FML4

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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.

```
#Loading packages
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.1.3
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.6     v dplyr   1.0.8
## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1
```

```
## Warning: package 'readr' was built under R version 4.1.3
```

```
## Warning: package 'forcats' was built under R version 4.1.3
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(factoextra)
```

```
## Warning: package 'factoextra' was built under R version 4.1.3
```

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

```
library(flexclust)
```

```
## Warning: package 'flexclust' was built under R version 4.1.3
```

```
## Loading required package: grid
```

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

```
## Loading required package: modeltools
```

```
## Loading required package: stats4
```

```
library(ggcorrplot)
```

```
## Warning: package 'ggcorrplot' was built under R version 4.1.3
```

```
library(FactoMineR)
```

```
## Warning: package 'FactoMineR' was built under R version 4.1.3
```

```
library(cluster)
```

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

```
##   Symbol                Name Market_Cap Beta PE_Ratio  ROE  ROA Asset_Turnover
## 1    ABT Abbott Laboratories      68.44 0.32     24.7 26.4 11.8            0.7
## 2    AGN      Allergan, Inc.       7.58 0.41     82.5 12.9  5.5            0.9
## 3    AHM        Amersham plc       6.30 0.46     20.7 14.9  7.8            0.9
## 4    AZN     AstraZeneca PLC      67.63 0.52     21.5 27.4 15.4            0.9
## 5    AVE             Aventis      47.16 0.32     20.1 21.8  7.5            0.6
## 6    BAY           Bayer AG       16.90 1.11     27.9  3.9  1.4            0.6
##   Leverage Rev_Growth Net_Profit_Margin Median_Recommendation Location Exchange
## 1     0.42       7.54              16.1          Moderate Buy       US     NYSE
## 2     0.60       9.16               5.5          Moderate Buy   CANADA     NYSE
## 3     0.27       7.05              11.2            Strong Buy       UK     NYSE
## 4     0.00      15.00              18.0         Moderate Sell       UK     NYSE
## 5     0.34      26.81              12.9          Moderate Buy   FRANCE     NYSE
## 6     0.00      -3.17               2.6                  Hold  GERMANY     NYSE
```

```
Pharmdata1 <- Pharmdata[3:11]
head(Pharmdata1)
```

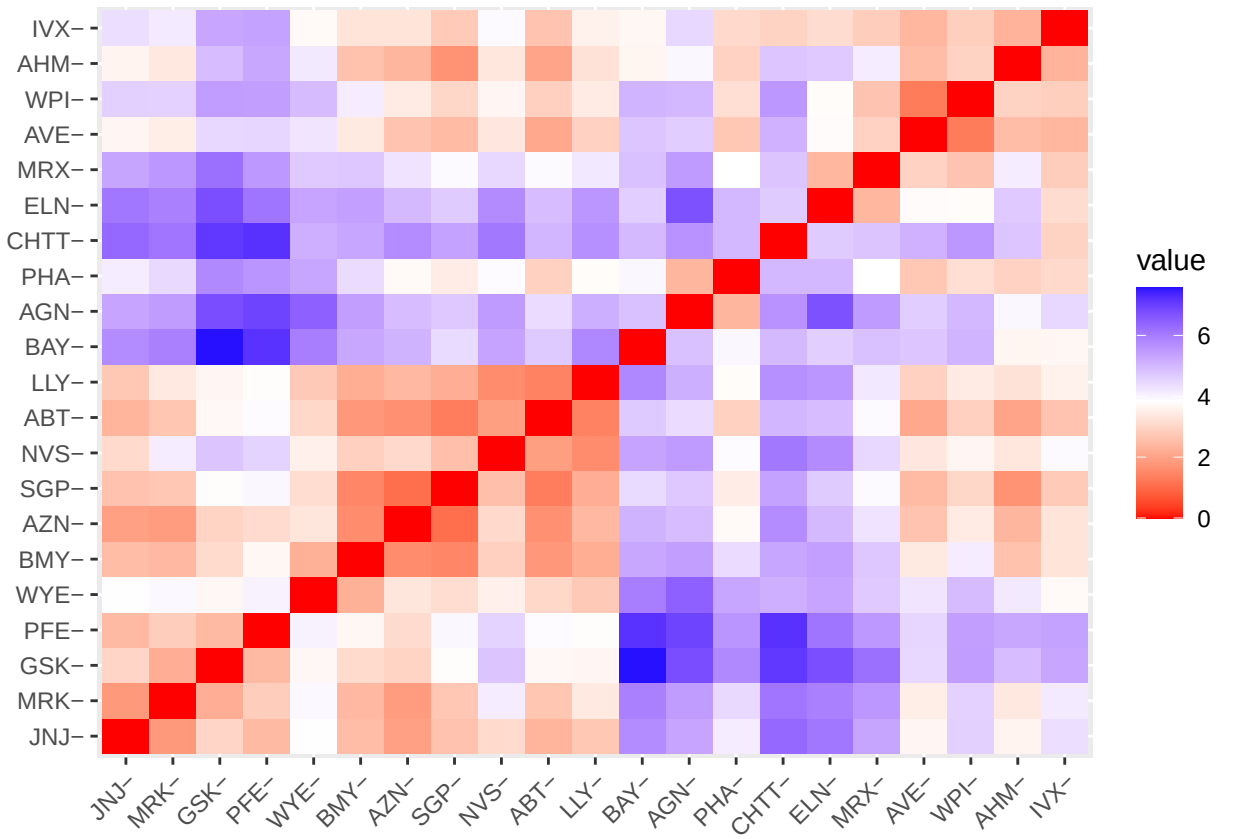
```
##   Market_Cap Beta PE_Ratio  ROE  ROA Asset_Turnover Leverage Rev_Growth
## 1      68.44 0.32     24.7 26.4 11.8            0.7     0.42       7.54
## 2       7.58 0.41     82.5 12.9  5.5            0.9     0.60       9.16
## 3       6.30 0.46     20.7 14.9  7.8            0.9     0.27       7.05
## 4      67.63 0.52     21.5 27.4 15.4            0.9     0.00      15.00
## 5      47.16 0.32     20.1 21.8  7.5            0.6     0.34      26.81
## 6      16.90 1.11     27.9  3.9  1.4            0.6     0.00      -3.17
##   Net_Profit_Margin
## 1              16.1
## 2               5.5
## 3              11.2
## 4              18.0
## 5              12.9
## 6               2.6
```

```
summary(Pharmdata1)
```

