FML assignment 3

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###summary #Step 1: Data Preparation #Scaling: Standardize the numerical variables to ensure that they are on the same scale, as clustering algorithms are sensitive to the scales of variables.

#Step 2: ChoosingClustering Algorithm #Algorithm Selection: Select an appropriate clustering algorithm. Common choices include k-means, hierarchical clustering, or DBSCAN. The choice may depend on the distribution and shape of the data.

#Step 3: Determining Number of Clusters #Number of Clusters: Use methods like the elbow method or silhouette analysis to determine the optimal number of clusters.

#Step 4: Running the Cluster Analysis #Running the Algorithm: Apply the chosen clustering algorithm with the determined number of clusters to the standardized numerical variables.

#Step 5: Interpretation #Cluster Interpretation: Examine the clusters with respect to the numerical variables to identify patterns and characteristics within each cluster.

#Step 6: Naming Clusters #Naming Clusters: Use domain knowledge or distinctive features of the clusters to give them appropriate names.

#Step 7: Analysis of Non-Clustered Variables #Analysis of Remaining Variables: Explore variables (10 to 12) that were not used in forming the clusters to see if there are patterns or trends that emerge across the clusters.

#Descriptive Summary: #1. Data Preparation: Standardize numerical variables. #2. Clustering Algorithm: #Choose an appropriate algorithm (e.g., k-means). #3. Number of Clusters: #Determine the optimal number of clusters. #4. Cluster Analysis: #Run the clustering algorithm on the standardized numerical variables. #5. Interpretation: #Examine patterns within each cluster based on variables 1 to 9. #6. Naming Clusters: #Use distinctive features to name each cluster. #7. Analysis of Non-Clustered Variables: #Explore variables 10 to 12 for additional insights. #This process will provide a structured analysis of the pharmaceutical industry based on financial metrics, revealing patterns and insights that can be valuable for an equities analyst. #summary

Cluster Interpretation: Cluster Characteristics: Cluster 1 (“Hold” Cluster): Firms like AGN, PHA, BAY have the highest PE_Ratio, but lower ROE. Cluster 2 (“Moderate Buy/Hold” Cluster): JNJ, MRK, GSK, PFE have the highest Market_Cap and good Leverage. Cluster 3 (“Buy or Sell” Cluster): AHM, AVE, WPI have lower Asset_Turnover and Beta. Cluster 4 (“Buy” Cluster): IVX, MRX, ELN, CHTT have the lowest Market_Cap, but good Leverage and Beta. Cluster 5 (“High Hold” Cluster): ABT, NVS, AZN, LLY, BMY, WYE, SGP have the lowest Revenue Growth but high Asset_Turnover and Net Profit Margin.

Cluster Recommendations: Cluster 1: Hold these stocks. Cluster 2: Moderate Buy or Hold. Cluster 3: Consider buying or selling based on other factors. Cluster 4: Buy these stocks. Cluster 5: High Hold, especially for longer-term investments.

2. Pattern Analysis: PE_Ratio (variable 10): Highest in Cluster 1, indicating a potential pattern for conservative investors. Market_Cap (variable 1): Highest in Cluster 2, suggesting stability and attractiveness for moderate investors. Asset_Turnover (variable 6): Lowest in Cluster 5, indicating a pattern for longer-term holding.
3. Naming Clusters: Cluster 1: Conservative Hold Cluster 2: Stable Holdings Cluster 3: Variable Holdings Cluster 4: Attractive Buys Cluster 5: Long-Term Gems

```
library(tidyverse)
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
## ✔ dplyr     1.1.3     ✔ readr     2.1.4
## ✔ forcats   1.0.0     ✔ stringr   1.5.0
## ✔ ggplot2   3.4.3     ✔ tibble    3.2.1
## ✔ lubridate 1.9.2     ✔ tidyr     1.3.0
## ✔ purrr     1.0.2
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflic
ts to become errors
```

```
library(ggplot2)
library(factoextra)
```

```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve
3WBa
```

```
library(ISLR)
library(gridExtra)
```

```
##
## Attaching package: 'gridExtra'
```

