Assignment 4-Clustering

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2023-11-17

```
knitr::opts_chunk$set(echo = TRUE, comment = NA)
```

An equities analyst is studying the pharmaceutical industry and would like your help in exploring and understanding the financial data collected by her firm. Her main objective is to understand the structure of the pharmaceutical industry using some basic financial measures. Financial data gathered on 21 firms in the pharmaceutical industry are available in the file Pharmaceuticals.csv

Use cluster analysis to explore and analyze the given dataset

```
library(factoextra)
```

```
Loading required package: ggplot2

Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```

```
library(ggplot2)
library(tidyverse)
```

```
-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v dplyr     1.1.3     v readr     2.1.4
v forcats   1.0.0     v stringr   1.5.0
v lubridate 1.9.2     v tibble    3.2.1
v purrr     1.0.2     v tidyr     1.3.0

-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(readr)

Pharmaceuticals <- read.csv("C:/Users/LENOVO/Desktop/Courses/FML/Assignment 4/Pharmaceuticals.csv")

summary(Pharmaceuticals)
```

```
    Symbol              Name             Market_Cap          Beta       
 Length:21          Length:21          Min.   :  0.41   Min.   :0.1800  
 Class :character   Class :character   1st Qu.:  6.30   1st Qu.:0.3500  
 Mode  :character   Mode  :character   Median : 48.19   Median :0.4600  
```

```
                                       Mean   : 57.65   Mean   :0.5257
                                       3rd Qu.: 73.84   3rd Qu.:0.6500
                                       Max.   :199.47   Max.   :1.1100
    PE_Ratio          ROE            ROA           Asset_Turnover    Leverage
 Min.   : 3.60   Min.   : 3.9   Min.   : 1.40   Min.   :0.3    Min.   :0.0000
 1st Qu.:18.90   1st Qu.:14.9   1st Qu.: 5.70   1st Qu.:0.6    1st Qu.:0.1600
 Median :21.50   Median :22.6   Median :11.20   Median :0.6    Median :0.3400
 Mean   :25.46   Mean   :25.8   Mean   :10.51   Mean   :0.7    Mean   :0.5857
 3rd Qu.:27.90   3rd Qu.:31.0   3rd Qu.:15.00   3rd Qu.:0.9    3rd Qu.:0.6000
 Max.   :82.50   Max.   :62.9   Max.   :20.30   Max.   :1.1    Max.   :3.5100
   Rev_Growth    Net_Profit_Margin Median_Recommendation   Location
 Min.   :-3.17   Min.   : 2.6      Length:21             Length:21
 1st Qu.: 6.38   1st Qu.:11.2      Class :character      Class :character
 Median : 9.37   Median :16.1      Mode  :character      Mode  :character
 Mean   :13.37   Mean   :15.7
 3rd Qu.:21.87   3rd Qu.:21.1
 Max.   :34.21   Max.   :25.5
   Exchange
 Length:21
 Class :character
 Mode  :character
```

Qustion (a): Use only the numerical variables (1 to 9) to cluster the 21 firms. Justify the various choices made in conducting the cluster analysis, such as weights for different variables, the specific clustering algorithm(s) used, the number of clusters formed, and so on.

Answer (a): Remove missing data and rescale variables for comparability before grouping the data.

```r
x <- na.omit(Pharmaceuticals) #Doing this will remove all the missing values in the data
x
```

```
   Symbol                               Name Market_Cap Beta PE_Ratio  ROE  ROA
1     ABT                Abbott Laboratories      68.44 0.32     24.7 26.4 11.8
2     AGN                     Allergan, Inc.       7.58 0.41     82.5 12.9  5.5
3     AHM                       Amersham plc       6.30 0.46     20.7 14.9  7.8
4     AZN                    AstraZeneca PLC      67.63 0.52     21.5 27.4 15.4
5     AVE                            Aventis      47.16 0.32     20.1 21.8  7.5
6     BAY                           Bayer AG      16.90 1.11     27.9  3.9  1.4
7     BMY       Bristol-Myers Squibb Company      51.33 0.50     13.9 34.8 15.1
8    CHTT                       Chattem, Inc       0.41 0.85     26.0 24.1  4.3
9     ELN              Elan Corporation, plc       0.78 1.08      3.6 15.1  5.1
10    LLY              Eli Lilly and Company      73.84 0.18     27.9 31.0 13.5
11    GSK                GlaxoSmithKline plc     122.11 0.35     18.0 62.9 20.3
12    IVX                   IVAX Corporation       2.60 0.65     19.9 21.4  6.8
13    JNJ                  Johnson & Johnson     173.93 0.46     28.4 28.6 16.3
14    MRX Medicis Pharmaceutical Corporation       1.20 0.75     28.6 11.2  5.4
15    MRK                  Merck & Co., Inc.     132.56 0.46     18.9 40.6 15.0
16    NVS                        Novartis AG      96.65 0.19     21.6 17.9 11.2
17    PFE                         Pfizer Inc     199.47 0.65     23.6 45.6 19.2
18    PHA              Pharmacia Corporation      56.24 0.40     56.5 13.5  5.7
19    SGP        Schering-Plough Corporation      34.10 0.51     18.9 22.6 13.3
```

