Assignment_4

2025-10-24

Loading packages

```
library(readr)
library(dplyr)

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

library(class)
library(gmodels)
library(tidyverse)

## ── Attaching core tidyverse packages ──────────────────────── tidyverse
2.0.0 ──
## ✓ forcats   1.0.1     ✓ stringr   1.5.2
## ✓ ggplot2   4.0.0     ✓ tibble    3.3.0
## ✓ lubridate 1.9.4     ✓ tidyr     1.3.1
## ✓ purrr     1.1.0

## ── 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
conflicts to become errors

library(factoextra)

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

library(flexclust)
```

Importing the dataset

```
pharma <- read_csv("./Pharmaceuticals.csv")

## Rows: 21 Columns: 14
## ── Column specification
```

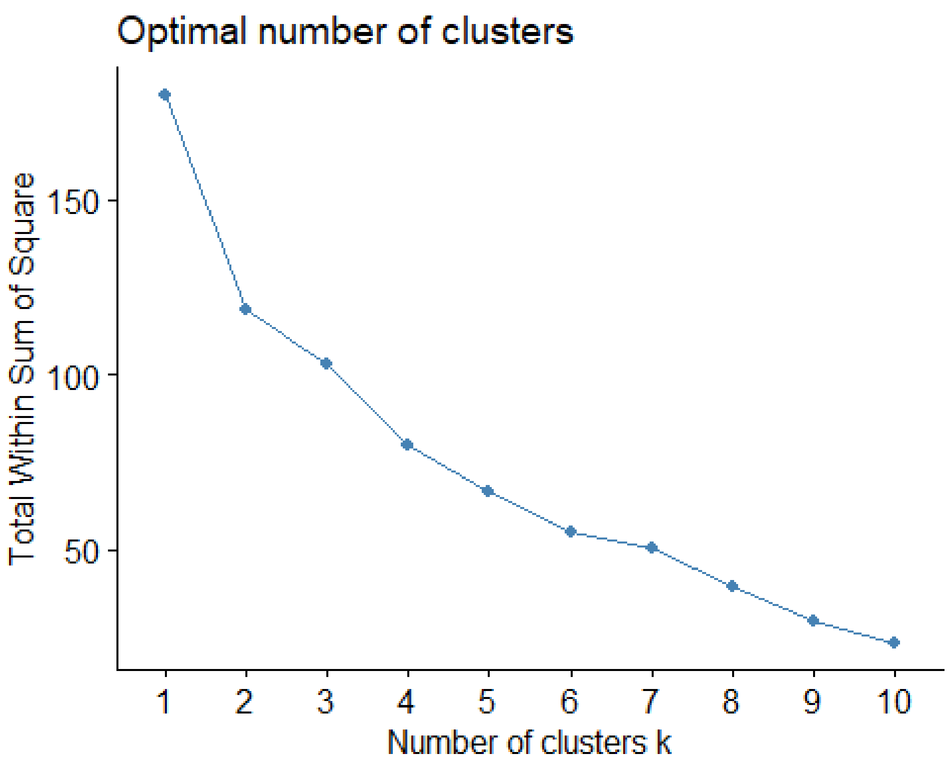
```
## ──────────────────────────────────────────────────────────
## Delimiter: ","
## chr (5): Symbol, Name, Median_Recommendation, Location, Exchange
## dbl (9): Market_Cap, Beta, PE_Ratio, ROE, ROA, Asset_Turnover, Leverage,
Rev...
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

Task 1

```
#separating numeric data
set.seed(135)
pharma.num <- pharma[, 3:11]
summary(pharma.num)

##    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

#This data is required normalization because the magnitude of Market_Cap is
too high compare to other variables, which will influence the whole result.

#normalizing the data
pharma.num.scaled <- scale(pharma.num)
summary(pharma.num.scaled)    #now all the data normalized and almost in the
same scale

##    Market_Cap            Beta             PE_Ratio             ROE
##  Min.   :-0.9768   Min.   :-1.3466   Min.   :-1.3404   Min.   :-1.4515
##  1st Qu.:-0.8763   1st Qu.:-0.6844   1st Qu.:-0.4023   1st Qu.:-0.7223
##  Median :-0.1614   Median :-0.2560   Median :-0.2429   Median :-0.2118
```

