

ML-Assignment4

Adari Lohit

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```
library(factoextra) # clustering algorithms & visualization
```

```
## Warning: package 'factoextra' was built under R version 4.2.2
```

```
## Loading required package: ggplot2
```

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

```
library(ISLR)
library(caret)
```

```
## Loading required package: lattice
```

```
#Importing the dataset
```

```
Pharmaceuticals <- read.csv("C:/Users/adari/Downloads/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
##
##
##
```

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.

#Remove missing data and rescale variables for comparability before clustering data.

```
Pharma<- na.omit(Pharmaceuticals) #gives the data after removing the missing values.
Pharma
```

##	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	BMJ	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			

#To cluster the 21 firms, just the quantitative variables (1-9) need be collected.

```
row.names(Pharma)<- Pharma[,1]
Pharma_1<- Pharma[,3:11]
head(Pharma_1)
```

##	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							

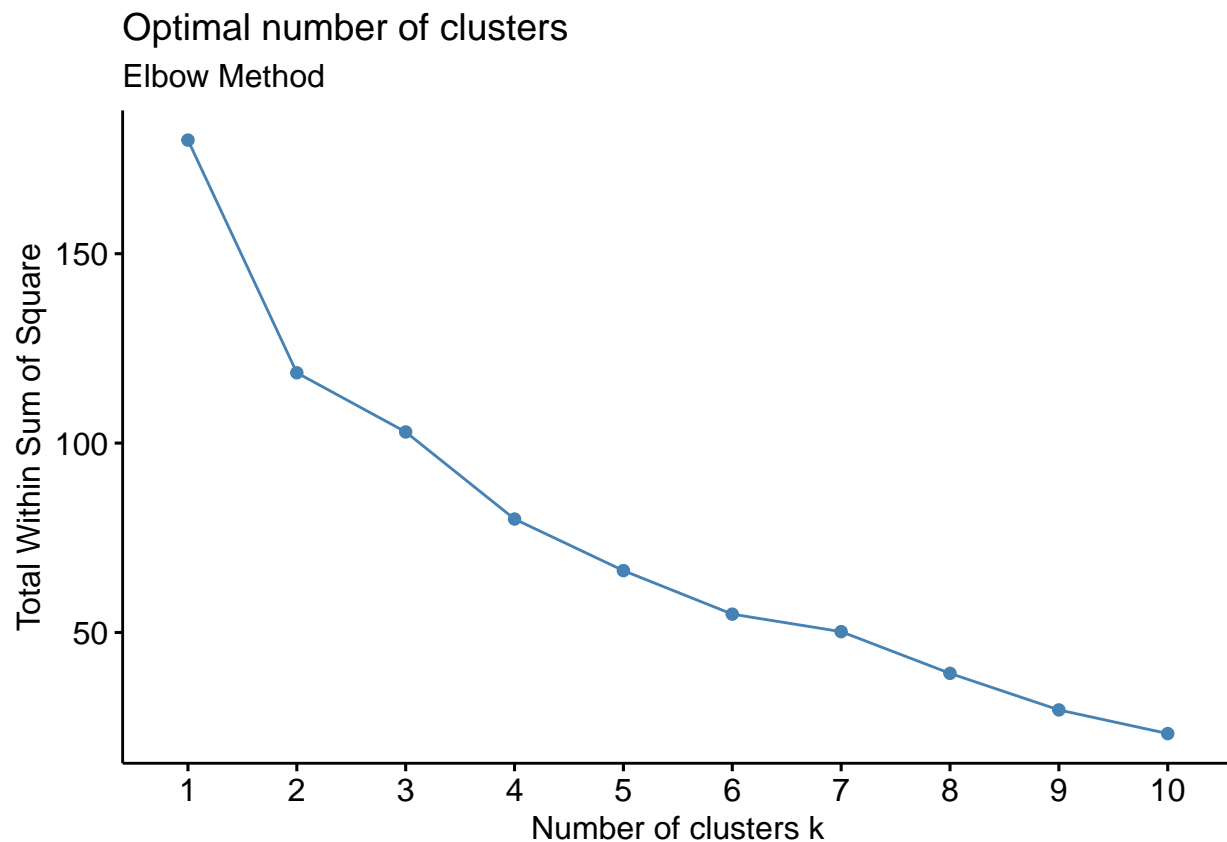
```
#Scale all the dataframe's quantitative variables
```