```
20    WPI       Watson Pharmaceuticals, Inc.       3.26 0.24     18.4 10.2  6.8
21    WYE                              Wyeth      48.19 0.63     13.1 54.9 13.4
   Asset_Turnover Leverage Rev_Growth Net_Profit_Margin Median_Recommendation
1             0.7     0.42       7.54              16.1          Moderate Buy
2             0.9     0.60       9.16               5.5          Moderate Buy
3             0.9     0.27       7.05              11.2            Strong Buy
4             0.9     0.00      15.00              18.0         Moderate Sell
5             0.6     0.34      26.81              12.9          Moderate Buy
6             0.6     0.00      -3.17               2.6                  Hold
7             0.9     0.57       2.70              20.6         Moderate Sell
8             0.6     3.51       6.38               7.5          Moderate Buy
9             0.3     1.07      34.21              13.3         Moderate Sell
10            0.6     0.53       6.21              23.4                  Hold
11            1.0     0.34      21.87              21.1                  Hold
12            0.6     1.45      13.99              11.0                  Hold
13            0.9     0.10       9.37              17.9          Moderate Buy
14            0.3     0.93      30.37              21.3          Moderate Buy
15            1.1     0.28      17.35              14.1                  Hold
16            0.5     0.06      -2.69              22.4                  Hold
17            0.8     0.16      25.54              25.2          Moderate Buy
18            0.6     0.35      15.00               7.3                  Hold
19            0.8     0.00       8.56              17.6                  Hold
20            0.5     0.20      29.18              15.1         Moderate Sell
21            0.6     1.12       0.36              25.5                  Hold
      Location Exchange
1           US     NYSE
2       CANADA     NYSE
3           UK     NYSE
4           UK     NYSE
5       FRANCE     NYSE
6      GERMANY     NYSE
7           US     NYSE
8           US   NASDAQ
9      IRELAND     NYSE
10          US     NYSE
11          UK     NYSE
12          US     AMEX
13          US     NYSE
14          US     NYSE
15          US     NYSE
16 SWITZERLAND     NYSE
17          US     NYSE
18          US     NYSE
19          US     NYSE
20          US     NYSE
21          US     NYSE
```

Having now eliminated the missing values from the data, we should gather only the quantitative variables (i.e., 1–9) in order to group the 21 companies.