```
##   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000
##   3rd Qu.: 0.2762   3rd Qu.: 0.4841   3rd Qu.: 0.1495   3rd Qu.: 0.3450
##   Max.   : 2.4200   Max.   : 2.2758   Max.   : 3.4971   Max.   : 2.4597
##        ROA         Asset_Turnover       Leverage          Rev_Growth
##   Min.   :-1.7128   Min.   :-1.8451   Min.   :-0.74966   Min.   :-1.4971
##   1st Qu.:-0.9047   1st Qu.:-0.4613   1st Qu.:-0.54487   1st Qu.:-0.6328
##   Median : 0.1289   Median :-0.4613   Median :-0.31449   Median :-0.3621
##   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.00000   Mean   : 0.0000
##   3rd Qu.: 0.8430   3rd Qu.: 0.9225   3rd Qu.: 0.01828   3rd Qu.: 0.7693
##   Max.   : 1.8389   Max.   : 1.8451   Max.   : 3.74280   Max.   : 1.8862
##   Net_Profit_Margin
##   Min.   :-1.99560
##   1st Qu.:-0.68504
##   Median : 0.06168
##   Mean   : 0.00000
##   3rd Qu.: 0.82364
##   Max.   : 1.49416
```

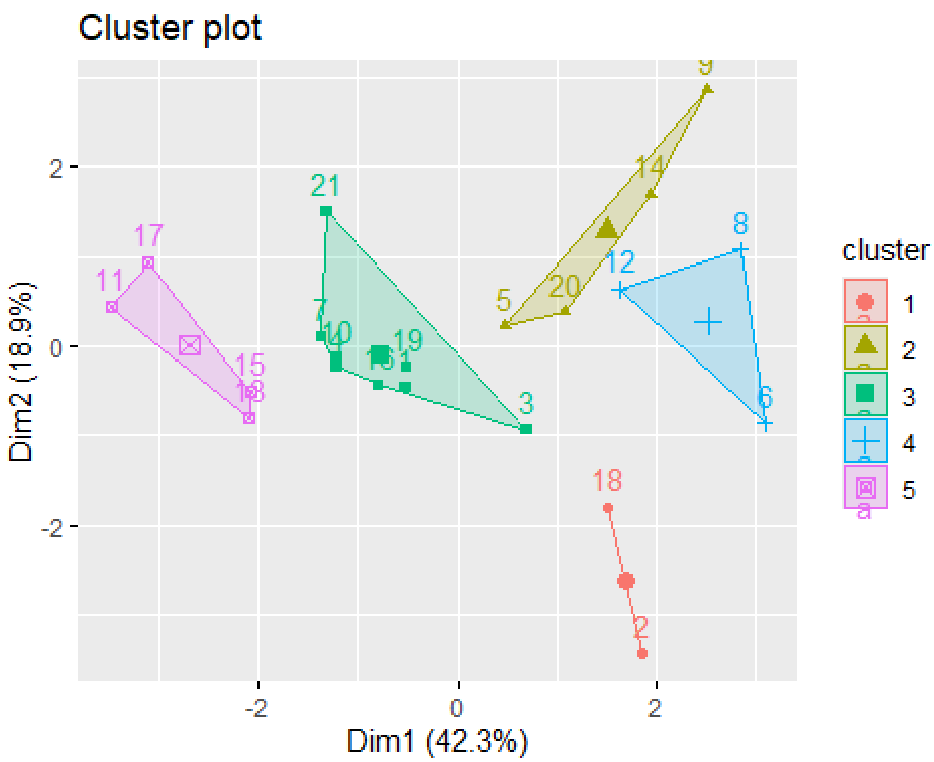
```
#I am going to use the "Elbow method" and "Average Silhouette method" to find
the best value for k
fviz_nbclust(pharma.num.scaled, kmeans, method="wss")  #Elbow method
```




```
#The elbow method suggests that the optimal number of clusters lies around 4,
5, or 6, because from 4 it started decreasing at a much smaller rate. In
other words, k=4/5/6 provides the best value between bias and overfitting.
However, the exact number of clusters remains somewhat ambiguous based on
this method alone.
```

```r
fviz_nbclust(pharma.num.scaled, kmeans, method="silhouette")  #Silhouette
method
```


```r
#On the other hand, the silhouette method provides a clearer indication,
identifying k = 5 as the optimal cluster number. Compared to the elbow
method, the silhouette approach is generally more reliable, objective, and
easier to interpret. It not only evaluates how cohesive (tight) the clusters
are internally but also how well-separated they are from each other.
#Therefore, I choose the k value 5

#visualizing the clusters
pharma.k <- kmeans(pharma.num.scaled,centers=5,nstart=25)
fviz_cluster(pharma.k, data=pharma.num.scaled)
```




```
#From the graph, it is clear that these five clusters are well defined and
separated
```

Task 2

