Chapter 6 HW

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```r
grocery <- read.csv('grocery.csv')
```

```r
grocery
```

```
      Y     X1   X2 X3
1  4264 305657 7.17  0
2  4496 328476 6.20  0
3  4317 317164 4.61  0
4  4292 366745 7.02  0
5  4945 265518 8.61  1
6  4325 301995 6.88  0
7  4110 269334 7.23  0
8  4111 267631 6.27  0
9  4161 296350 6.49  0
10 4560 277223 6.37  0
11 4401 269189 7.05  0
12 4251 277133 6.34  0
13 4222 282892 6.94  0
14 4063 306639 8.56  0
15 4343 328405 6.71  0
16 4833 321773 5.82  1
17 4453 272319 6.82  0
18 4195 293880 8.38  0
19 4394 300867 7.72  0
20 4099 296872 7.67  0
21 4816 245674 7.72  1
22 4867 211944 6.45  1
23 4114 227996 7.22  0
24 4314 248328 8.50  0
25 4289 249894 8.08  0
```

```
26 4269 302660 7.26  0
27 4347 273848 7.39  0
28 4178 245743 8.12  0
29 4333 267673 6.75  0
30 4226 256506 7.79  0
31 4121 271854 7.89  0
32 3998 293225 9.01  0
33 4475 269121 8.01  0
34 4545 322812 7.21  0
35 4016 252225 7.85  0
36 4207 261365 6.14  0
37 4148 287645 6.76  0
38 4562 289666 7.92  0
39 4146 270051 8.19  0
40 4555 265239 7.55  0
41 4365 352466 6.94  0
42 4471 426908 7.25  0
43 5045 369989 9.65  1
44 4469 472476 8.20  0
45 4408 414102 8.02  0
46 4219 302507 6.72  0
47 4211 382686 7.23  0
48 4993 442782 7.61  1
49 4309 322303 7.39  0
50 4499 290455 7.99  0
51 4186 411750 7.83  0
52 4342 292087 7.77  0
```

6.10

a Fit regression model (6.5) to the data for three predictor variables. State the estimated regression function. How are b_1, b_1, b_1 here?

```r
grocery.lm <- lm(Y ~ X1 + X2 + X3, data = grocery)
```

```r
grocery.lm
```

```
Call:
lm(formula = Y ~ X1 + X2 + X3, data = grocery)

Coefficients:
```

```
(Intercept)            X1            X2            X3 
  4.150e+03    7.871e-04   -1.317e+01    6.236e+02 
```

```
summary(grocery.lm)
```

```

Call:
lm(formula = Y ~ X1 + X2 + X3, data = grocery)

Residuals:
    Min      1Q  Median      3Q     Max 
-264.05 -110.73  -22.52   79.29  295.75 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  4.150e+03  1.956e+02  21.220  < 2e-16 ***
X1           7.871e-04  3.646e-04   2.159   0.0359 *  
X2          -1.317e+01  2.309e+01  -0.570   0.5712    
X3           6.236e+02  6.264e+01   9.954 2.94e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 143.3 on 48 degrees of freedom
Multiple R-squared:  0.6883,	Adjusted R-squared:  0.6689 
F-statistic: 35.34 on 3 and 48 DF,  p-value: 3.316e-12
```

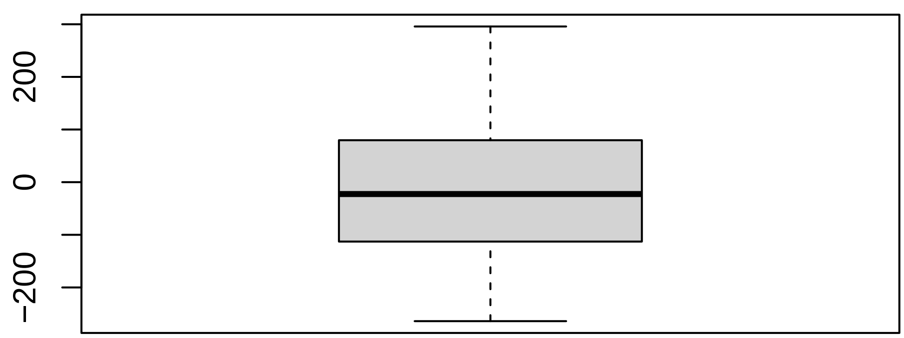
b. Obtain the residuals and prepare a box plot of the residuals. What information does this plot provide?