```
Pharma_2<-scale(Pharma_1)
head(Pharma_2)
```

```
##      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
```

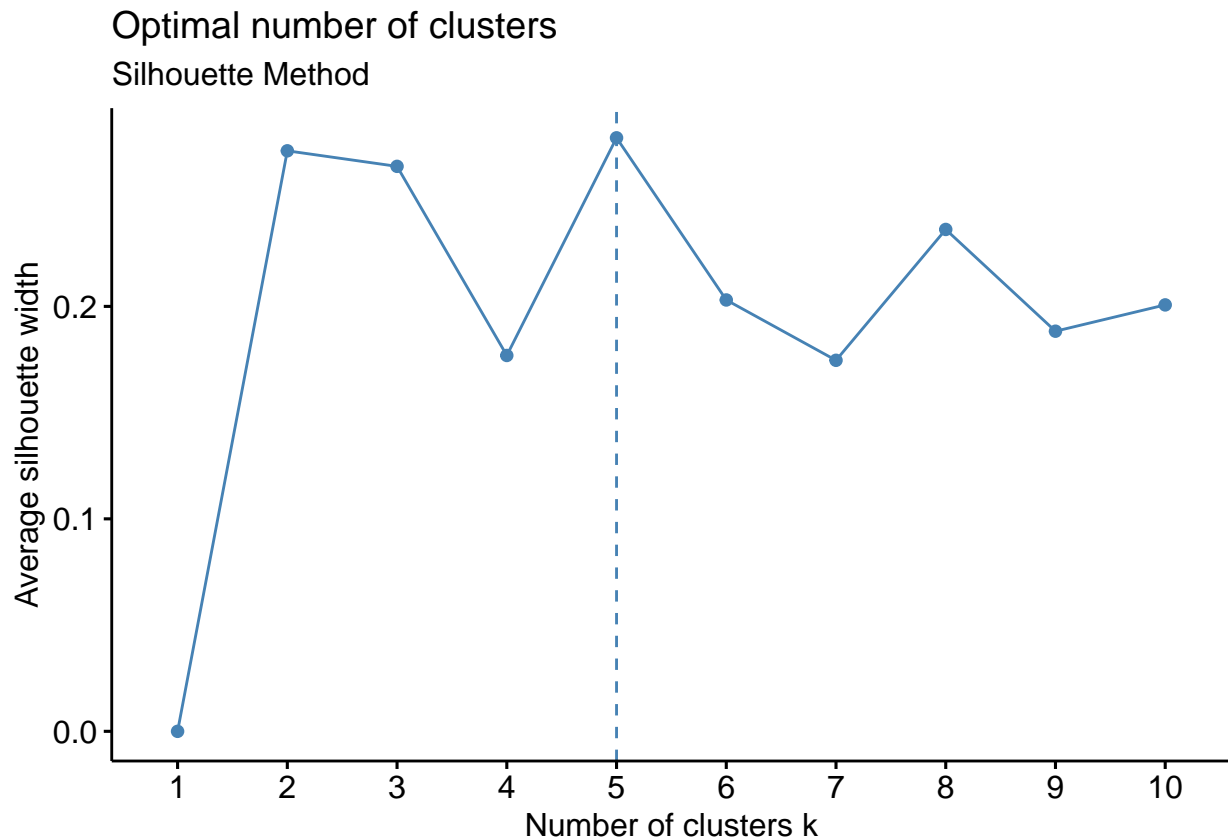
```
##Determining the no of clusters to do the cluster analysis using Elbow Method
```

```
fviz_nbclust(Pharma_2, kmeans, method = "wss") + labs(subtitle = "Elbow Method")
```