```
#adding the cluster to the original dataset to summarize and find relation
among cluster and variables
pharma$cluster <- pharma.k$cluster
#creating tables with mean values of all variables for each cluster
pharma.num.summary <- aggregate(pharma.num, by = list(Cluster =
pharma$cluster), mean)
pharma.num.summary

##   Cluster Market_Cap    Beta PE_Ratio      ROE       ROA Asset_Turnover
## 1       1  31.910000 0.40500  69.5000 13.20000  5.600000         0.7500
## 2       2  13.100000 0.59750  17.6750 14.57500  6.200000         0.4250
## 3       3  55.810000 0.41375  20.2875 28.73750 12.687500         0.7375
## 4       4   6.636667 0.87000  24.6000 16.46667  4.166667         0.6000
## 5       5 157.017500 0.48000  22.2250 44.42500 17.700000         0.9500
##   Leverage Rev_Growth Net_Profit_Margin
## 1 0.475000  12.080000          6.400000
## 2 0.635000  30.142500         15.650000
## 3 0.371250   5.591250         19.350000
## 4 1.653333   5.733333          7.033333
## 5 0.220000  18.532500         19.575000
```

```
#Cluster 1- medium market capital with moderate risk, revenue and low profit
margin
#Cluster 2- low market capital with high revenue, high debt and good profit
margin
#Cluster 3- large market capital with low risk, revenue but high profit
margin
#Cluster 4- very low market capital with high risk, debt and low revenue and
profit margin
#Cluster 5- largest market capital with low risk, debt and high revenue and
highest profitability
```

Task 3

```
#creating table to understand the distribution of these categorical variables
within clusters
pharma %>% group_by(cluster,Median_Recommendation) %>% summarise(RecomC=n())

## `summarise()` has grouped output by 'cluster'. You can override using the
## `.groups` argument.

## # A tibble: 12 × 3
## # Groups:   cluster [5]
##    cluster Median_Recommendation RecomC
##      <int> <chr>                  <int>
##  1       1 Hold                       1
##  2       1 Moderate Buy               1
##  3       2 Moderate Buy               2
##  4       2 Moderate Sell              2
##  5       3 Hold                       4
##  6       3 Moderate Buy               1
##  7       3 Moderate Sell              2
##  8       3 Strong Buy                 1
##  9       4 Hold                       2
## 10       4 Moderate Buy               1
## 11       5 Hold                       2
## 12       5 Moderate Buy               2

pharma %>% group_by(cluster,Location) %>% summarise(LocationC=n())

## `summarise()` has grouped output by 'cluster'. You can override using the
## `.groups` argument.

## # A tibble: 12 × 3
## # Groups:   cluster [5]
##    cluster Location    LocationC
##      <int> <chr>           <int>
##  1       1 CANADA              1
##  2       1 US                  1
##  3       2 FRANCE              1
##  4       2 IRELAND             1
##  5       2 US                  2
```

```
## 6       3 SWITZERLAND        1
## 7       3 UK                 2
## 8       3 US                 5
## 9       4 GERMANY            1
## 10      4 US                 2
## 11      5 UK                 1
## 12      5 US                 3
```

```
pharma %>% group_by(cluster,Exchange) %>% summarise(ExchangeC=n())
```

```
## `summarise()` has grouped output by 'cluster'. You can override using the
## `.groups` argument.
```

```
## # A tibble: 7 × 3
## # Groups:   cluster [5]
##   cluster Exchange ExchangeC
##     <int> <chr>        <int>
## 1       1 NYSE             2
## 2       2 NYSE             4
## 3       3 NYSE             8
## 4       4 AMEX             1
## 5       4 NASDAQ           1
## 6       4 NYSE             1
## 7       5 NYSE             4
```

```
#Cluster 1- Canada, US based and mostly NYSE
#Cluster 2- moderate buy-sell and mostly NYSE
#Cluster 3- Mix recommendation type, mostly US, NYSE
#Cluster 4- Mix of exchange type
#Cluster 5- Mostly US based and NYSE

#From my perspective I didn't find any specific pattern among those variables
and clusters. But I have some general observation that most companies are Us-
based and exchange type is NYSE across the clusters. Most recommendation
variations are in Cluster 3 and most exchange variations are in Cluster 4
```

Task 4:

```
#Naming the clusters corresponding the results of the variables representing
growth, profit and risk, found in task-2

#Cluster 1- mediocre stable companies [moderate growth, moderate risk and
revenue]
#Cluster 2- fast growing emerging companies [companies with high risk and
high growth with decent profit]
#Cluster 3- profitable companies [low risk and low growth but highly
profitable]
#Cluster 4- risky companies [low growth and low profit with high risk]
#Cluster 5- market dominating established companies [large growth and high
profit with minimum risk]
```