Supermarket_Sales_Unsupervised_Learning_Algorithms

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```
#Setting our working directory.
setwd("C://Users//Revolve//Documents//Basics Practice")
```

Project Overview

Carrefour means "crossroads" in French and is a multinational retailer headquartered in France. Majid Al Futtaim was the first to introduce the supermarkets in Africa, Asia and the Middle East. To date, Carrefour operates in more than 30 countries across these continents.

In Kenya, Carrefour launched its operations in 2016 and currently operates 7 stores located at Two Rivers Mall, The Hub in Karen, Thika Road Mall, The Junction Mall, Sarit Centre, Village Market store and Galleria Mall respectively.

##Specifying the Research question You are a Data analyst at Carrefour Kenya and are currently undertaking a project that will inform the marketing department on the most relevant marketing strategies that will result in the highest no. of sales (total price including tax). Your project has been divided into four parts where you'll explore a recent marketing dataset by performing various unsupervised learning techniques and later providing recommendations based on your insights.

Defining the Metric of Success

We should be able to draw meaningful insights by performing various unsupervised learning techniques and provide effective reommendations to be used by the marketing department.

Experimental Design

- Business Understanding.
- Data Understanding
- Data Analysis
- Applying the unsupervised learning algorithms
- Conclusion

Part 1: Dimensionality Reduction

This section of the project entails reducing your dataset to a low dimensional dataset using the t-SNE algorithm or PCA. You will be required to perform your analysis and provide insights gained from your analysis.

Part 2: Feature Selection

This section requires you to perform feature selection through the use of the unsupervised learning methods learned earlier this week. You will be required to perform your analysis and provide insights on the features that contribute the most information to the dataset.

Part 3: Association Rules

This section will require that you create association rules that will allow you to identify relationships between variables in the dataset. You are provided with a separate dataset that comprises groups of items that will be associated with others. Just like in the other sections, you will also be required to provide insights for your analysis.

Part 4: Anomaly Detection

You have also been requested to check whether there are any anomalies in the given sales dataset. The objective of this task being fraud detection.

Data Understanding

Loading our dataset

```
#Dataset 1
data_1 <- read.csv('Supermarket_Dataset_1 - Sales Data.csv')
print(head(data_1, 5)) #Previewing the first five records
```

```
##    Invoice.ID Branch Customer.type Gender           Product.line Unit.price
## 1 750-67-8428      A        Member Female      Health and beauty      74.69
## 2 226-31-3081      C        Normal Female Electronic accessories      15.28
## 3 631-41-3108      A        Normal   Male     Home and lifestyle      46.33
## 4 123-19-1176      A        Member   Male      Health and beauty      58.22
## 5 373-73-7910      A        Normal   Male      Sports and travel      86.31
##   Quantity     Tax      Date  Time     Payment   cogs gross.margin.percentage
## 1        7 26.1415  1/5/2019 13:08     Ewallet 522.83                4.761905
## 2        5  3.8200  3/8/2019 10:29        Cash  76.40                4.761905
## 3        7 16.2155  3/3/2019 13:23 Credit card 324.31                4.761905
## 4        8 23.2880 1/27/2019 20:33     Ewallet 465.76                4.761905
## 5        7 30.2085  2/8/2019 10:37     Ewallet 604.17                4.761905
##   gross.income Rating    Total
## 1      26.1415    9.1 548.9715
## 2       3.8200    9.6  80.2200
## 3      16.2155    7.4 340.5255
## 4      23.2880    8.4 489.0480
## 5      30.2085    5.3 634.3785
```

```
print(tail(data_1,5)) #Previewing the last five records
```

```
##       Invoice.ID Branch Customer.type Gender        Product.line Unit.price
## 996  233-67-5758      C        Normal   Male   Health and beauty      40.35
## 997  303-96-2227      B        Normal Female  Home and lifestyle      97.38
## 998  727-02-1313      A        Member   Male  Food and beverages      31.84
## 999  347-56-2442      A        Normal   Male  Home and lifestyle      65.82
## 1000 849-09-3807      A        Member Female Fashion accessories      88.34
##      Quantity     Tax      Date  Time Payment   cogs gross.margin.percentage
## 996         1  2.0175 1/29/2019 13:46 Ewallet  40.35                4.761905
```

```
## 997        10 48.6900  3/2/2019 17:16 Ewallet 973.80               4.761905
## 998         1  1.5920  2/9/2019 13:22    Cash  31.84               4.761905
## 999         1  3.2910 2/22/2019 15:33    Cash  65.82               4.761905
## 1000        7 30.9190 2/18/2019 13:28    Cash 618.38               4.761905
##      gross.income Rating     Total
## 996        2.0175    6.2   42.3675
## 997       48.6900    4.4 1022.4900
## 998        1.5920    7.7   33.4320
## 999        3.2910    4.1   69.1110
## 1000      30.9190    6.6  649.2990
```

```
#Dataset 2
data_2 <- read.csv('Supermarket_Sales_Dataset II.csv')
print(head(data_2, 5))#Previewing the first five records
```

```
##           shrimp   almonds    avocado   vegetables.mix green.grapes
## 1        burgers meatballs       eggs
## 2        chutney
## 3         turkey   avocado
## 4  mineral water      milk energy bar whole wheat rice    green tea
## 5 low fat yogurt
##   whole.weat.flour yams cottage.cheese energy.drink tomato.juice low.fat.yogurt
## 1
## 2
## 3
## 4
## 5
##   green.tea honey salad mineral.water salmon antioxydant.juice frozen.smoothie
## 1
## 2
## 3
## 4
## 5
##   spinach olive.oil
## 1              NA
## 2              NA
## 3              NA
## 4              NA
## 5              NA
```

```
print(tail(data_2, 5))#Previewing the last five records
```

```
##        shrimp           almonds     avocado vegetables.mix green.grapes
## 7496   butter        light mayo fresh bread
## 7497  burgers frozen vegetables        eggs   french fries    magazines
## 7498  chicken
## 7499 escalope         green tea
## 7500     eggs   frozen smoothie yogurt cake low fat yogurt
##      whole.weat.flour yams cottage.cheese energy.drink tomato.juice
## 7496
## 7497        green tea
## 7498
## 7499
```

```
## 7500
##      low.fat.yogurt green.tea honey salad mineral.water salmon
## 7496
## 7497
## 7498
## 7499
## 7500
##      antioxydant.juice frozen.smoothie spinach olive.oil
## 7496                                                  NA
## 7497                                                  NA
## 7498                                                  NA
## 7499                                                  NA
## 7500                                                  NA
```

```
#Dataset 3

data_3 <- read.csv('Supermarket_Sales_Forecasting - Sales.csv')
print(head(data_3, 5))  #Previewing the first five records
```

```
##        Date    Sales
## 1  1/5/2019 548.9715
## 2  3/8/2019  80.2200
## 3  3/3/2019 340.5255
## 4 1/27/2019 489.0480
## 5  2/8/2019 634.3785
```

```
print(tail(data_3, 5))  #Previewing the last ten records
```

```
##           Date     Sales
## 996  1/29/2019   42.3675
## 997   3/2/2019 1022.4900
## 998   2/9/2019   33.4320
## 999  2/22/2019   69.1110
## 1000 2/18/2019  649.2990
```

Accessing Basic Information about our datasets

```
#Dataset 1
print(str(data_1))#Returns column names with data types and factors
```

```
## 'data.frame':    1000 obs. of  16 variables:
##  $ Invoice.ID            : chr  "750-67-8428" "226-31-3081" "631-41-3108" "123-19-1176" ...
##  $ Branch                : chr  "A" "C" "A" "A" ...
##  $ Customer.type         : chr  "Member" "Normal" "Normal" "Member" ...
##  $ Gender                : chr  "Female" "Female" "Male" "Male" ...
##  $ Product.line          : chr  "Health and beauty" "Electronic accessories" "Home and lifestyle" "
##  $ Unit.price            : num  74.7 15.3 46.3 58.2 86.3 ...
##  $ Quantity              : int  7 5 7 8 7 7 6 10 2 3 ...
##  $ Tax                   : num  26.14 3.82 16.22 23.29 30.21 ...
##  $ Date                  : chr  "1/5/2019" "3/8/2019" "3/3/2019" "1/27/2019" ...
##  $ Time                  : chr  "13:08" "10:29" "13:23" "20:33" ...
##  $ Payment               : chr  "Ewallet" "Cash" "Credit card" "Ewallet" ...
```

```
##  $ cogs                   : num  522.8 76.4 324.3 465.8 604.2 ...
##  $ gross.margin.percentage: num  4.76 4.76 4.76 4.76 4.76 ...
##  $ gross.income           : num  26.14 3.82 16.22 23.29 30.21 ...
##  $ Rating                 : num  9.1 9.6 7.4 8.4 5.3 4.1 5.8 8 7.2 5.9 ...
##  $ Total                  : num  549 80.2 340.5 489 634.4 ...
## NULL
```

Our first dataset contains sales information of the supermarket. It has 1000 observations and 16 variables, 7 of which are numerical and the rest categorical.Some of our columns have details such as the Customer type, Product line, Product Unit prie, Branch, Quantity, Payment, Time,Rating and Sales Total e.t.c.We can spot some null values in our dataset which we will take care of during our data cleaning.

```
print(str(data_2))#Returns column names with data types and factors
```

```
## 'data.frame':    7500 obs. of  20 variables:
##  $ shrimp           : chr  "burgers" "chutney" "turkey" "mineral water" ...
##  $ almonds          : chr  "meatballs" "" "avocado" "milk" ...
##  $ avocado          : chr  "eggs" "" "" "energy bar" ...
##  $ vegetables.mix   : chr  "" "" "" "whole wheat rice" ...
##  $ green.grapes     : chr  "" "" "" "green tea" ...
##  $ whole.weat.flour : chr  "" "" "" "" ...
##  $ yams             : chr  "" "" "" "" ...
##  $ cottage.cheese   : chr  "" "" "" "" ...
##  $ energy.drink     : chr  "" "" "" "" ...
##  $ tomato.juice     : chr  "" "" "" "" ...
##  $ low.fat.yogurt   : chr  "" "" "" "" ...
##  $ green.tea        : chr  "" "" "" "" ...
##  $ honey            : chr  "" "" "" "" ...
##  $ salad            : chr  "" "" "" "" ...
##  $ mineral.water    : chr  "" "" "" "" ...
##  $ salmon           : chr  "" "" "" "" ...
##  $ antioxydant.juice: chr  "" "" "" "" ...
##  $ frozen.smoothie  : chr  "" "" "" "" ...
##  $ spinach          : chr  "" "" "" "" ...
##  $ olive.oil        : logi  NA NA NA NA NA NA ...
## NULL
```

Our second dataset contains a list of product items. The variables are mostly in string form and one logical variable. There are a couple of null values which we will need to investigate further.

```
print(str(data_3))#Returns column names with data types and factors
```

```
## 'data.frame':    1000 obs. of  2 variables:
##  $ Date : chr  "1/5/2019" "3/8/2019" "3/3/2019" "1/27/2019" ...
##  $ Sales: num  549 80.2 340.5 489 634.4 ...
## NULL
```

The third dataframe consists of 1000 observations and 2 variables. The Date and Sales variables are in character and numerial format.

```
#Checking for unique values in ur dataset

print(sapply(data_1, function(x) length(unique(x))))#checking for number of unique values in our datase
```

```
##              Invoice.ID                  Branch           Customer.type
##                    1000                       3                       2
##                  Gender            Product.line              Unit.price
##                       2                       6                     943
##                Quantity                     Tax                    Date
##                      10                     990                      89
##                    Time                 Payment                    cogs
##                     506                       3                     990
## gross.margin.percentage            gross.income                  Rating
##                       1                     990                      61
##                   Total
##                     990
```

```
print(sapply(data_2, function(x) length(unique(x))))#checking for number of unique values in our datase
```

```
##            shrimp           almonds           avocado    vegetables.mix
##               115               118               116               115
##      green.grapes  whole.weat.flour             yams    cottage.cheese
##               111               107               103                99
##      energy.drink      tomato.juice    low.fat.yogurt         green.tea
##                89                81                67                51
##             honey             salad     mineral.water            salmon
##                43                29                19                 8
## antioxydant.juice   frozen.smoothie           spinach         olive.oil
##                 3                 3                 3                 1
```

```
print(sapply(data_3, function(x) length(unique(x))))#checking for number of unique values in our datase
```

```
##  Date Sales
##    89   990
```

##Data cleaning

We will now go through some basic data preparation operations such as identifying anomalies, missing data, duplicated data.

We will import some packages that will be useful in the process.

```
library(funModeling)
```

```
## Loading required package: Hmisc
```

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

```
## Loading required package: survival
```

```
## Loading required package: Formula
```

```
## Loading required package: ggplot2

##
## Attaching package: 'Hmisc'

## The following objects are masked from 'package:base':
##
##     format.pval, units

## funModeling v.1.9.4 :)
## Examples and tutorials at livebook.datascienceheroes.com
##  / Now in Spanish: librovivodecienciadedatos.ai
```

```
library(dplyr)
```

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

## The following objects are masked from 'package:Hmisc':
##
##     src, summarize

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

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

```
library(tidyr)
library(tidyr)
library(ggplot2)
library(pander)
library(forcats)
library(tidyverse)
```

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

## v tibble  3.1.3     v purrr   0.3.4
## v readr   2.0.1     v stringr 1.4.0

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

Identifying Missing Values

We will profile our data set to find missing values, zeros, unique values and filter or remove where appropriate.

```
df_status(data_1)#function can help us by showing these numbers in relative and percentage values. It a
```

```
##                    variable q_zeros p_zeros q_na p_na q_inf p_inf      type
## 1                Invoice.ID       0       0    0    0     0     0 character
## 2                    Branch       0       0    0    0     0     0 character
## 3             Customer.type       0       0    0    0     0     0 character
## 4                    Gender       0       0    0    0     0     0 character
## 5              Product.line       0       0    0    0     0     0 character
## 6                Unit.price       0       0    0    0     0     0   numeric
## 7                  Quantity       0       0    0    0     0     0   integer
## 8                       Tax       0       0    0    0     0     0   numeric
## 9                      Date       0       0    0    0     0     0 character
## 10                     Time       0       0    0    0     0     0 character
## 11                  Payment       0       0    0    0     0     0 character
## 12                     cogs       0       0    0    0     0     0   numeric
## 13 gross.margin.percentage       0       0    0    0     0     0   numeric
## 14             gross.income       0       0    0    0     0     0   numeric
## 15                   Rating       0       0    0    0     0     0   numeric
## 16                    Total       0       0    0    0     0     0   numeric
##    unique
## 1    1000
## 2       3
## 3       2
## 4       2
## 5       6
## 6     943
## 7      10
## 8     990
## 9      89
## 10    506
## 11      3
## 12    990
## 13      1
## 14    990
## 15     61
## 16    990
```

There are no null values or zeros in our first dataset

```
df_status(data_2)#function can help us by showing these numbers in relative and percentage values. It a
```

```
##              variable q_zeros p_zeros q_na p_na q_inf p_inf      type unique
## 1              shrimp       0       0    0    0     0     0 character    115
## 2             almonds       0       0    0    0     0     0 character    118
## 3             avocado       0       0    0    0     0     0 character    116
## 4     vegetables.mix       0       0    0    0     0     0 character    115
## 5       green.grapes       0       0    0    0     0     0 character    111
## 6   whole.weat.flour       0       0    0    0     0     0 character    107
## 7               yams       0       0    0    0     0     0 character    103
## 8     cottage.cheese       0       0    0    0     0     0 character     99
## 9       energy.drink       0       0    0    0     0     0 character     89
## 10      tomato.juice       0       0    0    0     0     0 character     81
```

```
## 11    low.fat.yogurt       0       0    0    0     0     0 character     67
## 12         green.tea       0       0    0    0     0     0 character     51
## 13             honey       0       0    0    0     0     0 character     43
## 14             salad       0       0    0    0     0     0 character     29
## 15     mineral.water       0       0    0    0     0     0 character     19
## 16            salmon       0       0    0    0     0     0 character      8
## 17 antioxydant.juice       0       0    0    0     0     0 character      3
## 18   frozen.smoothie       0       0    0    0     0     0 character      3
## 19           spinach       0       0    0    0     0     0 character      3
## 20         olive.oil       0       0 7500  100     0     0   logical      0
```

There are 7500 null values. They seem like quite a number so we will have to investigate them fully by trying to understand the nature of the olive oil column

```
df_status(data_3)#function can help us by showing these numbers in relative and percentage values. It a
```

```
##   variable q_zeros p_zeros q_na p_na q_inf p_inf      type unique
## 1     Date       0       0    0    0     0     0 character     89
## 2    Sales       0       0    0    0     0     0   numeric    990
```

The third dataset has no null values as denoted by the 0 in q-na.

```
data_2$olive.oil #Investigating the column with null values.
```

```
##    [1] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##   [25] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##   [49] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##   [73] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##   [97] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [121] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [145] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [169] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [193] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [217] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [241] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [265] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [289] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [313] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [337] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [361] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [385] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [409] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [433] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [457] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [481] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [505] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [529] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [553] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [577] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [601] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [625] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [649] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
```

```
##  [673] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [697] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [721] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [745] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [769] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [793] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [817] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [841] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [865] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [889] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [913] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [937] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [961] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##  [985] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1009] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1033] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1057] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1081] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1105] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1129] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1153] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1177] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1201] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1225] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1249] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1273] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1297] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1321] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1345] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1369] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1393] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1417] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1441] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1465] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1489] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1513] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1537] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1561] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1585] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1609] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1633] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1657] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1681] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1705] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [1729] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
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```
data_2 <- na.omit(data_2) #We will drop the null values in the data_2 dataset
```

```
sum(is.na(data_2))
```

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

```
#data_2$olive.oil <- lapply(data_2$olive.oil, as.factor) #changing dtype of olive oil to match the rest
```

Let's then proceed to Identify duplicated records

```
print(sum(duplicated(data_1))) #Prints out the sum of duplicated records in dataset_1
```

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

```
print(sum(duplicated(data_2))) #Prints out the sum of duplicated records in dataset_2
```

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

```
print(sum(duplicated(data_3))) #Prints out the sum of duplicated records in dataset_3
```

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

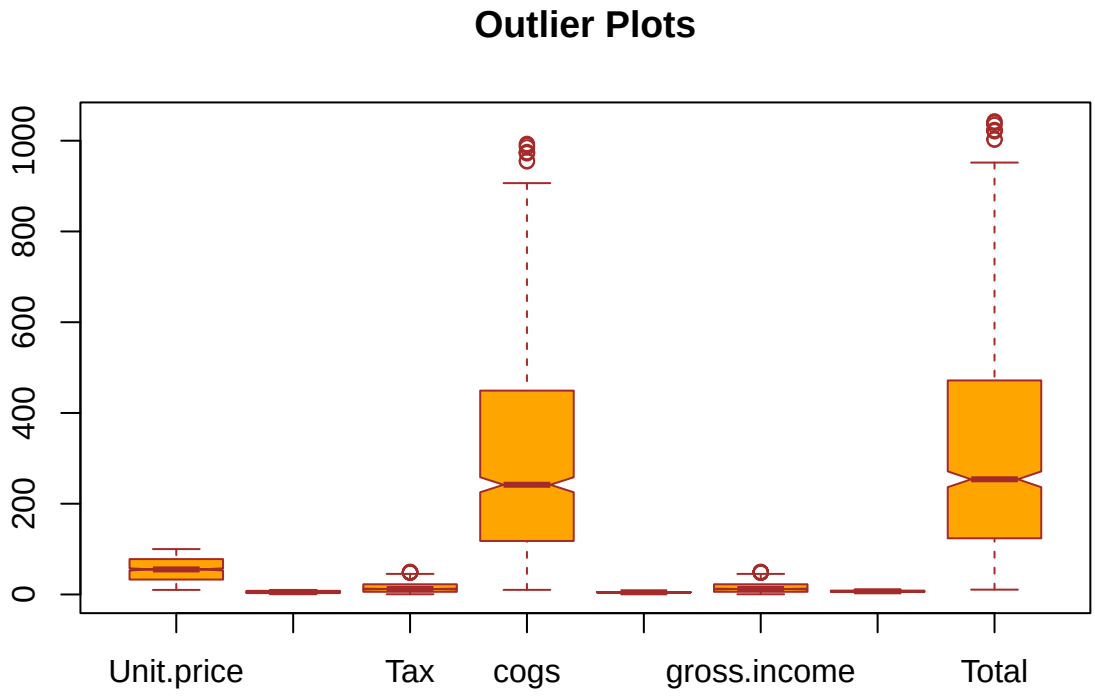
There are no duplicated records in our datasets.

Identifying Outliers

We will use boxplots to visualize our outliers

```
#Dataset 1 outliers

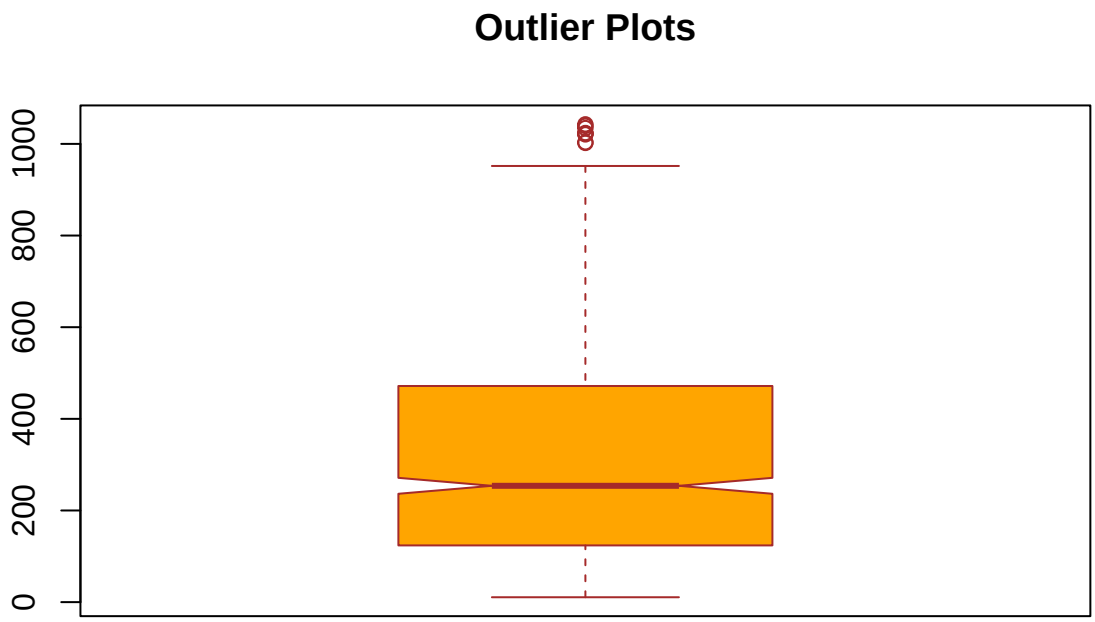
num_v <- select_if(data_1, is.numeric)# We will select the numerical variables
boxplot(num_v,
main = "Outlier Plots",
col = "orange",
border = "brown",
horizontal = FALSE,
notch = TRUE)
```



There are outliers in the cogs and total columns.

```
#Dataset 3 outliers

num_v_2 <- select_if(data_3, is.numeric)# We will select the numerical variables
boxplot(num_v_2,
main = "Outlier Plots",
col = "orange",
border = "brown",
horizontal = FALSE,
notch = TRUE)
```



The sales column appears to have outliers. We will not be dropping these in the meantime as they might be cause variations in our analysis and might not really be outliers in supermarket sales.

Exploratory Data Analysis

Measures of Central Tendancy

```
summary(data_1)#Displays the statistical summaries of our dataset including the min.max, median, mean a
```

```
##   Invoice.ID          Branch           Customer.type        Gender
##  Length:1000        Length:1000        Length:1000        Length:1000
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##  Product.line         Unit.price       Quantity          Tax
##  Length:1000        Min.   :10.08   Min.   : 1.00   Min.   : 0.5085
##  Class :character   1st Qu.:32.88   1st Qu.: 3.00   1st Qu.: 5.9249
##  Mode  :character   Median :55.23   Median : 5.00   Median :12.0880
##                     Mean   :55.67   Mean   : 5.51   Mean   :15.3794
##                     3rd Qu.:77.94   3rd Qu.: 8.00   3rd Qu.:22.4453
##                     Max.   :99.96   Max.   :10.00   Max.   :49.6500
##      Date               Time             Payment               cogs
##  Length:1000        Length:1000        Length:1000        Min.   : 10.17
```

```
##  Class :character   Class :character   Class :character   1st Qu.:118.50
##  Mode  :character   Mode  :character   Mode  :character   Median :241.76
##                                                          Mean   :307.59
##                                                          3rd Qu.:448.90
##                                                          Max.   :993.00
##  gross.margin.percentage  gross.income         Rating           Total
##  Min.   :4.762           Min.   : 0.5085   Min.   : 4.000   Min.   :  10.68
##  1st Qu.:4.762           1st Qu.: 5.9249   1st Qu.: 5.500   1st Qu.: 124.42
##  Median :4.762           Median :12.0880   Median : 7.000   Median : 253.85
##  Mean   :4.762           Mean   :15.3794   Mean   : 6.973   Mean   : 322.97
##  3rd Qu.:4.762           3rd Qu.:22.4453   3rd Qu.: 8.500   3rd Qu.: 471.35
##  Max.   :4.762           Max.   :49.6500   Max.   :10.000   Max.   :1042.65
```

Measures of Dispersion

```
library(moments)

#Skewness

skewness(num_v)#On our numerical variables
```

```
##              Unit.price                Quantity                     Tax
##             0.007066827             0.012921628             0.891230392
##                    cogs gross.margin.percentage            gross.income
##             0.891230392                     NaN             0.891230392
##                  Rating                   Total
##             0.008996129             0.891230392
```

