FML_Ass4_Clustering_811292363

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```
Pharmaceuticals <- read.csv("Pharmaceuticals.csv")
```

```
# Loading library for Data manipulation
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.3.2
```

```
## Warning: package 'ggplot2' was built under R version 4.3.2
```

```
## -- 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 ggplot2   3.4.4     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.0
## v purrr     1.0.2
## -- 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
```

```
# Loading library used for clustering algorithms and visualization
library(factoextra)
```

```
## Warning: package 'factoextra' was built under R version 4.3.2
```

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

```
library(dplyr)
library(ggplot2)
library(cluster)
```

```
Pharma_data <- na.omit(Pharmaceuticals)

# Data after removing the incomplete cases
Pharma_data
```

```
##    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
```

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.

```
# Taking the quantitative variables(1-9) to cluster the 21 firms
row.names(Pharma_data)<- Pharma_data[,1]
Pharma_data1<- Pharma_data[,3:11]

# Considering only numerical values i.e., 3-11 columns from csv file
head(Pharma_data1)
```

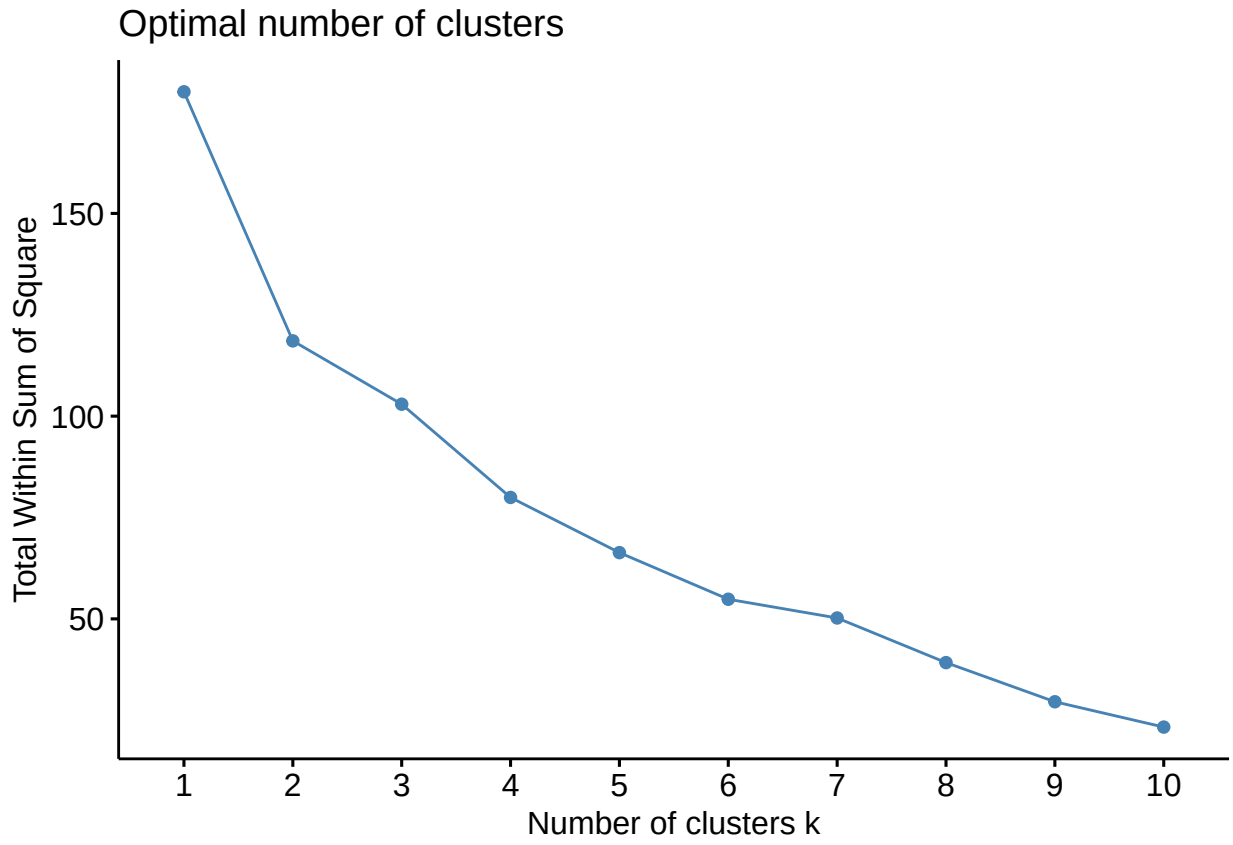
```
##     Market_Cap Beta PE_Ratio  ROE  ROA Asset_Turnover Leverage Rev_Growth
## ABT      68.44 0.32     24.7 26.4 11.8            0.7     0.42       7.54
## AGN       7.58 0.41     82.5 12.9  5.5            0.9     0.60       9.16
## AHM       6.30 0.46     20.7 14.9  7.8            0.9     0.27       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
```

