Lyft-Uber-Price-Prediction

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IMPORTING DATASETS AND CLEANING THEM

Importing dataset cab_rides

```
cab_rides <-
read.csv("C:/Users/AJAY/Downloads/Multivariate/project/cab_rides.csv")
summary(cab_rides)
```

```
##     distance     cab_type        time_stamp
##  Min.   :0.020   Lyft:307408   Min.   :1.543e+12
##  1st Qu.:1.280   Uber:385663   1st Qu.:1.543e+12
##  Median :2.160                 Median :1.544e+12
##  Mean   :2.189                 Mean   :1.544e+12
##  3rd Qu.:2.920                 3rd Qu.:1.545e+12
##  Max.   :7.860                 Max.   :1.545e+12
##
##              destination                    source          price
##  Financial District: 58851   Financial District: 58857   Min.   : 2.50
##  Theatre District  : 57798   Theatre District  : 57813   1st Qu.: 9.00
##  Back Bay          : 57780   Back Bay          : 57792   Median :13.50
##  Boston University : 57764   Boston University : 57764   Mean   :16.55
##  Haymarket Square  : 57764   North End         : 57763   3rd Qu.:22.50
##  Fenway            : 57757   Fenway            : 57757   Max.   :97.50
##  (Other)           :345357   (Other)           :345325   NA's   :55095
##  surge_multiplier                                  id
##  Min.   :1.000    00005b8c-5647-4104-9ac6-94fa6a40f3c3:     1
##  1st Qu.:1.000    00006eeb-0183-40c1-8198-c441d3c8a734:     1
##  Median :1.000    00008b42-5ecc-4f66-b4b9-b22a331634e6:     1
##  Mean   :1.014    000094c0-00c4-43f1-ae1b-4693eec2a580:     1
##  3rd Qu.:1.000    0000a8b2-e4d3-4227-8374-af8a2366e475:     1
##  Max.   :3.000    0000b5d6-59be-4534-b371-8214334d94f0:     1
##                   (Other)                            :693065
##                                product_id            name
##  6d318bcc-22a3-4af6-bddd-b409bfce1546: 55096   Black SUV: 55096
##  6f72dfc5-27f1-42e8-84db-ccc7a75f6969: 55096   UberXL   : 55096
##  9a0e7b09-b92b-4c41-9779-2ad22b4d779d: 55096   WAV      : 55096
##  6c84fd89-3f11-4782-9b50-97c468b19529: 55095   Black    : 55095
##  8cf7e821-f0d3-49c6-8eba-e679c0ebcf6a: 55095   Taxi     : 55095
##  55c66225-fbe7-4fd5-9072-eab1ece5e23e: 55094   UberX    : 55094
##  (Other)                             :362499   (Other)  :362499
```

```
cab_data<-cab_rides
```

Creating a date_time column

```
cab_data$date_time<-as.POSIXct((cab_data$time_stamp/1000),origin = "1970-01-
01 00:53:20", tz="GMT")
```

Importing dataset weather

```
weather <-
read.csv("C:/Users/AJAY/Downloads/Multivariate/project/weather.xls")
summary(weather)
```

```
##     ï..temp                     location        clouds
##  Min.   :19.62   Back Bay           : 523   Min.   :0.0000
##  1st Qu.:36.08   Beacon Hill        : 523   1st Qu.:0.4400
##  Median :40.13   Boston University  : 523   Median :0.7800
##  Mean   :39.09   Fenway             : 523   Mean   :0.6778
##  3rd Qu.:42.83   Financial District: 523   3rd Qu.:0.9700
##  Max.   :55.41   Haymarket Square   : 523   Max.   :1.0000
##                  (Other)            :3138
##     pressure           rain          time_stamp           humidity
##  Min.   : 988.2   Min.   :0.000   Min.   :1.543e+09   Min.   :0.450
##  1st Qu.: 997.7   1st Qu.:0.005   1st Qu.:1.543e+09   1st Qu.:0.670
##  Median :1007.7   Median :0.015   Median :1.544e+09   Median :0.760
##  Mean   :1008.4   Mean   :0.058   Mean   :1.544e+09   Mean   :0.764
##  3rd Qu.:1018.5   3rd Qu.:0.061   3rd Qu.:1.545e+09   3rd Qu.:0.890
##  Max.   :1035.1   Max.   :0.781   Max.   :1.545e+09   Max.   :0.990
##                   NA's   :5382
##       wind
##  Min.   : 0.290
##  1st Qu.: 3.518
##  Median : 6.570
##  Mean   : 6.803
##  3rd Qu.: 9.920
##  Max.   :18.180
##
```

```
str(weather)
```

```
## 'data.frame':    6276 obs. of  8 variables:
##  $ ï..temp   : num  42.4 42.4 42.5 42.1 43.1 ...
##  $ location  : Factor w/ 12 levels "Back Bay","Beacon Hill",..: 1 2 3 4 5
6 7 8 9 10 ...
##  $ clouds    : num  1 1 1 1 1 1 1 1 1 1 ...
##  $ pressure  : num  1012 1012 1012 1012 1012 ...
##  $ rain      : num  0.1228 0.1846 0.1089 0.0969 0.1786 ...
##  $ time_stamp: int  1545003901 1545003901 1545003901 1545003901 1545003901
1545003901 1545003901 1545003901 1545003901 1545003901 ...
```

```
##  $ humidity  : num  0.77 0.76 0.76 0.77 0.75 0.77 0.77 0.77 0.78 0.75 ...
##  $ wind      : num  11.2 11.3 11.1 11.1 11.5 ...

weather_data<-weather
```

creating a date_time column in weather_data

```
weather_data$date_time<-as.POSIXct(weather_data$time_stamp,origin = "1970-01-
01 00:53:20", tz="GMT")
str(weather_data)
```

```
## 'data.frame':    6276 obs. of  9 variables:
##  $ ï..temp   : num  42.4 42.4 42.5 42.1 43.1 ...
##  $ location  : Factor w/ 12 levels "Back Bay","Beacon Hill",..: 1 2 3 4 5
6 7 8 9 10 ...
##  $ clouds    : num  1 1 1 1 1 1 1 1 1 1 ...
##  $ pressure  : num  1012 1012 1012 1012 1012 ...
##  $ rain      : num  0.1228 0.1846 0.1089 0.0969 0.1786 ...
##  $ time_stamp: int  1545003901 1545003901 1545003901 1545003901 1545003901
1545003901 1545003901 1545003901 1545003901 1545003901 ...
##  $ humidity  : num  0.77 0.76 0.76 0.77 0.75 0.77 0.77 0.77 0.78 0.75 ...
##  $ wind      : num  11.2 11.3 11.1 11.1 11.5 ...
##  $ date_time : POSIXct, format: "2018-12-17 00:38:21" "2018-12-17
00:38:21" ...
```

merge the datasets to reflect the same time for a location

```
cab_data$merge_date<-paste(cab_data$source,"-",as.Date(cab_data$date_time),"-
",format(cab_data$date_time,"%H:%M:%S"))
weather_data$merge_date<-paste(weather_data$location,"-
",as.Date(weather_data$date_time),"-
",format(weather_data$date_time,"%H:%M:%S"))

#making those values as characters
weather_data$merge_date<-as.character(weather_data$merge_date)
cab_data$merge_date<-as.character(cab_data$merge_date)
```

verify that merge_date has unique values.

```
weather_data<-subset(weather_data,!duplicated(weather_data$merge_date))
isTRUE(duplicated(weather_data$merge_date))
```

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

Merging both the dataframes.

```
merge_data<-merge(x=weather_data, y=cab_data,by='merge_date', all.x=TRUE)
str(merge_data)
```

```
## 'data.frame':    9306 obs. of  21 variables:
##  $ merge_date      : chr  "Back Bay - 2018-11-26 - 04:34:05" "Back Bay -
2018-11-26 - 05:34:13" "Back Bay - 2018-11-26 - 05:34:58" "Back Bay - 2018-
11-26 - 05:36:38" ...
##  $ ï..temp         : num  41 40.6 40.6 40.6 40.6 ...
##  $ location        : Factor w/ 12 levels "Back Bay","Beacon Hill",..: 1 1
1 1 1 1 1 1 1 1 ...
##  $ clouds          : num  0.87 0.86 0.86 0.86 0.86 0.95 0.95 0.94 0.93
0.93 ...
##  $ pressure        : num  1014 1014 1014 1014 1014 ...
##  $ rain            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ time_stamp.x    : int  1543203645 1543207253 1543207298 1543207398
1543207398 1543207777 1543207777 1543208142 1543208578 1543209183 ...
##  $ humidity        : num  0.92 0.93 0.93 0.93 0.93 0.92 0.92 0.92 0.92
0.92 ...
##  $ wind            : num  1.46 2.57 2.59 2.65 2.65 2.59 2.59 2.83 3 3.01
...
##  $ date_time.x     : POSIXct, format: "2018-11-26 04:34:05" "2018-11-26
05:34:13" ...
##  $ distance        : num  NA NA 1.44 1.36 1.22 1.34 1.1 NA NA NA ...
##  $ cab_type        : Factor w/ 2 levels "Lyft","Uber": NA NA 2 1 2 2 2 NA
NA NA ...
##  $ time_stamp.y    : num  NA NA 1.54e+12 1.54e+12 1.54e+12 ...
##  $ destination     : Factor w/ 12 levels "Back Bay","Beacon Hill",..: NA
NA 3 10 9 4 9 NA NA NA ...
##  $ source          : Factor w/ 12 levels "Back Bay","Beacon Hill",..: NA
NA 1 1 1 1 1 NA NA NA ...
##  $ price           : num  NA NA 8.5 16.5 NA 26.5 7.5 NA NA NA ...
##  $ surge_multiplier: num  NA NA 1 1 1 1 1 NA NA NA ...
##  $ id              : Factor w/ 693071 levels "00005b8c-5647-4104-9ac6-
94fa6a40f3c3",..: NA NA 548701 610037 513190 566219 94420 NA NA NA ...
##  $ product_id      : Factor w/ 13 levels "55c66225-fbe7-4fd5-9072-
eab1ece5e23e",..: NA NA 7 10 5 3 1 NA NA NA ...
##  $ name            : Factor w/ 13 levels "Black","Black SUV",..: NA NA 13
4 9 2 11 NA NA NA ...
##  $ date_time.y     : POSIXct, format: NA NA ...
```