```
grocery.lm$residuals
```

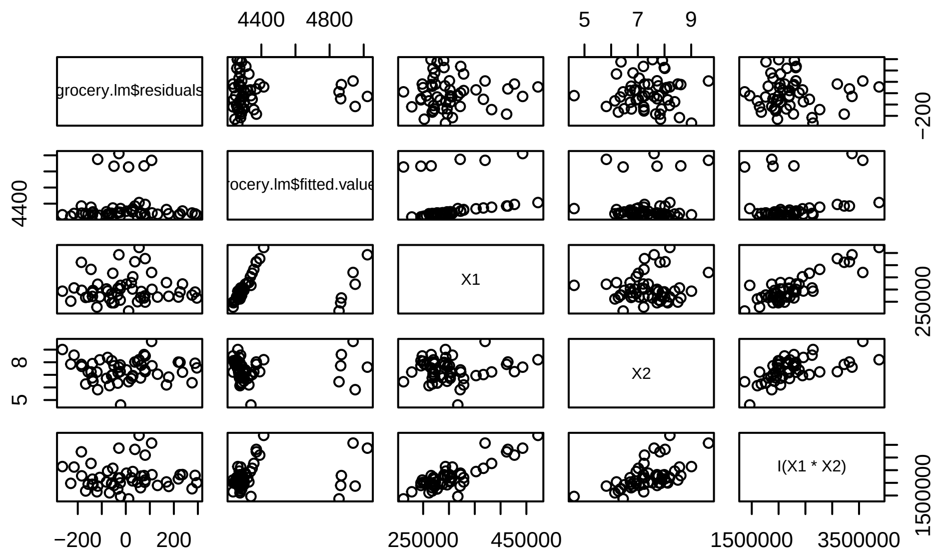
```
          1           2           3           4           5           6 
 -32.063483  169.205091  -21.825426  -54.119552   75.933724   28.000660 
          7           8           9          10          11          12 
-156.684401 -166.983381 -136.691019  275.783546  132.059842  -33.540598 
         13          14          15          16          17          18 
 -59.173782 -215.535629   22.975644 -117.076677  178.568096  -75.863154 
         19          20          21          22          23          24 
 108.947943 -183.565972  -49.165210   11.662167 -120.279732   80.569854 
         25          26          27          28          29          30 
```

```
 48.807558  -23.519661   78.869281  -58.398630   61.303251  -23.214763
        31          32          33          34          35          36
-138.978271 -264.053024  218.752742  235.960794 -229.055311  -67.763118
        37          38          39          40          41          42
-139.284659  288.397234 -108.609359  295.751820   29.065887   80.555515
        43          44          45          46          47          48
 107.399309   55.197555   37.772702  -80.508888 -144.901536  -28.753312
        49          50          51          52
  2.731302  225.697849 -184.877629   64.516810
```

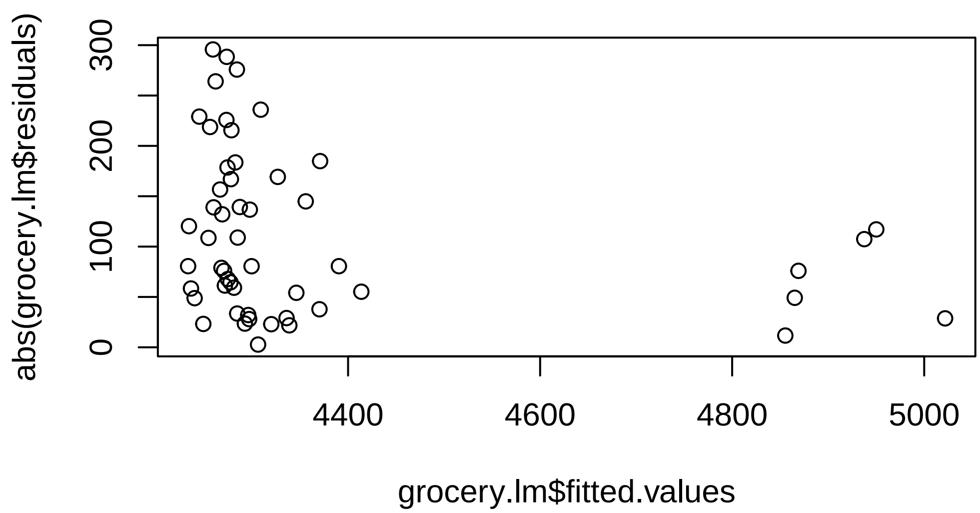
```r
boxplot(grocery.lm$residuals)
```




