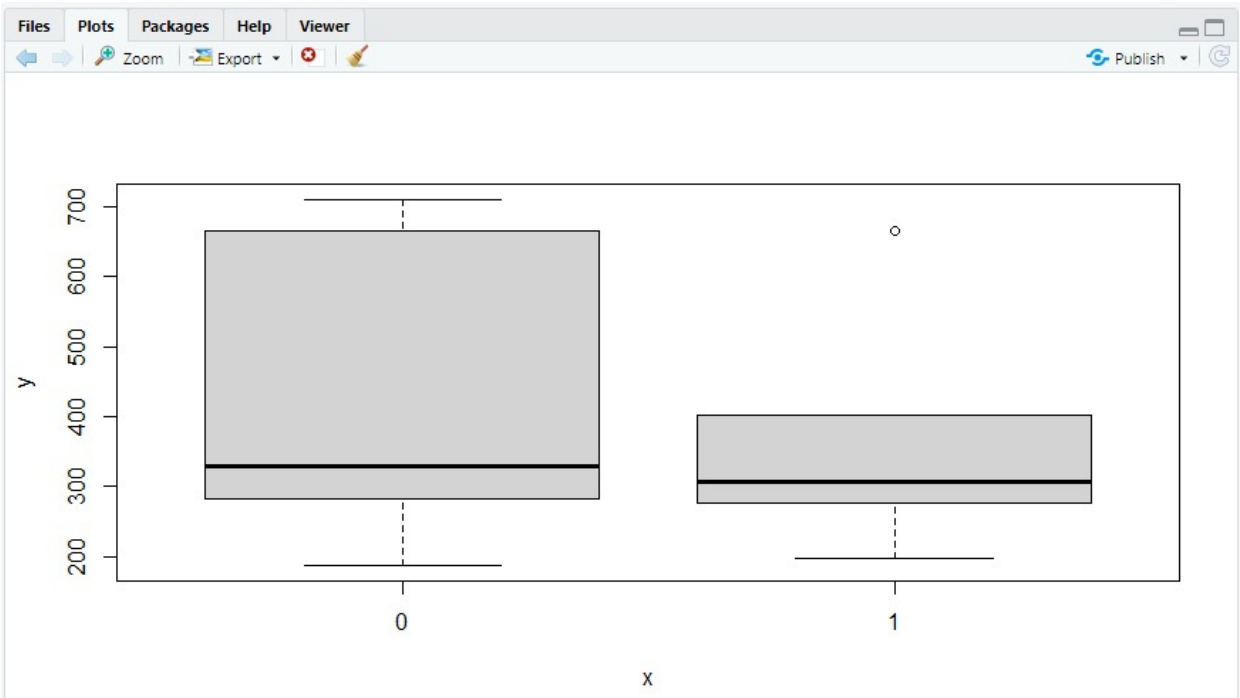



```
> plot(Boston$dis,Boston$crim)
>
```