```r
row.names(x) <- x[,1]
Pharma1<- x[,3:11]
head(Pharma1)
```

```
    Market_Cap Beta PE_Ratio  ROE  ROA Asset_Turnover Leverage Rev_Growth
ABT      68.44 0.32     24.7 26.4 11.8            0.7     0.42       7.54
AGN       7.58 0.41     82.5 12.9  5.5            0.9     0.60       9.16
AHM       6.30 0.46     20.7 14.9  7.8            0.9     0.27       7.05
AZN      67.63 0.52     21.5 27.4 15.4            0.9     0.00      15.00
AVE      47.16 0.32     20.1 21.8  7.5            0.6     0.34      26.81
BAY      16.90 1.11     27.9  3.9  1.4            0.6     0.00      -3.17
    Net_Profit_Margin
ABT              16.1
AGN               5.5
AHM              11.2
AZN              18.0
AVE              12.9
BAY               2.6
```

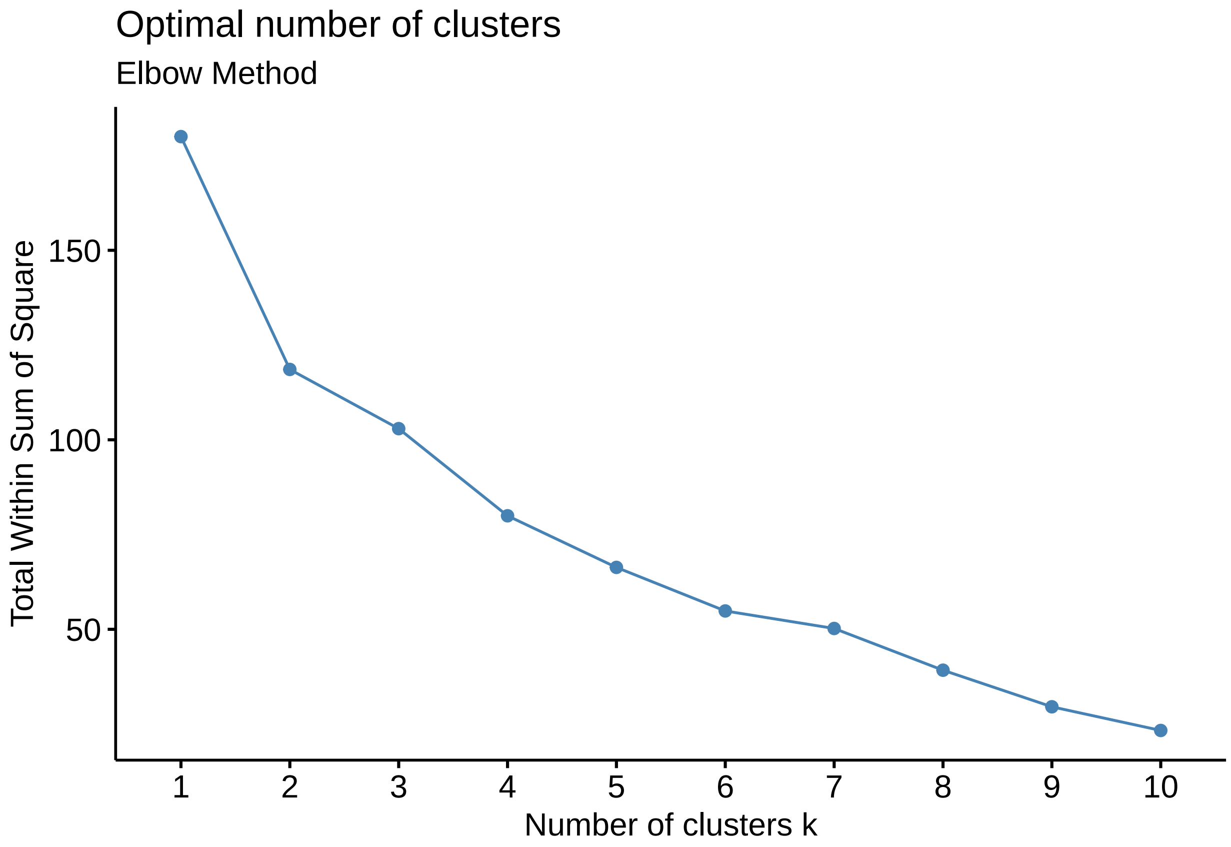
All of the quantitative variables in the dataframe are now scaled.