```
kurtosis(num_v)
```

```
##              Unit.price                Quantity                     Tax
##                1.781499                1.784528                2.912530
##                    cogs gross.margin.percentage            gross.income
##                2.912530                     NaN                2.912530
##                  Rating                   Total
##                1.848169                2.912530
```

The positive values skewness indicate that our data is skewed to the right means that the right tail is long relative to the left tail.

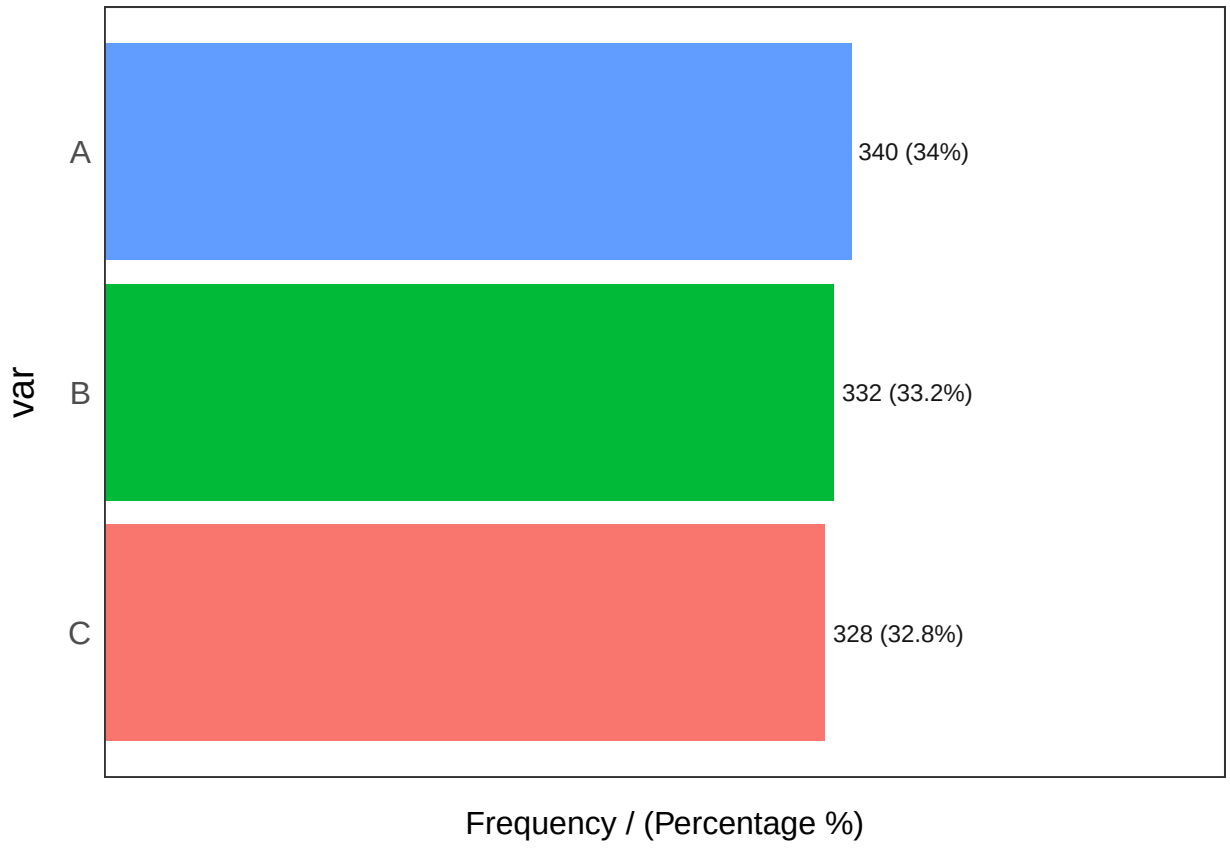
Univariate Analysis

Profiling our categorical variables

Branch

```
freq(data=data_1$Branch)
```

```
## Warning: `guides(<scale> = FALSE)` is deprecated. Please use `guides(<scale> =
## "none")` instead.
```



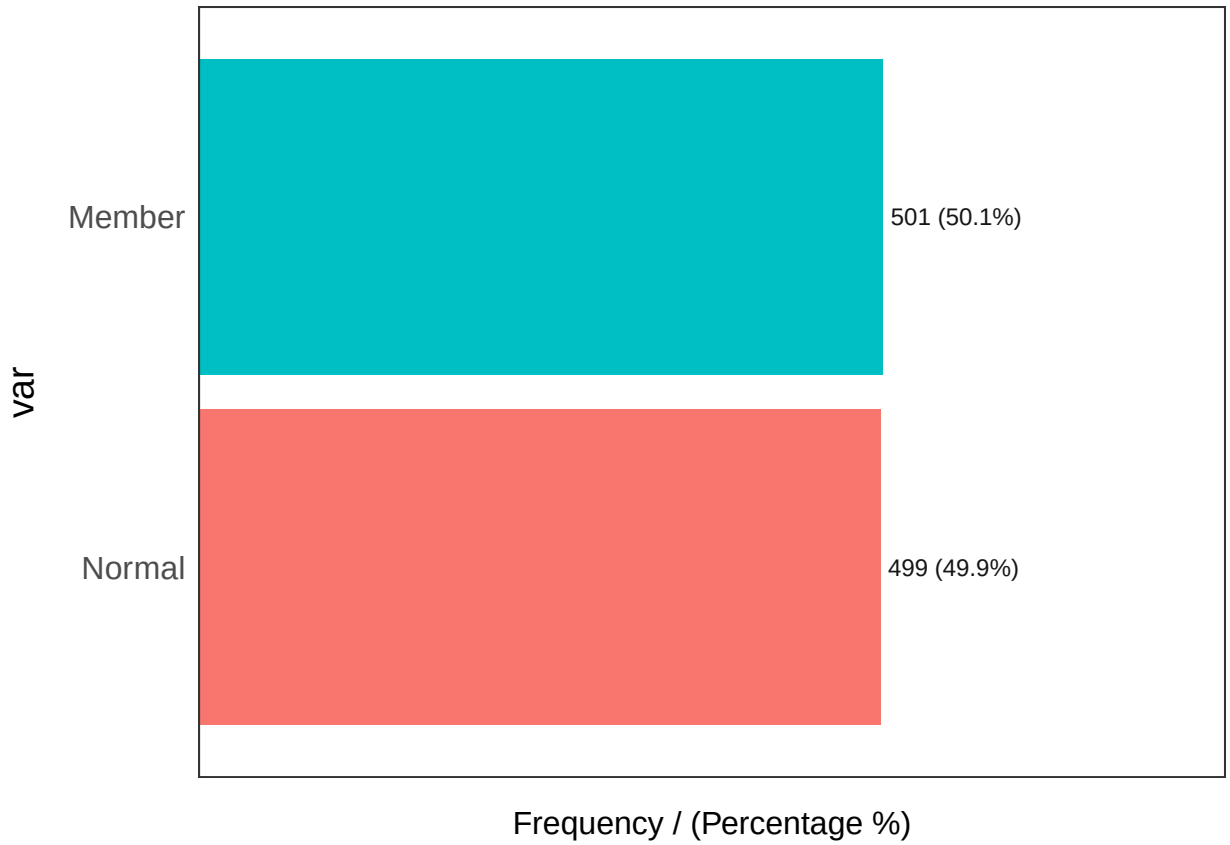

```
##   var frequency percentage cumulative_perc
## 1   A       340       34.0            34.0
## 2   B       332       33.2            67.2
## 3   C       328       32.8           100.0
```

There are three Carrefour Branches A,B and C. In the period of data collection Branch A had more customers than B and C though the difference margin is 0.8% and 0.4%.

Customer Type

```
freq(data=data_1$Customer.type)
```

```
## Warning: `guides(<scale> = FALSE)` is deprecated. Please use `guides(<scale> =
## "none")` instead.
```



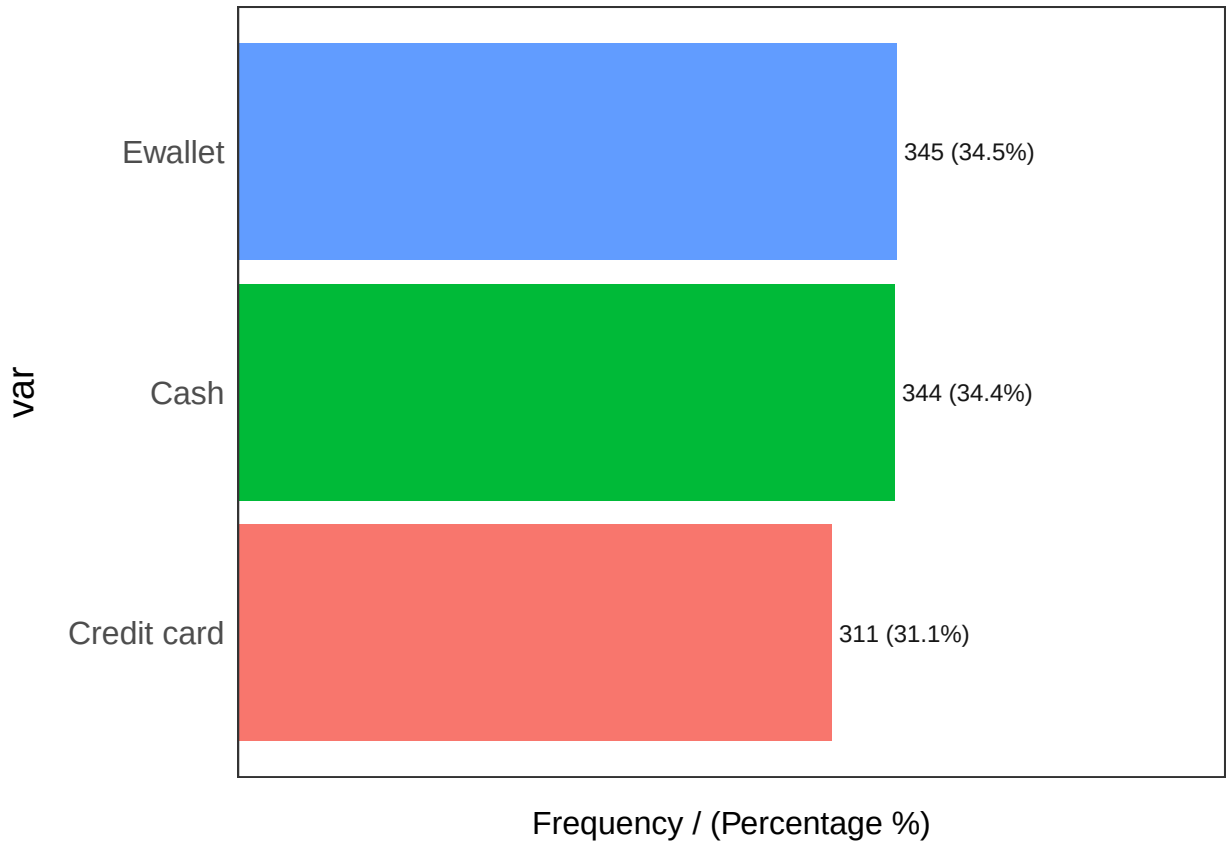

```
##      var frequency percentage cumulative_perc
## 1 Member       501       50.1            50.1
## 2 Normal       499       49.9           100.0
```

The percentage of Member and Normal customers are almost similar with "Member" customers being more at 50.1%

Payment Method

```
freq(data=data_1$Payment)
```

```
## Warning: `guides(<scale> = FALSE)` is deprecated. Please use `guides(<scale> =
## "none")` instead.
```



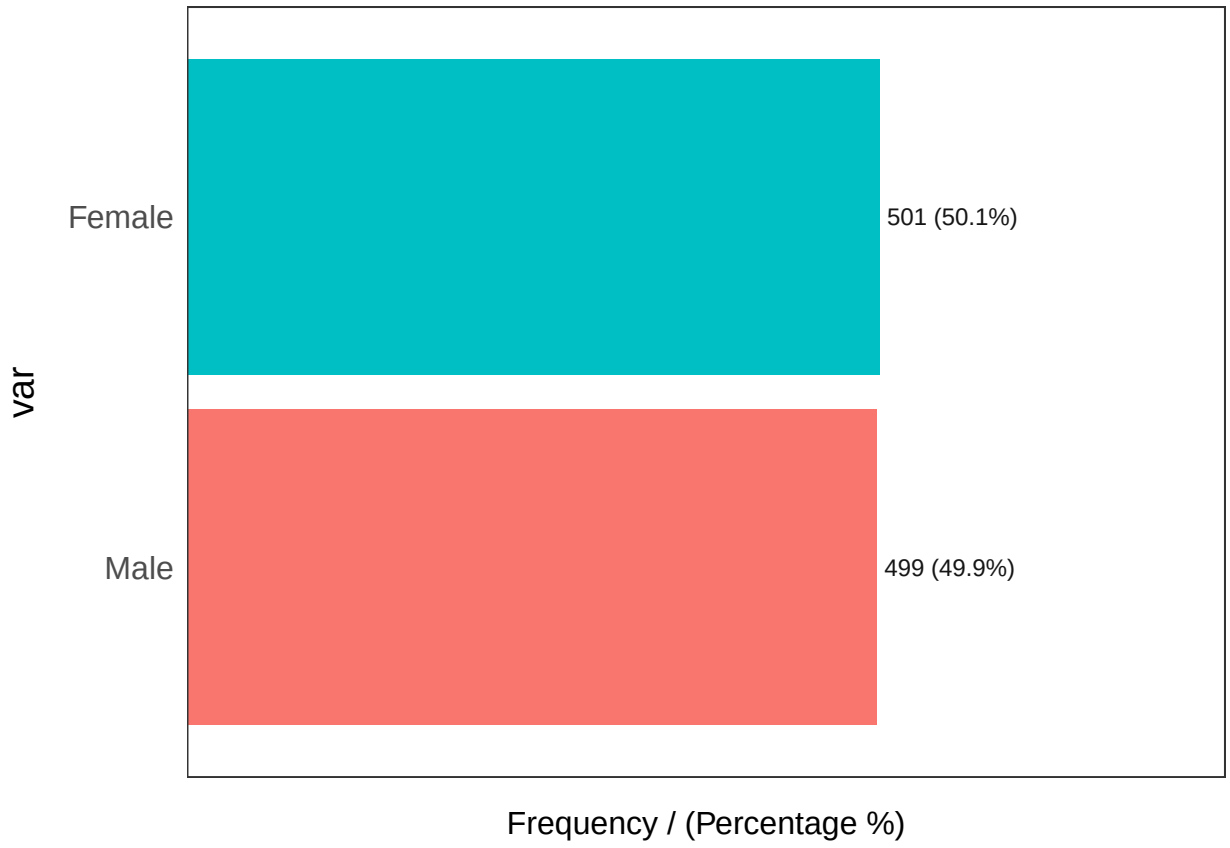

```
##           var frequency percentage cumulative_perc
## 1     Ewallet       345       34.5            34.5
## 2        Cash       344       34.4            68.9
## 3 Credit card       311       31.1           100.0
```

E wallet was the most preferred method of payment being used 34.5% of the time.Cash was used 34.4% of the time and Credit card 31.1%.

Gender

```
freq(data=data_1$Gender)
```

```
## Warning: `guides(<scale> = FALSE)` is deprecated. Please use `guides(<scale> =
## "none")` instead.
```



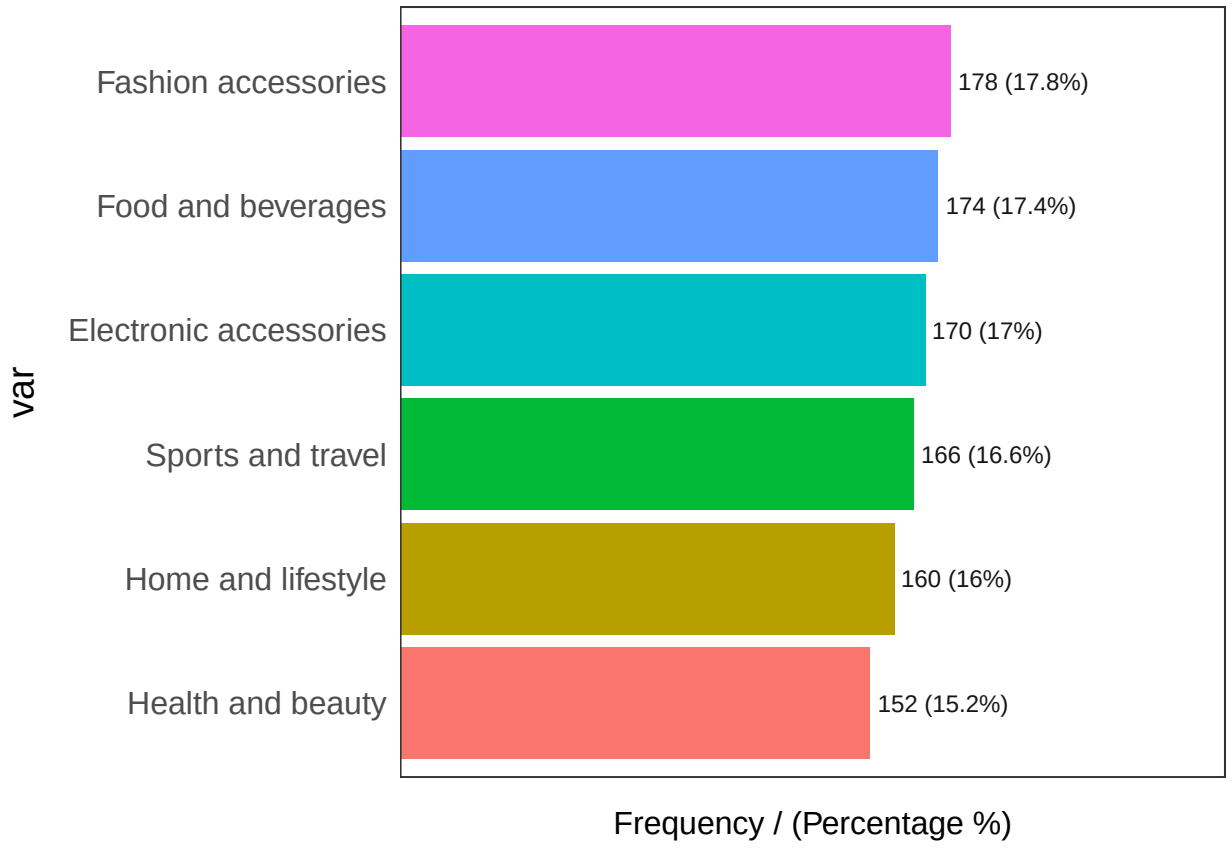

```
##      var frequency percentage cumulative_perc
## 1 Female       501       50.1            50.1
## 2   Male       499       49.9           100.0
```

Female customers form the majority of customers(50.1%) though the number does not differ greatly with male customers who are 49.9% of the customer base.

Product Line

```
freq(data=data_1$Product.line)
```

```
## Warning: `guides(<scale> = FALSE)` is deprecated. Please use `guides(<scale> =
## "none")` instead.
```




```
##                       var frequency percentage cumulative_perc
## 1    Fashion accessories       178       17.8            17.8
## 2     Food and beverages       174       17.4            35.2
## 3 Electronic accessories       170       17.0            52.2
## 4      Sports and travel       166       16.6            68.8
## 5     Home and lifestyle       160       16.0            84.8
## 6      Health and beauty       152       15.2           100.0
```

The top three most popular product line are Fashion Accessories,Food and Beverages and Electronic Accessories. The least popular product is Health and Beauty products with 15.2% orders.

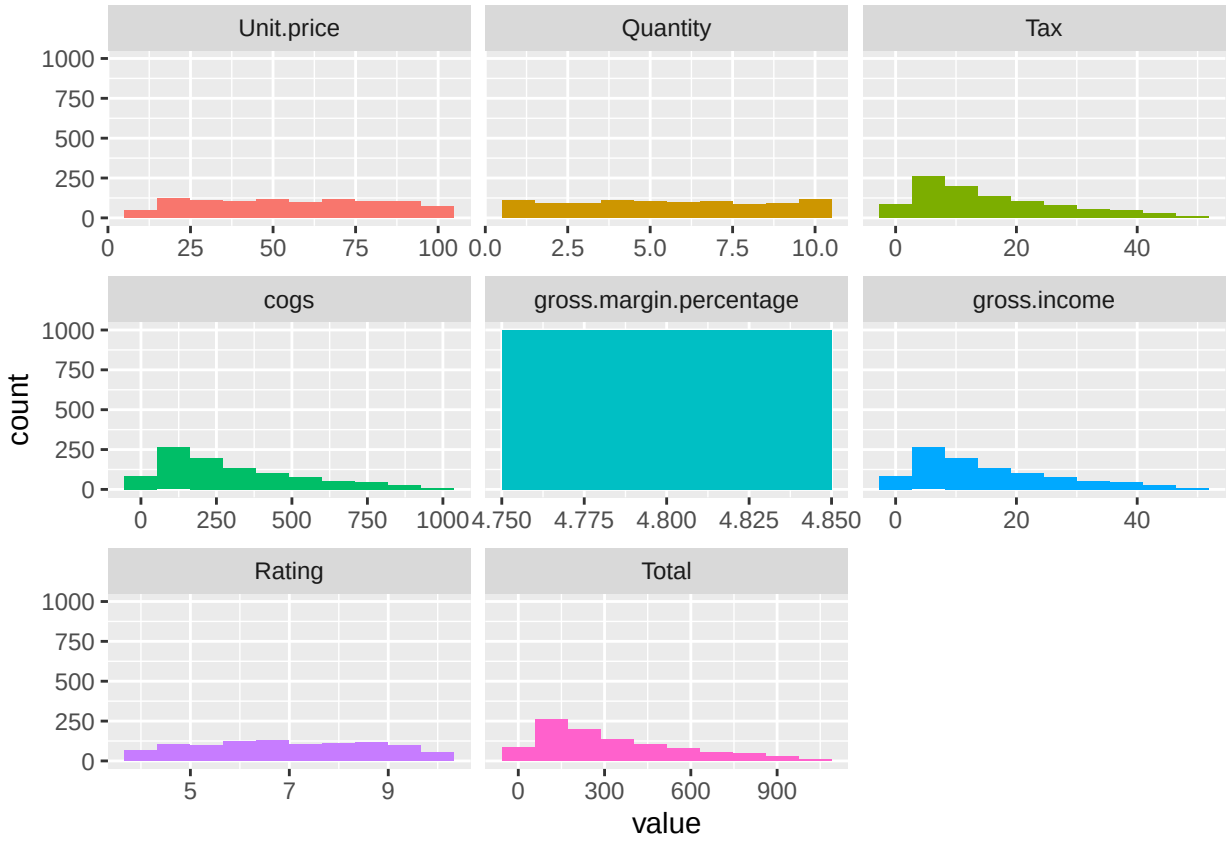
Profiling our Numerical Variables

```
#The Total and Sales Column in dataset 1 and in Dataset 3 seem similar
all(data_1$Total == data_3$Sales)
```

```
## [1] TRUE
```

```
plot_num(data_1)#This function  plots the distribution of every numerical variable while automatically
```

```
## Warning: `guides(<scale> = FALSE)` is deprecated. Please use `guides(<scale> =
## "none")` instead.
```



Most of our data distribution is right skewed meaning that the mode is the highest peak of most of our histograms and most values fall to the right side.

Correlation and Bivariate Analysis

```
#Loading packages we might need
#install.packages("corrplot")
library(corrplot)
```

```
## corrplot 0.90 loaded
```

```
library(ggplot2)
library(dplyr)
library(lessR)
```

```
##
## lessR 4.0.2  feedback: gerbing@pdx.edu  web: lessRstats.com/new
## ------------------------------------------------------------
## > d <- Read("")   Read text, Excel, SPSS, SAS, or R data file
##   d is default data frame, data= in analysis routines optional
##
## Learn about reading, writing, and manipulating data, graphics,
## testing means and proportions, regression, factor analysis,
## customization, and descriptive statistics from pivot tables.
##   Enter:  browseVignettes("lessR")
##
```

```
## View changes in this new version of lessR.
##   Enter: help(package=lessR)  Click: Package NEWS

##
## Attaching package: 'lessR'

## The following object is masked from 'package:moments':
##
##     kurtosis

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

## The following objects are masked from 'package:Hmisc':
##
##     label, Merge
```

```
library(reshape2)
```

```
##
## Attaching package: 'reshape2'

## The following object is masked from 'package:tidyr':
##
##     smiths
```

```
library(gridExtra) # allow us to plot two plots in a row
```

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

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

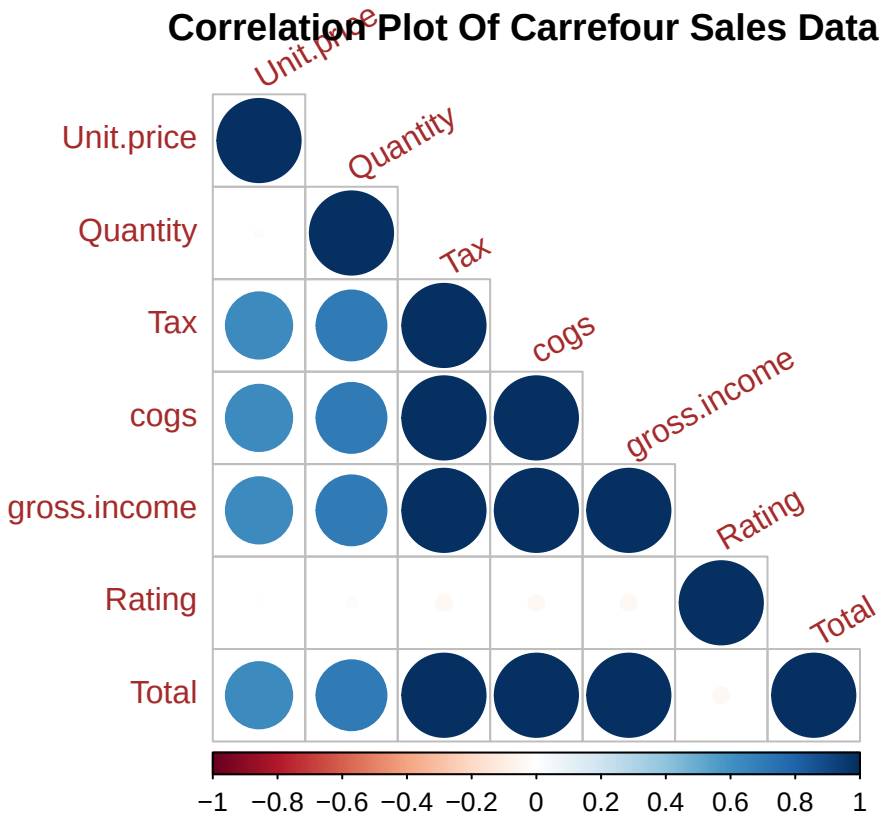
Correlation