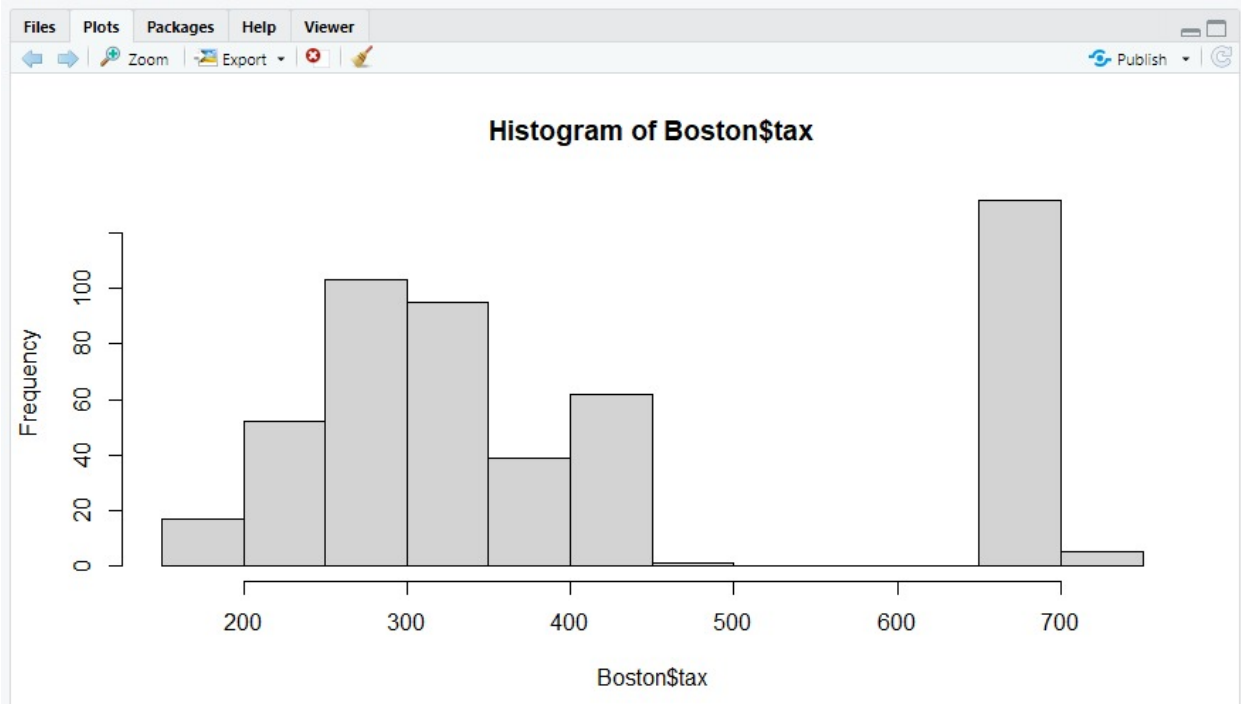


d. Do any of the suburbs of Boston appear to have particularly high crime rates? Tax rates? Pupil-teacher ratios? Comment on the range of each predictor.

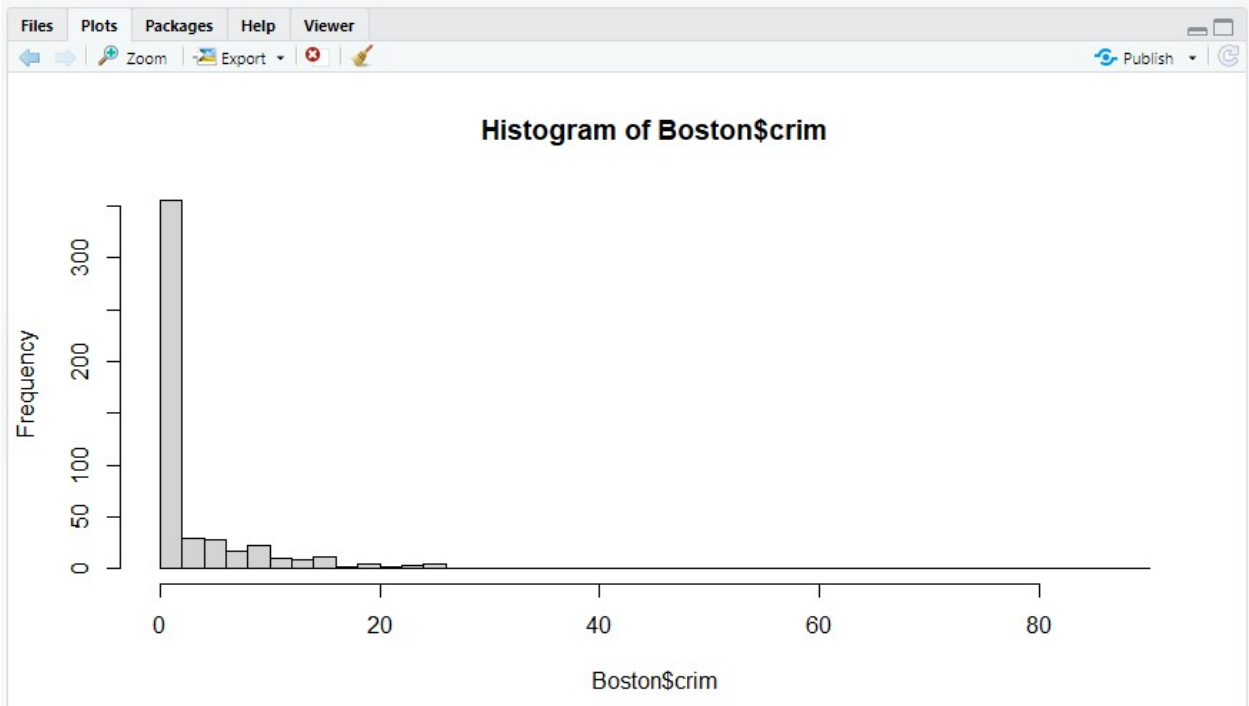
```
> plot(as.factor(Boston$chas),Boston$tax)
>
```




```
> range(Boston$crim)
[1]  0.00632 88.97620
> hist(Boston$tax)
```




```
> hist(Boston$crim,breaks = 50)
>
```



How many of the suburbs in this data set bound the Charles river?

What is the median pupil-teacher ratio among the towns in this data set?

```
> table(Boston$chas)

  0   1
471  35
> median(Boston$ptratio)
[1] 19.05
> |
```

Chapter - 3

8

```
Console   Terminal ×   Jobs ×
R 4.1.3 · ~/
> library(ISLR)
> data("Auto")
> lm.fit=lm(mpg~horsepower,data=Auto)
> summary(lm.fit)

Call:
lm(formula = mpg ~ horsepower, data = Auto)

Residuals:
     Min       1Q   Median       3Q      Max
-13.5710  -3.2592  -0.3435   2.7630  16.9240

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 39.935861   0.717499   55.66   <2e-16 ***
horsepower  -0.157845   0.006446  -24.49   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.906 on 390 degrees of freedom
Multiple R-squared:  0.6059,    Adjusted R-squared:  0.6049
F-statistic: 599.7 on 1 and 390 DF,  p-value: < 2.2e-16

> |
```

i. Is there a relationship between the predictor and the response?