Handling Missing values

```
#Filling NA values in price
merge_data$rain[is.na(merge_data$rain)]<-0

#Extracting the numerical columns in a new dataframe "df"
merge_data$temp<-merge_data[,c(2)] #renaming a column
df<-merge_data[,c(4,5,6,8,9,10,11,17,22,16)]

#Data preparation
#Dealing with missing values
summary(merge_data)
```

```
##   merge_date           ï..temp                          location
##  Length:9306        Min.   :19.62   Haymarket Square       : 843
##  Class :character   1st Qu.:36.74   North Station          : 801
##  Mode  :character   Median :39.73   Theatre District       : 800
##                     Mean   :39.12   Northeastern University: 788
##                     3rd Qu.:41.86   North End              : 772
##                     Max.   :55.41   Fenway                 : 771
##                                     (Other)                :4531
##      clouds          pressure           rain          time_stamp.x
##  Min.   :0.0000   Min.   : 988.2   Min.   :0.00000   Min.   :1.543e+09
##  1st Qu.:0.4500   1st Qu.: 992.2   1st Qu.:0.00000   1st Qu.:1.543e+09
##  Median :0.7700   Median :1002.2   Median :0.00000   Median :1.543e+09
##  Mean   :0.6799   Mean   :1005.2   Mean   :0.01197   Mean   :1.544e+09
##  3rd Qu.:0.9700   3rd Qu.:1014.4   3rd Qu.:0.00000   3rd Qu.:1.544e+09
##  Max.   :1.0000   Max.   :1035.1   Max.   :0.78070   Max.   :1.545e+09
##
##     humidity           wind         date_time.x
##  Min.   :0.4500   Min.   : 0.290   Min.   :2018-11-26 04:34:04
##  1st Qu.:0.6700   1st Qu.: 4.183   1st Qu.:2018-11-28 01:38:42
##  Median :0.7500   Median : 7.490   Median :2018-11-28 23:55:29
##  Mean   :0.7623   Mean   : 7.212   Mean   :2018-12-01 23:49:51
##  3rd Qu.:0.8800   3rd Qu.: 9.990   3rd Qu.:2018-12-02 09:31:14
##  Max.   :0.9900   Max.   :18.180   Max.   :2018-12-18 19:38:22
##
##     distance     cab_type     time_stamp.y                    destination
##  Min.   :0.020   Lyft:1732   Min.   :1.543e+12   Fenway            : 344
##  1st Qu.:1.250   Uber:2134   1st Qu.:1.543e+12   Financial District: 342
##  Median :2.140   NA's:5440   Median :1.543e+12   Back Bay          : 337
##  Mean   :2.168               Mean   :1.543e+12   Beacon Hill       : 335
##  3rd Qu.:2.947               3rd Qu.:1.543e+12   South Station     : 334
##  Max.   :7.460               Max.   :1.545e+12   (Other)           :2174
##  NA's   :5440                NA's   :5440        NA's              :5440
##                       source         price       surge_multiplier
##  Haymarket Square       : 392   Min.   : 2.50   Min.   :1.000
##  North Station          : 351   1st Qu.: 9.00   1st Qu.:1.000
##  Theatre District       : 344   Median :13.50   Median :1.000
##  Northeastern University: 329   Mean   :16.67   Mean   :1.018
##  North End              : 316   3rd Qu.:22.50   3rd Qu.:1.000
##  (Other)                :2134   Max.   :92.00   Max.   :2.000
##  NA's                   :5440   NA's   :5758    NA's   :5440
##                                     id
##  000baa63-5e1c-4f9d-891c-e4e78e830199:   1
##  002b15bc-b433-44a4-8174-b8ac95caebf8:   1
##  00423464-fb1b-4e96-9154-b55a00854181:   1
##  00552d6f-c5fa-4006-962a-4613097afabe:   1
##  005ca94d-9dad-4b34-a8ce-82a6de9058b4:   1
##  (Other)                              :3861
##  NA's                                 :5440
##                                product_id          name
##  8cf7e821-f0d3-49c6-8eba-e679c0ebcf6a: 318   Taxi     : 318
```

```
##  6d318bcc-22a3-4af6-bddd-b409bfce1546: 308   Black SUV: 308
##  6c84fd89-3f11-4782-9b50-97c468b19529: 307   Black    : 307
##  6f72dfc5-27f1-42e8-84db-ccc7a75f6969: 306   UberPool : 306
##  997acbb5-e102-41e1-b155-9df7de0a73f2: 306   UberXL   : 306
##  (Other)                               :2321   (Other)  :2321
##  NA's                                  :5440   NA's     :5440
##   date_time.y                         temp
##  Min.   :2018-11-26 04:34:06   Min.   :19.62
##  1st Qu.:2018-11-27 03:08:42   1st Qu.:36.74
##  Median :2018-11-28 14:25:28   Median :39.73
##  Mean   :2018-11-28 08:15:46   Mean   :39.12
##  3rd Qu.:2018-11-29 00:42:54   3rd Qu.:41.86
##  Max.   :2018-12-16 20:38:27   Max.   :55.41
##  NA's   :5440
```

```
summary(df)
```

```
##      clouds          pressure           rain            humidity
##  Min.   :0.0000   Min.   : 988.2   Min.   :0.00000   Min.   :0.4500
##  1st Qu.:0.4500   1st Qu.: 992.2   1st Qu.:0.00000   1st Qu.:0.6700
##  Median :0.7700   Median :1002.2   Median :0.00000   Median :0.7500
##  Mean   :0.6799   Mean   :1005.2   Mean   :0.01197   Mean   :0.7623
##  3rd Qu.:0.9700   3rd Qu.:1014.4   3rd Qu.:0.00000   3rd Qu.:0.8800
##  Max.   :1.0000   Max.   :1035.1   Max.   :0.78070   Max.   :0.9900
##
##       wind         date_time.x                     distance
##  Min.   : 0.290   Min.   :2018-11-26 04:34:04   Min.   :0.020
##  1st Qu.: 4.183   1st Qu.:2018-11-28 01:38:42   1st Qu.:1.250
##  Median : 7.490   Median :2018-11-28 23:55:29   Median :2.140
##  Mean   : 7.212   Mean   :2018-12-01 23:49:51   Mean   :2.168
##  3rd Qu.: 9.990   3rd Qu.:2018-12-02 09:31:14   3rd Qu.:2.947
##  Max.   :18.180   Max.   :2018-12-18 19:38:22   Max.   :7.460
##                                                 NA's   :5440
##  surge_multiplier      temp           price
##  Min.   :1.000    Min.   :19.62   Min.   : 2.50
##  1st Qu.:1.000    1st Qu.:36.74   1st Qu.: 9.00
##  Median :1.000    Median :39.73   Median :13.50
##  Mean   :1.018    Mean   :39.12   Mean   :16.67
##  3rd Qu.:1.000    3rd Qu.:41.86   3rd Qu.:22.50
##  Max.   :2.000    Max.   :55.41   Max.   :92.00
##  NA's   :5440                     NA's   :5758
```

```
merge_data$surge_multiplier = ifelse(is.na(merge_data$surge_multiplier),
                                     ave(merge_data$surge_multiplier , FUN =
function(x) mean(x, na.rm = TRUE)),
                                     merge_data$surge_multiplier)

merge_data$price = ifelse(is.na(merge_data$price),
                          ave(merge_data$price , FUN = function(x) mean(x,
na.rm = TRUE)),
```

```
                          merge_data$price)

df$distance = ifelse(is.na(df$distance),
                     ave(df$distance , FUN = function(x) mean(x, na.rm =
TRUE)),
                     df$distance)

df$surge_multiplier = ifelse(is.na(df$surge_multiplier),
                             ave(df$surge_multiplier , FUN = function(x)
mean(x, na.rm = TRUE)),
                             df$surge_multiplier)

df$price = ifelse(is.na(df$price),
                  ave(df$price , FUN = function(x) mean(x, na.rm = TRUE)),
                  df$price)
```

Checking for null values

```
any(is.na(df))
```

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

Adding date and time column in the df data set

```
df$day<-weekdays(df$date_time)
df$time<-format(df$date_time.x,"%H:%M:%S")
df$date_time<-as.Date(df$date_time.x)
merge_data$day=weekdays(merge_data$date_time.x)
```

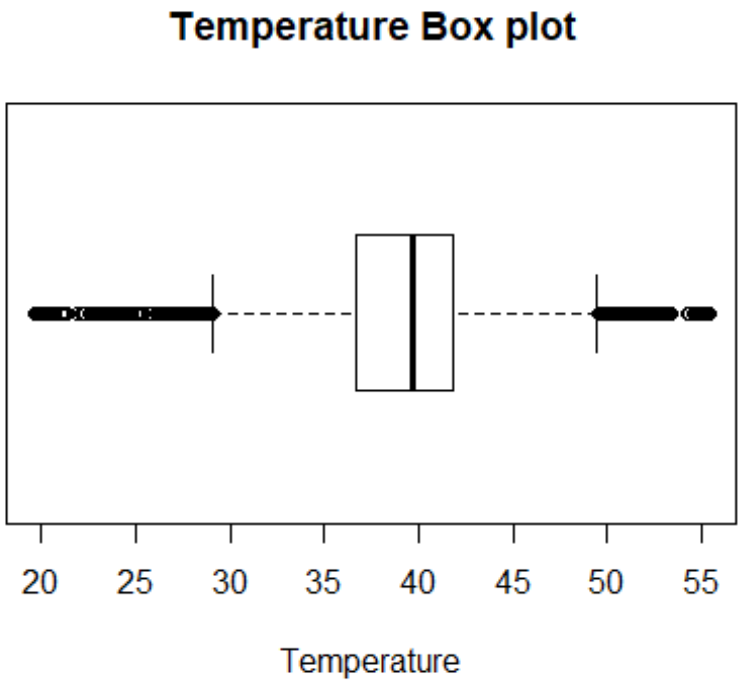
Creating a Numeric dataframe

```
x<-df[,c(1,2,3,4,5,7,9)]
str(x)
```

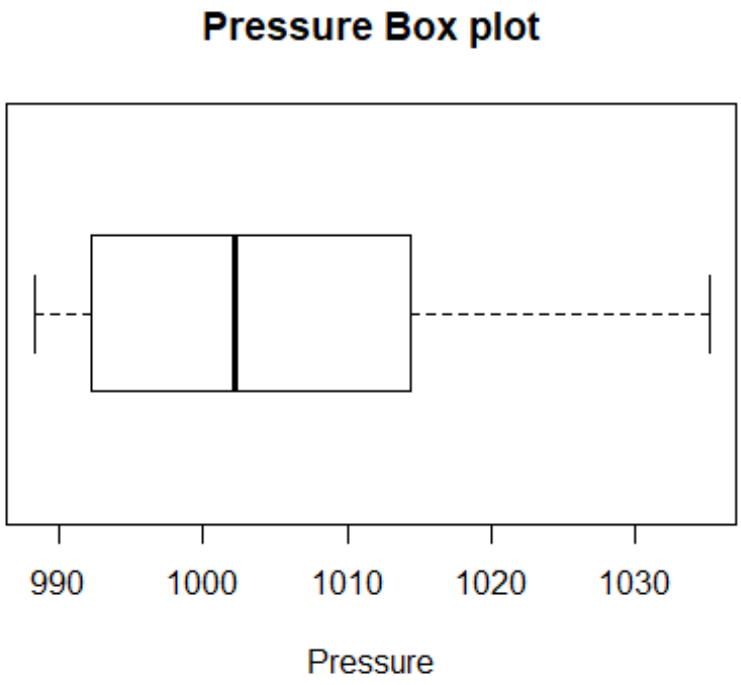
```
## 'data.frame':    9306 obs. of  7 variables:
##  $ clouds  : num  0.87 0.86 0.86 0.86 0.86 0.95 0.95 0.94 0.93 0.93 ...
##  $ pressure: num  1014 1014 1014 1014 1014 ...
##  $ rain    : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ humidity: num  0.92 0.93 0.93 0.93 0.93 0.92 0.92 0.92 0.92 0.92 ...
##  $ wind    : num  1.46 2.57 2.59 2.65 2.65 2.59 2.59 2.83 3 3.01 ...
##  $ distance: num  2.17 2.17 1.44 1.36 1.22 ...
##  $ temp    : num  41 40.6 40.6 40.6 40.6 ...
```

BOXPLOT

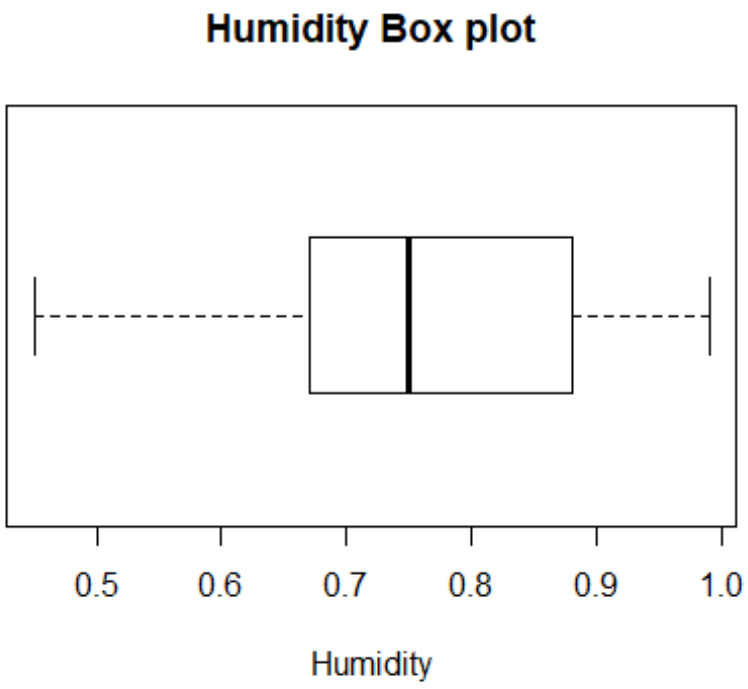
```
boxplot(x$temp, main="Temperature Box plot",yaxt="n", xlab="Temperature",
horizontal=TRUE)
```



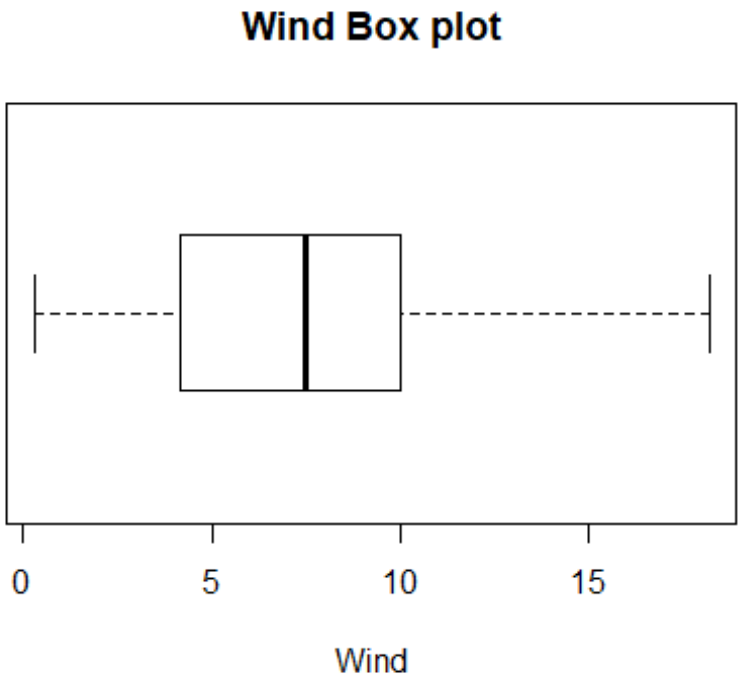

```
boxplot(x$pressure, main="Pressure Box plot",yaxt="n", xlab="Pressure",
horizontal=TRUE)
```