```r
Pharma2<-scale(Pharma1)
head(Pharma2)
```

```
    Market_Cap        Beta    PE_Ratio         ROE        ROA Asset_Turnover
ABT  0.1840960 -0.80125356 -0.04671323  0.04009035  0.2416121      0.0000000
AGN -0.8544181 -0.45070513  3.49706911 -0.85483986 -0.9422871      0.9225312
AHM -0.8762600 -0.25595600 -0.29195768 -0.72225761 -0.5100700      0.9225312
AZN  0.1702742 -0.02225704 -0.24290879  0.10638147  0.9181259      0.9225312
AVE -0.1790256 -0.80125356 -0.32874435 -0.26484883 -0.5664461     -0.4612656
BAY -0.6953818  2.27578267  0.14948233 -1.45146000 -1.7127612     -0.4612656
      Leverage Rev_Growth Net_Profit_Margin
ABT -0.2120979 -0.5277675        0.06168225
AGN  0.0182843 -0.3811391       -1.55366706
AHM -0.4040831 -0.5721181       -0.68503583
AZN -0.7496565  0.1474473        0.35122600
AVE -0.3144900  1.2163867       -0.42597037
BAY -0.7496565 -1.4971443       -1.99560225
```

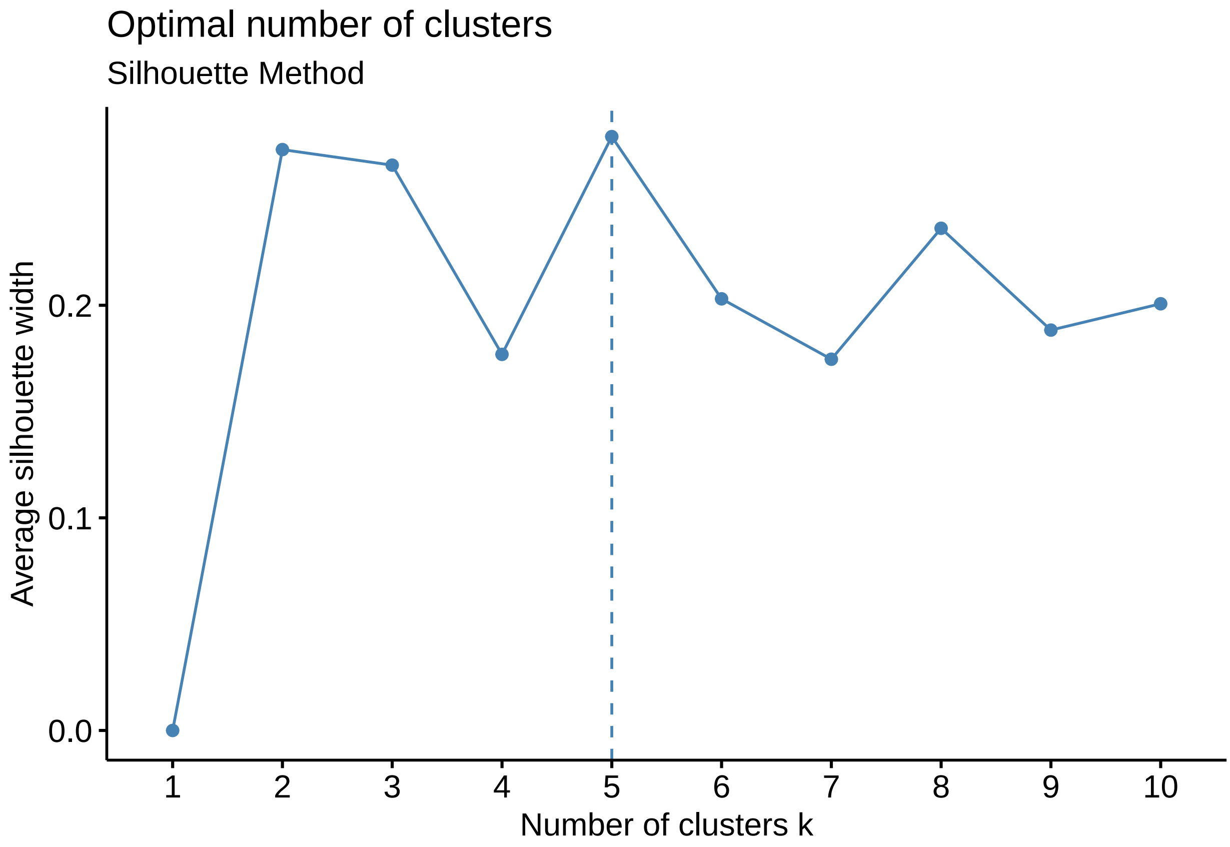
The next stage is to calculate the number of clusters for the Elbow Method cluster analysis.

```r
fviz_nbclust(Pharma2, kmeans, method = "wss") + labs(subtitle = "Elbow Method")
```



Finding the number of clusters using the silhouette method

```
fviz_nbclust(Pharma2, kmeans, method = "silhouette")+ labs(subtitle = "Silhouette Method")
```

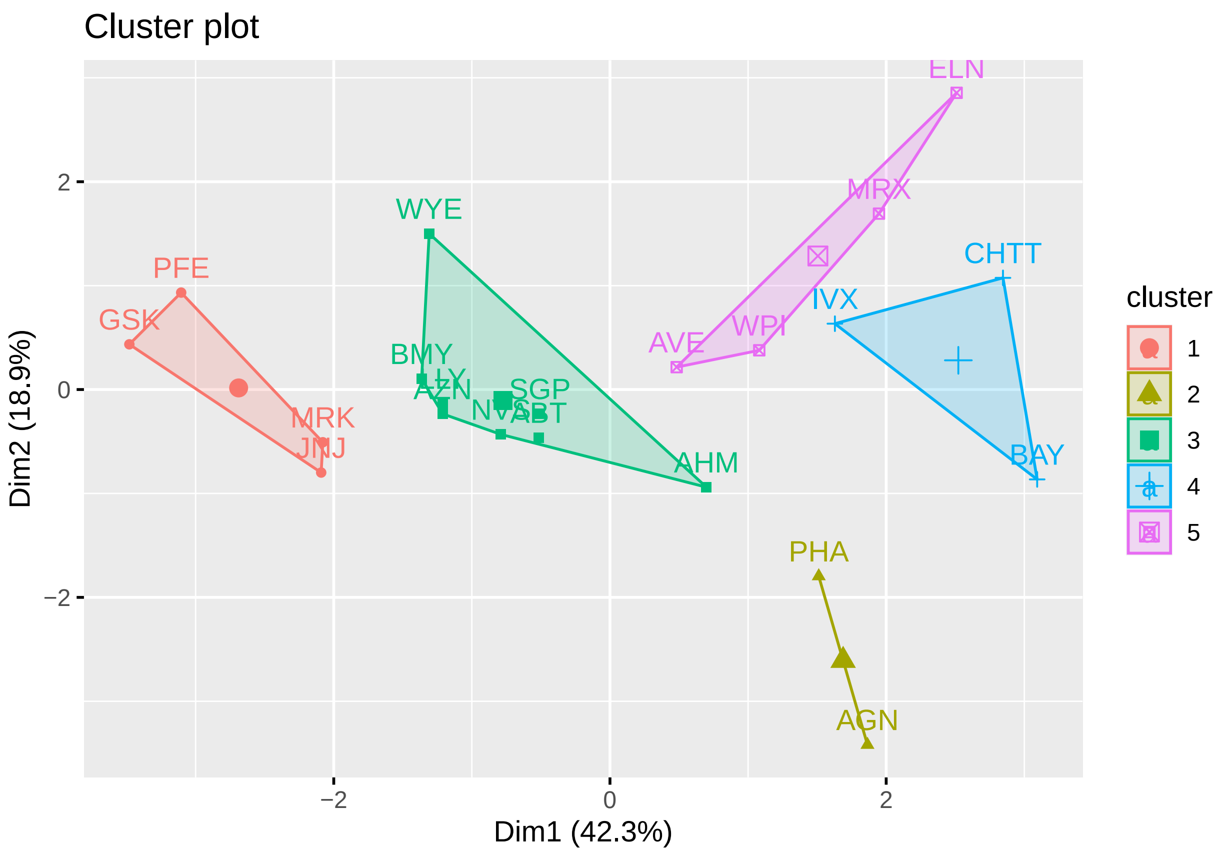


It is evident from the plots above that there are 5 clusters, which is sufficient to display the changes in the data.

