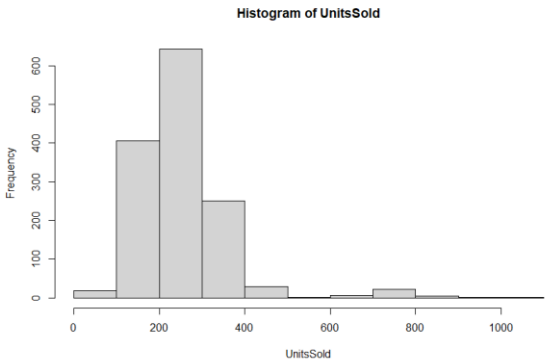
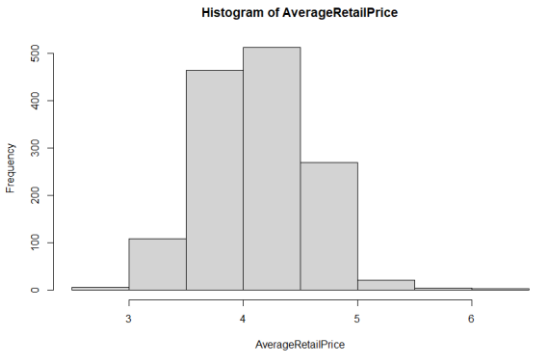
Business Analytics (110-1)

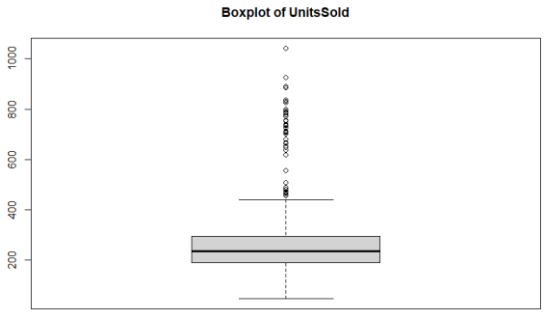
Assignment 2

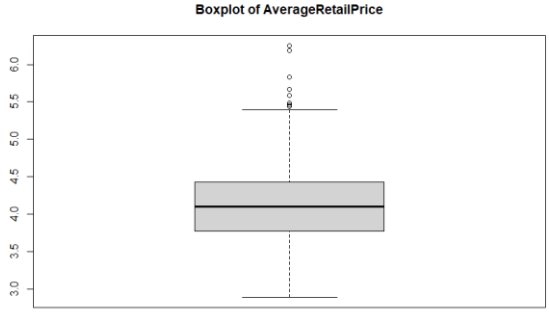
B08701244 工管三 蔡銍驊

(a) Do descriptive statistics, with R, to provide an overview for your retailing business. You may do it from any perspective with any EDA method. You may include some basic summaries as well as some emphases on interesting findings.

