

# Dimensional Reduction of currency pair

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## Introduction

The foreign exchange market is one of the largest in the world. Individuals, organizations, and major banks trade currencies every day. Risk management is very important in forex trading. In other words, it is possible to find currency pairs that are highly correlated with each other using the PCA method.

## Datasets

In this project, I will use 31 finance price data of H4 timeframe. I took these data from Metatrader4 platform using my ICmarket's account and python program. There is a MetaTrader5 library in python. It helps to import currency pairs data from MT4 Platform. And it is real time data. You can see python code below. I imported fx data from 2015.01.01 to 2022.12.31. After I import these datas, I saved it as 'df.RDS'. And I will use it from now on. It contains some confidential information. So I used \*.

```
import pyreadr
import MetaTrader5 as mt
import pandas as pd
import plotly as pl
from datetime import datetime
import plotly.express as px
import pandas_ta as ta
import plotly
import matplotlib.pyplot as plt
import statistics
from statistics import stdev
from statistics import variance
import os
import glob
import numpy as np
from datetime import datetime, date, timedelta
import talib as tl

mt.initialize()
login=***** # account number
password=***** # password
server='ICMarketsSC-Demo'
mt.login(login,password,server)
list_fx=["AUDCHF", "AUDJPY", "AUDCAD", "AUDNZD", "AUDUSD", "CADCHF", "CADJPY", "CHFJPY", "EURAUD", "EURCAD", "EURCHF", "EURNZD", "EURUSD", "GBPAUD", "GBPCAD", "GBPCHF", "GBPJPY", "GBPNZD", "GBPUSD", "NZDCAD", "NZDCHF", "NZDJPY", "NZDUSD", "USDCAD", "USDCNH", "USDJPY", "XAGUSD", "XAUUSD"]
```

```
df=pd.read_pickle('df.pkl')
for i in list_fx:
    df1=pd.DataFrame(mt.copy_rates_range(i,mt.TIMEFRAME_H4,datetime(2015,1,1),datetime(2022,12,31)))
    y="."+i+".pkl"
    df1['time']=pd.to_datetime(df1['time'],unit='s')
    df1=df1[['time', 'close']]
    df1=df1.rename(columns={'time': 'time', 'close': i})
    #df1.to_pickle(y)
    df=df.merge(df1, left_on='time', right_on='time')
    print('finished')
pyreadr.write_rds('df.RDS',df)
```

Our data has 10765 observations with 31 variables.

```
df=readRDS("df.RDS")
df$time <-as.POSIXct(df$time,"05/24/2017 06:13:10", format = "%Y-%m-%d %H:%M:%S")
dim(df)
```

```
## [1] 10765    32
```