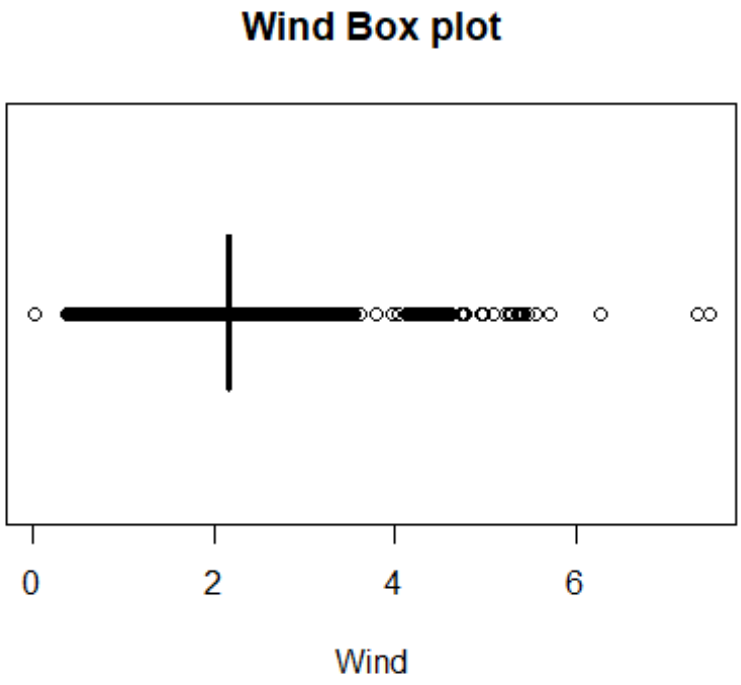
```r
boxplot(x$humidity, main="Humidity Box plot",yaxt="n", xlab="Humidity",
horizontal=TRUE)
```




```r
boxplot(x$wind, main="Wind Box plot",yaxt="n", xlab="Wind", horizontal=TRUE)
```

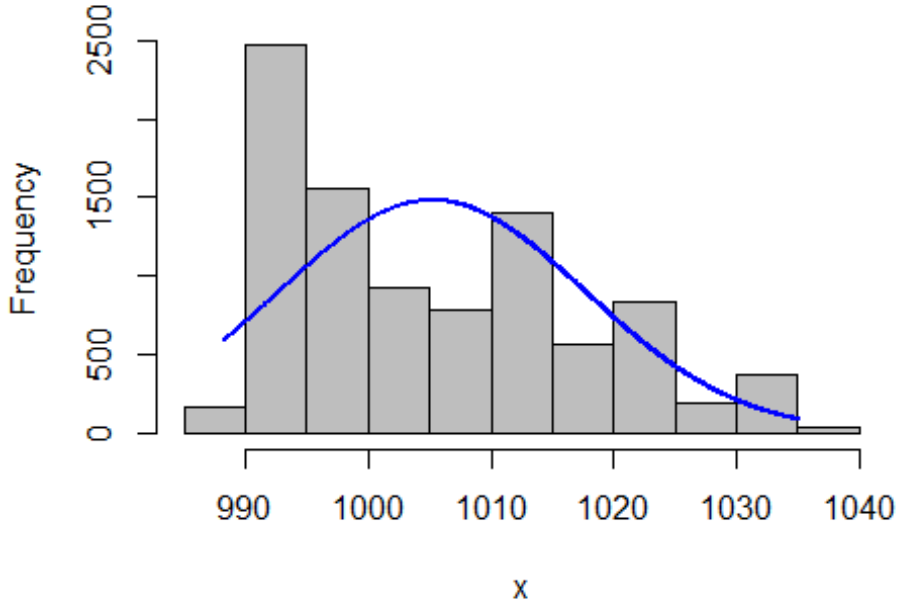



```r
boxplot(x$distance, main="Wind Box plot",yaxt="n", xlab="Wind",
horizontal=TRUE)
```

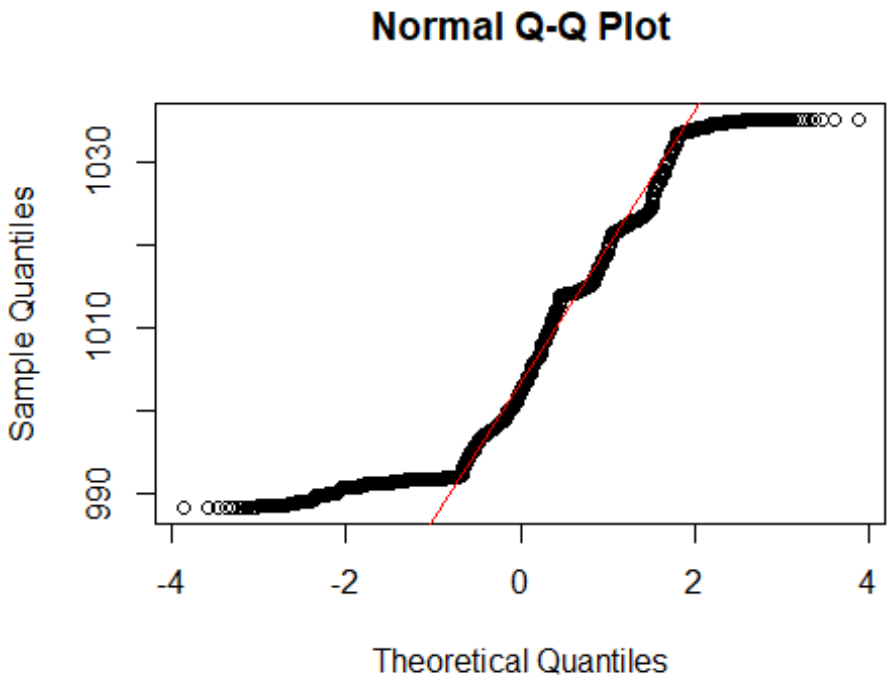


#Q-Q Plot to check normality..

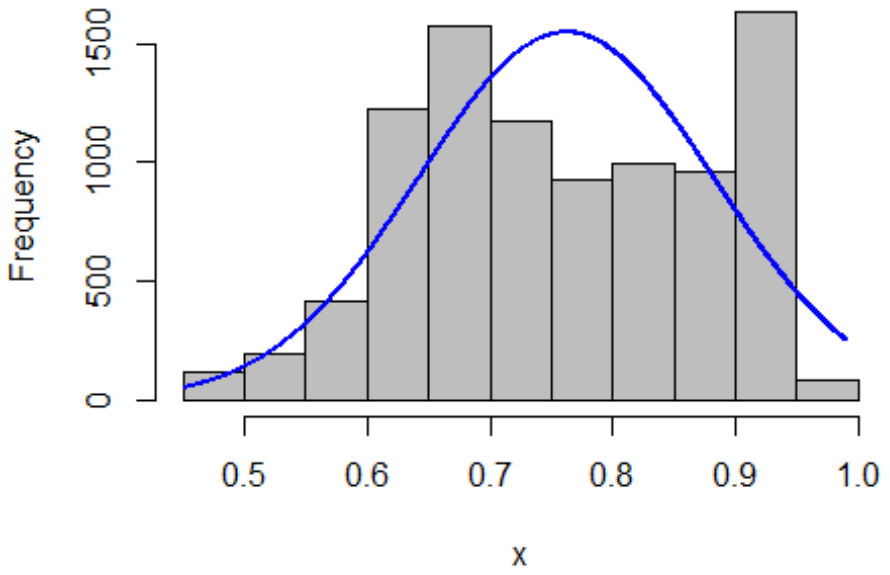
```
library(rcompanion)

## Warning: package 'rcompanion' was built under R version 3.5.3

plotNormalHistogram(x$pressure)
```



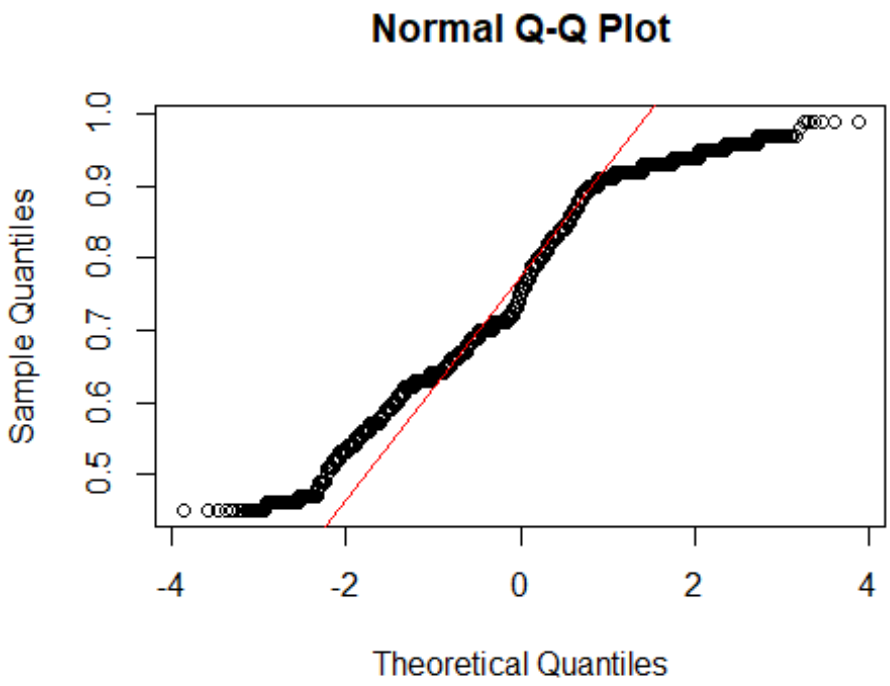

```
qqnorm(df$pressure)
qqline(df$pressure, col="red")
```



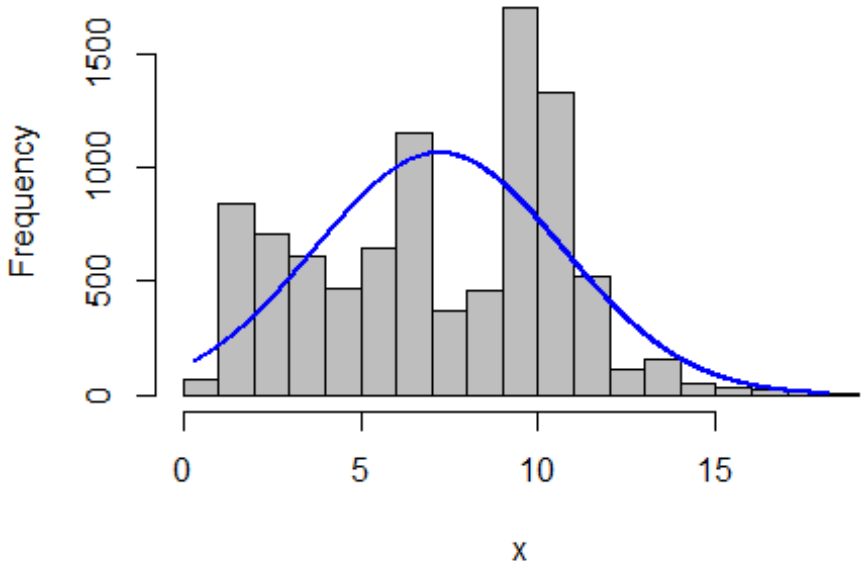

```
plotNormalHistogram(x$humidity)
```



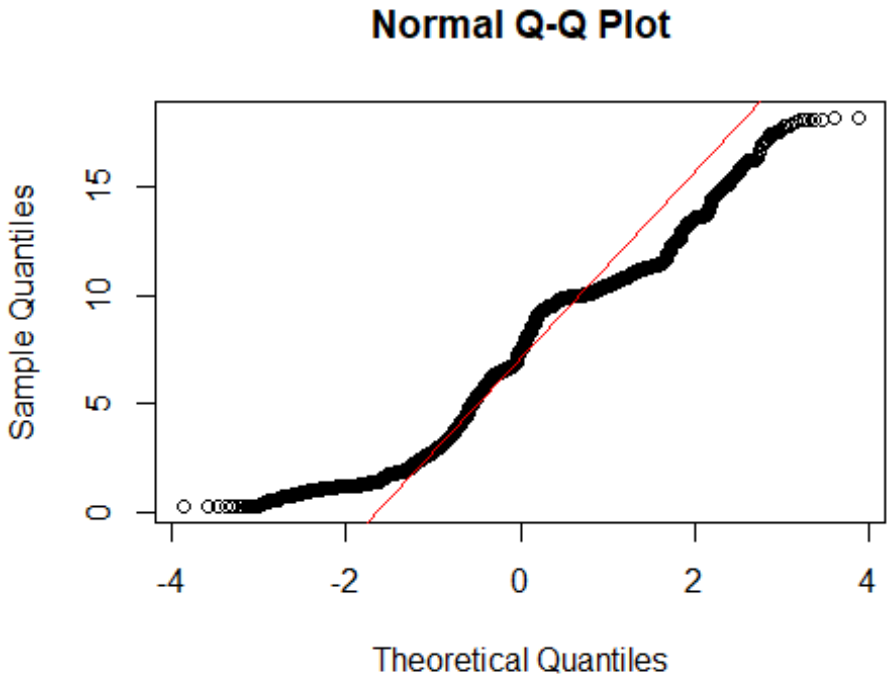
```r
qqnorm(df$humidity)
qqline(df$humidity, col="red")
```