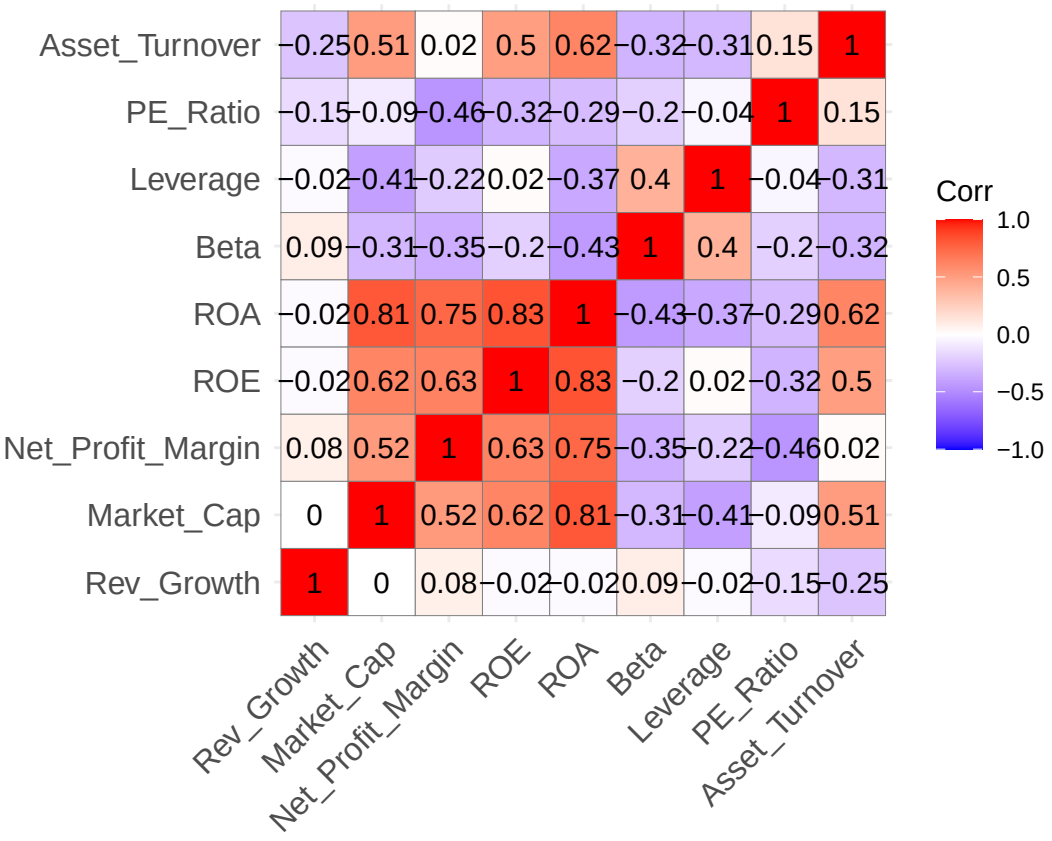
```
##    Market_Cap          Beta            PE_Ratio          ROE
##  Min.   :  0.41   Min.   :0.1800   Min.   : 3.60   Min.   : 3.9
```

```
##  1st Qu.:  6.30   1st Qu.:0.3500   1st Qu.:18.90   1st Qu.:14.9
##  Median : 48.19   Median :0.4600   Median :21.50   Median :22.6
##  Mean   : 57.65   Mean   :0.5257   Mean   :25.46   Mean   :25.8
##  3rd Qu.: 73.84   3rd Qu.:0.6500   3rd Qu.:27.90   3rd Qu.:31.0
##  Max.   :199.47   Max.   :1.1100   Max.   :82.50   Max.   :62.9
##       ROA         Asset_Turnover    Leverage        Rev_Growth
##  Min.   : 1.40   Min.   :0.3    Min.   :0.0000   Min.   :-3.17
##  1st Qu.: 5.70   1st Qu.:0.6    1st Qu.:0.1600   1st Qu.: 6.38
##  Median :11.20   Median :0.6    Median :0.3400   Median : 9.37
##  Mean   :10.51   Mean   :0.7    Mean   :0.5857   Mean   :13.37
##  3rd Qu.:15.00   3rd Qu.:0.9    3rd Qu.:0.6000   3rd Qu.:21.87
##  Max.   :20.30   Max.   :1.1    Max.   :3.5100   Max.   :34.21
##  Net_Profit_Margin
##  Min.   : 2.6
##  1st Qu.:11.2
##  Median :16.1
##  Mean   :15.7
##  3rd Qu.:21.1
##  Max.   :25.5
```

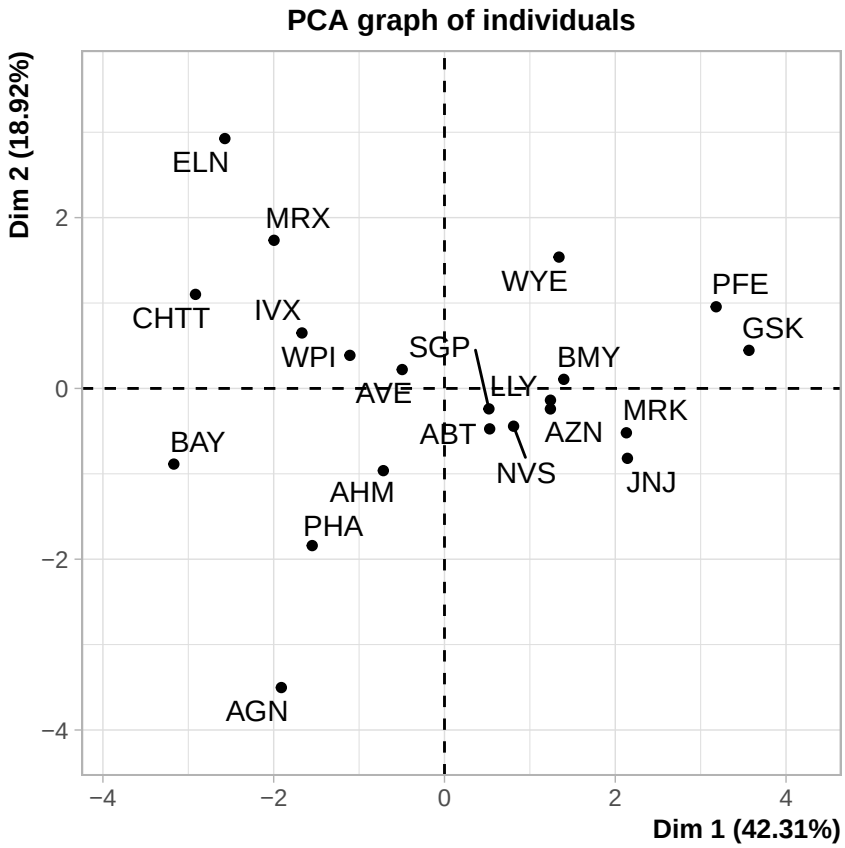
```
Pharmdata2 <- scale(Pharmdata1)
row.names(Pharmdata2) <- Pharmdata[,1]
distance <- get_dist(Pharmdata2)
fviz_dist(distance)
```