```
num_v <- subset (num_v, select = -gross.margin.percentage)

corr_tab<-cor(num_v)
```

Displaying the correlation in a matrix

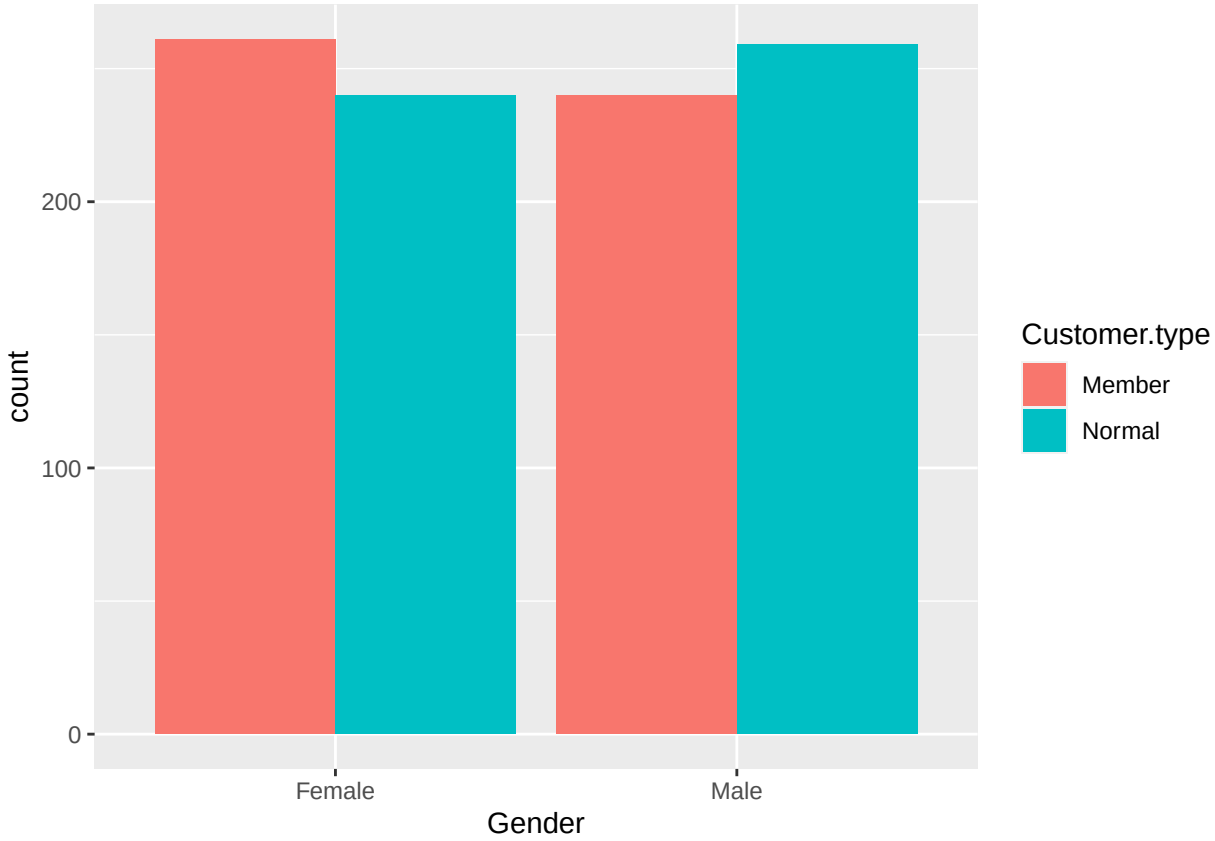
```
corrplot(corr_tab, tl.col = "brown", tl.srt = 30, bg = "White",
         title = "\n\n Correlation Plot Of Carrefour Sales Data",
         type = "lower")
```



Visualizing our bivariate relationships

Gender and Customer Type

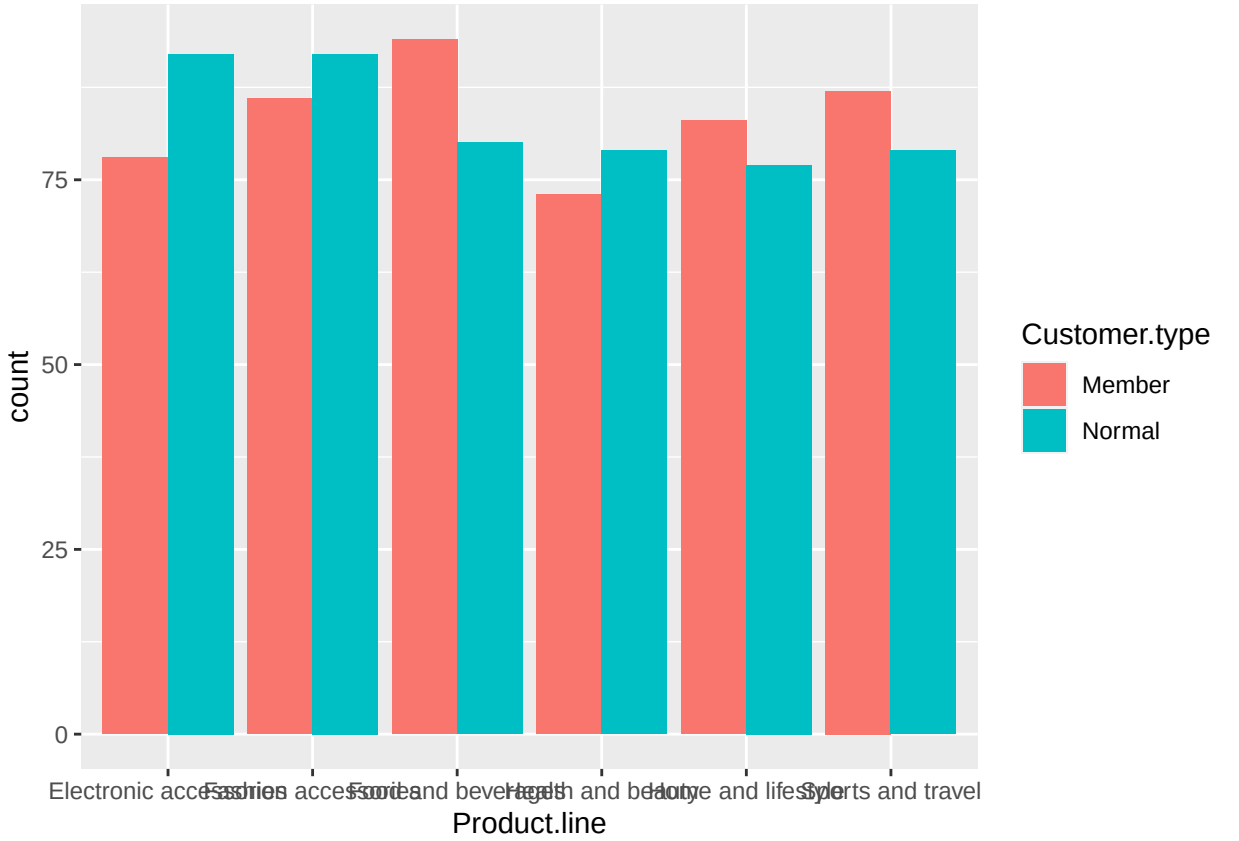
```
 # bar chart
ggplot(data_1,
       aes(x = Gender,
           fill = Customer.type)) +
    geom_bar(position = "dodge")
```



Females make up majority of the members while Males form majority of the Normal customer pool

Product Line and Customer Type

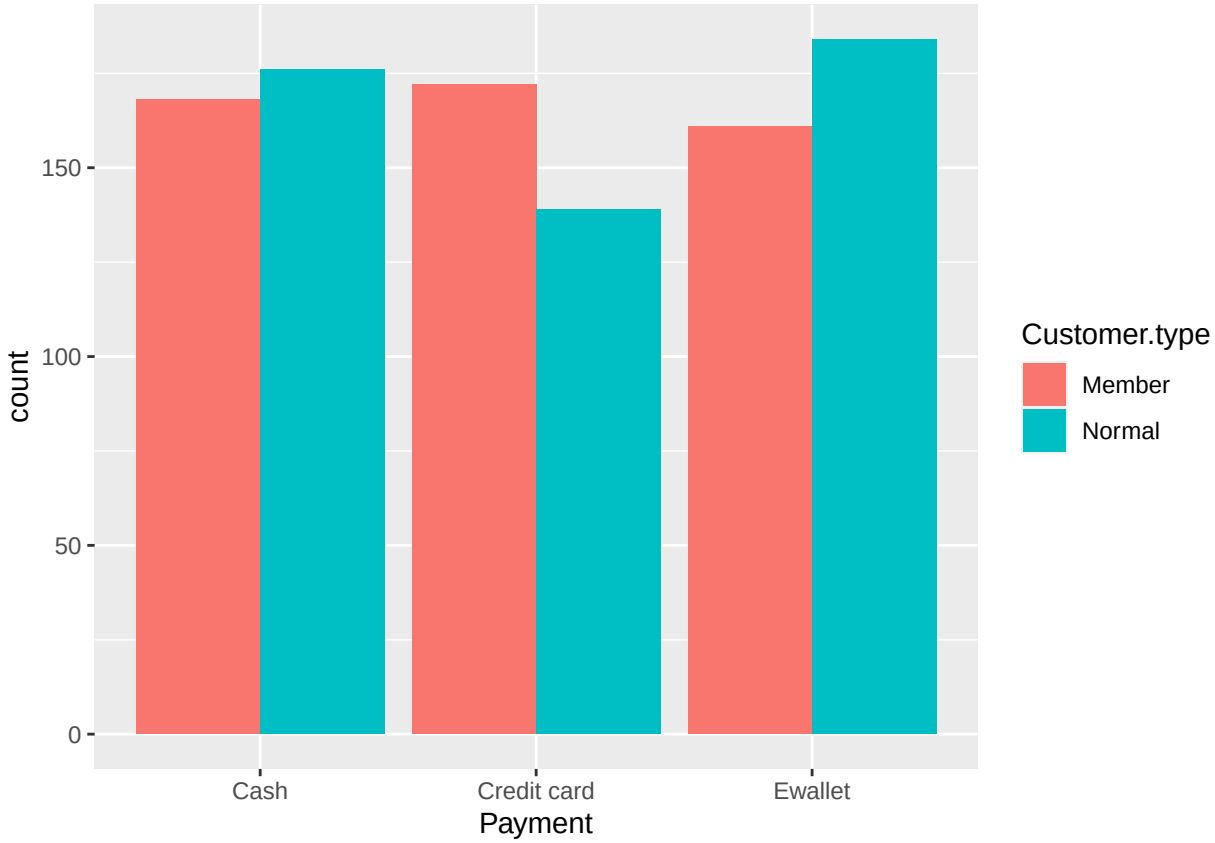
```
ggplot(data_1,
       aes(x = Product.line,
           fill = Customer.type)) +
    geom_bar(position = "dodge")
```



Most members buy Food and Beverages while regular customers buy Fashion accessories and Electronic Accessories.

Payment and Customer Type

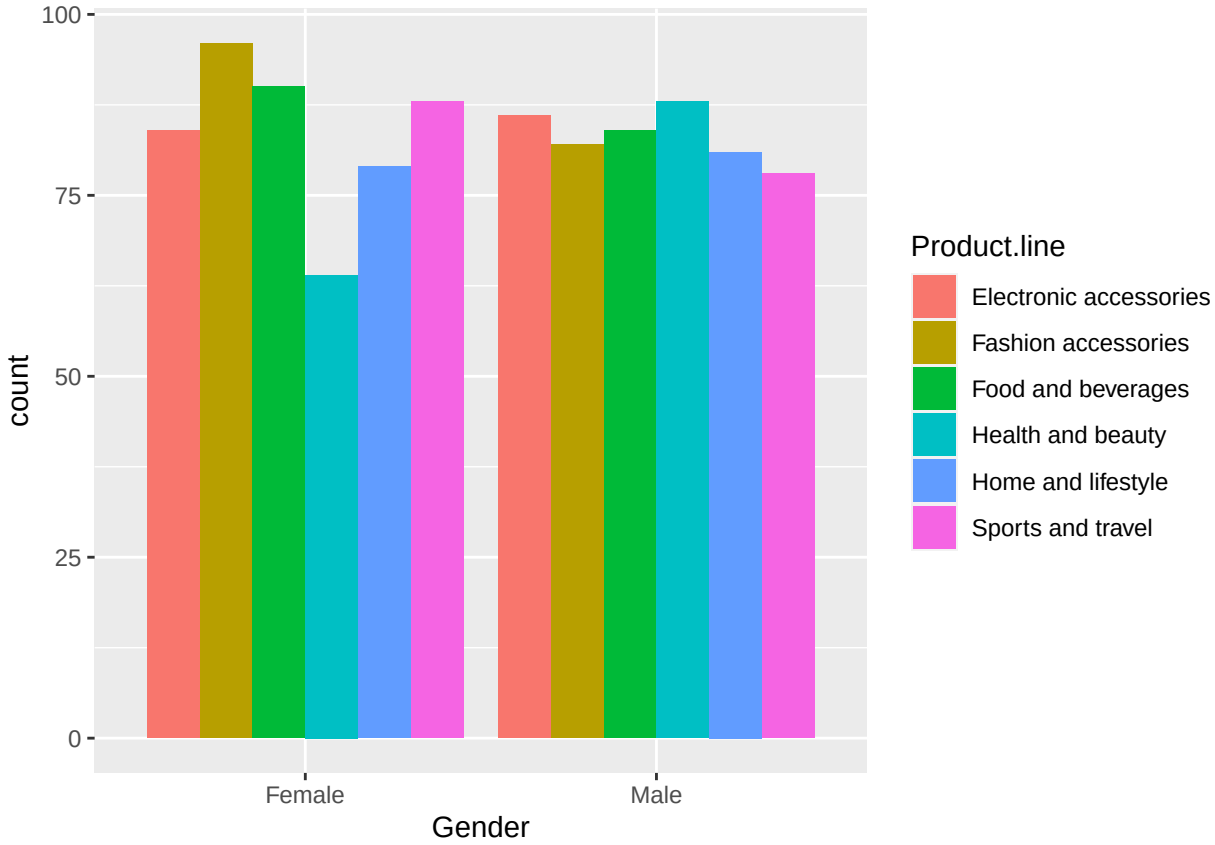
```
ggplot(data_1,
       aes(x = Payment,
           fill = Customer.type)) +
    geom_bar(position = "dodge")
```



Normal customers are more prone to paying using E-wallet than customers with membership. Customers with membership tend to pay more frequently using Credit Card.

-

```
ggplot(data_1,
       aes(x = Gender,
           fill = Product.line)) +
    geom_bar(position = "dodge")
```

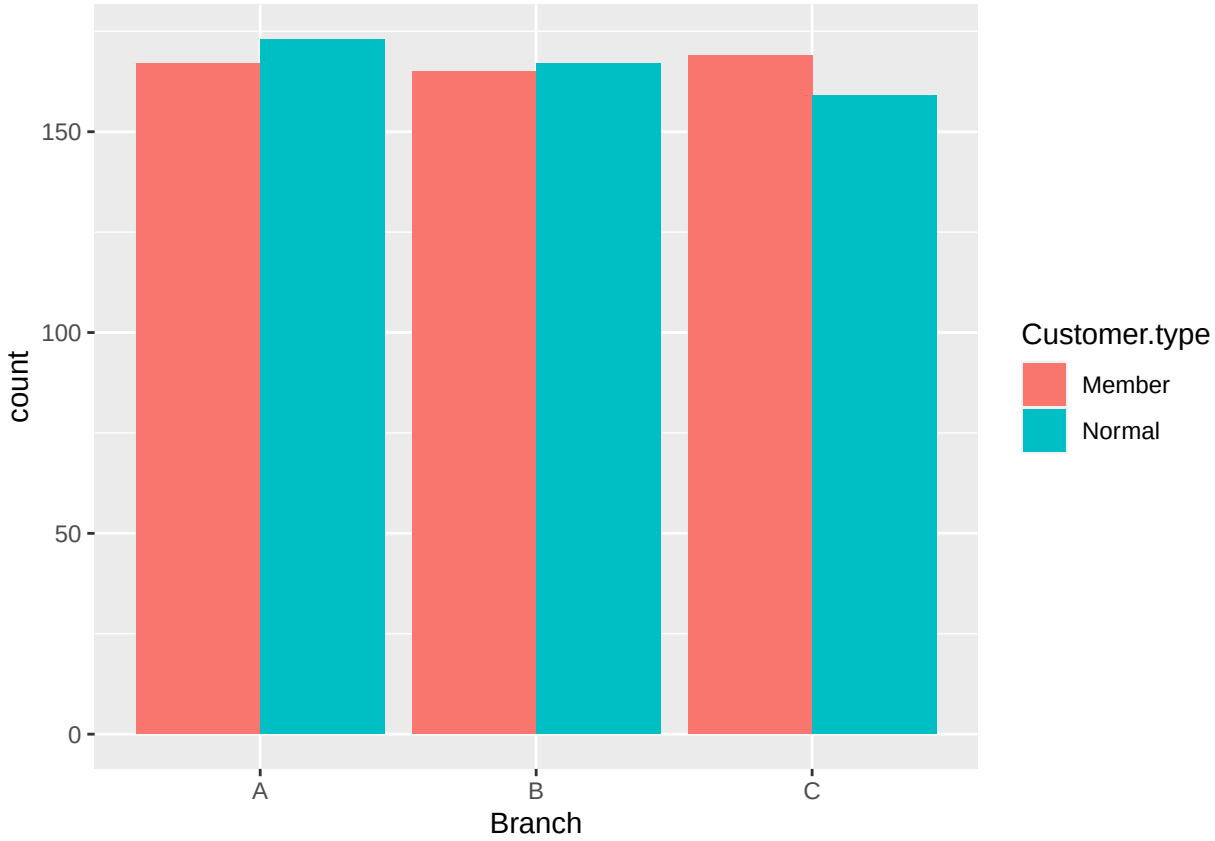


Female shoppers tend to buy fashion accessories the most, followed by food and beverages with the least sales in Health and Beauty in the data collection period.

Male customers have bought products in health and beauty line followed by electronic accessories the most.

Branch and Member

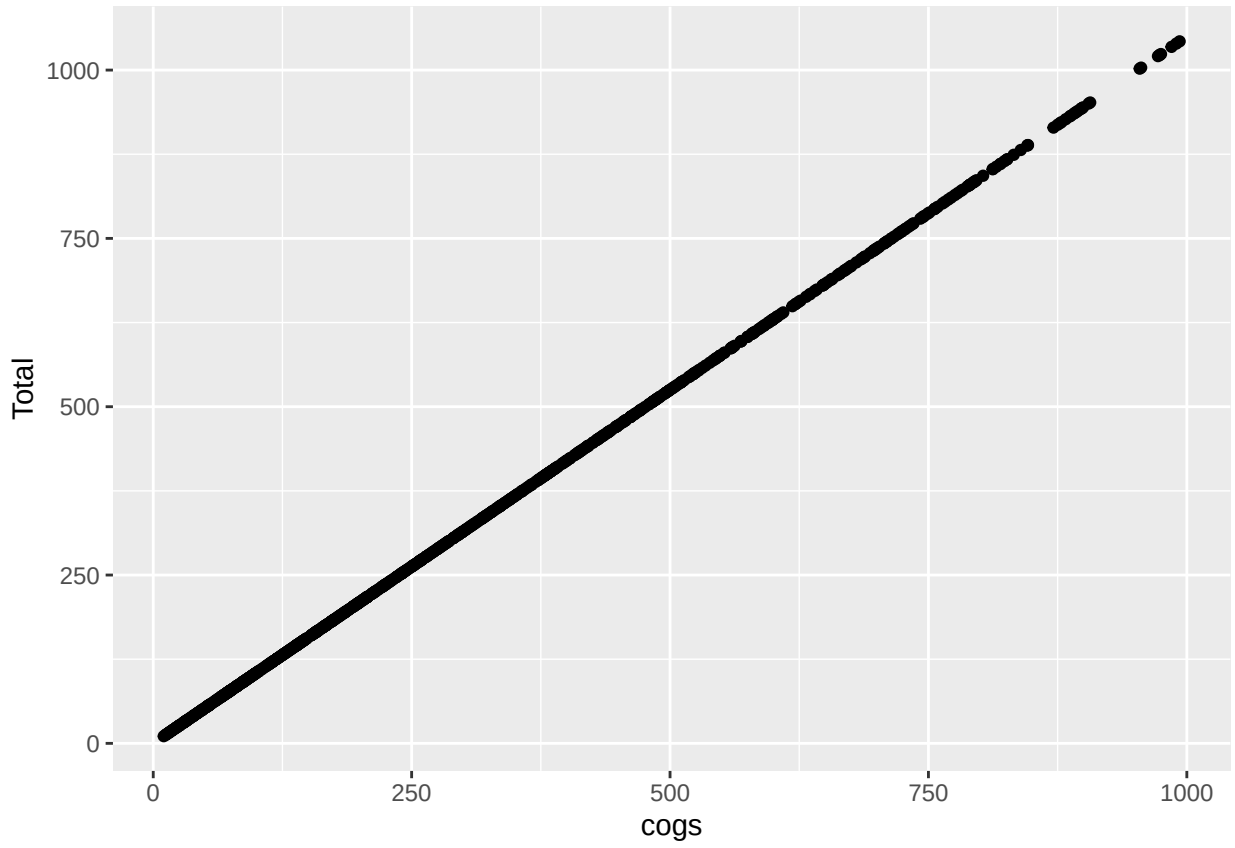
```
ggplot(data_1,
       aes(x = Branch,
           fill = Customer.type)) +
    geom_bar(position = "dodge")
```



Branch "c" has the most customers with memberships and "A" the most regular customers.

Cogs and Total

```
# simple scatterplot visualization of Cogs and Total
ggplot(data_1,
       aes(x = cogs,
           y = Total)) +
  geom_point()
```



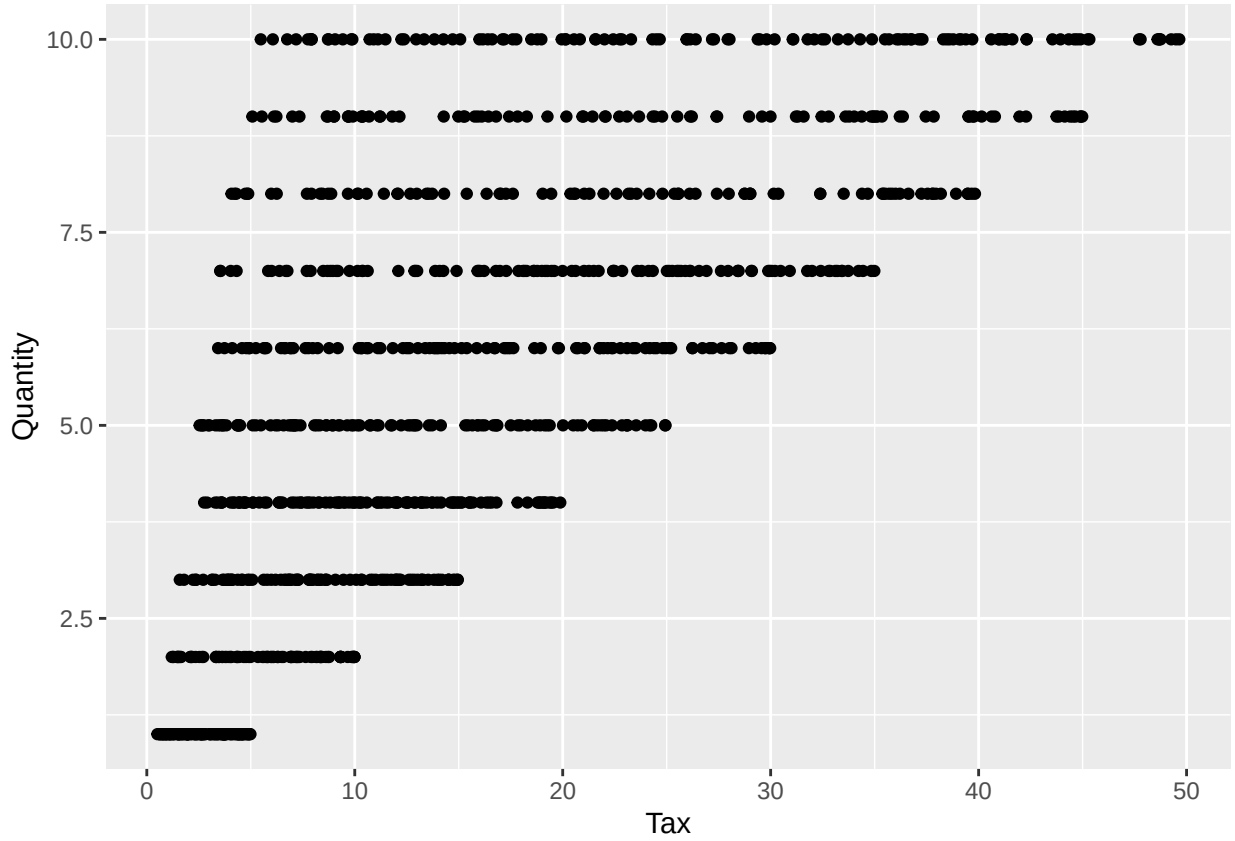

```
cor(data_1$cogs, data_1$Total, method="pearson")
```

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

Cost of goods sold (COGS) refers to the direct costs of producing the goods sold by a company. This amount includes the cost of the materials and labor directly used to create the good. It excludes indirect expenses, such as distribution costs and sales force costs. The total column represents the total sales unit of a product. The visualization above shows that cogs and the total sales are highly correlated.

Tax and Quantity

```
ggplot(data_1,
       aes(x = Tax,
           y = Quantity)) +
  geom_point()
```



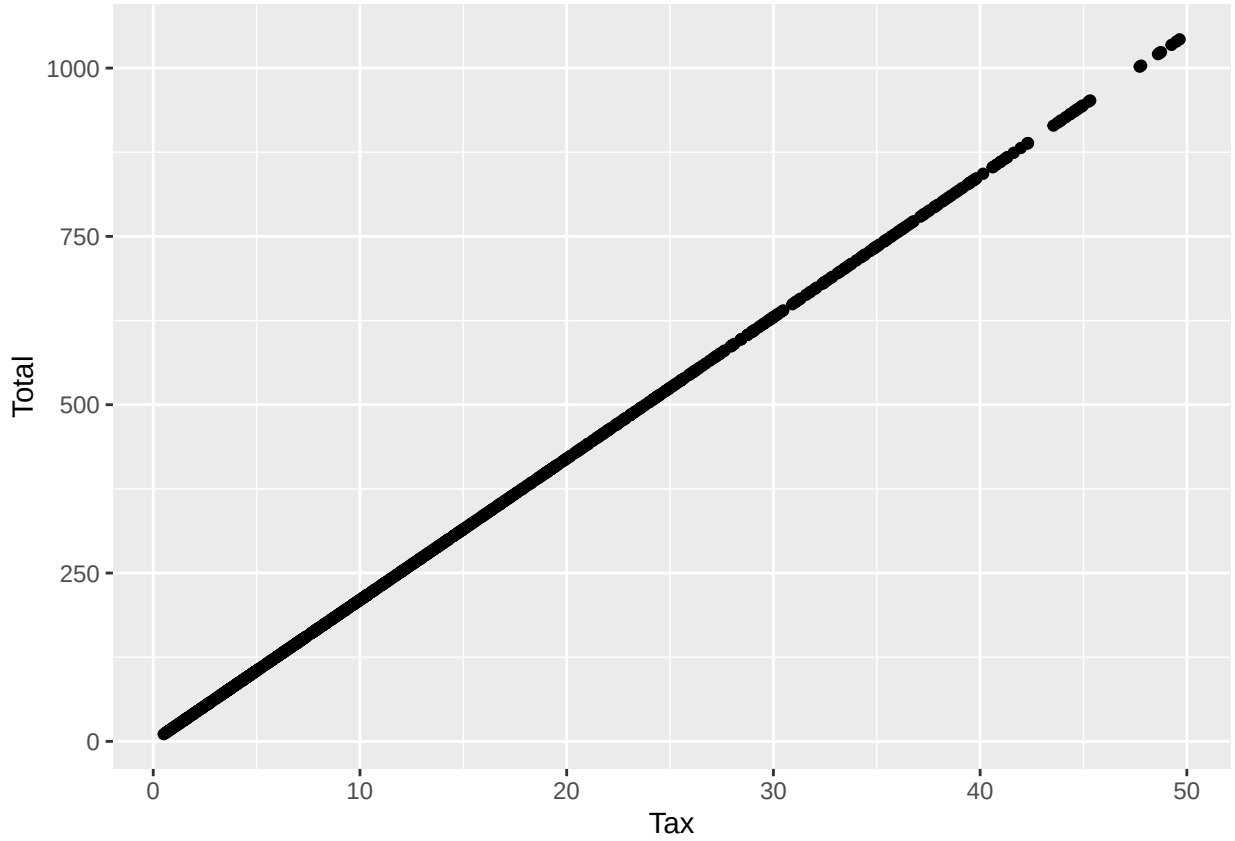

```
cor(data_1$Tax, data_1$Quantity, method="pearson")
```

```
## [1] 0.7055102
```

The tax paid for a product is correlated to the quantity of products sold

Tax and Total Sales

```
ggplot(data_1,
       aes(x = Tax,
           y = Total)) +
  geom_point()
```




```
cor(data_1$Tax, data_1$Total, method="pearson")
```

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

The tax paid for a product is correlated with the total sales.

#Principal Component Analysis (PCA)

PCA is a type of linear transformation on a given data set that has values for a certain number of variables (coordinates) for a certain amount of spaces. This linear transformation fits this dataset to a new coordinate system in such a way that the most significant variance is found on the first coordinate, and each subsequent coordinate is orthogonal to the last and has a lesser variance. In this way, you transform a set of x correlated variables over y samples to a set of p uncorrelated principal components over the same samples.