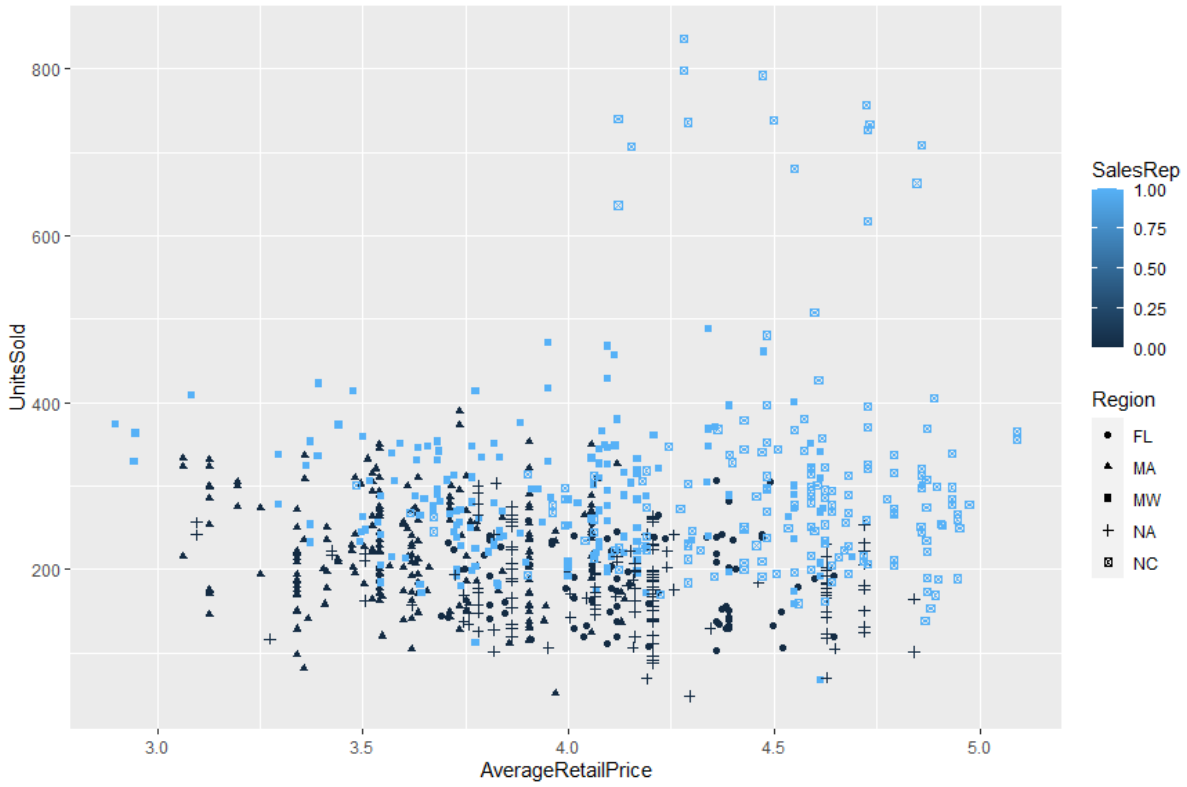


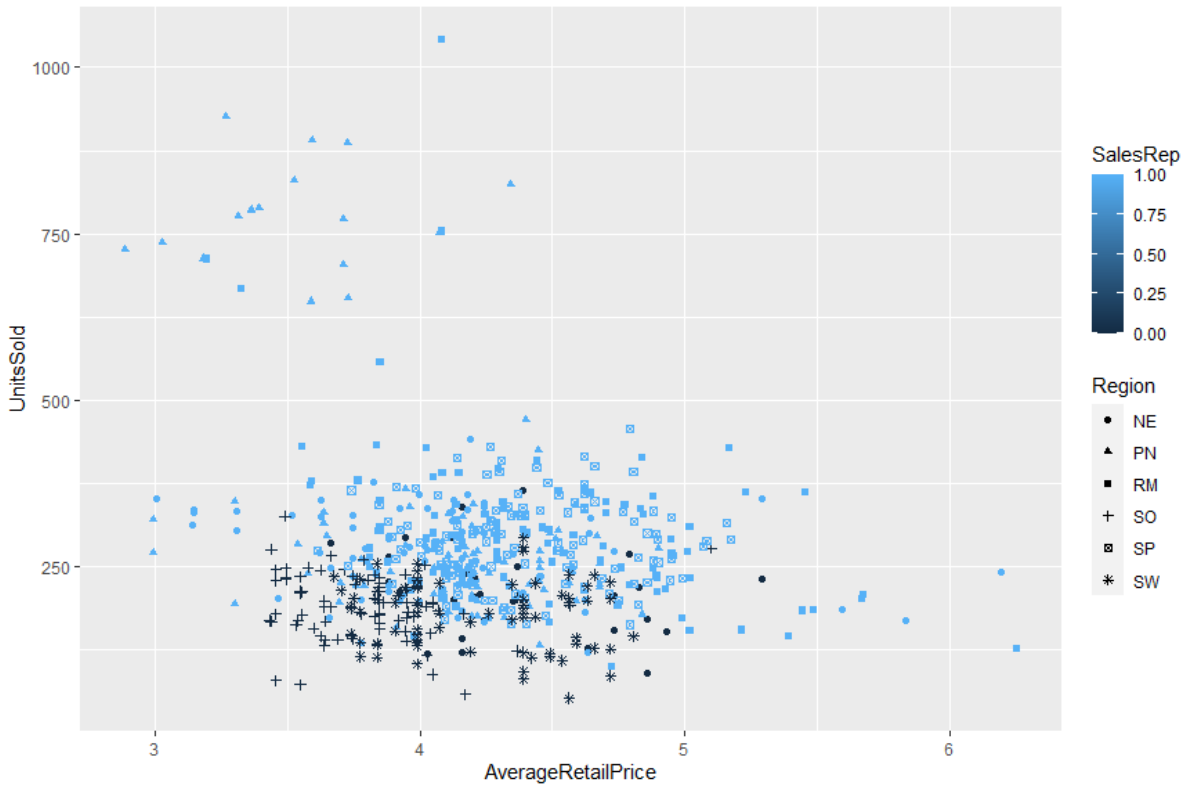




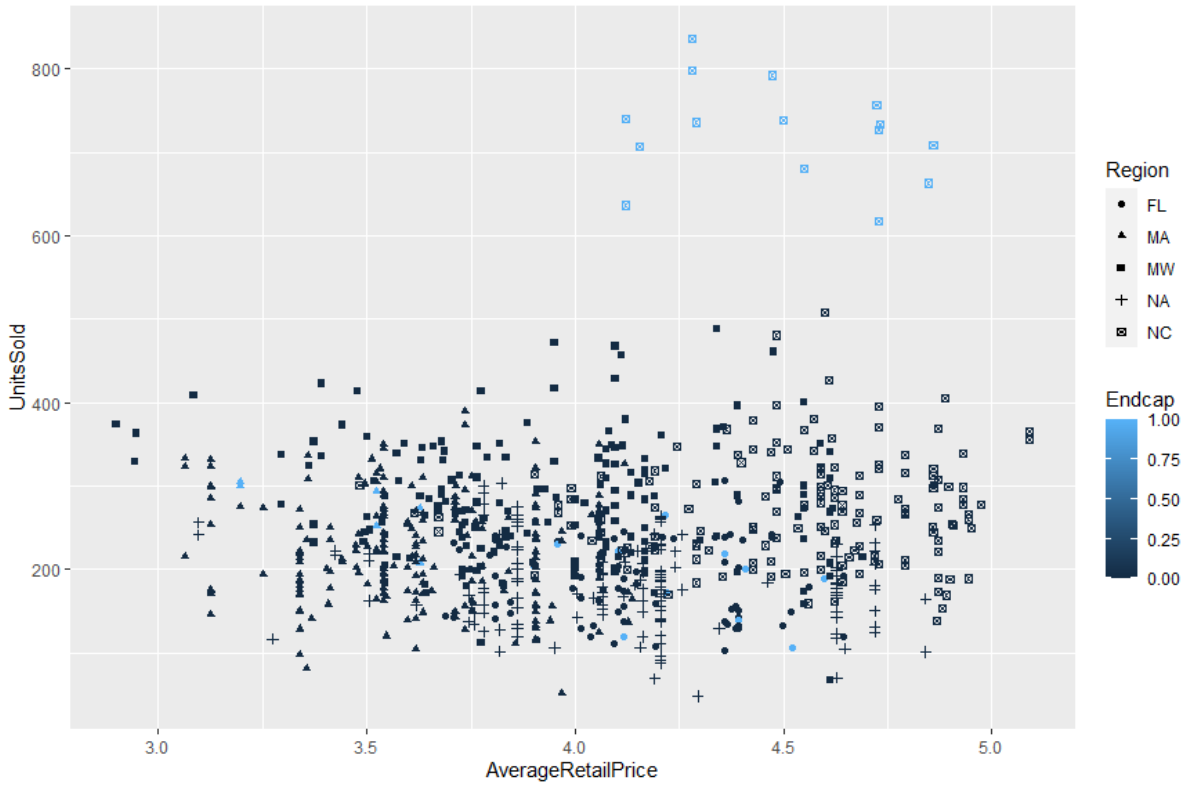