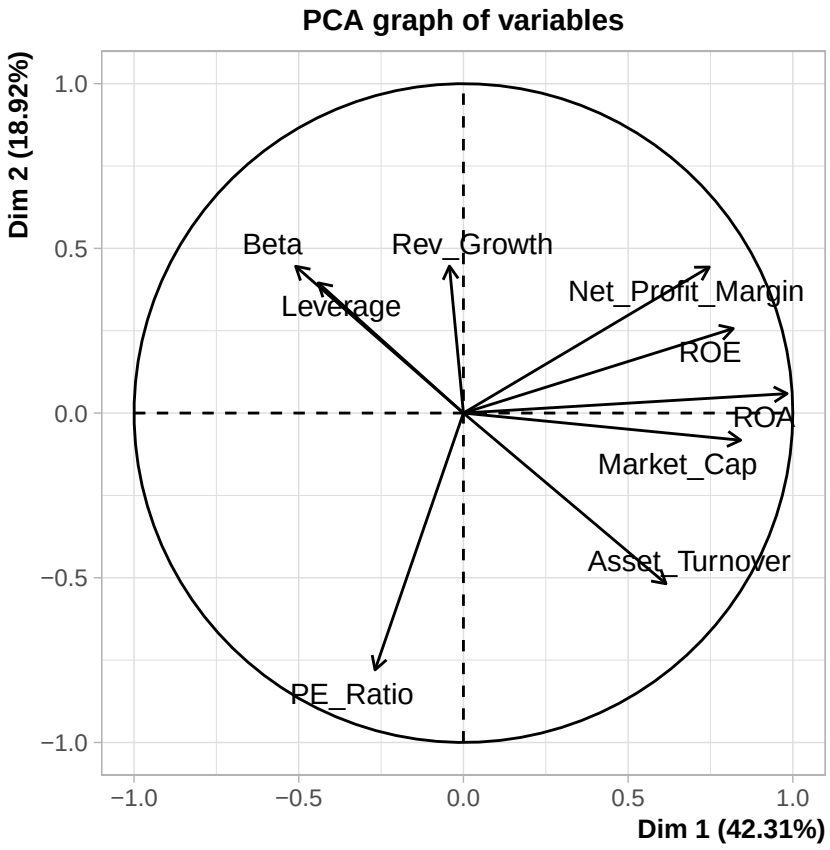


```
corr <- cor(Pharmdata2)
ggcorrplot(corr, outline.color = "grey50", lab = TRUE, hc.order = TRUE, type = "full")
```



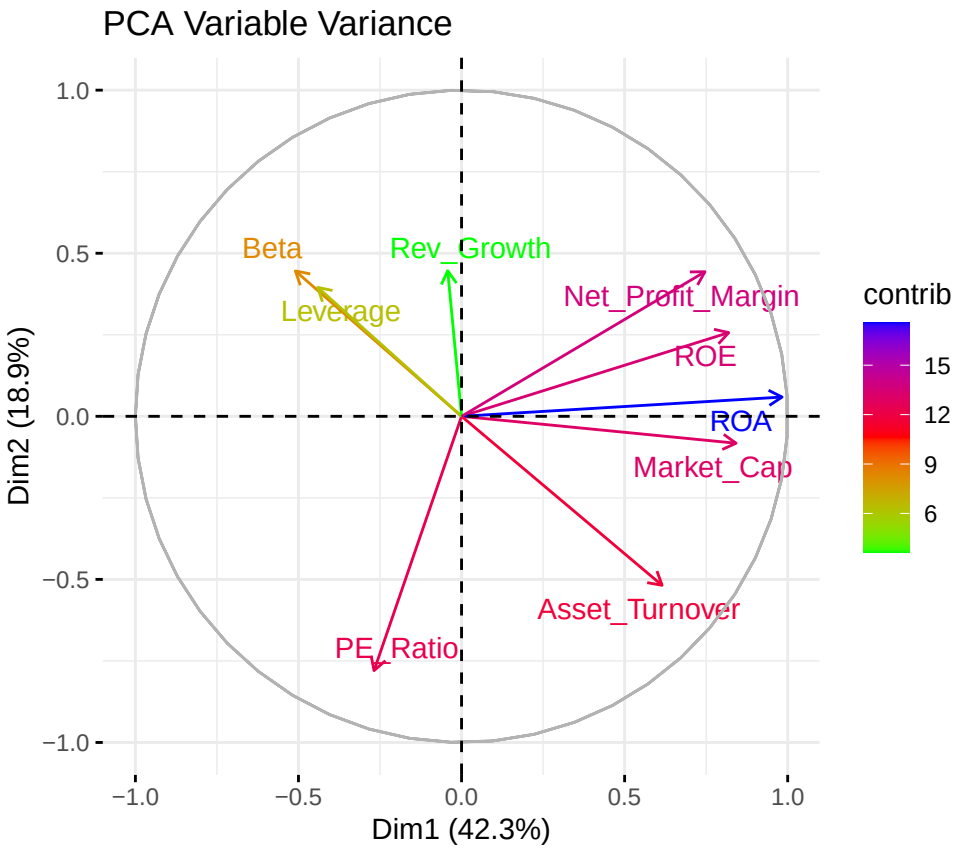

```
pca <- PCA(Pharmdata2)
```


PCA graph of individuals
Dim 2 (18.92%)
Dim 1 (42.31%)
ELN
MRX
CHTT
IVX
WPI
SGP
AVE
WYE
PFE
GSK
BMY
LLY
MRK
ABT
AZN
BAY
NVS
JNJ
AHM
PHA
AGN
2
0
−2
−4
−4
−2
0
2
4