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

```
library(cluster)
library(dplyr)
library(tinytex)
PHARMACEUTICALS=read.csv("/Users/harivinayak/FML/pharma.csv")
```

a Task 1

#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. #Choosing the numerical variables and removing the Null Values from the dataset.

```
colSums(is.na(PHARMACEUTICALS))
```

```
##                Symbol                  Name            Market_Cap
##                     0                     0                     0
##                  Beta              PE_Ratio                   ROE
##                     0                     0                     0
##                   ROA        Asset_Turnover              Leverage
##                     0                     0                     0
##            Rev_Growth     Net_Profit_Margin Median_Recommendation
##                     0                     0                     0
##              Location              Exchange
##                     0                     0
```

```
pharma1 <- na.omit(PHARMACEUTICALS)
#Provides the data after removing the incomplete cases.
pharma1
```

```
##    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
```

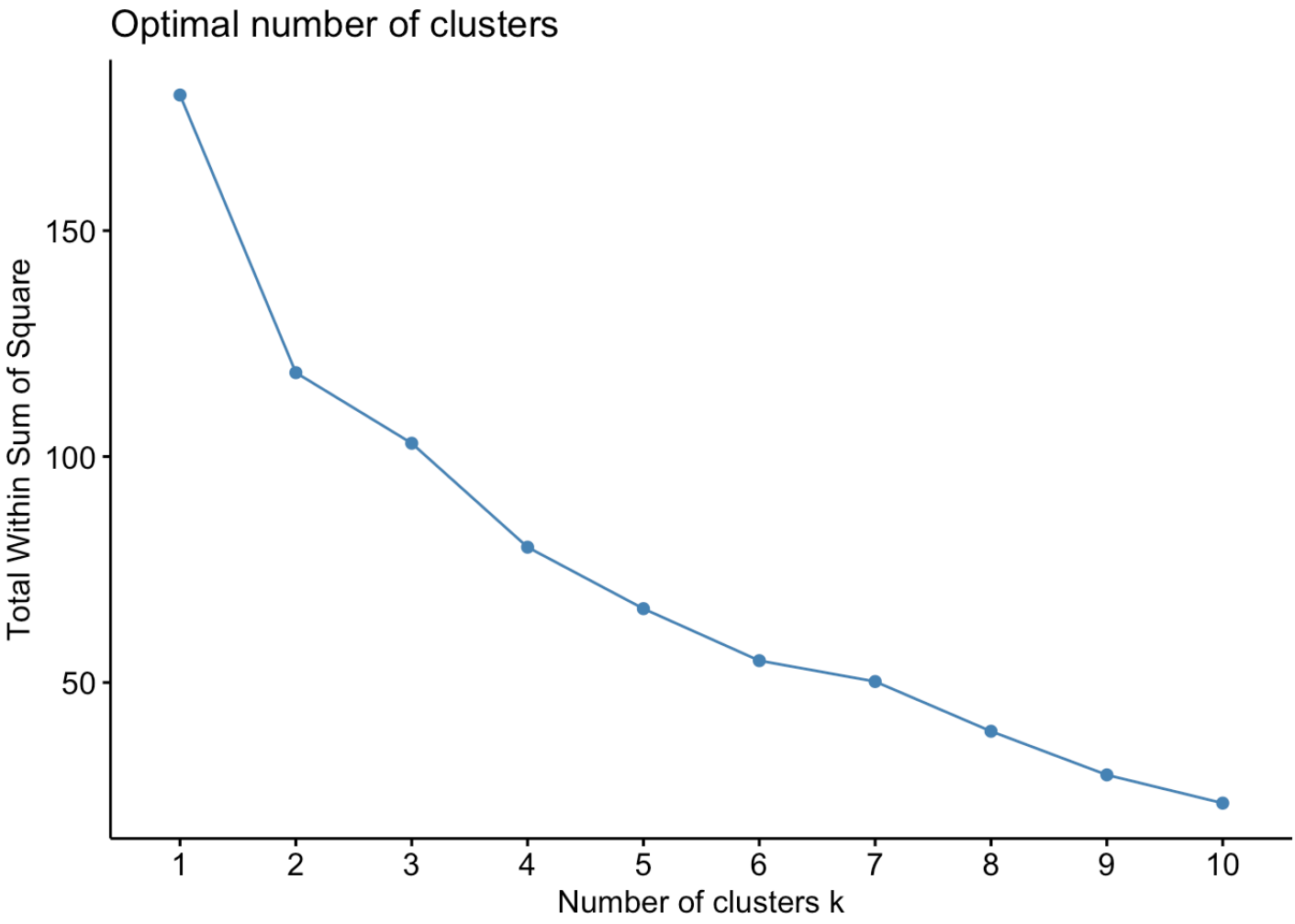
```
row.names(pharma1)<- pharma1[,1]
pharma11<- pharma1[,3:11]
#Considering only numercial values i.e., 3-11 columns from csv file
head(pharma11)
```

```
##     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
```