```r
set.seed(120)
k5<- kmeans(Pharma2,centers=5,nstart = 25)
#Visualize the output
k5$centers  #centroids
```

```
   Market_Cap       Beta    PE_Ratio        ROE        ROA Asset_Turnover
1  1.69558112 -0.1780563 -0.19845823  1.2349879  1.3503431      1.1531640
2 -0.43925134 -0.4701800  2.70002464 -0.8349525 -0.9234951      0.2306328
3 -0.03142211 -0.4360989 -0.31724852  0.1950459  0.4083915      0.1729746
4 -0.87051511  1.3409869 -0.05284434 -0.6184015 -1.1928478     -0.4612656
5 -0.76022489  0.2796041 -0.47742380 -0.7438022 -0.8107428     -1.2684804
     Leverage Rev_Growth Net_Profit_Margin
1 -0.46807818  0.4671788       0.591242521
2 -0.14170336 -0.1168459      -1.416514761
3 -0.27449312 -0.7041516       0.556954446
4  1.36644699 -0.6912914      -1.320000179
5  0.06308085  1.5180158      -0.006893899
```

```r
fviz_cluster(k5,data = Pharma2) # to Visualize the clusters
```

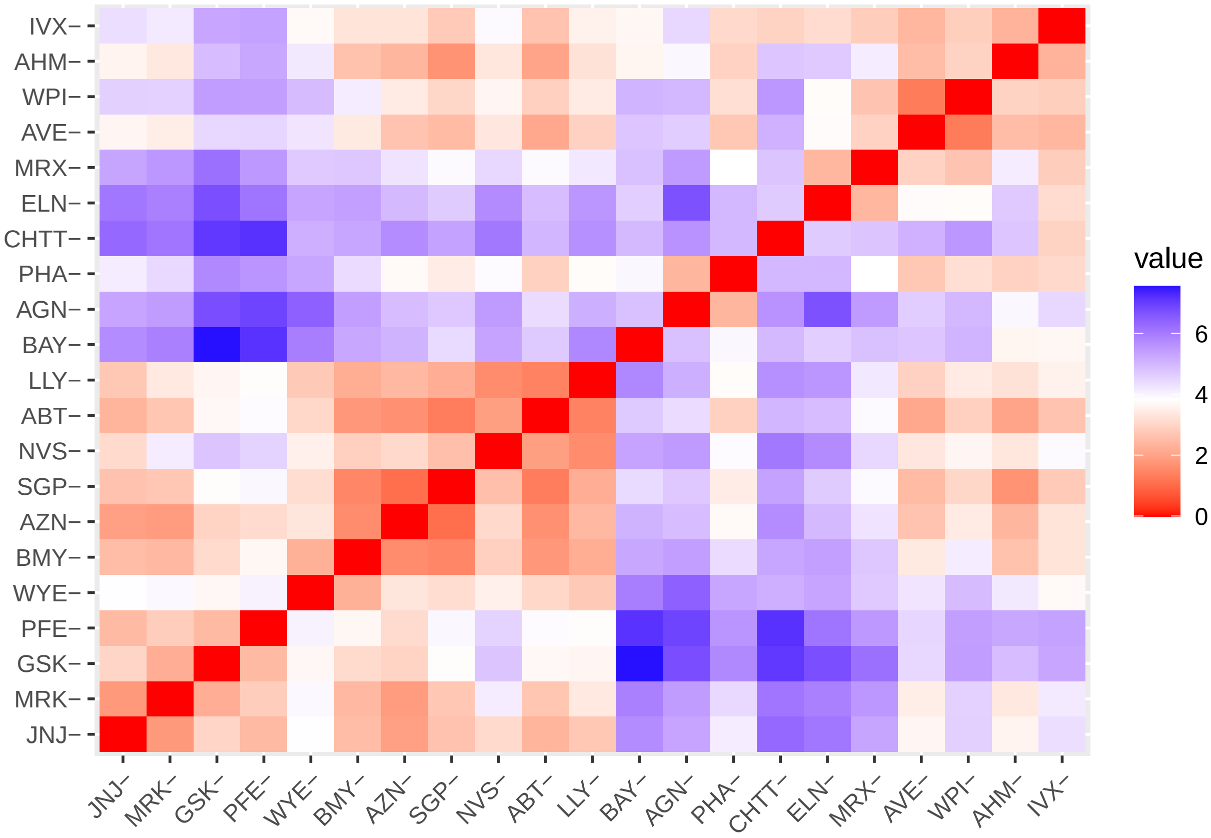