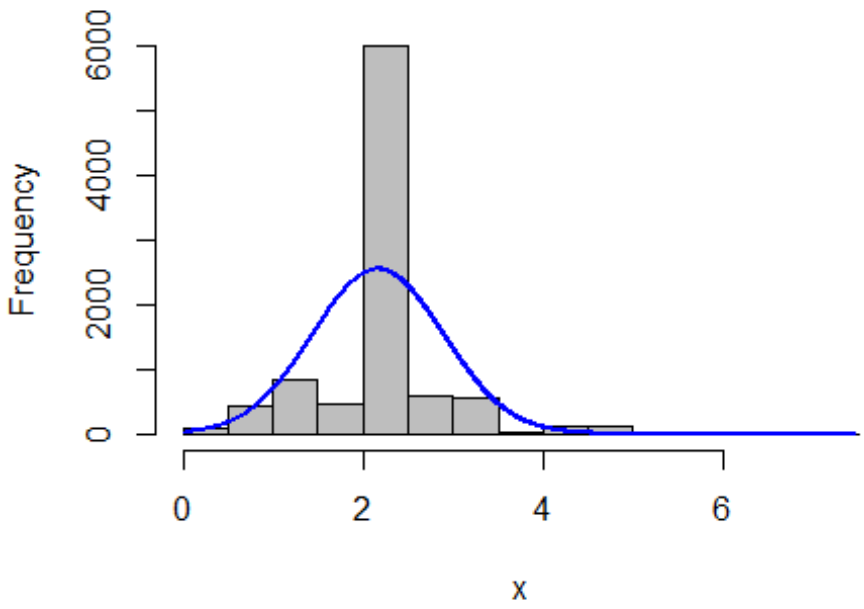

```r
plotNormalHistogram(x$wind)
```



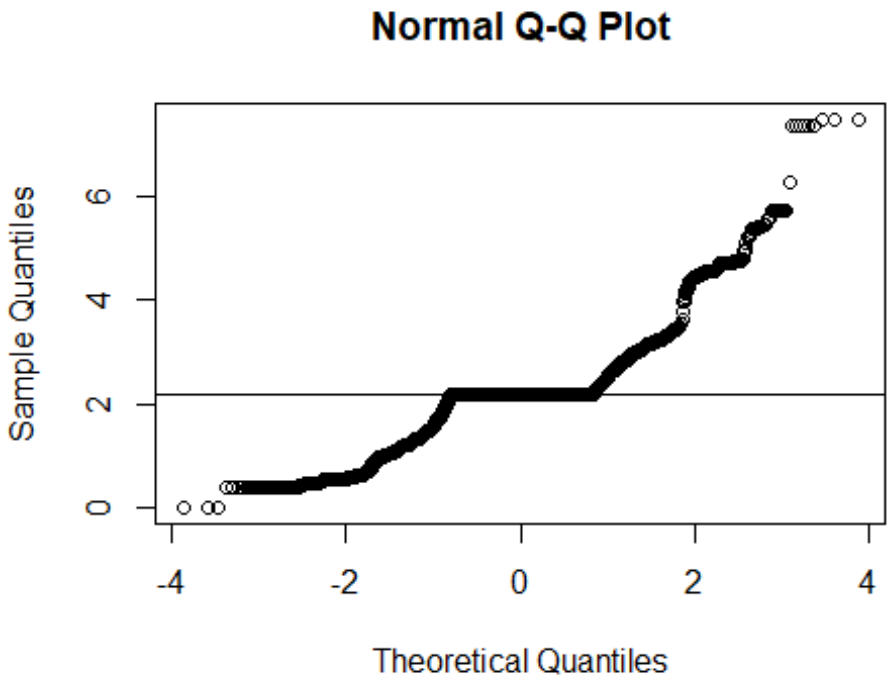

```r
qqnorm(df$wind)
qqline(df$wind, col="red")
```



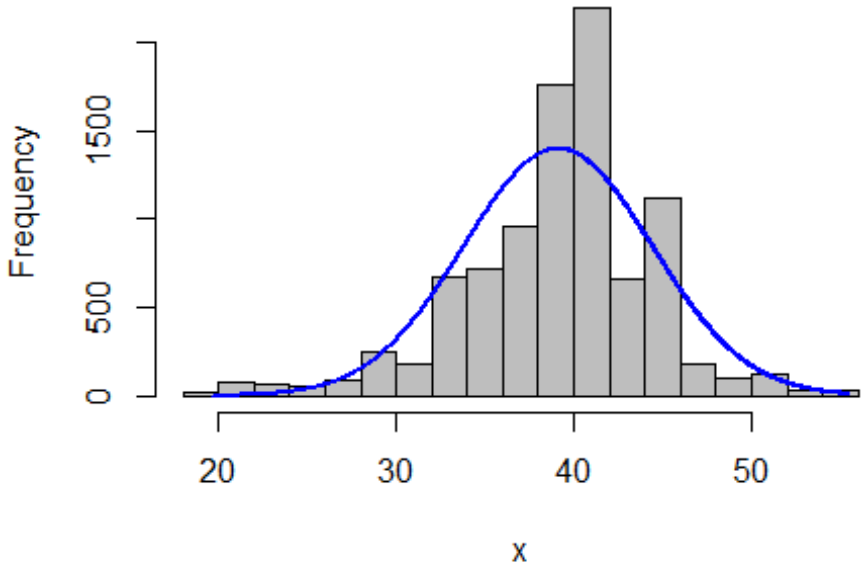
```
plotNormalHistogram(x$distance)
```



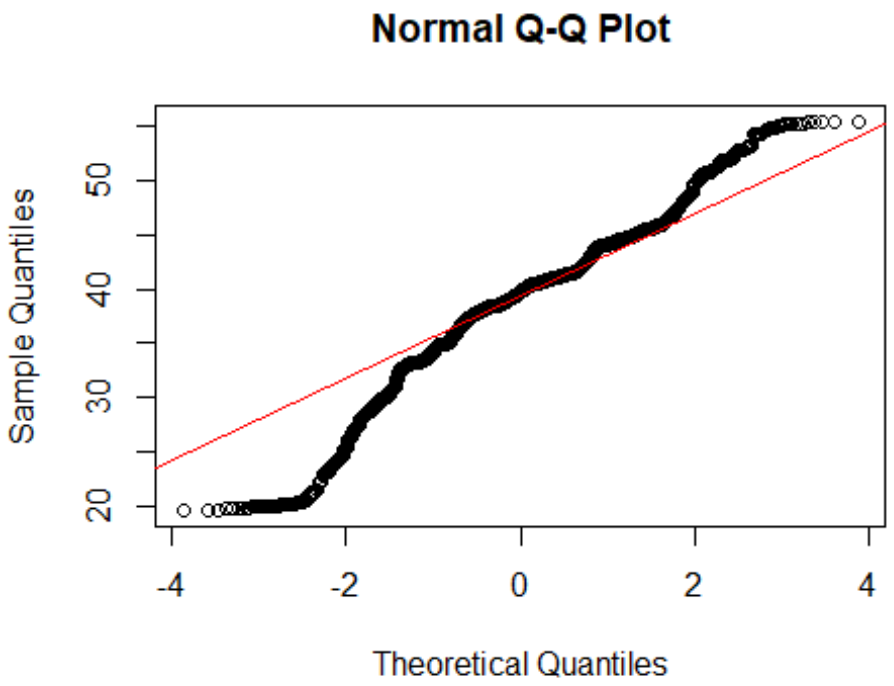

```
qqnorm(df$distance)
qqline(df$distance)
```




```
plotNormalHistogram(x$temp)
```



```r
qqnorm(df$temp)
qqline(df$temp, col="red")
```



Deviation from normality can be observed in our variables. Let's check for multivariate analysis using chi-squre plot

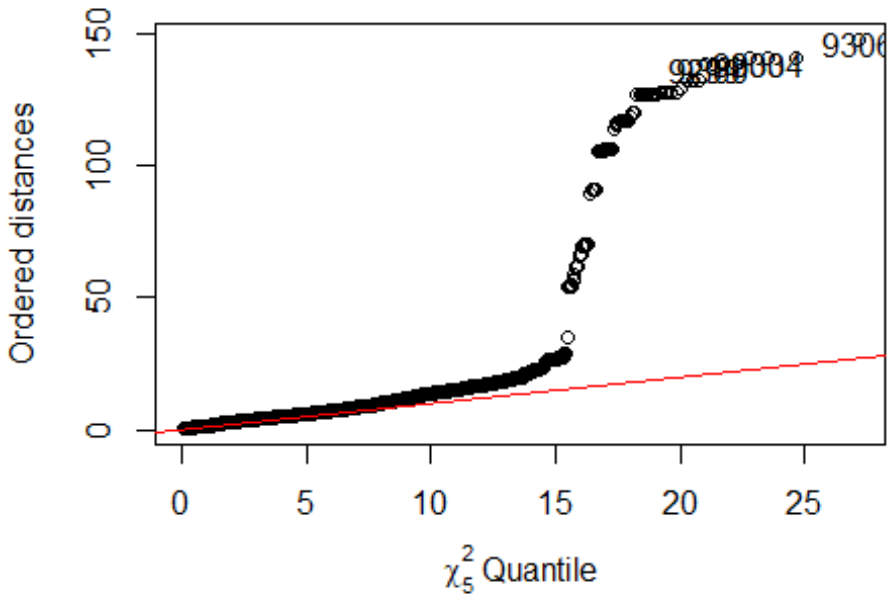
CORRELATION, COVARIANCE AND DISTANCE

```r
#We are calculating for: clouds, pressure, rain, humidity, wind, distance,
surge_multiplier, temp, price
covariance<-cov(x) #variamce-covariance matrix created
correlation<-cor(x) #standardized
#colmeans
cm<-colMeans(x)
distance<-dist(scale(x,center=FALSE))
#Calculating di(generalized distance for all observations of our data)
d <- apply(x, MARGIN = 1, function(x) + t(x - cm) %*% solve(covariance) %*%
(x - cm))
```

The sorted distance are now plotted against the appropriate quantiles of the chi-distribution

```r
plot(qc <- qchisq((1:nrow(x) - 1/2) / nrow(x), df = 5), sd <- sort(d),xlab =
expression(paste(chi[5]^2, " Quantile")),ylab = "Ordered distances")
oups <- which(rank(abs(qc - sd), ties = "random") > nrow(x) - 5)
```

```
text(qc[oups], sd[oups] - 1.5,oups)
abline(a=0,b=1,col="red")
```

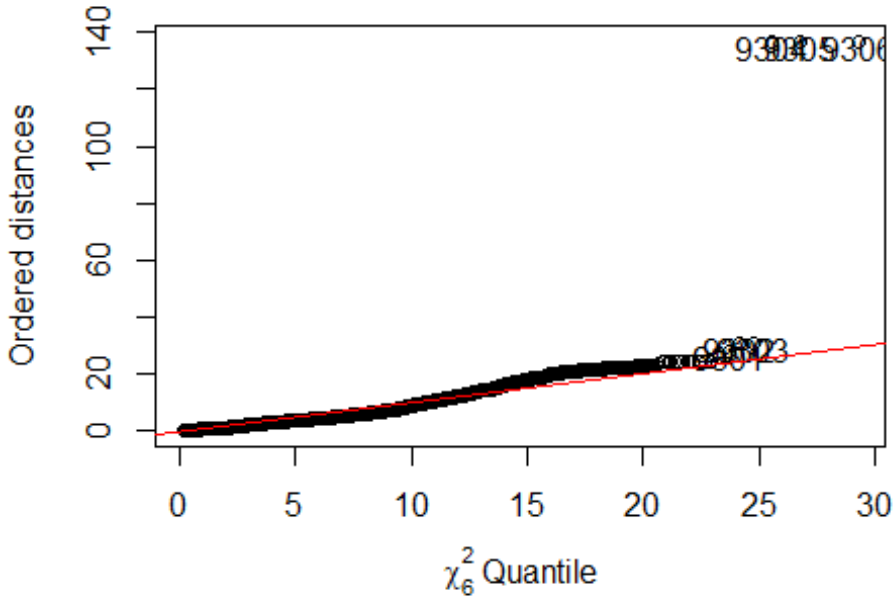



```
#Our observations seems to deviate from linearity after a certain point
```

There is a complete deviation from Normality. We will apply the log transformation on our dataset.

```
#x_new<-x+1
#x_new=log(x - (min(x) - 1))
x_new<-log(x[,c(2,4,5,6,7)])

covariance<-cov(x_new) #variamce-covariance matrix created
correlation<-cor(x_new) #standardized
#colmeans
cm<-colMeans(x_new)
distance<-dist(scale(x_new,center=FALSE))
#Calculating di(generalized distance for all observations of our data)
d <- apply(x_new, MARGIN = 1, function(x_new) + t(x_new - cm) %*%
solve(covariance) %*% (x_new - cm))

plot(qc <- qchisq((1:nrow(x_new) - 1/2) / nrow(x_new), df = 6), sd <-
sort(d),xlab = expression(paste(chi[6]^2, " Quantile")),ylab = "Ordered
distances")
oups <- which(rank(abs(qc - sd), ties = "random") > nrow(x) - 6)
```

```
text(qc[oups], sd[oups] - 1.5,oups)
abline(a=0,b=1,col="red")
```



We have normalized the data..