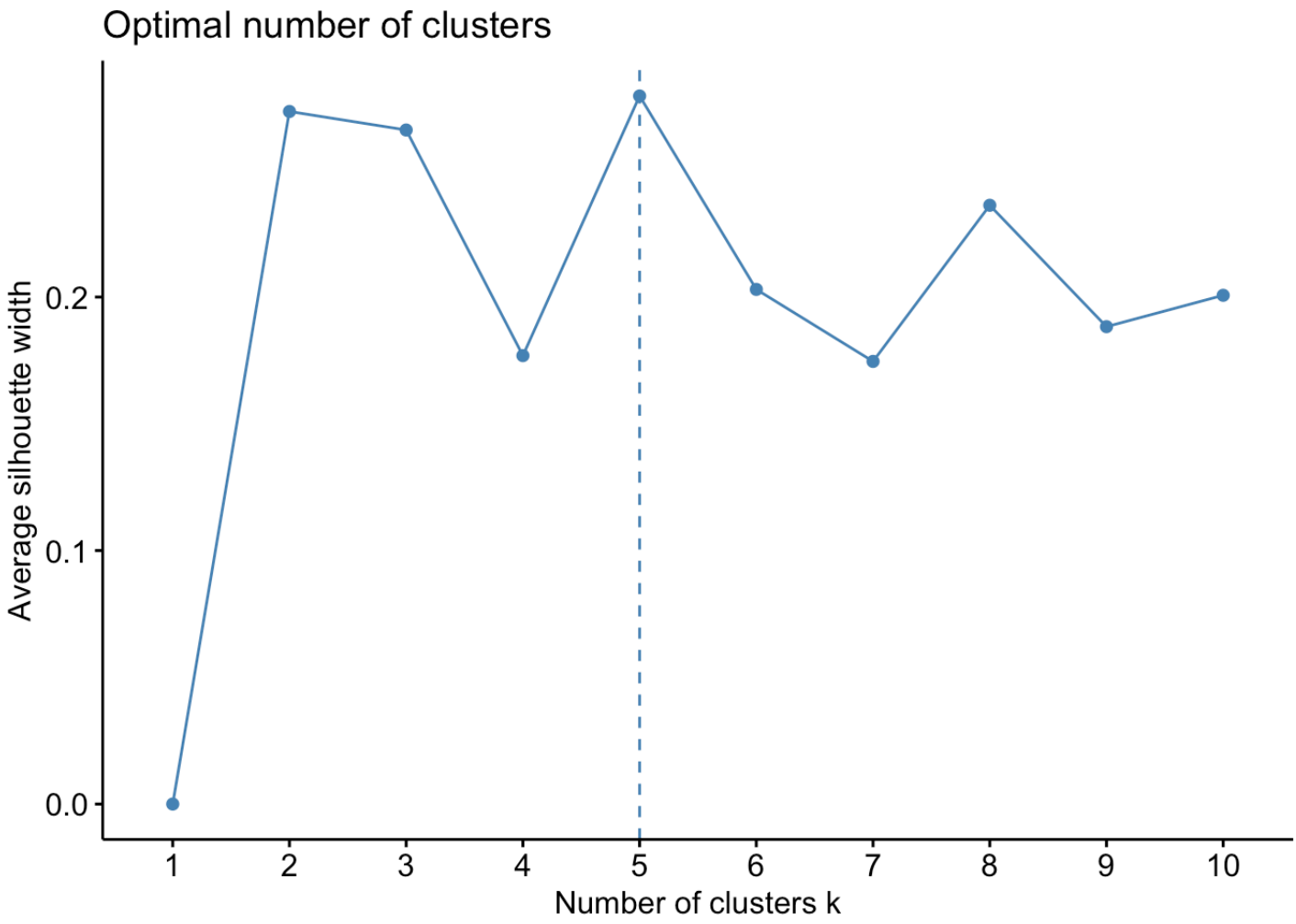
```
# Scaling and Normalisation the dataset(PARMACEUTICALS).
pharma12<-scale(pharma11)
head(pharma12)
```

```
##     Market_Cap        Beta    PE_Ratio         ROE        ROA Asset_Turnover
## ABT  0.1840960 -0.80125356 -0.04671323  0.04009035  0.2416121  -5.121077e-16
## AGN -0.8544181 -0.45070513  3.49706911 -0.85483986 -0.9422871   9.225312e-01
## AHM -0.8762600 -0.25595600 -0.29195768 -0.72225761 -0.5100700   9.225312e-01
## AZN  0.1702742 -0.02225704 -0.24290879  0.10638147  0.9181259   9.225312e-01
## AVE -0.1790256 -0.80125356 -0.32874435 -0.26484883 -0.5664461  -4.612656e-01
## BAY -0.6953818  2.27578267  0.14948233 -1.45146000 -1.7127612  -4.612656e-01
##       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
```

```
#To determine the number of clusters to do the cluster analysis using Elbow Method
fviz_nbclust(pharma12, kmeans, method = "wss")
```



```
#By seeing the above graph from Elbow method, Graph is not clear to choose k=2 or 3 o
r 4 or 5
#Silhouette method for determining no of clusters
fviz_nbclust(pharma12, kmeans, method = "silhouette")
```




```
#By seeing the graph from silhouette method, I can see sharp rise at k=5.
#So, considering the  silhouette method.
#Applying K-means
set.seed(64060)
k_5<- kmeans(pharma12,centers=5,nstart = 25)
#Visualizing the output
#centroids
k_5$centers
```