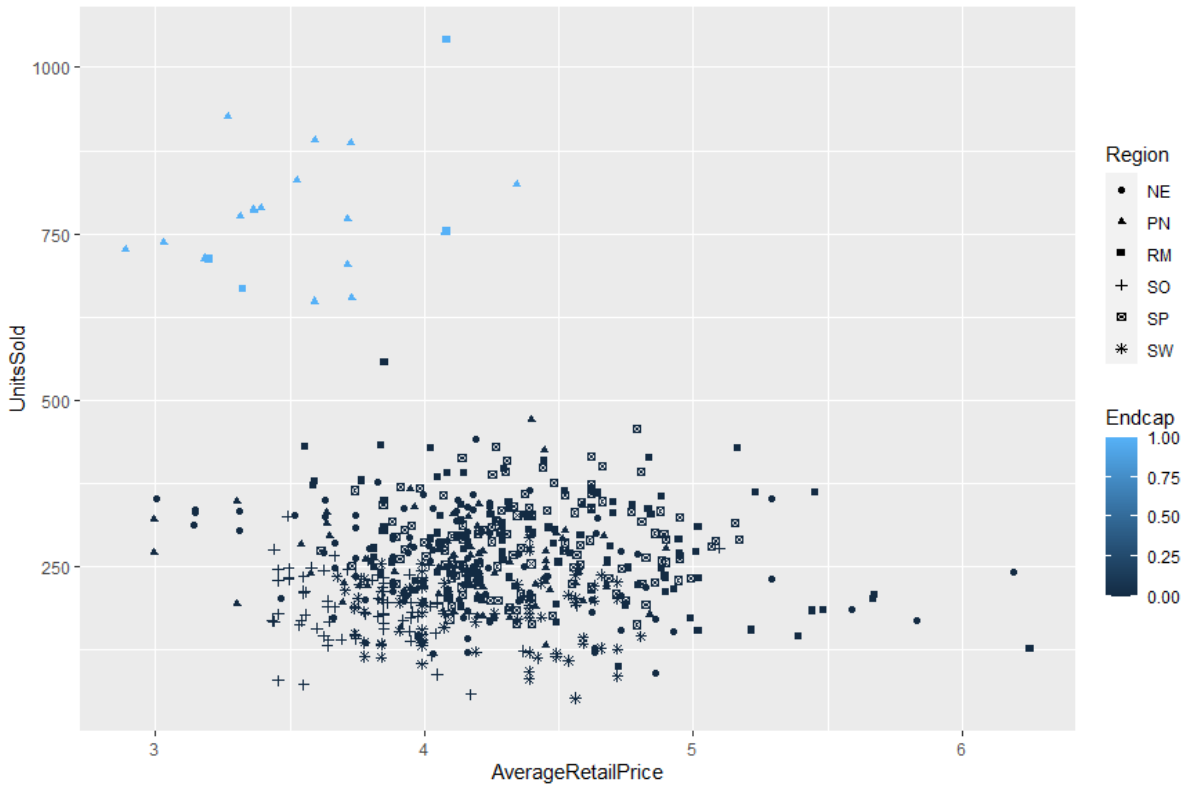
由上面兩張圖可以大致知道 UnitsSold 與 AverageRetailPrice 的分布狀況。而相較於 AverageRetailPrice，UnitsSold 的直方圖呈現右偏，也較多 outlier。





由這兩張圖可以看得出來 UnitsSold 與 AverageRetailPrice 都與地區有關係。
而 SalesRep 與 UnitsSold 關係比較顯著，與 AverageRetailPrice 的關係不明顯。