The P-values for the regression coefficients are nearly zero. This implies statistical significance, which in turn means that there is a relationship.

ii. How strong is the relationship between the predictor and the response?

The R^{2} value indicates that about 61% of the variation in the response variable(mpg) is due to the predictor variable(horsepower).

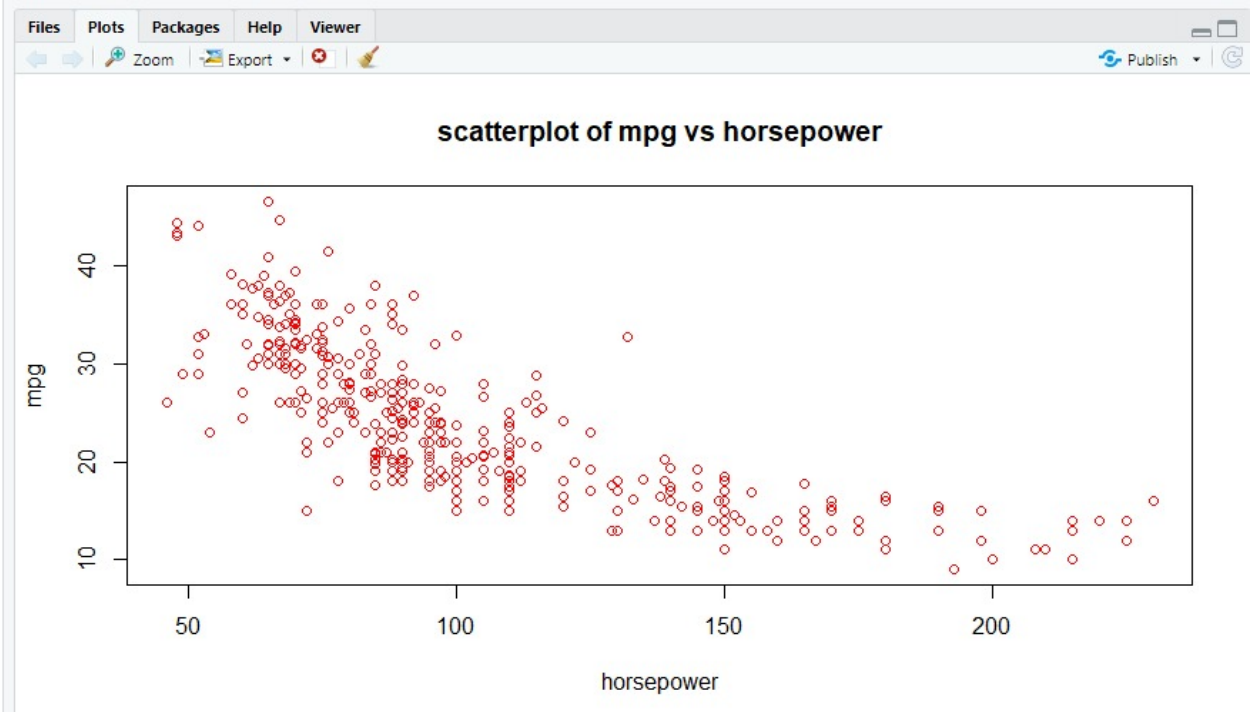
iii. Is the relationship between the predictor and the response positive or negative? The regression coefficient for ‘horsepower’ is negative. Hence, relationships are negative.

iv. What is the predicted mpg associated with a horsepower of 98? What are the associated 95 % confidence and prediction intervals?

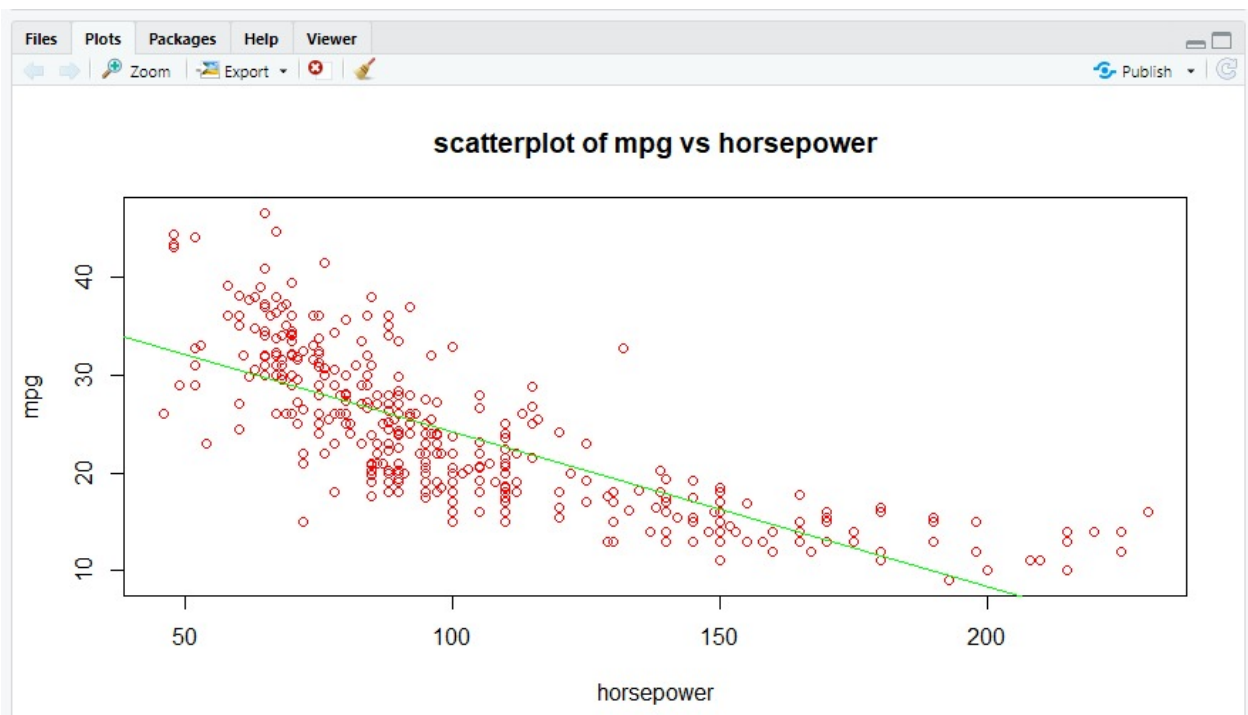
```
> predict(lm.fit,data.frame(horsepower=c(98)),interval = "prediction")
       fit     lwr      upr
1 24.46708 14.8094 34.12476
> predict(lm.fit,data.frame(horsepower=c(98)),interval = "confidence")
       fit      lwr      upr
1 24.46708 23.97308 24.96108
>
```