```
k5
```

```
K-means clustering with 5 clusters of sizes 4, 2, 8, 3, 4

Cluster means:
   Market_Cap       Beta    PE_Ratio        ROE        ROA Asset_Turnover
1  1.69558112 -0.1780563 -0.19845823  1.2349879  1.3503431      1.1531640
2 -0.43925134 -0.4701800  2.70002464 -0.8349525 -0.9234951      0.2306328
3 -0.03142211 -0.4360989 -0.31724852  0.1950459  0.4083915      0.1729746
4 -0.87051511  1.3409869 -0.05284434 -0.6184015 -1.1928478     -0.4612656
5 -0.76022489  0.2796041 -0.47742380 -0.7438022 -0.8107428     -1.2684804
     Leverage Rev_Growth Net_Profit_Margin
1 -0.46807818  0.4671788       0.591242521
2 -0.14170336 -0.1168459      -1.416514761
3 -0.27449312 -0.7041516       0.556954446
4  1.36644699 -0.6912914      -1.320000179
5  0.06308085  1.5180158      -0.006893899

Clustering vector:
 ABT  AGN  AHM  AZN  AVE  BAY  BMY CHTT  ELN  LLY  GSK  IVX  JNJ  MRX  MRK  NVS
   3    2    3    3    5    4    3    4    5    3    1    4    1    5    1    3
 PFE  PHA  SGP  WPI  WYE
   1    2    3    5    3

Within cluster sum of squares by cluster:
[1]  9.284424  2.803505 21.879320 15.595925 12.791257
```

```
 (between_SS / total_SS =  65.4 %)

Available components:

[1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
[6] "betweenss"    "size"         "iter"         "ifault"
```

```
distance<- dist(Pharma2, method = "euclidean")
fviz_dist(distance)
```



K-Means Cluster Analysis - Fit the data with 5 clusters

```
fit<-kmeans(Pharma2,5)
```

Now, we find the mean value of all quantitative variables for each cluster