```r
pairs(~grocery.lm$residuals+grocery.lm$fitted.values+X1+X2+I(X1*X2), data = grocery)
```

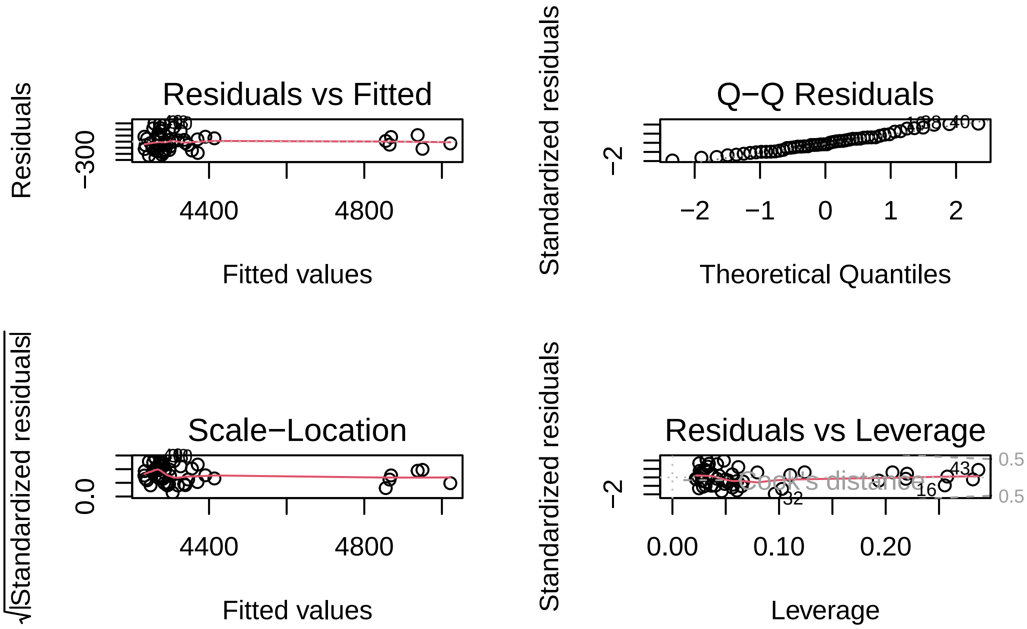