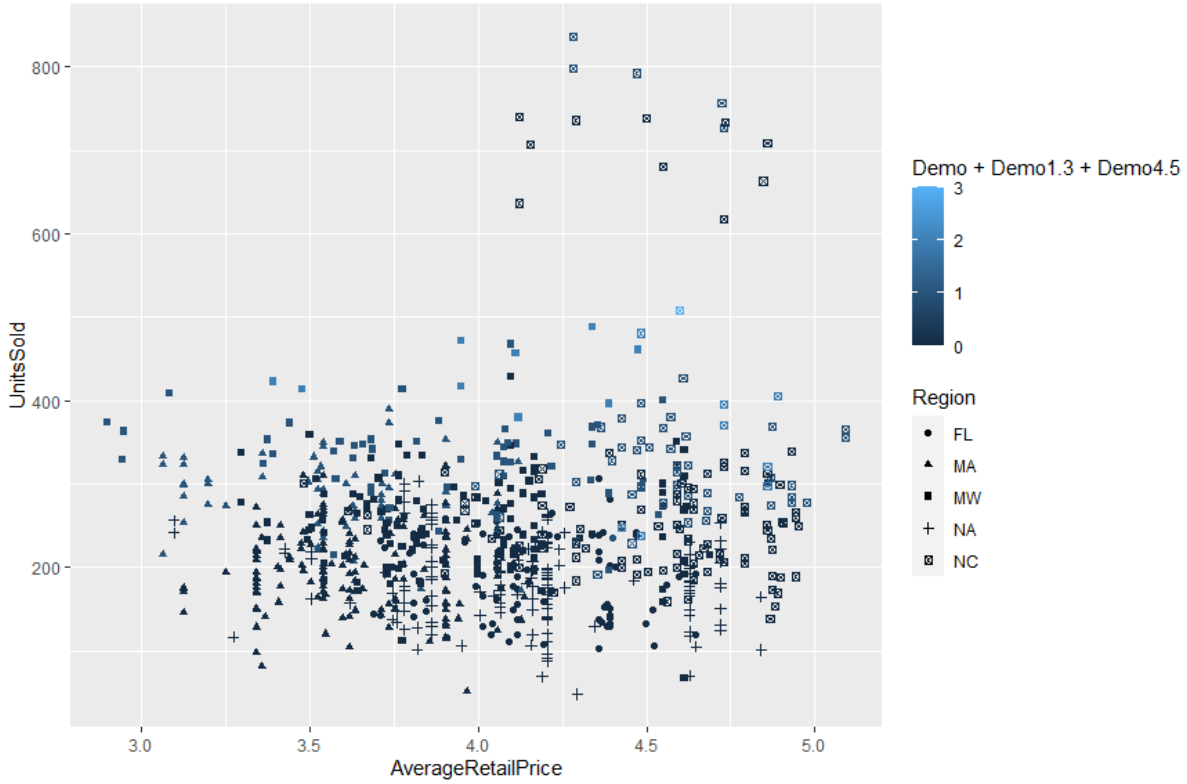


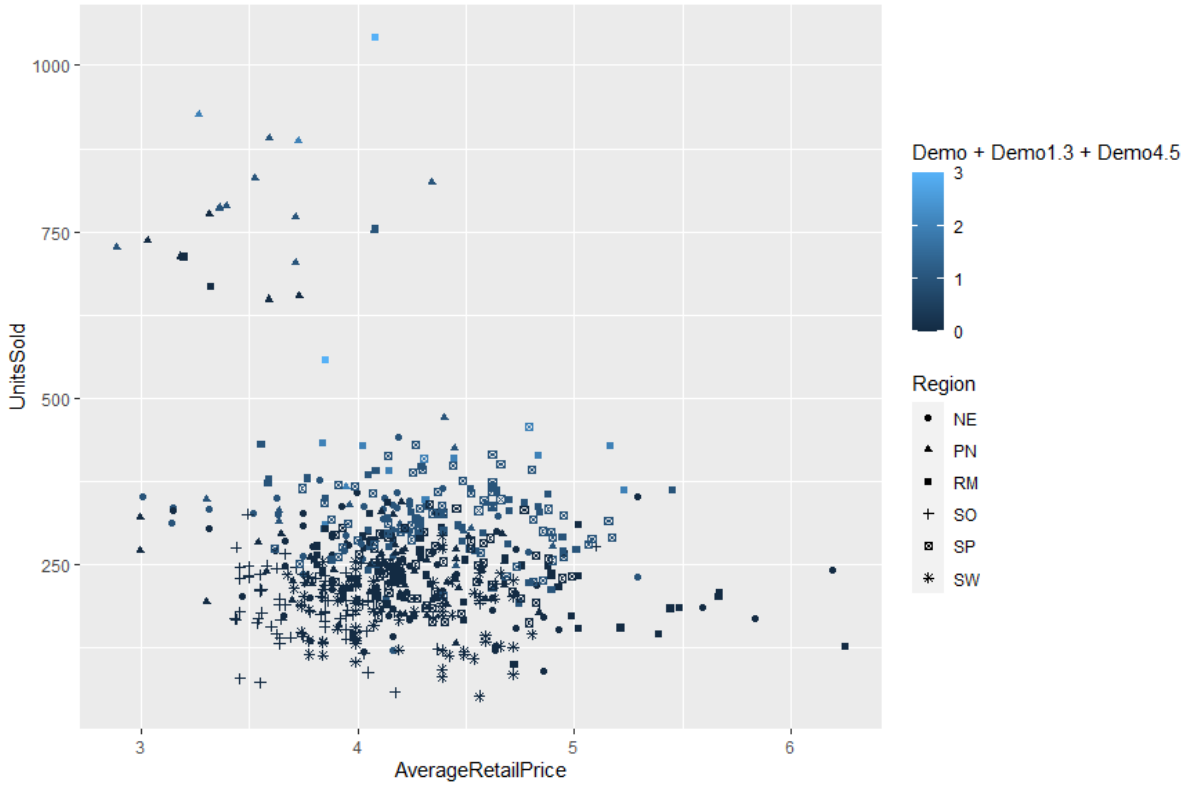


從這兩張圖可以發現在「某些地區」Endcap 對於 UnitsSold 的關係滿顯著的。例如第一張圖，同為 NC 地區的商店，有無 Endcap 的 UnitsSold 差異就滿大的。

但 Endcap 對於 AverageRetailPrice 的關係似乎不大，第一張圖有 Endcap 的商店的 AverageRetailPrice 偏高，第二張圖有 Endcap 的商店的 AverageRetailPrice 偏低，推測是

不同地區導致的差異。





由這兩張圖可以發現 Demo 總次數對於 UnitsSold 以及 AverageRetailPrice 的關係，並不比地區因素影響大。

(b) Based on your findings from (a), comment on the marketing activities about their effectiveness. Use some graphs and numbers to support your comments. You may comment on all of them, rank them, making suggestions about how to use them. Of course, your comments may be different from region to region, from time to time, or depending on any factor that you find useful.
從上面第 3 張圖（第一張顏色以 Endcap 來標記的圖）可以發現，對於 NC 來說 promotion 與 UnitsSold 的關係滿大的，但對於 MA 與 FL 來說關係就不顯著。

(c) Build a linear model to explain the relationship between sales and promotional efforts, and interpret the regression output.

```
Call:
lm(formula = UnitsSold ~ Endcap)

Residuals:
      Min        1Q    Median        3Q       Max