b. Plot the response and the predictor. Use the abline() function to display the least squares regression line.

```
> plot(Auto$horsepower,Auto$mpg,main = "scatterplot of mpg vs horsepower",xlab="horsepower", ylab="mpg",col="red")
>
```

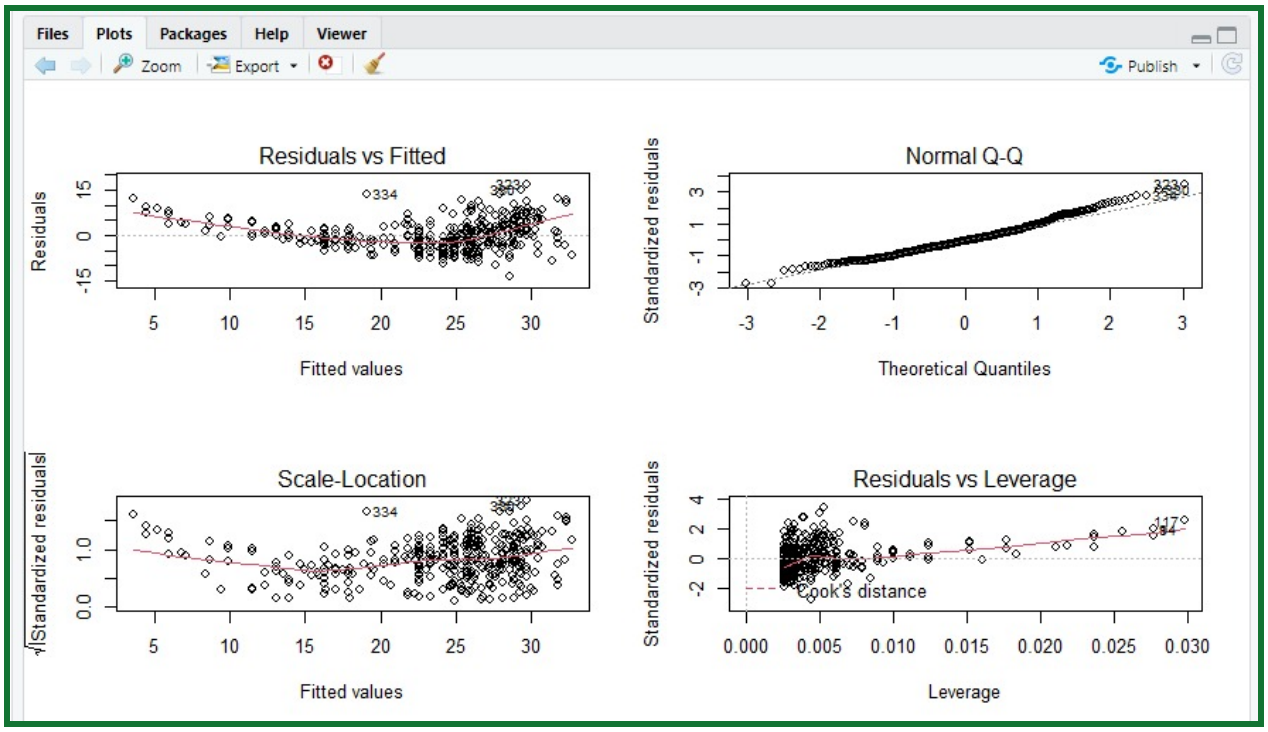



```
> abline(lm.fit,col="green")
>
```



c. Use the plot() function to produce diagnostic plots of the least squares regression fit. Comment on any problems you see with the fit.