```
aggregate(Pharma2,by=list(fit$cluster),FUN=mean)
```

```
  Group.1  Market_Cap       Beta     PE_Ratio        ROE        ROA
1       1 -0.87051511  1.3409869 -0.05284434 -0.6184015 -1.1928478
2       2  0.08926902 -0.4618336 -0.32086149  0.3260892  0.5396003
3       3 -0.96686975  1.5162611 -0.57398880 -0.8382671 -0.9892673
4       4  1.69558112 -0.1780563 -0.19845823  1.2349879  1.3503431
5       5 -0.57238455 -0.6220844  0.86927480 -0.7381675 -0.7242993
  Asset_Turnover   Leverage Rev_Growth Net_Profit_Margin
```

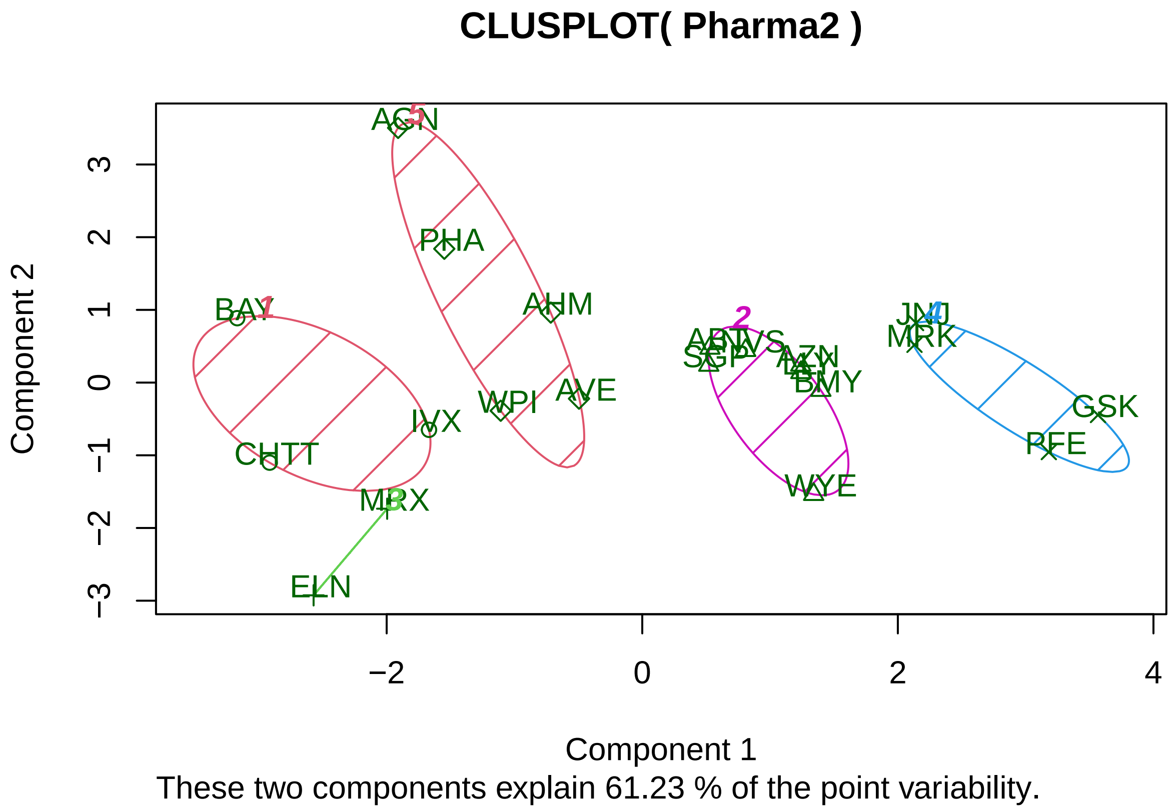
```
1  -4.612656e-01  1.3664470 -0.6912914        -1.3200002
2   6.589509e-02 -0.2559803 -0.7230135         0.7343816
3  -1.845062e+00  0.5302448  1.7123890         0.2445520
4   1.153164e+00 -0.4680782  0.4671788         0.5912425
5   1.776140e-16 -0.2991312  0.3682951        -0.8069490
```