```
plot(abs(grocery.lm$residuals)~grocery.lm$fitted.values, data = grocery)
```

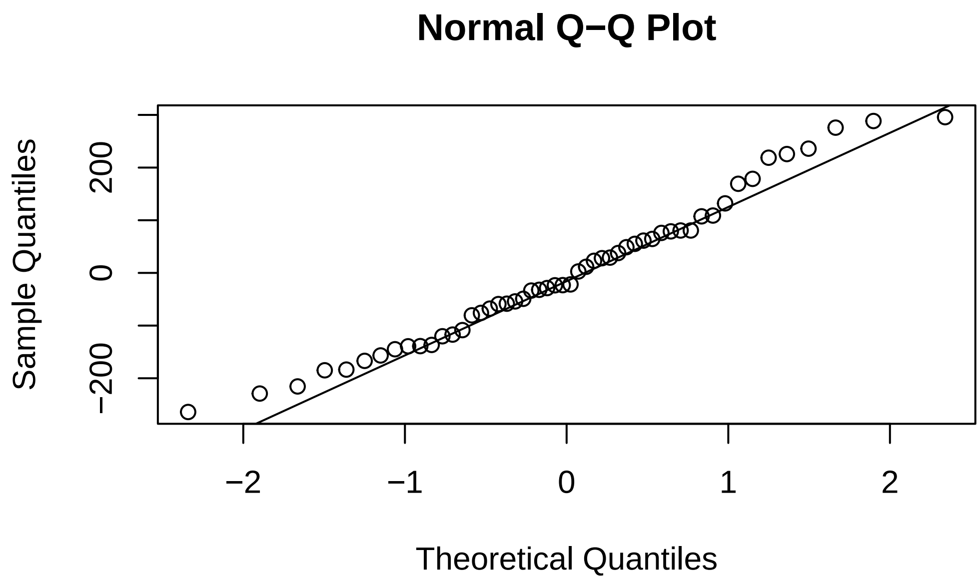


c. Plot the residuals against $\hat{Y}$, X_1, X_2, X_3, and X_1X_2 on separate graphs. Also prepare a normal probability plot. Interpret the plots and summarize your findings.

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




```
qqnorm(grocery.lm$residuals)
qqline(grocery.lm$residuals)
```




```r
shapiro.test(grocery.lm$residuals)
```

```
    Shapiro-Wilk normality test

data:  grocery.lm$residuals
W = 0.97575, p-value = 0.3644
```

```r
lillie.test(grocery.lm$residuals)
```

```
    Lilliefors (Kolmogorov-Smirnov) normality test

data:  grocery.lm$residuals
D = 0.08161, p-value = 0.5245
```

d. Prepare a time plot of the residuals. Is there any indication that the error term are correlated?

```r
grocery.resid <- resid(grocery.lm)
```

```r
grocery.resid
```

```
          1           2           3           4           5           6
 -32.063483  169.205091  -21.825426  -54.119552   75.933724   28.000660
          7           8           9          10          11          12
-156.684401 -166.983381 -136.691019  275.783546  132.059842  -33.540598
         13          14          15          16          17          18
 -59.173782 -215.535629   22.975644 -117.076677  178.568096  -75.863154
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 108.947943 -183.565972  -49.165210   11.662167 -120.279732   80.569854
         25          26          27          28          29          30
  48.807558  -23.519661   78.869281  -58.398630   61.303251  -23.214763
         31          32          33          34          35          36
-138.978271 -264.053024  218.752742  235.960794 -229.055311  -67.763118
         37          38          39          40          41          42
-139.284659  288.397234 -108.609359  295.751820   29.065887   80.555515
         43          44          45          46          47          48
 107.399309   55.197555   37.772702  -80.508888 -144.901536  -28.753312
         49          50          51          52
   2.731302  225.697849 -184.877629   64.516810
```
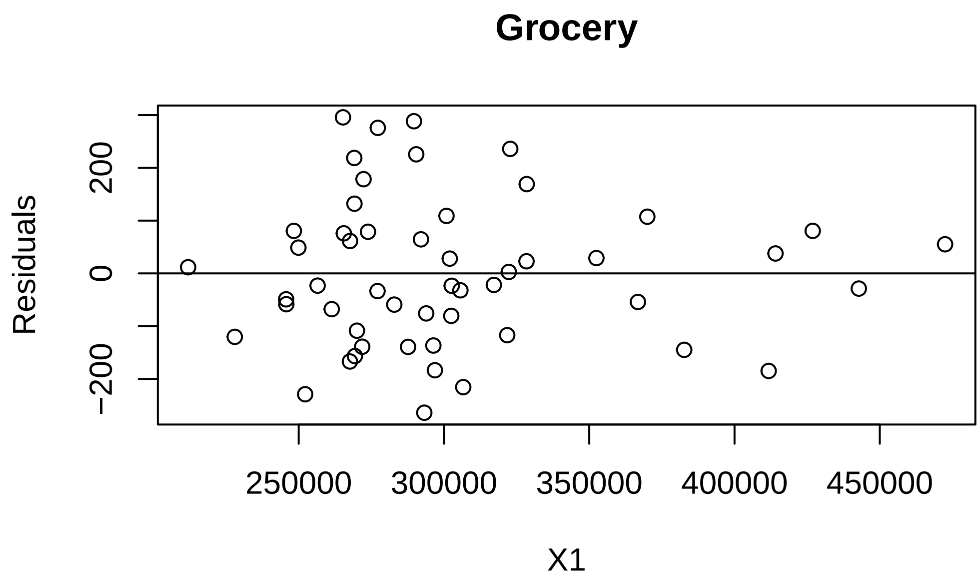