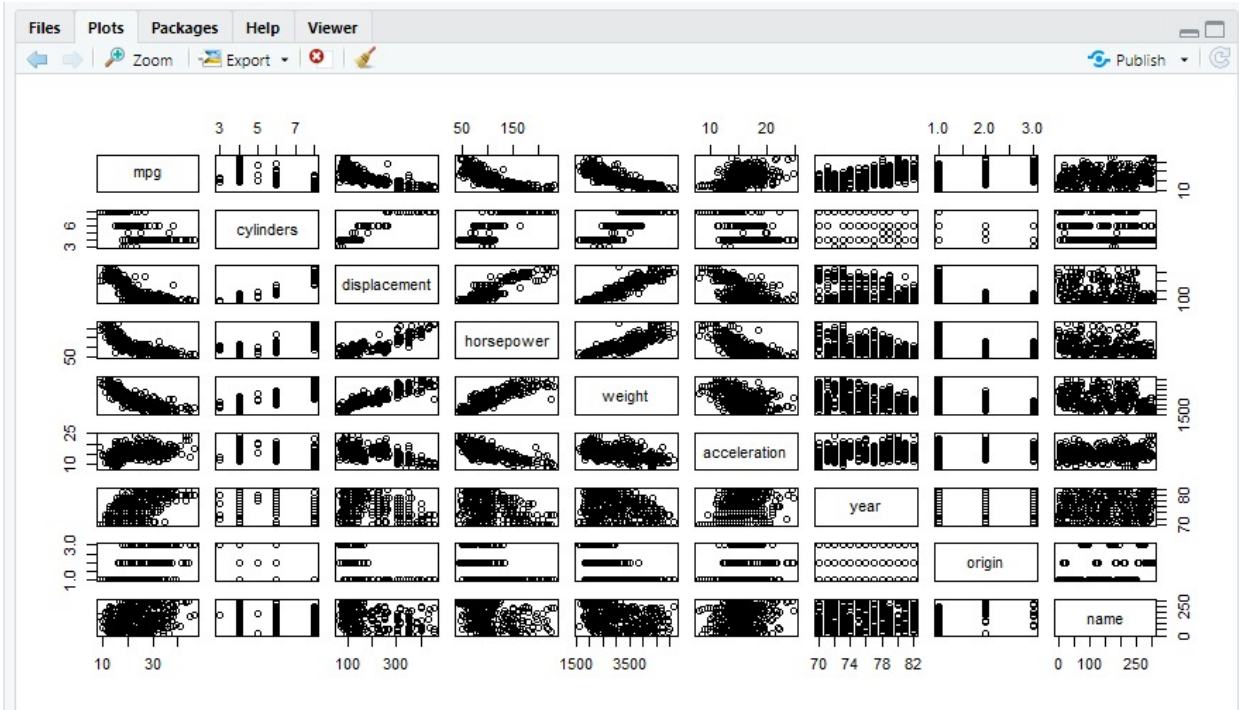
```
> par(mfrow=c(2,2))
> plot(lm.fit)
>
```



9)

a. Produce a scatterplot matrix which includes all the variables in the data set.

```
> pairs(Auto)
>
```



b. Compute the matrix of correlations between the variables using the function cor(). You will need to exclude the name variable, cor() which is qualitative.

```
> names(Auto)
[1] "mpg"          "cylinders"    "displacement" "horsepower"   "weight"       "acceleration" "year"
[8] "origin"       "name"
> cor(Auto[1:8])
                     mpg  cylinders displacement horsepower     weight acceleration       year     origin
mpg           1.0000000 -0.7776175   -0.8051269 -0.7784268 -0.8322442    0.4233285  0.5805410  0.5652088
cylinders    -0.7776175  1.0000000    0.9508233  0.8429834  0.8975273   -0.5046834 -0.3456474 -0.5689316
displacement -0.8051269  0.9508233    1.0000000  0.8972570  0.9329944   -0.5438005 -0.3698552 -0.6145351
horsepower   -0.7784268  0.8429834    0.8972570  1.0000000  0.8645377   -0.6891955 -0.4163615 -0.4551715
weight       -0.8322442  0.8975273    0.9329944  0.8645377  1.0000000   -0.4168392 -0.3091199 -0.5850054
acceleration  0.4233285 -0.5046834   -0.5438005 -0.6891955 -0.4168392    1.0000000  0.2903161  0.2127458
year          0.5805410 -0.3456474   -0.3698552 -0.4163615 -0.3091199    0.2903161  1.0000000  0.1815277
origin        0.5652088 -0.5689316   -0.6145351 -0.4551715 -0.5850054    0.2127458  0.1815277  1.0000000
>
```