```
#Since PCA works well with numerical variables, we will use the subset of numerical variables we made.
num_v
```

```
##      Unit.price Quantity     Tax   cogs gross.income Rating     Total
## 1         74.69        7 26.1415 522.83      26.1415    9.1  548.9715
## 2         15.28        5  3.8200  76.40       3.8200    9.6   80.2200
## 3         46.33        7 16.2155 324.31      16.2155    7.4  340.5255
## 4         58.22        8 23.2880 465.76      23.2880    8.4  489.0480
## 5         86.31        7 30.2085 604.17      30.2085    5.3  634.3785
## 6         85.39        7 29.8865 597.73      29.8865    4.1  627.6165
## 7         68.84        6 20.6520 413.04      20.6520    5.8  433.6920
```

```
## 8         73.56       10 36.7800 735.60      36.7800    8.0  772.3800
## 9         36.26        2  3.6260  72.52       3.6260    7.2   76.1460
## 10        54.84        3  8.2260 164.52       8.2260    5.9  172.7460
## 11        14.48        4  2.8960  57.92       2.8960    4.5   60.8160
## 12        25.51        4  5.1020 102.04       5.1020    6.8  107.1420
## 13        46.95        5 11.7375 234.75      11.7375    7.1  246.4875
## 14        43.19       10 21.5950 431.90      21.5950    8.2  453.4950
## 15        71.38       10 35.6900 713.80      35.6900    5.7  749.4900
## 16        93.72        6 28.1160 562.32      28.1160    4.5  590.4360
## 17        68.93        7 24.1255 482.51      24.1255    4.6  506.6355
## 18        72.61        6 21.7830 435.66      21.7830    6.9  457.4430
## 19        54.67        3  8.2005 164.01       8.2005    8.6  172.2105
## 20        40.30        2  4.0300  80.60       4.0300    4.4   84.6300
## 21        86.04        5 21.5100 430.20      21.5100    4.8  451.7100
## 22        87.98        3 13.1970 263.94      13.1970    5.1  277.1370
## 23        33.20        2  3.3200  66.40       3.3200    4.4   69.7200
## 24        34.56        5  8.6400 172.80       8.6400    9.9  181.4400
## 25        88.63        3 13.2945 265.89      13.2945    6.0  279.1845
## 26        52.59        8 21.0360 420.72      21.0360    8.5  441.7560
## 27        33.52        1  1.6760  33.52       1.6760    6.7   35.1960
## 28        87.67        2  8.7670 175.34       8.7670    7.7  184.1070
## 29        88.36        5 22.0900 441.80      22.0900    9.6  463.8900
## 30        24.89        9 11.2005 224.01      11.2005    7.4  235.2105
## 31        94.13        5 23.5325 470.65      23.5325    4.8  494.1825
## 32        78.07        9 35.1315 702.63      35.1315    4.5  737.7615
## 33        83.78        8 33.5120 670.24      33.5120    5.1  703.7520
## 34        96.58        2  9.6580 193.16       9.6580    5.1  202.8180
## 35        99.42        4 19.8840 397.68      19.8840    7.5  417.5640
## 36        68.12        1  3.4060  68.12       3.4060    6.8   71.5260
## 37        62.62        5 15.6550 313.10      15.6550    7.0  328.7550
## 38        60.88        9 27.3960 547.92      27.3960    4.7  575.3160
## 39        54.92        8 21.9680 439.36      21.9680    7.6  461.3280
## 40        30.12        8 12.0480 240.96      12.0480    7.7  253.0080
## 41        86.72        1  4.3360  86.72       4.3360    7.9   91.0560
## 42        56.11        2  5.6110 112.22       5.6110    6.3  117.8310
## 43        69.12        6 20.7360 414.72      20.7360    5.6  435.4560
## 44        98.70        8 39.4800 789.60      39.4800    7.6  829.0800
## 45        15.37        2  1.5370  30.74       1.5370    7.2   32.2770
## 46        93.96        4 18.7920 375.84      18.7920    9.5  394.6320
## 47        56.69        9 25.5105 510.21      25.5105    8.4  535.7205
## 48        20.01        9  9.0045 180.09       9.0045    4.1  189.0945
## 49        18.93        6  5.6790 113.58       5.6790    8.1  119.2590
## 50        82.63       10 41.3150 826.30      41.3150    7.9  867.6150
## 51        91.40        7 31.9900 639.80      31.9900    9.5  671.7900
## 52        44.59        5 11.1475 222.95      11.1475    8.5  234.0975
## 53        17.87        4  3.5740  71.48       3.5740    6.5   75.0540
## 54        15.43        1  0.7715  15.43       0.7715    6.1   16.2015
## 55        16.16        2  1.6160  32.32       1.6160    6.5   33.9360
## 56        85.98        8 34.3920 687.84      34.3920    8.2  722.2320
## 57        44.34        2  4.4340  88.68       4.4340    5.8   93.1140
## 58        89.60        8 35.8400 716.80      35.8400    6.6  752.6400
## 59        72.35       10 36.1750 723.50      36.1750    5.4  759.6750
## 60        30.61        6  9.1830 183.66       9.1830    9.3  192.8430
## 61        24.74        3  3.7110  74.22       3.7110   10.0   77.9310
```

```
## 62       55.73        6 16.7190 334.38      16.7190    7.0  351.0990
## 63       55.07        9 24.7815 495.63      24.7815   10.0  520.4115
## 64       15.81       10  7.9050 158.10       7.9050    8.6  166.0050
## 65       75.74        4 15.1480 302.96      15.1480    7.6  318.1080
## 66       15.87       10  7.9350 158.70       7.9350    5.8  166.6350
## 67       33.47        2  3.3470  66.94       3.3470    6.7   70.2870
## 68       97.61        6 29.2830 585.66      29.2830    9.9  614.9430
## 69       78.77       10 39.3850 787.70      39.3850    6.4  827.0850
## 70       18.33        1  0.9165  18.33       0.9165    4.3   19.2465
## 71       89.48       10 44.7400 894.80      44.7400    9.6  939.5400
## 72       62.12       10 31.0600 621.20      31.0600    5.9  652.2600
## 73       48.52        3  7.2780 145.56       7.2780    4.0  152.8380
## 74       75.91        6 22.7730 455.46      22.7730    8.7  478.2330
## 75       74.67        9 33.6015 672.03      33.6015    9.4  705.6315
## 76       41.65       10 20.8250 416.50      20.8250    5.4  437.3250
## 77       49.04        9 22.0680 441.36      22.0680    8.6  463.4280
## 78       20.01        9  9.0045 180.09       9.0045    5.7  189.0945
## 79       78.31       10 39.1550 783.10      39.1550    6.6  822.2550
## 80       20.38        5  5.0950 101.90       5.0950    6.0  106.9950
## 81       99.19        6 29.7570 595.14      29.7570    5.5  624.8970
## 82       96.68        3 14.5020 290.04      14.5020    6.4  304.5420
## 83       19.25        8  7.7000 154.00       7.7000    6.6  161.7000
## 84       80.36        4 16.0720 321.44      16.0720    8.3  337.5120
## 85       48.91        5 12.2275 244.55      12.2275    6.6  256.7775
## 86       83.06        7 29.0710 581.42      29.0710    4.0  610.4910
## 87       76.52        5 19.1300 382.60      19.1300    9.9  401.7300
## 88       49.38        7 17.2830 345.66      17.2830    7.3  362.9430
## 89       42.47        1  2.1235  42.47       2.1235    5.7   44.5935
## 90       76.99        6 23.0970 461.94      23.0970    6.1  485.0370
## 91       47.38        4  9.4760 189.52       9.4760    7.1  198.9960
## 92       44.86       10 22.4300 448.60      22.4300    8.2  471.0300
## 93       21.98        7  7.6930 153.86       7.6930    5.1  161.5530
## 94       64.36        9 28.9620 579.24      28.9620    8.6  608.2020
## 95       89.75        1  4.4875  89.75       4.4875    6.6   94.2375
## 96       97.16        1  4.8580  97.16       4.8580    7.2  102.0180
## 97       87.87       10 43.9350 878.70      43.9350    5.1  922.6350
## 98       12.45        6  3.7350  74.70       3.7350    4.1   78.4350
## 99       52.75        3  7.9125 158.25       7.9125    9.3  166.1625
## 100      82.70        6 24.8100 496.20      24.8100    7.4  521.0100
## 101      48.71        1  2.4355  48.71       2.4355    4.1   51.1455
## 102      78.55        9 35.3475 706.95      35.3475    7.2  742.2975
## 103      23.07        9 10.3815 207.63      10.3815    4.9  218.0115
## 104      58.26        6 17.4780 349.56      17.4780    9.9  367.0380
## 105      30.35        7 10.6225 212.45      10.6225    8.0  223.0725
## 106      88.67       10 44.3350 886.70      44.3350    7.3  931.0350
## 107      27.38        6  8.2140 164.28       8.2140    7.9  172.4940
## 108      62.13        6 18.6390 372.78      18.6390    7.4  391.4190
## 109      33.98        9 15.2910 305.82      15.2910    4.2  321.1110
## 110      81.97       10 40.9850 819.70      40.9850    9.2  860.6850
## 111      16.49        2  1.6490  32.98       1.6490    4.6   34.6290
## 112      98.21        3 14.7315 294.63      14.7315    7.8  309.3615
## 113      72.84        7 25.4940 509.88      25.4940    8.4  535.3740
## 114      58.07        9 26.1315 522.63      26.1315    4.3  548.7615
## 115      80.79        9 36.3555 727.11      36.3555    9.5  763.4655
```

```
## 116       27.02        3  4.0530  81.06       4.0530    7.1   85.1130
## 117       21.94        5  5.4850 109.70       5.4850    5.3  115.1850
## 118       51.36        1  2.5680  51.36       2.5680    5.2   53.9280
## 119       10.96       10  5.4800 109.60       5.4800    6.0  115.0800
## 120       53.44        2  5.3440 106.88       5.3440    4.1  112.2240
## 121       99.56        8 39.8240 796.48      39.8240    5.2  836.3040
## 122       57.12        7 19.9920 399.84      19.9920    6.5  419.8320
## 123       99.96        9 44.9820 899.64      44.9820    4.2  944.6220
## 124       63.91        8 25.5640 511.28      25.5640    4.6  536.8440
## 125       56.47        8 22.5880 451.76      22.5880    7.3  474.3480
## 126       93.69        7 32.7915 655.83      32.7915    4.5  688.6215
## 127       32.25        5  8.0625 161.25       8.0625    9.0  169.3125
## 128       31.73        9 14.2785 285.57      14.2785    5.9  299.8485
## 129       68.54        8 27.4160 548.32      27.4160    8.5  575.7360
## 130       90.28        9 40.6260 812.52      40.6260    7.2  853.1460
## 131       39.62        7 13.8670 277.34      13.8670    7.5  291.2070
## 132       92.13        6 27.6390 552.78      27.6390    8.3  580.4190
## 133       34.84        4  6.9680 139.36       6.9680    7.4  146.3280
## 134       87.45        6 26.2350 524.70      26.2350    8.8  550.9350
## 135       81.30        6 24.3900 487.80      24.3900    5.3  512.1900
## 136       90.22        3 13.5330 270.66      13.5330    6.2  284.1930
## 137       26.31        5  6.5775 131.55       6.5775    8.8  138.1275
## 138       34.42        6 10.3260 206.52      10.3260    9.8  216.8460
## 139       51.91       10 25.9550 519.10      25.9550    8.2  545.0550
## 140       72.50        8 29.0000 580.00      29.0000    9.2  609.0000
## 141       89.80       10 44.9000 898.00      44.9000    5.4  942.9000
## 142       90.50       10 45.2500 905.00      45.2500    8.1  950.2500
## 143       68.60       10 34.3000 686.00      34.3000    9.1  720.3000
## 144       30.41        1  1.5205  30.41       1.5205    8.4   31.9305
## 145       77.95        6 23.3850 467.70      23.3850    8.0  491.0850
## 146       46.26        6 13.8780 277.56      13.8780    9.5  291.4380
## 147       30.14       10 15.0700 301.40      15.0700    9.2  316.4700
## 148       66.14        4 13.2280 264.56      13.2280    5.6  277.7880
## 149       71.86        8 28.7440 574.88      28.7440    6.2  603.6240
## 150       32.46        8 12.9840 259.68      12.9840    4.9  272.6640
## 151       91.54        4 18.3080 366.16      18.3080    4.8  384.4680
## 152       34.56        7 12.0960 241.92      12.0960    7.3  254.0160
## 153       83.24        9 37.4580 749.16      37.4580    7.4  786.6180
## 154       16.48        6  4.9440  98.88       4.9440    9.9  103.8240
## 155       80.97        8 32.3880 647.76      32.3880    9.3  680.1480
## 156       92.29        5 23.0725 461.45      23.0725    9.0  484.5225
## 157       72.17        1  3.6085  72.17       3.6085    6.1   75.7785
## 158       50.28        5 12.5700 251.40      12.5700    9.7  263.9700
## 159       97.22        9 43.7490 874.98      43.7490    6.0  918.7290
## 160       93.39        6 28.0170 560.34      28.0170   10.0  588.3570
## 161       43.18        8 17.2720 345.44      17.2720    8.3  362.7120
## 162       63.69        1  3.1845  63.69       3.1845    6.0   66.8745
## 163       45.79        7 16.0265 320.53      16.0265    7.0  336.5565
## 164       76.40        2  7.6400 152.80       7.6400    6.5  160.4400
## 165       39.90       10 19.9500 399.00      19.9500    5.9  418.9500
## 166       42.57        8 17.0280 340.56      17.0280    5.6  357.5880
## 167       95.58       10 47.7900 955.80      47.7900    4.8 1003.5900
## 168       98.98       10 49.4900 989.80      49.4900    8.7 1039.2900
## 169       51.28        6 15.3840 307.68      15.3840    6.5  323.0640
```

```
## 170       69.52        7 24.3320 486.64      24.3320    8.5  510.9720
## 171       70.01        5 17.5025 350.05      17.5025    5.5  367.5525
## 172       80.05        5 20.0125 400.25      20.0125    9.4  420.2625
## 173       20.85        8  8.3400 166.80       8.3400    6.3  175.1400
## 174       52.89        6 15.8670 317.34      15.8670    9.8  333.2070
## 175       19.79        8  7.9160 158.32       7.9160    8.7  166.2360
## 176       33.84        9 15.2280 304.56      15.2280    8.8  319.7880
## 177       22.17        8  8.8680 177.36       8.8680    9.6  186.2280
## 178       22.51        7  7.8785 157.57       7.8785    4.8  165.4485
## 179       73.88        6 22.1640 443.28      22.1640    4.4  465.4440
## 180       86.80        3 13.0200 260.40      13.0200    9.9  273.4200
## 181       64.26        7 22.4910 449.82      22.4910    5.7  472.3110
## 182       38.47        8 15.3880 307.76      15.3880    7.7  323.1480
## 183       15.50       10  7.7500 155.00       7.7500    8.0  162.7500
## 184       34.31        8 13.7240 274.48      13.7240    5.7  288.2040
## 185       12.34        7  4.3190  86.38       4.3190    6.7   90.6990
## 186       18.08        3  2.7120  54.24       2.7120    8.0   56.9520
## 187       94.49        8 37.7960 755.92      37.7960    7.5  793.7160
## 188       46.47        4  9.2940 185.88       9.2940    7.0  195.1740
## 189       74.07        1  3.7035  74.07       3.7035    9.9   77.7735
## 190       69.81        4 13.9620 279.24      13.9620    5.9  293.2020
## 191       77.04        3 11.5560 231.12      11.5560    7.2  242.6760
## 192       73.52        2  7.3520 147.04       7.3520    4.6  154.3920
## 193       87.80        9 39.5100 790.20      39.5100    9.2  829.7100
## 194       25.55        4  5.1100 102.20       5.1100    5.7  107.3100
## 195       32.71        5  8.1775 163.55       8.1775    9.9  171.7275
## 196       74.29        1  3.7145  74.29       3.7145    5.0   78.0045
## 197       43.70        2  4.3700  87.40       4.3700    4.9   91.7700
## 198       25.29        1  1.2645  25.29       1.2645    6.1   26.5545
## 199       41.50        4  8.3000 166.00       8.3000    8.2  174.3000
## 200       71.39        5 17.8475 356.95      17.8475    5.5  374.7975
## 201       19.15        6  5.7450 114.90       5.7450    6.8  120.6450
## 202       57.49        4 11.4980 229.96      11.4980    6.6  241.4580
## 203       61.41        7 21.4935 429.87      21.4935    9.8  451.3635
## 204       25.90       10 12.9500 259.00      12.9500    8.7  271.9500
## 205       17.77        5  4.4425  88.85       4.4425    5.4   93.2925
## 206       23.03        9 10.3635 207.27      10.3635    7.9  217.6335
## 207       66.65        9 29.9925 599.85      29.9925    9.7  629.8425
## 208       28.53       10 14.2650 285.30      14.2650    7.8  299.5650
## 209       30.37        3  4.5555  91.11       4.5555    5.1   95.6655
## 210       99.73        9 44.8785 897.57      44.8785    6.5  942.4485
## 211       26.23        9 11.8035 236.07      11.8035    5.9  247.8735
## 212       93.26        9 41.9670 839.34      41.9670    8.8  881.3070
## 213       92.36        5 23.0900 461.80      23.0900    4.9  484.8900
## 214       46.42        3  6.9630 139.26       6.9630    4.4  146.2230
## 215       29.61        7 10.3635 207.27      10.3635    6.5  217.6335
## 216       18.28        1  0.9140  18.28       0.9140    8.3   19.1940
## 217       24.77        5  6.1925 123.85       6.1925    8.5  130.0425
## 218       94.64        3 14.1960 283.92      14.1960    5.5  298.1160
## 219       94.87        8 37.9480 758.96      37.9480    8.7  796.9080
## 220       57.34        3  8.6010 172.02       8.6010    7.9  180.6210
## 221       45.35        6 13.6050 272.10      13.6050    6.1  285.7050
## 222       62.08        7 21.7280 434.56      21.7280    5.4  456.2880
## 223       11.81        5  2.9525  59.05       2.9525    9.4   62.0025
```

```
## 224       12.54        1  0.6270  12.54       0.6270    8.2   13.1670
## 225       43.25        2  4.3250  86.50       4.3250    6.2   90.8250
## 226       87.16        2  8.7160 174.32       8.7160    9.7  183.0360
## 227       69.37        9 31.2165 624.33      31.2165    4.0  655.5465
## 228       37.06        4  7.4120 148.24       7.4120    9.7  155.6520
## 229       90.70        6 27.2100 544.20      27.2100    5.3  571.4100
## 230       63.42        8 25.3680 507.36      25.3680    7.4  532.7280
## 231       81.37        2  8.1370 162.74       8.1370    6.5  170.8770
## 232       10.59        3  1.5885  31.77       1.5885    8.7   33.3585
## 233       84.09        9 37.8405 756.81      37.8405    8.0  794.6505
## 234       73.82        4 14.7640 295.28      14.7640    6.7  310.0440
## 235       51.94       10 25.9700 519.40      25.9700    6.5  545.3700
## 236       93.14        2  9.3140 186.28       9.3140    4.1  195.5940
## 237       17.41        5  4.3525  87.05       4.3525    4.9   91.4025
## 238       44.22        5 11.0550 221.10      11.0550    8.6  232.1550
## 239       13.22        5  3.3050  66.10       3.3050    4.3   69.4050
## 240       89.69        1  4.4845  89.69       4.4845    4.9   94.1745
## 241       24.94        9 11.2230 224.46      11.2230    5.6  235.6830
## 242       59.77        2  5.9770 119.54       5.9770    5.8  125.5170
## 243       93.20        2  9.3200 186.40       9.3200    6.0  195.7200
## 244       62.65        4 12.5300 250.60      12.5300    4.2  263.1300
## 245       93.87        8 37.5480 750.96      37.5480    8.3  788.5080
## 246       47.59        8 19.0360 380.72      19.0360    5.7  399.7560
## 247       81.40        3 12.2100 244.20      12.2100    4.8  256.4100
## 248       17.94        5  4.4850  89.70       4.4850    6.8   94.1850
## 249       77.72        4 15.5440 310.88      15.5440    8.8  326.4240
## 250       73.06        7 25.5710 511.42      25.5710    4.2  536.9910
## 251       46.55        9 20.9475 418.95      20.9475    6.4  439.8975
## 252       35.19       10 17.5950 351.90      17.5950    8.4  369.4950
## 253       14.39        2  1.4390  28.78       1.4390    7.2   30.2190
## 254       23.75        4  4.7500  95.00       4.7500    5.2   99.7500
## 255       58.90        8 23.5600 471.20      23.5600    8.9  494.7600
## 256       32.62        4  6.5240 130.48       6.5240    9.0  137.0040
## 257       66.35        1  3.3175  66.35       3.3175    9.7   69.6675
## 258       25.91        6  7.7730 155.46       7.7730    8.7  163.2330
## 259       32.25        4  6.4500 129.00       6.4500    6.5  135.4500
## 260       65.94        4 13.1880 263.76      13.1880    6.9  276.9480
## 261       75.06        9 33.7770 675.54      33.7770    6.2  709.3170
## 262       16.45        4  3.2900  65.80       3.2900    5.6   69.0900
## 263       38.30        4  7.6600 153.20       7.6600    5.7  160.8600
## 264       22.24       10 11.1200 222.40      11.1200    4.2  233.5200
## 265       54.45        1  2.7225  54.45       2.7225    7.9   57.1725
## 266       98.40        7 34.4400 688.80      34.4400    8.7  723.2400
## 267       35.47        4  7.0940 141.88       7.0940    6.9  148.9740
## 268       74.60       10 37.3000 746.00      37.3000    9.5  783.3000
## 269       70.74        4 14.1480 282.96      14.1480    4.4  297.1080
## 270       35.54       10 17.7700 355.40      17.7700    7.0  373.1700
## 271       67.43        5 16.8575 337.15      16.8575    6.3  354.0075
## 272       21.12        2  2.1120  42.24       2.1120    9.7   44.3520
## 273       21.54        9  9.6930 193.86       9.6930    8.8  203.5530
## 274       12.03        2  1.2030  24.06       1.2030    5.1   25.2630
## 275       99.71        6 29.9130 598.26      29.9130    7.9  628.1730
## 276       47.97        7 16.7895 335.79      16.7895    6.2  352.5795
## 277       21.82       10 10.9100 218.20      10.9100    7.1  229.1100
```

```
## 278       95.42        4 19.0840 381.68      19.0840    6.4  400.7640
## 279       70.99       10 35.4950 709.90      35.4950    5.7  745.3950
## 280       44.02       10 22.0100 440.20      22.0100    9.6  462.2100
## 281       69.96        8 27.9840 559.68      27.9840    6.4  587.6640
## 282       37.00        1  1.8500  37.00       1.8500    7.9   38.8500
## 283       15.34        1  0.7670  15.34       0.7670    6.5   16.1070
## 284       99.83        6 29.9490 598.98      29.9490    8.5  628.9290
## 285       47.67        4  9.5340 190.68       9.5340    9.1  200.2140
## 286       66.68        5 16.6700 333.40      16.6700    7.6  350.0700
## 287       74.86        1  3.7430  74.86       3.7430    6.9   78.6030
## 288       23.75        9 10.6875 213.75      10.6875    9.5  224.4375
## 289       48.51        7 16.9785 339.57      16.9785    5.2  356.5485
## 290       94.88        7 33.2080 664.16      33.2080    4.2  697.3680
## 291       40.30       10 20.1500 403.00      20.1500    7.0  423.1500
## 292       27.85        7  9.7475 194.95       9.7475    6.0  204.6975
## 293       62.48        1  3.1240  62.48       3.1240    4.7   65.6040
## 294       36.36        2  3.6360  72.72       3.6360    7.1   76.3560
## 295       18.11       10  9.0550 181.10       9.0550    5.9  190.1550
## 296       51.92        5 12.9800 259.60      12.9800    7.5  272.5800
## 297       28.84        4  5.7680 115.36       5.7680    6.4  121.1280
## 298       78.38        6 23.5140 470.28      23.5140    5.8  493.7940
## 299       60.01        4 12.0020 240.04      12.0020    4.5  252.0420
## 300       88.61        1  4.4305  88.61       4.4305    7.7   93.0405
## 301       99.82        2  9.9820 199.64       9.9820    6.7  209.6220
## 302       39.01        1  1.9505  39.01       1.9505    4.7   40.9605
## 303       48.61        1  2.4305  48.61       2.4305    4.4   51.0405
## 304       51.19        4 10.2380 204.76      10.2380    4.7  214.9980
## 305       14.96        8  5.9840 119.68       5.9840    8.6  125.6640
## 306       72.20        7 25.2700 505.40      25.2700    4.3  530.6700
## 307       40.23        7 14.0805 281.61      14.0805    9.6  295.6905
## 308       88.79        8 35.5160 710.32      35.5160    4.1  745.8360
## 309       26.48        3  3.9720  79.44       3.9720    4.7   83.4120
## 310       81.91        2  8.1910 163.82       8.1910    7.8  172.0110
## 311       79.93        6 23.9790 479.58      23.9790    5.5  503.5590
## 312       69.33        2  6.9330 138.66       6.9330    9.7  145.5930
## 313       14.23        5  3.5575  71.15       3.5575    4.4   74.7075
## 314       15.55        9  6.9975 139.95       6.9975    5.0  146.9475
## 315       78.13       10 39.0650 781.30      39.0650    4.4  820.3650
## 316       99.37        2  9.9370 198.74       9.9370    5.2  208.6770
## 317       21.08        3  3.1620  63.24       3.1620    7.3   66.4020
## 318       74.79        5 18.6975 373.95      18.6975    4.9  392.6475
## 319       29.67        7 10.3845 207.69      10.3845    8.1  218.0745
## 320       44.07        4  8.8140 176.28       8.8140    8.4  185.0940
## 321       22.93        9 10.3185 206.37      10.3185    5.5  216.6885
## 322       39.42        1  1.9710  39.42       1.9710    8.4   41.3910
## 323       15.26        6  4.5780  91.56       4.5780    9.8   96.1380
## 324       61.77        5 15.4425 308.85      15.4425    6.7  324.2925
## 325       21.52        6  6.4560 129.12       6.4560    9.4  135.5760
## 326       97.74        4 19.5480 390.96      19.5480    6.4  410.5080
## 327       99.78        5 24.9450 498.90      24.9450    5.4  523.8450
## 328       94.26        4 18.8520 377.04      18.8520    8.6  395.8920
## 329       51.13        4 10.2260 204.52      10.2260    4.0  214.7460
## 330       36.36        4  7.2720 145.44       7.2720    7.6  152.7120
## 331       22.02        9  9.9090 198.18       9.9090    6.8  208.0890
```