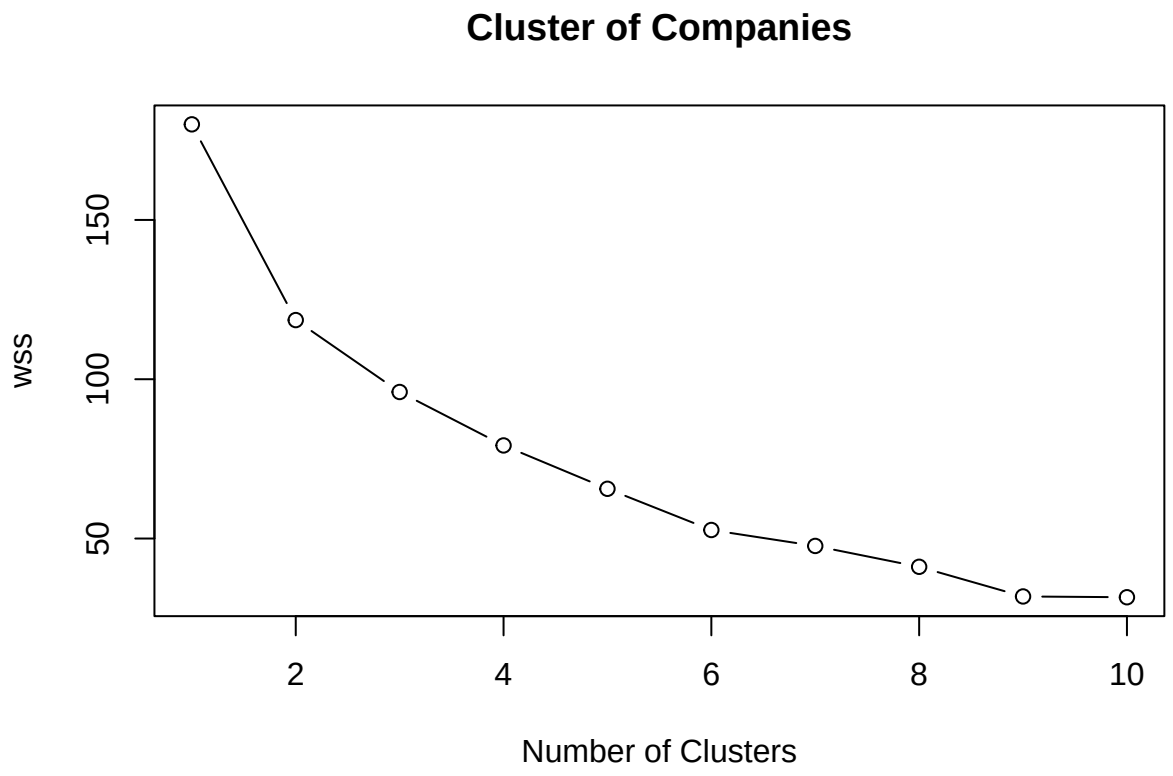



```
var <- get_pca_var(pca)

fviz_pca_var(pca, col.var="contrib",
             gradient.cols = c("green", "red", "blue"),
             repel = TRUE
             ) +
  labs( title = "PCA Variable Variance")
```




```
set.seed(10)
wss <- vector()
for(i in 1:10) wss[i] <- sum(kmeans(Pharmdata2,i)$withinss)
plot(1:10, wss , type = "b" , main = paste('Cluster of Companies') , xlab = "Number of Clusters", ylab=
```

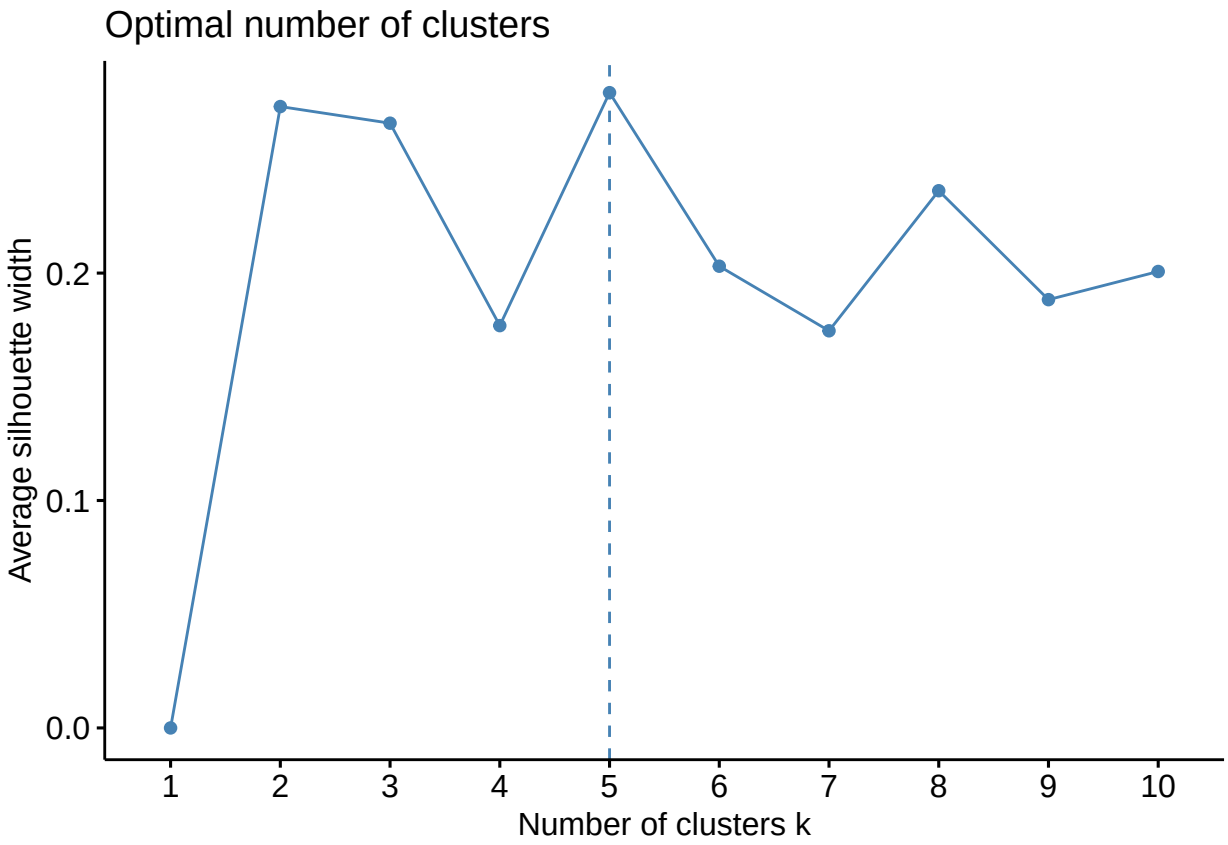



```
wss
```

```
##  [1] 180.00000 118.56934  95.99420  79.21748  65.61035  52.67476  47.66961
##  [8]  41.12605  31.81763  31.57252
```