```
# Normalizing the data frame with scale method
Pharma_data2<-scale(Pharma_data1)
head(Pharma_data2)
```

```
##     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
```

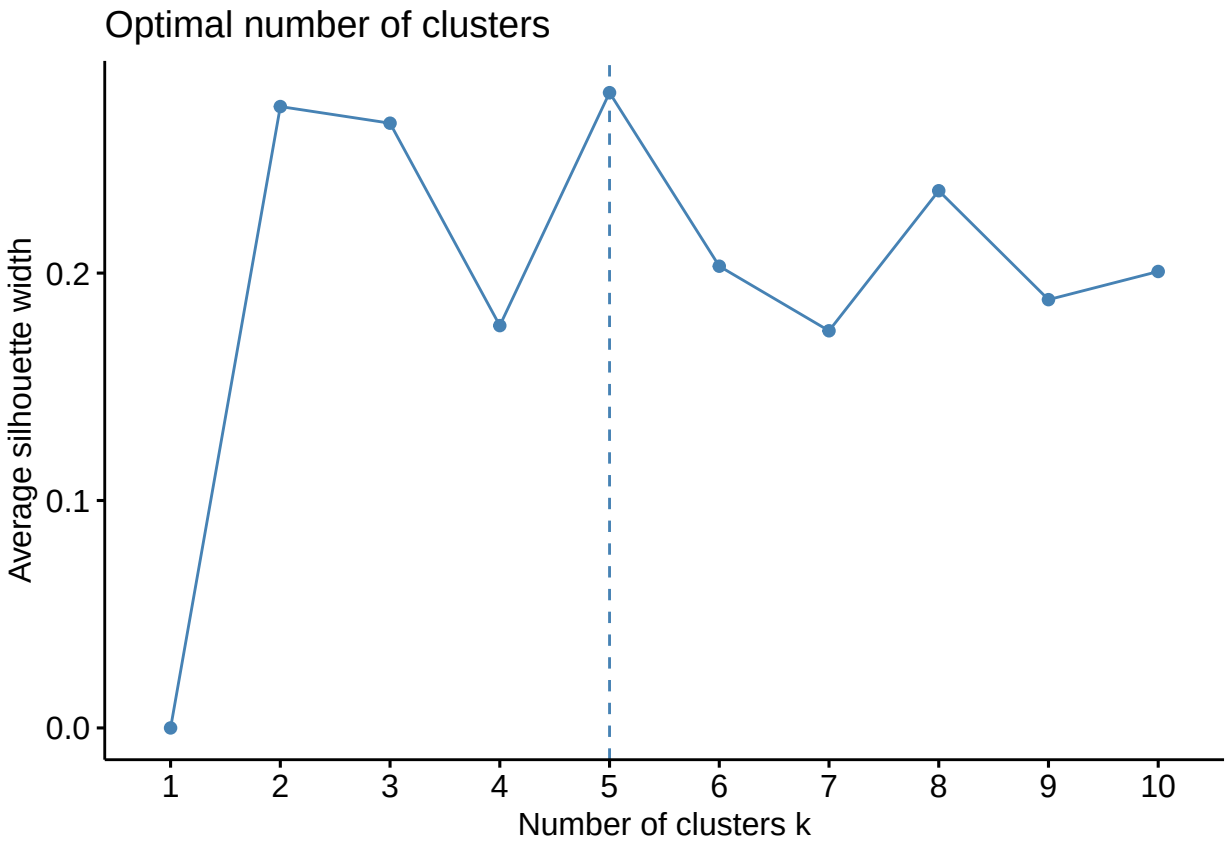
```
## AVE -0.1790256 -0.80125356 -0.32874435 -0.26484883 -0.5664461     -0.4612656
## BAY -0.6953818  2.27578267  0.14948233 -1.45146000 -1.7127612     -0.4612656
##       Leverage Rev_Growth Net_Profit_Margin
## ABT -0.2120979 -0.5277675        0.06168225
## AGN  0.0182843 -0.3811391       -1.55366706
## 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
```