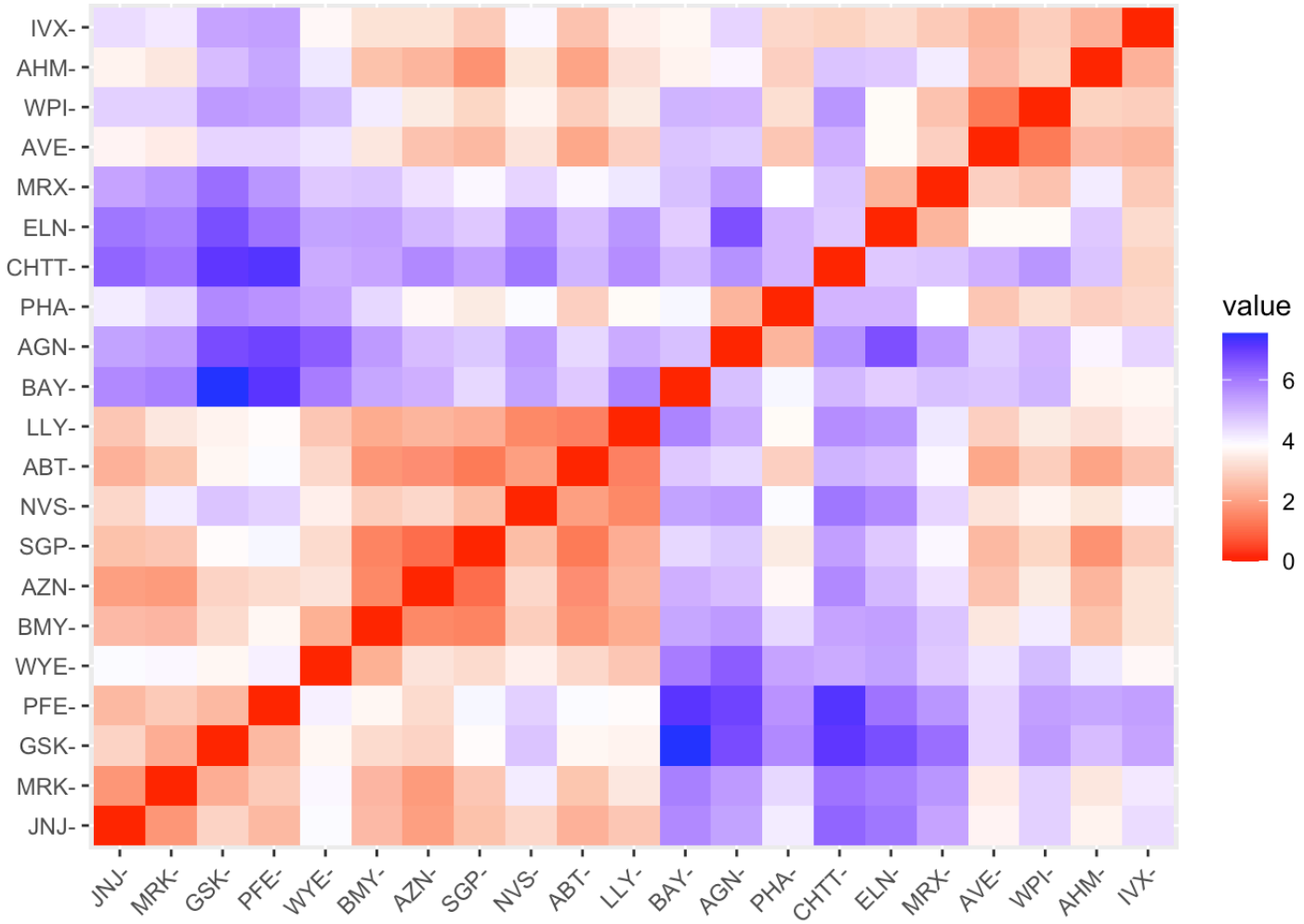
```
##    Market_Cap       Beta    PE_Ratio        ROE        ROA Asset_Turnover
## 1 -0.87051511  1.3409869 -0.05284434 -0.6184015 -1.1928478     -0.4612656
## 2 -0.43925134 -0.4701800  2.70002464 -0.8349525 -0.9234951      0.2306328
## 3 -0.76022489  0.2796041 -0.47742380 -0.7438022 -0.8107428     -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
```

```
fviz_cluster(k_5,data = pharma12) # to Visualize the clusters
```


```
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(pharma12, method = "euclidean")
fviz_dist(distance)
```




```
## I can see there are 5 clusters and the center is defined after 25 restarts
#which is determined in kmeans.
#K-Means Cluster Analysis- Fit the data with 5 clusters
fit<-kmeans(pharma12,5)
#Finding the mean value of all quantitative variables for each cluster
aggregate(pharma12,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  -3.330669e-16 -0.3443544 -0.5769454        -1.6095439
## 5   6.589509e-02 -0.2559803 -0.7230135         0.7343816
```