## Exploratory Data Analysis

### Variable identification

We have 29 currency pair variables such AUDCHF, AUDJPY and so on. For example AUDCHF=0,71992. It means 1 AUD equal to 0,71992 CHF. And we have 2 commodity product's prices such as gold and silver.

```
library(tidyverse)
colnames(df)[-1] # 31 currency pairs data
```

```
## [1] "AUDCHF" "AUDJPY" "AUDCAD" "AUDNZD" "AUDUSD" "CADCHF" "CADJPY" "CHFJPY"
## [9] "EURAUD" "EURCAD" "EURCHF" "EURGBP" "EURJPY" "EURNZD" "EURUSD" "GBPAUD"
## [17] "GBPCAD" "GBPCHF" "GBPJPY" "GBPNZD" "GBPUSD" "NZDCAD" "NZDCHF" "NZDJPY"
## [25] "NZDUSD" "USDCAD" "USDCHF" "USDCNH" "USDJPY" "XAGUSD" "XAUUSD"
```

```
head(df)
```

```
##           time AUDCHF AUDJPY AUDCAD AUDNZD AUDUSD CADCHF CADJPY CHFJPY
## 1 2015-11-18 0.71992 87.601 0.94574 1.09726 0.70962 0.76094 92.602 121.660
## 2 2015-11-19 0.72752 88.330 0.94926 1.09500 0.71566 0.76614 93.041 121.405
## 3 2015-11-20 0.72910 88.386 0.95570 1.09392 0.71888 0.76266 92.466 121.206
## 4 2015-11-23 0.73402 88.540 0.96233 1.10222 0.71925 0.76249 91.983 120.595
## 5 2015-11-24 0.73259 88.364 0.96087 1.10248 0.72009 0.76215 91.943 120.594
## 6 2015-11-25 0.73737 88.823 0.96484 1.10465 0.72582 0.76398 92.036 120.428
##      EURAUD EURCAD EURCHF EURGBP EURJPY EURNZD EURUSD GBPAUD GBPCAD
## 1 1.49847 1.41759 1.07903 0.69956 131.295 1.64440 1.06354 2.14183 2.02614
## 2 1.49536 1.41979 1.08811 0.70025 132.117 1.63752 1.07028 2.13515 2.02727
## 3 1.49066 1.42504 1.08713 0.70141 131.792 1.63081 1.07178 2.12501 2.03140
## 4 1.47534 1.42014 1.08320 0.69957 130.649 1.62630 1.06130 2.10867 2.02969
## 5 1.47740 1.42002 1.08264 0.70318 130.580 1.62892 1.06405 2.10087 2.01918
```

```
## 6 1.46897 1.41776 1.08348 0.70655 130.507 1.62287 1.06641 2.07896 2.00631
##      GBPCHF GBPJPY GBPNZD GBPUSD NZDCAD NZDCHF NZDJPY NZDUSD USDCAD
## 1 1.54225 187.661 2.35074 1.52015 0.86164 0.65583 79.809 0.64645 1.33294
## 2 1.55364 188.642 2.33862 1.52829 0.86661 0.66408 80.639 0.65332 1.32655
## 3 1.54976 187.862 2.32530 1.52789 0.87337 0.66623 80.772 0.65690 1.32961
## 4 1.54811 186.731 2.32479 1.51690 0.87282 0.66572 80.303 0.65228 1.33811
## 5 1.53946 185.680 2.31675 1.51311 0.87126 0.66419 80.127 0.65292 1.33455
## 6 1.53326 184.686 2.29692 1.50917 0.87316 0.66725 80.387 0.65681 1.32948
##      USDCNF USDCNH USDJPY XAGUSD XAUUSD
## 1 1.01459 6.41493 123.450 14.177 1070.69
## 2 1.01665 6.40793 123.437 14.258 1082.11
## 3 1.01433 6.41119 122.960 14.185 1077.98
## 4 1.02063 6.42533 123.102 14.133 1068.94
## 5 1.01744 6.42907 122.715 14.187 1075.58
## 6 1.01601 6.42667 122.377 14.183 1071.33
```

## Missing values

There is no NA rows.

```
sapply(df, function(x) sum(is.na(x)))
```

```
##      time AUDCHF AUDJPY AUDCAD AUDNZD AUDUSD CADCHF CADJPY CHFJPY EURAUD EURCAD
##         0         0         0         0         0         0         0         0         0         0         0
## EURCHF EURGBP EURJPY EURNZD EURUSD GBPAUD GBPCAD GBPCHF GBPJPY GBPNZD GBPUSD
##         0         0         0         0         0         0         0         0         0         0         0
## NZDCAD NZDCHF NZDJPY NZDUSD USDCAD USDCNF USDCNH USDJPY XAGUSD XAUUSD
##         0         0         0         0         0         0         0         0         0         0         0
```

## Univariate analysis-Statistic

You can see some important statistics of dataset from below table.

```
library(e1071)
library(moments)
library(tidyr)
library(tibble)
library(tidyverse)
library(psych)
df=df[-1]
describeBy(df)
```

```
##      vars      n    mean      sd median trimmed      mad      min      max     range
## AUDCHF     1 10765     0.70    0.04     0.70     0.70     0.05     0.54     0.78     0.24
## AUDJPY     2 10765    81.76    6.22    81.81    81.56     5.63    60.75    98.39    37.64
## AUDCAD     3 10765     0.95    0.04     0.95     0.95     0.05     0.81     1.03     0.22
## AUDNZD     4 10765     1.07    0.02     1.07     1.07     0.03     1.00     1.15     0.14
## AUDUSD     5 10765     0.73    0.04     0.73     0.73     0.04     0.56     0.81     0.25
## CADCHF     6 10765     0.74    0.02     0.74     0.74     0.02     0.66     0.79     0.13
## CADJPY     7 10765    86.33    7.31    84.64    85.15     4.94    74.25   110.47    36.22
## CHFJPY     8 10765   116.92    9.90   114.00   115.04     4.89   102.03   150.38    48.35
```