Pca || T-test || F-test

Get the Correlations between the measurements

```
cor(x_new)
```

```
##              pressure     humidity         wind     distance         temp
## pressure  1.00000000  0.037667720 -0.57053758  0.091084564 -0.190802751
## humidity  0.03766772  1.000000000 -0.34918388  0.007457245  0.342394254
## wind     -0.57053758 -0.349183876  1.00000000 -0.036561758  0.107101055
## distance  0.09108456  0.007457245 -0.03656176  1.000000000 -0.002908013
## temp     -0.19080275  0.342394254  0.10710106 -0.002908013  1.000000000
```

```
sapply(x_new, sd, na.rm = TRUE)
```

```
##   pressure   humidity       wind   distance       temp
## 0.01242771 0.16241660 0.67116505 0.39696563 0.14798758
```

```
#There are not considerable differences between these standard deviations..
Still let's see the PCAs.
```

Using prcomp to compute the principal components (eigenvalues and eigenvectors).

With scale=TRUE, variable means are set to zero, and variances set to one

```
x_pca <- prcomp(x_new,scale=TRUE)
x_pca
```

```
## Standard deviations (1, .., p=5):
## [1] 1.3050862 1.1732928 0.9966622 0.7718227 0.5754028
##
## Rotation (n x k) = (5 x 5):
##                 PC1         PC2         PC3         PC4         PC5
## pressure -0.6258199  0.23938719 -0.01737613  0.51939957 -0.53006170
## humidity -0.3194217 -0.65993093 -0.04083935 -0.52331376 -0.43236070
## wind      0.6908793  0.04300622  0.11994313  0.09716528 -0.70498852
## distance -0.1208578  0.04613105  0.98636820 -0.09381744  0.03926031
## temp      0.1199934 -0.70937108  0.10354529  0.66190935  0.18316287
```

```
summary(x_pca)
```

```
## Importance of components:
##                           PC1    PC2    PC3    PC4     PC5
## Standard deviation     1.3051 1.1733 0.9967 0.7718 0.57540
## Proportion of Variance 0.3407 0.2753 0.1987 0.1191 0.06622
## Cumulative Proportion  0.3407 0.6160 0.8146 0.9338 1.00000
```

```
#x_pca$rotation
```

We see that the first four components account for nearly 80% of the total variance.

sample scores stored in x_pca$x # singular values (square roots of eigenvalues) stored in x_pca$sdev

loadings (eigenvectors) are stored in x_pca$rotation # variable means stored in x_pca$center

variable standard deviations stored in x_pca$scale

A table containing eigenvalues and %'s accounted, follows

Eigenvalues are sdev^2

```
(eigen_x <- x_pca$sdev^2)
```

```
## [1] 1.7032500 1.3766159 0.9933355 0.5957103 0.3310884
```

```
names(eigen_x) <- paste("PC",1:5,sep="")
eigen_x
```

```
##       PC1       PC2       PC3       PC4       PC5
## 1.7032500 1.3766159 0.9933355 0.5957103 0.3310884
```

```
sumlambdas <- sum(eigen_x)
sumlambdas #total sample variance
```

```
## [1] 5
```

```
propvar <- eigen_x/sumlambdas
propvar
```

```
##        PC1        PC2        PC3        PC4        PC5
## 0.34065000 0.27532318 0.19866709 0.11914205 0.06621768
```

```
cumvar_x <- cumsum(propvar)
cumvar_x
```

```
##       PC1       PC2       PC3       PC4       PC5
## 0.3406500 0.6159732 0.8146403 0.9337823 1.0000000
```

```
matlambdas <- rbind(eigen_x,propvar,cumvar_x)
rownames(matlambdas) <- c("Eigenvalues","Prop. variance","Cum. prop.
```

```
variance")
round(matlambdas,4)
```

```
##                          PC1    PC2    PC3    PC4    PC5
## Eigenvalues           1.7033 1.3766 0.9933 0.5957 0.3311
## Prop. variance        0.3407 0.2753 0.1987 0.1191 0.0662
## Cum. prop. variance 0.3407 0.6160 0.8146 0.9338 1.0000
```

Sample scores stored in x_pca$x

We need to calculate the scores on each of these components for each individual in our sample.

```
#x_pca$x
xtyp_pca <- cbind(data.frame(df$price),x_pca$x)
str(xtyp_pca)
```

```
## 'data.frame':    9306 obs. of  6 variables:
##  $ df.price: num  16.7 16.7 8.5 16.5 16.7 ...
##  $ PC1     : num  -2.29 -1.73 -1.6 -1.56 -1.52 ...
##  $ PC2     : num  -1.003 -0.967 -1.014 -1.017 -1.029 ...
##  $ PC3     : num  -0.1144 -0.0228 -1.0382 -1.1765 -1.4464 ...
##  $ PC4     : num  -0.225 -0.232 -0.134 -0.12 -0.094 ...
##  $ PC5     : num  0.647 0.021 -0.0276 -0.0579 -0.0686 ...
```

```
#xtyp_pca
```

Merging price column

```
colnames(xtyp_pca)[colnames(xtyp_pca)=="df.price"] <- "price"
str(xtyp_pca)
```

```
## 'data.frame':    9306 obs. of  6 variables:
##  $ price: num  16.7 16.7 8.5 16.5 16.7 ...
##  $ PC1  : num  -2.29 -1.73 -1.6 -1.56 -1.52 ...
##  $ PC2  : num  -1.003 -0.967 -1.014 -1.017 -1.029 ...
##  $ PC3  : num  -0.1144 -0.0228 -1.0382 -1.1765 -1.4464 ...
##  $ PC4  : num  -0.225 -0.232 -0.134 -0.12 -0.094 ...
##  $ PC5  : num  0.647 0.021 -0.0276 -0.0579 -0.0686 ...
```

Sample scores stoted. x_pca$x

T-Test– We see that true difference in all the means is different from zero.

```
t.test(xtyp_pca$PC1,xtyp_pca$price,var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  xtyp_pca$PC1 and xtyp_pca$price
## t = -265.73, df = 18610, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -16.79675 -16.55077
## sample estimates:
##     mean of x     mean of y
## -1.534642e-14  1.667376e+01
```

```
t.test(xtyp_pca$PC2,xtyp_pca$price,var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  xtyp_pca$PC2 and xtyp_pca$price
## t = -266.92, df = 18610, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -16.79620 -16.55132
## sample estimates:
##    mean of x    mean of y
## 4.850155e-15 1.667376e+01
```

```
t.test(xtyp_pca$PC3,xtyp_pca$price,var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  xtyp_pca$PC3 and xtyp_pca$price
## t = -268.34, df = 18610, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -16.79555 -16.55197
## sample estimates:
##     mean of x     mean of y
## -3.485127e-16  1.667376e+01
```

```
t.test(xtyp_pca$PC4,xtyp_pca$price,var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  xtyp_pca$PC4 and xtyp_pca$price
## t = -269.84, df = 18610, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -16.79488 -16.55264
## sample estimates:
```

```
##    mean of x    mean of y
## 1.371754e-14 1.667376e+01
```

```
t.test(xtyp_pca$PC5,xtyp_pca$price,var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  xtyp_pca$PC5 and xtyp_pca$price
## t = -270.85, df = 18610, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -16.79443 -16.55309
## sample estimates:
##     mean of x     mean of y
## -1.304992e-14  1.667376e+01
```

```
#F-Test #Testing Variation
```

Variance Test- Test for variance

```
var.test(xtyp_pca$PC1,xtyp_pca$price)
```

```
##
##  F test to compare two variances
##
## data:  xtyp_pca$PC1 and xtyp_pca$price
## F = 0.048752, num df = 9305, denom df = 9305, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.04681082 0.05077444
## sample estimates:
## ratio of variances
##         0.04875236
```

```
var.test(xtyp_pca$PC2,xtyp_pca$price)
```

```
##
##  F test to compare two variances
##
## data:  xtyp_pca$PC2 and xtyp_pca$price
## F = 0.039403, num df = 9305, denom df = 9305, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.03783386 0.04103737
## sample estimates:
## ratio of variances
##         0.03940307
```

```
var.test(xtyp_pca$PC3,xtyp_pca$price)
```

```
##
##  F test to compare two variances
##
## data:  xtyp_pca$PC3 and xtyp_pca$price
## F = 0.028432, num df = 9305, denom df = 9305, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.02730007 0.02961165
## sample estimates:
## ratio of variances
##         0.02843238
```

```
var.test(xtyp_pca$PC4,xtyp_pca$price)
```

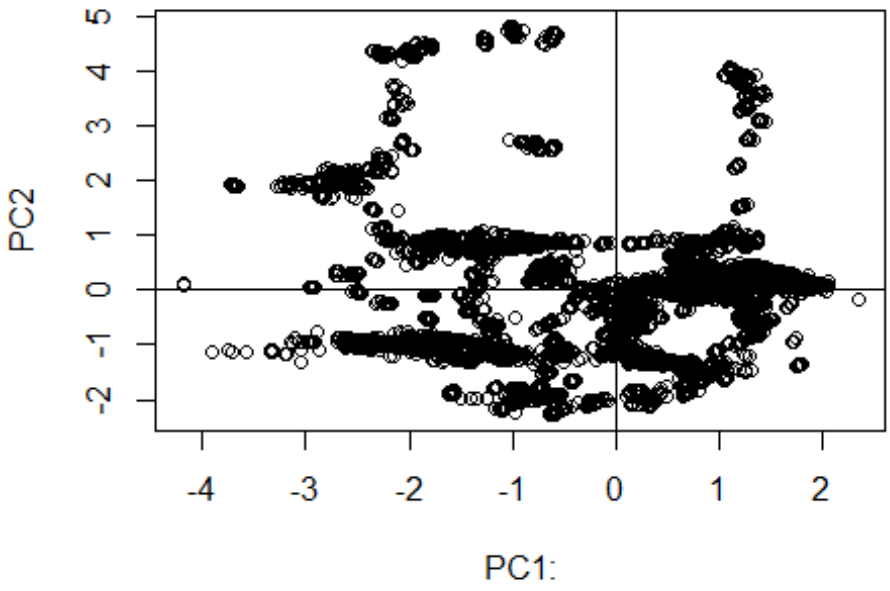
```
##
##  F test to compare two variances
##
## data:  xtyp_pca$PC4 and xtyp_pca$price
## F = 0.017051, num df = 9305, denom df = 9305, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.01637204 0.01775832
## sample estimates:
## ratio of variances
##          0.0170511
```

```
var.test(xtyp_pca$PC5,xtyp_pca$price)
```

```
##
##  F test to compare two variances
##
## data:  xtyp_pca$PC5 and xtyp_pca$price
## F = 0.0094768, num df = 9305, denom df = 9305, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.009099379 0.009869852
## sample estimates:
## ratio of variances
##        0.009476789
```

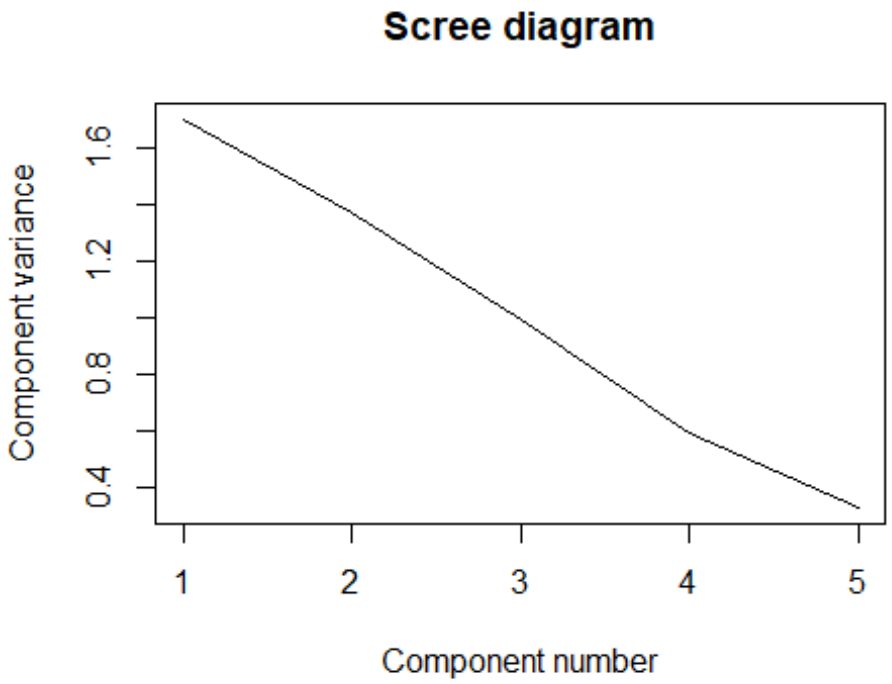
Plotting the scores of Pricipal Component 1 and Principal component 2

```
plot(xtyp_pca$PC1, xtyp_pca$PC2,xlab="PC1:", ylab="PC2")
abline(h=0)
abline(v=0)
```