```r
# To determine the number of clusters to do the cluster analysis using Elbow Method
fviz_nbclust(Pharma_data2, kmeans, method = "wss")
```




```r
# By observing the above results of the graph from Elbow method,
# We can say that graph is not clear to choose whether k=2 or 3 or 4 or 5.
# Using Silhouette method for determining no of clusters

fviz_nbclust(Pharma_data2, kmeans, method = "silhouette")
```

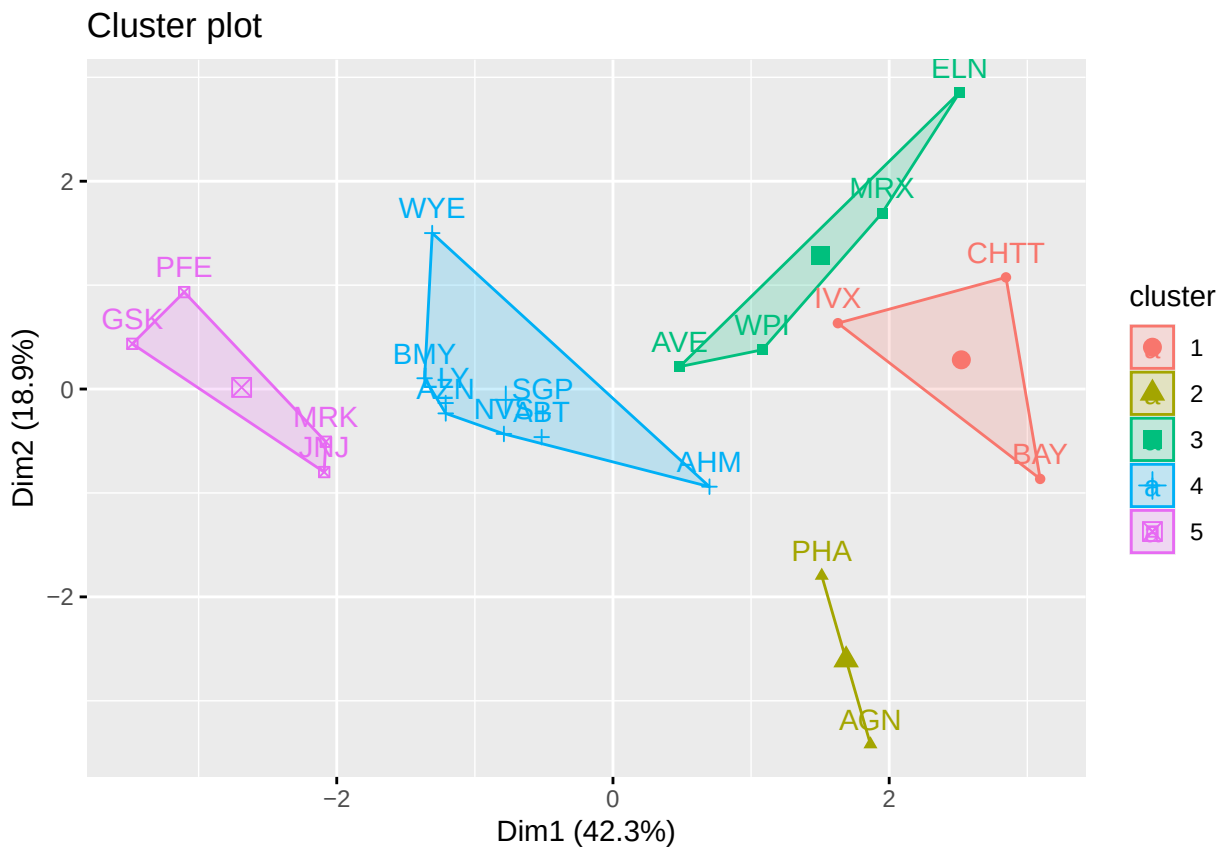