C)

i) Is there a relationship between the predictors and the response?

```
> lm.fit2=lm(mpg~.-name,data=Auto)
> summary(lm.fit2)

Call:
lm(formula = mpg ~ . - name, data = Auto)

Residuals:
    Min      1Q  Median      3Q     Max 
-9.5903 -2.1565 -0.1169  1.8690 13.0604 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)    
(Intercept)  -17.218435   4.644294  -3.707  0.00024 ***
cylinders     -0.493376   0.323282  -1.526  0.12780    
displacement   0.019896   0.007515   2.647  0.00844 ** 
horsepower    -0.016951   0.013787  -1.230  0.21963    
weight        -0.006474   0.000652  -9.929  < 2e-16 ***
acceleration   0.080576   0.098845   0.815  0.41548    
year           0.750773   0.050973  14.729  < 2e-16 ***
origin         1.426141   0.278136   5.127 4.67e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.328 on 384 degrees of freedom
Multiple R-squared:  0.8215,	Adjusted R-squared:  0.8182 
F-statistic: 252.4 on 7 and 384 DF,  p-value: < 2.2e-16
```

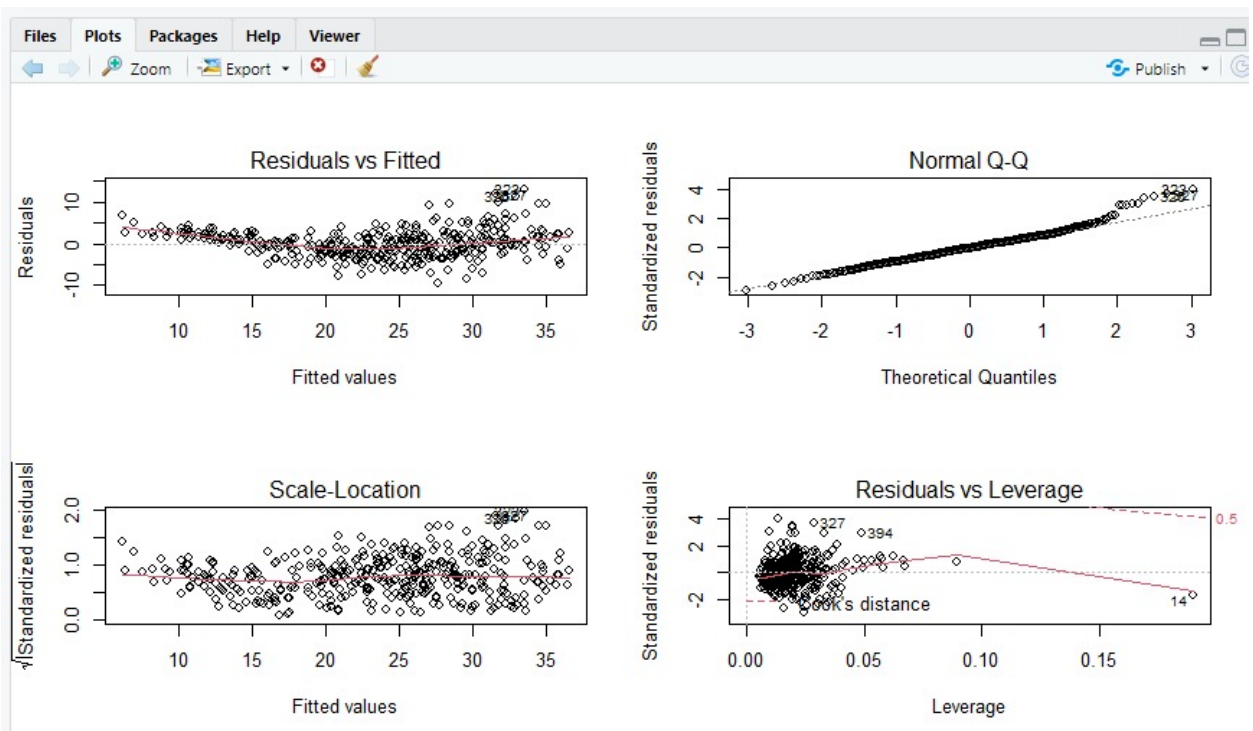
ii. Which predictors appear to have a statistically significant relationship to the response?

We can answer this by checking P-values associated with each predictor's t-statistic. We may all include this statistically except ‘cylinders’, ‘horsepower’ and ‘acceleration’.

iii. What does the coefficient for the year variable suggest?
The coefficient of the ‘year’ variable suggests that the average effect of an increase of 1 year is an increase pf 0.7507727 in ‘mpg’.

d. Use the plot() function to produce diagnostic plots of the linear regression fit. Comment on any problems you see with the fit. Do the residual plots suggest any unusually large outliers? Does the leverage plot identify any observations with unusually high leverage?

```
> par(mfrow=c(2,2))
> plot(lm.fit2)
>
```