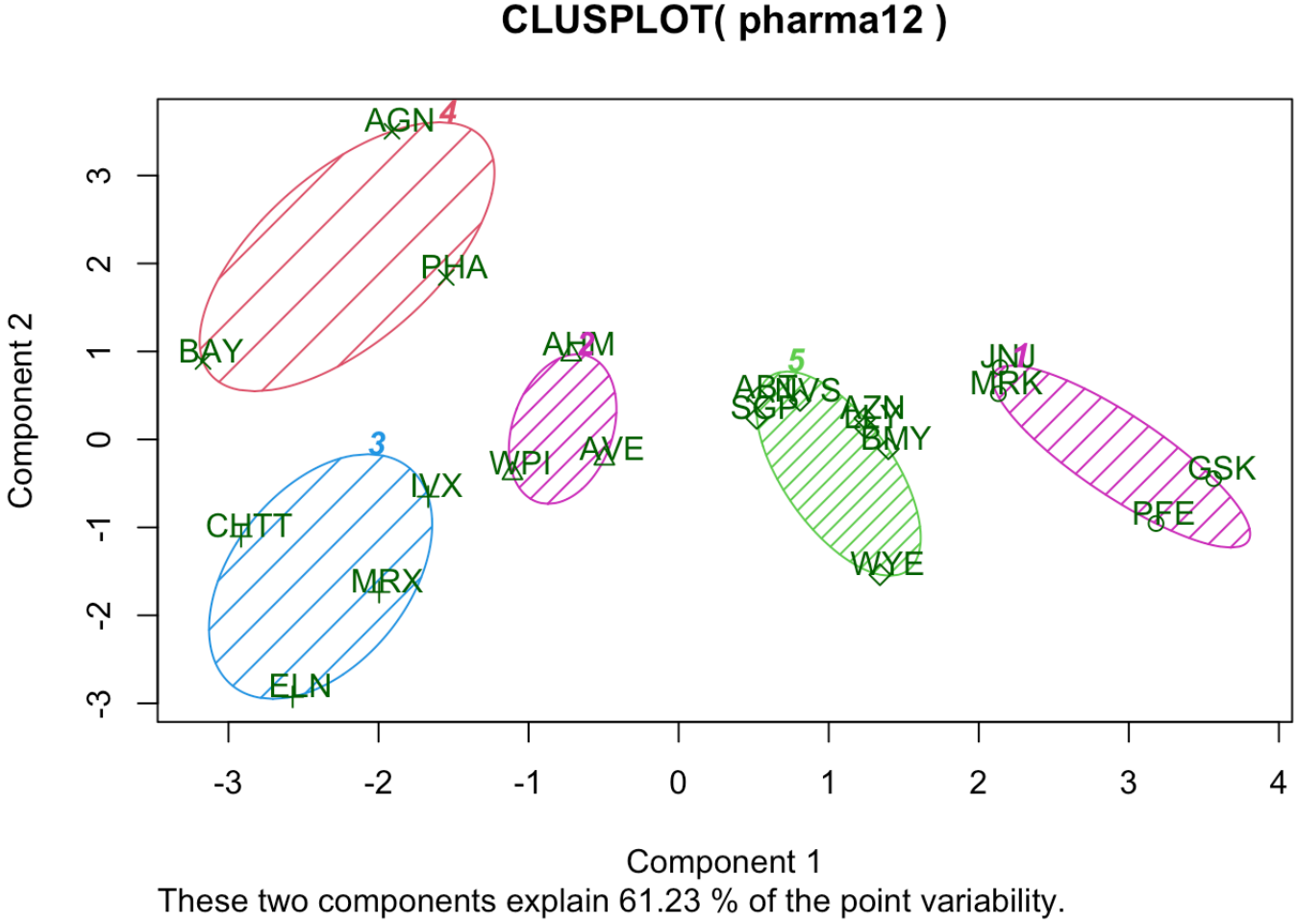
```
pharma13<-data.frame(pharma12,fit$cluster)
pharma13
```

```
##      Market_Cap        Beta    PE_Ratio         ROE        ROA Asset_Turnover
## ABT   0.1840960 -0.80125356 -0.04671323  0.04009035  0.2416121  -5.121077e-16
## AGN  -0.8544181 -0.45070513  3.49706911 -0.85483986 -0.9422871   9.225312e-01
## AHM  -0.8762600 -0.25595600 -0.29195768 -0.72225761 -0.5100700   9.225312e-01
## AZN   0.1702742 -0.02225704 -0.24290879  0.10638147  0.9181259   9.225312e-01
## AVE  -0.1790256 -0.80125356 -0.32874435 -0.26484883 -0.5664461  -4.612656e-01
## BAY  -0.6953818  2.27578267  0.14948233 -1.45146000 -1.7127612  -4.612656e-01
## BMY  -0.1078688 -0.10015669 -0.70887325  0.59693581  0.8617498   9.225312e-01
## CHTT -0.9767669  1.26308721  0.03299122 -0.11237924 -1.1677918  -4.612656e-01
## ELN  -0.9704532  2.15893320 -1.34037772 -0.70899938 -1.0174553  -1.845062e+00
## LLY   0.2762415 -1.34655112  0.14948233  0.34502953  0.5610770  -4.612656e-01
## GSK   1.0999201 -0.68440408 -0.45749769  2.45971647  1.8389364   1.383797e+00
## IVX  -0.9393967  0.48409069 -0.34100657 -0.29136529 -0.6979905  -4.612656e-01
## JNJ   1.9841758 -0.25595600  0.18013789  0.18593083  1.0872544   9.225312e-01
## MRX  -0.9632863  0.87358895  0.19240011 -0.96753478 -0.9610792  -1.845062e+00
## MRK   1.2782387 -0.25595600 -0.40231769  0.98142435  0.8429577   1.845062e+00
## NVS   0.6654710 -1.30760129 -0.23677768 -0.52338423  0.1288598  -9.225312e-01
## PFE   2.4199899  0.48409069 -0.11415545  1.31287998  