```
# Applying K-means
set.seed(64060)
k_5<- kmeans(Pharma_data2,centers=5,nstart = 25)
```

```
# Visualizing the output
# Centroids
k_5$centers
```

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

```
# To Visualize the clusters
fviz_cluster(k_5,data = Pharma_data2)
```

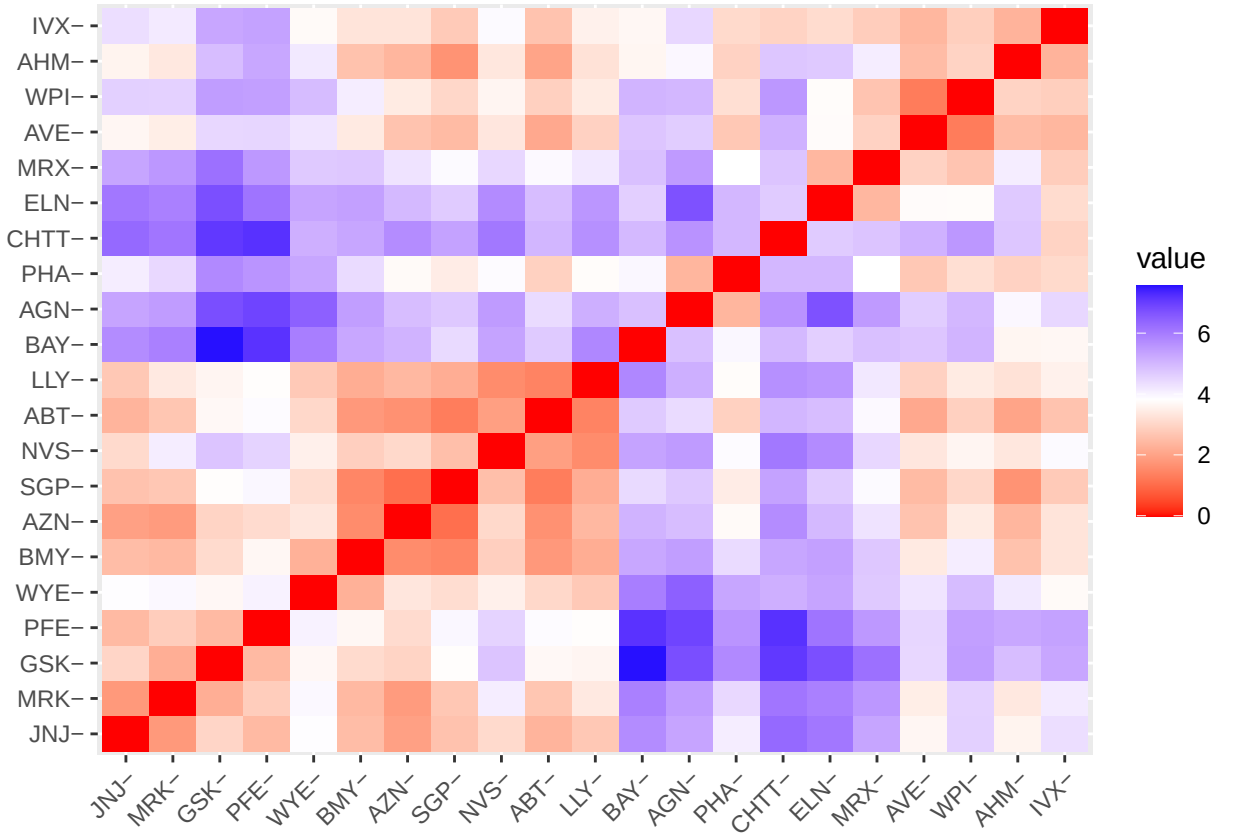