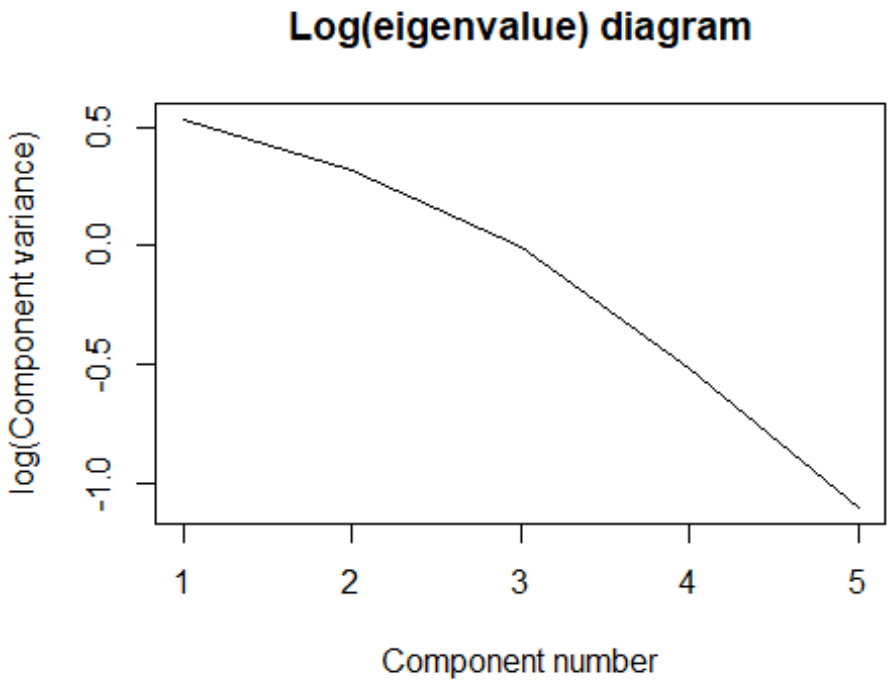
Plotting the Variance of Principal Components

```
plot(eigen_x, xlab = "Component number", ylab = "Component variance", type =
"l", main = "Scree diagram")
```



#Plotting the Log variance of COmponents

```
plot(log(eigen_x), xlab = "Component number",ylab = "log(Component
variance)", type="l",main = "Log(eigenvalue) diagram")
```



#Variance of the principal components

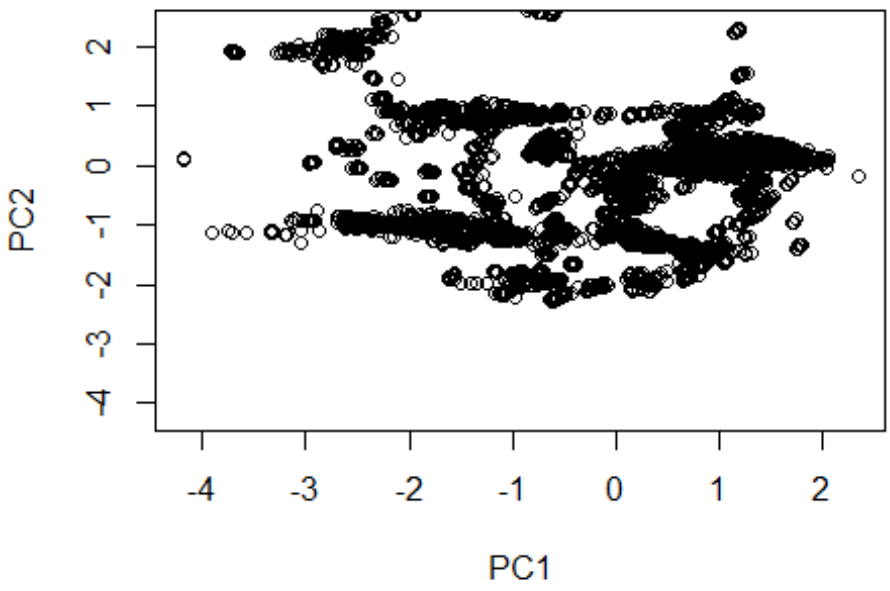
```
#View(x_pca)
diag(cov(x_pca$x))
```

```
##       PC1       PC2       PC3       PC4       PC5
## 1.7032500 1.3766159 0.9933355 0.5957103 0.3310884
```

```
#x_pca$x[,1]
#x_pca$x
```

Plotting the scores

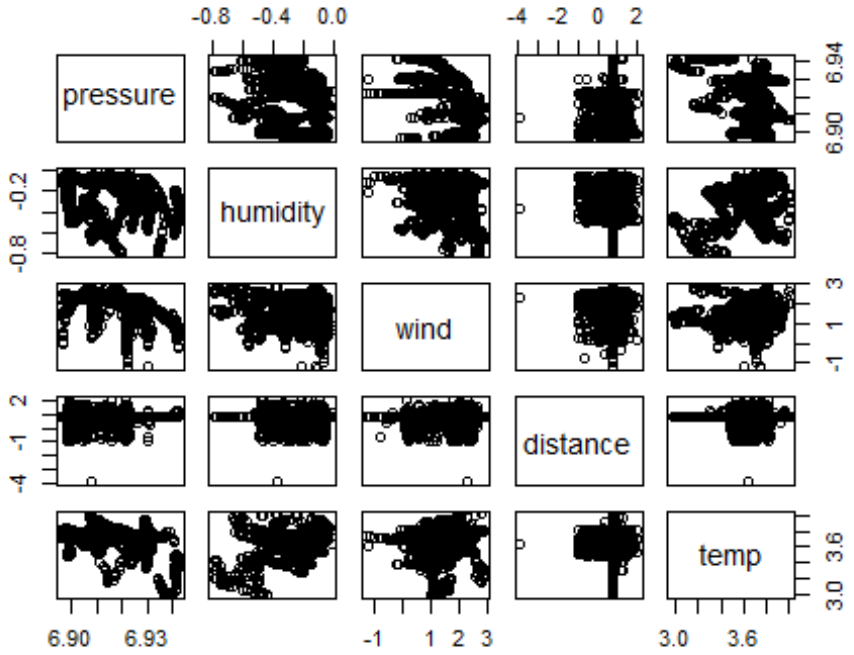
```
xlim <- range(x_pca$x[,1])
plot(x_pca$x,xlim=xlim,ylim=xlim)
```




```
#x_pca$rotation[,1]
#x_pca$rotation
```

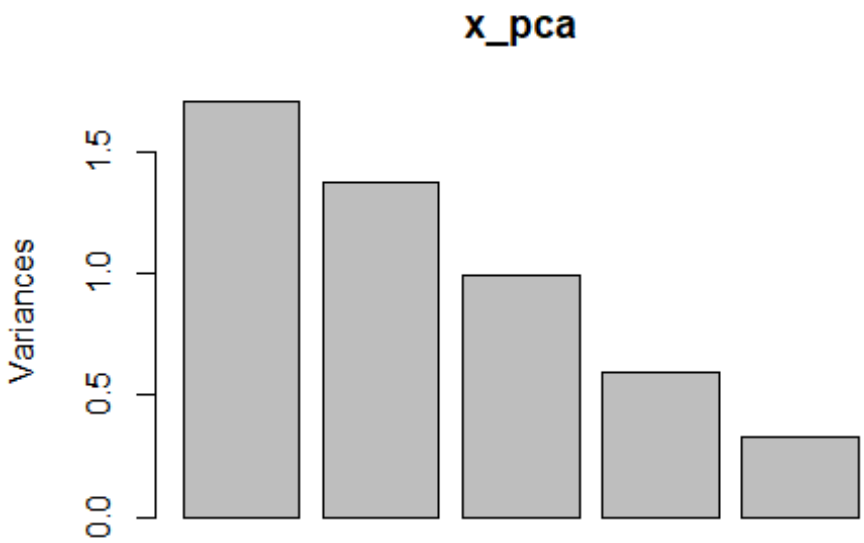
Scatter plot matrix of the actual data

```
plot(x_new)
```



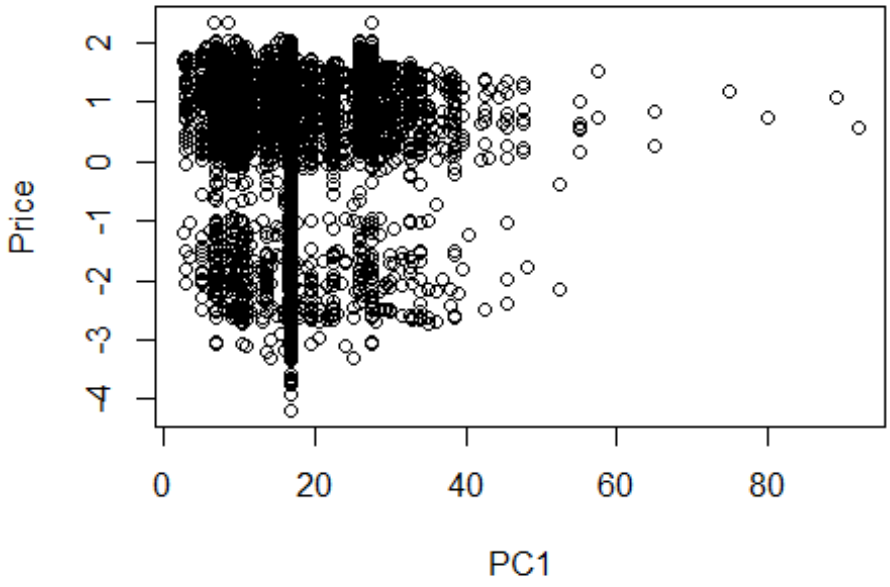
Variance plot for each component. We can see that all components play a dominant role.