```
## 332       32.90        3  4.9350  98.70       4.9350    9.1  103.6350
## 333       77.02        5 19.2550 385.10      19.2550    5.5  404.3550
## 334       23.48        2  2.3480  46.96       2.3480    7.9   49.3080
## 335       14.70        5  3.6750  73.50       3.6750    8.5   77.1750
## 336       28.45        5  7.1125 142.25       7.1125    9.1  149.3625
## 337       76.40        9 34.3800 687.60      34.3800    7.5  721.9800
## 338       57.95        6 17.3850 347.70      17.3850    5.2  365.0850
## 339       47.65        3  7.1475 142.95       7.1475    9.5  150.0975
## 340       42.82        9 19.2690 385.38      19.2690    8.9  404.6490
## 341       48.09        3  7.2135 144.27       7.2135    7.8  151.4835
## 342       55.97        7 19.5895 391.79      19.5895    8.9  411.3795
## 343       76.90        7 26.9150 538.30      26.9150    7.7  565.2150
## 344       97.03        5 24.2575 485.15      24.2575    9.3  509.4075
## 345       44.65        3  6.6975 133.95       6.6975    6.2  140.6475
## 346       77.93        9 35.0685 701.37      35.0685    7.6  736.4385
## 347       71.95        1  3.5975  71.95       3.5975    7.3   75.5475
## 348       89.25        8 35.7000 714.00      35.7000    4.7  749.7000
## 349       26.02        7  9.1070 182.14       9.1070    5.1  191.2470
## 350       13.50       10  6.7500 135.00       6.7500    4.8  141.7500
## 351       99.30       10 49.6500 993.00      49.6500    6.6 1042.6500
## 352       51.69        7 18.0915 361.83      18.0915    5.5  379.9215
## 353       54.73        7 19.1555 383.11      19.1555    8.5  402.2655
## 354       27.00        9 12.1500 243.00      12.1500    4.8  255.1500
## 355       30.24        1  1.5120  30.24       1.5120    8.4   31.7520
## 356       89.14        4 17.8280 356.56      17.8280    7.8  374.3880
## 357       37.55       10 18.7750 375.50      18.7750    9.3  394.2750
## 358       95.44       10 47.7200 954.40      47.7200    5.2 1002.1200
## 359       27.50        3  4.1250  82.50       4.1250    6.5   86.6250
## 360       74.97        1  3.7485  74.97       3.7485    5.6   78.7185
## 361       80.96        8 32.3840 647.68      32.3840    7.4  680.0640
## 362       94.47        8 37.7880 755.76      37.7880    9.1  793.5480
## 363       99.79        2  9.9790 199.58       9.9790    8.0  209.5590
## 364       73.22        6 21.9660 439.32      21.9660    7.2  461.2860
## 365       41.24        4  8.2480 164.96       8.2480    7.1  173.2080
## 366       81.68        4 16.3360 326.72      16.3360    9.1  343.0560
## 367       51.32        9 23.0940 461.88      23.0940    5.6  484.9740
## 368       65.94        4 13.1880 263.76      13.1880    6.0  276.9480
## 369       14.36       10  7.1800 143.60       7.1800    5.4  150.7800
## 370       21.50        9  9.6750 193.50       9.6750    7.8  203.1750
## 371       26.26        7  9.1910 183.82       9.1910    9.9  193.0110
## 372       60.96        2  6.0960 121.92       6.0960    4.9  128.0160
## 373       70.11        6 21.0330 420.66      21.0330    5.2  441.6930
## 374       42.08        6 12.6240 252.48      12.6240    8.9  265.1040
## 375       67.09        5 16.7725 335.45      16.7725    9.1  352.2225
## 376       96.70        5 24.1750 483.50      24.1750    7.0  507.6750
## 377       35.38        9 15.9210 318.42      15.9210    9.6  334.3410
## 378       95.49        7 33.4215 668.43      33.4215    8.7  701.8515
## 379       96.98        4 19.3960 387.92      19.3960    9.4  407.3160
## 380       23.65        4  4.7300  94.60       4.7300    4.0   99.3300
## 381       82.33        4 16.4660 329.32      16.4660    7.5  345.7860
## 382       26.61        2  2.6610  53.22       2.6610    4.2   55.8810
## 383       99.69        5 24.9225 498.45      24.9225    9.9  523.3725
## 384       74.89        4 14.9780 299.56      14.9780    4.2  314.5380
## 385       40.94        5 10.2350 204.70      10.2350    9.9  214.9350
```

```
## 386       75.82        1  3.7910  75.82       3.7910    5.8   79.6110
## 387       46.77        6 14.0310 280.62      14.0310    6.0  294.6510
## 388       32.32       10 16.1600 323.20      16.1600   10.0  339.3600
## 389       54.07        9 24.3315 486.63      24.3315    9.5  510.9615
## 390       18.22        7  6.3770 127.54       6.3770    6.6  133.9170
## 391       80.48        3 12.0720 241.44      12.0720    8.1  253.5120
## 392       37.95       10 18.9750 379.50      18.9750    9.7  398.4750
## 393       76.82        1  3.8410  76.82       3.8410    7.2   80.6610
## 394       52.26       10 26.1300 522.60      26.1300    6.2  548.7300
## 395       79.74        1  3.9870  79.74       3.9870    7.3   83.7270
## 396       77.50        5 19.3750 387.50      19.3750    4.3  406.8750
## 397       54.27        5 13.5675 271.35      13.5675    4.6  284.9175
## 398       13.59        9  6.1155 122.31       6.1155    5.8  128.4255
## 399       41.06        6 12.3180 246.36      12.3180    8.3  258.6780
## 400       19.24        9  8.6580 173.16       8.6580    8.0  181.8180
## 401       39.43        6 11.8290 236.58      11.8290    9.4  248.4090
## 402       46.22        4  9.2440 184.88       9.2440    6.2  194.1240
## 403       13.98        1  0.6990  13.98       0.6990    9.8   14.6790
## 404       39.75        5  9.9375 198.75       9.9375    9.6  208.6875
## 405       97.79        7 34.2265 684.53      34.2265    4.9  718.7565
## 406       67.26        4 13.4520 269.04      13.4520    8.0  282.4920
## 407       13.79        5  3.4475  68.95       3.4475    7.8   72.3975
## 408       68.71        4 13.7420 274.84      13.7420    4.1  288.5820
## 409       56.53        4 11.3060 226.12      11.3060    5.5  237.4260
## 410       23.82        5  5.9550 119.10       5.9550    5.4  125.0550
## 411       34.21       10 17.1050 342.10      17.1050    5.1  359.2050
## 412       21.87        2  2.1870  43.74       2.1870    6.9   45.9270
## 413       20.97        5  5.2425 104.85       5.2425    7.8  110.0925
## 414       25.84        3  3.8760  77.52       3.8760    6.6   81.3960
## 415       50.93        8 20.3720 407.44      20.3720    9.2  427.8120
## 416       96.11        1  4.8055  96.11       4.8055    7.8  100.9155
## 417       45.38        4  9.0760 181.52       9.0760    8.7  190.5960
## 418       81.51        1  4.0755  81.51       4.0755    9.2   85.5855
## 419       57.22        2  5.7220 114.44       5.7220    8.3  120.1620
## 420       25.22        7  8.8270 176.54       8.8270    8.2  185.3670
## 421       38.60        3  5.7900 115.80       5.7900    7.5  121.5900
## 422       84.05        3 12.6075 252.15      12.6075    9.8  264.7575
## 423       97.21       10 48.6050 972.10      48.6050    8.7 1020.7050
## 424       25.42        8 10.1680 203.36      10.1680    6.7  213.5280
## 425       16.28        1  0.8140  16.28       0.8140    5.0   17.0940
## 426       40.61        9 18.2745 365.49      18.2745    7.0  383.7645
## 427       53.17        7 18.6095 372.19      18.6095    8.9  390.7995
## 428       20.87        3  3.1305  62.61       3.1305    8.0   65.7405
## 429       67.27        5 16.8175 336.35      16.8175    6.9  353.1675
## 430       90.65       10 45.3250 906.50      45.3250    7.3  951.8250
## 431       69.08        2  6.9080 138.16       6.9080    6.9  145.0680
## 432       43.27        2  4.3270  86.54       4.3270    5.7   90.8670
## 433       23.46        6  7.0380 140.76       7.0380    6.4  147.7980
## 434       95.54        7 33.4390 668.78      33.4390    9.6  702.2190
## 435       47.44        1  2.3720  47.44       2.3720    6.8   49.8120
## 436       99.24        9 44.6580 893.16      44.6580    9.0  937.8180
## 437       82.93        4 16.5860 331.72      16.5860    9.6  348.3060
## 438       33.99        6 10.1970 203.94      10.1970    7.7  214.1370
## 439       17.04        4  3.4080  68.16       3.4080    7.0   71.5680
```

```
## 440       40.86        8 16.3440 326.88      16.3440    6.5  343.2240
## 441       17.44        5  4.3600  87.20       4.3600    8.1   91.5600
## 442       88.43        8 35.3720 707.44      35.3720    4.3  742.8120
## 443       89.21        9 40.1445 802.89      40.1445    6.5  843.0345
## 444       12.78        1  0.6390  12.78       0.6390    9.5   13.4190
## 445       19.10        7  6.6850 133.70       6.6850    9.7  140.3850
## 446       19.15        1  0.9575  19.15       0.9575    9.5   20.1075
## 447       27.66       10 13.8300 276.60      13.8300    8.9  290.4300
## 448       45.74        3  6.8610 137.22       6.8610    6.5  144.0810
## 449       27.07        1  1.3535  27.07       1.3535    5.3   28.4235
## 450       39.12        1  1.9560  39.12       1.9560    9.6   41.0760
## 451       74.71        6 22.4130 448.26      22.4130    6.7  470.6730
## 452       22.01        6  6.6030 132.06       6.6030    7.6  138.6630
## 453       63.61        5 15.9025 318.05      15.9025    4.8  333.9525
## 454       25.00        1  1.2500  25.00       1.2500    5.5   26.2500
## 455       20.77        4  4.1540  83.08       4.1540    4.7   87.2340
## 456       29.56        5  7.3900 147.80       7.3900    6.9  155.1900
## 457       77.40        9 34.8300 696.60      34.8300    4.5  731.4300
## 458       79.39       10 39.6950 793.90      39.6950    6.2  833.5950
## 459       46.57       10 23.2850 465.70      23.2850    7.6  488.9850
## 460       35.89        1  1.7945  35.89       1.7945    7.9   37.6845
## 461       40.52        5 10.1300 202.60      10.1300    4.5  212.7300
## 462       73.05       10 36.5250 730.50      36.5250    8.7  767.0250
## 463       73.95        4 14.7900 295.80      14.7900    6.1  310.5900
## 464       22.62        1  1.1310  22.62       1.1310    6.4   23.7510
## 465       51.34        5 12.8350 256.70      12.8350    9.1  269.5350
## 466       54.55       10 27.2750 545.50      27.2750    7.1  572.7750
## 467       37.15        7 13.0025 260.05      13.0025    7.7  273.0525
## 468       37.02        6 11.1060 222.12      11.1060    4.5  233.2260
## 469       21.58        1  1.0790  21.58       1.0790    7.2   22.6590
## 470       98.84        1  4.9420  98.84       4.9420    8.4  103.7820
## 471       83.77        6 25.1310 502.62      25.1310    5.4  527.7510
## 472       40.05        4  8.0100 160.20       8.0100    9.7  168.2100
## 473       43.13       10 21.5650 431.30      21.5650    5.5  452.8650
## 474       72.57        8 29.0280 580.56      29.0280    4.6  609.5880
## 475       64.44        5 16.1100 322.20      16.1100    6.6  338.3100
## 476       65.18        3  9.7770 195.54       9.7770    6.3  205.3170
## 477       33.26        5  8.3150 166.30       8.3150    4.2  174.6150
## 478       84.07        4 16.8140 336.28      16.8140    4.4  353.0940
## 479       34.37       10 17.1850 343.70      17.1850    6.7  360.8850
## 480       38.60        1  1.9300  38.60       1.9300    6.7   40.5300
## 481       65.97        8 26.3880 527.76      26.3880    8.4  554.1480
## 482       32.80       10 16.4000 328.00      16.4000    6.2  344.4000
## 483       37.14        5  9.2850 185.70       9.2850    5.0  194.9850
## 484       60.38       10 30.1900 603.80      30.1900    6.0  633.9900
## 485       36.98       10 18.4900 369.80      18.4900    7.0  388.2900
## 486       49.49        4  9.8980 197.96       9.8980    6.6  207.8580
## 487       41.09       10 20.5450 410.90      20.5450    7.3  431.4450
## 488       37.15        4  7.4300 148.60       7.4300    8.3  156.0300
## 489       22.96        1  1.1480  22.96       1.1480    4.3   24.1080
## 490       77.68        9 34.9560 699.12      34.9560    9.8  734.0760
## 491       34.70        2  3.4700  69.40       3.4700    8.2   72.8700
## 492       19.66       10  9.8300 196.60       9.8300    7.2  206.4300
## 493       25.32        8 10.1280 202.56      10.1280    8.7  212.6880
```