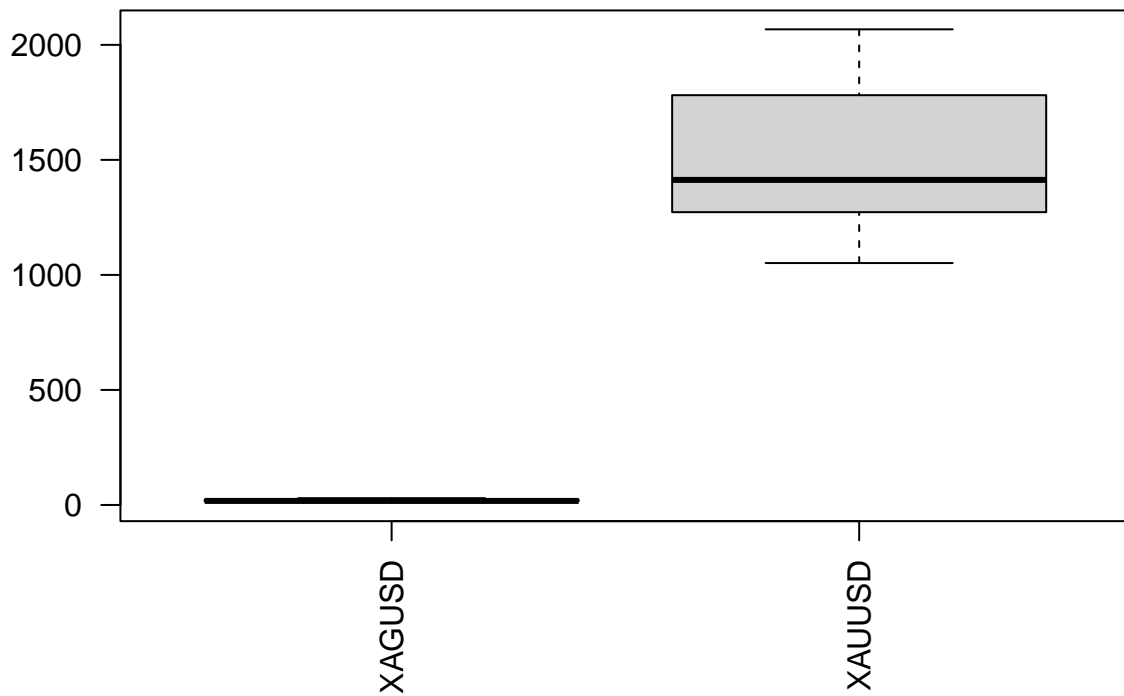
##	EURAUD	9	10765	1.56	0.07	1.57	1.56	0.07	1.37	1.96	0.59
##	EURCAD	10	10765	1.48	0.06	1.48	1.48	0.05	1.29	1.61	0.33
##	EURCHF	11	10765	1.09	0.05	1.09	1.09	0.03	0.94	1.20	0.26
##	EURGBP	12	10765	0.87	0.03	0.87	0.87	0.03	0.70	0.95	0.25
##	EURJPY	13	10765	127.04	7.14	126.97	126.73	6.92	110.86	147.80	36.94
##	EURNZD	14	10765	1.67	0.07	1.68	1.67	0.06	1.45	1.96	0.51
##	EURUSD	15	10765	1.13	0.06	1.13	1.13	0.06	0.96	1.25	0.30
##	GBPAUD	16	10765	1.80	0.09	1.80	1.80	0.08	1.58	2.14	0.56
##	GBPCAD	17	10765	1.71	0.08	1.71	1.70	0.05	1.41	2.09	0.67
##	GBPCHF	18	10765	1.26	0.07	1.26	1.26	0.06	1.02	1.55	0.53
##	GBPJPY	19	10765	146.93	10.15	145.99	146.51	9.98	125.12	188.64	63.52
##	GBPNZD	20	10765	1.93	0.09	1.93	1.93	0.06	1.68	2.35	0.67
##	GBPUSD	21	10765	1.31	0.07	1.31	1.31	0.07	1.04	1.53	0.49
##	NZDCAD	22	10765	0.89	0.04	0.88	0.89	0.04	0.76	0.98	0.22
##	NZDCHF	23	10765	0.65	0.04	0.65	0.66	0.04	0.54	0.73	0.19
##	NZDJPY	24	10765	76.28	4.99	76.45	76.28	4.54	60.48	88.01	27.53
##	NZDUSD	25	10765	0.68	0.04	0.68	0.68	0.04	0.55	0.75	0.20
##	USDCAD	26	10765	1.31	0.04	1.31	1.30	0.04	1.20	1.46	0.26
##	USDCHF	27	10765	0.96	0.03	0.97	0.97	0.03	0.88	1.03	0.15
##	USDCNH	28	10765	6.72	0.24	6.72	6.71	0.30	6.25	