Silhouette Method

```
fviz_nbclust(Pharmdata2, kmeans, method = "silhouette")
```



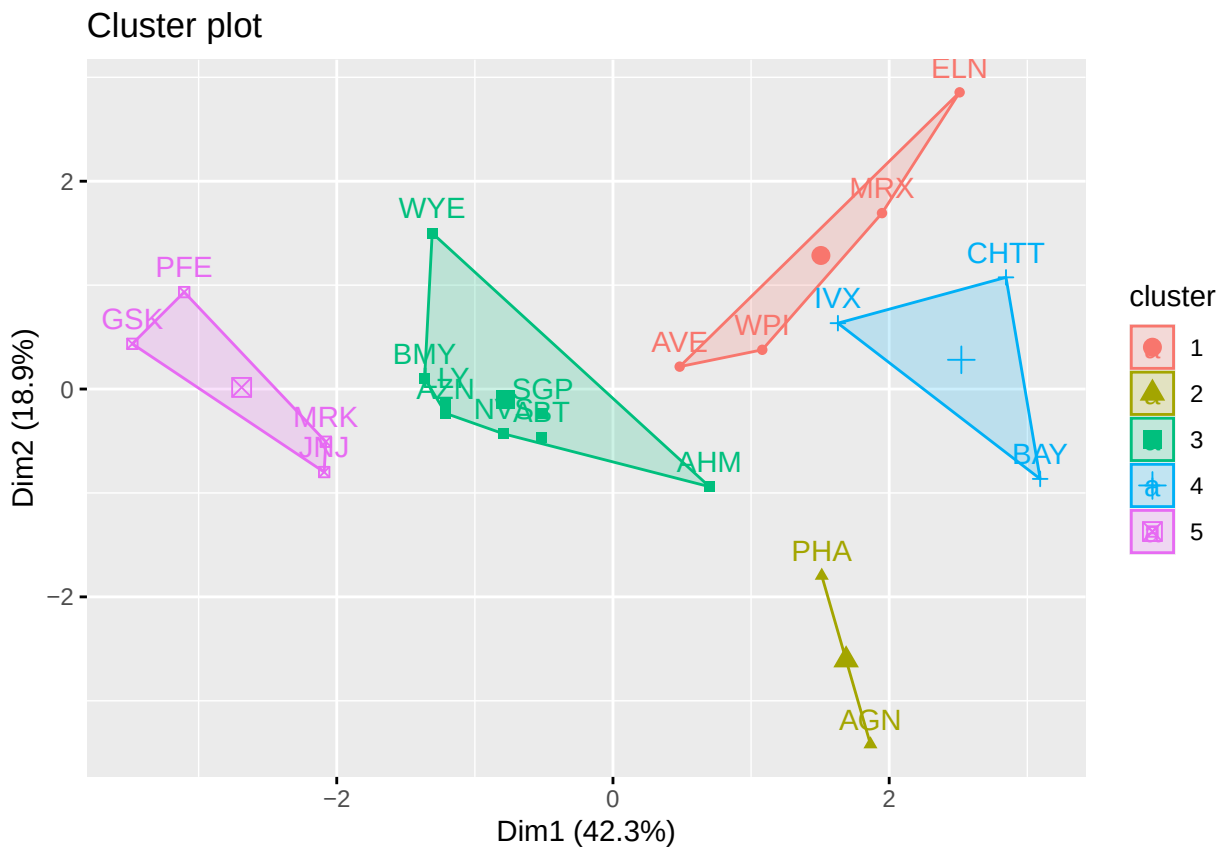

```
set.seed(1)
k5 <- kmeans(Pharmdata2, centers = 5, nstart = 25) # k = 5, number of restarts = 25
# Visualize the output
k5$centers # output the centers
```

```
##    Market_Cap       Beta    PE_Ratio        ROE        ROA Asset_Turnover
## 1 -0.76022489  0.2796041 -0.47742380 -0.7438022 -0.8107428     -1.2684804
## 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  1.69558112 -0.1780563 -0.19845823  1.2349879  1.3503431      1.1531640
##      Leverage Rev_Growth Net_Profit_Margin
## 1  0.06308085  1.5180158      -0.006893899
## 2 -0.14170336 -0.1168459      -1.416514761
## 3 -0.27449312 -0.7041516       0.556954446
## 4  1.36644699 -0.6912914      -1.320000179
## 5 -0.46807818  0.4671788       0.591242521
```

```
k5$size # Number of companies in each cluster
```

```
## [1] 4 2 8 3 4
```

```
fviz_cluster(k5, data = Pharmdata2) # Visualize the output
```



