# 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?

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

```
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
```

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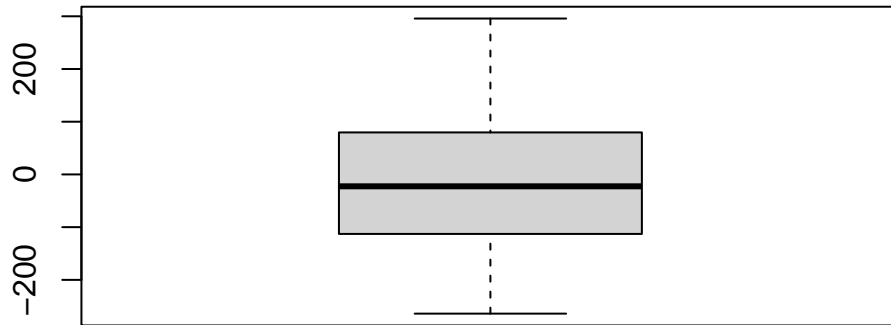


```
pairs(~grocery.lm$residuals+grocery.lm$fitted.values+X1+X2+I(X1*X2), data = grocery)
```
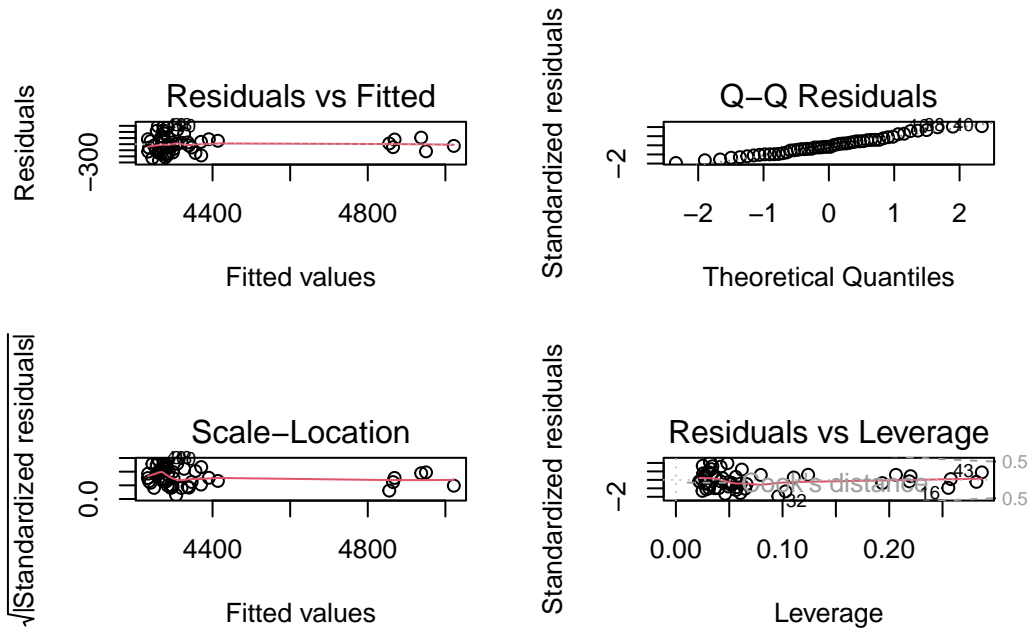
4
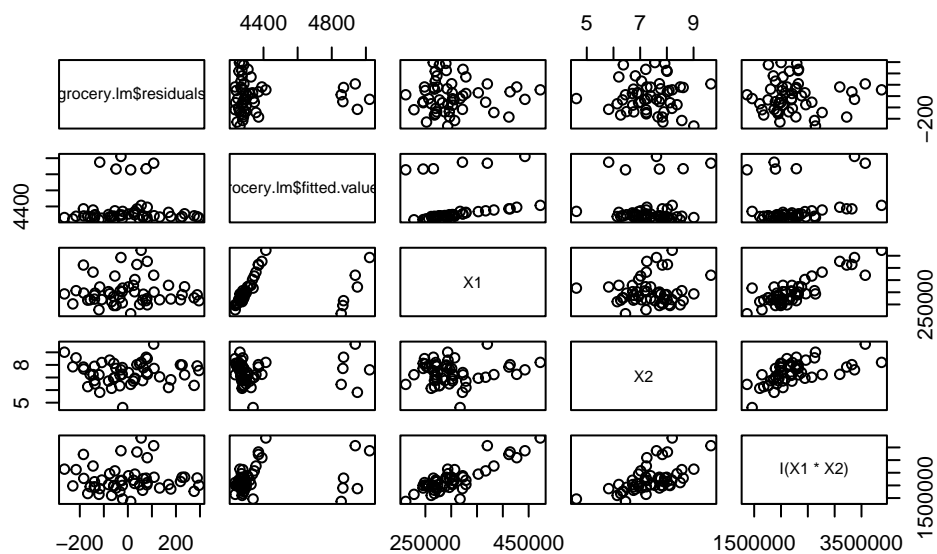
```r
plot(abs(grocery.lm$residuals)~grocery.lm$fitted.values, data = grocery)
```
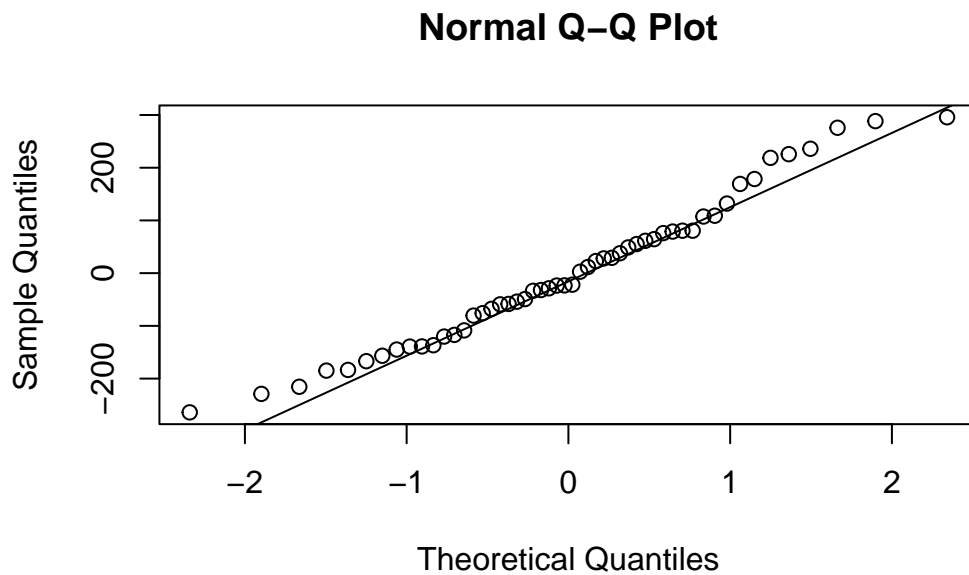
**c.** Plot the residuals against $\hat{Y}$, $X_1$, $X_2$, $X_3$, and $X_1 X_2$ on separate graphs. Also prepare a normal probability plot. Interpret the plots and summarize your findings.

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



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

## Normal Q–Q Plot



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

```
    Shapiro-Wilk normality test

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

```
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?

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

```
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
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          19          20          21          22          23          24
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          49          50          51          52
   2.731302  225.697849 -184.877629   64.516810
```

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

**Grocery**



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

## Grocery



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

**Grocery**



*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)
```

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

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(Intercept)  4.150e+03  1.956e+02  21.220  < 2e-16 ***
X1           7.871e-04  3.646e-04   2.159   0.0359 *
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X3           6.236e+02  6.264e+01   9.954 2.94e-13 ***
```

11

```
---
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
```

```
  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.

```
  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?

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

```
Call:
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Residuals:
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