```
Pharma3<-data.frame(Pharma2,fit$cluster)
Pharma3
```

```
     Market_Cap        Beta    PE_Ratio         ROE        ROA Asset_Turnover
ABT   0.1840960 -0.80125356 -0.04671323  0.04009035  0.2416121      0.0000000
AGN  -0.8544181 -0.45070513  3.49706911 -0.85483986 -0.9422871      0.9225312
AHM  -0.8762600 -0.25595600 -0.29195768 -0.72225761 -0.5100700      0.9225312
AZN   0.1702742 -0.02225704 -0.24290879  0.10638147  0.9181259      0.9225312
AVE  -0.1790256 -0.80125356 -0.32874435 -0.26484883 -0.5664461     -0.4612656
BAY  -0.6953818  2.27578267  0.14948233 -1.45146000 -1.7127612     -0.4612656
BMY  -0.1078688 -0.10015669 -0.70887325  0.59693581  0.8617498      0.9225312
CHTT -0.9767669  1.26308721  0.03299122 -0.11237924 -1.1677918     -0.4612656
ELN  -0.9704532  2.15893320 -1.34037772 -0.70899938 -1.0174553     -1.8450624
LLY   0.2762415 -1.34655112  0.14948233  0.34502953  0.5610770     -0.4612656
GSK   1.0999201 -0.68440408 -0.45749769  2.45971647  1.8389364      1.3837968
IVX  -0.9393967  0.48409069 -0.34100657 -0.29136529 -0.6979905     -0.4612656
JNJ   1.9841758 -0.25595600  0.18013789  0.18593083  1.0872544      0.9225312
MRX  -0.9632863  0.87358895  0.19240011 -0.96753478 -0.9610792     -1.8450624
MRK   1.2782387 -0.25595600 -0.40231769  0.98142435  0.8429577      1.8450624
NVS   0.6654710 -1.30760129 -0.23677768 -0.52338423  0.1288598     -0.9225312
PFE   2.4199899  0.48409069 -0.11415545  1.31287998  1.6322239      0.4612656
PHA  -0.0240846 -0.48965495  1.90298017 -0.81506519 -0.9047030     -0.4612656
SGP  -0.4018812 -0.06120687 -0.40231769 -0.21181593  0.5234929      0.4612656
WPI  -0.9281345 -1.11285216 -0.43297324 -1.03382590 -0.6979905     -0.9225312
WYE  -0.1614497  0.40619104 -0.75792214  1.92938746  0.5422849     -0.4612656
        Leverage  Rev_Growth Net_Profit_Margin fit.cluster
ABT  -0.21209793 -0.52776752        0.06168225           2
AGN   0.01828430 -0.38113909       -1.55366706           5
AHM  -0.40408312 -0.57211809       -0.68503583           5
AZN  -0.74965647  0.14744734        0.35122600           2
AVE  -0.31449003  1.21638667       -0.42597037           5
BAY  -0.74965647 -1.49714434       -1.99560225           1
BMY  -0.02011273 -0.96584257        0.74744375           2
CHTT  3.74279705 -0.63276071       -1.24888417           1
ELN   0.61983791  1.88617085       -0.36501379           3
LLY  -0.07130879 -0.64814764        1.17413980           2
GSK  -0.31449003  0.76926048        0.82363947           4
IVX   1.10620040  0.05603085       -0.71551412           1
JNJ  -0.62166634 -0.36213170        0.33598685           4
MRX   0.44065173  1.53860717        0.85411776           3
MRK  -0.39128411  0.36014907       -0.24310064           4
NVS  -0.67286239 -1.45369888        1.02174835           2
PFE  -0.54487226  1.10143723        1.44844440           4
PHA  -0.30169102  0.14744734       -1.27936246           5
SGP  -0.74965647 -0.43544591        0.29026942           2
WPI  -0.49367621  1.43089863       -0.09070919           5
WYE   0.68383297 -1.17763919        1.49416183           2
```

FOr viewing the cluster plot

```r
library(cluster)
clusplot(Pharma2,fit$cluster,color = TRUE,shade = TRUE,labels = 2,lines = 0)
```



Question (b): Interpret the clusters with respect to the numerical variables used in forming the clusters.

Answer(b):

By observing the mean values of all quantitative variables for each cluster

Cluster 1 - BAY, CHTT, IVX

Cluster 2 - ABT, AZN, BMY, LLY, NVS, SGP,WYE

Cluster 3 - ELN, MRX

Cluster 4 - JNJ, MRK, PFE, GSK

Cluster 5 - AGN, AHM, AVE, PHA, WPI

Cluster 1 has highest Beta , Leverage and lowest Market_Cap, ROE, ROA, Leverage, Rev_Growth, Net_Profit_Margin Cluster 2 has highest Net_Profit_Margin and lowest Beta. Cluster 3 has highest Rev_Growth and lowest PE_Ratio, Asset_Turnover. Cluster 4 has highest Market_Cap, ROE, ROA,Asset_Turnover Cluster 5 has highest PE_Ratio.

Question(c): Is there a pattern in the clusters with respect to the numerical variables (10 to 12)? (those not used in forming the clusters)

Answer(c):

There is a pattern in the clusters with respect to Media recommendation variable.

Cluster 1 with highest Beta, highest Leverage has mostly Moderate Buy Recommendation.

Cluster 2 with highest Net_Profit_Margin has mostly Hold Recommendation

Cluster 3 with lowest PE_Ratio and lowest Asset_Turnover has Hold Recommendation

Cluster 4 with highest Market_Cap, highest ROE, highest ROA, highest Asset_Turnover has equal Hold and Moderate Buy Recommendation

Cluster 5 with highest PE_Ratio has the Strong Buy Recommendation, because high PE_Ratio indicates the company is growing fast.

Could see a pattern among the clusters with respect to variables(10 to 12)

Clusters 1,4 has mostly Moderate Buy Recommendation

Clusters 2,3,4 has Hold Recommendation

Question(d): Provide an appropriate name for each cluster using any or all of the variables in the dataset.

Answer(d): Cluster1 - high Beta, Leverage cluster (or) Buy Cluster.

Cluster2 - high Net_Profit_Margin cluster (or) high hold cluster.

Cluster3 - Low PE_Ratio, Asset_Turnover cluster (or) hold cluster.

Cluster4 - Moderate Buy cluster

Cluster5 - high PE_Ratio cluster (or) high Buy cluster.