Clustering

PART 1

1. LOAD THE DATA

```
hospital_data=read.csv("hospitalUSA.csv",header = T)
head(hospital_data)

##    ZIP    HID                  CITY STATE BEDS RBEDS   OUTV   ADM   SIR
SALES
## 1  919  44604  San Juan               PR    386     0      0 12975  4106
4
## 2  935   5004  San Juan               PR    311     0 118065 11309 21049
NA
## 3 1060 157014  Northampton            MA    175     0 114912  7365  5862
1
## 4 1104 194014  Springfield            MA    324     0  95702 10406 13648
57
## 5 1199 195514  Springfield            MA    507     0 108258 22361 15081
7
## 6 1420  93014  Fitchburg              MA    175    25  26428  5619  5701
17
##   HIP KNEE TH TRAUMA REHAB HIP2 KNEE2 FEMUR
## 1  90  101  0      0     0  101   137   100
## 2  70   26  1      0     0   66    40   330
## 3  93   60  0      0     0   97    64    58
## 4 122   94  0      0     0  152    95   116
## 5 148   97  1      1     0  166   110   236
## 6  61   48  1      1     1   57    44    40

# Load the required packages
library(tidyverse)  # data manipulation

## -- Attaching packages ---------------------------------------------------
--------------- tidyverse 1.3.0 --

## v ggplot2 3.2.1     v purrr   0.3.3
## v tibble  2.1.3     v dplyr   0.8.3
## v tidyr   1.0.0     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.5.0

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

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

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

# Sample 3000 hospitals at random
dim(hospital_data)

## [1] 4703   18

hospital_data = sample_n(hospital_data,3000)
dim(hospital_data)

## [1] 3000   18

# Exclude the dependent variable and categorical variables
hospital_data <- hospital_data[,-c(1,3,4)]
colnames(hospital_data)

##  [1] "HID"    "BEDS"   "RBEDS"  "OUTV"   "ADM"    "SIR"    "SALES"  "HIP"
##  [9] "KNEE"   "TH"     "TRAUMA" "REHAB"  "HIP2"   "KNEE2"  "FEMUR"

# Convert the Hospital ID (HID) to the index
rownames(hospital_data) <- hospital_data$HID
hospital_data=hospital_data[,-1] #then drop the HID
head(hospital_data)

##         BEDS RBEDS   OUTV   ADM   SIR SALES HIP KNEE TH TRAUMA REHAB HIP2
KNEE2
## 12042   425     0 260111 16236 12695    NA 132   84  1      0     0  140
125
## 348593   79     0  10950  1768  2867    23  15    0  0      0     0   11
0
## 62073    74     0   3242  1045   739     1   2    9  0      0     0    6
4
## 135063  836    35 147309 28504 21635    62 344  377  0      1     1  412
376
## 214044  449     0 128960 17205 10331   280 138   94  1      1     0  121
103
## 103536  116     0      0  5415  4426    NA  25    2  0      0     0   29
6
##         FEMUR
## 12042    143
## 348593    29
## 62073      7
## 135063   282
## 214044    92
## 103536    46
```

2. TRANSFORMATION

```
# Transform the data through scalling
hospital_data<-scale(hospital_data)
head(hospital_data)

##              BEDS      RBEDS       OUTV        ADM         SIR      SALES
## 12042   1.3609389 -0.3449574  2.1772375  1.4235912  1.54410966         NA
## 348593 -0.6543810 -0.3449574 -0.3802857 -0.7432698 -0.40410043 -0.4350562
## 62073  -0.6835041 -0.3449574 -0.4594048 -0.8515529 -0.82593509 -0.5396399
## 135063  3.7548594  1.4407125  1.0193768  3.2609599  3.31629101 -0.2496577
## 214044  1.5007299 -0.3449574  0.8310327  1.5687176  1.07549258  0.7866720
## 103536 -0.4388699 -0.3449574 -0.4926824 -0.1970614 -0.09505896         NA
##               HIP       KNEE         TH     TRAUMA      REHAB       HIP2
## 12042   1.1856469  0.6577627  1.6370974 -0.3796271 -0.4731972  1.2526164
## 348593 -0.5252363 -0.6417967 -0.6106336 -0.3796271 -0.4731972 -0.5892076
## 62073  -0.7153344 -0.5025582 -0.6106336 -0.3796271 -0.4731972 -0.6605961
## 135063  4.2857088  5.1907499 -0.6106336  2.6332861  2.1125796  5.1361524
## 214044  1.2733845  0.8124722  1.6370974  2.6332861 -0.4731972  0.9813400
## 103536 -0.3790069 -0.6108548 -0.6106336 -0.3796271 -0.4731972 -0.3322089
##             KNEE2       FEMUR
## 12042   1.3204987  1.85310275
## 348593 -0.6640279 -0.40382511
## 62073  -0.6005230 -0.83937259
## 135063  5.3054280  4.60497092
## 214044  0.9712220  0.84342450
## 103536 -0.5687706 -0.06726569
```

3. DIMENSION REDUCTION

Use the factor method to summarize the demographic variables and the operation variables and come out with a final reduced list of factor variables (perhaps 3 or 4). Use the rotated factors in order to find a good interpretation of the factors and try to make a good story

Factor Analysis

Factor analysis can only be used to reduce continuous variables of the dataset. Therefore, we will be removing categorical variables

- Removing the dependent and categorical variables As mentioned above, factor analysis works in an unsupervised setup only for the numerical variables, therefore, we will get rid of the categorical and the dependent variable.

```
df=hospital_data[,-6] #remove SALES variable
colnames(df)

##  [1] "BEDS"   "RBEDS"  "OUTV"   "ADM"    "SIR"    "HIP"    "KNEE"   "TH"
##  [9] "TRAUMA" "REHAB"  "HIP2"   "KNEE2"  "FEMUR"
```

```
# Create a matrix out of the data frame
Factor1 = subset(df)
class(Factor1)

## [1] "matrix"

head(Factor1)

##              BEDS      RBEDS       OUTV        ADM         SIR        HIP
## 12042   1.3609389 -0.3449574  2.1772375  1.4235912  1.54410966  1.1856469
## 348593 -0.6543810 -0.3449574 -0.3802857 -0.7432698 -0.40410043 -0.5252363
## 62073  -0.6835041 -0.3449574 -0.4594048 -0.8515529 -0.82593509 -0.7153344
## 135063  3.7548594  1.4407125  1.0193768  3.2609599  3.31629101  4.2857088
## 214044  1.5007299 -0.3449574  0.8310327  1.5687176  1.07549258  1.2733845
## 103536 -0.4388699 -0.3449574 -0.4926824 -0.1970614 -0.09505896 -0.3790069
##              KNEE         TH     TRAUMA      REHAB       HIP2      KNEE2
## 12042   0.6577627  1.6370974 -0.3796271 -0.4731972  1.2526164  1.3204987
## 348593 -0.6417967 -0.6106336 -0.3796271 -0.4731972 -0.5892076 -0.6640279
## 62073  -0.5025582 -0.6106336 -0.3796271 -0.4731972 -0.6605961 -0.6005230
## 135063  5.1907499 -0.6106336  2.6332861  2.1125796  5.1361524  5.3054280
## 214044  0.8124722  1.6370974  2.6332861 -0.4731972  0.9813400  0.9712220
## 103536 -0.6108548 -0.6106336 -0.3796271 -0.4731972 -0.3322089 -0.5687706
##              FEMUR
## 12042   1.85310275
## 348593 -0.40382511
## 62073  -0.83937259
## 135063  4.60497092
## 214044  0.84342450
## 103536 -0.06726569

# Creating Correlation Matrix for the above dataset
# This will give us an idea of the variables that are highly correlated to
each other.
corrm<- cor(Factor1)
corrm

##             BEDS        RBEDS         OUTV        ADM         SIR
HIP
## BEDS   1.0000000  0.110960695  0.438887403 0.89659485  0.79190237
0.583960917
## RBEDS  0.1109607  1.000000000 -0.003721587 0.01243735 -0.02645928
0.001525624
## OUTV   0.4388874 -0.003721587  1.000000000 0.44803187  0.35396418
0.194154639
## ADM    0.8965949  0.012437349  0.448031869 1.00000000  0.87239542
0.647694010
## SIR    0.7919024 -0.026459276  0.353964179 0.87239542  1.00000000
0.673471966
## HIP    0.5839609  0.001525624  0.194154639 0.64769401  0.67347197
1.000000000
## KNEE   0.5131743  0.008733660  0.163715661 0.57051326  0.62797498
```

```
0.907787724
## TH     0.5557170  0.104143102  0.293094236 0.53069767  0.46070663
0.319229049
## TRAUMA 0.4279584  0.026459080  0.256693820 0.48442316  0.41098091
0.286319409
## REHAB  0.1926882  0.728993001  0.051088831 0.13275304  0.11097776
0.119205040
## HIP2   0.5920893  0.001924356  0.192402678 0.65727536  0.68210579
0.970150315
## KNEE2  0.5304357  0.005790647  0.155049667 0.58742270  0.64698709
0.886574245
## FEMUR  0.7134768 -0.028525534  0.241497649 0.80345839  0.77425902
0.756739357
##              KNEE        TH     TRAUMA      REHAB        HIP2       KNEE2
## BEDS   0.51317431 0.5557170 0.42795842 0.19268822 0.592089303 0.530435698
## RBEDS  0.00873366 0.1041431 0.02645908 0.72899300 0.001924356 0.005790647
## OUTV   0.16371566 0.2930942 0.25669382 0.05108883 0.192402678 0.155049667
## ADM    0.57051326 0.5306977 0.48442316 0.13275304 0.657275358 0.587422701
## SIR    0.62797498 0.4607066 0.41098091 0.11097776 0.682105792 0.646987091
## HIP    0.90778772 0.3192290 0.28631941 0.11920504 0.970150315 0.886574245
## KNEE   1.00000000 0.2871889 0.25459050 0.11893655 0.888538845 0.953507956
## TH     0.28718888 1.0000000 0.30780963 0.17026500 0.325823909 0.289652532
## TRAUMA 0.25459050 0.3078096 1.00000000 0.11904554 0.279976887 0.245851623
## REHAB  0.11893655 0.1702650 0.11904554 1.00000000 0.120224223 0.117981226
## HIP2   0.88853884 0.3258239 0.27997689 0.12022422 1.000000000 0.904953197
## KNEE2  0.95350796 0.2896525 0.24585162 0.11798123 0.904953197 1.000000000
## FEMUR  0.65747046 0.3817256 0.43441924 0.12197505 0.779706444 0.700431591
##              FEMUR
## BEDS    0.71347676
## RBEDS  -0.02852553
## OUTV    0.24149765
## ADM     0.80345839
## SIR     0.77425902
## HIP     0.75673936
## KNEE    0.65747046
## TH      0.38172561
## TRAUMA  0.43441924
## REHAB   0.12197505
## HIP2    0.77970644
## KNEE2   0.70043159
## FEMUR   1.00000000
```

Finding Eigen Values

We will now find the eigenvalues to decide the number of factors that will correctly group the features on the level of their similarity allowing us to manually select features from each of these groups.

```
eigen(corrm)$values
```

```
##  [1] 6.73073342 1.78358851 1.53454609 0.75250428 0.68048942 0.55840732
##  [7] 0.27357727 0.23273020 0.17684169 0.13288798 0.07350926 0.05269135
## [13] 0.01749321
```

Coming up with other useful values such as cumulative eigenvalue, percentage variance and cumulative percentage variance.

```
eigen_values <- mutate(data.frame(eigen(corrm)$values),
                       cum_sum_eigen=cumsum(eigen.corrm..values),
                       pct_var=eigen.corrm..values/sum(eigen.corrm..values),
                       cum_pct_var=cum_sum_eigen/sum(eigen.corrm..values))
eigen_values
```

```
##    eigen.corrm..values cum_sum_eigen     pct_var cum_pct_var
## 1           6.73073342      6.730733 0.517748725   0.5177487
## 2           1.78358851      8.514322 0.137199116   0.6549478
## 3           1.53454609     10.048868 0.118042007   0.7729898
## 4           0.75250428     10.801372 0.057884945   0.8308748
## 5           0.68048942     11.481862 0.052345340   0.8832201
## 6           0.55840732     12.040269 0.042954409   0.9261745
## 7           0.27357727     12.313846 0.021044405   0.9472189
## 8           0.23273020     12.546577 0.017902323   0.9651213
## 9           0.17684169     12.723418 0.013603207   0.9787245
## 10          0.13288798     12.856306 0.010222152   0.9889466
## 11          0.07350926     12.929815 0.005654559   0.9946012
## 12          0.05269135     12.982507 0.004053181   0.9986544
## 13          0.01749321     13.000000 0.001345632   1.0000000
```

Clearly, the four factors explain approximately 78% of the variance. Therefore, the number of factors will be equal to 4 in our case.

```
# Reducing Variable using Factor Analysis
# Using FA to perform factor analysis.
require(psych)
```

```
## Loading required package: psych
```

```
##
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

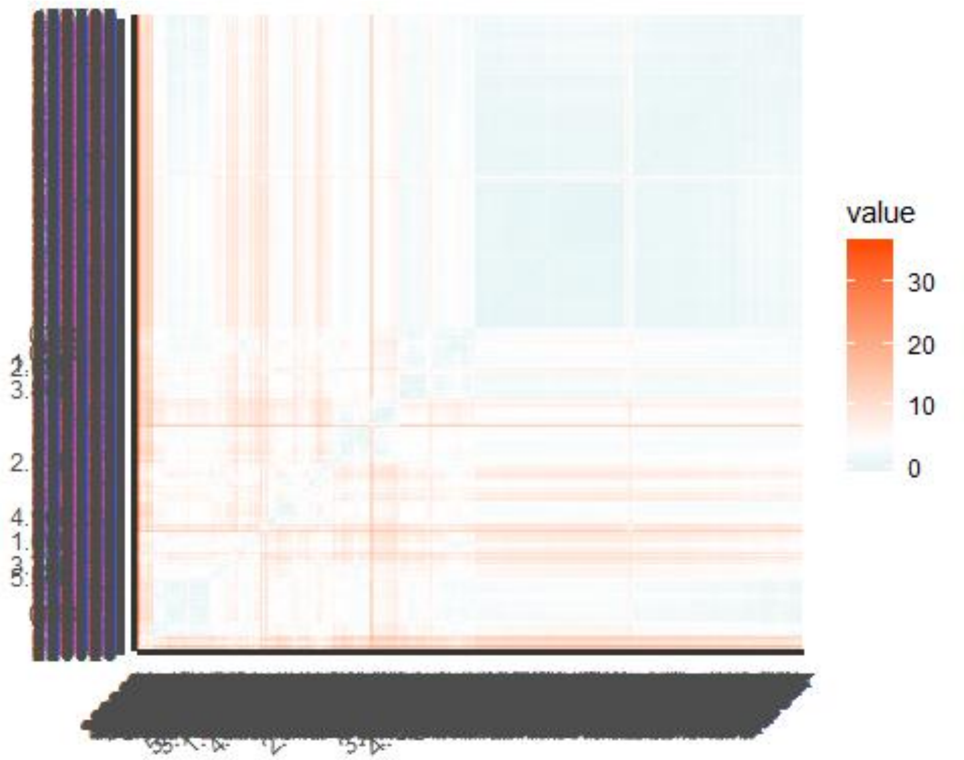
```
FA<-fa(r=corrm, 4, rotate="varimax", fm="ml")
FA_SORT<-fa.sort(FA)

# Grouping variables.
load1 = FA_SORT$loadings
load1
```

```
##
## Loadings:
##        ML1    ML3    ML2    ML4   
## KNEE    0.938  0.253        -0.222
## KNEE2   0.916  0.275        -0.102
## HIP2    0.911  0.333         0.232
## HIP     0.909  0.328         0.137
## ADM     0.374  0.912              
## BEDS    0.326  0.844  0.119       
## SIR     0.467  0.764              
## FEMUR   0.577  0.632         0.191
## TH      0.163  0.518  0.109       
## TRAUMA  0.138  0.475              
## OUTV           0.473              
## RBEDS                 0.991       
## REHAB          0.104  0.738       
##
##                  ML1   ML3   ML2   ML4
## SS loadings    4.226 3.614 1.558 0.174
## Proportion Var 0.325 0.278 0.120 0.013
## Cumulative Var 0.325 0.603 0.723 0.736
```

MARKET SEGMENTATION

- (i). K-means clustering