7.37	1.12
##	USDJPY	29	10765	112.63	9.30	110.22	110.69	4.20	99.84	151.47	51.63
##	XAGUSD	30	10765	19.10	3.91	17.58	18.73	3.15	11.85	29.48	17.63
##	XAUUSD	31	10765	1507.99	263.88	1413.02	1496.75	283.21	1051.54	2067.38	1015.84
##				skew	kurtosis						se
##	AUDCHF			-0.21		-0.61					0.00
##	AUDJPY			0.13		-0.03					0.06
##	AUDCAD			-0.12		-0.87					0.00
##	AUDNZD			0.33		-0.30					0.00
##	AUDUSD			-0.50		0.08					0.00
##	CADCHF			-0.61		-0.20					0.00
##	CADJPY			1.43		1.73					0.07
##	CHFJPY			1.76		2.64					0.10
##	EURAUD			0.07		0.72					0.00
##	EURCAD			-0.72		0.37					0.00
##	EURCHF			-0.40		0.32					0.00
##	EURGBP			-1.24		2.49					0.00
##	EURJPY			0.37		0.03					0.07
##	EURNZD			-0.55		0.35					0.00
##	EURUSD			-0.38		0.01					0.00
##	GBPAUD			0.26		0.42					0.00
##	GBPCAD			0.88		3.62					0.00
##	GBPCHF			0.36		0.96					0.00
##	GBPJPY			0.39		-0.20					0.10
##	GBPNZD			0.09		1.00					0.00
##	GBPUSD			-0.08		0.09					0.00
##	NZDCAD			-0.28		-0.06					0.00
##	NZDCHF			-0.24		-0.69					0.00
##	NZDJPY			-0.08		-0.20					0.05
##	NZDUSD			-0.63		0.05					0.00
##	USDCAD			0.28		0.27					0.00
##	USDCHF			-0.52		-0.80					0.00
##	USDCNH			0.07		-1.00					0.00
##	USDJPY			2.11		4.18					0.09
##	XAGUSD			0.75		-0.71					0.04