```r
plot(grocery$X1, grocery.resid,
     ylab = "Residuals", xlab = "X1",
     main = "Grocery")
abline(0, 0)                      # the horizon
```




```
plot(grocery$X2, grocery.resid,
     ylab = "Residuals", xlab = "X2",
     main = "Grocery")
abline(0, 0)                    # the horizon
```


```r
plot(grocery$X2, grocery.resid,
     ylab = "Residuals", xlab = "X3",
     main = "Grocery")
abline(0, 0)                     # the horizon
```

6.11

a. Test whether there is a regression relation, using level of significance 0.05. State the alternatives, decision rule, and conclusion. What does your result imply B_1, B_2, and B_3? What is the P-value of the test?

```
summary(grocery.lm)
```

```
Call:
lm(formula = Y ~ X1 + X2 + X3, data = grocery)

Residuals:
    Min      1Q  Median      3Q     Max
-264.05 -110.73  -22.52   79.29  295.75

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.150e+03  1.956e+02  21.220  < 2e-16 ***
X1           7.871e-04  3.646e-04   2.159   0.0359 *
X2          -1.317e+01  2.309e+01  -0.570   0.5712
X3           6.236e+02  6.264e+01   9.954 2.94e-13 ***
```

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

Residual standard error: 143.3 on 48 degrees of freedom
Multiple R-squared:  0.6883,    Adjusted R-squared:  0.6689
F-statistic: 35.34 on 3 and 48 DF,  p-value: 3.316e-12
```

```r
Anova(grocery.lm, type = 'III')
```

```
Anova Table (Type III tests)

Response: Y
             Sum Sq Df  F value    Pr(>F)
(Intercept) 9245215  1 450.2861 < 2.2e-16 ***
X1            95707  1   4.6614   0.03588 *
X2             6675  1   0.3251   0.57123
X3          2034514  1  99.0905 2.941e-13 ***
Residuals    985530 48
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

H_0: $B_1 = B_2 = B_3$

H_a: not all $B_k = 0$ ($k = 1, 2, 3$).

$MSR = 725{,}535$

$MSE = 20{,}531$

$F^* = 725{,}535/531.9 = 35.337$

$F(0.95; 3, 48) = 2.79806$.

If $F^* < 2.79806$ conclude H_0, otherwise H_a.

Conclude H_a. P-value $= < 0.05$.

b. Estimate B_1 and B_3 jointly by the Bonferroni procedure, using a 95 percent family confidence coefficient. Interpret your result.

```r
confint.lm(grocery.lm)
```

```
                    2.5 %       97.5 %
(Intercept)  3.756677e+03 4.543098e+03
X1           5.409544e-05 1.520065e-03
X2          -5.959506e+01 3.326302e+01
X3           4.976064e+02 7.495025e+02
```

c. Calculate the coefficient of multiple determination R^2. How is this measure interpreted here?

```r
summary(grocery.lm)
```

```

Call:
lm(formula = Y ~ X1 + X2 + X3, data = grocery)

Residuals:
    Min      1Q  Median      3Q     Max 
-264.05 -110.73  -22.52   79.29  295.75 

Coefficients:
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X3           6.236e+02  6.264e+01   9.954 2.94e-13 ***
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```