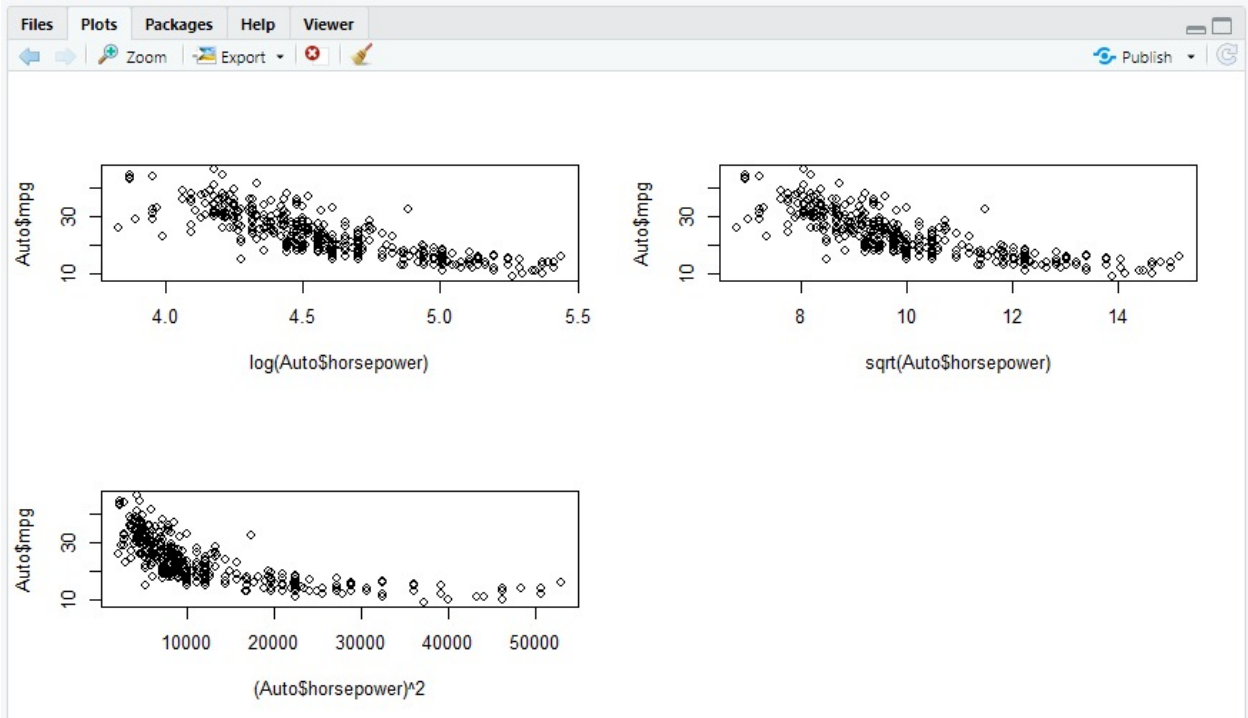


e. Use the * and : symbols to fit linear regression models with interaction effects. Do any interactions appear to be statistically significant?

```
> lm.fit3=lm(mpg~cylinders*displacement+displacement*weight,data=Auto[,1:8])
> summary(lm.fit3)

Call:
lm(formula = mpg ~ cylinders * displacement + displacement *
    weight, data = Auto[, 1:8])

Residuals:
     Min       1Q   Median       3Q      Max
-13.2934  -2.5184  -0.3476   1.8399  17.7723

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)            5.262e+01  2.237e+00  23.519  < 2e-16 ***
cylinders              7.606e-01  7.669e-01   0.992    0.322
displacement          -7.351e-02  1.669e-02  -4.403 1.38e-05 ***
weight                -9.888e-03  1.329e-03  -7.438 6.69e-13 ***
cylinders:displacement -2.986e-03  3.426e-03  -0.872    0.384
displacement:weight    2.128e-05  5.002e-06   4.254 2.64e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.103 on 386 degrees of freedom
Multiple R-squared:  0.7272,    Adjusted R-squared:  0.7237
F-statistic: 205.8 on 5 and 386 DF,  p-value: < 2.2e-16
```

f. Try a few different transformations of the variables, such as log(X), √ X, X2. Comment on your findings.

```
> par(mfrow=c(2,2))
> plot(log(Auto$horsepower),Auto$mpg)
> plot(sqrt(Auto$horsepower),Auto$mpg)
> plot((Auto$horsepower)^2,Auto$mpg)
>
```



10)

a)Fit a multiple regression model to predict Sales using Price, Urban, and US.

```
> data(Carseats)
> lm.fit4=lm(Sales~Price+Urban+US,data=Carseats)
> summary(lm.fit4)

Call:
lm(formula = Sales ~ Price + Urban + US, data = Carseats)

Residuals:
    Min      1Q  Median      3Q     Max 
-6.9206 -1.6220 -0.0564  1.5786  7.0581 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 13.043469   0.651012  20.036  < 2e-16 ***
Price       -0.054459   0.005242 -10.389  < 2e-16 ***
UrbanYes    -0.021916   0.271650  -0.081    0.936    
USYes        1.200573   0.259042   4.635 4.86e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.472 on 396 degrees of freedom
Multiple R-squared:  0.2393,	Adjusted R-squared:  0.2335 
F-statistic: 41.52 on 3 and 396 DF,  p-value: < 2.2e-16

> |
```

b. Provide an interpretation of each coefficient in the model. Be careful—some of the variables in the model are qualitative!

The coefficient of the ‘price’ variables may be interpreted by saying that the average effect of a price of 1 dollar is a decrease of 54.4588492 units in the sales all other predictors remaining fixed. The coefficient of the ‘urban’ variables may be interpreted by saying that the average sales in the us store are 1200.572 units more than in a no US store all other predictors.

c. Write out the model in equation form, being careful to handle the qualitative variables properly.