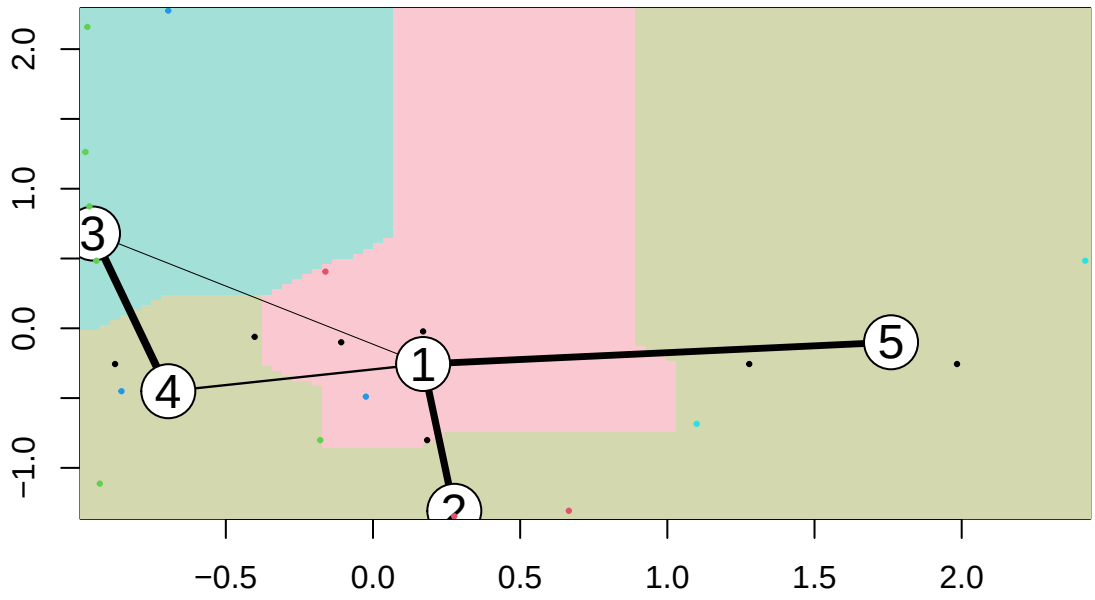

```
set.seed(1)
k51 = kcca(Pharmdata2, k=5, kccaFamily("kmedians"))
k51
```

```
## kcca object of family 'kmedians'
##
## call:
## kcca(x = Pharmdata2, k = 5, family = kccaFamily("kmedians"))
##
## cluster sizes:
##
## 1 2 3 4 5
## 7 3 6 3 2
```

```
clusters_index <- predict(k51)
dist(k51@centers)
```

```
##          1        2        3        4
## 2 2.150651
## 3 3.513242 4.146567
## 4 3.878726 4.246051 3.388339
## 5 3.018500 3.737739 5.124420 6.043691
```

```
image(k51)
points(Pharmdata2, col=clusters_index, pch=19, cex=0.3)
```



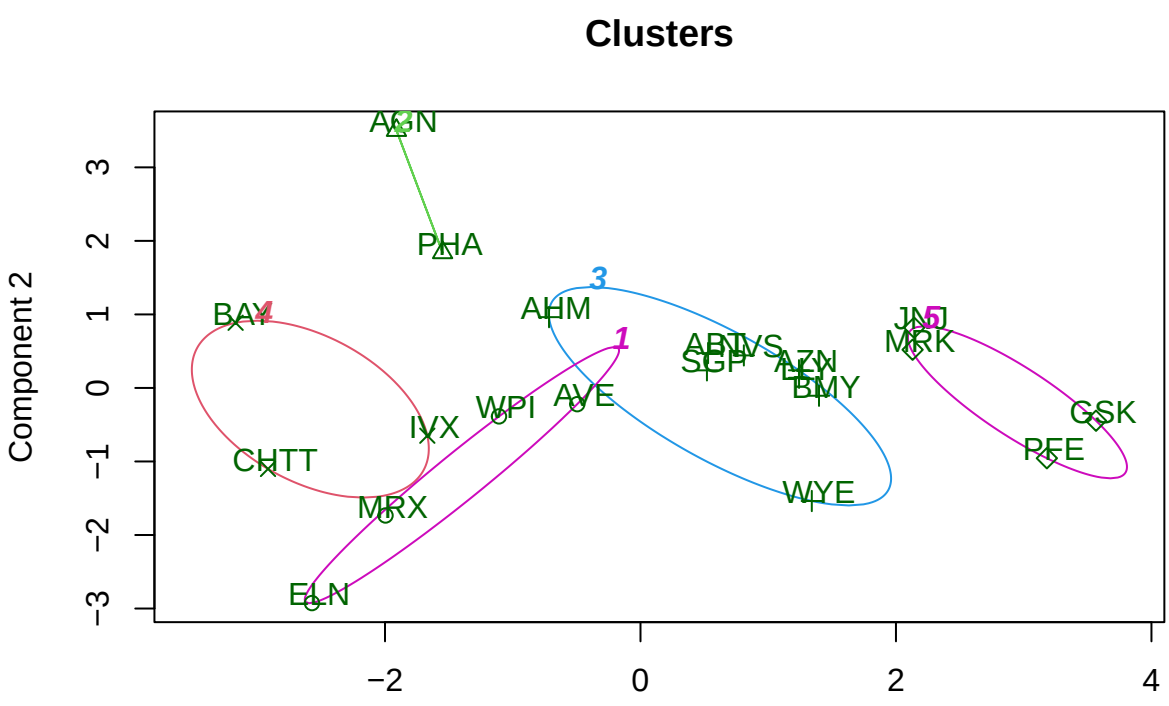
b.Interpret the clusters with respect to the numerical variables used in forming the clusters

#Calculating Mean of all variables for every cluster and plotting them

```
Pharmdata1 %>% mutate(Cluster = k5$cluster) %>% group_by(Cluster) %>% summarise_all("mean")
```

```
## # A tibble: 5 x 10
##   Cluster Market_Cap  Beta PE_Ratio   ROE   ROA Asset_Turnover Leverage
##     <int>      <dbl> <dbl>    <dbl> <dbl> <dbl>          <dbl>    <dbl>
## 1       1      13.1  0.598     17.7  14.6  6.2           0.425    0.635
## 2       2      31.9  0.405     69.5  13.2  5.6           0.75     0.475
## 3       3      55.8  0.414     20.3  28.7 12.7           0.738    0.371
## 4       4       6.64 0.87      24.6  16.5  4.17          0.6      1.65
## 5       5     157.   0.48      22.2  44.4 17.7           0.95     0.22
## # ... with 2 more variables: Rev_Growth <dbl>, Net_Profit_Margin <dbl>
```

```
clusplot(Pharmdata2,k5$cluster, main="Clusters",color = TRUE, labels = 2,lines = 0)
```



These two components explain 61.23 % of the point variability.