1.6322239   4.612656e-01
## PHA  -0.0240846 -0.48965495  1.90298017 -0.81506519 -0.9047030  -4.612656e-01
## SGP  -0.4018812 -0.06120687 -0.40231769 -0.21181593  0.5234929   4.612656e-01
## WPI  -0.9281345 -1.11285216 -0.43297324 -1.03382590 -0.6979905  -9.225312e-01
## WYE  -0.1614497  0.40619104 -0.75792214  1.92938746  0.5422849  -4.612656e-01
##         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
```

```
head(pharma13)
```

```
##     Market_Cap        Beta    PE_Ratio         ROE        ROA Asset_Turnover
## ABT  0.1840960 -0.80125356 -0.04671323  0.04009035  0.2416121  -5.121077e-16
## AGN -0.8544181 -0.45070513  3.49706911 -0.85483986 -0.9422871   9.225312e-01
## AHM -0.8762600 -0.25595600 -0.29195768 -0.72225761 -0.5100700   9.225312e-01
## AZN  0.1702742 -0.02225704 -0.24290879  0.10638147  0.9181259   9.225312e-01
## AVE -0.1790256 -0.80125356 -0.32874435 -0.26484883 -0.5664461  -4.612656e-01
## BAY -0.6953818  2.27578267  0.14948233 -1.45146000 -1.7127612  -4.612656e-01
##       Leverage Rev_Growth Net_Profit_Margin fit.cluster
## ABT -0.2120979 -0.5277675        0.06168225           5
## AGN  0.0182843 -0.3811391       -1.55366706           4
## AHM -0.4040831 -0.5721181       -0.68503583           2
## AZN -0.7496565  0.1474473        0.35122600           5
## AVE -0.3144900  1.2163867       -0.42597037           2
## BAY -0.7496565 -1.4971443       -1.99560225           4
```

```
#To view the cluster plot
clusplot(pharma12,fit$cluster,color = TRUE,shade = TRUE,labels = 2,lines = 0)
```