```r
# visualize the distance matrix
distance <- get_dist(df)
fviz_dist(distance, gradient = list(low = "#00AFBB", mid = "white", high =
"#FC4E07"))
```

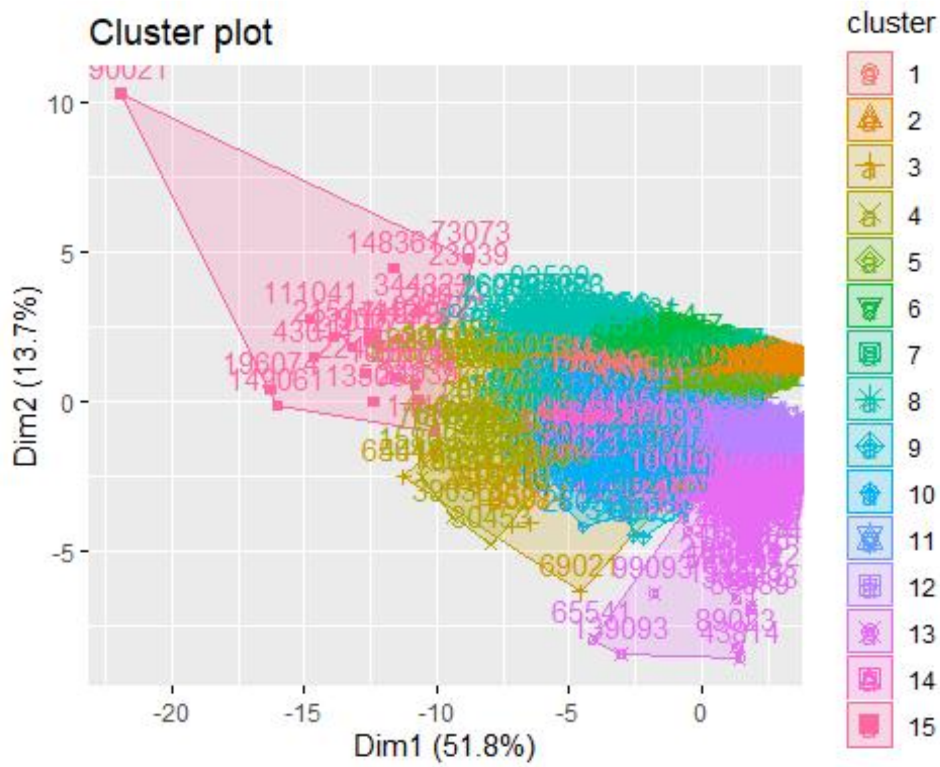



```
# Here will group the data into fifteen clusters
k2 <- kmeans(df, centers = 15, nstart = 25)
str(k2)
```

```
## List of 9
##  $ cluster     : Named int [1:3000] 1 2 2 15 10 7 7 2 2 6 ...
##   ..- attr(*, "names")= chr [1:3000] "12042" "348593" "62073" "135063" ...
##  $ centers     : num [1:15, 1:13] 0.99172 -0.70955 2.65321 2.88026 -
0.00334 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:15] "1" "2" "3" "4" ...
##   .. ..$ : chr [1:13] "BEDS" "RBEDS" "OUTV" "ADM" ...
##  $ totss       : num 38987
##  $ withinss    : num [1:15] 512 386 653 969 469 ...
##  $ tot.withinss: num 9747
##  $ betweenss   : num 29240
##  $ size        : int [1:15] 131 995 22 58 221 223 502 102 55 150 ...
##  $ iter        : int 7
##  $ ifault      : int 0
##  - attr(*, "class")= chr "kmeans"
```

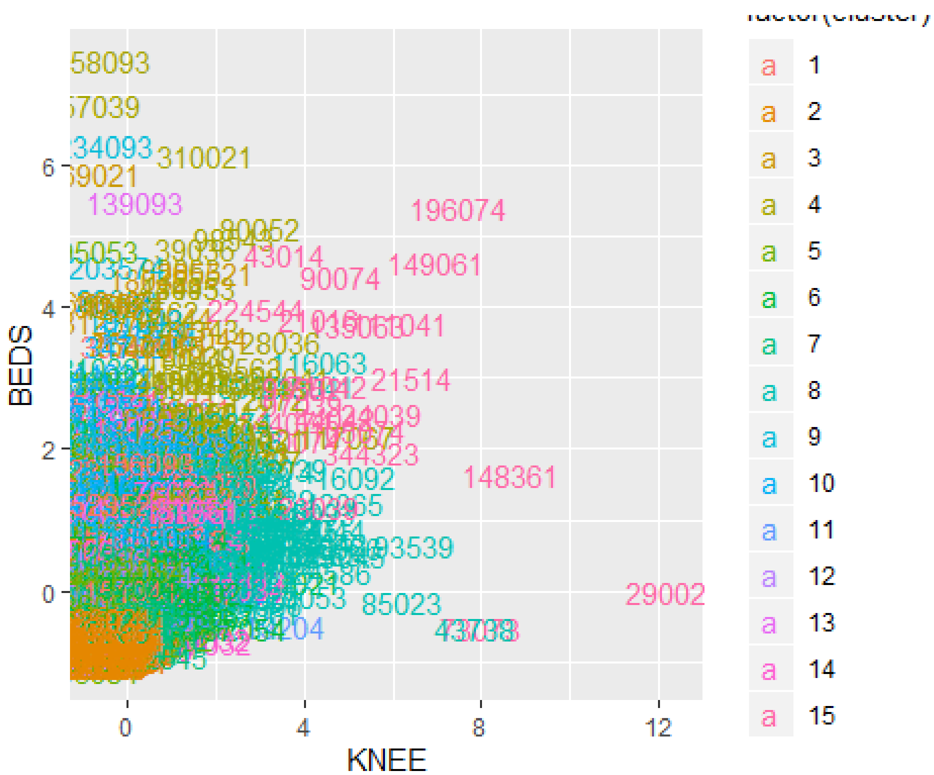
We can also view our results by using fviz_cluster. This provides a nice illustration of the clusters. If there are more than two dimensions (variables) fviz_cluster will perform principal component analysis (PCA) and plot the data points according to the first two principal components that explain the majority of the variance.

```
fviz_cluster(k2, data = df)
```



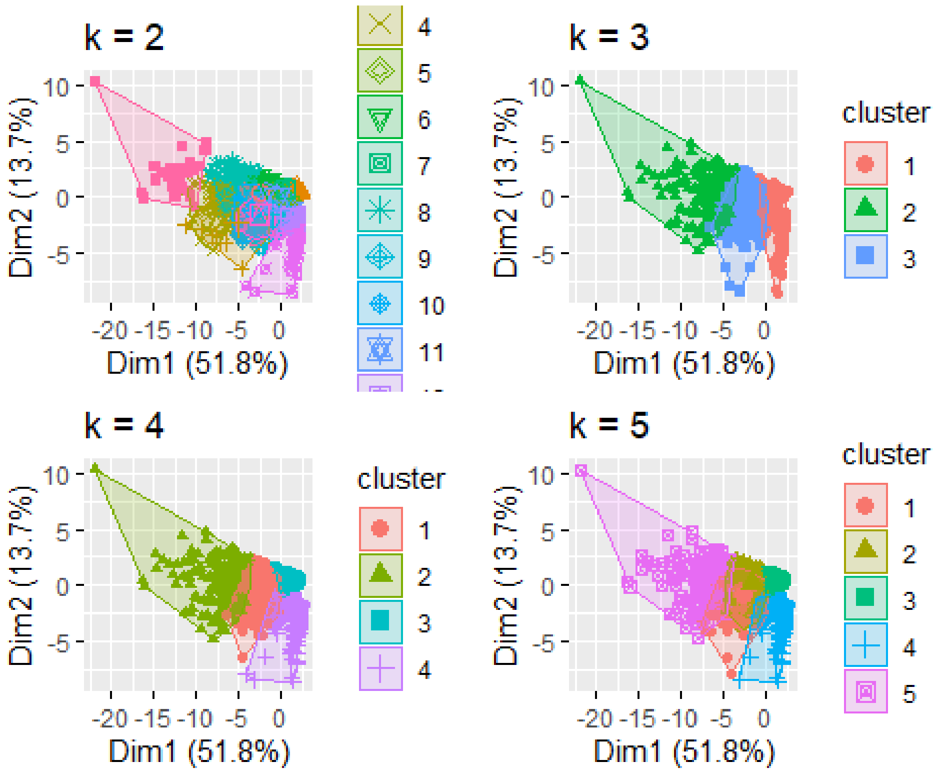
Alternatively, you can use standard pairwise scatter plots to illustrate the clusters compared to the original variables.

```
df %>%
  as_tibble() %>%
  mutate(cluster = k2$cluster,
         hospitals = row.names(df)) %>%
  ggplot(aes(KNEE, BEDS, color = factor(cluster), label = hospitals)) +
  geom_text()
```



Because the number of clusters (k) must be set before we start the algorithm, it is often advantageous to use several different values of k and examine the differences in the results. We can execute the same process for 3, 4, and 5 clusters, and the results are shown in the figure:

```
k3 <- kmeans(df, centers = 3, nstart = 25)
k4 <- kmeans(df, centers = 4, nstart = 25)
k5 <- kmeans(df, centers = 5, nstart = 25)

# plots to compare
p1 <- fviz_cluster(k2, geom = "point", data = df) + ggtitle("k = 2")
p2 <- fviz_cluster(k3, geom = "point",  data = df) + ggtitle("k = 3")
p3 <- fviz_cluster(k4, geom = "point",  data = df) + ggtitle("k = 4")
p4 <- fviz_cluster(k5, geom = "point",  data = df) + ggtitle("k = 5")

library(gridExtra)

##
## Attaching package: 'gridExtra'

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

grid.arrange(p1, p2, p3, p4, nrow = 2)
```



Although this visual assessment tells us where true dilineations occur(or do not occur) between clusters,it does not tell us what the optimal number of clusters is.

Determining Optimal Clusters

As you may recall the analyst specifies the number of clusters to use;preferably the analyst would like to use the optimal number of clusters. To aid the analyst,the following explains the three most popular methods for determining the optimal clusters, which includes:

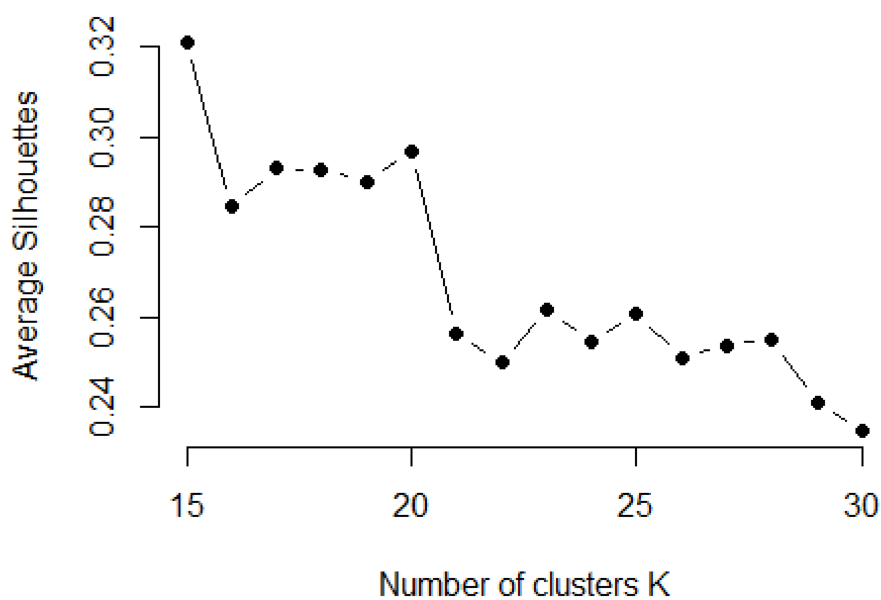
Average Silhouette Method

In short, the average silhouette approach measures the quality of a clustering. That is, it determines how well each object lies within its cluster. A high average silhouette width indicates a good clustering. The average silhouette method computes the average silhouette of observations for different values of k. The optimal number of clusters k is the one that maximizes the average silhouette over a range of possible values for k.2

- We can use the silhouette function in the cluster package to compuate the average silhouette width. The following code computes this approach for 1-15 clusters. The results show that 2 clusters maximize the average silhouette values with 4 clusters coming in as second optimal number of clusters. function to compute average silhouette for k clusters

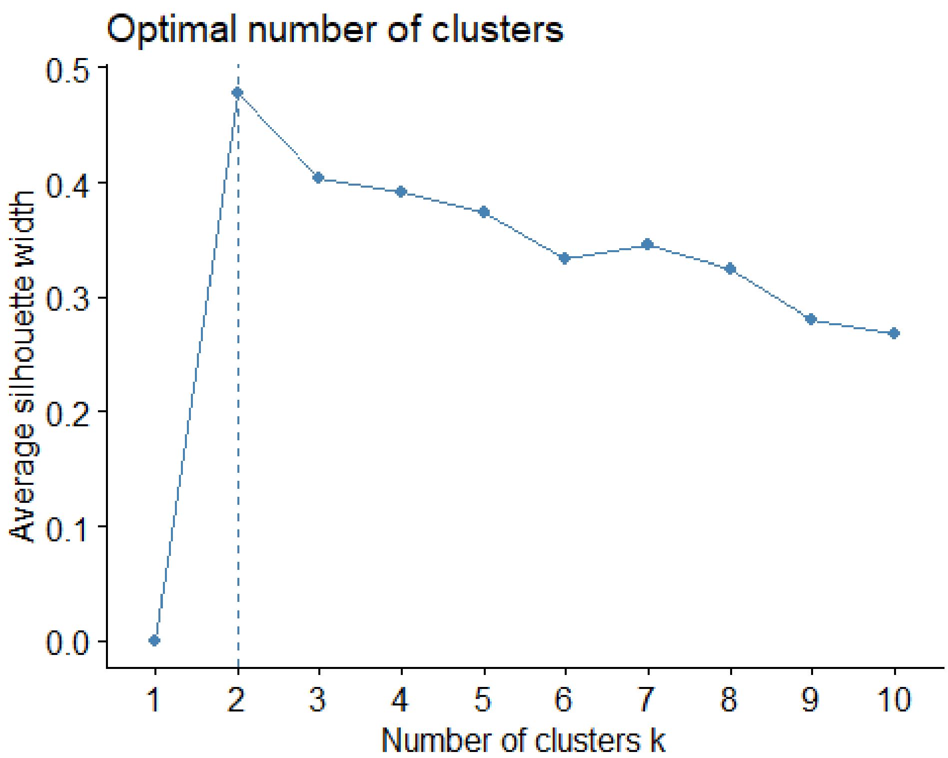
```
avg_sil <- function(k) {
  km.res <- kmeans(df, centers = k, nstart = 25)
  ss <- silhouette(km.res$cluster, dist(df))
  mean(ss[, 3])
```

```
}


# Compute and plot wss for k = 15 to k = 30
k.values <- 15:30

# extract avg silhouette for 2-15 clusters
avg_sil_values <- map_dbl(k.values, avg_sil)

plot(k.values, avg_sil_values,
     type = "b", pch = 19, frame = FALSE,
     xlab = "Number of clusters K",
     ylab = "Average Silhouettes")
```



Similar to the elbow method, this process to compute the “average silhoutte method” has been wrapped up in a single function (fviz_nbclust):

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

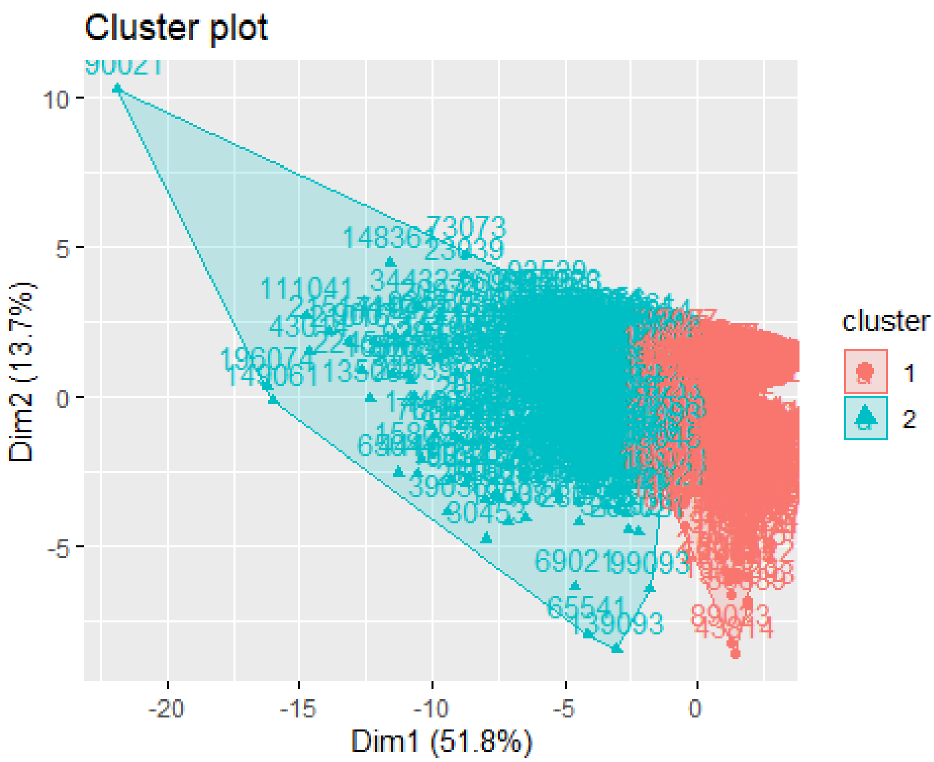



```r
# Now will group the data into two clusters since thats optimal k
k3 <- kmeans(df, centers = 2, nstart = 25)
str(k3)
```

```
## List of 9
##  $ cluster     : Named int [1:3000] 2 1 1 2 2 1 1 1 1 1 ...
##   ..- attr(*, "names")= chr [1:3000] "12042" "348593" "62073" "135063" ...
##  $ centers     : num [1:2, 1:13] -0.3702 1.2947 -0.0383 0.134 -0.1735 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:2] "1" "2"
##   .. ..$ : chr [1:13] "BEDS" "RBEDS" "OUTV" "ADM" ...
##  $ totss       : num 38987
##  $ withinss    : num [1:2] 11347 14218
##  $ tot.withinss: num 25565
##  $ betweenss   : num 13422
##  $ size        : int [1:2] 2333 667
##  $ iter        : int 1
##  $ ifault      : int 0
##  - attr(*, "class")= chr "kmeans"
```

We can also view our results by using fviz_cluster. This provides a nice illustration of the clusters. If there are more than two dimensions (variables) fviz_cluster will perform principal component analysis (PCA) and plot the data points according to the first two principal components that explain the majority of the variance.

```r
fviz_cluster(k3, data = df)
```




```
# Partitioning Around Medoids (PAM)
#execute the pam algorithm with the dataset created for the example
result <- pam(df, 2, FALSE, "euclidean")

#print the results data in the screen
summary(result)

## Medoids:
##          ID       BEDS      RBEDS       OUTV        ADM        SIR
HIP
## 36084 2238  1.1221293 -0.3449574  0.0513485  0.7397450  1.0439739
0.9078112
## 4074   824 -0.6019594 -0.3449574 -0.3018133 -0.4563119 -0.6170001 -
0.4959904
##             KNEE         TH     TRAUMA      REHAB       HIP2      KNEE2
## 36084  0.7351175  1.6370974 -0.3796271 -0.4731972  1.0241731  0.8442123
## 4074  -0.4561454 -0.6106336 -0.3796271 -0.4731972 -0.5035414 -0.4893895
##            FEMUR
## 36084  0.7444364
## 4074  -0.5424084
## Clustering vector:
##    12042  348593   62073  135063  214044  103536  147023    3561
##        1       2       2       1       1       2       2       2
##    33254  117014  135021  139963   64462   23066  284593   46034
##        2       1       2       2       2       2       2       2
##    17551  231874  733339  196045  373593  178243  161074  245544
##        2       2       2       2       2       2       2       2
```

```
##   906973    94563    11588   311023     9012   405721     9639   313043
##        2        2        2        2        2        2        2        2
##     6088    49539    69021   253043    43532    55538   135514    76553
##        2        1        1        2        2        1        2        2
##     2016   265023    11067     7388    50493    23041    79039    47532
##        1        2        2        1        2        2        2        2
##   116043    11034   166044   104023    35012    17311   229044     1672
##        2        2        2        1        2        2        1        2
##    98539   144042    77767   211993   291174    45081   388993   533021
##        2        2        2        2        2        2        2        1
##    10539    80073    62072   150074    56671    48139    94039    21093
##        2        1        2        2        2        1        1        2
##   139063   111041    10531    97038    44162   166045    57239    29082
##        2        1        1        2        2        2        1        2
##    84052   116534    60563    14584   113045   174043     5535   112042
##        2        2        2        1        2        2        2        2
##   112074    47062    77567    69074   105022      785    64061    94393
##        2        2        1        2        2        2        2        1
##    55511    11093   167545   478521    95241   266074    96623    51532
##        1        1        2        2        2        2        1        2
##   344093   910023    63039   455021     6083   912074    11044    21016
##        2        2        2        2        2        2        1        1
##    16539   294043    94439   050A73    62061   232523     6091    20523
##        2        2        2        2        2        1        1        1
##   183544    45591    47014    24566    16063    69354   276593   237044
##        2        2        1        2        2        2        2        2
##    45538   207545    68072   131522   192043    76539   256774    61034
##        2        2        1        2        1        2        2        2
##     3534     3093     3065    45073    33044   122062    34535    31062
##        1        2        2        2        2        2        1        2
##   280023   307021   226793   168536   247041   137036   186061    54041
##        2        1        1        1        2        2        2        1
##    49542    24082    10094    41073    67037   208545   104562   200774
##        1        2        2        2        2        1        2        2
##    63239   921563    16022    79051   199044     4554   228043   167014
##        2        2        2        1        2        2        2        2
##    85084    38092     5086   168574   231541    29041    48039   347593
##        1        2        2        2        2        1        2        1
##   514021   805653    88014   258023   230023   222543   274021    40074
##        2        2        2        1        1        2        2        2
##   178074    76043    88572    71054   278393 4.90E+63    46552   176274
##        2        1        2        2        2        2        2        2
##   138793    28351    32266    17566    16286     5583    88993   100063
##        2        2        2        2        2        2        2        1
##   110074   112044   135093    14253    69038   195061   111014   200093
##        1        2        1        2        2        2        2        2
##     6988    11051    95284    85066   725352   809953    86093    87672
##        1        1        2        2        2        2        2        2
##   357174   252093   124022   146041    61571    10586    52538   168636
##        2        1        2        2        1        2        2        2
```

```
##    206174    17064    40544   170041    39581   113521    93021    52153
##         2        1        1        2        2        2        1        2
##     59854    83039    92054   214041    38593   146042   148536   916084
##         2        1        2        2        1        2        2        2
##    912092   380293    28038    65061   139022    62074   107044    20045
##         2        2        1        2        1        2        2        2
##     84061    11544   927074   239093   116063     4034    16704   259574
##         1        1        2        2        1        1        2        2
##    216674    74774   373093   118521    50066    58741    69014   280043
##         2        2        2        2        2        2        1        1
##    104539    21282   228044    44036    31023    68039    51092   311843
##         2        2        1        1        2        1        1        2
##    302838   104061   300674    61092   123021   318021     4043    50839
##         2        2        2        2        2        1        2        2
##    105039    58562   150022    88053     3085    64014    42034    67061
##         2        2        1        2        2        2        2        2
##     22087     4091   123063     2039   218093    57563    53042   291274
##         1        2        1        2        2        2        2        2
##     88672    56032   115043   200974     1038   204014    19093   167061
##         2        2        2        2        1        2        2        1
##     83091    29011   160045   106043    35561    75074   157014   116563
##         2        2        2        1        2        2        2        1
##     87022   101144    38072    11593    48581    38562    26004    93652
##         1        1        2        2        2        2        1        2
##    232393    83393   147021     3031    56061   190041    83539   167043
##         2        2        2        2        2        2        1        1
##    224093   255593   218043   170536   173061   245021   246174    45084
##         1        1        2        2        2        1        2        2
##     11585   526021    26053   183045    48593   203774    96053    41062
##         2        2        1        2        2        2        1        1
##    141562   291093    62042     7593   177521    25038   411021     9011
##         2        2        1        2        2        2        1        2
##     39186    32053    47045    86073     1092   908041   160043   253021
##         2        2        2        1        2        2        2        2
##    198574    40062    13092   917363    41439   117873    84539    76061
##         2        2        2        2        2        2        2        1
##     71538   392593    64093   231093 2.69E+95    28022   230093   155044
##         2        2        2        2        2        1        1        1
##     63535   348093     3545   217023   297023    21071   116274   277093
##         2        2        2        2        1        1        2        1
##     16591    20193    46338    39538    72061   105067   272021   156041
##         2        2        2        2        2        2        1        1
##    200043     8251    57554    58016   397721    32043    10045   404021
##         2        2        2        2        2        2        2        2
##    441021   107021   144014     3587   126014    65541    22571    37486
##         2        1        2        2        1        1        2        2
##    138562   189574    57073    86874    12016    84545    34037   148374
##         2        1        2        2        2        2        2        1
##     88072    80041    38238   216545    32937   382021    78544   337793
##         2        1        2        1        2        2        2        1
```

```
##    48838   139062   247044    16711    22586   243023    11583    74545
##        1        2        2        2        2        1        2        2
##    12065    10073   227023    19041     2037   128014     6016    99374
##        2        2        2        2        2        2        1        1
##    19084   138674    13022   258993   119045   156014   333521   175044
##        1        2        2        2        1        2        1        2
##    66639     8542    40021    24062    34063   340593    39552    20023
##        2        2        1        2        2        1        1        2
##    10061    43539   436021   906088   169043    30039    48037   117042
##        2        2        1        2        1        2        2        2
##    11039    39095    74084    80536    60035    77639    16851    21514
##        1        2        2        2        1        1        2        1
##    55536    14051    89023   278593    10035    53052   340293    67044
##        2        2        2        1        2        1        1        2
##    79023    18051    21474   116552     8594    27073   124752   134774
##        2        2        2        2        2        2        2        2
##   117073    65022    93045    96034   101074   131561    75093     3033
##        2        1        2        1        2        2        2        2
##   116938   201544   202574   125038   161574   100391    37154 1.10E+52
##        2        2        2        2        1        2        2        1
##    34536    89062    56932    94034     9074   131042    24586    94063
##        2        2        1        2        1        2        1        2
##    17023    50372    10016     3044   260393   246544    66852    52134
##        2        2        1        2        2        2        2        2
##    23587   227043    95084    23044     7092     2385   206021    33038
##        2        2        2        2        1        2        1        2
##   192093    10186    47051    71251   100039   132044    75091    75062
##        2        2        1        2        1        2        1        2
##   282023   399021    73073   113044    13042   193074   036G84   101539
##        2        1        1        1        1        1        1        2
##     6072    50552    16551    29762   102753   137043    36032   269574
##        2        1        2        2        2        1        1        2
##    98014   183193   112493   009A74    14533   239074   249021   114545
##        2        2        1        2        2        2        2        1
##    86567   346693   291023   149021    59023    26541     4036    11032
##        2        2        1        2        2        2        2        2
##   139A93    11037     9032    23573   176014    27566    89541    19551
##        2        2        2        2        2        2        2        2
##   148042   248074    45293    87054    94084    61493    15062   378093
##        2        2        2        2        2        2        2        2
##    31022   139522    20067    71551   419521    15654    83084    23163
##        2        1        2        2        2        2        2        2
##    36086    52411   118374   203074   309021    74022     7041   310021
##        2        2        2        2        1        1        1        1
##    40767    52086    39036     4061   242044   926523   985144    35092
##        2        2        1        2        2        2        1        2
##    29081   134023    44571   119552    93239    84543    17062   103491
##        2        2        1        2        2        2        1        2
##   387293   136563   143874   156043   103041   138074   252674   394093
##        2        2        2        2        2        1        2        2
```

```
##    64567    33023    10067   144074    40091   250043   276993   118041 
##        2        2        2        1        2        2        2        1 
##   434021    16045   193044   195074   323593    20583    52093   331093 
##        2        2        2        1        1        2        2        2 
##    73061    27092     1513   136642    45571    18014   114562   175045 
##        2        2        2        1        2        1        2        2 
##    61054    50652   139093   243043    16266   143041   177043   184074 
##        2        2        1        1        2        2        2        2 
##   930839    88043   103039   312074   205874   103044    78053   203293 
##        2        1        1        1        2        1        2        2 
##    22015   102791    26283   113634   176493   200041    31044    12866 
##        2        2        2        2        2        2        2        2 
##    44045   103844    19204    69016    84573    28016    25161    45434 
##        1        1        1        1        2        2        2        2 
##    41035    20154    97036    50034    74093    95022     8012    56551 
##        2        2        2        2        2        1        2        1 
##   108061   011A72     5037     8993   514088   915372   101543     5021 
##        1        2        2        2        2        2        2        1 
##    51081   223074    84035    94541   205061     4571   254F23    87572 
##        2        2        2        1        1        2        1        2 
##   216044   102062    42035   102036   237041    86974    33032    75051 
##        1        2        2        2        2        2        1        2 
##    64739    75084    46066   464021    25016   186021    83042   244093 
##        2        2        1        2        1        2        2        2 
##    45067    92042    52091   210945    79584    90014    84072     1031 
##        2        2        1        2        2        2        2        1 
##    44067    37986    52071    96073    40593    71751   223521   208043 
##        2        2        1        2        2        2        2        2 
##   122014     9084   110023    81552   109962    45051   427021   123041 
##        2        2        2        2        2        2        2        2 
##     8014   107093    42563    89034    74066    83034   247023   200023 
##        2        2        2        2        1        2        2        2 
##   164041    23004    86293    52066    50339   327043     4064    61051 
##        2        2        2        2        2        2        1        1 
##    56638    95593    73593   107562    93136   512452    42091    11539 
##        2        1        1        2        2        2        2        2 
##   133023   276093    37034    48567    17544    29563   110839     9066 
##        1        1        2        2        2        2        2        2 
##    98039    12013   157045     9053   149042    20072   200074    19074 
##        2        2        2        2        2        2        1        1 
##   224041   384593   237274   235543    22043    31045   229093    19039 
##        2        2        1        2        2        1        1        2 
##   256174   239544   207041     8041   935493    41034    44064   109023 
##        2        2        2        2        2        2        2        1 
##    44595   290023   380093    75036    40939    28084   298043    24539 
##        2        2        2        2        1        2        1        2 
##   300543    60591    20082    21516    91039   183F44   203544   134061 
##        2        1        2        1        2        2        1        2 
##    90567   105043   179061   190844    29723   809339   136036     4074 
##        2        2        2        2        1        1        2        2 
```

```
##  166544   16392    4763  110339   30093  253093  808341  250093 
##       2       2       2       1       1       1       2       2 
##   80042  104567   52072   76023  149022  215544   94051   42065 
##       1       2       2       1       2       2       2       1 
##   40751  111021   34504   15083  350093  290521   16062   74593 
##       1       1       2       2       2       2       2       2 
##    9037  180521  119042   67016  143541  103045  298074   78562 
##       1       2       1       2       2       2       1       2 
##   59551   34054  106091  178541   94741   67639   28092  163074 
##       2       2       1       2       2       2       1       2 
##  300243    2072  155521   60039  304074  163144  371593  145063 
##       2       1       1       2       2       2       2       2 
##   23134   16023  155074   48016  143022    8851    1012  102052 
##       2       1       2       1       1       2       2       2 
##    6374   62023   98393   25085   56835   80053   34053   87039 
##       1       2       2       2       1       2       2       1 
##    3523   57552   33063   75016  370093   24038   30453   99474 
##       2       1       1       1       2       2       1       2 
##   20074   99939   44073   76074  123014   11504   88045   29087 
##       1       2       2       1       2       2       2       1 
##   80034   30553  188021  219243  140523   68563  192593  902043 
##       2       2       1       2       2       2       2       2 
##   24286  290021    6085   24051   32222  203093  251044  907054 
##       1       1       1       2       2       2       2       2 
##  530021    2963   24045   88552    6752   24041  141014   75063 
##       2       2       2       2       2       2       2       2 
##   25686   27063    5083   46539  262574  161621   80093  257374 
##       2       2       2       2       2       2       1       2 
##  916554    7054   20539   59035   31653  302093   45539   27552 
##       2       2       2       2       2       1       2       2 
##  192993   15013  374021   37786  116567   81514  102042  170544 
##       1       2       2       1       2       2       2       2 
##   67439  340393  105593  170514  165074   18451   76884   36054 
##       2       2       1       1       2       2       2       2 
##   81072  298023   38084   69045  373521  807439  324023   68034 
##       2       1       1       1       1       2       2       2 
##   32051   85034   93063   21536   10673  163536  174014   55738 
##       2       1       1       2       2       1       2       2 
##   66554   79574  321093   58241   95539  159541    3839  913186 
##       2       2       1       1       2       2       1       2 
##   78732  241043   24341  106552  179561  211041   11042  319543 
##       2       2       2       2       2       1       2       2 
##  502553   49038   75536    5541   59072  172044   33262  158044 
##       2       2       1       2       2       1       2       2 
##  050G42   85042    3539   92262  211893   34032   51034  209061 
##       1       2       2       1       1       2       2       2 
##   50265    4038  166043   44072  201093   28045   17086   68063 
##       2       1       1       2       2       2       1       2 
##   18793  107593  124023    4583    7573   18012   17239   55051 
##       1       2       2       2       1       2       2       1 
```

```
##    84143   920539   107023   329593   232823   521021    67344     3081
##        1        2        2        2        2        1        2        1
##   235043    25514    87021    45563    18039   185774    87351   197543
##        2        1        1        2        2        2        2        2
##   243543    19033    45561    32061   392054   163041    40061     5573
##        2        1        2        2        1        2        1        2
##   179093     4088    96042   960674    39085     7283   180014   234693
##        1        2        2        2        1        2        2        2
##    31087    98052   203021   109552    24011   368393   198074    27014
##        2        2        2        2        2        1        1        1
##   183044    49516   905551   100042   326093   189021    39032   509021
##        2        2        2        2        2        2        2        2
##   118067    52042    83044    76063    51253    28087    22034   144036
##        1        2        2        2        2        2        1        2
##   204543   283021   122038     5033    38011   119041    78034    78523
##        2        1        2        1        2        1        2        2
##   378021     1094   248043    84639    41095    76561    69541   228493
##        2        2        2        1        1        1        1        2
##   109022   113561     8371    34836    44053   312574    32585   132041
##        2        2        2        2        2        1        2        1
##   317043    54543    12044    29037   328074    56071   147036   122252
##        2        1        2        2        2        2        2        2
##   117393   100043    43538    25083    78323    63539    16153   385393
##        1        2        2        2        2        2        1        1
##   358021    62066   110193    80291    61039   174293    78044   358521
##        1        1        2        2        2        2        1        1
##    34072    11072    71016   354093     7011     5072   220093    35004
##        2        1        2        2        2        2        2        2
##   158045    48571    28639   256093   166944    16041   127044    71523
##        1        2        2        2        1        2        2        2
##   100539    22734   116234    10074    16004   400063   267043   306093
##        2        2        1        2        2        2        2        1
##      842   152574   297923   154061     2073    71066    12061   101014
##        2        2        2        1        2        1        2        2
##   351093   296474     9762    72873    53061    18032   498521    38039
##        2        2        2        1        2        1        2        1
##    43865   348893    21822    37322    18021    63084   261093   155036
##        2        2        2        2        2        1        1        2
##   100593    44039   316293   361093    57051    72023    41772    54222
##        2        2        2        2        2        2        2        2
##   184061    26038    18572   128063   147543   224544   950174   193041
##        2        1        2        2        1        1        2        1
##   126022   108044    48091   432021    31554    95074    88539    51022
##        2        2        2        1        1        1        2        2
##    67452   323093   125041    57674    20038    84093   258521    17032
##        2        1        2        2        1        1        2        1
##    77553     6694   188074 3.80E+85   128574    15015     4082     8085
##        2        2        2        2        1        1        1        1
##   100053   286474   161674    30573   102043    77052   152536   149061
##        2        2        2        2        1        1        2        1
```

```
##     16563    53939   145044   388593    78522    67534    59586   218041
##         2        1        2        1        1        2        2        1
##     39039   307074   101066    56022    40065   342074      591    18537
##         1        2        2        1        2        1        2        2
##    232043   124074     2081   903023    45042     1523    89038    44085
##         2        1        1        2        1        2        2        2
##     37551    36554   112839    75038   110041    42553   131574   167844
##         1        1        2        2        1        2        2        2
##    203043   271043    39993    21741   121534    65041   174021   117034
##         2        2        2        2        2        2        2        2
##     11562   300074   160636    23034    62772   439021   269023    92593
##         1        1        1        2        2        2        1        2
##     78284    28585   133043   125593   114044   392321    34023   268093
##         2        1        2        2        1        1        2        1
##     18571   130042     6264   371021      336    29072   278493    17592
##         2        1        2        2        2        2        2        2
##     37993   137536    81066   548845    89073     7287    24585    95093
##         2        2        1        2        2        2        2        2
##    113038    92041    70872    23051   170593   267021    48023   474021
##         2        1        2        2        2        2        2        1
##    286674    45039    27022   516521    83573    80052    78663   306074
##         2        2        1        2        2        1        2        1
##     18036     3754   225574     8063    17053    19522    83473   114039
##         2        2        2        2        2        2        1        1
##    016A39   112023    32052   121841    55535    27043    82362    70043
##         2        1        2        2        1        1        2        2
##    337093    17092    77038   197723   529021    96474   127593   370021
##         1        2        2        2        2        2        2        2
##     21452    90238    77672   295043    77092    64038   217045   111939
##         2        2        1        1        2        2        2        1
##     10093     6784     7188    60093   375593    39022   103091   121561
##         2        2        1        2        1        2        1        2
##     15663    19052   915063   337193    61538    22004   126044   174493
##         2        2        2        2        2        2        1        2
##    203023   204043   515521    17571    21061   241293    94045   103043
##         1        2        2        2        2        2        2        2
##     85139   160561    66052    80062   160044   115036     7088     9052
##         2        1        2        2        1        1        2        2
##    163014    55091   369021    44511    76562   363074    26022    84939
##         1        2        1        2        1        2        2        1
##     63044    71072   135014    38061    24034   129036   187274    92134
##         1        2        2        2        2        2        2        1
##     56016   347023    86042    17041    58052    15585   365093    19081
##         1        1        2        2        2        2        2        2
##    400086    36044   186093     1271     9023    11839    90052   107534
##         2        2        2        2        2        2        2        2
##     59016    33565     7587    42051    27064   105093    39037    43365
##         2        1        2        1        2        1        2        2
##     50032    52553   151143    63114    20374   185841   158323     9115
##         2        2        2        2        2        2        2        1
```

```
##     51545    278574     37537    113014     35572    912084    353021    137574
##         2         2         1         1         1         2         2         2
##      7023      7093    216435    129045     39092     37062    108245     77063
##         2         2         2         1         2         1         1         2
##     77023     85023     64752    121043     51539     72016    135693     40545
##         2         1         2         1         2         2         2         2
##    310023     81393     77538      5562     32044     77253     26023    117341
##         1         2         1         1         2         2         1         2
##    137045     73032     78267     58036     51071     44673    334093      5585
##         2         2         2         1         2         2         2         1
##      8038    118036     72066    161044     78863      8137    150044    906041
##         1         2         1         1         2         2         1         2
##      4251     30639     17012    122022     25065    119022     10042    163841
##         2         2         1         1         2         1         2         2
##     90738     52061     45171     64536     24036     43081    101023    601263
##         2         2         2         1         2         1         2         2
##    117522    272574     92036    114861     31987     57572    184093    441441
##         2         2         2         2         1         2         2         1
##     59537     22082    272043     15764    429021     95041     82572    252874
##         2         2         2         1         1         1         1         2
##     85045     60593      3504     99534    111062     88041     49538    907063
##         2         2         2         1         2         1         2         2
##    368093    241021     23591    187193    251023    139514    111591      1082
##         2         2         2         2         1         2         2         2
##    387021     27004    902591     52223     97039     98543    107043     93551
##         2         2         2         2         1         1         1         2
##    313074     19062    100293    371374     29472    344323     18515    140062
##         1         2         2         2         2         1         1         2
##     82022     93539    210521     15272    507021     74021     39012    213574
##         1         1         1         2         2         2         2         2
##    120041     48071    104052    189841      1037    190014     99022      3591
##         1         2         1         2         2         1         2         2
##    196093     76593      2094      7031    202041      6439     23015     16961
##         2         2         1         2         2         1         1         2
##     10064     84039     41061     45041    262593     81035    167045    364593
##         2         2         1         1         2         2         2         2
##     19539     10032     32334    252044    137041     12532    305093    155022
##         1         1         2         1         2         1         1         2
##     77036    118042     14041    221023     13054    219021    146593    129074
##         1         2         2         2         2         2         2         1
##    120523    263023    100091    216074    148074      7582     27085    214844
##         2         1         2         2         2         2         2         2
##      7845    163022    365993     91042     48535    374493     45035    285023
##         2         1         2         2         2         2         2         2
##    314023     17392    193023    292023    452021     77072     50061     14042
##         2         2         1         2         2         2         2         2
##    157043    181574    260021      5087     43738     40023     61535     25054
##         2         2         1         2         1         1         2         2
##     43204     34532     25084     52139     31534     68045    286093     14023
##         2         2         2         2         2         1         2         2
```

```
##  295093   28054  158061   20041   10536   16016   84534   29522
##       2       2       2       1       1       1       1       1
##   53038   11472   19092   15674  206043   87772  908081  297334
##       2       2       2       2       2       1       2       2
##  128593  100093  405021   36022   83567  163021   21562   83534
##       2       2       2       1       2       2       2       1
##   26086  120023   84563  343793    4033   17021   58563   23764
##       2       2       2       2       2       2       2       1
##  301023   68021   51086   94021   37886   54722   14534  142136
##       1       1       1       2       1       2       1       2
##  113039   76022   30021  351593  115023  227044  319143  190023
##       1       2       2       2       2       1       1       1
##  372193  106041   29244   49062   81143   50016   19332  107052
##       2       1       2       2       2       2       2       1
##   35985  256023  901023  277074   65045   64584    6523   87552
##       2       1       2       1       2       2       2       2
##  212293    1021  189043   26085   25839   82036   74552  239541
##       2       1       1       2       2       2       2       2
##   43034   85542   44021   47067    4771  299093  176893   88034
##       1       2       1       1       2       1       2       2
##  132036   25787  126042   44504   60043  113974   93084  100763
##       2       2       2       2       1       2       2       2
##   54086   61016    8552   36095   35016   22332  232774  134042
##       2       2       2       1       2       2       1       2
##  335093  368593    5042   95061  414021   70539   21074   29091
##       2       2       2       1       2       2       2       1
##   16011   17004   44074   28083   53084   39034   87872   33564
##       2       2       2       2       1       2       2       2
##   25522   61045  109045   47053   14566  288093  367021   10087
##       2       2       1       2       2       1       1       2
##   13563   16553   47636    1087    7788   44071   65039   90344
##       1       1       1       2       2       1       2       2
##   59052   13072    4086   97923   82534  150014  118063  216543
##       2       2       2       1       2       2       2       2
##  189044   31263    8062  175893    5032  366074  182014  211074
##       1       2       2       2       1       1       1       2
##  325543   55036  184744  264023  266574    3037   59084  343023
##       2       2       1       2       2       1       2       1
##   71035   78532   38711  370852  106052   37023   47036   36093
##       1       1       2       2       1       1       2       2
##  171023   70553  179593  388793   45045   43023  129563    6388
##       1       1       2       2       1       2       2       2
##  198593  285074  908563   59838  109039  102574  203961   55593
##       2       2       2       2       2       1       2       2
##  161421  120014  209574   36066   18035   77014  287023   51053
##       1       2       2       1       2       2       1       1
##    5095   15085   87041   24292   57544  262043   85014  351993
##       2       2       1       2       2       1       2       2
##   87451   50091   67051  129044  108063   88023   54037  230293
##       2       1       1       2       2       2       2       2
```

```
##   157941    2011  151093   78074  109544  116045  185045   20543
##        2       2       2       2       2       1       2       2
##    22522  174793  118073  108345   74072  215041   58211   77552
##        1       2       1       2       2       1       2       2
##    54038  102738  154044   78067  218074  196074  907044  102542
##        2       1       1       2       2       1       2       2
##    33521   86063  120074   78093   18086   56039   54011    2044
##        2       1       2       2       2       2       2       2
##    71438   22843  286574   17083   18081  305043  154043  173974
##        2       2       2       2       2       2       2       2
##    62051   85523  136062  114522  161043   35053  313574    2032
##        2       2       1       2       1       1       2       1
##    34014    1004   76516   44014  228014  433021   17045   58037
##        2       2       2       1       1       1       2       1
##   278043  133014  258021  354423   76034  162023  117067    1088
##        1       2       2       2       2       2       1       2
##   076A39   67638   25438  121538  202543   98874   38572  106093
##        2       2       1       2       1       2       2       2
##    10033   10552   29704  329174  222041   55521   53073   46514
##        1       1       1       2       2       1       2       1
##   211793  130062   27035  183043    7071   76039   23083   92023
##        2       1       2       2       2       2       2       1
##    91063   75042  163593   46023  182543  906511  129073   28032
##        2       2       2       2       2       2       2       1
##    53534  207523   23542    4013   53066   42072   10504  912573
##        2       2       2       2       2       2       2       1
##    45091  104041  798743   56043  301021   46042    7053  261543
##        1       1       2       1       1       2       1       1
##    51686  214574   99439    3035  126061   37837    2063  121023
##        1       2       1       2       2       2       2       2
##    37051  340023    9552   55343   92043   81093  164044  362174
##        2       1       2       1       2       1       2       2
##     4093  121138   64738   51572   80344    1043   15742   50042
##        2       2       2       2       2       1       2       1
##    63172   19022   30086   73542  106063  230493   64042  117574
##        1       1       2       1       1       2       2       2
##    39522   72739   52038   15087  350023   35052  100167   66762
##        2       2       2       2       1       2       2       2
##     9293   67561   64893  169545   24061   45034  105874  225043
##        2       2       2       2       2       2       2       1
##   129041  234043   13039  329093  135044   45537   24737   49036
##        1       2       1       2       2       2       2       2
##    24172  203044   61561   59574   21037    3939   46438   78551
##        2       2       2       2       1       2       2       2
##   355023   63071   29004   11674   22066  188044  111036   33353
##        1       2       1       2       2       1       1       2
##   488521  209043  208074 5.50E+24  130721   28067    5091   58032
##        1       2       2       1       2       2       2       1
##   389093   44493   91053   44022   20454   28063   57038   64032
##        2       1       2       2       2       1       1       2
```

```
##    23067   223541   141063     9473    27595    12592     5016   248944
##        2        2        2        2        2        2        2        2
##    75034   489021   120062    35034     1084    73084    26033   179544
##        1        1        2        2        2        2        1        2
##   185543    32293    35551   234541    62736   006F61    81561   918323
##        2        2        2        2        2        2        1        2
##    93043    80035   124774   339021    73034    57839   953074   517021
##        1        2        2        1        2        1        2        2
##    33743    53039    92084   172374    38095    49052     6504    60037
##        2        1        2        2        1        2        1        1
##   136042     7567   143021    21722    51967   337293     7095    88534
##        2        2        2        2        2        2        2        2
##    21571    80054    47554    26839    73042    67093   273093   205545
##        2        2        2        2        2        2        1        2
##    19023   248543     4044   158541    39793    65038    26545   274593
##        2        1        2        2        2        2        2        1
##    37353    33591    50023    17044   111022   320023    90554   229041
##        1        2        2        2        2        2        2        1
##    24587   118241    29066   223093    87593    55081    89039   148161
##        1        1        1        2        2        2        2        2
##   376574   118021     1582   231041    35035    85054    29562    11031
##        2        2        2        2        2        2        2        2
##   927574    32093   191043   163093      536     7072    90067   167044
##        2        2        1        1        2        2        1        2
##    92051   125114   118093    12033   115334    41081     3034   332023
##        2        2        2        1        1        2        2        1
## 2.91E+95    59063   141042   131093   239021   326723    63574   418021
##        2        2        1        2        2        2        2        2
##    28011   239044   121034    24437   110239    39141    82766    11041
##        2        2        2        2        2        1        2        2
##   130043    41052    22012    44604    51072    46574    99236    73036
##        2        1        2        1        1        2        2        2
##   173041    64538   117893   138541    18563    59753   254023    94584
##        2        2        1        2        2        2        1        2
##    62045   234241   232593 3.70E+94   105563   104244   400039   182043
##        2        2        1        1        2        1        2        2
##   115042     9739    74061    82023     1053    51051   231044   277874
##        2        2        2        2        2        1        2        2
##   303043   181021    79773   124044     5594   243593    65262    11574
##        2        1        2        2        2        2        2        2
##    39521    54045   116023   905523    59092    28041    63566   171043
##        2        1        1        2        1        1        2        2
##   132541    23572   310574    58042    54571   121052    73693    74051
##        2        2        1        2        2        2        2        2
##    78014   246344   279021   113091    11543   170043    67339    26561
##        1        1        2        1        2        2        2        2
##    57738    81272    24763   158741    13063    51032    56066   162045
##        2        2        2        1        2        2        2        2
##     7012    42539    67021    67052   712937     2573    81551    80791
##        2        2        2        2        2        2        1        1
```

```
##   440721     6065    84839    30012    13581   142043   130014    50553
##        2        2        2        2        2        2        2        2
##    92022   138522     8044   394593    53016    36084    85044   150036
##        1        2        2        2        1        1        1        2
##    81593   905086   242043    37067   270043    94536   130063    82067
##        2        2        2        2        1        2        2        2
##   277593    21538     4051    14066    79563    36043   196021    52011
##        2        2        1        2        2        2        1        2
##    26239    13512   117022   189014    93052   217021   100014   250021
##        2        2        1        2        2        2        2        2
##    46072    54022    12337   333074    72753   104044   475021   116393
##        1        1        2        2        2        1        2        2
##   121067   281023   222541    93062   119591   230545    12563    61043
##        2        2        2        2        1        2        2        2
##   151023   118062    59274    40595    40571   282593    24872    17511
##        1        2        2        1        2        1        2        2
##   192893   324074    88067    23021    24374    43011   242523    26139
##        1        2        1        2        2        1        2        2
##   109842    18038   130093     5014   292174     1531    62052    19871
##        2        1        2        2        2        2        2        2
##    90538   911541    33045   239574    80544   136263   323074    95038
##        2        2        1        2        1        2        2        1
##   392393   300023    21545   135222    86038    40551    43042    46063
##        2        1        2        1        2        2        2        1
##   203574   149045   178193   122452     6013    41053    28538    10974
##        1        2        2        2        2        2        1        2
##    78554    13038    63636    15086   379074    63553   140036   214274
##        2        1        2        2        1        2        2        2
##   107022    80541   148022   929023   137023     2023   924041   285043
##        2        1        1        2        2        1        2        2
##   228021   510021   915053   184041    30339    48672    73493    34041
##        2        2        2        2        2        2        2        2
##    40051   213014   910273   087F61    24886    81572    48032   101723
##        2        2        2        1        2        2        1        2
##    62541   229241    56863    68022     3153     6045     4083   367093
##        1        2        1        1        2        1        1        2
##    33563     7039    38582   123522    23039    88793    26037    66237
##        1        1        2        1        1        1        1        2
##    12072    41753   515021    74566   107591   174393     8867    44061
##        1        2        1        2        2        2        2        2
##    29084   137863   163023   253574    37586 1.00E+24    15573   496021
##        1        2        2        1        2        1        2        2
##   347021    43814    40193   140541    66037   137523   293643    19087
##        1        2        2        2        2        1        1        2
##   106862   241343     6274    72462     4084   400139   279093   137021
##        2        1        2        2        2        1        2        2
##   168093    25004    41054   996073   188043   904552    81332   285523
##        1        1        1        2        2        2        1        2
##   997293   189023    48552    76053     7016   358074    40035    46086
##        2        1        2        1        1        2        1        1
```

```
##   231341   372021   922574    47562    81042     6652    28023   387493
##        2        1        2        2        1        2        2        2
##    24392    24016    46032   188093    22783    37032   312274    55039
##        2        1        2        2        2        2        1        2
##   110063    25722   852193   112014    89372   191093   207074   125014
##        1        2        1        2        2        2        2        2
##   318093   316043     5038    56639    32036    85073    44011   184045
##        2        2        1        2        1        1        1        2
##    71041    44023    32591    95053    18045    10066    88091   172023
##        1        2        2        1        2        2        1        2
##   197021    19065   150045    68035   029A04    54092   365074    83073
##        2        2        2        2        2        1        1        1
##    43037   395021     4011     6739    80523   135023   220593    65542
##        2        2        2        2        2        2        1        2
##    95051    31972    19042   180043   385193    46652    41261    34064
##        2        2        2        2        2        1        2        1
##   108538     2074   189074     8693    17073    73174    35543    23722
##        2        1        1        2        2        2        2        2
##   235093    17138   011A71    64037    61592   428021   111152   380074
##        1        1        2        2        2        1        2        2
##    28071   101722   140736   204541    83451   134036   191143    68532
##        2        1        2        1        2        2        2        2
##   143061    83062    33144    44538   178393    21252   931539    11266
##        2        2        2        2        2        2        2        2
##    81052    74392     4954     7588    19563    25081    34038   318974
##        1        2        2        1        2        1        1        2
##    51563   257523    15993     4951   147045   202044   906538     1039
##        1        1        2        2        2        2        2        2
##    10071    29054    13594   545021     3582    14038    82016   146323
##        2        2        2        2        2        2        2        2
##   113574    16504     4588   245344   101062     3038   914563    64537
##        2        2        2        2        2        2        2        2
##    17039    52036    65074    25052   902534   127023    89472    87043
##        2        2        2        2        2        2        2        1
##    81023    97021    39693   172041    64235   154041    50286   220014
##        2        2        2        2        2        1        2        2
##    25034    28036   139074    81053    73038    49639    24372   146014
##        2        1        1        2        1        1        2        1
##   198041   202774   253174   456841   487021   125536    47737     8539
##        2        2        2        2        1        2        2        2
##    26651   015A63    24044    89491   178793    86791   152545   006G61
##        2        2        2        1        2        2        2        1
##   171045   127062     5581   122552   197023   380493    13021    75535
##        2        1        2        2        1        1        2        2
##    31014    65044   116022    93552      142    56084    41872     4045
##        1        1        1        1        2        1        1        2
##   198021    51586   176393   161774    38082    81363    81038    23063
##        1        2        2        2        1        2        2        2
##   931074   349574   177021    47032    53539     6574    30073   163423
##        2        2        2        1        2        1        2        1
```

```
##    49022   803038    55034   928541    65072    34052   315174   310043
##        2        2        1        2        1        2        2        1
##   355093    82793    86572   528021   158023   105074   117534    20792
##        2        2        2        2        1        1        2        2
##    82035    30091     6104    38538    24192    56593   110039   112739
##        1        2        2        2        2        2        1        2
##    26081    28085    88036   102061    81863    91023   136523    18072
##        2        2        2        1        2        1        2        2
##    12093   341139    20654    23293    22053    22021    46504     5082
##        1        2        2        2        2        2        2        1
##   133045    94523   219844    40095     2588    43014   346023   955074
##        2        2        1        2        2        1        1        2
##   160023    22583    41023   309023    66662     2912    19263   237774
##        2        2        2        1        2        2        2        2
##   132043    28021    59037   282093     4563    91052    89634    25452
##        1        1        2        1        2        2        1        2
##   213041    56051     4041    15539    36081   245041   128045    16231
##        1        1        2        2        2        1        2        2
##   202593    99093    74551   136536   379974    12041    46036    86051
##        2        1        2        2        2        2        2        2
##     6552   143042   152822    24039   101043   341574    61032    26044
##        1        2        2        1        1        1        1        2
##   114023   106039   910554    60051    32571    48034    54572    54032
##        1        2        2        2        2        2        2        1
##    28044    25045    39081   909045   339093   113061   119044    89539
##        2        2        2        2        1        2        2        2
##   129093    46386    25386    29545   233044   124091     9004    26087
##        1        2        1        2        2        1        2        1
##     9593    92034    57474   139193    70054    56092   129521    10062
##        2        1        2        2        1        2        2        2
##    58067   189874    78073    40066   192045   213743   388093    33034
##        2        2        2        1        2        2        2        2
##   121038   160014    66023    22051    14187     3067    17553   132074
##        2        2        1        2        2        2        1        1
##    75254   302738   852293    90051   158093    14484   108534    34016
##        2        2        2        2        1        2        2        1
##   114067   236043   104042   197523    82535   163044   117274   271974
##        2        1        1        2        2        1        2        2
##    96539   158593    89063    49562   177014   215074    33095    43543
##        2        2        2        1        2        2        1        2
##    79239    25874    38241   188023   108067    40016    21594   211561
##        1        1        2        1        2        1        2        2
##   336334    60754   901671   201874   110639     3474    16092   492321
##        2        2        2        1        1        2        1        2
##   116539   317023    17667   139536   914539    67032     8067   401021
##        1        2        2        2        2        2        2        2
##    35565   172045   118536    58054   317093    63014    19571   133545
##        2        2        1        2        2        1        1        2
##    16766   131063     4534   151543   191023    81252   269093   312374
##        2        2        2        2        1        1        1        2
```

```
##    21012    38073   139041   917541   186014    46081     5004    29012
##        2        1        2        2        2        2        1        2
##   240274   111839   138044   303574    33067    21092    12593   978072
##        2        2        2        1        2        2        2        2
##    61551    73022     2504     6351   277023    21191    90074    39061
##        1        1        2        2        2        2        1        2
##    45038    88022     1962    51052   348523    16554    45016    19763
##        2        2        2        1        2        2        2        2
##    77539   181074   202045   911193    30939   115052   102552   116134
##        2        2        1        2        2        2        1        2
##    51054    19061    38536    61037   332093   203393   148361    47652
##        2        2        2        1        1        2        1        2
##    46067   546021    93693   283074   117593    29053    29095    40038
##        2        2        2        2        2        1        2        2
##   105042    44095    46752   178544    92493    10739   471021    48939
##        1        2        2        1        2        2        1        1
##     9022   240044    15023    44539   298543    80063   187023    41016
##        2        2        2        2        2        2        1        1
##    78042   127562    90514    24393    78563    91551    34093   186023
##        2        1        1        1        1        2        1        2
##   910061    58043    21552    44042    32086   114093    71042   144093
##        2        1        2        1        2        1        1        2
##   236044    33593    14034    78023   529521     4592   180041    67539
##        2        2        2        1        1        1        2        2
##   168014    31036   112539   299074   904562     1011     3004    43085
##        2        2        2        2        2        1        2        2
##   191593   180141    91584    13023   356593   189041   227093    67034
##        2        2        2        1        2        2        2        2
##   945593    19095   211061   225041   191041    22593    12034     5011
##        2        2        2        2        2        2        1        1
##   283093   145074    41972    29452   234093    55052   118045   137641
##        2        2        2        2        1        1        1        2
##    28042   333793    64574    89536    57039   177061   153014   118091
##        2        2        2        2        1        2        1        2
##    35472    49771   211593    81051   910063     5034    19091   192793
##        2        2        1        1        2        2        2        2
##   196974    31074    41165   307438   223021   273043   380021    61292
##        2        2        2        2        2        2        2        2
##    45072   265521   129136   213021   246244    18367    33084    73074
##        2        1        2        2        2        2        1        2
##   151041    86053     4071   109352   156093   136021     6086     5053
##        1        2        2        2        1        2        2        2
##   386593   227593   158561    22539    97045    24972    37004    23974
##        2        2        1        1        1        2        2        2
## Objective function:
##    build     swap 
## 2.376369 2.354030 
## 
## Numerical information per cluster:
##      size max_diss  av_diss diameter separation
```

```
## [1,]  861 30.39395 4.076859 35.85149   0.372815
## [2,] 2139 11.94174 1.660549 15.09580   0.372815
##
## Isolated clusters:
##  L-clusters: character(0)
##  L*-clusters: character(0)
##
## Silhouette plot information:
##         cluster neighbor    sil_width
## 114044        1        2  0.3236163418
## 489021        1        2  0.3232157307
## 429021        1        2  0.3212124210
## 355023        1        2  0.3190291250
## 28041         1        2  0.3179181620
## 295043        1        2  0.3167842608
## 298043        1        2  0.3154395351
## 54092         1        2  0.3138191066
## 73038         1        2  0.3137301115
## 54543         1        2  0.3137119073
## 55052         1        2  0.3119554188
## 104042        1        2  0.3109832178
## 15015         1        2  0.3108201225
## 103039        1        2  0.3107716201
## 43011         1        2  0.3107664187
## 104052        1        2  0.3100070765
## 5585          1        2  0.3100014058
## 433021        1        2  0.3099809099
## 111021        1        2  0.3095624933
## 51086         1        2  0.3081552977
## 263023        1        2  0.3076455502
## 116045        1        2  0.3074024234
## 68022         1        2  0.3070365204
## 190023        1        2  0.3066121286
## 13039         1        2  0.3062280782
## 18038         1        2  0.3061115153
## 84143         1        2  0.3058621480
## 78044         1        2  0.3054030639
## 40544         1        2  0.3049011136
## 80544         1        2  0.3044300960
## 262043        1        2  0.3032397224
## 41016         1        2  0.3026994240
## 25016         1        2  0.3024787076
## 241343        1        2  0.3020687455
## 487021        1        2  0.3004599316
## 116563        1        2  0.3003715682
## 235093        1        2  0.3001038857
## 28036         1        2  0.3000320305
## 92134         1        2  0.2998101796
## 195074        1        2  0.2977685936
## 112023        1        2  0.2970735941
```

```
## 38095          1        2  0.2969139836
## 245021         1        2  0.2968318090
## 76023          1        2  0.2966424265
## 230093         1        2  0.2961741343
## 81561          1        2  0.2951030220
## 278593         1        2  0.2948705456
## 118041         1        2  0.2945303581
## 106052         1        2  0.2936672635
## 273093         1        2  0.2927232837
## 26087          1        2  0.2924818563
## 117067         1        2  0.2922376218
## 119041         1        2  0.2920733788
## 118536         1        2  0.2916135754
## 218041         1        2  0.2913975304
## 166043         1        2  0.2911074950
## 51053          1        2  0.2899243089
## 91023          1        2  0.2897064126
## 93063          1        2  0.2893898658
## 26023          1        2  0.2886353148
## 110039         1        2  0.2865545075
## 104041         1        2  0.2864231022
## 154044         1        2  0.2860530382
## 6552           1        2  0.2834409714
## 12072          1        2  0.2828088364
## 71066          1        2  0.2820544002
## 39039          1        2  0.2819168879
## 113044         1        2  0.2815930195
## 14584          1        2  0.2812287917
## 10016          1        2  0.2810752884
## 92022          1        2  0.2810581205
## 278043         1        2  0.2808580255
## 144074         1        2  0.2786788132
## 53039          1        2  0.2785913544
## 80052          1        2  0.2781550001
## 121043         1        2  0.2774633932
## 72066          1        2  0.2762829716
## 342074         1        2  0.2762792728
## 93552          1        2  0.2755856772
## 339093         1        2  0.2754134830
## 81252          1        2  0.2738039400
## 51052          1        2  0.2734897392
## 297023         1        2  0.2733756531
## 68045          1        2  0.2730341299
## 102574         1        2  0.2727507223
## 117393         1        2  0.2722471555
## 72873          1        2  0.2718083050
## 123522         1        2  0.2711653536
## 41872          1        2  0.2708736107
## 224093         1        2  0.2708252998
## 95061          1        2  0.2695686040
```

```
## 6988          1        2  0.2691268518
## 10531         1        2  0.2689470616
## 64536         1        2  0.2687944317
## 5011          1        2  0.2686988287
## 103844        1        2  0.2682750349
## 44042         1        2  0.2682692300
## 71042         1        2  0.2682376279
## 2016          1        2  0.2676788413
## 84061         1        2  0.2664314049
## 4082          1        2  0.2663571961
## 163423        1        2  0.2654736180
## 129093        1        2  0.2645347167
## 158561        1        2  0.2642393018
## 98543         1        2  0.2636130701
## 41061         1        2  0.2634218434
## 312274        1        2  0.2633076473
## 155044        1        2  0.2627533344
## 116063        1        2  0.2622045914
## 92041         1        2  0.2619724214
## 44036         1        2  0.2611585102
## 1021          1        2  0.2610288269
## 81093         1        2  0.2603166702
## 189023        1        2  0.2593517042
## 160044        1        2  0.2593491974
## 130042        1        2  0.2593366661
##  087F61       1        2  0.2593014914
## 44493         1        2  0.2580219088
## 90074         1        2  0.2577601943
## 61037         1        2  0.2576401074
## 3.70E+94      1        2  0.2572317348
## 1.00E+24      1        2  0.2569985307
## 45045         1        2  0.2569274685
## 206021        1        2  0.2560395879
## 251023        1        2  0.2552133281
## 39036         1        2  0.2551869814
## 96053         1        2  0.2550069099
## 2023          1        2  0.2543256426
## 21016         1        2  0.2542778592
## 20074         1        2  0.2540758378
## 224544        1        2  0.2534597214
## 39552         1        2  0.2524426014
## 76074         1        2  0.2523559961
## 310021        1        2  0.2517969668
## 200074        1        2  0.2514872418
## 26037         1        2  0.2513501006
## 38084         1        2  0.2509338045
## 36022         1        2  0.2507255921
## 82572         1        2  0.2491286736
## 160636        1        2  0.2490693112
## 12042         1        2  0.2481062052
```

```
## 60591             1         2  0.2479363254
## 156093            1         2  0.2473529458
## 248543            1         2  0.2470110799
## 78023             1         2  0.2466311066
## 74022             1         2  0.2459240559
## 169043            1         2  0.2457720386
## 102061            1         2  0.2455192503
## 5082              1         2  0.2451987101
## 208545            1         2  0.2450659174
## 123063            1         2  0.2448014892
## 135063            1         2  0.2434125117
## 97045             1         2  0.2429057201
## 81332             1         2  0.2424000985
## 127062            1         2  0.2422834089
## 24039             1         2  0.2418487548
## 77538             1         2  0.2416992440
## 30453             1         2  0.2415043550
## 214044            1         2  0.2407394433
## 3037              1         2  0.2407183454
## 346023            1         2  0.2388225187
## 102738            1         2  0.2385884846
## 344323            1         2  0.2385069717
## 319143            1         2  0.2373519706
## 37551             1         2  0.2370216787
## 182014            1         2  0.2368230594
## 97039             1         2  0.2364856392
## 120041            1         2  0.2357098830
## 365074            1         2  0.2354710834
## 29087             1         2  0.2353141293
## 12033             1         2  0.2348834254
## 16092             1         2  0.2333385697
## 168536            1         2  0.2325169785
## 105074            1         2  0.2321696897
## 61551             1         2  0.2313888694
## 192043            1         2  0.2312229689
## 46652             1         2  0.2302650345
## 23764             1         2  0.2298796307
## 40066             1         2  0.2291388144
## 83039             1         2  0.2291061053
## 21514             1         2  0.2289298735
## 42065             1         2  0.2282500819
## 226793            1         2  0.2275980186
## 84534             1         2  0.2268783449
## 269093            1         2  0.2267209163
## 111041            1         2  0.2265306554
## 75016             1         2  0.2262514905
## 17012             1         2  0.2260547892
## 139522            1         2  0.2256352083
## 268093            1         2  0.2255033569
## 43014             1         2  0.2254859244
```

```
## 809339         1        2  0.2243463888
## 56084          1        2  0.2240205821
## 228044         1        2  0.2239288905
## 9074           1        2  0.2238688013
## 85044          1        2  0.2235478338
## 106091         1        2  0.2235245723
## 3839           1        2  0.2232027017
## 29041          1        2  0.2231306017
## 21071          1        2  0.2227609164
## 54041          1        2  0.2212467232
## 211593         1        2  0.2212366260
## 17086          1        2  0.2209233328
## 161574         1        2  0.2205159443
## 48838          1        2  0.2204162437
## 63084          1        2  0.2200229579
## 115036         1        2  0.2184849023
## 88793          1        2  0.2172958376
## 111939         1        2  0.2170410150
## 474021         1        2  0.2151303882
## 17062          1        2  0.2146777719
## 83539          1        2  0.2143886854
## 40061          1        2  0.2134135565
## 347021         1        2  0.2125239328
## 57038          1        2  0.2123526581
## 189074         1        2  0.2119754708
## 70553          1        2  0.2102388321
## 118067         1        2  0.2101400689
## 37886          1        2  0.2094346557
## 488521         1        2  0.2083916028
## 6091           1        2  0.2080979469
## 40016          1        2  0.2064919437
## 57552          1        2  0.2046421197
## 154061         1        2  0.2024431889
## 126044         1        2  0.2023897855
## 25874          1        2  0.2006685721
## 178544         1        2  0.2006566566
## 11044          1        2  0.2001041872
## 40751          1        2  0.1999658967
## 149061         1        2  0.1986107324
## 83534          1        2  0.1980610662
## 20038          1        2  0.1973317638
## 33032          1        2  0.1972645743
## 57839          1        2  0.1972438799
## 52091          1        2  0.1967201832
## 196074         1        2  0.1959259335
## 3081           1        2  0.1957089945
## 28032          1        2  0.1949296831
## 34016          1        2  0.1939442861
## 102043         1        2  0.1936393060
## 167043         1        2  0.1930539118
```

```
## 19074              1         2  0.1929679775
## 65022              1         2  0.1929671084
## 108061             1         2  0.1925678109
## 265521             1         2  0.1923493148
## 43034              1         2  0.1921396831
## 88043              1         2  0.1918179740
## 56022              1         2  0.1914255019
## 4064               1         2  0.1894760369
## 106063             1         2  0.1891339996
## 22539              1         2  0.1885930535
## 22087              1         2  0.1885231476
## 38039              1         2  0.1885180875
## 58032              1         2  0.1882251183
## 288093             1         2  0.1880803988
## 105093             1         2  0.1876588115
## 104044             1         2  0.1870745877
## 53084              1         2  0.1864840693
## 53939              1         2  0.1859250764
## 96623              1         2  0.1854866161
## 63172              1         2  0.1854037033
## 12532              1         2  0.1851318548
## 24286              1         2  0.1800353696
## 161044             1         2  0.1792269788
## 95074              1         2  0.1790575368
## 94541              1         2  0.1781857081
## 23039              1         2  0.1774094097
## 150044             1         2  0.1761047867
## 48139              1         2  0.1756858491
## 95022              1         2  0.1753109727
## 114039             1         2  0.1751200776
## 333521             1         2  0.1746420895
## 17138              1         2  0.1731705310
## 73022              1         2  0.1729033113
## 13038              1         2  0.1727437193
## 385393             1         2  0.1720017991
## 88091              1         2  0.1714447564
## 16153              1         2  0.1712763111
## 153014             1         2  0.1705693102
## 167061             1         2  0.1702748634
## 71041              1         2  0.1701984100
## 56835              1         2  0.1695053410
## 332023             1         2  0.1674887848
## 129045             1         2  0.1668457986
## 24586              1         2  0.1663122851
## 146014             1         2  0.1661186355
## 148361             1         2  0.1656306066
## 13563              1         2  0.1656271564
## 136062             1         2  0.1652024778
## 127562             1         2  0.1648310619
## 56551              1         2  0.1646455067
```

```
## 16023           1        2  0.1637578284
## 69014           1        2  0.1632724308
## 110063          1        2  0.1628274167
## 6016            1        2  0.1627357041
## 32036           1        2  0.1610766114
## 373521          1        2  0.1606308199
## 40023           1        2  0.1597458364
## 44071           1        2  0.1586454398
## 78532           1        2  0.1584855944
## 17553           1        2  0.1580156477
## 192893          1        2  0.1578598419
## 44021           1        2  0.1564135917
## 28022           1        2  0.1561991639
## 6439            1        2  0.1551427721
## 87041           1        2  0.1539990883
## 230023          1        2  0.1532811513
## 51051           1        2  0.1526055779
## 60043           1        2  0.1512847052
## 97923           1        2  0.1511624682
## 256023          1        2  0.1504840065
## 257523          1        2  0.1504372997
## 80041           1        2  0.1503293189
## 158093          1        2  0.1500134045
## 92023           1        2  0.1498137972
## 8038            1        2  0.1489382473
## 515021          1        2  0.1484128383
## 93539           1        2  0.1476816055
## 57039           1        2  0.1475181779
## 114545          1        2  0.1470885667
## 436021          1        2  0.1470382076
## 172044          1        2  0.1469719167
## 85023           1        2  0.1464779098
## 7041            1        2  0.1453142859
## 53016           1        2  0.1453106732
## 76562           1        2  0.1445740245
## 220593          1        2  0.1444656591
## 95593           1        2  0.1441290294
## 9037            1        2  0.1434426999
## 128574          1        2  0.1428695480
## 67051           1        2  0.1419978539
## 10536           1        2  0.1418617847
## 122022          1        2  0.1411196951
## 37353           1        2  0.1409233318
## 49562           1        2  0.1408446444
## 210521          1        2  0.1402810608
## 107021          1        2  0.1399822450
## 216545          1        2  0.1398882923
## 26053           1        2  0.1387335585
## 55521           1        2  0.1368590733
## 43738           1        2  0.1356125263
```

```
## 110339          1        2  0.1348890145
## 51686           1        2  0.1344988095
## 282093          1        2  0.1336106754
## 7188            1        2  0.1332493498
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## 36084           1        2  0.1290443447
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## 46514           1        2  0.1280833153
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## 93693            2        1  0.7167800043
## 284593           2        1  0.7167631592
## 9011             2        1  0.7167585415
## 21545            2        1  0.7167095734
## 85066            2        1  0.7166893798
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## 218074           2        1  0.7162951322
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## 125041           2        1  0.7162689550
## 131093           2        1  0.7162320713
## 19092            2        1  0.7162220527
## 73493            2        1  0.7162202129
## 392593           2        1  0.7162191069
```

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## 71054           2        1  0.7159110114
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## 43365          2        1  0.7136552437
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```

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## 41439          2        1  0.7084020084
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```

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```

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## 209061          2         1  0.6855855689
## 6739            2         1  0.6855525153
## 66052           2         1  0.6854376144
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## 160023          2         1  0.6831484800
## 4571            2         1  0.6830793821
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## 90051           2         1  0.6830153008
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## 78554            2         1  0.6817206737
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## 4554             2         1  0.6750866096
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## 123014           2         1  0.6746164246
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## 928541           2         1  0.6743797304
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## 85054             2         1  0.6716823397
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## 103536            2         1  0.6702624562
## 30573             2         1  0.6702369601
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## 192593            2         1  0.6618467185
## 89038             2         1  0.6617181409
## 100043            2         1  0.6613306107
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## 190844          2        1  0.6593491762
## 118521          2        1  0.6592907086
## 17023           2        1  0.6589702897
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## 38582           2        1  0.6585535258
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```

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## 4036            2        1  0.6125010840
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```

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## 24437          2        1  0.6102876802
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## 91042          2        1  0.6088107784
## 318974         2        1  0.6087106901
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## 12563          2        1  0.6082276001
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## 14042          2        1  0.6062955568
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```

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## 842             2        1  0.5893509740
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## 23067           2        1  0.5885508860
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## 19023           2        1  0.5728035493
## 400039          2        1  0.5716074733
## 239074          2        1  0.5710956146
## 75051           2        1  0.5710204261
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## 110839          2        1  0.5704590806
```

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## 5014               2        1  0.5639371222
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## 81552              2        1  0.5482081155
## 78042              2        1  0.5481908421
## 114562             2        1  0.5481316421
## 87593              2        1  0.5478983385
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## 93084              2        1  0.5474654321
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```

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## 118062          2        1  0.5441927879
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## 115023          2        1  0.5347965054
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## 152545          2        1  0.5346290893
## 64037           2        1  0.5344515078
## 82535           2        1  0.5340729477
## 81272           2        1  0.5340307309
## 130721          2        1  0.5339916323
## 163041          2        1  0.5335193225
## 43204           2        1  0.5333840924
## 367093          2        1  0.5329326322
## 84543           2        1  0.5327603830
## 24585           2        1  0.5327043800
## 103041          2        1  0.5326325992
## 37993           2        1  0.5323383605
## 356593          2        1  0.5318208890
## 41035           2        1  0.5317323824
## 104539          2        1  0.5312694907
## 152822          2        1  0.5311895025
## 23134           2        1  0.5309531062
## 121038          2        1  0.5307019144
## 78523           2        1  0.5304093688
## 59753           2        1  0.5303623184
## 331093          2        1  0.5299880411
## 35985           2        1  0.5296504246
## 33521           2        1  0.5295796166
## 62072           2        1  0.5294420897
## 87552           2        1  0.5289135028
## 68563           2        1  0.5286755875
## 116274          2        1  0.5283128230
## 262574          2        1  0.5282972132
## 54086           2        1  0.5281975174
## 186023          2        1  0.5281545100
## 100763          2        1  0.5280523725
## 89073           2        1  0.5280521932
## 300543          2        1  0.5279490555
## 8137            2        1  0.5278791247
## 28023           2        1  0.5277608767
## 5016            2        1  0.5274888498
## 67037           2        1  0.5268774830
## 10673           2        1  0.5268360820
## 140541          2        1  0.5267086020
## 63239           2        1  0.5263720976
## 7788            2        1  0.5263617596
## 237774          2        1  0.5261302871
## 163593          2        1  0.5258627607
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## 136263          2        1  0.5250366193
## 81593           2        1  0.5247615080
## 13022           2        1  0.5247136621
```

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## 258021          2        1  0.5245370758
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## 94021           2        1  0.5237367598
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## 33144           2        1  0.5204769099
## 16022           2        1  0.5202448565
## 201093          2        1  0.5200648148
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## 53038           2        1  0.5191391770
## 50652           2        1  0.5189692534
## 99939           2        1  0.5188214930
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## 48593           2        1  0.5167704840
## 911193          2        1  0.5153480929
## 215544          2        1  0.5151196081
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## 8063            2        1  0.5144949502
## 88023           2        1  0.5144281210
## 54722           2        1  0.5143220191
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## 204014          2        1  0.5137586677
## 25686           2        1  0.5136599344
## 101023          2        1  0.5133317180
## 39522           2        1  0.5131389155
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## 55091           2        1  0.5110205136
## 124774          2        1  0.5107836711
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## 98052           2        1  0.5098899464
```

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## 117873          2        1  0.5089792201
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## 139041          2        1  0.5085348444
## 351993          2        1  0.5083621935
## 246174          2        1  0.5078373364
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## 337193          2        1  0.5054005083
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## 74774           2        1  0.4993467996
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## 35035           2        1  0.4992627562
## 192093          2        1  0.4992555093
## 349574          2        1  0.4992481748
## 125114          2        1  0.4992360282
## 26239           2        1  0.4991546173
## 16851           2        1  0.4991508091
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## 18571           2        1  0.4973068510
## 203074          2        1  0.4970704390
## 80034           2        1  0.4959231618
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## 37586           2        1  0.4918134172
## 8044            2        1  0.4898073358
## 313574          2        1  0.4894336309
## 78732           2        1  0.4893404836
## 112839          2        1  0.4890464861
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## 498521          2        1  0.4885390899
```

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## 202044          2        1  0.4867744710
## 7088            2        1  0.4867386586
## 63114           2        1  0.4865703903
## 40062           2        1  0.4864896554
## 913186          2        1  0.4863685689
## 230545          2        1  0.4852165260
## 61043           2        1  0.4850577510
## 290521          2        1  0.4846890752
## 67052           2        1  0.4840933723
## 902043          2        1  0.4839218148
## 21061           2        1  0.4836948220
## 16062           2        1  0.4835713673
## 43042           2        1  0.4835445644
## 227093          2        1  0.4831753051
## 111014          2        1  0.4829171694
## 228021          2        1  0.4826467337
## 27004           2        1  0.4825533412
## 157045          2        1  0.4824319218
## 34032           2        1  0.4821470210
## 58054           2        1  0.4818024618
## 1672            2        1  0.4814334160
## 44538           2        1  0.4813270246
## 242523          2        1  0.4812369236
## 72739           2        1  0.4810522761
## 247023          2        1  0.4809735443
## 31263           2        1  0.4806212021
## 84563           2        1  0.4798776380
## 114861          2        1  0.4797387251
## 54038           2        1  0.4789317950
## 47737           2        1  0.4787638288
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##  076A39         2        1  0.4731514123
```

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## 71438              2          1  0.4728652702
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## 20539              2          1  0.4711876331
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## 248944             2          1  0.4698676428
## 64235              2          1  0.4696816140
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## 5083               2          1  0.4684272860
## 176274             2          1  0.4683969793
## 9593               2          1  0.4675601031
## 65041              2          1  0.4675171659
## 25839              2          1  0.4674675257
## 63553              2          1  0.4672807622
## 90014              2          1  0.4661927160
## 25034              2          1  0.4658506922
##  029A04            2          1  0.4657700317
## 222041             2          1  0.4657001222
## 1012               2          1  0.4644743799
## 94051              2          1  0.4641594462
## 29472              2          1  0.4639411068
## 85042              2          1  0.4624887546
## 808341             2          1  0.4624710269
## 49052              2          1  0.4622226973
## 211061             2          1  0.4618135273
## 405021             2          1  0.4601029002
## 6351               2          1  0.4590563383
## 143042             2          1  0.4588816363
## 137036             2          1  0.4585798379
## 24172              2          1  0.4582252508
## 242043             2          1  0.4572728068
## 404021             2          1  0.4571309292
## 439021             2          1  0.4566838814
## 62772              2          1  0.4564936339
## 133014             2          1  0.4564587894
## 20792              2          1  0.4560189852
## 111022             2          1  0.4544420584
## 48567              2          1  0.4541927190
## 28054              2          1  0.4539547393
## 117341             2          1  0.4535619579
## 93052              2          1  0.4535497213
## 324074             2          1  0.4535280885
## 154043             2          1  0.4530049819
```

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## 180043          2        1  0.4529581528
## 65542           2        1  0.4522881192
## 35092           2        1  0.4520815663
## 21252           2        1  0.4501118046
## 334093          2        1  0.4497710844
## 54011           2        1  0.4493219179
## 378021          2        1  0.4491104047
## 388793          2        1  0.4478508345
## 87672           2        1  0.4476840927
## 271043          2        1  0.4476700899
## 27552           2        1  0.4476270288
## 401021          2        1  0.4471700291
## 14253           2        1  0.4465699835
## 17592           2        1  0.4463645065
## 18072           2        1  0.4457911655
## 105022          2        1  0.4445167343
## 357174          2        1  0.4444449252
## 252674          2        1  0.4444449252
## 116567          2        1  0.4444449252
## 134042          2        1  0.4444449252
## 28067           2        1  0.4444110936
## 46752           2        1  0.4443501258
## 46386           2        1  0.4442925346
## 93239           2        1  0.4442527880
## 138674          2        1  0.4441543762
## 206174          2        1  0.4441204811
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## 183044          2        1  0.4422590611
## 46032           2        1  0.4420743248
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## 2037            2        1  0.4417737686
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## 24192           2        1  0.4408212022
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```

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## 427021          2        1  0.4398835765
## 232043          2        1  0.4390028126
## 545021          2        1  0.4389726152
## 11588           2        1  0.4383716595
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## 374493          2        1  0.4381143751
## 59072           2        1  0.4376066092
## 151143          2        1  0.4375787091
## 213021          2        1  0.4373077885
## 135514          2        1  0.4366731183
## 372193          2        1  0.4366346452
## 3153            2        1  0.4366167300
## 64061           2        1  0.4358094058
## 2.91E+95        2        1  0.4351578922
## 48034           2        1  0.4351369015
## 163841          2        1  0.4350039473
## 361093          2        1  0.4349913699
## 27092           2        1  0.4347005665
## 285074          2        1  0.4345969095
## 158061          2        1  0.4345039634
## 73034           2        1  0.4340267285
## 7072            2        1  0.4329031079
## 7011            2        1  0.4327893663
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```

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## 15993           2        1  0.4210085645
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## 265023          2        1  0.4200154149
## 47062           2        1  0.4199155434
## 167014          2        1  0.4192485708
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## 546021          2        1  0.4185899780
## 31062           2        1  0.4183140495
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## 25038           2        1  0.4165109960
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## 77092           2        1  0.4156796018
## 18451           2        1  0.4153803553
## 16045           2        1  0.4151765196
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## 93062           2        1  0.4145192929
## 441021          2        1  0.4140227106
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## 21722           2        1  0.4138585341
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```

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## 39061            2         1  0.3884478085
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```

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## 142136         2        1  0.3705136858
## 49771          2        1  0.3704415631
## 115043         2        1  0.3697025205
## 264023         2        1  0.3681510379
## 10586          2        1  0.3676814598
## 69354          2        1  0.3669624644
## 141014         2        1  0.3669040518
## 95539          2        1  0.3666576975
## 203093         2        1  0.3665003100
## 71538          2        1  0.3650139806
## 92593          2        1  0.3647687087
## 302838         2        1  0.3645700889
## 77539          2        1  0.3644967124
## 278493         2        1  0.3644917492
```

```
## 77552          2        1  0.3642024282
## 317043         2        1  0.3637886848
## 105067         2        1  0.3635948642
## 54222          2        1  0.3634501642
## 200023         2        1  0.3633498598
## 186093         2        1  0.3623736876
## 81038          2        1  0.3623339617
## 8851           2        1  0.3622773924
## 78034          2        1  0.3622620112
## 97021          2        1  0.3618331348
## 148074         2        1  0.3613687483
## 29072          2        1  0.3605925764
## 75063          2        1  0.3602474479
## 71751          2        1  0.3590804249
## 316293         2        1  0.3590518502
## 91052          2        1  0.3575142290
## 94439          2        1  0.3571604151
## 354423         2        1  0.3565788177
## 341139         2        1  0.3564633853
## 14023          2        1  0.3553136342
## 89063          2        1  0.3551103483
## 102052         2        1  0.3541275177
## 147021         2        1  0.3539623624
## 146323         2        1  0.3534680865
## 20543          2        1  0.3534496053
## 39022          2        1  0.3532328635
## 19093          2        1  0.3531944287
## 44053          2        1  0.3526251705
## 13063          2        1  0.3508252469
## 22053          2        1  0.3505347493
## 42091          2        1  0.3504011170
## 111062         2        1  0.3499103945
## 230493         2        1  0.3488484220
## 177043         2        1  0.3482525789
## 5042           2        1  0.3469894282
## 137041         2        1  0.3466537930
## 277023         2        1  0.3463568137
## 507021         2        1  0.3457571023
## 24051          2        1  0.3453684515
## 113521         2        1  0.3452991881
## 30939          2        1  0.3452376345
## 285523         2        1  0.3451376524
## 4084           2        1  0.3447098333
## 28016          2        1  0.3445080303
## 239541         2        1  0.3438168232
## 248074         2        1  0.3431733513
## 18012          2        1  0.3425604488
## 34532          2        1  0.3416404822
## 267021         2        1  0.3410247946
## 20154          2        1  0.3399751995
```

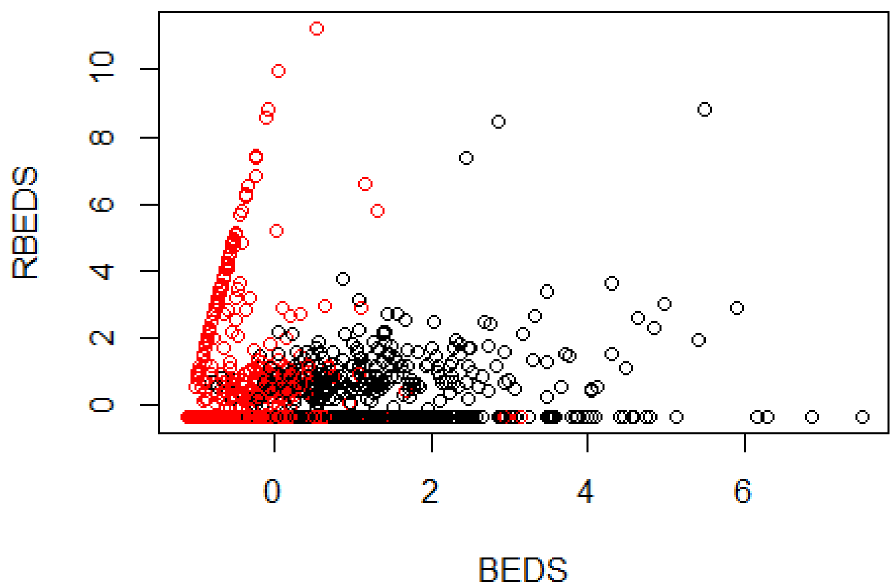
```
## 95241          2         1  0.3396331437
##  006F61        2         1  0.3396109307
## 214844         2         1  0.3391905314
## 144093         2         1  0.3365147875
## 241021         2         1  0.3363077477
## 26022          2         1  0.3356824853
## 8012           2         1  0.3351667180
## 297923         2         1  0.3340927545
## 32222          2         1  0.3325532865
## 81023          2         1  0.3325451483
## 241043         2         1  0.3320885872
## 31036          2         1  0.3319190968
## 11593          2         1  0.3319186982
## 16563          2         1  0.3317860723
## 17044          2         1  0.3310372847
## 266074         2         1  0.3310362741
## 134036         2         1  0.3309945566
## 798743         2         1  0.3308565232
## 351593         2         1  0.3308223791
## 18051          2         1  0.3302503878
## 160043         2         1  0.3294510869
## 28084          2         1  0.3290894732
## 28087          2         1  0.3268963664
## 203043         2         1  0.3268086418
## 27595          2         1  0.3265988843
## 128045         2         1  0.3252501251
## 14187          2         1  0.3250998584
## 101543         2         1  0.3250671147
## 365093         2         1  0.3231358146
## 96474          2         1  0.3222291202
## 25522          2         1  0.3221397904
## 387021         2         1  0.3215067953
## 276593         2         1  0.3211825957
## 78544          2         1  0.3207252324
## 20082          2         1  0.3202351354
## 20374          2         1  0.3198655054
## 46023          2         1  0.3198131417
## 119044         2         1  0.3187722054
## 145074         2         1  0.3173671331
## 72016          2         1  0.3173557280
## 3474           2         1  0.3165471821
## 117522         2         1  0.3161439906
## 208043         2         1  0.3150447594
## 50286          2         1  0.3150387458
## 16551          2         1  0.3148581563
## 39012          2         1  0.3147541307
## 235043         2         1  0.3144796453
## 17039          2         1  0.3138351429
## 329593         2         1  0.3137403059
## 414021         2         1  0.3121826602
```

```
## 30012           2        1  0.3116635625
## 206043          2        1  0.3109516278
## 136523          2        1  0.3103707378
## 191593          2        1  0.3090701789
## 92042           2        1  0.3071451423
## 514021          2        1  0.3045259197
## 108345          2        1  0.3026791416
## 101539          2        1  0.2997755017
## 117034          2        1  0.2987089051
## 12337           2        1  0.2969663586
## 83084           2        1  0.2963515880
## 253043          2        1  0.2960626231
## 34063           2        1  0.2957548583
## 15087           2        1  0.2943341227
## 809953          2        1  0.2936314506
## 19039           2        1  0.2927885623
## 40551           2        1  0.2924292133
## 348523          2        1  0.2917507327
## 280023          2        1  0.2916423959
## 135023          2        1  0.2898899857
## 286574          2        1  0.2896098380
## 174043          2        1  0.2891219311
## 54572           2        1  0.2886880013
## 41073           2        1  0.2880450435
## 100053          2        1  0.2880235373
## 64014           2        1  0.2832280805
## 81143           2        1  0.2829885622
## 38241           2        1  0.2820928825
## 59551           2        1  0.2807444025
## 197723          2        1  0.2800198660
## 78093           2        1  0.2789883784
## 59023           2        1  0.2782588983
## 2.69E+95        2        1  0.2766328946
## 13021           2        1  0.2761581839
## 243543          2        1  0.2744199634
## 33067           2        1  0.2736297209
## 19522           2        1  0.2716030583
## 180014          2        1  0.2710457901
## 67016           2        1  0.2701956418
## 200043          2        1  0.2697962929
## 455021          2        1  0.2678606973
## 363074          2        1  0.2643719113
## 111839          2        1  0.2635028789
## 24038           2        1  0.2563204326
## 319543          2        1  0.2546049155
## 38011           2        1  0.2520248643
## 33034           2        1  0.2511033333
## 45034           2        1  0.2510851416
## 189874          2        1  0.2504811468
## 19563           2        1  0.2474446024
```

```
## 64893            2        1  0.2457553699
## 214041           2        1  0.2441971390
## 70539            2        1  0.2417753938
## 120014           2        1  0.2390121028
## 106093           2        1  0.2373699293
## 7054             2        1  0.2369116226
## 94563            2        1  0.2354103303
## 71523            2        1  0.2334206903
## 113045           2        1  0.2319737811
## 16539            2        1  0.2304796767
## 217021           2        1  0.2301206233
## 40767            2        1  0.2295727878
## 316043           2        1  0.2264117971
## 39521            2        1  0.2255682500
## 231093           2        1  0.2248101082
## 509021           2        1  0.2240506322
## 17053            2        1  0.2239879106
## 218093           2        1  0.2235109114
## 39095            2        1  0.2234653857
## 277593           2        1  0.2226832600
## 97038            2        1  0.2198901575
## 118063           2        1  0.2188337009
## 39032            2        1  0.2156102716
## 49038            2        1  0.2149355548
## 58741            2        1  0.2119753739
## 80344            2        1  0.2089114059
## 70043            2        1  0.2089071651
## 14038            2        1  0.2078339028
## 138522           2        1  0.2067635506
## 34072            2        1  0.2043999175
## 220093           2        1  0.2037442350
## 22332            2        1  0.2014639096
## 24034            2        1  0.1985733814
## 160014           2        1  0.1952609486
## 49062            2        1  0.1930939503
## 279021           2        1  0.1923343901
## 156043           2        1  0.1852108527
## 274021           2        1  0.1846219979
## 3033             2        1  0.1845864724
## 529021           2        1  0.1827606678
## 3034             2        1  0.1822778756
## 11543            2        1  0.1802639595
## 174014           2        1  0.1767077932
## 368093           2        1  0.1689364225
## 197523           2        1  0.1676697631
## 286093           2        1  0.1644920738
## 56639            2        1  0.1630138385
## 130043           2        1  0.1629988642
## 37154            2        1  0.1591337199
## 17551            2        1  0.1561032964
```

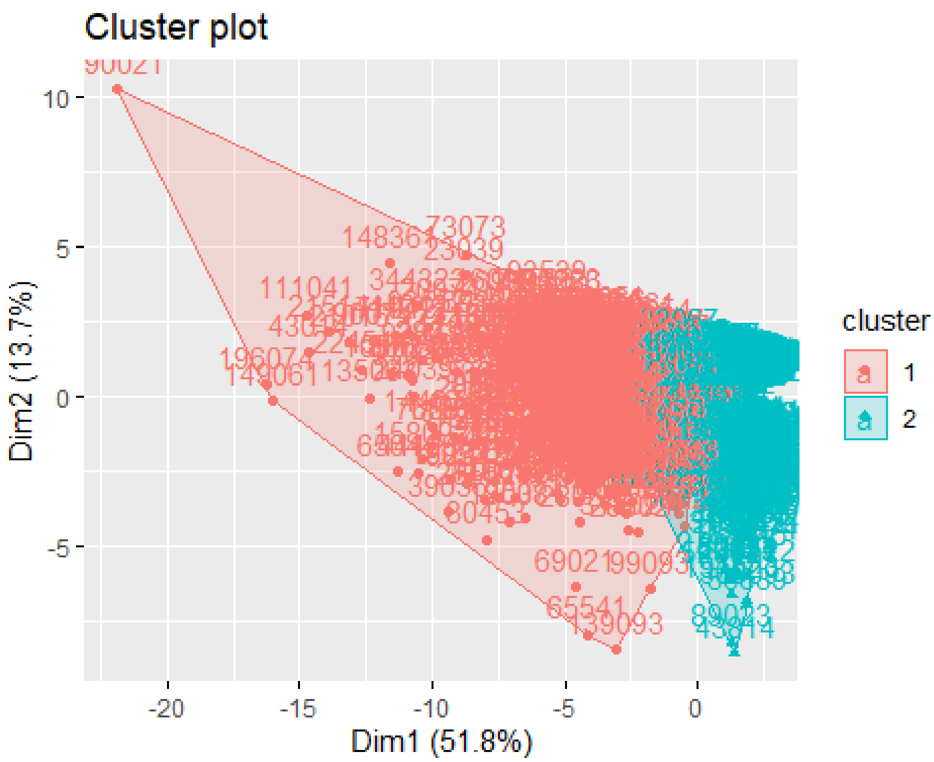
```
## 121841         2        1  0.1429971528
## 9084           2        1  0.1173791910
## 89023          2        1  0.1137060672
## 103045         2        1  0.1106019975
## 43814          2        1  0.1051434926
## 5573           2        1  0.1016803925
## 60563          2        1  0.1005076922
## 137574         2        1  0.0334452147
## 370021         2        1  0.0308946473
## Average silhouette width per cluster:
## [1] 0.04573536 0.59030629
## Average silhouette width of total data set:
## [1] 0.4340144
##
## Available components:
##  [1] "medoids"    "id.med"     "clustering" "objective"  "isolation"
##  [6] "clusinfo"   "silinfo"    "diss"       "call"       "data"
```

```r
#plot a graphic showing the clusters and the medoids of each cluster
plot(result$data, col = result$clustering)
points(result$medoids, col = 1:2, pch = 4)
```




```r
# Compute PAM
library("cluster")
pam.res <- pam(df, 2)
```

```r
# Visualize
fviz_cluster(pam.res)
```

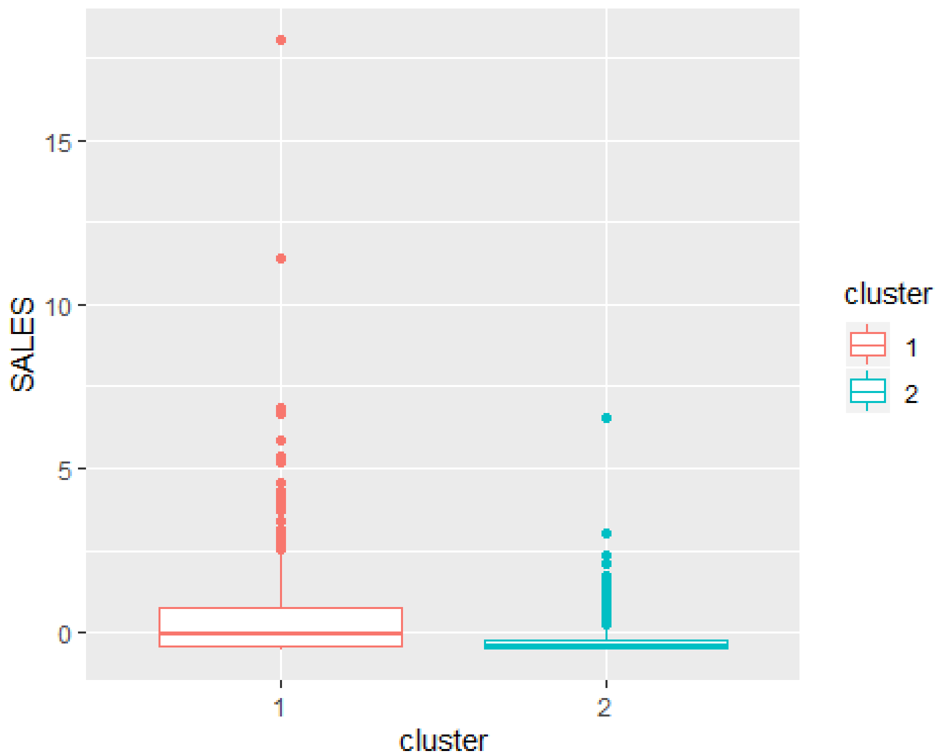


ii). Summary statistics for each cluster

```r
clust=data.frame("cluster"=pam.res$clustering)
clust$cluster=as.factor(clust$cluster)

# Make the index into a column for the clustered_data
Hospital_ID <- rownames(clust)
clust<- cbind(Hospital_ID,clust)
head(clust)

##        Hospital_ID cluster
## 12042        12042       1
## 348593      348593       2
## 62073        62073       2
## 135063      135063       1
## 214044      214044       1
## 103536      103536       2

str(clust)

## 'data.frame':    3000 obs. of  2 variables:
##  $ Hospital_ID: Factor w/ 3000 levels " 006F61"," 006G61",..: 309 1649
2344 427 1009 86 521 1681 1588 261 ...
##  $ cluster    : Factor w/ 2 levels "1","2": 1 2 2 1 1 2 2 2 2 1 ...
```

```r
# Make the index into a column for the hospital_data
Hospital_ID <- rownames(hospital_data)
sales=data.frame("SALES"=hospital_data[,6])
sales_data <- cbind(Hospital_ID,sales)
head(sales_data)

##        Hospital_ID      SALES
## 12042        12042         NA
## 348593      348593 -0.4350562
## 62073        62073 -0.5396399
## 135063      135063 -0.2496577
## 214044      214044  0.7866720
## 103536      103536         NA

str(sales_data)

## 'data.frame':    3000 obs. of  2 variables:
##  $ Hospital_ID: Factor w/ 3000 levels " 006F61"," 006G61",..: 309 1649
2344 427 1009 86 521 1681 1588 261 ...
##  $ SALES      : num  NA -0.435 -0.54 -0.25 0.787 ...

new_df = merge(x=sales_data,y=clust,by='Hospital_ID')
head(new_df)

##   Hospital_ID      SALES cluster
## 1      006F61 -0.5206247       2
## 2      006G61         NA       1
## 3      009A74         NA       2
## 4      011A71         NA       2
## 5      011A72 -0.4445638       2
## 6      015A63         NA       2

str(new_df)

## 'data.frame':    3000 obs. of  3 variables:
##  $ Hospital_ID: Factor w/ 3000 levels " 006F61"," 006G61",..: 1 2 3 4 5 6
7 8 9 10 ...
##  $ SALES      : num  -0.521 NA NA NA -0.445 ...
##  $ cluster    : Factor w/ 2 levels "1","2": 2 1 2 2 2 2 2 2 1 2 ...

# Box plot of sales by clusters
# From the box plots cluster 1 had the highest average sales, and had  the
most outliers

attach(new_df)

## The following object is masked _by_ .GlobalEnv:
##
##     Hospital_ID
```

```r
p<-ggplot(new_df, aes(x=cluster, y=SALES, color=cluster)) +
  geom_boxplot()
p

## Warning: Removed 1280 rows containing non-finite values (stat_boxplot).
```



PART 2

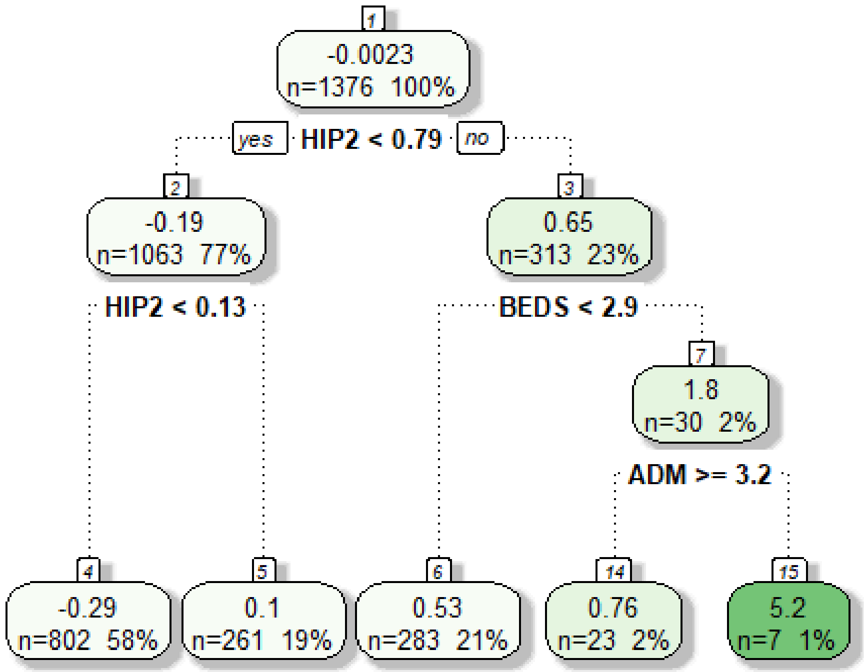
```r
# Data preparation

hospital_data=as.data.frame(hospital_data)
dim(hospital_data)

## [1] 3000   14

sum(is.na(hospital_data)) #how many missing values

## [1] 1280

hospitals=na.omit(hospital_data)#remove missing values
dim(hospitals)

## [1] 1720   14

#Split the data into train and test data
smp_size <- floor(0.80 * nrow(hospitals))
train_ind <- sample(seq_len(nrow(hospitals)), size = smp_size)
```

```r
train.set <- hospitals[train_ind, ]
validation.set <- hospitals[-train_ind, ]
```

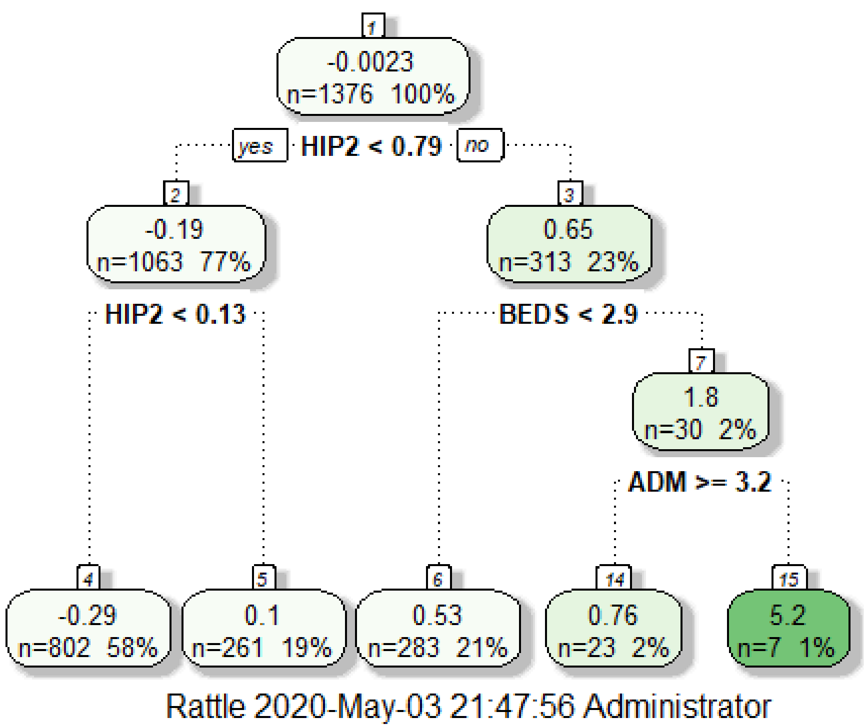
Decision tree model

Thus model will be used predict the sales using the independent variables (operational and demographic)

```r
library(rpart)
mytree <- rpart(
  SALES ~ .,
  data = train.set)
mytree

## n= 1376
##
## node), split, n, deviance, yval
##       * denotes terminal node
##
##  1) root 1376 1365.42400 -0.00225944
##    2) HIP2< 0.788591 1063  334.56940 -0.19447690
##      4) HIP2< 0.1318165 802  166.64450 -0.29142250 *
##      5) HIP2>=0.1318165 261  137.22600  0.10341710 *
##    3) HIP2>=0.788591 313  858.19380  0.65054300
##      6) BEDS< 2.863692 283  421.77380  0.53055440 *
##      7) BEDS>=2.863692 30  393.91020  1.78243600
##       14) ADM>=3.188247 23   73.42777  0.75504880 *
##       15) ADM< 3.188247 7  216.43790  5.15813600 *

library(rattle)

## Rattle: A free graphical interface for data science with R.
## Version 5.3.0 Copyright (c) 2006-2018 Togaware Pty Ltd.
## Type 'rattle()' to shake, rattle, and roll your data.

library(rpart.plot)
library(RColorBrewer)

# plot mytree
fancyRpartPlot(mytree, caption = NULL)
```




```
# Full-grown tree with 6 splits using  different variables (Not running the
line below - do it to see the tree)
fancyRpartPlot(mytree)
```



```r
# As always, predict and evaluate on the test set, here the predicted vales
of transformed sales is compared with actual validation test data and the
mean squared error is calculated to check the error of our prediction, the
smaller the better.
test.pred.rtree <- predict(mytree,validation.set)

RMSE.rtree <- sqrt(mean((test.pred.rtree-validation.set$SALES)^2))
RMSE.rtree

## [1] 0.7926431

#Mean absolute error
MAE.rtree <- mean(abs(test.pred.rtree-validation.set$SALES))
MAE.rtree

## [1] 0.4762711

# Now that we have a full-grown tree, let’s see if it’s possible to prune it…

# Check cross-validation results (xerror column)
printcp(mytree)

##
## Regression tree:
## rpart(formula = SALES ~ ., data = train.set)
##
## Variables actually used in tree construction:
## [1] ADM  BEDS HIP2
##
## Root node error: 1365.4/1376 = 0.99231
##
## n= 1376
##
##         CP nsplit rel error  xerror    xstd
## 1 0.126452      0   1.00000 1.00111 0.25342
## 2 0.053666      1   0.87355 0.89584 0.23517
## 3 0.022483      3   0.76622 0.93729 0.23676
## 4 0.010000      4   0.74373 0.94176 0.23990
```