```
## 494       12.12       10  6.0600 121.20       6.0600    8.4  127.2600
## 495       99.89        2  9.9890 199.78       9.9890    7.1  209.7690
## 496       75.92        8 30.3680 607.36      30.3680    5.5  637.7280
## 497       63.22        2  6.3220 126.44       6.3220    8.5  132.7620
## 498       90.24        6 27.0720 541.44      27.0720    6.2  568.5120
## 499       98.13        1  4.9065  98.13       4.9065    8.9  103.0365
## 500       51.52        8 20.6080 412.16      20.6080    9.6  432.7680
## 501       73.97        1  3.6985  73.97       3.6985    5.4   77.6685
## 502       31.90        1  1.5950  31.90       1.5950    9.1   33.4950
## 503       69.40        2  6.9400 138.80       6.9400    9.0  145.7400
## 504       93.31        2  9.3310 186.62       9.3310    6.3  195.9510
## 505       88.45        1  4.4225  88.45       4.4225    9.5   92.8725
## 506       24.18        8  9.6720 193.44       9.6720    9.8  203.1120
## 507       48.50        3  7.2750 145.50       7.2750    6.7  152.7750
## 508       84.05        6 25.2150 504.30      25.2150    7.7  529.5150
## 509       61.29        5 15.3225 306.45      15.3225    7.0  321.7725
## 510       15.95        6  4.7850  95.70       4.7850    5.1  100.4850
## 511       90.74        7 31.7590 635.18      31.7590    6.2  666.9390
## 512       42.91        5 10.7275 214.55      10.7275    6.1  225.2775
## 513       54.28        7 18.9980 379.96      18.9980    9.3  398.9580
## 514       99.55        7 34.8425 696.85      34.8425    7.6  731.6925
## 515       58.39        7 20.4365 408.73      20.4365    8.2  429.1665
## 516       51.47        1  2.5735  51.47       2.5735    8.5   54.0435
## 517       54.86        5 13.7150 274.30      13.7150    9.8  288.0150
## 518       39.39        5  9.8475 196.95       9.8475    8.7  206.7975
## 519       34.73        2  3.4730  69.46       3.4730    9.7   72.9330
## 520       71.92        5 17.9800 359.60      17.9800    4.3  377.5800
## 521       45.71        3  6.8565 137.13       6.8565    7.7  143.9865
## 522       83.17        6 24.9510 499.02      24.9510    7.3  523.9710
## 523       37.44        6 11.2320 224.64      11.2320    5.9  235.8720
## 524       62.87        2  6.2870 125.74       6.2870    5.0  132.0270
## 525       81.71        6 24.5130 490.26      24.5130    8.0  514.7730
## 526       91.41        5 22.8525 457.05      22.8525    7.1  479.9025
## 527       39.21        4  7.8420 156.84       7.8420    9.0  164.6820
## 528       59.86        2  5.9860 119.72       5.9860    6.7  125.7060
## 529       54.36       10 27.1800 543.60      27.1800    6.1  570.7800
## 530       98.09        9 44.1405 882.81      44.1405    9.3  926.9505
## 531       25.43        6  7.6290 152.58       7.6290    7.0  160.2090
## 532       86.68        8 34.6720 693.44      34.6720    7.2  728.1120
## 533       22.95       10 11.4750 229.50      11.4750    8.2  240.9750
## 534       16.31        9  7.3395 146.79       7.3395    8.4  154.1295
## 535       28.32        5  7.0800 141.60       7.0800    6.2  148.6800
## 536       16.67        7  5.8345 116.69       5.8345    7.4  122.5245
## 537       73.96        1  3.6980  73.96       3.6980    5.0   77.6580
## 538       97.94        1  4.8970  97.94       4.8970    6.9  102.8370
## 539       73.05        4 14.6100 292.20      14.6100    4.9  306.8100
## 540       87.48        6 26.2440 524.88      26.2440    5.1  551.1240
## 541       30.68        3  4.6020  92.04       4.6020    9.1   96.6420
## 542       75.88        1  3.7940  75.88       3.7940    7.1   79.6740
## 543       20.18        4  4.0360  80.72       4.0360    5.0   84.7560
## 544       18.77        6  5.6310 112.62       5.6310    5.5  118.2510
## 545       71.20        1  3.5600  71.20       3.5600    9.2   74.7600
## 546       38.81        4  7.7620 155.24       7.7620    4.9  163.0020
## 547       29.42       10 14.7100 294.20      14.7100    8.9  308.9100
```

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## 548       60.95        9 27.4275 548.55      27.4275    6.0  575.9775
## 549       51.54        5 12.8850 257.70      12.8850    4.2  270.5850
## 550       66.06        6 19.8180 396.36      19.8180    7.3  416.1780
## 551       57.27        3  8.5905 171.81       8.5905    6.5  180.4005
## 552       54.31        9 24.4395 488.79      24.4395    8.9  513.2295
## 553       58.24        9 26.2080 524.16      26.2080    9.7  550.3680
## 554       22.21        6  6.6630 133.26       6.6630    8.6  139.9230
## 555       19.32        7  6.7620 135.24       6.7620    6.9  142.0020
## 556       37.48        3  5.6220 112.44       5.6220    7.7  118.0620
## 557       72.04        2  7.2040 144.08       7.2040    9.5  151.2840
## 558       98.52       10 49.2600 985.20      49.2600    4.5 1034.4600
## 559       41.66        6 12.4980 249.96      12.4980    5.6  262.4580
## 560       72.42        3 10.8630 217.26      10.8630    8.2  228.1230
## 561       21.58        9  9.7110 194.22       9.7110    7.3  203.9310
## 562       89.20       10 44.6000 892.00      44.6000    4.4  936.6000
## 563       42.42        8 16.9680 339.36      16.9680    5.7  356.3280
## 564       74.51        6 22.3530 447.06      22.3530    5.0  469.4130
## 565       99.25        2  9.9250 198.50       9.9250    9.0  208.4250
## 566       81.21       10 40.6050 812.10      40.6050    6.3  852.7050
## 567       49.33       10 24.6650 493.30      24.6650    9.4  517.9650
## 568       65.74        9 29.5830 591.66      29.5830    7.7  621.2430
## 569       79.86        7 27.9510 559.02      27.9510    5.5  586.9710
## 570       73.98        7 25.8930 517.86      25.8930    4.1  543.7530
## 571       82.04        5 20.5100 410.20      20.5100    7.6  430.7100
## 572       26.67       10 13.3350 266.70      13.3350    8.6  280.0350
## 573       10.13        7  3.5455  70.91       3.5455    8.3   74.4555
## 574       72.39        2  7.2390 144.78       7.2390    8.1  152.0190
## 575       85.91        5 21.4775 429.55      21.4775    8.6  451.0275
## 576       81.31        7 28.4585 569.17      28.4585    6.3  597.6285
## 577       60.30        4 12.0600 241.20      12.0600    5.8  253.2600
## 578       31.77        4  6.3540 127.08       6.3540    6.2  133.4340
## 579       64.27        4 12.8540 257.08      12.8540    7.7  269.9340
## 580       69.51        2  6.9510 139.02       6.9510    8.1  145.9710
## 581       27.22        3  4.0830  81.66       4.0830    7.3   85.7430
## 582       77.68        4 15.5360 310.72      15.5360    8.4  326.2560
## 583       92.98        2  9.2980 185.96       9.2980    8.0  195.2580
## 584       18.08        4  3.6160  72.32       3.6160    9.5   75.9360
## 585       63.06        3  9.4590 189.18       9.4590    7.0  198.6390
## 586       51.71        4 10.3420 206.84      10.3420    9.8  217.1820
## 587       52.34        3  7.8510 157.02       7.8510    9.2  164.8710
## 588       43.06        5 10.7650 215.30      10.7650    7.7  226.0650
## 589       59.61       10 29.8050 596.10      29.8050    5.3  625.9050
## 590       14.62        5  3.6550  73.10       3.6550    4.4   76.7550
## 591       46.53        6 13.9590 279.18      13.9590    4.3  293.1390
## 592       24.24        7  8.4840 169.68       8.4840    9.4  178.1640
## 593       45.58        1  2.2790  45.58       2.2790    9.8   47.8590
## 594       75.20        3 11.2800 225.60      11.2800    4.8  236.8800
## 595       96.80        3 14.5200 290.40      14.5200    5.3  304.9200
## 596       14.82        3  2.2230  44.46       2.2230    8.7   46.6830
## 597       52.20        3  7.8300 156.60       7.8300    9.5  164.4300
## 598       46.66        9 20.9970 419.94      20.9970    5.3  440.9370
## 599       36.85        5  9.2125 184.25       9.2125    9.2  193.4625
## 600       70.32        2  7.0320 140.64       7.0320    9.6  147.6720
## 601       83.08        1  4.1540  83.08       4.1540    6.4   87.2340
```

```
## 602       64.99        1  3.2495  64.99       3.2495    4.5   68.2395
## 603       77.56       10 38.7800 775.60      38.7800    6.9  814.3800
## 604       54.51        6 16.3530 327.06      16.3530    7.8  343.4130
## 605       51.89        7 18.1615 363.23      18.1615    4.5  381.3915
## 606       31.75        4  6.3500 127.00       6.3500    8.6  133.3500
## 607       53.65        7 18.7775 375.55      18.7775    5.2  394.3275
## 608       49.79        4  9.9580 199.16       9.9580    6.4  209.1180
## 609       30.61        1  1.5305  30.61       1.5305    5.2   32.1405
## 610       57.89        2  5.7890 115.78       5.7890    8.9  121.5690
## 611       28.96        1  1.4480  28.96       1.4480    6.2   30.4080
## 612       98.97        9 44.5365 890.73      44.5365    6.7  935.2665
## 613       93.22        3 13.9830 279.66      13.9830    7.2  293.6430
## 614       80.93        1  4.0465  80.93       4.0465    9.0   84.9765
## 615       67.45       10 33.7250 674.50      33.7250    4.2  708.2250
## 616       38.72        9 17.4240 348.48      17.4240    4.2  365.9040
## 617       72.60        6 21.7800 435.60      21.7800    6.9  457.3800
## 618       87.91        5 21.9775 439.55      21.9775    4.4  461.5275
## 619       98.53        6 29.5590 591.18      29.5590    4.0  620.7390
## 620       43.46        6 13.0380 260.76      13.0380    8.5  273.7980
## 621       71.68        3 10.7520 215.04      10.7520    9.2  225.7920
## 622       91.61        1  4.5805  91.61       4.5805    9.8   96.1905
## 623       94.59        7 33.1065 662.13      33.1065    4.9  695.2365
## 624       83.25       10 41.6250 832.50      41.6250    4.4  874.1250
## 625       91.35        1  4.5675  91.35       4.5675    6.8   95.9175
## 626       78.88        2  7.8880 157.76       7.8880    9.1  165.6480
## 627       60.87        2  6.0870 121.74       6.0870    8.7  127.8270
## 628       82.58       10 41.2900 825.80      41.2900    5.0  867.0900
## 629       53.30        3  7.9950 159.90       7.9950    7.5  167.8950
## 630       12.09        1  0.6045  12.09       0.6045    8.2   12.6945
## 631       64.19       10 32.0950 641.90      32.0950    6.7  673.9950
## 632       78.31        3 11.7465 234.93      11.7465    5.4  246.6765
## 633       83.77        2  8.3770 167.54       8.3770    7.0  175.9170
## 634       99.70        3 14.9550 299.10      14.9550    4.7  314.0550
## 635       79.91        3 11.9865 239.73      11.9865    5.0  251.7165
## 636       66.47       10 33.2350 664.70      33.2350    5.0  697.9350
## 637       28.95        7 10.1325 202.65      10.1325    6.0  212.7825
## 638       46.20        1  2.3100  46.20       2.3100    6.3   48.5100
## 639       17.63        5  4.4075  88.15       4.4075    8.5   92.5575
## 640       52.42        3  7.8630 157.26       7.8630    7.5  165.1230
## 641       98.79        3 14.8185 296.37      14.8185    6.4  311.1885
## 642       88.55        8 35.4200 708.40      35.4200    4.7  743.8200
## 643       55.67        2  5.5670 111.34       5.5670    6.0  116.9070
## 644       72.52        8 29.0080 580.16      29.0080    4.0  609.1680
## 645       12.05        5  3.0125  60.25       3.0125    5.5   63.2625
## 646       19.36        9  8.7120 174.24       8.7120    8.7  182.9520
## 647       70.21        6 21.0630 421.26      21.0630    7.4  442.3230
## 648       33.63        1  1.6815  33.63       1.6815    5.6   35.3115
## 649       15.49        2  1.5490  30.98       1.5490    6.3   32.5290
## 650       24.74       10 12.3700 247.40      12.3700    7.1  259.7700
## 651       75.66        5 18.9150 378.30      18.9150    7.8  397.2150
## 652       55.81        6 16.7430 334.86      16.7430    9.9  351.6030
## 653       72.78       10 36.3900 727.80      36.3900    7.3  764.1900
## 654       37.32        9 16.7940 335.88      16.7940    5.1  352.6740
## 655       60.18        4 12.0360 240.72      12.0360    9.4  252.7560
```

```
## 656       15.69        3  2.3535  47.07       2.3535    5.8   49.4235
## 657       99.69        1  4.9845  99.69       4.9845    8.0  104.6745
## 658       88.15        3 13.2225 264.45      13.2225    7.9  277.6725
## 659       27.93        5  6.9825 139.65       6.9825    5.9  146.6325
## 660       55.45        1  2.7725  55.45       2.7725    4.9   58.2225
## 661       42.97        3  6.4455 128.91       6.4455    9.3  135.3555
## 662       17.14        7  5.9990 119.98       5.9990    7.9  125.9790
## 663       58.75        6 17.6250 352.50      17.6250    5.9  370.1250
## 664       87.10       10 43.5500 871.00      43.5500    9.9  914.5500
## 665       98.80        2  9.8800 197.60       9.8800    7.7  207.4800
## 666       48.63        4  9.7260 194.52       9.7260    7.6  204.2460
## 667       57.74        3  8.6610 173.22       8.6610    7.7  181.8810
## 668       17.97        4  3.5940  71.88       3.5940    6.4   75.4740
## 669       47.71        6 14.3130 286.26      14.3130    4.4  300.5730
## 670       40.62        2  4.0620  81.24       4.0620    4.1   85.3020
## 671       56.04       10 28.0200 560.40      28.0200    4.4  588.4200
## 672       93.40        2  9.3400 186.80       9.3400    5.5  196.1400
## 673       73.41        3 11.0115 220.23      11.0115    4.0  231.2415
## 674       33.64        8 13.4560 269.12      13.4560    9.3  282.5760
## 675       45.48       10 22.7400 454.80      22.7400    4.8  477.5400
## 676       83.77        2  8.3770 167.54       8.3770    4.6  175.9170
## 677       64.08        7 22.4280 448.56      22.4280    7.3  470.9880
## 678       73.47        4 14.6940 293.88      14.6940    6.0  308.5740
## 679       58.95       10 29.4750 589.50      29.4750    8.1  618.9750
## 680       48.50        6 14.5500 291.00      14.5500    9.4  305.5500
## 681       39.48        1  1.9740  39.48       1.9740    6.5   41.4540
## 682       34.81        1  1.7405  34.81       1.7405    7.0   36.5505
## 683       49.32        6 14.7960 295.92      14.7960    7.1  310.7160
## 684       21.48        2  2.1480  42.96       2.1480    6.6   45.1080
## 685       23.08        6  6.9240 138.48       6.9240    4.9  145.4040
## 686       49.10        2  4.9100  98.20       4.9100    6.4  103.1100
## 687       64.83        2  6.4830 129.66       6.4830    8.0  136.1430
## 688       63.56       10 31.7800 635.60      31.7800    4.3  667.3800
## 689       72.88        2  7.2880 145.76       7.2880    6.1  153.0480
## 690       67.10        3 10.0650 201.30      10.0650    7.5  211.3650
## 691       70.19        9 31.5855 631.71      31.5855    6.7  663.2955
## 692       55.04        7 19.2640 385.28      19.2640    5.2  404.5440
## 693       48.63       10 24.3150 486.30      24.3150    8.8  510.6150
## 694       73.38        7 25.6830 513.66      25.6830    9.5  539.3430
## 695       52.60        9 23.6700 473.40      23.6700    7.6  497.0700
## 696       87.37        5 21.8425 436.85      21.8425    6.6  458.6925
## 697       27.04        4  5.4080 108.16       5.4080    6.9  113.5680
## 698       62.19        4 12.4380 248.76      12.4380    4.3  261.1980
## 699       69.58        9 31.3110 626.22      31.3110    7.8  657.5310
## 700       97.50       10 48.7500 975.00      48.7500    8.0 1023.7500
## 701       60.41        8 24.1640 483.28      24.1640    9.6  507.4440
## 702       32.32        3  4.8480  96.96       4.8480    4.3  101.8080
## 703       19.77       10  9.8850 197.70       9.8850    5.0  207.5850
## 704       80.47        9 36.2115 724.23      36.2115    9.2  760.4415
## 705       88.39        9 39.7755 795.51      39.7755    6.3  835.2855
## 706       71.77        7 25.1195 502.39      25.1195    8.9  527.5095
## 707       43.00        4  8.6000 172.00       8.6000    7.6  180.6000
## 708       68.98        1  3.4490  68.98       3.4490    4.8   72.4290
## 709       15.62        8  6.2480 124.96       6.2480    9.1  131.2080
```

```
## 710       25.70        3  3.8550  77.10       3.8550    6.1   80.9550
## 711       80.62        6 24.1860 483.72      24.1860    9.1  507.9060
## 712       75.53        4 15.1060 302.12      15.1060    8.3  317.2260
## 713       77.63        9 34.9335 698.67      34.9335    7.2  733.6035
## 714       13.85        9  6.2325 124.65       6.2325    6.0  130.8825
## 715       98.70        8 39.4800 789.60      39.4800    8.5  829.0800
## 716       35.68        5  8.9200 178.40       8.9200    6.6  187.3200
## 717       71.46        7 25.0110 500.22      25.0110    4.5  525.2310
## 718       11.94        3  1.7910  35.82       1.7910    8.1   37.6110
## 719       45.38        3  6.8070 136.14       6.8070    7.2  142.9470
## 720       17.48        6  5.2440 104.88       5.2440    6.1  110.1240
## 721       25.56        7  8.9460 178.92       8.9460    7.1  187.8660
## 722       90.63        9 40.7835 815.67      40.7835    5.1  856.4535
## 723       44.12        3  6.6180 132.36       6.6180    7.9  138.9780
## 724       36.77        7 12.8695 257.39      12.8695    7.4  270.2595
## 725       23.34        4  4.6680  93.36       4.6680    7.4   98.0280
## 726       28.50        8 11.4000 228.00      11.4000    6.6  239.4000
## 727       55.57        3  8.3355 166.71       8.3355    5.9  175.0455
## 728       69.74       10 34.8700 697.40      34.8700    8.9  732.2700
## 729       97.26        4 19.4520 389.04      19.4520    6.8  408.4920
## 730       52.18        7 18.2630 365.26      18.2630    9.3  383.5230
## 731       22.32        4  4.4640  89.28       4.4640    4.4   93.7440
## 732       56.00        3  8.4000 168.00       8.4000    4.8  176.4000
## 733       19.70        1  0.9850  19.70       0.9850    9.5   20.6850
## 734       75.88        7 26.5580 531.16      26.5580    8.9  557.7180
## 735       53.72        1  2.6860  53.72       2.6860    6.4   56.4060
## 736       81.95       10 40.9750 819.50      40.9750    6.0  860.4750
## 737       81.20        7 28.4200 568.40      28.4200    8.1  596.8200
## 738       58.76       10 29.3800 587.60      29.3800    9.0  616.9800
## 739       91.56        8 36.6240 732.48      36.6240    6.0  769.1040
## 740       93.96        9 42.2820 845.64      42.2820    9.8  887.9220
## 741       55.61        7 19.4635 389.27      19.4635    8.5  408.7335
## 742       84.83        1  4.2415  84.83       4.2415    8.8   89.0715
## 743       71.63        2  7.1630 143.26       7.1630    8.8  150.4230
## 744       37.69        2  3.7690  75.38       3.7690    9.5   79.1490
## 745       31.67        8 12.6680 253.36      12.6680    5.6  266.0280
## 746       38.42        1  1.9210  38.42       1.9210    8.6   40.3410
## 747       65.23       10 32.6150 652.30      32.6150    5.2  684.9150
## 748       10.53        5  2.6325  52.65       2.6325    5.8   55.2825
## 749       12.29        9  5.5305 110.61       5.5305    8.0  116.1405
## 750       81.23        7 28.4305 568.61      28.4305    9.0  597.0405
## 751       22.32        4  4.4640  89.28       4.4640    4.1   93.7440
## 752       27.28        5  6.8200 136.40       6.8200    8.6  143.2200
## 753       17.42       10  8.7100 174.20       8.7100    7.0  182.9100
## 754       73.28        5 18.3200 366.40      18.3200    8.4  384.7200
## 755       84.87        3 12.7305 254.61      12.7305    7.4  267.3405
## 756       97.29        8 38.9160 778.32      38.9160    6.2  817.2360
## 757       35.74        8 14.2960 285.92      14.2960    4.9  300.2160
## 758       96.52        6 28.9560 579.12      28.9560    4.5  608.0760
## 759       18.85       10  9.4250 188.50       9.4250    5.6  197.9250
## 760       55.39        4 11.0780 221.56      11.0780    8.0  232.6380
## 761       77.20       10 38.6000 772.00      38.6000    5.6  810.6000
## 762       72.13       10 36.0650 721.30      36.0650    4.2  757.3650
## 763       63.88        8 25.5520 511.04      25.5520    9.9  536.5920
```

```
## 764       10.69        5  2.6725  53.45       2.6725    7.6   56.1225
## 765       55.50        4 11.1000 222.00      11.1000    6.6  233.1000
## 766       95.46        8 38.1840 763.68      38.1840    4.7  801.8640
## 767       76.06        3 11.4090 228.18      11.4090    9.8  239.5890
## 768       13.69        6  4.1070  82.14       4.1070    6.3   86.2470
## 769       95.64        4 19.1280 382.56      19.1280    7.9  401.6880
## 770       11.43        6  3.4290  68.58       3.4290    7.7   72.0090
## 771       95.54        4 19.1080 382.16      19.1080    4.5  401.2680
## 772       85.87        7 30.0545 601.09      30.0545    8.0  631.1445
## 773       67.99        7 23.7965 475.93      23.7965    5.7  499.7265
## 774       52.42        1  2.6210  52.42       2.6210    6.3   55.0410
## 775       65.65        2  6.5650 131.30       6.5650    6.0  137.8650
## 776       28.86        5  7.2150 144.30       7.2150    8.0  151.5150
## 777       65.31        7 22.8585 457.17      22.8585    4.2  480.0285
## 778       93.38        1  4.6690  93.38       4.6690    9.6   98.0490
## 779       25.25        5  6.3125 126.25       6.3125    6.1  132.5625
## 780       87.87        9 39.5415 790.83      39.5415    5.6  830.3715
## 781       21.80        8  8.7200 174.40       8.7200    8.3  183.1200
## 782       94.76        4 18.9520 379.04      18.9520    7.8  397.9920
## 783       30.62        1  1.5310  30.62       1.5310    4.1   32.1510
## 784       44.01        8 17.6040 352.08      17.6040    8.8  369.6840
## 785       10.16        5  2.5400  50.80       2.5400    4.1   53.3400
## 786       74.58        7 26.1030 522.06      26.1030    9.0  548.1630
## 787       71.89        8 28.7560 575.12      28.7560    5.5  603.8760
## 788       10.99        5  2.7475  54.95       2.7475    9.3   57.6975
## 789       60.47        3  9.0705 181.41       9.0705    5.6  190.4805
## 790       58.91        7 20.6185 412.37      20.6185    9.7  432.9885
## 791       46.41        1  2.3205  46.41       2.3205    4.0   48.7305
## 792       68.55        4 13.7100 274.20      13.7100    9.2  287.9100
## 793       97.37       10 48.6850 973.70      48.6850    4.9 1022.3850
## 794       92.60        7 32.4100 648.20      32.4100    9.3  680.6100
## 795       46.61        2  4.6610  93.22       4.6610    6.6   97.8810
## 796       27.18        2  2.7180  54.36       2.7180    4.3   57.0780
## 797       60.87        1  3.0435  60.87       3.0435    5.5   63.9135
## 798       24.49       10 12.2450 244.90      12.2450    8.1  257.1450
## 799       92.78        1  4.6390  92.78       4.6390    9.8   97.4190
## 800       86.69        5 21.6725 433.45      21.6725    9.4  455.1225
## 801       23.01        6  6.9030 138.06       6.9030    7.9  144.9630
## 802       30.20        8 12.0800 241.60      12.0800    5.1  253.6800
## 803       67.39        7 23.5865 471.73      23.5865    6.9  495.3165
## 804       48.96        9 22.0320 440.64      22.0320    8.0  462.6720
## 805       75.59        9 34.0155 680.31      34.0155    8.0  714.3255
## 806       77.47        4 15.4940 309.88      15.4940    4.2  325.3740
## 807       93.18        2  9.3180 186.36       9.3180    8.5  195.6780
## 808       50.23        4 10.0460 200.92      10.0460    9.0  210.9660
## 809       17.75        1  0.8875  17.75       0.8875    8.6   18.6375
## 810       62.18       10 31.0900 621.80      31.0900    6.0  652.8900
## 811       10.75        8  4.3000  86.00       4.3000    6.2   90.3000
## 812       40.26       10 20.1300 402.60      20.1300    5.0  422.7300
## 813       64.97        5 16.2425 324.85      16.2425    6.5  341.0925
## 814       95.15        1  4.7575  95.15       4.7575    6.0   99.9075
## 815       48.62        8 19.4480 388.96      19.4480    5.0  408.4080
## 816       53.21        8 21.2840 425.68      21.2840    5.0  446.9640
## 817       45.44        7 15.9040 318.08      15.9040    9.2  333.9840
```

```
## 818       33.88        8 13.5520 271.04      13.5520    9.6  284.5920
## 819       96.16        4 19.2320 384.64      19.2320    8.4  403.8720
## 820       47.16        5 11.7900 235.80      11.7900    6.0  247.5900
## 821       52.89        4 10.5780 211.56      10.5780    6.7  222.1380
## 822       47.68        2  4.7680  95.36       4.7680    4.1  100.1280
## 823       10.17        1  0.5085  10.17       0.5085    5.9   10.6785
## 824       68.71        3 10.3065 206.13      10.3065    8.7  216.4365
## 825       60.08        7 21.0280 420.56      21.0280    4.5  441.5880
## 826       22.01        4  4.4020  88.04       4.4020    6.6   92.4420
## 827       72.11        9 32.4495 648.99      32.4495    7.7  681.4395
## 828       41.28        3  6.1920 123.84       6.1920    8.5  130.0320
## 829       64.95       10 32.4750 649.50      32.4750    5.2  681.9750
## 830       74.22       10 37.1100 742.20      37.1100    4.3  779.3100
## 831       10.56        8  4.2240  84.48       4.2240    7.6   88.7040
## 832       62.57        4 12.5140 250.28      12.5140    9.5  262.7940
## 833       11.85        8  4.7400  94.80       4.7400    4.1   99.5400
## 834       91.30        1  4.5650  91.30       4.5650    9.2   95.8650
## 835       40.73        7 14.2555 285.11      14.2555    5.4  299.3655
## 836       52.38        1  2.6190  52.38       2.6190    5.8   54.9990
## 837       38.54        5  9.6350 192.70       9.6350    5.6  202.3350
## 838       44.63        6 13.3890 267.78      13.3890    5.1  281.1690
## 839       55.87       10 27.9350 558.70      27.9350    5.8  586.6350
## 840       29.22        6  8.7660 175.32       8.7660    5.0  184.0860
## 841       51.94        3  7.7910 155.82       7.7910    7.9  163.6110
## 842       60.30        1  3.0150  60.30       3.0150    6.0   63.3150
## 843       39.47        2  3.9470  78.94       3.9470    5.0   82.8870
## 844       14.87        2  1.4870  29.74       1.4870    8.9   31.2270
## 845       21.32        1  1.0660  21.32       1.0660    5.9   22.3860
## 846       93.78        3 14.0670 281.34      14.0670    5.9  295.4070
## 847       73.26        1  3.6630  73.26       3.6630    9.7   76.9230
## 848       22.38        1  1.1190  22.38       1.1190    8.6   23.4990
## 849       72.88        9 32.7960 655.92      32.7960    4.0  688.7160
## 850       99.10        6 29.7300 594.60      29.7300    4.2  624.3300
## 851       74.10        1  3.7050  74.10       3.7050    9.2   77.8050
## 852       98.48        2  9.8480 196.96       9.8480    9.2  206.8080
## 853       53.19        7 18.6165 372.33      18.6165    5.0  390.9465
## 854       52.79       10 26.3950 527.90      26.3950   10.0  554.2950
## 855       95.95        5 23.9875 479.75      23.9875    8.8  503.7375
## 856       36.51        9 16.4295 328.59      16.4295    4.2  345.0195
## 857       21.12        8  8.4480 168.96       8.4480    6.3  177.4080
## 858       28.31        4  5.6620 113.24       5.6620    8.2  118.9020
## 859       57.59        6 17.2770 345.54      17.2770    5.1  362.8170
## 860       47.63        9 21.4335 428.67      21.4335    5.0  450.1035
## 861       86.27        1  4.3135  86.27       4.3135    7.0   90.5835
## 862       12.76        2  1.2760  25.52       1.2760    7.8   26.7960
## 863       11.28        9  5.0760 101.52       5.0760    4.3  106.5960
## 864       51.07        7 17.8745 357.49      17.8745    7.0  375.3645
## 865       79.59        3 11.9385 238.77      11.9385    6.6  250.7085
## 866       33.81        3  5.0715 101.43       5.0715    7.3  106.5015
## 867       90.53        8 36.2120 724.24      36.2120    6.5  760.4520
## 868       62.82        2  6.2820 125.64       6.2820    4.9  131.9220
## 869       24.31        3  3.6465  72.93       3.6465    4.3   76.5765
## 870       64.59        4 12.9180 258.36      12.9180    9.3  271.2780
## 871       24.82        7  8.6870 173.74       8.6870    7.1  182.4270
```

```
## 872       56.50        1  2.8250  56.50       2.8250    9.6   59.3250
## 873       21.43       10 10.7150 214.30      10.7150    6.2  225.0150
## 874       89.06        6 26.7180 534.36      26.7180    9.9  561.0780
## 875       23.29        4  4.6580  93.16       4.6580    5.9   97.8180
## 876       65.26        8 26.1040 522.08      26.1040    6.3  548.1840
## 877       52.35        1  2.6175  52.35       2.6175    4.0   54.9675
## 878       39.75        1  1.9875  39.75       1.9875    6.1   41.7375
## 879       90.02        8 36.0080 720.16      36.0080    4.5  756.1680
## 880       12.10        8  4.8400  96.80       4.8400    8.6  101.6400
## 881       33.21       10 16.6050 332.10      16.6050    6.0  348.7050
## 882       10.18        8  4.0720  81.44       4.0720    9.5   85.5120
## 883       31.99       10 15.9950 319.90      15.9950    9.9  335.8950
## 884       34.42        6 10.3260 206.52      10.3260    7.5  216.8460
## 885       83.34        2  8.3340 166.68       8.3340    7.6  175.0140
## 886       45.58        7 15.9530 319.06      15.9530    5.0  335.0130
## 887       87.90        1  4.3950  87.90       4.3950    6.7   92.2950
## 888       73.47       10 36.7350 734.70      36.7350    9.5  771.4350
## 889       12.19        8  4.8760  97.52       4.8760    6.8  102.3960
## 890       76.92       10 38.4600 769.20      38.4600    5.6  807.6600
## 891       83.66        5 20.9150 418.30      20.9150    7.2  439.2150
## 892       57.91        8 23.1640 463.28      23.1640    8.1  486.4440
## 893       92.49        5 23.1225 462.45      23.1225    8.6  485.5725
## 894       28.38        5  7.0950 141.90       7.0950    9.4  148.9950
## 895       50.45        6 15.1350 302.70      15.1350    8.9  317.8350
## 896       99.16        8 39.6640 793.28      39.6640    4.2  832.9440
## 897       60.74        7 21.2590 425.18      21.2590    5.0  446.4390
## 898       47.27        6 14.1810 283.62      14.1810    8.8  297.8010
## 899       85.60        7 29.9600 599.20      29.9600    5.3  629.1600
## 900       35.04        9 15.7680 315.36      15.7680    4.6  331.1280
## 901       44.84        9 20.1780 403.56      20.1780    7.5  423.7380
## 902       45.97        4  9.1940 183.88       9.1940    5.1  193.0740
## 903       27.73        5  6.9325 138.65       6.9325    4.2  145.5825
## 904       11.53        7  4.0355  80.71       4.0355    8.1   84.7455
## 905       58.32        2  5.8320 116.64       5.8320    6.0  122.4720
## 906       78.38        4 15.6760 313.52      15.6760    7.9  329.1960
## 907       84.61       10 42.3050 846.10      42.3050    8.8  888.4050
## 908       82.88        5 20.7200 414.40      20.7200    6.6  435.1200
## 909       79.54        2  7.9540 159.08       7.9540    6.2  167.0340
## 910       49.01       10 24.5050 490.10      24.5050    4.2  514.6050
## 911       29.15        3  4.3725  87.45       4.3725    7.3   91.8225
## 912       56.13        4 11.2260 224.52      11.2260    8.6  235.7460
## 913       93.12        8 37.2480 744.96      37.2480    6.8  782.2080
## 914       51.34        8 20.5360 410.72      20.5360    7.6  431.2560
## 915       99.60        3 14.9400 298.80      14.9400    5.8  313.7400
## 916       35.49        6 10.6470 212.94      10.6470    4.1  223.5870
## 917       42.85        1  2.1425  42.85       2.1425    9.3   44.9925
## 918       94.67        4 18.9340 378.68      18.9340    6.8  397.6140
## 919       68.97        3 10.3455 206.91      10.3455    8.7  217.2555
## 920       26.26        3  3.9390  78.78       3.9390    6.3   82.7190
## 921       35.79        9 16.1055 322.11      16.1055    5.1  338.2155
## 922       16.37        6  4.9110  98.22       4.9110    7.0  103.1310
## 923       12.73        2  1.2730  25.46       1.2730    5.2   26.7330
## 924       83.14        7 29.0990 581.98      29.0990    6.6  611.0790
## 925       35.22        6 10.5660 211.32      10.5660    6.5  221.8860
```

```
## 926       13.78        4  2.7560  55.12       2.7560    9.0   57.8760
## 927       88.31        1  4.4155  88.31       4.4155    5.2   92.7255
## 928       39.62        9 17.8290 356.58      17.8290    6.8  374.4090
## 929       88.25        9 39.7125 794.25      39.7125    7.6  833.9625
## 930       25.31        2  2.5310  50.62       2.5310    7.2   53.1510
## 931       99.92        6 29.9760 599.52      29.9760    7.1  629.4960
## 932       83.35        2  8.3350 166.70       8.3350    9.5  175.0350
## 933       74.44       10 37.2200 744.40      37.2200    5.1  781.6200
## 934       64.08        7 22.4280 448.56      22.4280    7.6  470.9880
## 935       63.15        6 18.9450 378.90      18.9450    9.8  397.8450
## 936       85.72        3 12.8580 257.16      12.8580    5.1  270.0180
## 937       78.89        7 27.6115 552.23      27.6115    7.5  579.8415
## 938       89.48        5 22.3700 447.40      22.3700    7.4  469.7700
## 939       92.09        3 13.8135 276.27      13.8135    4.2  290.0835
## 940       57.29        6 17.1870 343.74      17.1870    5.9  360.9270
## 941       66.52        4 13.3040 266.08      13.3040    6.9  279.3840
## 942       99.82        9 44.9190 898.38      44.9190    6.6  943.2990
## 943       45.68       10 22.8400 456.80      22.8400    5.7  479.6400
## 944       50.79        5 12.6975 253.95      12.6975    5.3  266.6475
## 945       10.08        7  3.5280  70.56       3.5280    4.2   74.0880
## 946       93.88        7 32.8580 657.16      32.8580    7.3  690.0180
## 947       84.25        2  8.4250 168.50       8.4250    5.3  176.9250
## 948       53.78        1  2.6890  53.78       2.6890    4.7   56.4690
## 949       35.81        5  8.9525 179.05       8.9525    7.9  188.0025
## 950       26.43        8 10.5720 211.44      10.5720    8.9  222.0120
## 951       39.91        3  5.9865 119.73       5.9865    9.3  125.7165
## 952       21.90        3  3.2850  65.70       3.2850    4.7   68.9850
## 953       62.85        4 12.5700 251.40      12.5700    8.7  263.9700
## 954       21.04        4  4.2080  84.16       4.2080    7.6   88.3680
## 955       65.91        6 19.7730 395.46      19.7730    5.7  415.2330
## 956       42.57        7 14.8995 297.99      14.8995    6.8  312.8895
## 957       50.49        9 22.7205 454.41      22.7205    5.4  477.1305
## 958       46.02        6 13.8060 276.12      13.8060    7.1  289.9260
## 959       15.80       10  7.9000 158.00       7.9000    7.8  165.9000
## 960       98.66        9 44.3970 887.94      44.3970    8.4  932.3370
## 961       91.98        1  4.5990  91.98       4.5990    9.8   96.5790
## 962       20.89        2  2.0890  41.78       2.0890    9.8   43.8690
## 963       15.50        1  0.7750  15.50       0.7750    7.4   16.2750
## 964       96.82        3 14.5230 290.46      14.5230    6.7  304.9830
## 965       33.33        2  3.3330  66.66       3.3330    6.4   69.9930
## 966       38.27        2  3.8270  76.54       3.8270    5.8   80.3670
## 967       33.30        9 14.9850 299.70      14.9850    7.2  314.6850
## 968       81.01        3 12.1515 243.03      12.1515    9.3  255.1815
## 969       15.80        3  2.3700  47.40       2.3700    9.5   49.7700
## 970       34.49        5  8.6225 172.45       8.6225    9.0  181.0725
## 971       84.63       10 42.3150 846.30      42.3150    9.0  888.6150
## 972       36.91        7 12.9185 258.37      12.9185    6.7  271.2885
## 973       87.08        7 30.4780 609.56      30.4780    5.5  640.0380
## 974       80.08        3 12.0120 240.24      12.0120    5.4  252.2520
## 975       86.13        2  8.6130 172.26       8.6130    8.2  180.8730
## 976       49.92        2  4.9920  99.84       4.9920    7.0  104.8320
## 977       74.66        4 14.9320 298.64      14.9320    8.5  313.5720
## 978       26.60        6  7.9800 159.60       7.9800    4.9  167.5800
## 979       25.45        1  1.2725  25.45       1.2725    5.1   26.7225
```

```
## 980       67.77        1  3.3885  67.77       3.3885    6.5   71.1585
## 981       59.59        4 11.9180 238.36      11.9180    9.8  250.2780
## 982       58.15        4 11.6300 232.60      11.6300    8.4  244.2300
## 983       97.48        9 43.8660 877.32      43.8660    7.4  921.1860
## 984       99.96        7 34.9860 699.72      34.9860    6.1  734.7060
## 985       96.37        7 33.7295 674.59      33.7295    6.0  708.3195
## 986       63.71        5 15.9275 318.55      15.9275    8.5  334.4775
## 987       14.76        2  1.4760  29.52       1.4760    4.3   30.9960
## 988       62.00        8 24.8000 496.00      24.8000    6.2  520.8000
## 989       82.34       10 41.1700 823.40      41.1700    4.3  864.5700
## 990       75.37        8 30.1480 602.96      30.1480    8.4  633.1080
## 991       56.56        5 14.1400 282.80      14.1400    4.5  296.9400
## 992       76.60       10 38.3000 766.00      38.3000    6.0  804.3000
## 993       58.03        2  5.8030 116.06       5.8030    8.8  121.8630
## 994       17.49       10  8.7450 174.90       8.7450    6.6  183.6450
## 995       60.95        1  3.0475  60.95       3.0475    5.9   63.9975
## 996       40.35        1  2.0175  40.35       2.0175    6.2   42.3675
## 997       97.38       10 48.6900 973.80      48.6900    4.4 1022.4900
## 998       31.84        1  1.5920  31.84       1.5920    7.7   33.4320
## 999       65.82        1  3.2910  65.82       3.2910    4.1   69.1110
## 1000      88.34        7 30.9190 618.38      30.9190    6.6  649.2990
```

```
data.pca <- prcomp(num_v, center = TRUE,scale. = TRUE)

summary(data.pca)
```

```
## Importance of components:
##                           PC1    PC2    PC3     PC4                    PC5
## Standard deviation     2.2185 1.0002 0.9939 0.30001 0.0000000000000002981
## Proportion of Variance 0.7031 0.1429 0.1411 0.01286 0.0000000000000000000
## Cumulative Proportion  0.7031 0.8460 0.9871 1.00000 1.0000000000000000000
##                                         PC6                    PC7
## Standard deviation     0.0000000000000001493 0.0000000000000000009831
## Proportion of Variance 0.0000000000000000000 0.0000000000000000000
## Cumulative Proportion  1.0000000000000000000 1.0000000000000000000
```

We obtained 7 principal components. PC1 has a cumulative proportion of 70% and PC2 80% meaning almost all components of the dataset can be encapsulated in this components.