```
k_5
```

```
## K-means clustering with 5 clusters of sizes 3, 2, 4, 8, 4
##
## Cluster means:
##    Market_Cap       Beta    PE_Ratio        ROE        ROA Asset_Turnover
## 1 -0.87051511  1.3409869 -0.05284434 -0.6184015 -1.1928478     -0.4612656
## 2 -0.43925134 -0.4701800  2.70002464 -0.8349525 -0.9234951      0.2306328
## 3 -0.76022489  0.2796041 -0.47742380 -0.7438022 -0.8107428     -1.2684804
## 4 -0.03142211 -0.4360989 -0.31724852  0.1950459  0.4083915      0.1729746
## 5  1.69558112 -0.1780563 -0.19845823  1.2349879  1.3503431      1.1531640
##      Leverage Rev_Growth Net_Profit_Margin
## 1  1.36644699 -0.6912914      -1.320000179
## 2 -0.14170336 -0.1168459      -1.416514761
## 3  0.06308085  1.5180158      -0.006893899
## 4 -0.27449312 -0.7041516       0.556954446
## 5 -0.46807818  0.4671788       0.591242521
##
## Clustering vector:
##  ABT  AGN  AHM  AZN  AVE  BAY  BMY CHTT  ELN  LLY  GSK  IVX  JNJ  MRX  MRK  NVS
##    4    2    4    4    3    1    4    1    3    4    5    1    5    3    5    4
##  PFE  PHA  SGP  WPI  WYE
##    5    2    4    3    4
##
## Within cluster sum of squares by cluster:
## [1] 15.595925  2.803505 12.791257 21.879320  9.284424
```

```
##  (between_SS / total_SS =  65.4 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```
distance<- dist(Pharma_data2, method = "euclidean")
fviz_dist(distance)
```




```
# From the observations, there are 5 clusters and
# the center is defined after 25 restarts which is determined in k-means.
# K - Means Cluster Analysis - Fit the data with 5 clusters
fit<-kmeans(Pharma_data2,5)
```

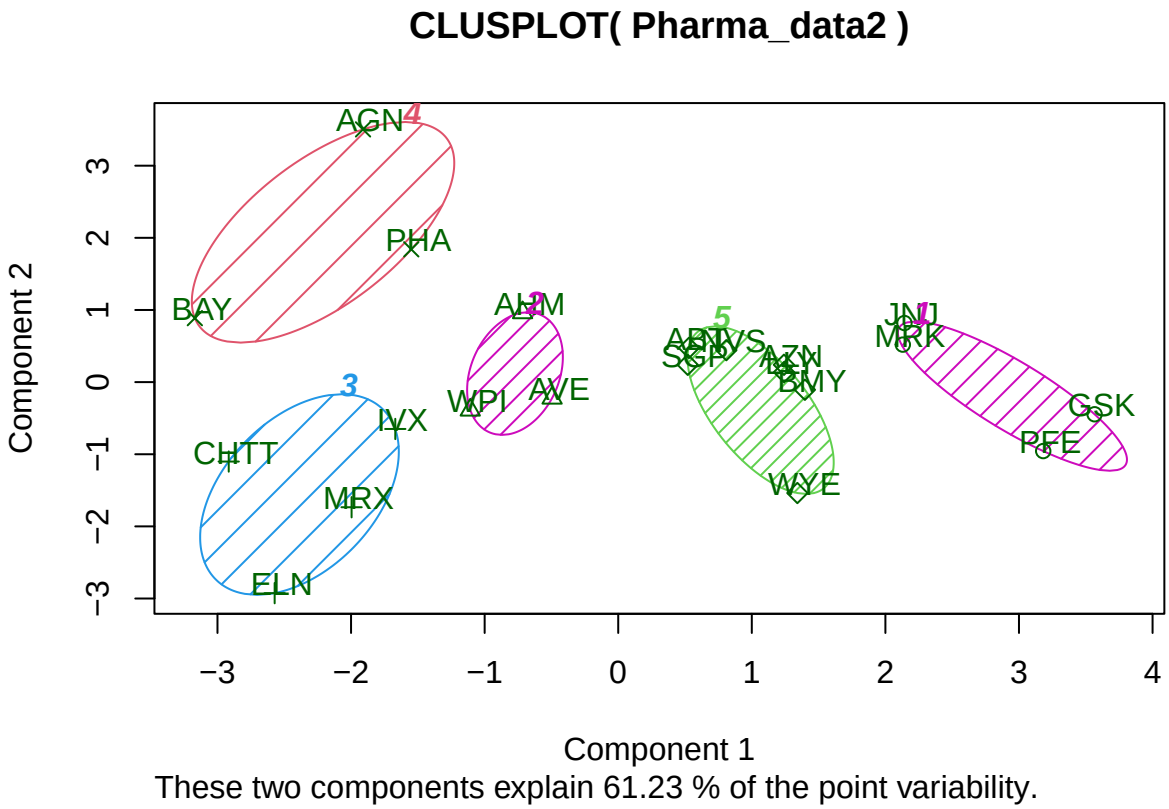
```
# Finding the mean value of all quantitative variables for each cluster
aggregate(Pharma_data2,by=list(fit$cluster),FUN=mean)
```