-477.51    -52.63     -4.79     54.26    457.28

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)    240.696          2.448     98.31     <2e-16 ***
Endcap           343.229        12.521     27.41     <2e-16 ***
---
Signif. codes:    0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 89.39 on 1384 degrees of freedom
Multiple R-squared:    0.3519,       Adjusted R-squared:    0.3514
F-statistic: 751.5 on 1 and 1384 DF,    p-value: < 2.2e-16
```

線性回歸模型跑出來後發現，Endcap 的 p-value<0.05（Endcap 也就是 promotion 與 UnitsSold 也就是 Sales 有關係），係數為 343.229，代表若有 promotion，我們預估 Sales 會上升 343.229。

(d) Does the in-store demo program boost the sales? If so, for how long does the sales lift last?

```
Call:
lm(formula = UnitsSold ~ Demo + Demo1.3 + Demo4.5)
```

Residuals:

Min	1Q	Median	3Q	Max
-183.59	-48.56	-10.63	29.09	555.29

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	221.003	2.897	76.278	<2e-16	***
Demo	150.622	10.754	14.006	<2e-16	***
Demo1.3	113.173	6.942	16.303	<2e-16	***
Demo4.5	83.110	9.528	8.723	<2e-16	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 93.85 on 1382 degrees of freedom