Plotting PCA

```
#install.packages("devtools")
library(devtools)
```

```
## Loading required package: usethis
```

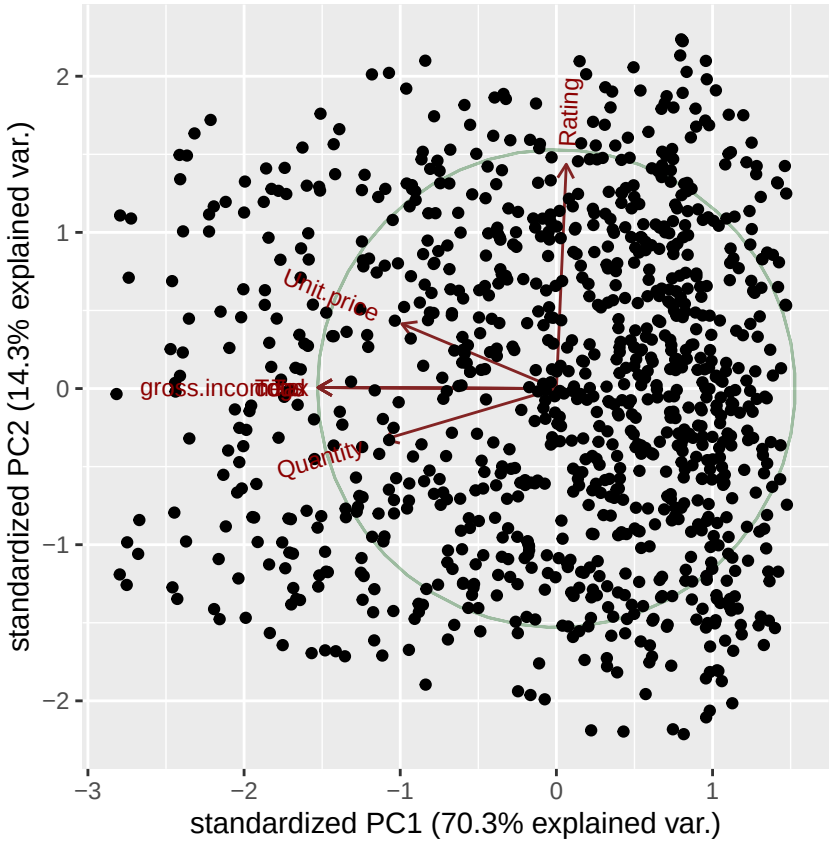
```
#install_github("vqv/ggbiplot")#Plotting the necessary library
```

```
library(ggbiplot)
```

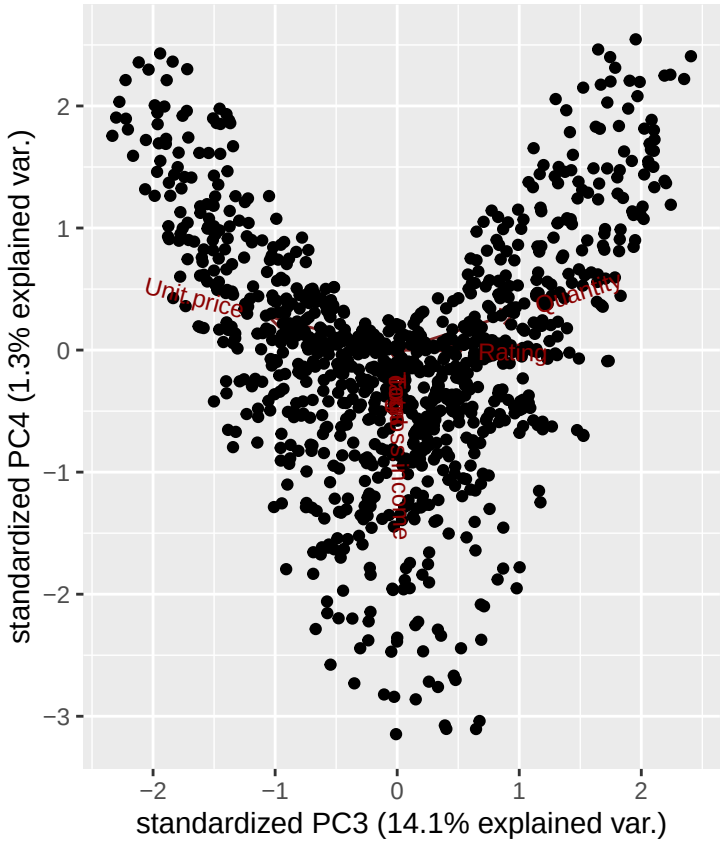
```
## Loading required package: plyr
```

```
## ------------------------------------------------------------------------------

## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:
## library(plyr); library(dplyr)

## ------------------------------------------------------------------------------

##
## Attaching package: 'plyr'

## The following object is masked from 'package:lessR':
##
##     .

## The following object is masked from 'package:purrr':
##
##     compact

## The following objects are masked from 'package:dplyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize

## The following objects are masked from 'package:Hmisc':
##
##     is.discrete, summarize

## Loading required package: scales

##
## Attaching package: 'scales'

## The following object is masked from 'package:lessR':
##
##     rescale

## The following object is masked from 'package:purrr':
##
##     discard

## The following object is masked from 'package:readr':
##
##     col_factor

## Loading required package: grid
```

```
ggbiplot(data.pca,ellipse=TRUE,circle=TRUE)
```




```
ggbiplot(data.pca,ellipse=TRUE,choices =c(3,4))
```



PC3 account for 14% variation.

The quantity, unit price, rating, gross income form the PC1 and PC2 component which accounts for 70.3% variance.Quantity, unit price, gross income, and rating are the factors that provide the most information about our dataset.

##Feature Selection

We wil use the Caret R package provides the findCorrelation which will analyze a correlation matrix of our data's attributes report on attributes that can be removed.

```
#set.seed(7)
# load the library
#install.packages("mlbench")
library(mlbench)
library(caret)
```

```
##
## Attaching package: 'caret'
```

```
## The following object is masked from 'package:purrr':
##
##     lift
```

```
## The following object is masked from 'package:survival':
##
##     cluster
```

```r
# calculate correlation matrix
correlationMatrix <- cor(num_v)
# summarize the correlation matrix
print(correlationMatrix)
```

```
##                Unit.price    Quantity        Tax       cogs gross.income
## Unit.price    1.000000000  0.01077756  0.6339621  0.6339621    0.6339621
## Quantity      0.010777564  1.00000000  0.7055102  0.7055102    0.7055102
## Tax           0.633962089  0.70551019  1.0000000  1.0000000    1.0000000
## cogs          0.633962089  0.70551019  1.0000000  1.0000000    1.0000000
## gross.income  0.633962089  0.70551019  1.0000000  1.0000000    1.0000000
## Rating       -0.008777507 -0.01581490 -0.0364417 -0.0364417   -0.0364417
## Total         0.633962089  0.70551019  1.0000000  1.0000000    1.0000000
##                     Rating      Total
## Unit.price   -0.008777507  0.6339621
## Quantity     -0.015814905  0.7055102
## Tax          -0.036441705  1.0000000
## cogs         -0.036441705  1.0000000
## gross.income -0.036441705  1.0000000
## Rating        1.000000000 -0.0364417
## Total        -0.036441705  1.0000000
```

```r
# find attributes that are highly corrected (ideally >0.75)
highlyCorrelated <- findCorrelation(correlationMatrix, cutoff=0.5)
# print indexes of highly correlated attributes
print(highlyCorrelated)
```

```
## [1] 4 7 3 5
```

```r
#Printing the names of the highly correlated features
names(num_v[,highlyCorrelated])
```

```
## [1] "cogs"         "Total"        "Tax"          "gross.income"
```

cogs, Total and Tax account are highly correlated hence are redundant features in our data.

```r
#Removing the redundant features and plotting the graphical representation

df<- num_v[-highlyCorrelated]
```

```r
corrplot(cor(df),order="hclust")
```

We reduced our features to the ones that provide the most information about our dataset which are Quantity, Unit price and Rating.

Association Analysis

Association analysis is used when you want to find an association between different objects in a set, find frequent patterns in a transaction database, relational databases or any other information repository. Dataset 2 contains transaction data and items bought in transactions.

```
#install and load package arules
#install.packages("arules")
library(arules)
```

```
## Loading required package: Matrix
```

```
##
## Attaching package: 'Matrix'
```

```
## The following objects are masked from 'package:tidyr':
##
##     expand, pack, unpack
```

```
##
## Attaching package: 'arules'
```

```
## The following object is masked from 'package:lessR':
##
##     recode

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

## The following objects are masked from 'package:base':
##
##     abbreviate, write
```

```
#install and load arulesViz
#install.packages("arulesViz")
library(arulesViz)
```

Loading our dataset

```
tr <- read.transactions('Supermarket_Sales_Dataset II.csv', format = 'basket', sep=',')
```

viewing the tr dataset and summaries

```
summary(tr)
```

```
## transactions as itemMatrix in sparse format with
##  7501 rows (elements/itemsets/transactions) and
##  119 columns (items) and a density of 0.03288973
##
## most frequent items:
## mineral water          eggs     spaghetti  french fries     chocolate
##          1788          1348          1306          1282          1229
##       (Other)
##         22405
##
## element (itemset/transaction) length distribution:
## sizes
##    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16
## 1754 1358 1044  816  667  493  391  324  259  139  102   67   40   22   17    4
##   18   19   20
##    1    2    1
##
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.000   2.000   3.000   3.914   5.000  20.000
##
## includes extended item information - examples:
##              labels
## 1           almonds
## 2 antioxydant juice
## 3         asparagus
```

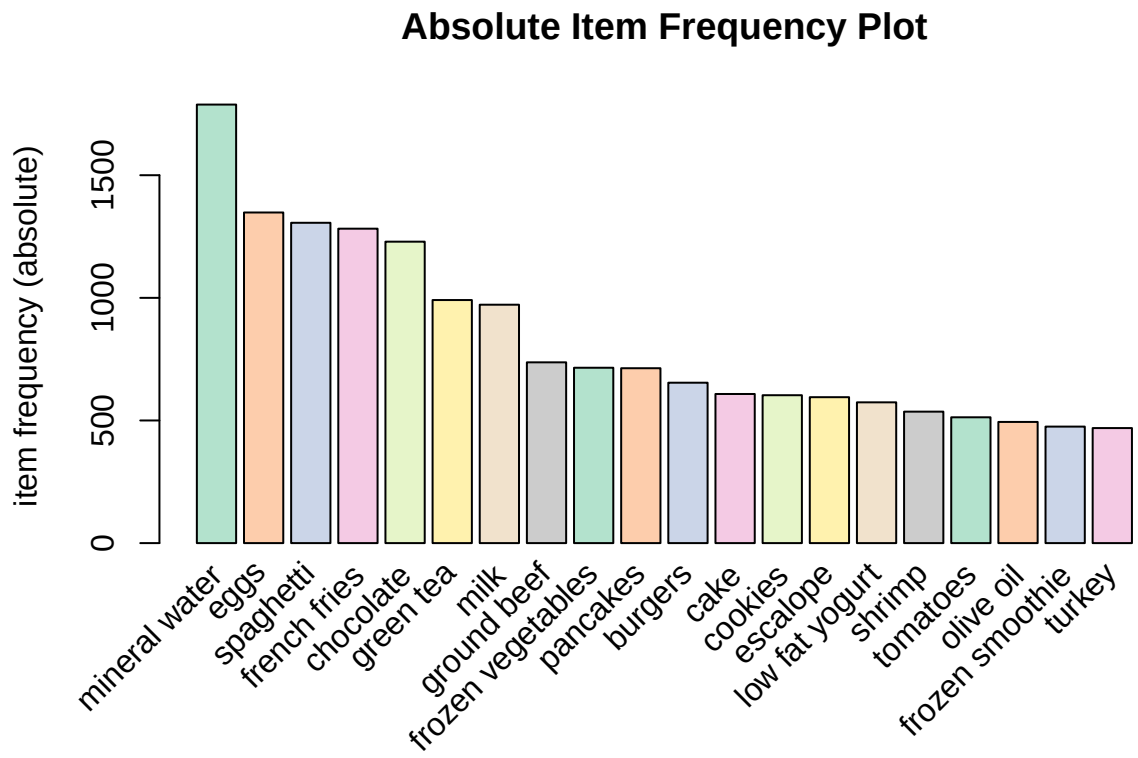
The dataset has 7501 rows (elements/itemsets/transactions) and 119 columns (items). The most frequently bought items are: mineral water, eggs, spaghetti, french fries and chocolates

We can also generate a frequency visualization to show the frequency of the items boughts.

```
# Create an item frequency plot for the top 20 items
if (!require("RColorBrewer")) {
install.packages("RColorBrewer")  # install color package of R
#include library RColorBrewer
library(RColorBrewer)
}
```

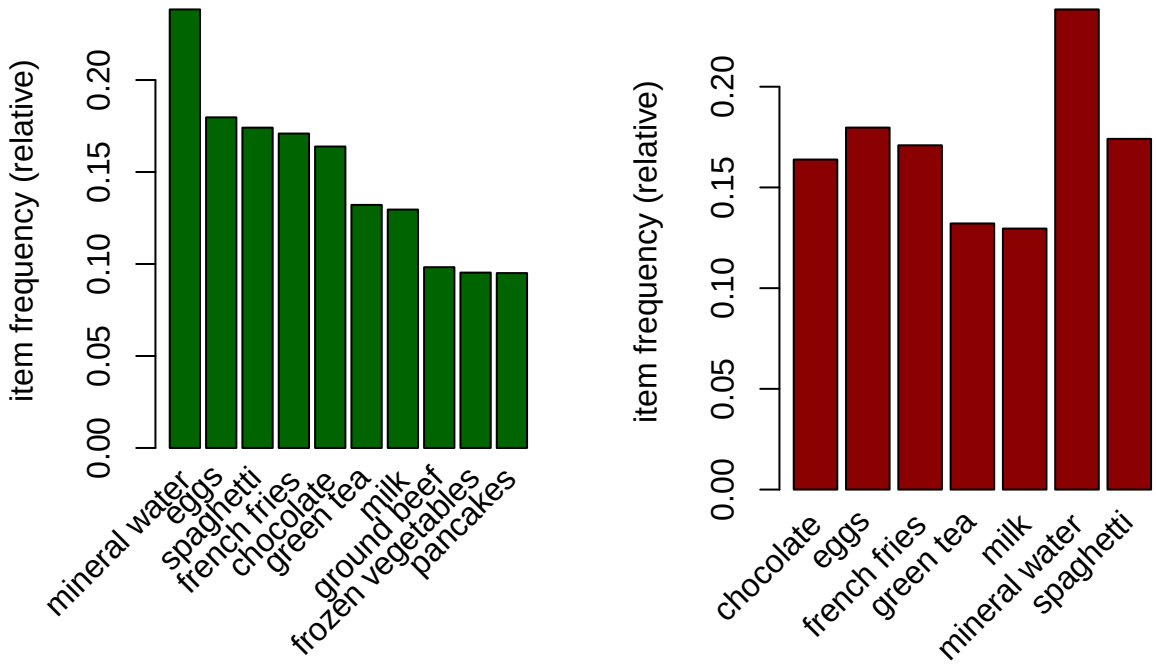
```
## Loading required package: RColorBrewer
```

```
itemFrequencyPlot(tr,topN=20,type="absolute",col=brewer.pal(8,'Pastel2'), main="Absolute Item Frequency
```



This plot confirms that mineral water and eggs are the most frequently bought items.

```
# Displaying top 10 most common items in the transactions dataset
# and the items whose relative importance is at least 10%
#
par(mfrow = c(1, 2))

# plot the frequency of items
itemFrequencyPlot(tr, topN = 10,col="darkgreen")
itemFrequencyPlot(tr, support = 0.1,col="darkred")
```



Building a model using association rules. We will use the apriori function

```
# Min Support as 0.001, confidence as 0.8.
association.rules <- apriori(tr, parameter = list(supp=0.001, conf=0.8,maxlen=10))
```

```
## Apriori
##
## Parameter specification:
##  confidence minval smax arem  aval originalSupport maxtime support minlen
##         0.8    0.1    1 none FALSE            TRUE       5   0.001      1
##  maxlen target  ext
##      10  rules TRUE
##
## Algorithmic control:
##  filter tree heap memopt load sort verbose
##     0.1 TRUE TRUE  FALSE TRUE    2    TRUE
##
## Absolute minimum support count: 7
##
## set item appearances ...[0 item(s)] done [0.00s].
## set transactions ...[119 item(s), 7501 transaction(s)] done [0.00s].
## sorting and recoding items ... [116 item(s)] done [0.00s].
## creating transaction tree ... done [0.01s].
## checking subsets of size 1 2 3 4 5 6 done [0.01s].
## writing ... [74 rule(s)] done [0.00s].
## creating S4 object  ... done [0.00s].
```

Lets print the first 10 association rules

```
inspect(association.rules[1:10])
```

```
##      lhs                              rhs             support     confidence
## [1]  {frozen smoothie,spinach}     => {mineral water} 0.001066524 0.8888889
## [2]  {bacon,pancakes}              => {spaghetti}     0.001733102 0.8125000
## [3]  {nonfat milk,turkey}          => {mineral water} 0.001199840 0.8181818
## [4]  {ground beef,nonfat milk}     => {mineral water} 0.001599787 0.8571429
## [5]  {mushroom cream sauce,pasta} => {escalope}      0.002532996 0.9500000
## [6]  {milk,pasta}                  => {shrimp}        0.001599787 0.8571429
## [7]  {cooking oil,fromage blanc}   => {mineral water} 0.001199840 0.8181818
## [8]  {black tea,salmon}            => {mineral water} 0.001066524 0.8000000
## [9]  {black tea,frozen smoothie}   => {milk}          0.001199840 0.8181818
## [10] {red wine,tomato sauce}       => {chocolate}     0.001066524 0.8000000
##      coverage    lift      count
## [1]  0.001199840  3.729058  8
## [2]  0.002133049  4.666587 13
## [3]  0.001466471  3.432428  9
## [4]  0.001866418  3.595877 12
## [5]  0.002666311 11.976387 19
## [6]  0.001866418 11.995203 12
## [7]  0.001466471  3.432428  9
## [8]  0.001333156  3.356152  8
## [9]  0.001466471  6.313973  9
## [10] 0.001333156  4.882669  8
```

Using the analysis above, we can see that 88% of customers who bough frozen smoothie and spinach bought mineral water, 95% of those who bought mushroom cream sauce and pasta also bought escalope, 81% of those who bought black tea and frozen smoothies also bought milk, 85% of customers who bought milk and pasta also bought shrimp

Removing redundant rules

```
subset.rules <- which(colSums(is.subset(association.rules, association.rules)) > 1) # get subset rules
print(length(subset.rules))
```

```
## [1] 12
```

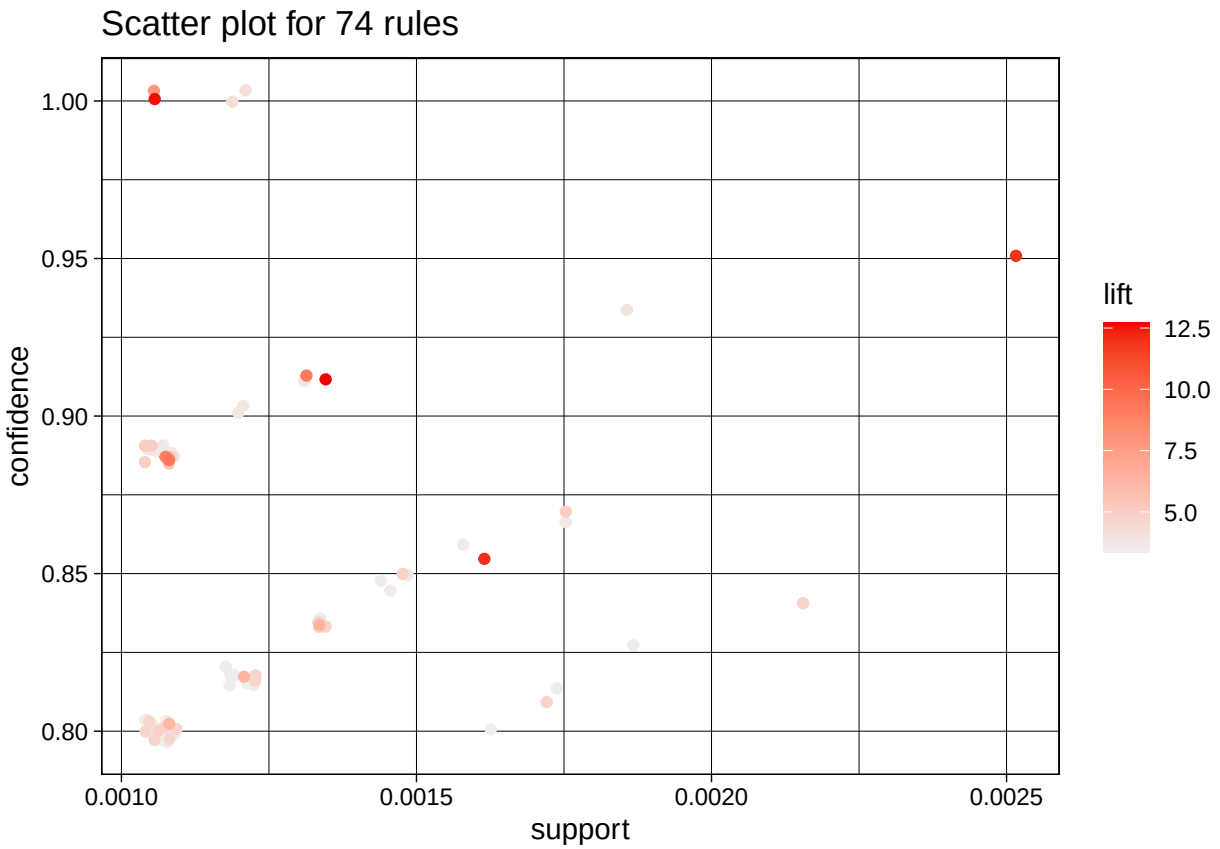
```
subset.association.rules <- association.rules[-subset.rules] # remove subset rules.
print(subset.association.rules)
```

```
## set of 62 rules
```

Plotting the subrules using a scatterplot

```
# Filter rules with confidence greater than 0.4 or 40%
subRules<-association.rules[quality(association.rules)$confidence>0.4]
#Plot SubRules
plot(subRules)
```

```
## To reduce overplotting, jitter is added! Use jitter = 0 to prevent jitter.
```



Anomaly Detection

Anomalies are considered the data points that are outliers or an exceptional event.

```
library(tidyverse)
library(tibble)
library(tibbletime)
```

```
##
## Attaching package: 'tibbletime'

## The following object is masked from 'package:stats':
##
##     filter
```

```
library(anomalize) #Installing the anomalize package
```

```
## == Use anomalize to improve your Forecasts by 50%! ==============================
## Business Science offers a 1-hour course - Lab #18: Time Series Anomaly Detection!
## </> Learn more at: https://university.business-science.io/p/learning-labs-pro </>
```

Loading our dataset

```
#As we had already loaded our dataset previously, we will just preview the summary

glimpse(data_3)
```

```
## Rows: 1,000
## Columns: 2
## $ Date  <chr> "1/5/2019", "3/8/2019", "3/3/2019", "1/27/2019", "2/8/2019", "3/~
## $ Sales <dbl> 548.9715, 80.2200, 340.5255, 489.0480, 634.3785, 627.6165, 433.6~
```