```
##Using Silhouette method for determining no of clusters
```

```
fviz_nbclust(Pharma_2, kmeans, method = "silhouette")+ labs(subtitle = "Silhouette Method")
```



The number of clusters is 5 in the above plots, which is sufficient to display the data variations.

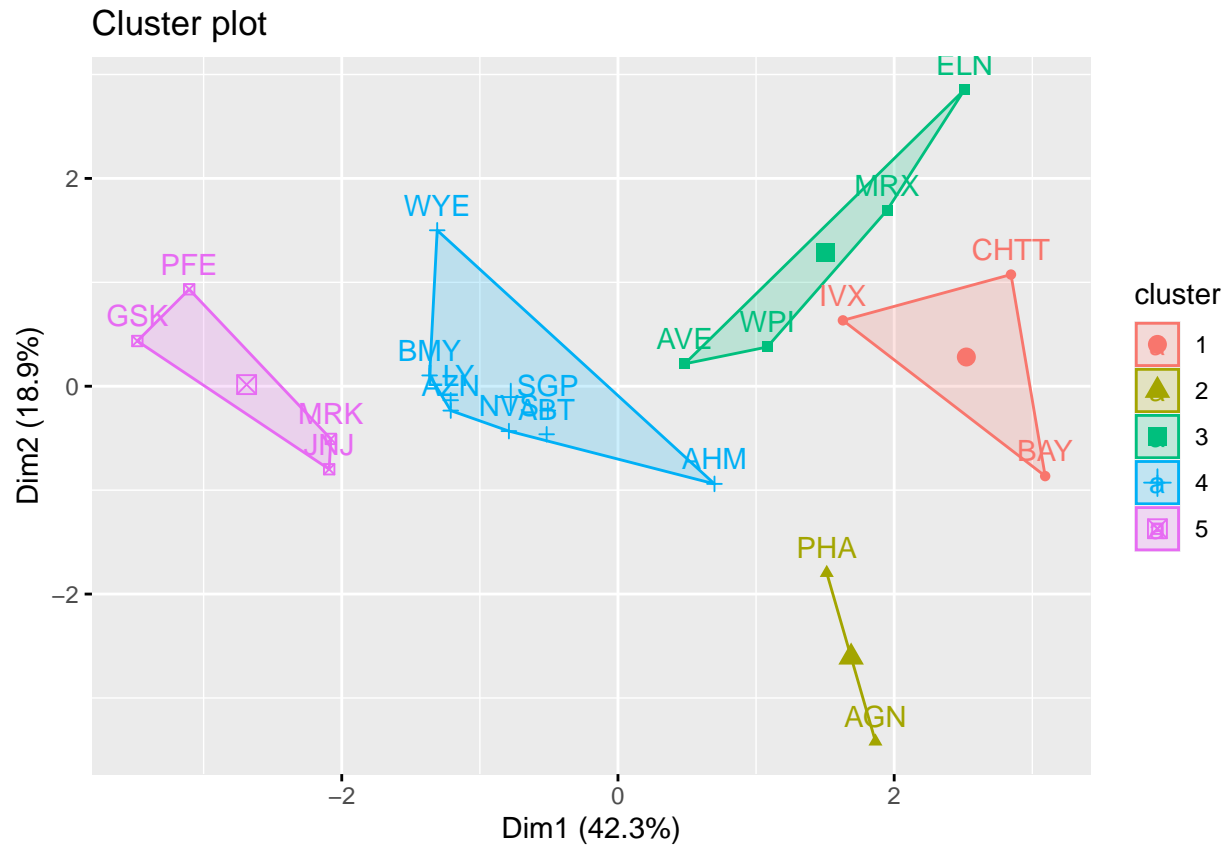
```
set.seed(64060)
k5<- kmeans(Pharma_2,centers=5,nstart = 25)
```

#Visualizing the output

```
k5$centers #for centroids
```

##	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			

```
fviz_cluster(k5,data = Pharma_2) # to Visualize the clusters
```



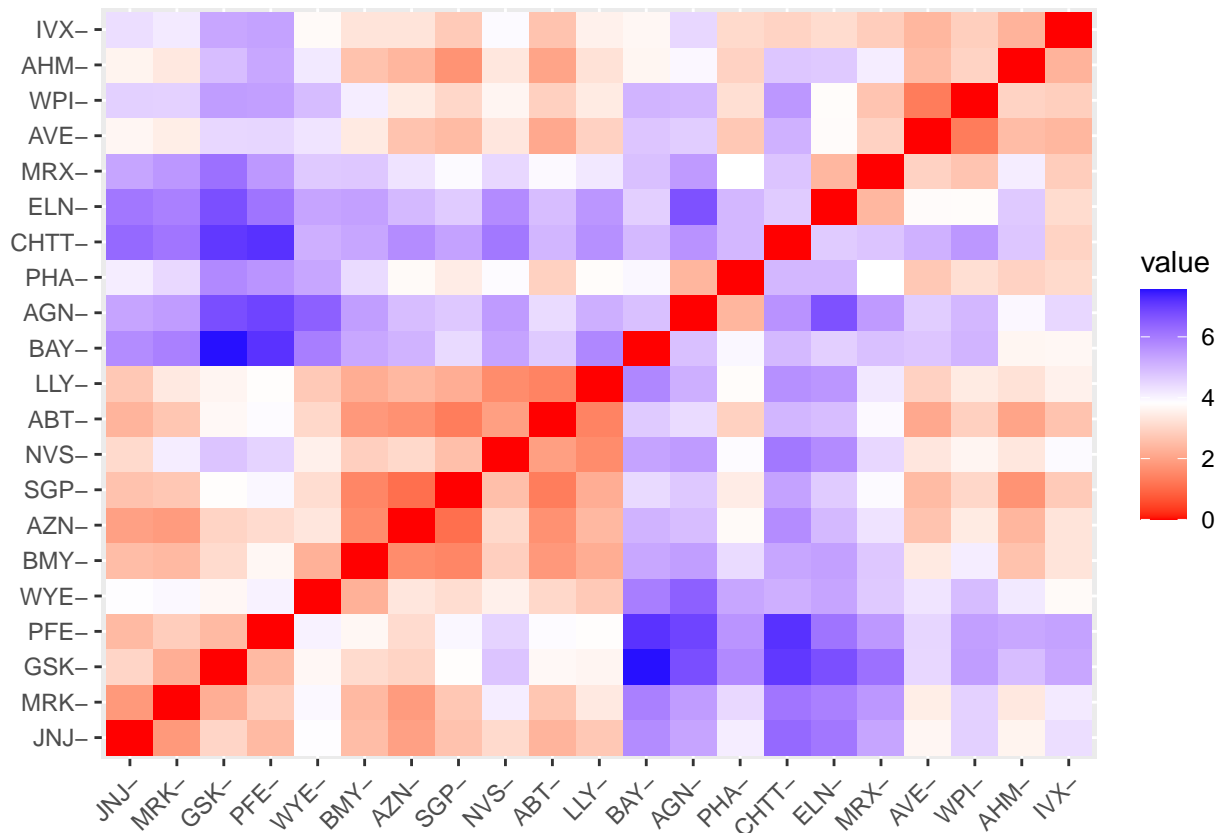
k5