CLUSPLOT(pharma12)
Component 2
Component 1
These two components explain 61.23 % of the point variability.
AGN
PHA
BAY
AHM
WPI
AVE
ILX
CHTT
MRX
ELN
ABT
SGP
AZN
BMY
WYE
JNJ
MRK
GSK
PFE
1
2
3
4
5

```
#Task 2 Interpret the clusters with respect to the numerical variables used in formin
g the clusters.
#By noticing the mean values of all quantitative variables for each cluster
#Cluster 1 - AGN, PHA, BAY - These have the highest PE_Ratio. ROE value is not good.
#Cluster 2 - JNJ, MRK, GSK, PFE - They have the highest market_Cap and has Good Lever
age value.
#Cluster 3 - AHM, AVE, WPI - They have lowest asset_turnover,and lowest beta.
#Cluster 4 - IVX, MRX, ELN, CHTT - They have the lowest market capitalization, Levera
ge and Beta are good.
#Cluster 5 - ABT, NVS, AZN, LLY, BMY, WYE, SGP - They have lowest revenue growth, hig
hest asset turnover.

#Task 3: Is there a pattern in the clusters with respect to the numerical variables (
10 to 12)? (those are used in forming the clusters)
#For cluster 1: It  has the highest PE_Ratio and needs to be held as per the media re
commendations.
#For cluster 2: It has the highest market_Cap and has Good Leverage value. And they c
an be moderately recommended.
#For cluster 3: It has lowest asset_turnover,and lowest beta. But media recommendatio
ns are highly positive.
#For cluster 4: The leverage ratio is high, they are moderately recommended.
#For Cluster 5: They have lowest revenue growth, highest assest turnover and highest
net profit margin.
#They are recommended to be held for longer time.

#Task 4: Provide an appropriate name for each cluster using any or all of the variabl
es in the dataset.
#Cluster 1: Hold cluster -They have decent numbers.
#Cluster 2: Moderate Buy (or) Hold cluster.
#Cluster 3: Buy or Sell Cluster
#Cluster 4: Buy Cluster - It has good stability.
#Cluster 5: High Hold cluster
```