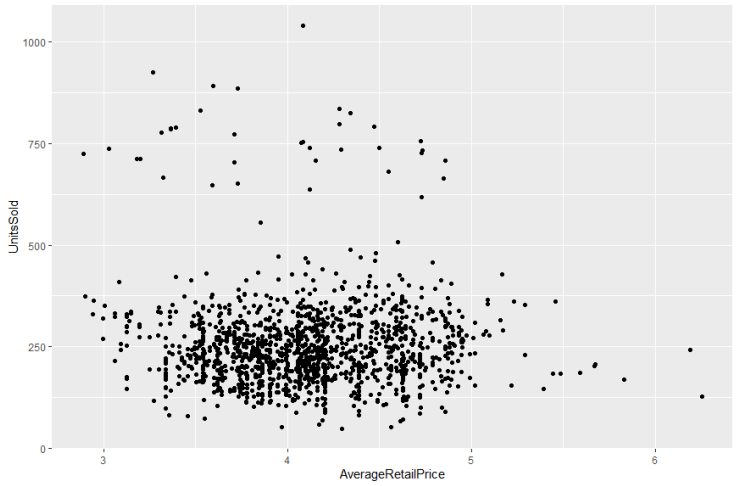
Multiple R-squared: 0.2867, Adjusted R-squared: 0.2852

F-statistic: 185.2 on 3 and 1382 DF, p-value: < 2.2e-16

三個有關 Demo 的變數的 p-value 都小於 0.05（Demo 與 Sales 有關係），係數分別為 150.622, 113.173, 83.110，代表若分別有這三個 Demo，則我們預估 Sales 會上升的幅度分別為 150.622, 113.173, 83.110。

但此擁有三個自變數的模型的解釋力（R_squared）還比上面只有 promotion 為自變數的模型的解釋力還來的小。此推論也可以拿第 3, 4 張圖（關於 promotion）去與第 5, 6 張圖（關於 demo）比較。

(e) Does the placement of the product within the store affect the sales?



lm(formula = UnitsSold ~ AverageRetailPrice)

Residuals:

```
      Min          1Q    Median          3Q         Max
-205.42    -63.44    -16.86      41.63    787.27

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                  272.327         26.583    10.244      <2e-16 ***
AverageRetailPrice       -4.506          6.432    -0.701       0.484
---
Signif. codes:    0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 111 on 1384 degrees of freedom
Multiple R-squared:    0.0003545,  Adjusted R-squared:    -0.0003678
F-statistic: 0.4908 on 1 and 1384 DF,    p-value: 0.4837
```

AverageRetailPrice 這想變數的 p-value 高達 0.484。由此模型可以發現商店內擺放商品的價格與銷售額關係不大。

(f) What other factors affect the sales of Goodbelly’s products? Based on the regression output, what are your recommendations to Goodbelly’s management?

```
Call:
lm(formula = UnitsSold ~ Region)

Residuals:
      Min          1Q    Median          3Q         Max
-216.14    -54.98    -10.80      40.21    738.81

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)    188.486         10.402    18.120    < 2e-16 ***
RegionMA          33.917         12.400      2.735    0.00632 **
RegionMW          94.039         12.740      7.381 2.70e-13 ***
RegionNA          -7.170         13.221    -0.542    0.58770
RegionNC         123.875         12.881      9.617    < 2e-16 ***
RegionNE          65.888         13.956      4.721 2.58e-06 ***
RegionPN         155.315         14.296    10.864    < 2e-16 ***
RegionRM         113.904         13.956      8.162 7.39e-16 ***
RegionSO           3.676         15.227      0.241    0.80926
RegionSP          97.302         13.429      7.246 7.15e-13 ***
RegionSW         -10.127         15.227    -0.665    0.50614
```

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 97.58 on 1375 degrees of freedom
Multiple R-squared: 0.2327, Adjusted R-squared: 0.2271
F-statistic: 41.71 on 10 and 1375 DF, p-value: < 2.2e-16

某些地區與銷售額也有關係，像是若以 FL 地區為 default，則位於 MA, MW, NC, NE, PN, RM, SP 的預測值就會與原本以 FL 為 default 的預測值不同。
建立預測 Sales 的 model 時，自變數應包含 Region, Store, UnitsSold, AverageRetailPrice, SalesRep, Endcap, Demo, Demo1-3, Demo4-5。

(g) Are there any suggestions to improve and refine the model?