Cluster 1: ELN, MRX, WPI and AVE

Cluster 2: AGN and PHA

Cluster 3: AHM,WYE,BMY,AZN, LLY, ABT, NVS and SGP

Cluster 4: BAY, CHTT and IVX

Cluster 5: JNJ, MRK, PFE and GSK

Cluster 1 has got highest revenue growth , very good Net profit Margin and leverage with lowest PE ratio. It can be bought or hold.

Cluster 2 PE ratio is very high , inferring that investors are expecting high growth , however, growth rate is only 12% and Net profit Margin is also low , making it overvalued and may not be a good choice overall.

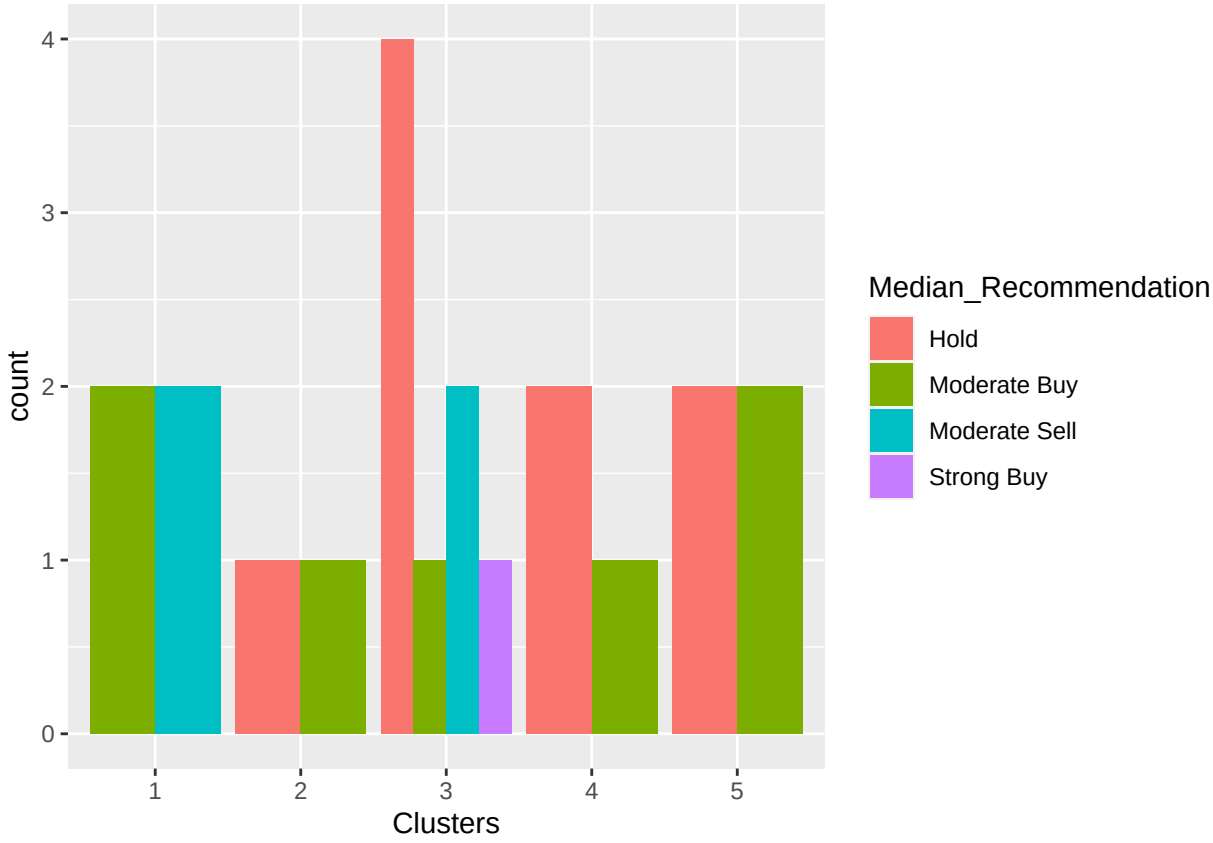
Cluster 3 has average risk (Beta) and relatively high Market Cap, ROE, ROA, Asset Turnover and Net Profit Margin ,high leverage.Attractive (relatively low) PE ratio indicates that the stock price is moderately valued hence can be bought and hold , making it ideal to own.

Cluster 4 Though it has a good PE ratio, it carries a very high risk , very very high leverage and low Net Profit margin , making it very risky to own. Revenue growth is also very low.