```
##   Group.1  Market_Cap       Beta   PE_Ratio        ROE        ROA
## 1       1  1.69558112 -0.1780563 -0.1984582  1.2349879  1.3503431
## 2       2 -0.66114002 -0.7233539 -0.3512251 -0.6736441 -0.5915022
## 3       3 -0.96247577  1.1949250 -0.3639982 -0.5200697 -0.9610792
## 4       4 -0.52462814  0.4451409  1.8498439 -1.0404550 -1.1865838
## 5       5  0.08926902 -0.4618336 -0.3208615  0.3260892  0.5396003
##   Asset_Turnover   Leverage Rev_Growth Net_Profit_Margin
```

```
## 1   1.153164e+00 -0.4680782  0.4671788         0.5912425
## 2  -1.537552e-01 -0.4040831  0.6917224        -0.4005718
## 3  -1.153164e+00  1.4773718  0.7120120        -0.3688236
## 4   1.480297e-16 -0.3443544 -0.5769454        -1.6095439
## 5   6.589509e-02 -0.2559803 -0.7230135         0.7343816
```

```
# To view the cluster plot

clusplot(Pharma_data2,fit$cluster,color =
           TRUE,shade = TRUE,labels = 2,lines = 0)
```



These two components explain 61.23 % of the point variability.

Interpret the clusters with respect to the numerical variables used in forming the clusters.

Cluster_1 - AGN, PHA, BAY - These have the highest PE_Ratio. By observing the mean values of all quantitative variables for each cluster, the ROE value is poor.

Cluster_2 - JNJ, MRK, GSK, and PFE. They have the biggest market capitalization and good leverage value.

Cluster_3 - AHM, AVE, and WPI. They have the lowest beta and asset turnover.

Cluster_4 - IVX, MRX, ELN, and CHTT. They exhibit lowest market capitalization, leverage, and beta. They're good and their revenue growth is the highest.

Cluster_5 - ABT, NVS, AZN, LLY, BMY, WYE, SGP. These companies have the largest net profit margin, the biggest asset turnover, and the lowest sales growth.

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

For cluster 1: It should be held in accordance with media recommendations as it has the highest PE Ratio.

For cluster 2: It has a good leverage value and the largest market capitalization. Additionally, they can be rather violent.

For cluster 3: Its beta and asset turnover are the lowest. However, media endorsements are very positive.

For cluster 4: They come with a modest recommendation despite the high leverage ratio.

For Cluster 5: They have the largest net profit margin, the highest asset turnover and the lowest revenue growth.

Provide an appropriate name for each cluster using any or all of the variables in the dataset.

Cluster 1: Hold cluster – Their numbers are respectable.

Cluster 2: Mild Purchase or Hold cluster.

Cluster 3: To Purchase or To Sell

Cluster 4: Purchase Cluster; as it is fairly stable.

Cluster 5: High Hold Cluster