```
## 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_2, method = "euclidean")
fviz_dist(distance)
```



```
#Using K-Means Cluster Analysis- to Fit the data with 5 clusters
```

```
fit<-kmeans(Pharma_2,5)
```

```
#calculating the mean of all quantitative variables in each cluster
```

```
aggregate(Pharma_2,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
```

```
Pharma_3<-data.frame(Pharma_2,fit$cluster)
Pharma_3
```

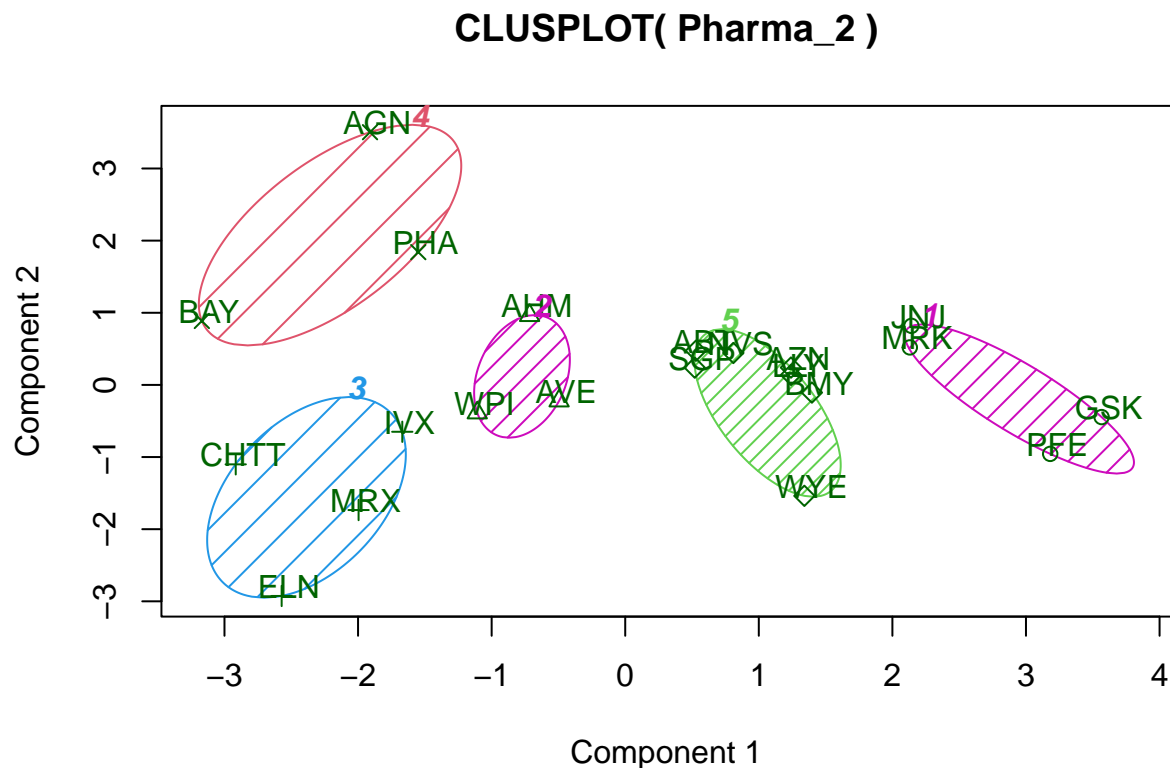
```
##      Market_Cap      Beta  PE_Ratio      ROE      ROA Asset_Turnover
## ABT  0.1840960 -0.80125356 -0.04671323  0.04009035  0.2416121  0.0000000
## AGN -0.8544181 -0.45070513  3.49706911 -0.85483986 -0.9422871  0.9225312
## AHM -0.8762600 -0.25595600 -0.29195768 -0.72225761 -0.5100700  0.9225312
## 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      5
## AGN  0.01828430 -0.38113909     -1.55366706      4
## AHM -0.40408312 -0.57211809     -0.68503583      2
## AZN -0.74965647  0.14744734      0.35122600      5
## AVE -0.31449003  1.21638667     -0.42597037      2
## BAY -0.74965647 -1.49714434     -1.99560225      4
## BMY -0.02011273 -0.96584257      0.74744375      5
## CHTT 3.74279705 -0.63276071     -1.24888417      3
## ELN  0.61983791  1.88617085     -0.36501379      3
## LLY -0.07130879 -0.64814764      1.17413980      5
## GSK -0.31449003  0.76926048      0.82363947      1
## IVX  1.10620040  0.05603085     -0.71551412      3
## JNJ -0.62166634 -0.36213170      0.33598685      1
## MRX  0.44065173  1.53860717      0.85411776      3
## MRK -0.39128411  0.36014907     -0.24310064      1
## NVS -0.67286239 -1.45369888      1.02174835      5
## PFE -0.54487226  1.10143723      1.44844440      1
## PHA -0.30169102  0.14744734     -1.27936246      4
## SGP -0.74965647 -0.43544591      0.29026942      5
```