The data set contains two variables. The Date variable is a time series, while the Sales variable contains the sales over the specified period of time

```
#We will convert the Date column to timeseries
#install.packages("magrittr")
library(magrittr)
```

```
##
## Attaching package: 'magrittr'

## The following object is masked from 'package:purrr':
##
##     set_names

## The following object is masked from 'package:tidyr':
##
##     extract
```

```
data_3$Date<- as.Date(data_3$Date,"%m/%d/%y")

#atr <- data_3 %>% rownames_to_column() %>% as.tibble() %>%
#  mutate(date = as.Date(rowname)) %>% select(-one_of('rowname'))


#Confirming that the change has been implemented and arranging our data by sales
data_3= data_3%>%arrange(Date)
print(data_3)
```

```
##            Date     Sales
## 1    2020-01-01  457.4430
## 2    2020-01-01  399.7560
## 3    2020-01-01  470.6730
## 4    2020-01-01  388.2900
## 5    2020-01-01  132.7620
## 6    2020-01-01  132.0270
## 7    2020-01-01  621.2430
## 8    2020-01-01  113.5680
## 9    2020-01-01  779.3100
## 10   2020-01-01  184.0860
## 11   2020-01-01  177.4080
## 12   2020-01-01  888.6150
## 13   2020-01-02   44.5935
```

```
## 14   2020-01-02  209.6220
## 15   2020-01-02  359.2050
## 16   2020-01-02  383.7645
## 17   2020-01-02  138.6630
## 18   2020-01-02  262.4580
## 19   2020-01-02  266.0280
## 20   2020-01-02  281.1690
## 21   2020-01-03  367.5525
## 22   2020-01-03  217.6335
## 23   2020-01-03   44.3520
## 24   2020-01-03  352.2225
## 25   2020-01-03   79.6740
## 26   2020-01-03   98.0490
## 27   2020-01-03  397.8450
## 28   2020-01-03  520.8000
## 29   2020-01-04   75.7785
## 30   2020-01-04  629.8425
## 31   2020-01-04  146.2230
## 32   2020-01-04  373.1700
## 33   2020-01-04  288.5820
## 34   2020-01-04  110.0925
## 35   2020-01-05  548.9715
## 36   2020-01-05  172.4940
## 37   2020-01-05  263.1300
## 38   2020-01-05  297.1080
## 39   2020-01-05  334.3410
## 40   2020-01-05   33.4950
## 41   2020-01-05  225.2775
## 42   2020-01-05   77.6580
## 43   2020-01-05   74.7600
## 44   2020-01-05  239.5890
## 45   2020-01-05  579.8415
## 46   2020-01-05  690.0180
## 47   2020-01-06  939.5400
## 48   2020-01-06  494.7600
## 49   2020-01-06   16.1070
## 50   2020-01-06  343.0560
## 51   2020-01-06  214.9350
## 52   2020-01-06  261.1980
## 53   2020-01-06  760.4415
## 54   2020-01-06  271.2780
## 55   2020-01-06  312.8895
## 56   2020-01-07   71.5260
## 57   2020-01-07  614.9430
## 58   2020-01-07  326.4240
## 59   2020-01-07  203.5530
## 60   2020-01-07  352.5795
## 61   2020-01-07  229.1100
## 62   2020-01-07  374.3880
## 63   2020-01-07  575.9775
## 64   2020-01-07   85.7430
## 65   2020-01-08  299.8485
## 66   2020-01-08  575.7360
## 67   2020-01-08  783.3000
```

```
## 68   2020-01-08  190.5960
## 69   2020-01-08   13.4190
## 70   2020-01-08  194.9850
## 71   2020-01-08  152.7750
## 72   2020-01-08  381.3915
## 73   2020-01-08  103.1100
## 74   2020-01-08  136.1430
## 75   2020-01-08  175.0455
## 76   2020-01-08  684.9150
## 77   2020-01-08  210.9660
## 78   2020-01-08  688.7160
## 79   2020-01-08   26.7960
## 80   2020-01-08  250.7085
## 81   2020-01-08   76.5765
## 82   2020-01-08  348.7050
## 83   2020-01-09  463.4280
## 84   2020-01-09 1002.1200
## 85   2020-01-09  310.7160
## 86   2020-01-09   99.5400
## 87   2020-01-09  202.3350
## 88   2020-01-09   68.9850
## 89   2020-01-09  165.9000
## 90   2020-01-09  708.3195
## 91   2020-01-10   76.1460
## 92   2020-01-10  703.7520
## 93   2020-01-10  161.5530
## 94   2020-01-10  493.7940
## 95   2020-01-10  392.6475
## 96   2020-01-10  586.9710
## 97   2020-01-10  611.0790
## 98   2020-01-10   57.8760
## 99   2020-01-10  477.1305
## 100  2020-01-11  183.0360
## 101  2020-01-11   94.1745
## 102  2020-01-11  235.6830
## 103  2020-01-11  345.7860
## 104  2020-01-11   72.3975
## 105  2020-01-11  305.5500
## 106  2020-01-11  270.2595
## 107  2020-01-11  608.0760
## 108  2020-01-12  189.0945
## 109  2020-01-12  931.0350
## 110  2020-01-12  419.8320
## 111  2020-01-12  120.1620
## 112  2020-01-12   28.4235
## 113  2020-01-12  308.9100
## 114  2020-01-12  874.1250
## 115  2020-01-12 1023.7500
## 116  2020-01-12  769.1040
## 117  2020-01-12  144.9630
## 118  2020-01-12  375.3645
## 119  2020-01-13  437.3250
## 120  2020-01-13   78.0045
## 121  2020-01-13  147.7980
```

```
## 122  2020-01-13  125.7060
## 123  2020-01-13  152.0190
## 124  2020-01-13  457.3800
## 125  2020-01-13  335.0130
## 126  2020-01-13  374.4090
## 127  2020-01-13   88.3680
## 128  2020-01-13  255.1815
## 129  2020-01-14  451.3635
## 130  2020-01-14  536.9910
## 131  2020-01-14  507.6750
## 132  2020-01-14  523.3725
## 133  2020-01-14  133.4340
## 134  2020-01-14   75.9360
## 135  2020-01-14  588.4200
## 136  2020-01-14   36.5505
## 137  2020-01-14   89.0715
## 138  2020-01-14  190.4805
## 139  2020-01-14   18.6375
## 140  2020-01-14  390.9465
## 141  2020-01-14  423.7380
## 142  2020-01-15  590.4360
## 143  2020-01-15  575.3160
## 144  2020-01-15  154.3920
## 145  2020-01-15   91.5600
## 146  2020-01-15  843.0345
## 147  2020-01-15  140.3850
## 148  2020-01-15  175.9170
## 149  2020-01-15  697.9350
## 150  2020-01-15  397.2150
## 151  2020-01-15  597.0405
## 152  2020-01-15   72.0090
## 153  2020-01-15 1022.3850
## 154  2020-01-15  586.6350
## 155  2020-01-16   53.9280
## 156  2020-01-16 1003.5900
## 157  2020-01-16  881.3070
## 158  2020-01-16  666.9390
## 159  2020-01-16  164.6820
## 160  2020-01-16   32.5290
## 161  2020-01-16  125.9790
## 162  2020-01-16  667.3800
## 163  2020-01-16  497.0700
## 164  2020-01-16  195.6780
## 165  2020-01-17   91.0560
## 166  2020-01-17  135.5760
## 167  2020-01-17  377.5800
## 168  2020-01-17  852.7050
## 169  2020-01-17  121.5690
## 170  2020-01-17  695.2365
## 171  2020-01-17   85.3020
## 172  2020-01-17   80.9550
## 173  2020-01-17  137.8650
## 174  2020-01-17  432.9885
## 175  2020-01-17  131.9220
```

```
## 176  2020-01-18  138.1275
## 177  2020-01-18  166.2360
## 178  2020-01-18   41.3910
## 179  2020-01-18  182.9520
## 180  2020-01-18  277.6725
## 181  2020-01-18  110.1240
## 182  2020-01-18  856.4535
## 183  2020-01-18  561.0780
## 184  2020-01-18  446.4390
## 185  2020-01-19  548.7615
## 186  2020-01-19  362.7120
## 187  2020-01-19  323.0640
## 188  2020-01-19  333.2070
## 189  2020-01-19   93.0405
## 190  2020-01-19  282.4920
## 191  2020-01-19  198.6390
## 192  2020-01-19   84.9765
## 193  2020-01-19  673.9950
## 194  2020-01-19   37.6110
## 195  2020-01-19  284.5920
## 196  2020-01-19  624.3300
## 197  2020-01-19  101.6400
## 198  2020-01-19  235.7460
## 199  2020-01-19  479.6400
## 200  2020-01-19  250.2780
## 201  2020-01-20  759.6750
## 202  2020-01-20  112.2240
## 203  2020-01-20  195.5940
## 204  2020-01-20  749.7000
## 205  2020-01-20  348.3060
## 206  2020-01-20  118.0620
## 207  2020-01-20  131.2080
## 208  2020-01-20  536.5920
## 209  2020-01-20  233.1000
## 210  2020-01-20  470.9880
## 211  2020-01-21  172.2105
## 212  2020-01-21  624.8970
## 213  2020-01-21  491.0850
## 214  2020-01-21   76.3560
## 215  2020-01-21  461.2860
## 216  2020-01-21  390.7995
## 217  2020-01-21  103.0365
## 218  2020-01-21   72.4290
## 219  2020-01-22  705.6315
## 220  2020-01-22  106.9950
## 221  2020-01-22   85.5855
## 222  2020-01-22  206.7975
## 223  2020-01-22   96.6420
## 224  2020-01-22  351.6030
## 225  2020-01-22  151.5150
## 226  2020-01-23  161.7000
## 227  2020-01-23  198.9960
## 228  2020-01-23  942.9000
## 229  2020-01-23  323.1480
```

```
## 230  2020-01-23   94.1850
## 231  2020-01-23  264.7575
## 232  2020-01-23  527.7510
## 233  2020-01-23  416.1780
## 234  2020-01-23   87.2340
## 235  2020-01-23   32.1405
## 236  2020-01-23  620.7390
## 237  2020-01-23   57.6975
## 238  2020-01-23  333.9840
## 239  2020-01-23  503.7375
## 240  2020-01-23  450.1035
## 241  2020-01-23  244.2300
## 242  2020-01-23  734.7060
## 243  2020-01-24  827.0850
## 244  2020-01-24  423.1500
## 245  2020-01-24  406.8750
## 246  2020-01-24  728.1120
## 247  2020-01-24  293.6430
## 248  2020-01-24  145.4040
## 249  2020-01-24  557.7180
## 250  2020-01-24  384.7200
## 251  2020-01-24   63.9135
## 252  2020-01-24  408.4080
## 253  2020-01-24   88.7040
## 254  2020-01-24  270.0180
## 255  2020-01-24  804.3000
## 256  2020-01-25  463.8900
## 257  2020-01-25   16.2015
## 258  2020-01-25  291.2070
## 259  2020-01-25  950.2500
## 260  2020-01-25  288.2040
## 261  2020-01-25  247.8735
## 262  2020-01-25  356.5485
## 263  2020-01-25  252.0420
## 264  2020-01-25  214.7460
## 265  2020-01-25  128.0160
## 266  2020-01-25   45.9270
## 267  2020-01-25  100.9155
## 268  2020-01-25  168.2100
## 269  2020-01-25  167.8950
## 270  2020-01-25  663.2955
## 271  2020-01-25  267.3405
## 272  2020-01-25   77.8050
## 273  2020-01-26  304.5420
## 274  2020-01-26  471.0300
## 275  2020-01-26  420.2625
## 276  2020-01-26  107.3100
## 277  2020-01-26  655.5465
## 278  2020-01-26  170.8770
## 279  2020-01-26  379.9215
## 280  2020-01-26  398.4750
## 281  2020-01-26  270.5850
## 282  2020-01-26  193.4625
## 283  2020-01-26   68.2395
```

```
## 284  2020-01-26  165.6480
## 285  2020-01-26   12.6945
## 286  2020-01-26   22.3860
## 287  2020-01-26  106.5015
## 288  2020-01-26   69.9930
## 289  2020-01-26  640.0380
## 290  2020-01-27  489.0480
## 291  2020-01-27  169.3125
## 292  2020-01-27   25.2630
## 293  2020-01-27  150.7800
## 294  2020-01-27  510.9615
## 295  2020-01-27  488.9850
## 296  2020-01-27  568.5120
## 297  2020-01-27  145.7400
## 298  2020-01-27  398.9580
## 299  2020-01-27  514.7730
## 300  2020-01-27  178.1640
## 301  2020-01-27  403.8720
## 302  2020-01-27   76.9230
## 303  2020-01-27  514.6050
## 304  2020-01-28  737.7615
## 305  2020-01-28  680.1480
## 306  2020-01-28  273.4200
## 307  2020-01-28  293.2020
## 308  2020-01-28   91.4025
## 309  2020-01-28  125.0550
## 310  2020-01-28   20.1075
## 311  2020-01-28  203.1120
## 312  2020-01-28  118.2510
## 313  2020-01-28  681.4395
## 314  2020-01-28  225.0150
## 315  2020-01-28  832.9440
## 316  2020-01-28   84.7455
## 317  2020-01-28  633.1080
## 318  2020-01-29  786.6180
## 319  2020-01-29  120.6450
## 320  2020-01-29  137.0040
## 321  2020-01-29  265.1040
## 322  2020-01-29   40.5300
## 323  2020-01-29  529.5150
## 324  2020-01-29  280.0350
## 325  2020-01-29  146.6325
## 326  2020-01-29  458.6925
## 327  2020-01-29  616.9800
## 328  2020-01-29   92.4420
## 329  2020-01-29   42.3675
## 330  2020-01-30  160.4400
## 331  2020-01-30  509.4075
## 332  2020-01-30   99.3300
## 333  2020-01-30   24.1080
## 334  2020-01-30 1034.4600
## 335  2020-01-30  356.3280
## 336  2020-01-30   55.2825
## 337  2020-01-30  295.4070
```

```
## 338  2020-01-30   23.4990
## 339  2020-01-31  285.7050
## 340  2020-01-31  155.6520
## 341  2020-01-31   69.6675
## 342  2020-01-31  224.4375
## 343  2020-01-31  503.5590
## 344  2020-01-31   79.6110
## 345  2020-01-31  145.0680
## 346  2020-01-31   87.2340
## 347  2020-01-31  180.6000
## 348  2020-01-31  829.0800
## 349  2020-01-31  757.3650
## 350  2020-01-31  830.3715
## 351  2020-01-31  652.8900
## 352  2020-01-31  431.2560
## 353  2020-02-01  218.0115
## 354  2020-02-01  763.4655
## 355  2020-02-01  510.9720
## 356  2020-02-01   74.7075
## 357  2020-02-01  551.1240
## 358  2020-02-01  326.2560
## 359  2020-02-02  117.8310
## 360  2020-02-02   19.2465
## 361  2020-02-02  115.0800
## 362  2020-02-02  788.5080
## 363  2020-02-02  439.8975
## 364  2020-02-02  400.7640
## 365  2020-02-02  193.0110
## 366  2020-02-02  452.8650
## 367  2020-02-02  554.1480
## 368  2020-02-02  432.7680
## 369  2020-02-02  187.8660
## 370  2020-02-02   40.3410
## 371  2020-02-02  223.5870
## 372  2020-02-02  175.0350
## 373  2020-02-03  671.7900
## 374  2020-02-03  520.4115
## 375  2020-02-03  697.3680
## 376  2020-02-03  404.3550
## 377  2020-02-03  212.7300
## 378  2020-02-03  310.5900
## 379  2020-02-03   77.6685
## 380  2020-02-03  517.9650
## 381  2020-02-03  708.2250
## 382  2020-02-03  764.1900
## 383  2020-02-03  135.3555
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## 904  2020-03-21  149.3625
## 905  2020-03-21  207.8580
## 906  2020-03-21  756.1680
## 907  2020-03-21  360.9270
## 908  2020-03-22  441.7560
## 909  2020-03-22   75.0540
## 910  2020-03-22  391.4190
## 911  2020-03-22   19.1940
## 912  2020-03-22  427.8120
## 913  2020-03-22  742.8120
## 914  2020-03-22  233.2260
## 915  2020-03-22  451.0275
## 916  2020-03-22   99.9075
## 917  2020-03-22  296.9400
## 918  2020-03-23  461.3280
## 919  2020-03-23  166.1625
## 920  2020-03-23  384.4680
## 921  2020-03-23  465.4440
## 922  2020-03-23  162.7500
## 923  2020-03-23   26.5545
## 924  2020-03-23  156.0300
## 925  2020-03-23  596.8200
## 926  2020-03-23  408.7335
## 927  2020-03-23  495.3165
## 928  2020-03-23  771.4350
## 929  2020-03-24  321.1110
## 930  2020-03-24  130.0425
## 931  2020-03-24   78.6030
```
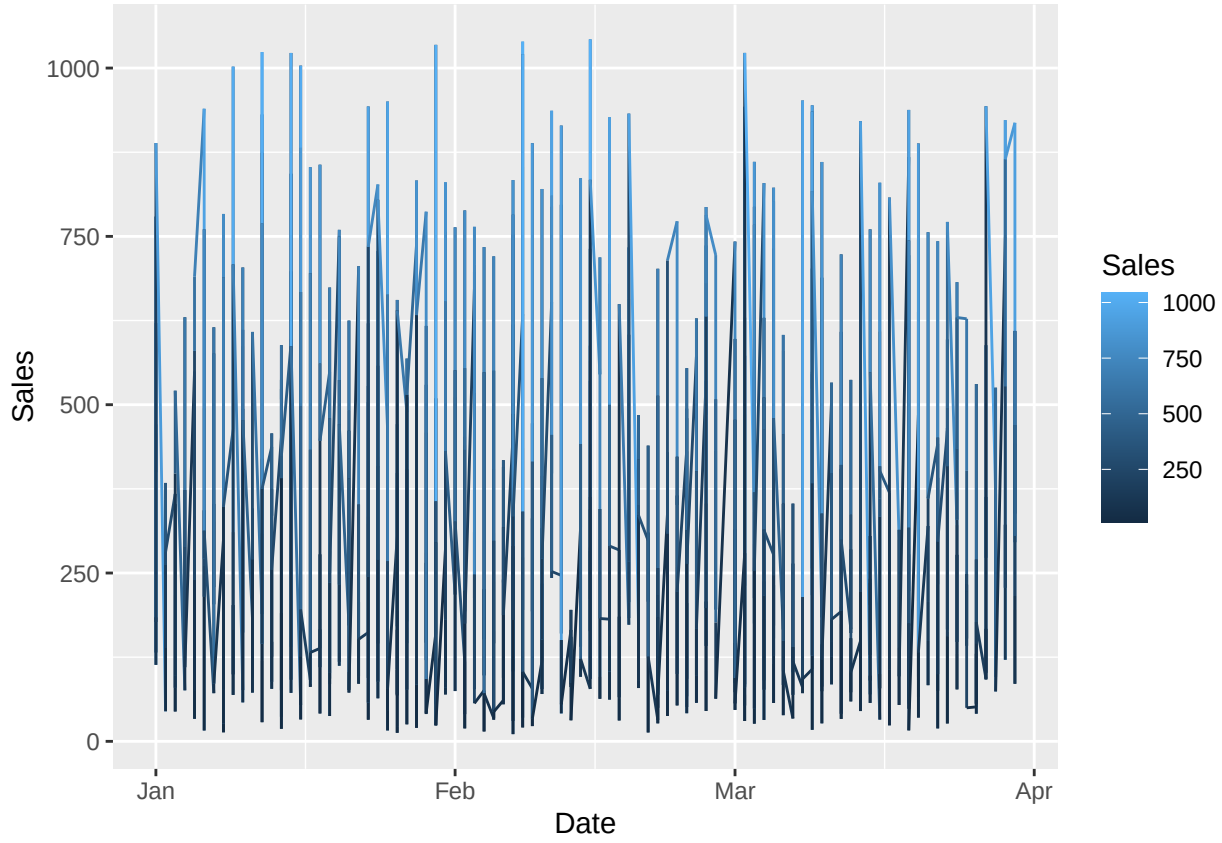

```
## 932  2020-03-24   77.1750
## 933  2020-03-24  276.9480
## 934  2020-03-24  147.6720
## 935  2020-03-24  370.1250
## 936  2020-03-24  681.9750
## 937  2020-03-24  329.1960
## 938  2020-03-24  435.1200
## 939  2020-03-24  629.4960
## 940  2020-03-25  627.6165
## 941  2020-03-25  401.7300
## 942  2020-03-25  152.7120
## 943  2020-03-25  248.4090
## 944  2020-03-25  195.9510
## 945  2020-03-25  142.0020
## 946  2020-03-25  232.6380
## 947  2020-03-25  222.1380
## 948  2020-03-25   49.7700
## 949  2020-03-26   51.1455
## 950  2020-03-26   91.7700
## 951  2020-03-26  530.6700
## 952  2020-03-26   41.0760
## 953  2020-03-26  143.9865
## 954  2020-03-26  154.1295
## 955  2020-03-26  269.9340
## 956  2020-03-26  116.1405
## 957  2020-03-26   56.1225
## 958  2020-03-26  130.0320
## 959  2020-03-26   54.9990
## 960  2020-03-26  145.5825
## 961  2020-03-26  176.9250
## 962  2020-03-27   93.1140
## 963  2020-03-27  362.9430
## 964  2020-03-27  272.6640
## 965  2020-03-27  588.3570
## 966  2020-03-27  164.8710
## 967  2020-03-27  116.9070
## 968  2020-03-27  101.8080
## 969  2020-03-27  167.0340
## 970  2020-03-27   91.8225
## 971  2020-03-27  943.2990
## 972  2020-03-28  367.0380
## 973  2020-03-28   95.6655
## 974  2020-03-28  150.0975
## 975  2020-03-28  191.2470
## 976  2020-03-28  121.5900
## 977  2020-03-28  269.5350
## 978  2020-03-28  209.1180
## 979  2020-03-28  225.7920
## 980  2020-03-28  525.2310
## 981  2020-03-28   74.0880
## 982  2020-03-29  749.4900
## 983  2020-03-29  922.6350
## 984  2020-03-29  121.1280
## 985  2020-03-29  321.7725
```

```
## 986  2020-03-29  288.0150
## 987  2020-03-29  228.1230
## 988  2020-03-29  527.5095
## 989  2020-03-29  864.5700
## 990  2020-03-30  918.7290
## 991  2020-03-30  295.6905
## 992  2020-03-30  609.5880
## 993  2020-03-30  338.3100
## 994  2020-03-30  609.1680
## 995  2020-03-30  442.3230
## 996  2020-03-30  196.1400
## 997  2020-03-30   85.5120
## 998  2020-03-30  216.8460
## 999  2020-03-30  469.7700
## 1000 2020-03-30  304.9830
```

Sales distribution

```
#Plotting data
library(ggplot2)
ggplot(data_3, aes(x=Date, y=Sales, color=Sales)) + geom_line()
```



From the plot above, we cannot spot any anomalies. But we will have to confirm

Timeseries decomposition Next we will try to use the time_decompose() function which give four outputs which are: observed, season, trend, and remainder.Once the components are decomposed, anomalize can detect and flag anomalies in the decomposed data of the reminder component which then could be visualized with plot_anomaly_decomposition()but before that we will convert the data into tbl_df format

```
data_3=aggregate(Sales~Date,data_3,mean)
```

```
data_3=tbl_time(data_3, Date)
class(data_3)
```

```
## [1] "tbl_time"   "tbl_df"     "tbl"        "data.frame"
```

As mentioned earlier the time series is decomposed into four columns that are observed, season, trend, and remainder. The default method used for decomposition is stl, which is a seasonal decomposition utilizing a Loess smoother.

```
#data_3  = data_3 %>%
#  time_decompose(Sales)

#data_3%>% glimpse()
```

```
#data_3 = data_3%>%
#  anomalize(remainder)

#data_3%>% glimpse()
```

Anomalies are high leverage points that distort the distribution. One of the methods that anomalize implements that is resistant to high leverage points is the GESD: Generalized Extreme Studentized Deviate Test

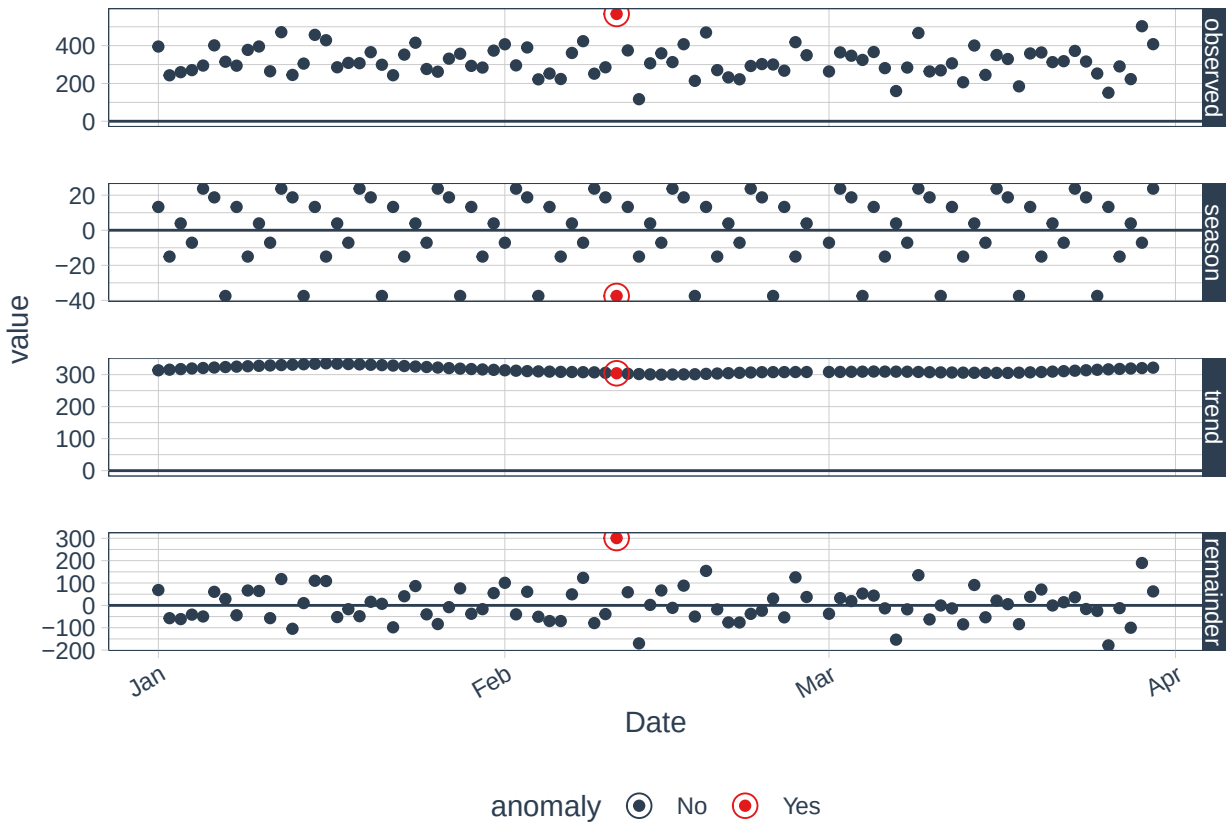
Visualizing the time decomposition and anomalies

```
data_3 %>%
  time_decompose(Sales, method = "stl", frequency = "auto", trend = "auto") %>%
  anomalize(remainder, method = "gesd", alpha = 0.05, max_anoms = 0.2) %>%
  plot_anomaly_decomposition()
```

```
## frequency = 7 days
```

```
## trend = 30 days
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

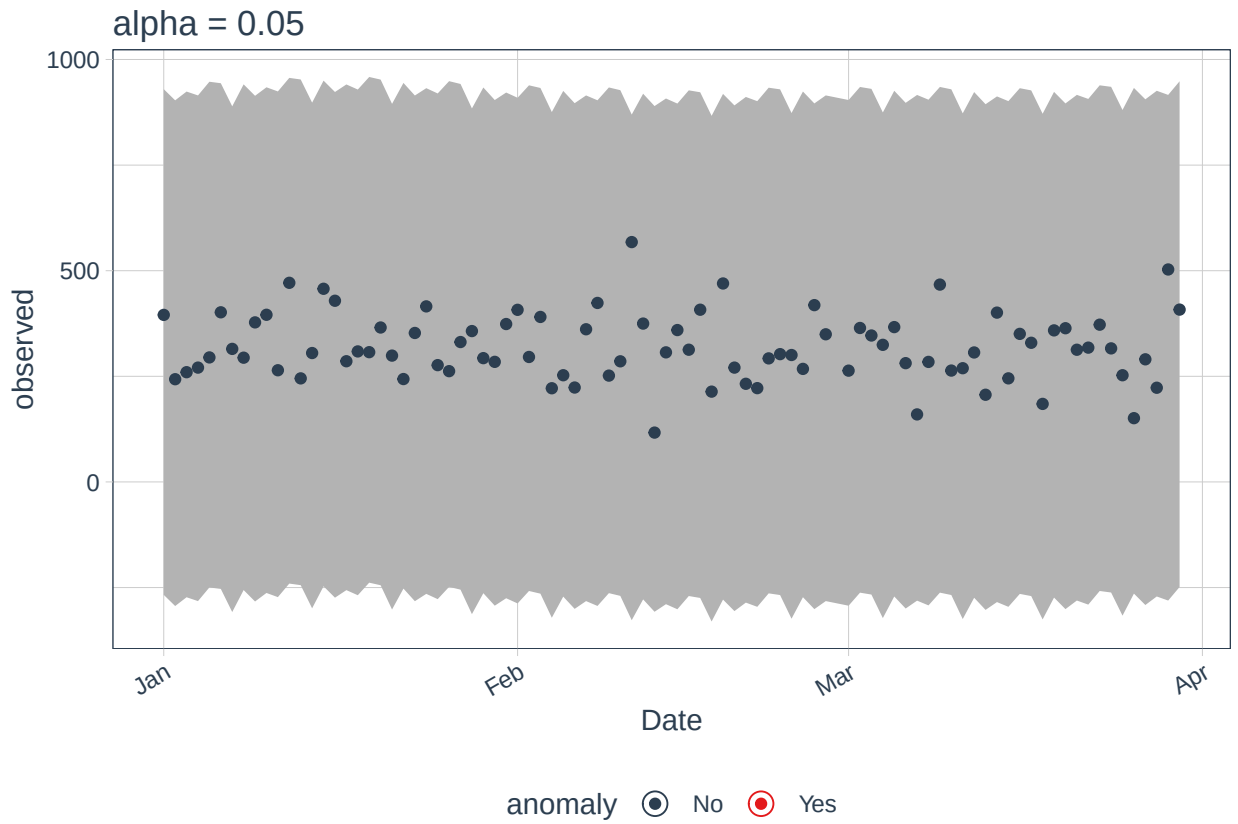


Adjusting Parameters for Anomaly detection anomaly is being decided according to the values of remainder calculating limits for categorizing the outliers. The alpha and max_anoms are two parameters that control anomalize() function. In simple words alpha control the band of the limit by default it is set to 0.05 decreasing its value will increase the size of the band thus making difficult for a point to be an anomaly.We will then create lower and upper bounds around the observed values with time_recompose.

```
data_3%>%
  time_decompose(Sales)%>%
  anomalize(remainder, alpha = 0.03,max_anoms = 0.2)%>%
  time_recompose()%>%
  plot_anomalies(time_recompose = T)+
  ggtitle("alpha = 0.05")
```

```
## frequency = 7 days
```

```
## trend = 30 days
```



The anomaly found in our data was in mid February indicated by higher sales. This is most likely due to the Valentines season which occur mid Feb.

```
##rlang::last_error()
```

Recommendations

As noted above the marketing team might use some of the data mining insights and try strategies to improve on product promotion and sales. There were noticeable trends during special days e.g in February, we realized that the sales were high especially a round valentines day. The mart should consider adding promotional items during these seasons. They should take advantage of the market basket items identified and add them next to the fast selling items e.g placing milk next to frozen milk and black tea may cause it to sell faster as it has been proven that (81%) of these customers who tend to buy frozen milk and black tea tend to buy milk. Internal Variables such as the quantity, rating, unit price of an item are vital in understanding the sales.