原本模型：

Call:
lm(formula = UnitsSold ~ Region + AverageRetailPrice + SalesRep +
Endcap + Demo + Demo1.3 + Demo4.5 + Natural + Fitness)

Residuals:

Min	1Q	Median	3Q	Max
-356.80	-35.22	1.02	37.40	233.90

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	286.8903	21.1406	13.571	< 2e-16	***
RegionMA	24.0038	8.5591	2.804	0.005111	**
RegionMW	60.7394	15.9747	3.802	0.000150	***
RegionNA	31.6328	8.6316	3.665	0.000257	***
RegionNC	81.5800	16.2518	5.020	5.85e-07	***
RegionNE	54.4885	13.4711	4.045	5.53e-05	***
RegionPN	80.1268	16.4637	4.867	1.27e-06	***
RegionRM	64.7195	16.5474	3.911	9.64e-05	***
RegionSO	31.0466	10.1072	3.072	0.002170	**
RegionSP	66.4552	16.3813	4.057	5.26e-05	***
RegionSW	30.0176	9.9486	3.017	0.002598	**
AverageRetailPrice	-32.6520	4.7842	-6.825	1.32e-11	***
SalesRep	35.2423	13.5991	2.592	0.009657	**
Endcap	302.7750	9.3902	32.244	< 2e-16	***

```
Demo                    112.8824     7.4014  15.251  < 2e-16 ***
Demo1.3                  73.8848     4.9371  14.965  < 2e-16 ***
Demo4.5                  65.8542     6.6019   9.975  < 2e-16 ***
Natural                  -1.3787     1.8222  -0.757 0.449412
Fitness                  -0.1166     1.1465  -0.102 0.919013
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 63.04 on 1367 degrees of freedom
Multiple R-squared:  0.6817,    Adjusted R-squared:  0.6775
F-statistic: 162.6 on 18 and 1367 DF,  p-value: < 2.2e-16
```

去掉 Natural 與 Fitness 這兩個變數後，做一次 nested model test

```
Model 1: UnitsSold ~ Region + AverageRetailPrice + SalesRep + Endcap +
    Demo + Demo1.3 + Demo4.5
Model 2: UnitsSold ~ Region + AverageRetailPrice + SalesRep + Endcap +
    Demo + Demo1.3 + Demo4.5 + Natural + Fitness
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1   1369 5434097
2   1367 5431822  2    2275.1 0.2863 0.7511
```

Since the p-value of 0.7511 is more than our significance level (0.05), we cannot reject the null hypothesis.
Removing “Natural” & “Fitness” these two indicators improves the values of adjusted R2 from 0.6775 to 0.6778

最後模型：

```
Call:
lm(formula = UnitsSold ~ Region + AverageRetailPrice + SalesRep +
    Endcap + Demo + Demo1.3 + Demo4.5)

Residuals:
     Min       1Q   Median       3Q      Max
-358.36  -34.99    1.06   37.66  234.50

Coefficients:
```

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	284.862	20.958	13.592	< 2e-16	***
RegionMA	23.668	8.542	2.771	0.005668	**
RegionMW	60.092	15.892	3.781	0.000163	***
RegionNA	31.590	8.618	3.665	0.000256	***
RegionNC	80.995	16.217	4.994	6.66e-07	***
RegionNE	54.304	13.450	4.037	5.71e-05	***
RegionPN	80.505	16.398	4.909	1.02e-06	***
RegionRM	64.888	16.533	3.925	9.11e-05	***
RegionSO	31.480	10.065	3.128	0.001800	**
RegionSP	66.179	16.368	4.043	5.56e-05	***
RegionSW	30.710	9.901	3.102	0.001963	**
AverageRetailPrice	-32.683	4.739	-6.897	8.08e-12	***
SalesRep	35.228	13.591	2.592	0.009645	**
Endcap	302.131	9.347	32.325	< 2e-16	***
Demo	113.022	7.395	15.284	< 2e-16	***
Demo1.3	74.078	4.928	15.032	< 2e-16	***
Demo4.5	65.957	6.596	9.999	< 2e-16	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 63 on 1369 degrees of freedom

Multiple R-squared: 0.6815, Adjusted R-squared: 0.6778

F-statistic: 183.1 on 16 and 1369 DF, p-value: < 2.2e-16