The model may be written as

Sales = 13.0434+(-0.0544)*price+(-0.02191)*urban+(1.2005727)*US + E

d. For which of the predictors can you reject the null hypothesis H0 : βj = 0?
We can reject the null hypothesis for the ‘price’ and ‘us’ variables.

e. On the basis of your response to the previous question, fit a smaller model that only uses the predictors for which there is evidence of association with the outcome.

```
> lm.fit5=lm(Sales~Price+US,data=Carseats)
> summary(lm.fit5)

Call:
lm(formula = Sales ~ Price + US, data = Carseats)

Residuals:
    Min      1Q  Median      3Q     Max 
-6.9269 -1.6286 -0.0574  1.5766  7.0515 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 13.03079    0.63098  20.652  < 2e-16 ***
Price       -0.05448    0.00523 -10.416  < 2e-16 ***
USYes        1.19964    0.25846   4.641 4.71e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.469 on 397 degrees of freedom
Multiple R-squared:  0.2393,	Adjusted R-squared:  0.2354 
F-statistic: 62.43 on 2 and 397 DF,  p-value: < 2.2e-16

> |
```

f. How well do the models in (a) and (e) fit the data?

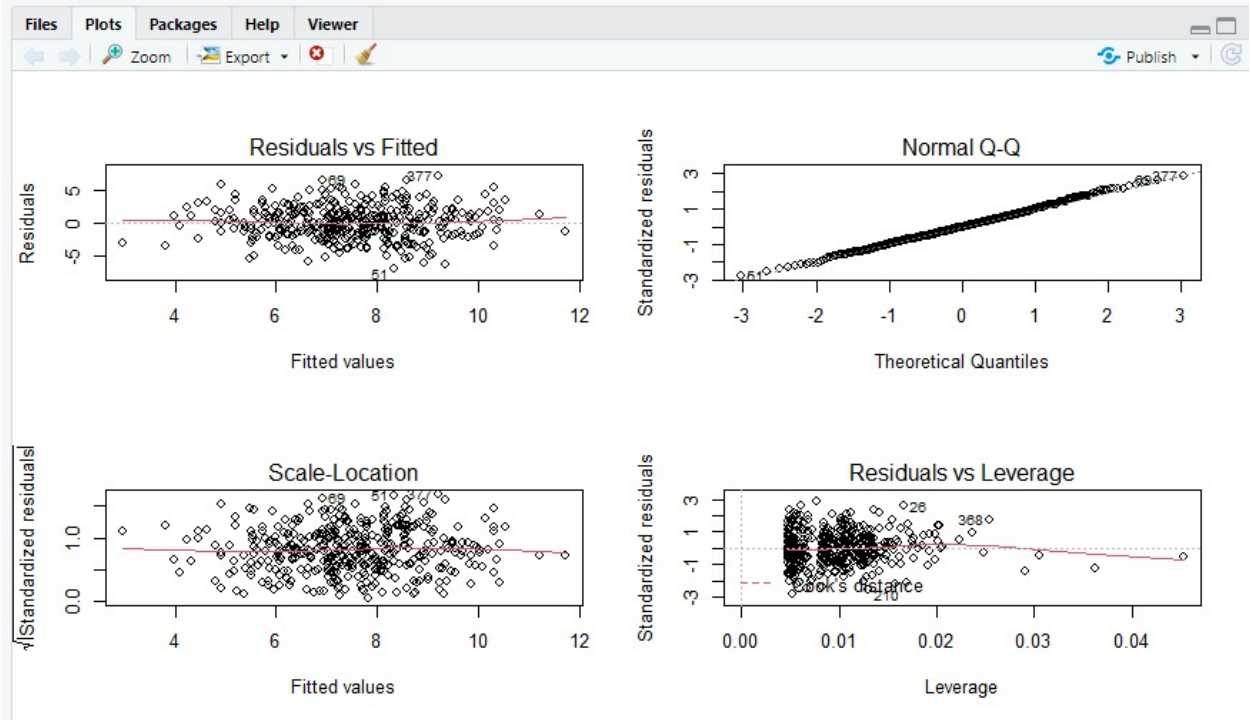
The R square for the smaller model is marginally better than for the bigger model. Essentially about 23.92% of the variability is explained by the model.

g. Using the model from (e), obtain 95 % confidence intervals for the coefficient(s).

```
> confint(lm.fit5)
                  2.5 %      97.5 %
(Intercept) 11.79032020 14.27126531
Price       -0.06475984 -0.04419543
USYes        0.69151957  1.70776632
> |
```

h. Is there evidence of outliers or high leverage observations in the model from (e)?

```
> par(mfrow=c(2,2))
> plot(Carseats.fit4)
Error in plot(Carseats.fit4) : object 'Carseats.fit4' not found
> plot(lm.fit4)
> |
```


Files
Plots
Packages
Help
Viewer
Zoom
Export
Publish
Residuals vs Fitted
Residuals
Fitted values
Normal Q-Q
Standardized residuals
Theoretical Quantiles
Scale-Location
√|Standardized residuals|
Fitted values
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage