R Notebook

1. DEFINING THE QUESTION

a) Specifying the Question

Performing clustering stating insights drawn from your analysis and visualizations.

b) Defining the Metrics of Success

Performing Bivariates and univariate Exploratory data analysis and Performing clustering stating insights drawn from the analysis and visualizations. Upon implementation, provide comparisons between the approaches of K-Means clustering vs Hierarchical clustering highlighting the strengths and limitations of each approach in the context of your analysis.

c) Understanding the context

Kira Plastinina is a Russian brand that is sold through a defunct chain of retail stores in Russia, Ukraine, Kazakhstan, Belarus, China, Philippines, and Armenia. The brand's Sales and Marketing team would like to understand their customer's behavior from data that they have collected over the past year. More specifically, they would like to learn the characteristics of customer groups.

d) Recording the Experimental Design

1. Define the question, the metric for success, the context, experimental design taken.
2. Reading and exploring the dataset.
3. Finding and dealing with outliers, anomalies, and missing data within the dataset.
4. Perform univariate and bivariate analysis.
5. Perform clustering stating insights drawn from the analysis and visualizations.

e) Relevance of the data

The data used for this project is necessary for understanding their customer's behavior from data that they have collected over the past year. The dataset link: http://bit.ly/EcommerceCustomersDataset

2. DATA ANALYSIS

a) Checking the Data

```
# loading libraries
library(relaimpo)
```

```
## Loading required package: MASS

## Loading required package: boot

## Loading required package: survey

## Loading required package: grid

## Loading required package: Matrix

## Loading required package: survival

##
## Attaching package: 'survival'

## The following object is masked from 'package:boot':
##
##     aml

##
## Attaching package: 'survey'

## The following object is masked from 'package:graphics':
##
##     dotchart

## Loading required package: mitools

## This is the global version of package relaimpo.

## If you are a non-US user, a version with the interesting additional metric pmvd is available

## from Ulrike Groempings web site at prof.beuth-hochschule.de/groemping.
```

```
library(data.table)

library(ggplot2) # Data visualization
library(ggthemes) # Plot themes
```

```
library(dplyr) # Data manipulation
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:data.table':
##
##     between, first, last
```

```
## The following object is masked from 'package:MASS':
##
##     select

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

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

```
library(psych) # Correlation visualization
```

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

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

## The following object is masked from 'package:boot':
##
##     logit
```

```
library(cluster)    # clustering algorithms
```

```
# Reading the data
df2 <- fread('http://bit.ly/EcommerceCustomersDataset')
df2
```

```
##        Administrative Administrative_Duration Informational
##                 <int>                   <num>         <int>
##     1:              0                       0             0
##     2:              0                       0             0
##     3:              0                      -1             0
##     4:              0                       0             0
##     5:              0                       0             0
##    ---
## 12326:              3                     145             0
## 12327:              0                       0             0
## 12328:              0                       0             0
## 12329:              4                      75             0
## 12330:              0                       0             0
##        Informational_Duration ProductRelated ProductRelated_Duration
##                         <num>          <int>                   <num>
##     1:                      0              1                0.000000
##     2:                      0              2               64.000000
##     3:                     -1              1               -1.000000
##     4:                      0              2                2.666667
##     5:                      0             10              627.500000
```

```
##    ---
## 12326:                      0             53             1783.791667
## 12327:                      0              5              465.750000
## 12328:                      0              6              184.250000
## 12329:                      0             15              346.000000
## 12330:                      0              3               21.250000
##        BounceRates  ExitRates PageValues SpecialDay  Month OperatingSystems
##              <num>      <num>      <num>      <num> <char>            <int>
##     1: 0.200000000 0.20000000    0.00000          0    Feb                1
##     2: 0.000000000 0.10000000    0.00000          0    Feb                2
##     3: 0.200000000 0.20000000    0.00000          0    Feb                4
##     4: 0.050000000 0.14000000    0.00000          0    Feb                3
##     5: 0.020000000 0.05000000    0.00000          0    Feb                3
##    ---
## 12326: 0.007142857 0.02903061   12.24172          0    Dec                4
## 12327: 0.000000000 0.02133333    0.00000          0    Nov                3
## 12328: 0.083333333 0.08666667    0.00000          0    Nov                3
## 12329: 0.000000000 0.02105263    0.00000          0    Nov                2
## 12330: 0.000000000 0.06666667    0.00000          0    Nov                3
##        Browser Region TrafficType       VisitorType Weekend Revenue
##          <int>  <int>       <int>            <char>  <lgcl>  <lgcl>
##     1:       1      1           1 Returning_Visitor   FALSE   FALSE
##     2:       2      1           2 Returning_Visitor   FALSE   FALSE
##     3:       1      9           3 Returning_Visitor   FALSE   FALSE
##     4:       2      2           4 Returning_Visitor   FALSE   FALSE
##     5:       3      1           4 Returning_Visitor    TRUE   FALSE
##    ---
## 12326:       6      1           1 Returning_Visitor    TRUE   FALSE
## 12327:       2      1           8 Returning_Visitor    TRUE   FALSE
## 12328:       2      1          13 Returning_Visitor    TRUE   FALSE
## 12329:       2      3          11 Returning_Visitor   FALSE   FALSE
## 12330:       2      1           2       New_Visitor    TRUE   FALSE
```

b) Data Checking

```
# Viewing the dataset
View(df2)
```

```
# Viewing the column names
colnames(df2)
```

```
##  [1] "Administrative"          "Administrative_Duration"
##  [3] "Informational"           "Informational_Duration"
##  [5] "ProductRelated"          "ProductRelated_Duration"
##  [7] "BounceRates"             "ExitRates"
##  [9] "PageValues"              "SpecialDay"
## [11] "Month"                   "OperatingSystems"
## [13] "Browser"                 "Region"
## [15] "TrafficType"             "VisitorType"
## [17] "Weekend"                 "Revenue"
```

```
# Previewing the class dataset
class(df2)
```

```
## [1] "data.table" "data.frame"
```

```
# Viewing the datatypes of the dataset
sapply(df2, class)
```

```
##          Administrative Administrative_Duration           Informational
##               "integer"               "numeric"               "integer"
##  Informational_Duration          ProductRelated ProductRelated_Duration
##               "numeric"               "integer"               "numeric"
##             BounceRates              ExitRates              PageValues
##               "numeric"               "numeric"               "numeric"
##              SpecialDay                  Month        OperatingSystems
##               "numeric"             "character"               "integer"
##                 Browser                 Region             TrafficType
##               "integer"               "integer"               "integer"
##             VisitorType                Weekend                 Revenue
##             "character"               "logical"               "logical"
```

```
# Previewing the top of the dataset
head(df2, n = 5)
```

```
##    Administrative Administrative_Duration Informational Informational_Duration
##             <int>                   <num>         <int>                   <num>
## 1:              0                       0             0                       0
## 2:              0                       0             0                       0
## 3:              0                      -1             0                      -1
## 4:              0                       0             0                       0
## 5:              0                       0             0                       0
##    ProductRelated ProductRelated_Duration BounceRates ExitRates PageValues
##             <int>                   <num>       <num>     <num>      <num>
## 1:              1                0.000000        0.20      0.20          0
## 2:              2               64.000000        0.00      0.10          0
## 3:              1               -1.000000        0.20      0.20          0
## 4:              2                2.666667        0.05      0.14          0
## 5:             10              627.500000        0.02      0.05          0
##    SpecialDay  Month OperatingSystems Browser Region TrafficType
##         <num> <char>            <int>   <int>  <int>       <int>
## 1:          0    Feb                1       1      1           1
## 2:          0    Feb                2       2      1           2
## 3:          0    Feb                4       1      9           3
## 4:          0    Feb                3       2      2           4
## 5:          0    Feb                3       3      1           4
##          VisitorType Weekend Revenue
##               <char>  <lgcl>  <lgcl>
## 1: Returning_Visitor   FALSE   FALSE
## 2: Returning_Visitor   FALSE   FALSE
## 3: Returning_Visitor   FALSE   FALSE
## 4: Returning_Visitor   FALSE   FALSE
## 5: Returning_Visitor    TRUE   FALSE
```

```r
# Previewing the bottom of the dataset
tail(df2, n = 5)
```

```
##    Administrative Administrative_Duration Informational Informational_Duration
##             <int>                   <num>         <int>                   <num>
## 1:              3                     145             0                       0
## 2:              0                       0             0                       0
## 3:              0                       0             0                       0
## 4:              4                      75             0                       0
## 5:              0                       0             0                       0
##    ProductRelated ProductRelated_Duration BounceRates  ExitRates PageValues
##             <int>                   <num>       <num>      <num>      <num>
## 1:             53                1783.792 0.007142857 0.02903061   12.24172
## 2:              5                 465.750 0.000000000 0.02133333    0.00000
## 3:              6                 184.250 0.083333333 0.08666667    0.00000
## 4:             15                 346.000 0.000000000 0.02105263    0.00000
## 5:              3                  21.250 0.000000000 0.06666667    0.00000
##    SpecialDay  Month OperatingSystems Browser Region TrafficType
##         <num> <char>            <int>   <int>  <int>       <int>
## 1:          0    Dec                4       6      1           1
## 2:          0    Nov                3       2      1           8
## 3:          0    Nov                3       2      1          13
## 4:          0    Nov                2       2      3          11
## 5:          0    Nov                3       2      1           2
##          VisitorType Weekend Revenue
##                <char>  <lgcl>  <lgcl>
## 1: Returning_Visitor    TRUE   FALSE
## 2: Returning_Visitor    TRUE   FALSE
## 3: Returning_Visitor    TRUE   FALSE
## 4: Returning_Visitor   FALSE   FALSE
## 5:       New_Visitor    TRUE   FALSE
```

```r
# Checking the structure of the data
str(df2)
```

```
## Classes 'data.table' and 'data.frame':   12330 obs. of  18 variables:
##  $ Administrative         : int  0 0 0 0 0 0 0 1 0 0 ...
##  $ Administrative_Duration: num  0 0 -1 0 0 0 -1 -1 0 0 ...
##  $ Informational          : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ Informational_Duration : num  0 0 -1 0 0 0 -1 -1 0 0 ...
##  $ ProductRelated         : int  1 2 1 2 10 19 1 1 2 3 ...
##  $ ProductRelated_Duration: num  0 64 -1 2.67 627.5 ...
##  $ BounceRates            : num  0.2 0 0.2 0.05 0.02 ...
##  $ ExitRates              : num  0.2 0.1 0.2 0.14 0.05 ...
##  $ PageValues             : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ SpecialDay             : num  0 0 0 0 0 0 0.4 0 0.8 0.4 ...
##  $ Month                  : chr  "Feb" "Feb" "Feb" "Feb" ...
##  $ OperatingSystems       : int  1 2 4 3 3 2 2 1 2 2 ...
##  $ Browser                : int  1 2 1 2 3 2 4 2 2 4 ...
##  $ Region                 : int  1 1 9 2 1 1 3 1 2 1 ...
##  $ TrafficType            : int  1 2 3 4 4 3 3 5 3 2 ...
##  $ VisitorType            : chr  "Returning_Visitor" "Returning_Visitor" "Returning_Visitor" "Returni
##  $ Weekend                : logi  FALSE FALSE FALSE FALSE TRUE FALSE ...
```

```
##  $ Revenue                : logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
##  - attr(*, ".internal.selfref")=<externalptr>
```

```
# Checking the shape of the data
dim(df2)
```

```
## [1] 12330    18
```

There 12330 rows and 18 columns

```
# Viewing the column names of the dataset
colnames(df2)
```

```
##  [1] "Administrative"          "Administrative_Duration"
##  [3] "Informational"           "Informational_Duration"
##  [5] "ProductRelated"          "ProductRelated_Duration"
##  [7] "BounceRates"             "ExitRates"
##  [9] "PageValues"              "SpecialDay"
## [11] "Month"                   "OperatingSystems"
## [13] "Browser"                 "Region"
## [15] "TrafficType"             "VisitorType"
## [17] "Weekend"                 "Revenue"
```

```
# selecting needed columns
df3 <- subset(df2, select = c("ProductRelated", "ProductRelated_Duration", "PageValues", "Month", "Visi
colnames(df3)
```

```
## [1] "ProductRelated"          "ProductRelated_Duration"
## [3] "PageValues"              "Month"
## [5] "VisitorType"             "Weekend"
```

These columns are to be majorly focused on.

c) Data Cleaning

Missing Values

```
# checking for missing values
sum(is.na(df3))
```

```
## [1] 28
```

There are 28 missing values

```
# Removing the missing values
df4 <- na.omit(df3)
```

The missing values are now deleted.

```r
# checking for missing values
sum(is.na(df4))
```

```
## [1] 0
```

There are 0 missing values.

Duplicates

```r
# checking for duplicates
duplicated_rows <- df4[duplicated(df4),]
duplicated_rows
```

```
##      ProductRelated ProductRelated_Duration PageValues  Month       VisitorType
##               <int>                   <num>      <num> <char>            <char>
##   1:              1                   -1.00          0    Feb Returning_Visitor
##   2:              1                   -1.00          0    Feb Returning_Visitor
##   3:              1                   -1.00          0    Feb Returning_Visitor
##   4:              1                   -1.00          0    Feb Returning_Visitor
##   5:              1                   -1.00          0    Feb Returning_Visitor
##  ---
## 736:              3                    0.00          0    Nov Returning_Visitor
## 737:              1                    0.00          0    Dec Returning_Visitor
## 738:              2                    0.00          0    Nov Returning_Visitor
## 739:              2                    0.00          0    Nov Returning_Visitor
## 740:              3                   21.25          0    Nov       New_Visitor
##      Weekend
##       <lgcl>
##   1:   FALSE
##   2:   FALSE
##   3:   FALSE
##   4:    TRUE
##   5:   FALSE
##  ---
## 736:   FALSE
## 737:    TRUE
## 738:   FALSE
## 739:   FALSE
## 740:    TRUE
```

There are 740 duplicates in the data

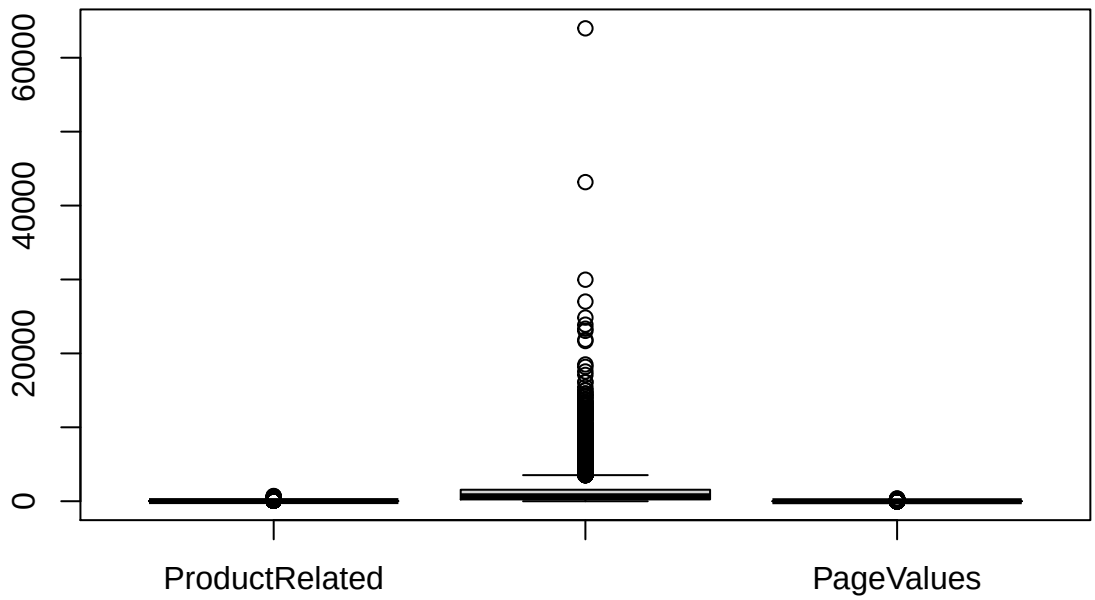
```r
# Displaying the unique items and assigning to a variable unique_items
df5 <- unique(df4)
df5
```

```
##        ProductRelated ProductRelated_Duration PageValues  Month
##                 <int>                   <num>      <num> <char>
##     1:              1                0.000000    0.00000    Feb
##     2:              2               64.000000    0.00000    Feb
```

```
##     3:              1               -1.000000    0.00000    Feb
##     4:              2                2.666667    0.00000    Feb
##     5:             10              627.500000    0.00000    Feb
##    ---
## 11572:             16              503.000000    0.00000    Nov
## 11573:             53             1783.791667   12.24172    Dec
## 11574:              5              465.750000    0.00000    Nov
## 11575:              6              184.250000    0.00000    Nov
## 11576:             15              346.000000    0.00000    Nov
##              VisitorType Weekend
##                    <char>  <lgcl>
##     1: Returning_Visitor   FALSE
##     2: Returning_Visitor   FALSE
##     3: Returning_Visitor   FALSE
##     4: Returning_Visitor   FALSE
##     5: Returning_Visitor    TRUE
##    ---
## 11572: Returning_Visitor   FALSE
## 11573: Returning_Visitor    TRUE
## 11574: Returning_Visitor    TRUE
## 11575: Returning_Visitor    TRUE
## 11576: Returning_Visitor   FALSE
```

Outliers

```
# Visualizing  outliers using a boxplot
df6 <- df5 %>% select_if(is.numeric)
boxplot(df6)
```



There are several outliers but removing them will interfere with the analysis so i will use the data with the outliers.

3. EXPLORATORY DATA ANALYSIS

a) Univariate Analysis

```
summary(df2)
```

```
##  Administrative   Administrative_Duration Informational
##  Min.   : 0.000   Min.   :  -1.00         Min.   : 0.000
##  1st Qu.: 0.000   1st Qu.:   0.00         1st Qu.: 0.000
##  Median : 1.000   Median :   8.00         Median : 0.000
##  Mean   : 2.318   Mean   :  80.91         Mean   : 0.504
##  3rd Qu.: 4.000   3rd Qu.:  93.50         3rd Qu.: 0.000
##  Max.   :27.000   Max.   :3398.75         Max.   :24.000
##  NA's   :14       NA's   :14              NA's   :14
##  Informational_Duration ProductRelated   ProductRelated_Duration
##  Min.   :  -1.00        Min.   :  0.00   Min.   :   -1.0
##  1st Qu.:   0.00        1st Qu.:  7.00   1st Qu.:  185.0
##  Median :   0.00        Median : 18.00   Median :  599.8
##  Mean   :  34.51        Mean   : 31.76   Mean   : 1196.0
##  3rd Qu.:   0.00        3rd Qu.: 38.00   3rd Qu.: 1466.5
```

```
##  Max.   :2549.38        Max.   :705.00   Max.   :63973.5
##  NA's   :14              NA's   :14       NA's   :14
##   BounceRates         ExitRates         PageValues        SpecialDay
##  Min.   :0.000000   Min.   :0.00000   Min.   :  0.000   Min.   :0.00000
##  1st Qu.:0.000000   1st Qu.:0.01429   1st Qu.:  0.000   1st Qu.:0.00000
##  Median :0.003119   Median :0.02512   Median :  0.000   Median :0.00000
##  Mean   :0.022152   Mean   :0.04300   Mean   :  5.889   Mean   :0.06143
##  3rd Qu.:0.016684   3rd Qu.:0.05000   3rd Qu.:  0.000   3rd Qu.:0.00000
##  Max.   :0.200000   Max.   :0.20000   Max.   :361.764   Max.   :1.00000
##  NA's   :14         NA's   :14
##     Month           OperatingSystems    Browser           Region
##  Length:12330       Min.   :1.000    Min.   : 1.000   Min.   :1.000
##  Class :character   1st Qu.:2.000    1st Qu.: 2.000   1st Qu.:1.000
##  Mode  :character   Median :2.000    Median : 2.000   Median :3.000
##                     Mean   :2.124    Mean   : 2.357   Mean   :3.147
##                     3rd Qu.:3.000    3rd Qu.: 2.000   3rd Qu.:4.000
##                     Max.   :8.000    Max.   :13.000   Max.   :9.000
##
##   TrafficType    VisitorType         Weekend         Revenue
##  Min.   : 1.00   Length:12330       Mode :logical   Mode :logical
##  1st Qu.: 2.00   Class :character   FALSE:9462      FALSE:10422
##  Median : 2.00   Mode  :character   TRUE :2868      TRUE :1908
##  Mean   : 4.07
##  3rd Qu.: 4.00
##  Max.   :20.00
##
```

Very few people visited the brand website during the weekends as compared to the weekdays. The revenue collected from the brand website was little considering that, of the total count of rows and input, only 1908 rendered a 'TRUE' in the revenue section while more than 10,000 entries rendered no revenue.

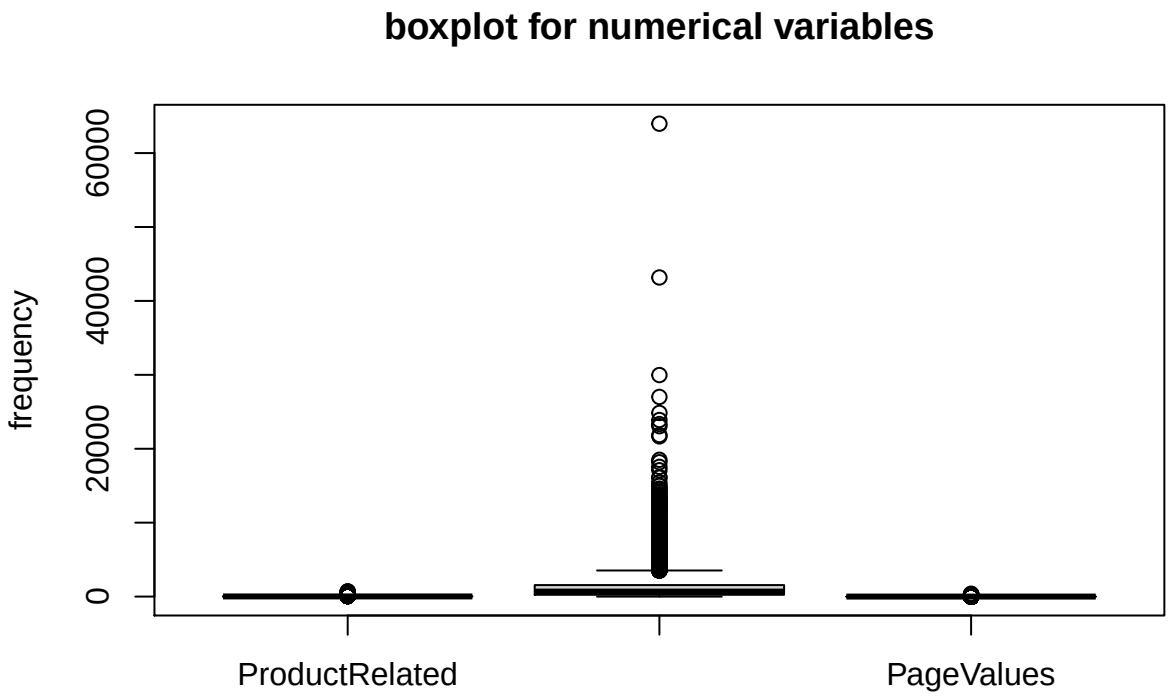
```
# Descriptive statistics
describe(df5)
```

```
## Warning in FUN(newX[, i], ...): no non-missing arguments to min; returning Inf

## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning -Inf

##                          vars     n    mean      sd median trimmed    mad min
## ProductRelated              1 11576   33.70   45.21  20.00   24.58  19.27   0
## ProductRelated_Duration     2 11576 1272.01 1950.12 671.59  893.09 771.39  -1
## PageValues                  3 11576    6.27   19.10   0.00    1.54   0.00   0
## Month*                      4 11576    6.17    2.39   7.00    6.36   1.48   1
## VisitorType*                5 11576    2.71    0.70   3.00    2.88   0.00   1
## Weekend                     6 11576     NaN      NA     NA     NaN     NA Inf
##                             max    range  skew kurtosis    se
## ProductRelated            705.00   705.00  4.29    30.35  0.42
## ProductRelated_Duration 63973.52 63974.52  7.20   134.21 18.13
## PageValues                361.76   361.76  6.19    61.75  0.18
## Month*                     10.00     9.00 -0.83    -0.39  0.02
## VisitorType*                3.00     2.00 -1.99     1.98  0.01
## Weekend                     -Inf     -Inf    NA       NA    NA
```

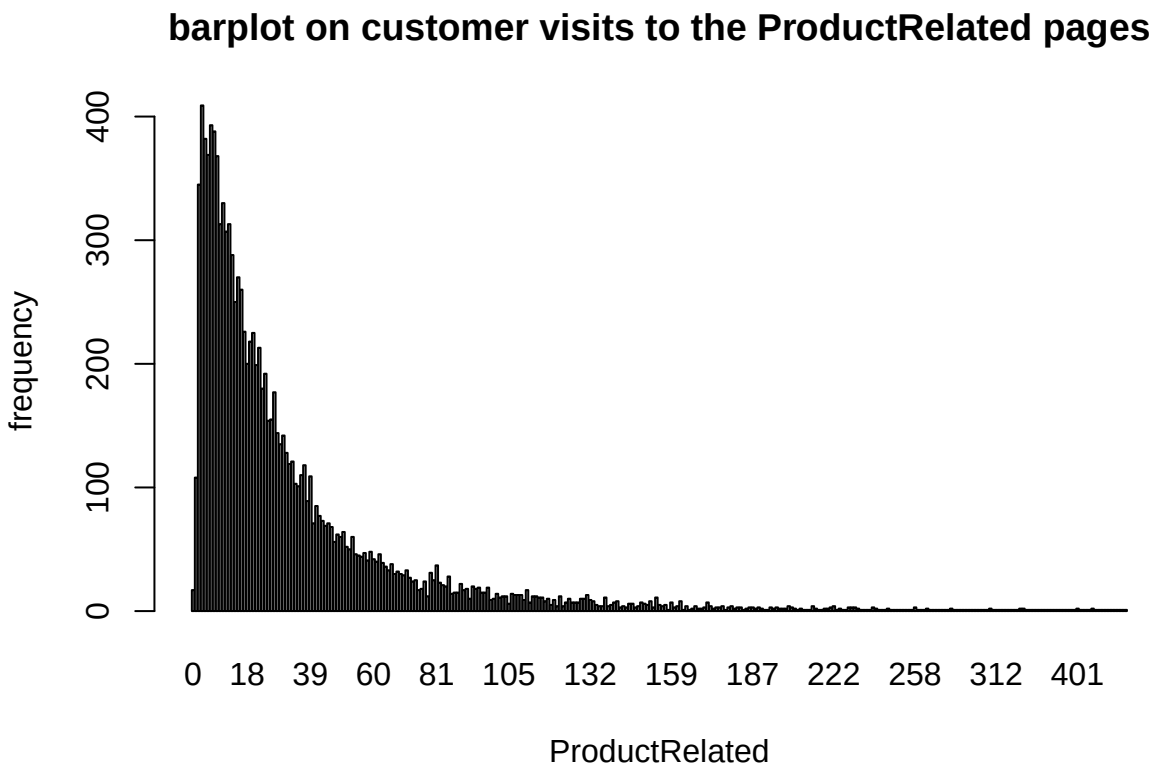
The columns with null values are those with character datatypes

Univariate Graphical

```
# creating a boxplot graph for the numerical variables
boxplot(df6, ylab = 'frequency', main = 'boxplot for numerical variables')
```

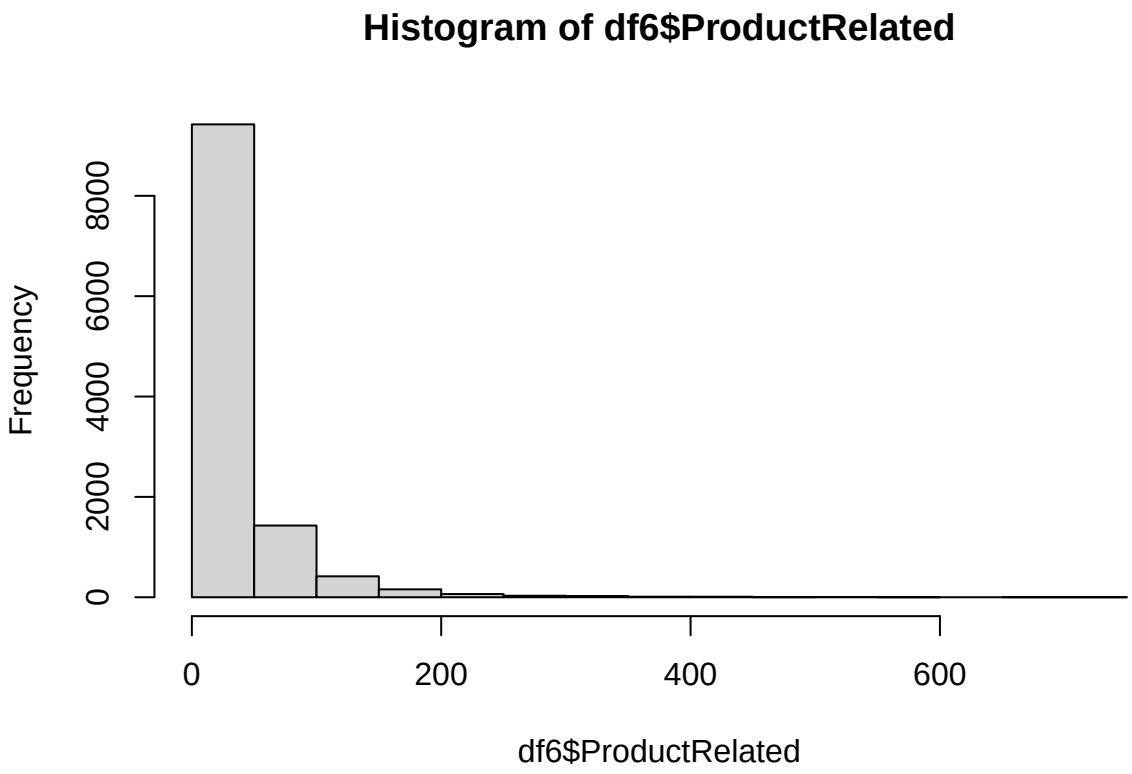



```
# Getting the columns
ProductRelated <- df6$ProductRelated

# Getting the frequency distribution
ProductRelated_frequency <- table(ProductRelated)

# plotting the bargraph
barplot(ProductRelated_frequency,  xlab = 'ProductRelated', ylab = 'frequency',  main = 'barplot on cus
```



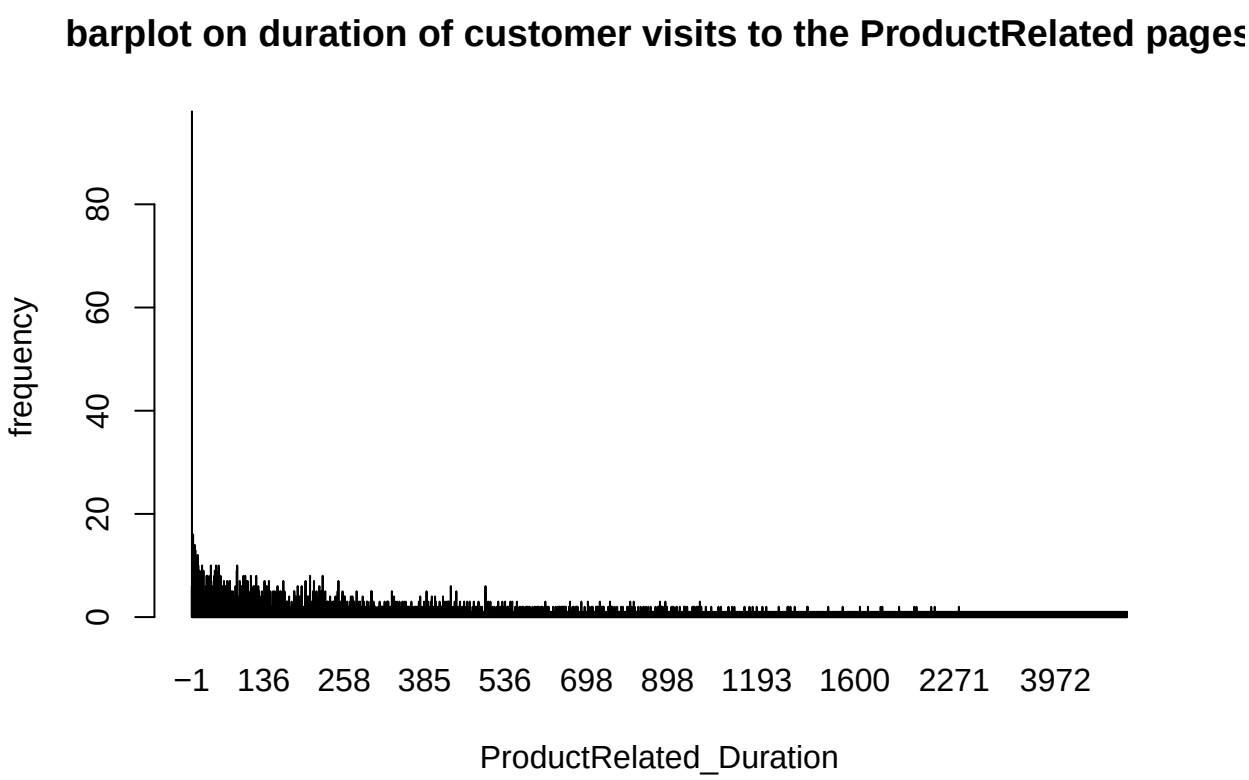
The product related is deceasing in number.

```
# Getting the columns
hist(df6$ProductRelated)
```



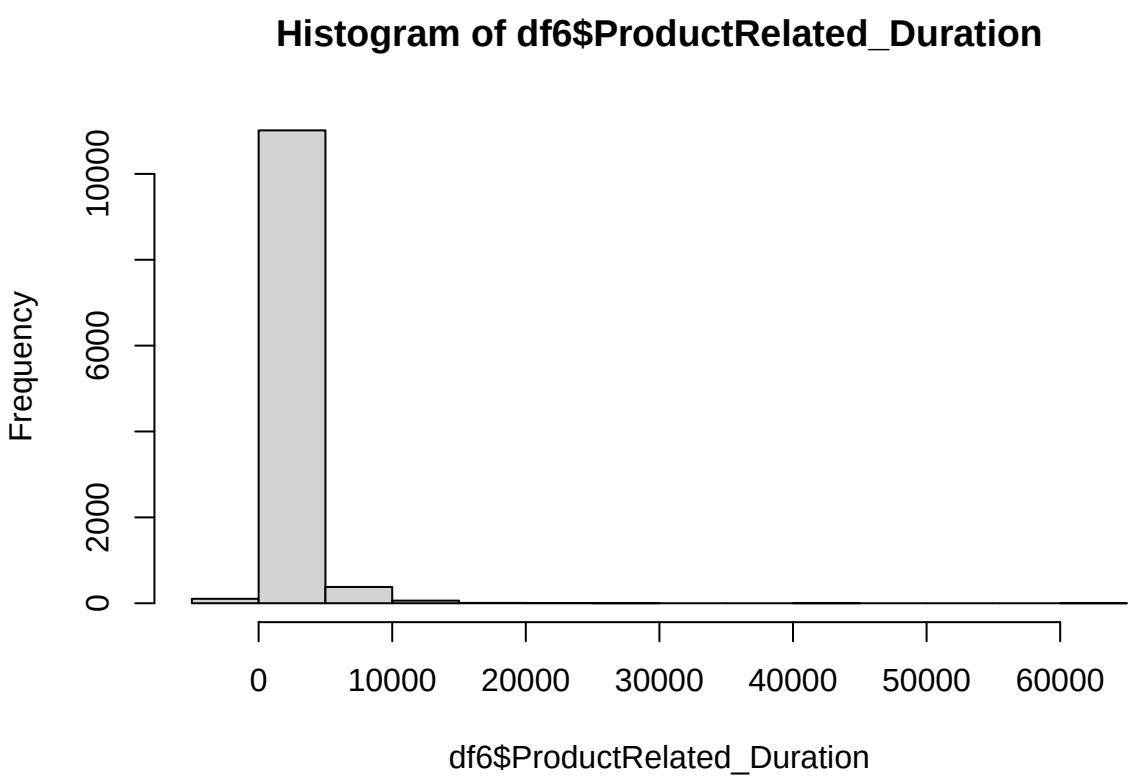
As the product related increase the frequency decreases.

```
# Getting the columns
ProductRelated_Duration <- df6$ProductRelated_Duration

# Getting the frequency distribution
ProductRelated_Duration_frequency <- table(ProductRelated_Duration)

# plotting the bargraph
barplot(ProductRelated_Duration_frequency,  xlab = 'ProductRelated_Duration', ylab = 'frequency',  main
```



The product related duration increases the frequency decreases.

```
# Getting the columns
hist(df6$ProductRelated_Duration)
```



The product related duration increases the frequency decreases.

Bivariate Analysis

```
# Covariance of the numerical variables
covariance <- df5 %>% select_if(is.numeric)
cov(covariance)
```

```
##                           ProductRelated ProductRelated_Duration PageValues
## ProductRelated              2043.67420               75563.101   37.18262
## ProductRelated_Duration    75563.10148             3802973.668 1514.59772
## PageValues                    37.18262                1514.598  364.83994
```

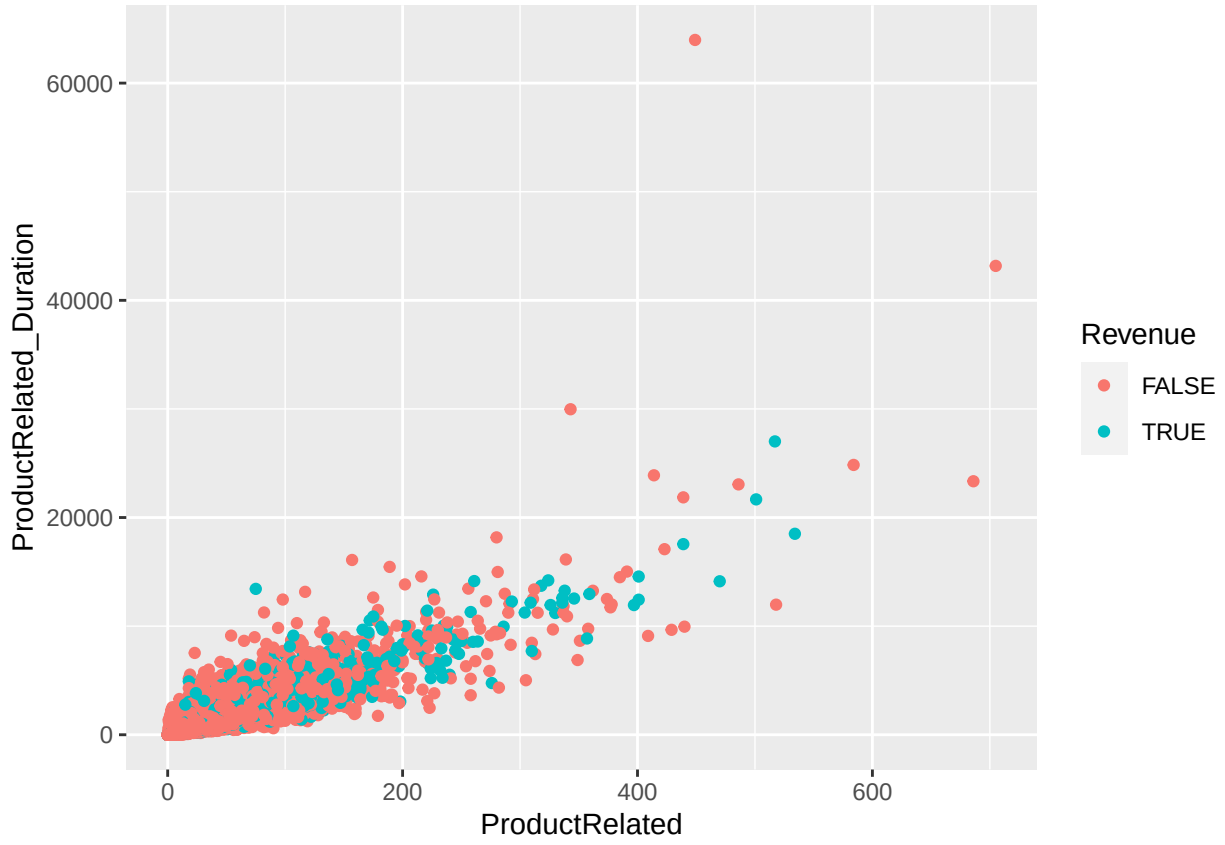
```
# The correlation coefficients
cor(covariance)
```

```
##                           ProductRelated ProductRelated_Duration PageValues
## ProductRelated              1.00000000               0.8571213 0.04306088
## ProductRelated_Duration     0.85712129               1.0000000 0.04066160
## PageValues                  0.04306088               0.0406616 1.00000000
```

There is a positive correlation.

```
# Scatterplot
df2$`Revenue` <- as.factor(df2$`Revenue`)
ggplot(df2, aes(x=`ProductRelated`,y=`ProductRelated_Duration`, color= `Revenue`)) + geom_point()
```

```
## Warning: Removed 14 rows containing missing values (geom_point).
```



4. IMPLEMENTING THE SOLUTION

UNSUPERVISED LEARNING

K-Means Clustering

```
# Generating 25 initial configurations
k2 <- kmeans(df6, centers = 2, nstart = 25)
str(k2)
```

```
## List of 9
##  $ cluster     : int [1:11576] 2 2 2 2 2 2 2 2 2 2 ...
##  $ centers     : num [1:2, 1:3] 137.28 24.99 6194.84 858 7.27 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:2] "1" "2"
```

```
##   .. ..$ : chr [1:3] "ProductRelated" "ProductRelated_Duration" "PageValues"
##  $ totss       : num 4.4e+10
##  $ withinss    : num [1:2] 1.33e+10 7.13e+09
##  $ tot.withinss: num 2.04e+10
##  $ betweenss   : num 2.36e+10
##  $ size        : int [1:2] 898 10678
##  $ iter        : int 1
##  $ ifault      : int 0
##  - attr(*, "class")= chr "kmeans"
```

25 configurations are produced as the output.

```
# Grouping 2 clusters
k2
```

```
## K-means clustering with 2 clusters of sizes 898, 10678
##
## Cluster means:
##   ProductRelated ProductRelated_Duration PageValues
## 1       137.2762               6194.8397   7.270426
## 2        24.9852                858.0042   6.188959
##
## Clustering vector:
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## [11557] 2 2 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##
## Within cluster sum of squares by cluster:
## [1] 13314525831  7129751699
##  (between_SS / total_SS =  53.6 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

The groupings resulted in 2 cluster sizes of 10678 and 898.

```
# Normalizing the dataset so that no particular attribute
# has more impact on clustering algorithm than others.

normalize <- function(x){
  return ((x-min(x)) / (max(x)-min(x)))
}
```

Normalization of the attributes.

```
df6$ProductRelated<- normalize(df6$ProductRelated)
df6$ProductRelated_Duration<- normalize(df6$ProductRelated_Duration)
df6$PageValues<- normalize(df6$PageValues)
head(df6)
```

```
##    ProductRelated ProductRelated_Duration PageValues
##             <num>                   <num>      <num>
## 1:    0.001418440            1.563122e-05          0
## 2:    0.002836879            1.016029e-03          0
## 3:    0.001418440            0.000000e+00          0
## 4:    0.002836879            5.731448e-05          0
## 5:    0.014184397            9.824223e-03          0
## 6:    0.026950355            2.426226e-03          0
```

Elbow Method

```
install.packages("purrr")
```

```
## Installing package into '/home/mary/R/x86_64-pc-linux-gnu-library/4.0'
## (as 'lib' is unspecified)
```

```
library(purrr)
```

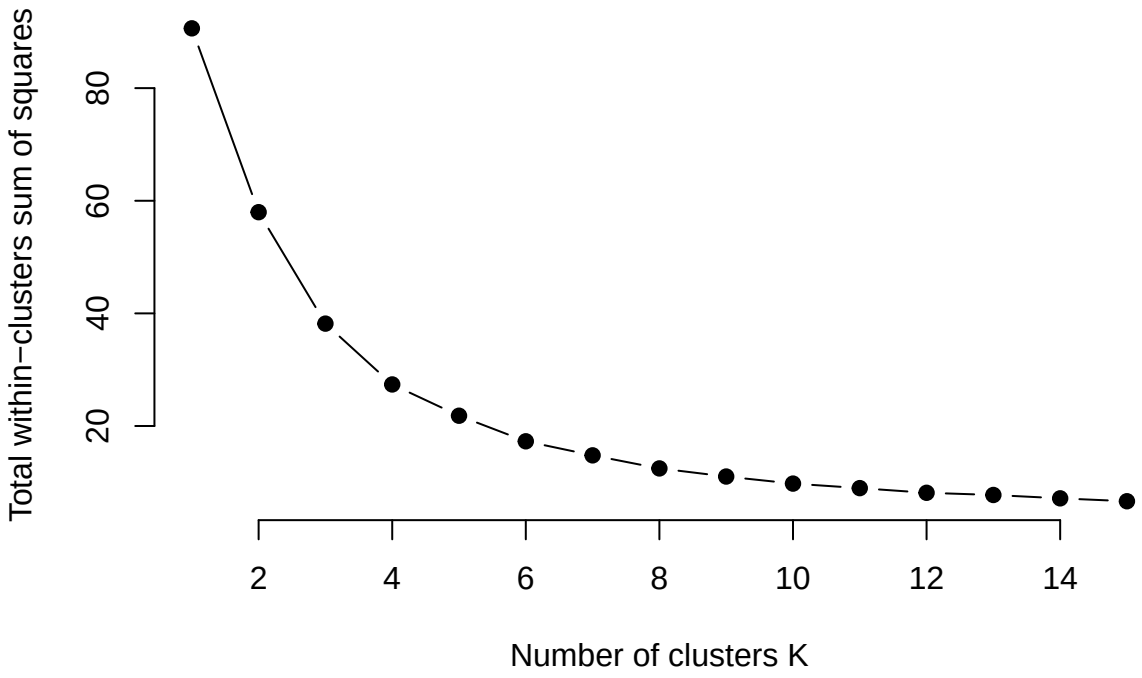
```
##
## Attaching package: 'purrr'
```

```
## The following object is masked from 'package:data.table':
##
##     transpose
```

```
set.seed(123)

# function to compute total within-cluster sum of square
wss <- function(k) {
  kmeans(df6, k, nstart = 10 )$tot.withinss
}

# Compute and plot wss for k = 1 to k = 15
k.values <- 1:15

# extract wss for 2-15 clusters
wss_values <- map_dbl(k.values, wss)
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations
```

```
plot(k.values, wss_values,
       type="b", pch = 19, frame = FALSE,
       xlab="Number of clusters K",
       ylab="Total within-clusters sum of squares")
```



The results suggest that 4 is the optimal number of clusters as it appears to be the bend in the knee (or elbow).

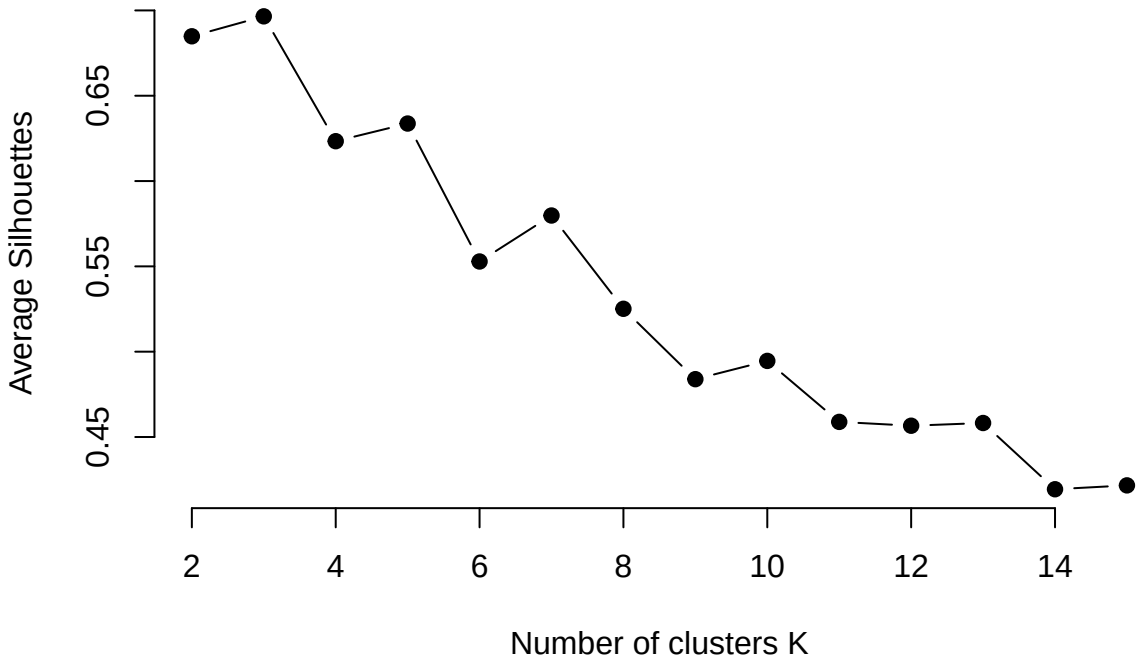
Average Silhouette Method

```
# function to compute average silhouette for k clusters
avg_sil <- function(k) {
  km.res <- kmeans(df6, centers = k, nstart = 25)
  ss <- silhouette(km.res$cluster, dist(df6))
  mean(ss[, 3])
}

# Compute and plot wss for k = 2 to k = 15
k.values <- 2:15

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

```
## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

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



The results show that 2 clusters maximize the average silhouette values with 4 clusters coming in as second optimal number of clusters.

Gap Statistic Method

```
# compute gap statistic
set.seed(123)
gap_stat <- clusGap(df6, FUN = kmeans, nstart = 25,
                    K.max = 10, B = 50)
```

```
## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

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## Warning: did not converge in 10 iterations

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## Warning: did not converge in 10 iterations

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## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

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## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

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## Warning: did not converge in 10 iterations

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## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations
```

```
## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

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## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: Quick-TRANSfer stage steps exceeded maximum (= 578800)

## Warning: did not converge in 10 iterations
```

```
# Print the result
print(gap_stat, method = "firstmax")
```

```
## Clustering Gap statistic ["clusGap"] from call:
## clusGap(x = df6, FUNcluster = kmeans, K.max = 10, B = 50, nstart = 25)
## B=50 simulated reference sets, k = 1..10; spaceH0="scaledPCA"
##  --> Number of clusters (method 'firstmax'): 10
##           logW   E.logW      gap      SE.sim
##  [1,] 5.452189 7.583212 2.131023 0.002348894
##  [2,] 5.220775 7.377820 2.157045 0.002402954
##  [3,] 5.027489 7.237377 2.209888 0.002511151
##  [4,] 4.867465 7.117976 2.250512 0.002901250
##  [5,] 4.792702 7.054642 2.261940 0.002552383
##  [6,] 4.653237 6.992177 2.338940 0.002359896
##  [7,] 4.560812 6.940514 2.379703 0.002270059
##  [8,] 4.485721 6.887907 2.402185 0.002498968
##  [9,] 4.411582 6.847278 2.435696 0.002256017
## [10,] 4.347283 6.808254 2.460971 0.002215195
```

The gap statistic and standard error of the output

Extracting Results

```
# Compute k-means clustering with k = 4
set.seed(123)
final <- kmeans(df6, 4, nstart = 25)
print(final)
```

```
## K-means clustering with 4 clusters of sizes 644, 9039, 180, 1713
##
## Cluster means:
##   ProductRelated ProductRelated_Duration  PageValues
## 1     0.04315449              0.01868728 0.189241642
## 2     0.02607644              0.01089029 0.006065891
## 3     0.39174153              0.16665644 0.012250214
## 4     0.12800652              0.05246730 0.012736389
##
## Clustering vector:
##     [1] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2
##    [37] 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2
##    [73] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2
##   [109] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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##   [181] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##   [217] 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 1 2 2 2 2 1
##   [253] 2 2 2 2 2 4 2 2 2 2 2 2 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2
##   [289] 2 2 2 4 2 2 2 2 2 2 2 4 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##   [325] 2 2 2 2 2 2 4 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 4
##   [361] 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2
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##   [757] 2 4 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 1
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##  [3421] 2 2 2 2 2 2 2 2 2 1 2 2 4 2 2 2 4 2 4 2 2 2 2 2 2 3 2 2 2 2 2 1 4 2 2 2 2 2
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##  [3565] 2 2 2 2 4 2 2 2 4 1 4 4 4 1 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 4 2 2 1 2 4
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##  (between_SS / total_SS =  69.8 %)
##
## Available components:
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The results are displayed in 4 clusters.

```
# Applying the K-means clustering algorithm with no. of centroids(k)=3
result<- kmeans(df6,3)
# Previewing the no. of records in each cluster
result$size
```

```
## [1]   658 10032   886
```

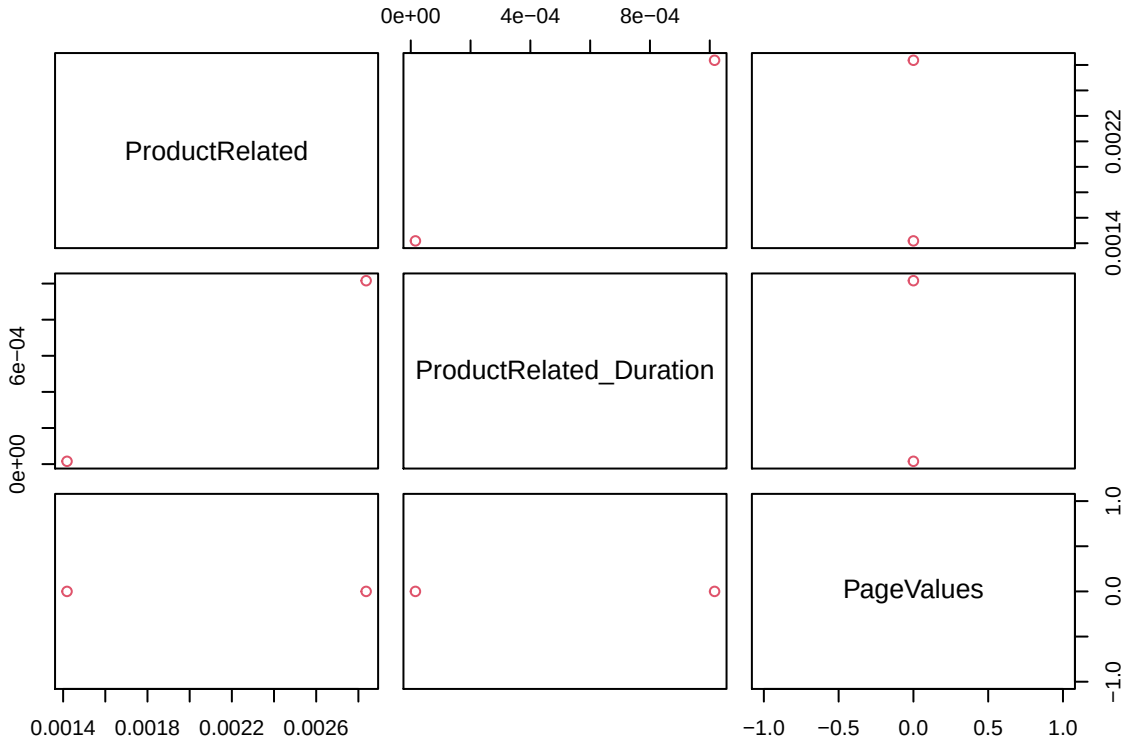
```
# Acquiring the value of cluster center datapoint value(3 centers for k=3)

result$centers
```

```
##   ProductRelated ProductRelated_Duration  PageValues
## 1     0.04379055              0.01881582 0.187263442
## 2     0.03311248              0.01379485 0.006538671
## 3     0.21702768              0.08981467 0.013440616
```

```
# Verifying the results of clustering
# ---
#
par(mfrow = c(2,2), mar = c(5,4,2,2))

# Plotting to see how  data points have been distributed in clusters
plot(df6[c(1,2)], col = result$cluster)
```




```
# Getting the cluster vector that shows the cluster
result$cluster
```

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```
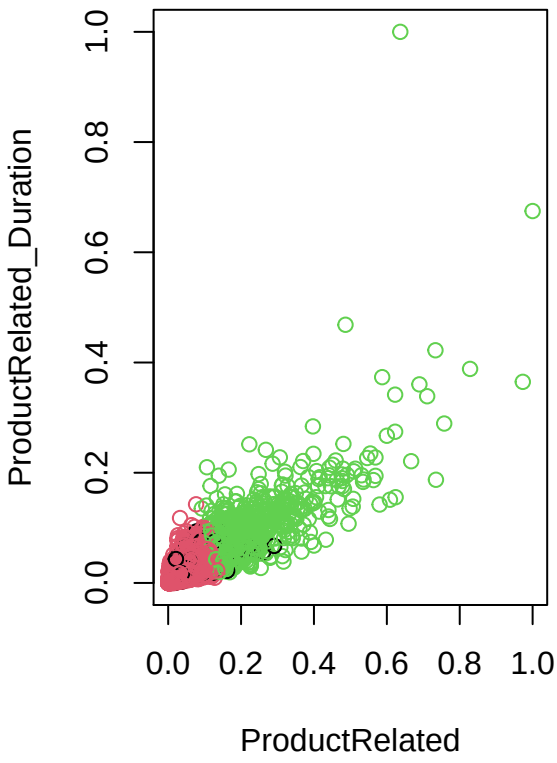
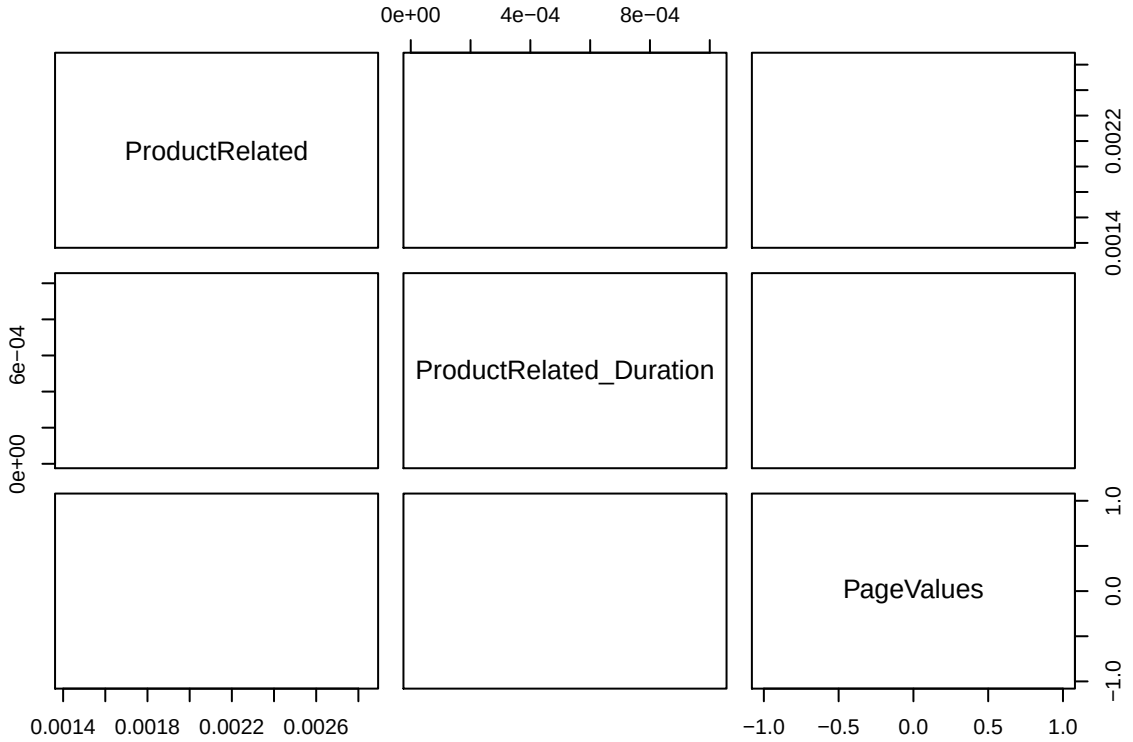

```r
# Visualizing the  clustering results

par(mfrow = c(1,2), mar = c(5,4,2,2))

# Plotting to see how  data points have been distributed in clusters

plot(df6[,1:2], col = result$cluster)
```




```
# Plotting to see how the data points have been distributed

df6.class<- df6[, "PageValues"]
plot(df6[c(1,2)], col = df6.class)
```

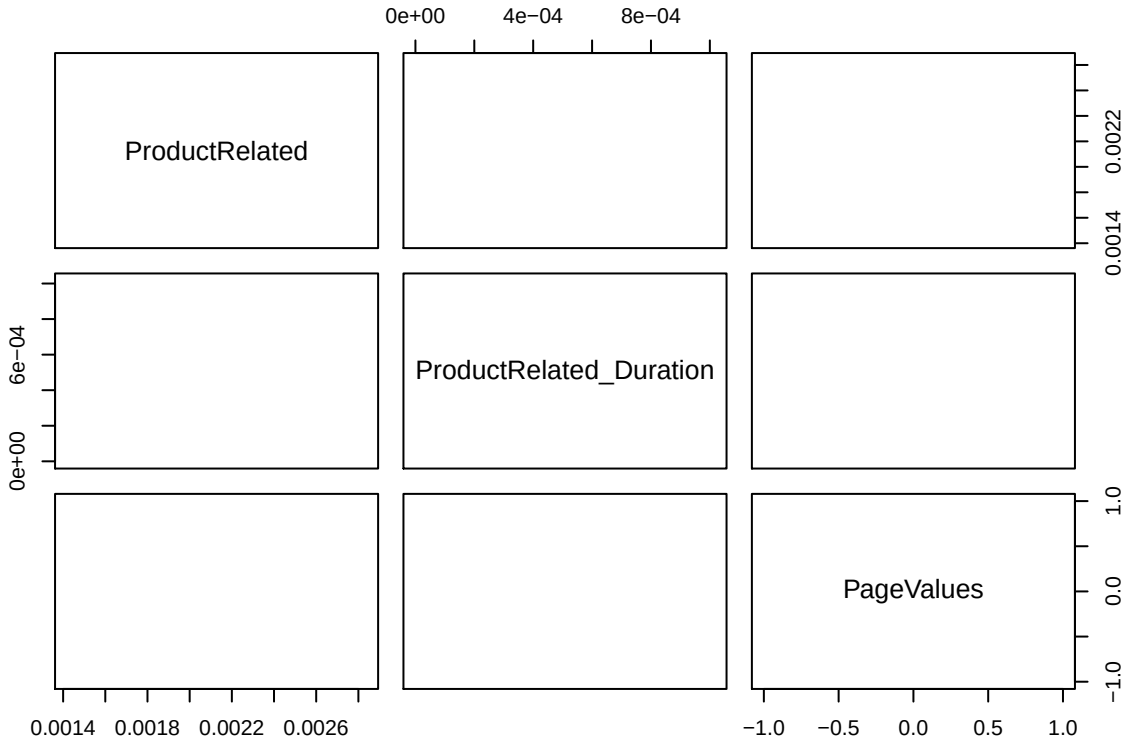
```
## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character
```

```
## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character
```

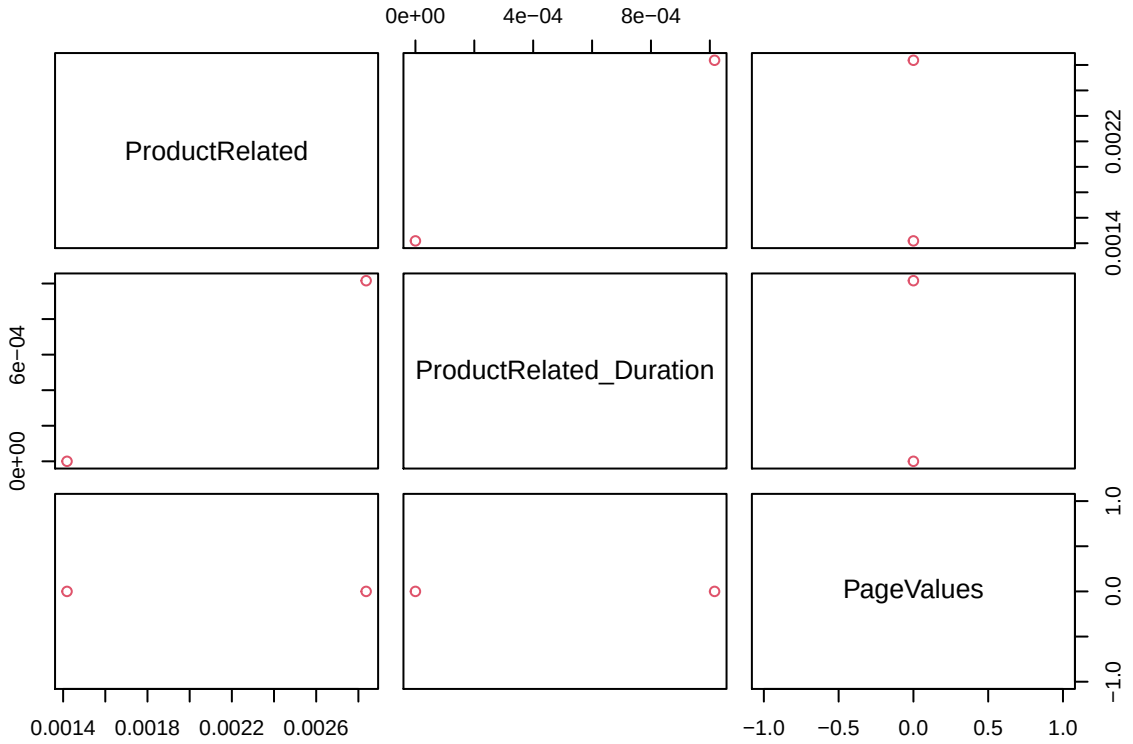


```
plot(df6[c(2,3)], col = df6.class)
```

```
## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character

## Warning in plot.xy(xy.coords(x, y), type = type, ...): supplied color is neither
## numeric nor character

## Warning in plot.xy(xy, type, ...): supplied color is neither numeric nor
## character
```




```
plot(df6[c(2,3)], col = result$cluster)
```



Hierachical Clustering

```
# we start by scaling the data using the R function scale()
df6 <- scale(df6)
head(df6)
```

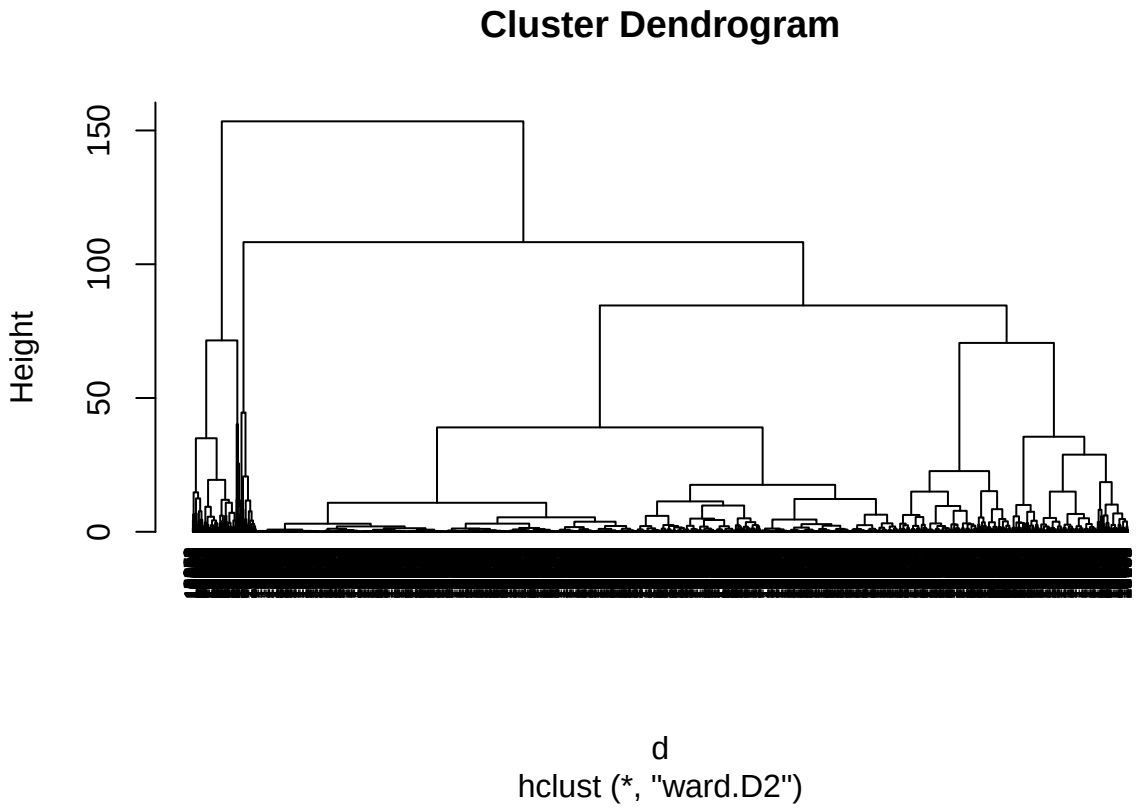
```
##      ProductRelated ProductRelated_Duration PageValues
## [1,]     -0.7232527              -0.6522699 -0.3284082
## [2,]     -0.7011322              -0.6194514 -0.3284082
## [3,]     -0.7232527              -0.6527827 -0.3284082
## [4,]     -0.7011322              -0.6509024 -0.3284082
## [5,]     -0.5241685              -0.3304950 -0.3284082
## [6,]     -0.3250844              -0.5731893 -0.3284082
```

```
# Using the dist() function to compute the Euclidean distance

d <- dist(df6, method = "euclidean")
```

d will be the first argument in the hclust() function dissimilarity matrix

```
# We then hierarchical clustering using the Ward's method

res.hc <- hclust(d, method = "ward.D2" )
```

```r
# Plotting the obtained dendrogram

plot(res.hc, cex = 0.6, hang = -1)
```



5. FOLLOW UP QUESTIONS

At this point, we can refine our question or collect new data, all in an iterative process to get at the truth.

a). Did we have the right data? Yes

b). Do we need other data to answer our question?Yes, More conclusive features should be included.

c). Did we have the right question? Yes