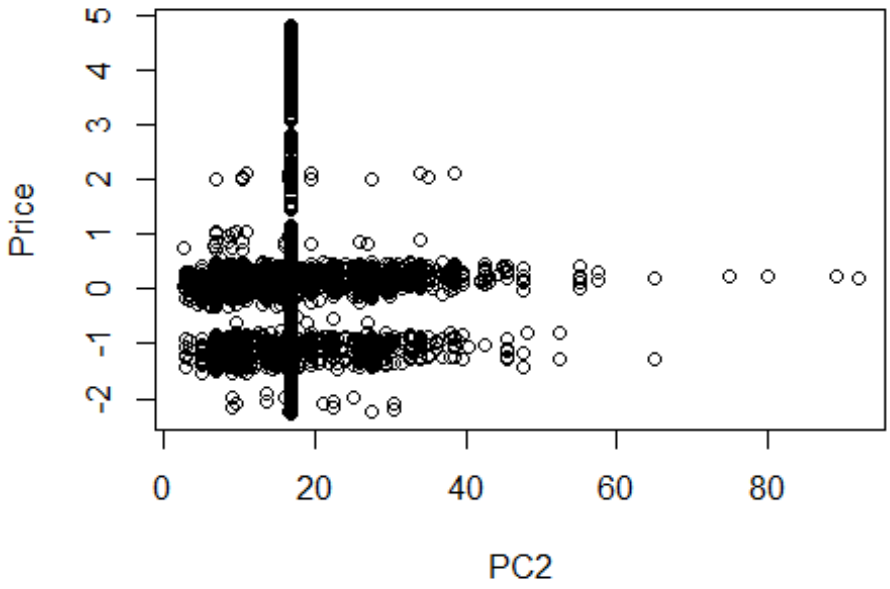
```
plot(x_pca)
```

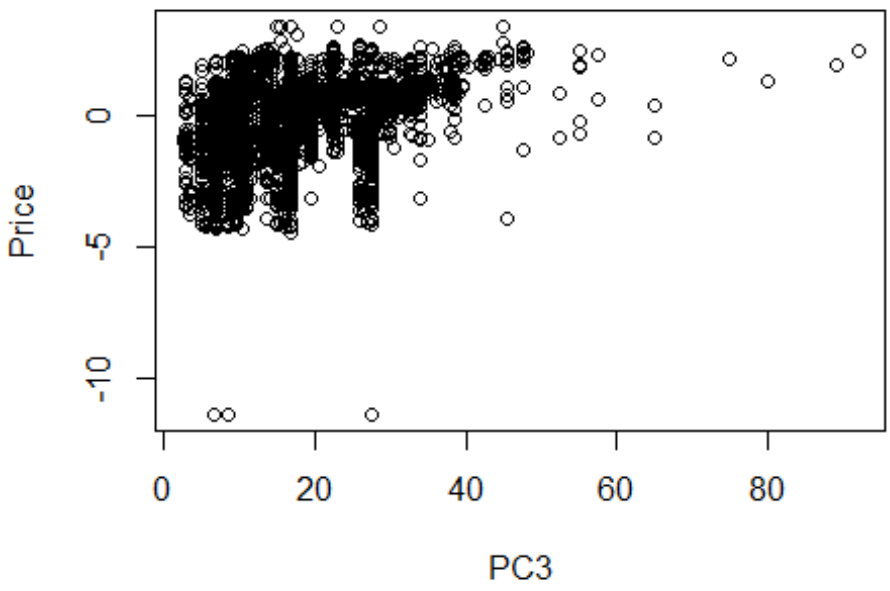


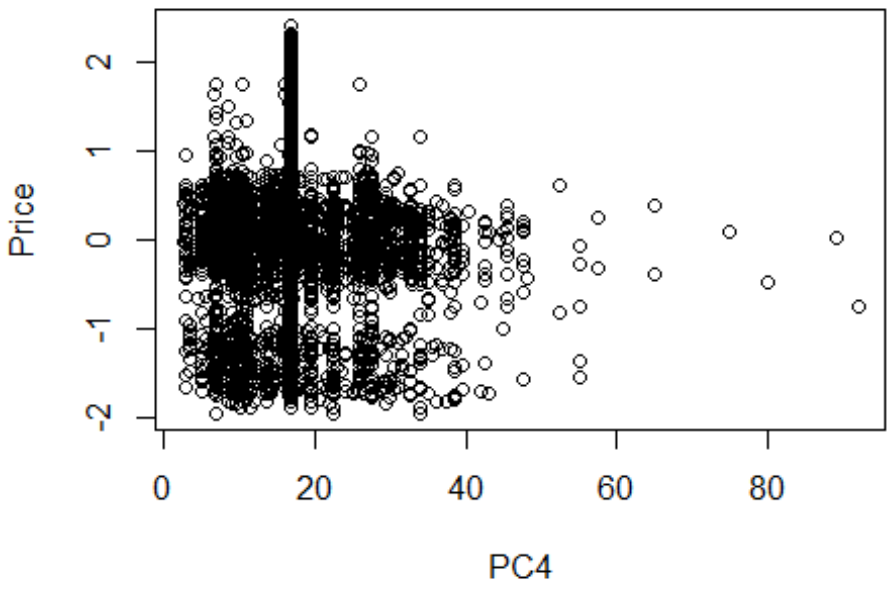

```r
#get the original value of the data based on PCA
center <- x_pca$center
scale <- x_pca$scale
new_x <- as.matrix(x_new)
#drop(scale(new_x,center=center, scale=scale)%*%x_pca$rotation[,1])
#predict(x_pca)[,1]
#The aboved two gives us the same thing. predict is a good function to know.

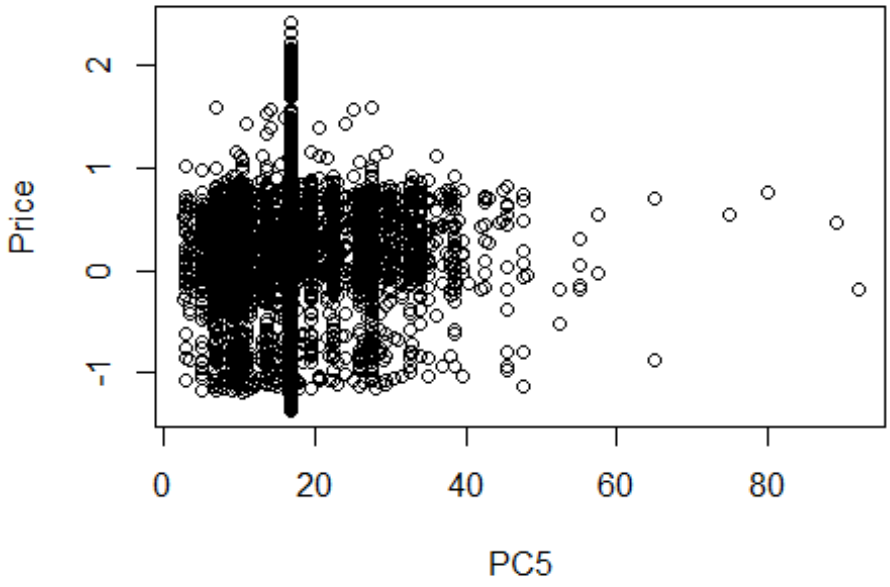
x_new$price<-df$price
out <- sapply(1:5,
function(i){plot(x_new$price,x_pca$x[,i],xlab=paste("PC",i,sep=""),
                                    ylab="Price")})
```


Price
2
1
0
-1
-2
-3
-4
0
20
40
60
80
PC1

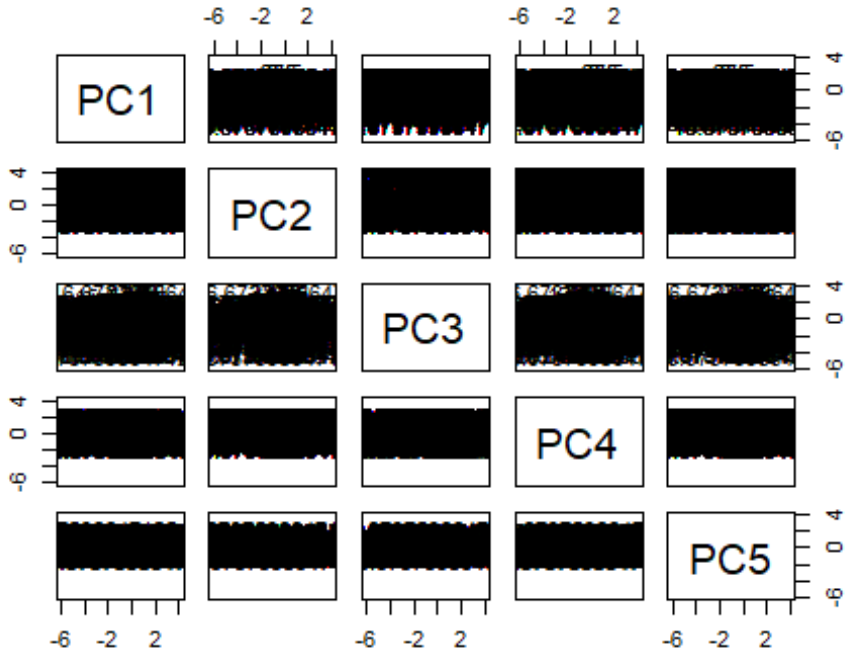

Price
5
4
3
2
1
0
-1
-2
0
20
40
60
80
PC2


Price
0
-5
-10
0
20
40
60
80
PC3


Price
2
1
0
-1
-2
0
20
40
60
80
PC4




```
pairs(x_pca$x[,1:5], ylim = c(-6,4),xlim = c(-
6,4),panel=function(x,y,...){text(x,y,x_new$price)})
```



CLuster Analysis

```
#install.packages("cluster",
#lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")
library(cluster)

## Warning: package 'cluster' was built under R version 3.5.3
```

Pulling the numerical variables in the “Cluster” dataframe. Scaling the values..

```
cluster <- df[,c(1,2,4,5,7,9)]
matstd.cluster <- scale(cluster)
dim(matstd.cluster)

## [1] 9306    6
```

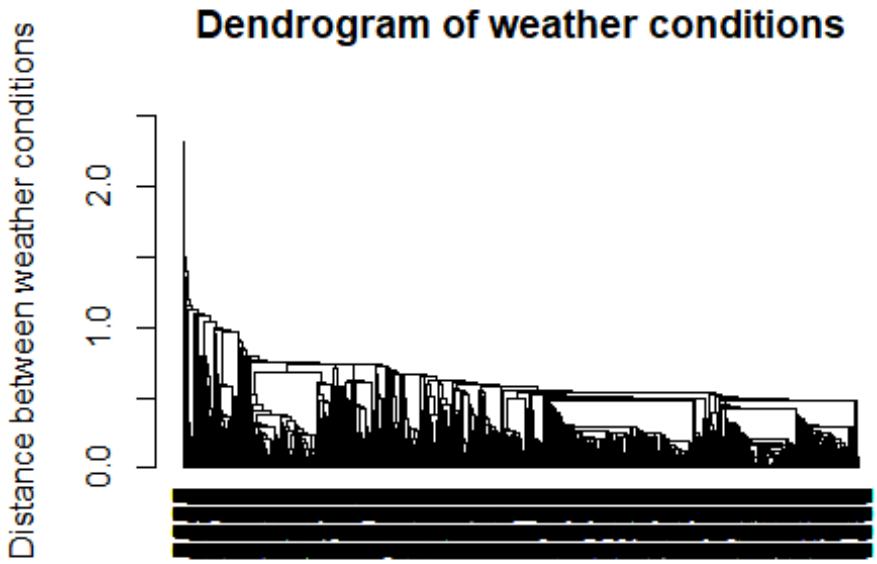
Calculating the distance between all observations..

```
dist.cluster <- dist(matstd.cluster, method="euclidean")
length(dist.cluster)

## [1] 43296165
```

Invoking hclust command (cluster analysis by single linkage method)

```
hclust_cluster <- hclust(dist.cluster, method = "single")
par(mar=c(6, 4, 4, 2) + 0.1)
plot(as.dendrogram(hclust_cluster),ylab="Distance between weather
conditions",ylim=c(0,2.5),main="Dendrogram of weather conditions")
```



K-means Clustering for k=2 and then computing the percentage variance

```
#attach(cluster)
matstd.cluster <- scale(cluster)
# Computing the percentage of variation accounted for. Two clusters
kmeans2.cluster <- kmeans(matstd.cluster,2,nstart = 10)
perc.var.2 <- round(100*(1 -
kmeans2.cluster$betweenss/kmeans2.cluster$totss),1)
names(perc.var.2) <- "Perc. 2 clus"
perc.var.2

## Perc. 2 clus
##         75.4
```

Computing the percentage of variation accounted for. Three clusters

```
kmeans3.cluster <- kmeans(matstd.cluster,3,nstart = 10)
perc.var.3 <- round(100*(1 -
kmeans3.cluster$betweenss/kmeans3.cluster$totss),1)
names(perc.var.3) <- "Perc. 3 clus"
perc.var.3

## Perc. 3 clus
##         58.3
```

Computing the percentage of variation accounted for. Four clusters

```
kmeans4.cluster <- kmeans(matstd.cluster,4,nstart = 10)
perc.var.4 <- round(100*(1 -
kmeans4.cluster$betweenss/kmeans4.cluster$totss),1)
names(perc.var.4) <- "Perc. 4 clus"
perc.var.4
```

```
## Perc. 4 clus
##         50.9
```

Computing the percentage of variation accounted for. Five clusters

```
kmeans5.cluster <- kmeans(matstd.cluster,5,nstart = 10)
perc.var.5 <- round(100*(1 -
kmeans5.cluster$betweenss/kmeans5.cluster$totss),1)
names(perc.var.5) <- "Perc. 5 clus"
perc.var.5
```

```
## Perc. 5 clus
##         44.5
```

Computing the percentage of variation accounted for. Six clusters

```
kmeans6.cluster <- kmeans(matstd.cluster,6,nstart = 10)
perc.var.6 <- round(100*(1 -
kmeans6.cluster$betweenss/kmeans6.cluster$totss),1)
names(perc.var.6) <- "Perc. 6 clus"
perc.var.6
```

```
## Perc. 6 clus
##         38.7
```

plots to compare

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

```
## Warning: package 'VIM' was built under R version 3.5.3
```

```
## Loading required package: colorspace
```

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

```
## Loading required package: data.table
```

```
## VIM is ready to use.
##  Since version 4.0.0 the GUI is in its own package VIMGUI.
##
##           Please use the package to use the new (and old) GUI.
```

```
## Suggestions and bug-reports can be submitted at:
https://github.com/alexkowa/VIM/issues

##
## Attaching package: 'VIM'

## The following object is masked from 'package:datasets':
##
##     sleep

#install.packages("tidyverse")
library(tidyverse)  # data manipulation

## Warning: package 'tidyverse' was built under R version 3.5.3

## -- Attaching packages ---------------------------------------------------
------- tidyverse 1.2.1 --

## v ggplot2 3.1.1       v purrr   0.3.0
## v tibble  2.0.1       v dplyr   0.8.0.1
## v tidyr   0.8.3       v stringr 1.3.1
## v readr   1.3.1       v forcats 0.3.0

## Warning: package 'ggplot2' was built under R version 3.5.3

## Warning: package 'tidyr' was built under R version 3.5.3

## -- Conflicts ------------------------------------------------------------
- tidyverse_conflicts() --
## x dplyr::between()   masks data.table::between()
## x dplyr::filter()    masks stats::filter()
## x dplyr::first()     masks data.table::first()
## x dplyr::lag()       masks stats::lag()
## x dplyr::last()      masks data.table::last()
## x purrr::transpose() masks data.table::transpose()

#install.packages("cluster")
library(cluster)    # clustering algorithms
#install.packages("factoextra")
library(factoextra)

## Warning: package 'factoextra' was built under R version 3.5.3

## Welcome! Related Books: `Practical Guide To Cluster Analysis in R` at
https://goo.gl/13EFCZ

p1 <- fviz_cluster(kmeans2.cluster, geom = "point", data = cluster) +
ggtitle("k = 2")
p2 <- fviz_cluster(kmeans3.cluster, geom = "point",  data = cluster) +
ggtitle("k = 3")
p3 <- fviz_cluster(kmeans4.cluster, geom = "point",  data = cluster) +
ggtitle("k = 4")
p4 <- fviz_cluster(kmeans5.cluster, geom = "point",  data = cluster) +
```

```
ggtitle("k = 5")
p5 <- fviz_cluster(kmeans6.cluster, geom = "point",  data = cluster) +
ggtitle("k = 6")
```