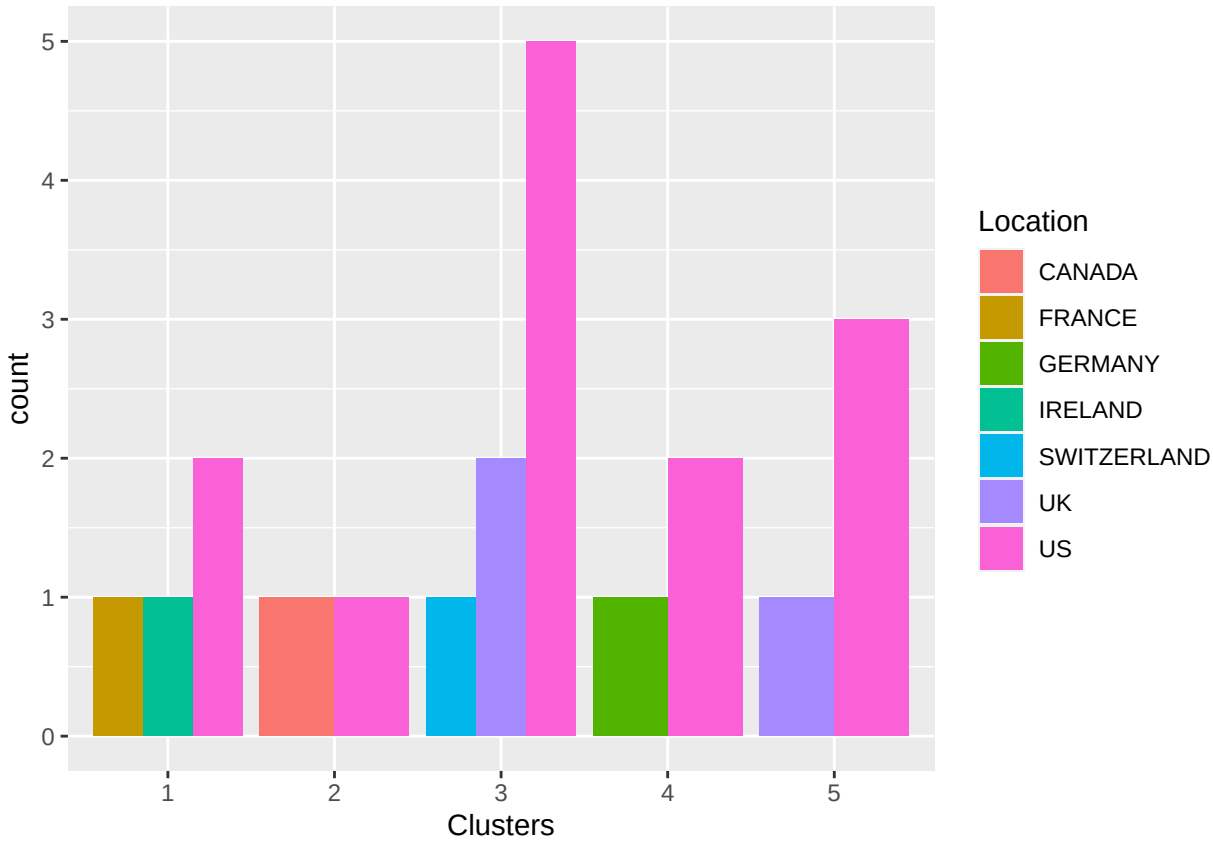
Cluster 5 is great with High Market Cap, ROE, ROA, Asset Turnover and Net Profit Margin. With a relatively low PE ratio the stock price is moderately valued, hence can be bought and hold.Further , revenue growth of 18.5% is good.

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

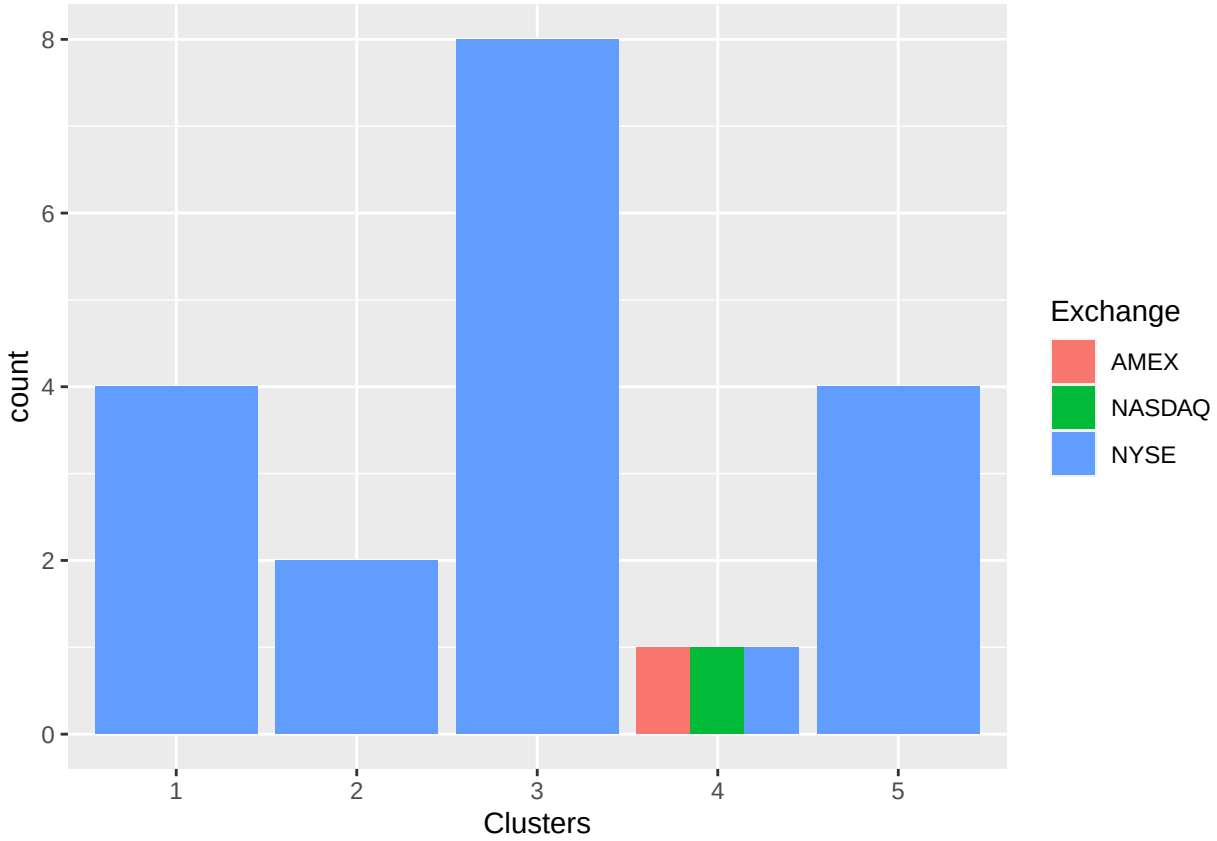
```
Pharmdata3 <- Pharmdata[12:14] %>% mutate(Clusters=k5$cluster)
ggplot(Pharmdata3, mapping = aes(factor(Clusters), fill =Median_Recommendation))+geom_bar(position='dod
```




```
ggplot(Pharmdata3, mapping = aes(factor(Clusters),fill = Location))+geom_bar(position = 'dodge')+labs(x
```




```
ggplot(Pharmdata3, mapping = aes(factor(Clusters),fill = Exchange))+geom_bar(position = 'dodge')+labs(x
```



d.Provide an appropriate name for each cluster using any or all of the variables in the dataset. Cluster 1: Good to buy or to hold Cluster 2: Risk better to sell Cluster 3: Take chance to buy or to hold Cluster 4: Highly Risky better to sell Cluster 5: Best time to buy or to hold