```
## WPI -0.49367621 1.43089863 -0.09070919 2
## WYE 0.68383297 -1.17763919 1.49416183 5
```

#view of the cluster plot

```
library(cluster)
clusplot(Pharma_2,fit$cluster,color = TRUE,shade = TRUE,labels = 2,lines = 0)
```



These two components explain 61.23 % of the point variability.

#b. Interpret the clusters with respect to the numerical variables used in forming the clusters. By looking at the mean values of all quantitative variables in each cluster.

Cluster 1 - JNJ, MRK, PFE, GSK ~ Cluster 1 has highest Market_cap, ROA, ROE, Asset_Turnover and lowest is Beta, PE_Ratio.

Cluster 2 - AHM, WPI, AVE ~ Cluster 2 has highest Rev_Growth and lowest PE_Ratio, Asset_Turnover

Cluster 3 - CHTT, ELN, MRX, IVX ~ Cluster 3 has highest Beta, Leverage and lowest Market_Cap, ROE, ROA, Leverage, Rev_Growth, Net_Profit_Margin.

Cluster 4 - BAY, PHA, AGN ~ Cluster 4 has highest PE_Ratio and lowest Leverage, Asset_Turnover.

Cluster 5 - AZN, ABT, NVS, BMY, WYE, SGP, LLY ~ Cluster 5 has highest Net_Profit_Margin and lowest leverage, Beta.

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

With respect to the Media recommendation variable, there is a pattern in the clusters.

Cluster 1 with highest Market_Cap, highest ROE, highest ROA, highest Asset_Turnover has equal Hold and Moderate Buy Recommendation.

Cluster 2 with lowest PE_Ratio and lowest Asset_Turnover has Hold Recommendation.

Cluster-3 with highest Beta, highest Leverage has mostly Moderate Buy Recommendation.

Cluster 4 with highest PE_Ratio has Hold Recommendation.

Cluster 5 with highest Net_Profit_Margin has mostly Hold Recommendation.

In terms of variables, I have seen a pattern among the clusters (10 to 12)

Clusters 1,3 has mostly Moderate Buy Recommendation

Clusters 1,2,4,5 has Hold Recommendation

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

Cluster-1 - Moderate Buy (or) Hold cluster.

Cluster-2 - Low PE_Ratio, Asset_Turnover cluster (or) Hold cluster.

Cluster-3 - High Beta, Leverage cluster (or) Buy Cluster.

Cluster-4 - High PE_Ratio cluster (or) High Hold cluster.

Cluster-5 - High Net_Profit_Margin cluster (or) High Hold cluster.