Grid plot

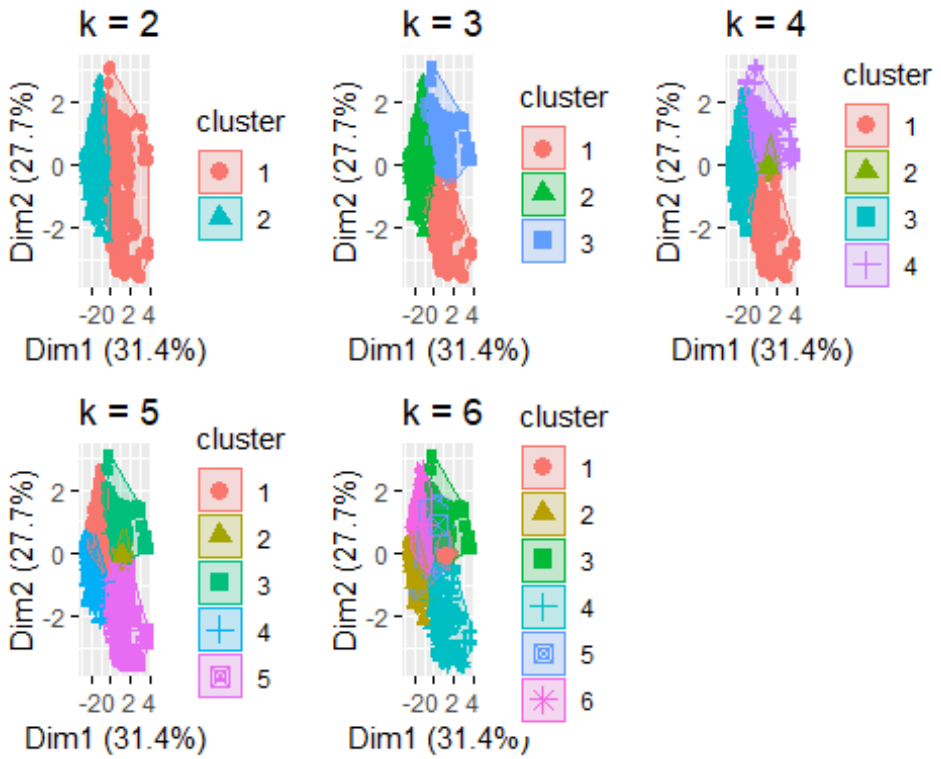
```
library(gridExtra)

## Warning: package 'gridExtra' was built under R version 3.5.3

##
## Attaching package: 'gridExtra'

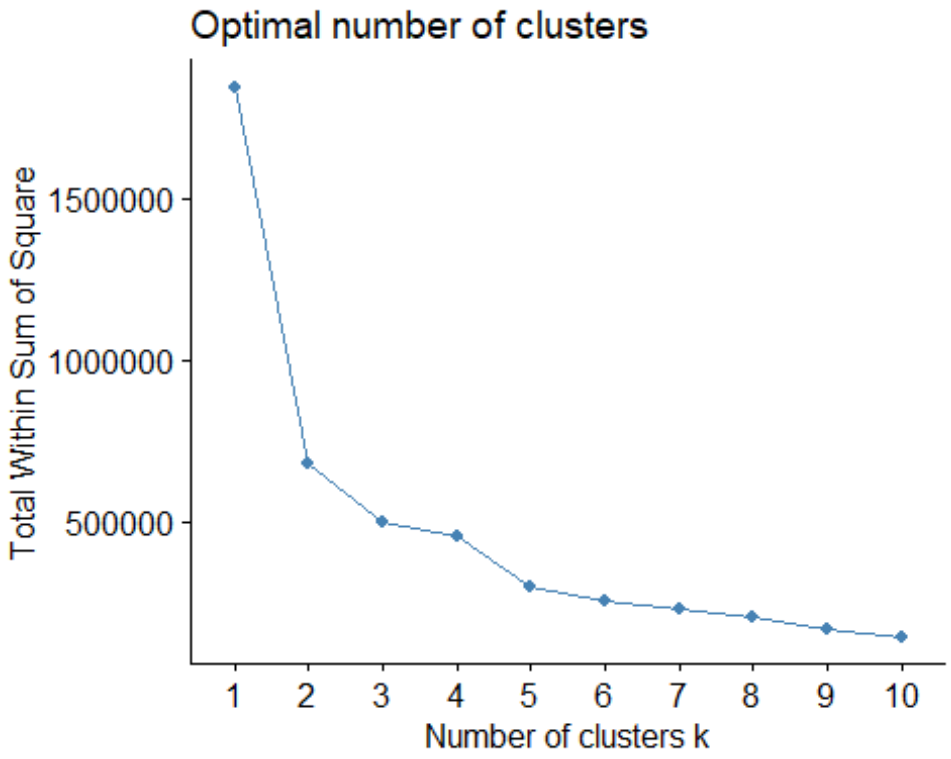
## The following object is masked from 'package:dplyr':
##
##     combine

grid.arrange(p1, p2, p3, p4,p5, nrow = 2)
```



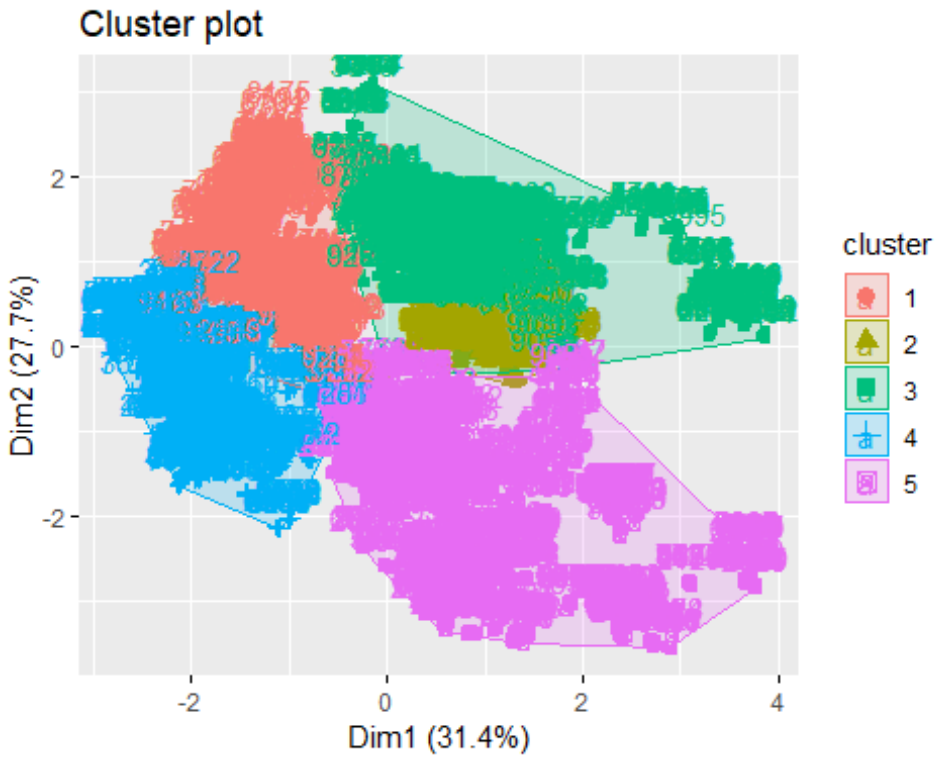
Determining Optimal Clusters

```
set.seed(123)
fviz_nbclust(cluster, kmeans, method = "wss")
```

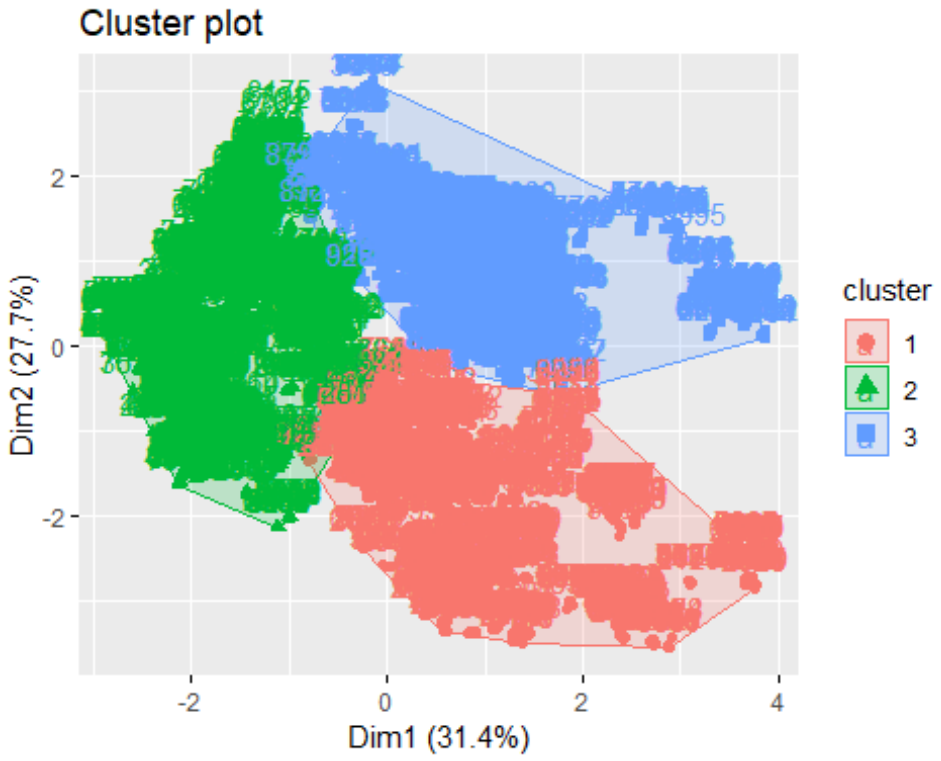


K=5 seems optimal number of clusters

```
fviz_cluster(kmeans5.cluster, data = cluster)
```




```
fviz_cluster(kmeans3.cluster, data = cluster)
```



Adding cluster number to the file for each observation-

```
clusterFile <- cbind(df, clusterNum = kmeans5.cluster$cluster)
head(clusterFile)
```

```
##   clouds pressure rain humidity wind         date_time.x distance
## 1   0.87  1014.39    0     0.92 1.46 2018-11-26 04:34:05 2.168125
## 2   0.86  1014.17    0     0.93 2.57 2018-11-26 05:34:13 2.168125
## 3   0.86  1014.17    0     0.93 2.59 2018-11-26 05:34:58 1.440000
## 4   0.86  1014.17    0     0.93 2.65 2018-11-26 05:36:38 1.360000
## 5   0.86  1014.17    0     0.93 2.65 2018-11-26 05:36:38 1.220000
## 6   0.95  1013.78    0     0.92 2.59 2018-11-26 05:42:57 1.340000
##   surge_multiplier  temp    price    day     time  date_time clusterNum
## 1         1.018365 41.04 16.67376 Monday 04:34:05 2018-11-26          4
## 2         1.018365 40.63 16.67376 Monday 05:34:13 2018-11-26          4
## 3         1.000000 40.63  8.50000 Monday 05:34:58 2018-11-26          4
## 4         1.000000 40.61 16.50000 Monday 05:36:38 2018-11-26          4
## 5         1.000000 40.61 16.67376 Monday 05:36:38 2018-11-26          4
## 6         1.000000 40.72 26.50000 Monday 05:42:57 2018-11-26          4
```

Factor Analysis:

We concluded during Principal Component Analysis that all the variables of our dataset are not highly correlated and all are significant. Hence, we did not apply Factor Analysis on our data.

```
#We found that all our columns are significant and are not so highly correlated. Hence, we would
keep them as they are. There were no considerable differences between their standard
deviations.. Still we checked with PCA and decided to keep all the variables . We need not to do
the Factor ANalysis in our dataset.. still we will verify doing so!

##Factor Analysis

```{r}
# Multiplying each column of the eigenvector's matrix by the square-root of the
#corresponding eigenvalue in order to get the factor loadings
eigvec.x <- x_pca$rotation
print(x_pca)
unrot.fact.x <- sweep(eigvec.x ,MARGIN=2,x_pca$sdev[1:5],`*`)
unrot.fact.x
```
```

```
Standard deviations (1, .., p=5):
[1] 1.3050862 1.1732928 0.9966622 0.7718227 0.5754028

Rotation (n x k) = (5 x 5):
                PC1         PC2         PC3         PC4         PC5
pressure -0.6258199  0.23938719 -0.01737613  0.51939957 -0.53006170
humidity -0.3194217 -0.65993093 -0.04083935 -0.52331376 -0.43236070
wind      0.6908793  0.04300622  0.11994313  0.09716528 -0.70498852
distance -0.1208578  0.04613105  0.98636820 -0.09381744  0.03926031
temp      0.1199934 -0.70937108  0.10354529  0.66190935  0.18316287
                PC1         PC2         PC3         PC4         PC5
pressure -0.8167489  0.28087126 -0.01731813  0.40088437 -0.30499898
humidity -0.4168729 -0.77429218 -0.04070304 -0.40390543 -0.24878156
wind      0.9016570  0.05045888  0.11954278  0.07499436 -0.40565237
distance -0.1577298  0.05412523  0.98307587 -0.07241043  0.02259049
temp      0.1566017 -0.83229996  0.10319967  0.51087665  0.10539243
```

Computing communalities

```{r}
communalities.x <- rowSums(unrot.fact.x^2)
communalities.x
```

```
pressure humidity     wind distance     temp
       1        1        1        1        1
```

#Hence we can see we will not proceed with the Factor Analysis