### Univariate analysis-Boxplot

Box plot showing the number of non-zero elements in the estimated covariance matrix for various currency pairs. The y-axis represents the number of non-zero elements, ranging from 0 to 150. The x-axis lists the currency pairs. Most pairs have 0 non-zero elements, while a few have higher counts, with GBPJPY having the highest median around 145.

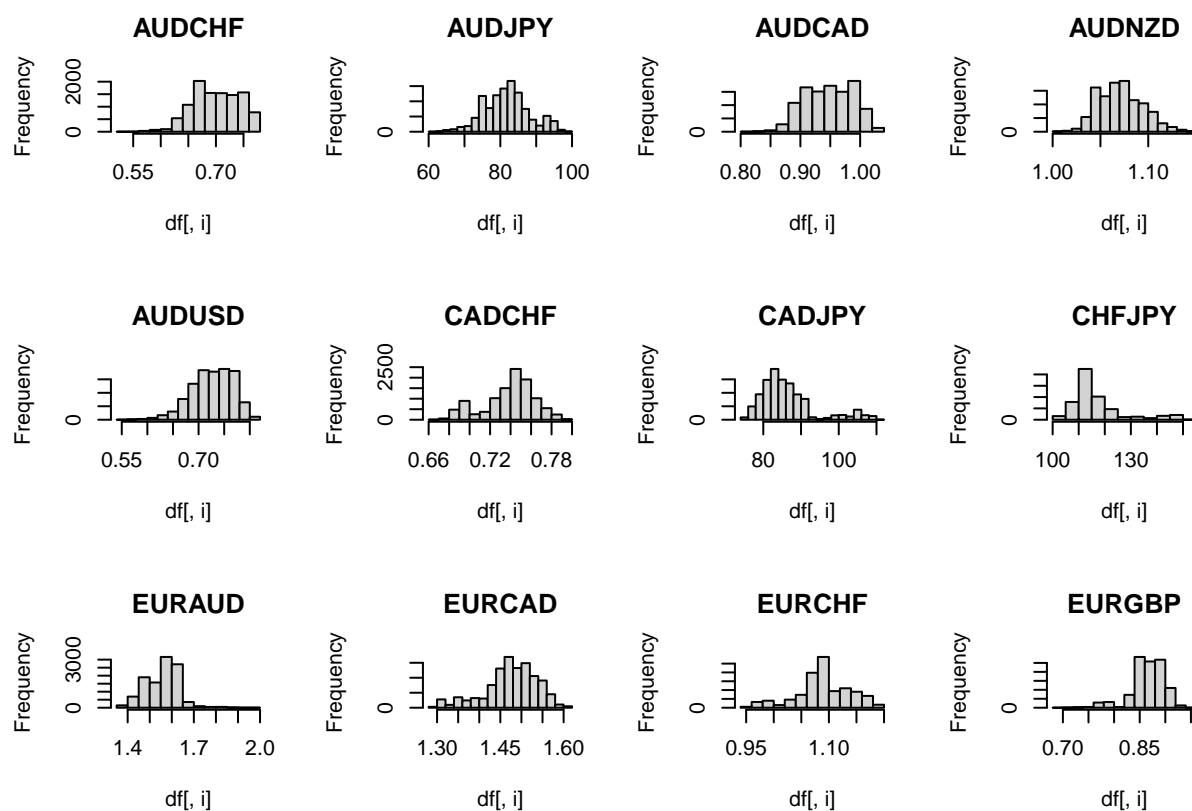
Currency Pair	Min	Q1	Median	Q3	Max
AUDCHF	0	0	0	0	0
AUDJPY	60	75	80	85	100
AUDCAD	0	0	0	0	0
AUDNZD	0	0	0	0	0
AUDUSD	0	0	0	0	0
CADCHF	0	0	0	0	0
CADJPY	75	85	90	95	110
CHFJPY	100	115	120	125	150
EURAUD	0	0	0	0	0
EURCAD	0	0	0	0	0
EURCHF	0	0	0	0	0
EURGBP	0	0	0	0	0
EURJPY	110	125	130	135	150
EURNZD	0	0	0	0	0
EURUSD	0	0	0	0	0
GBPAUD	0	0	0	0	0
GBPCAD	0	0	0	0	0
GBPCHF	0	0	0	0	0
GBPJPY	125	140	145	155	190
GBPNZD	0	0	0	0	0
GBPUSD	0	0	0	0	0
NZDCAD	0	0	0	0	0
NZDCHF	0	0	0	0	0
NZDJPY	60	75	80	85	90
NZDUSD	0	0	0	0	0
USDCAD	0	0	0	0	0
USDCHF	0	0	0	0	0
USDCNH	0	0	0	0	0
USDJPY	100	110	115	120	150

5

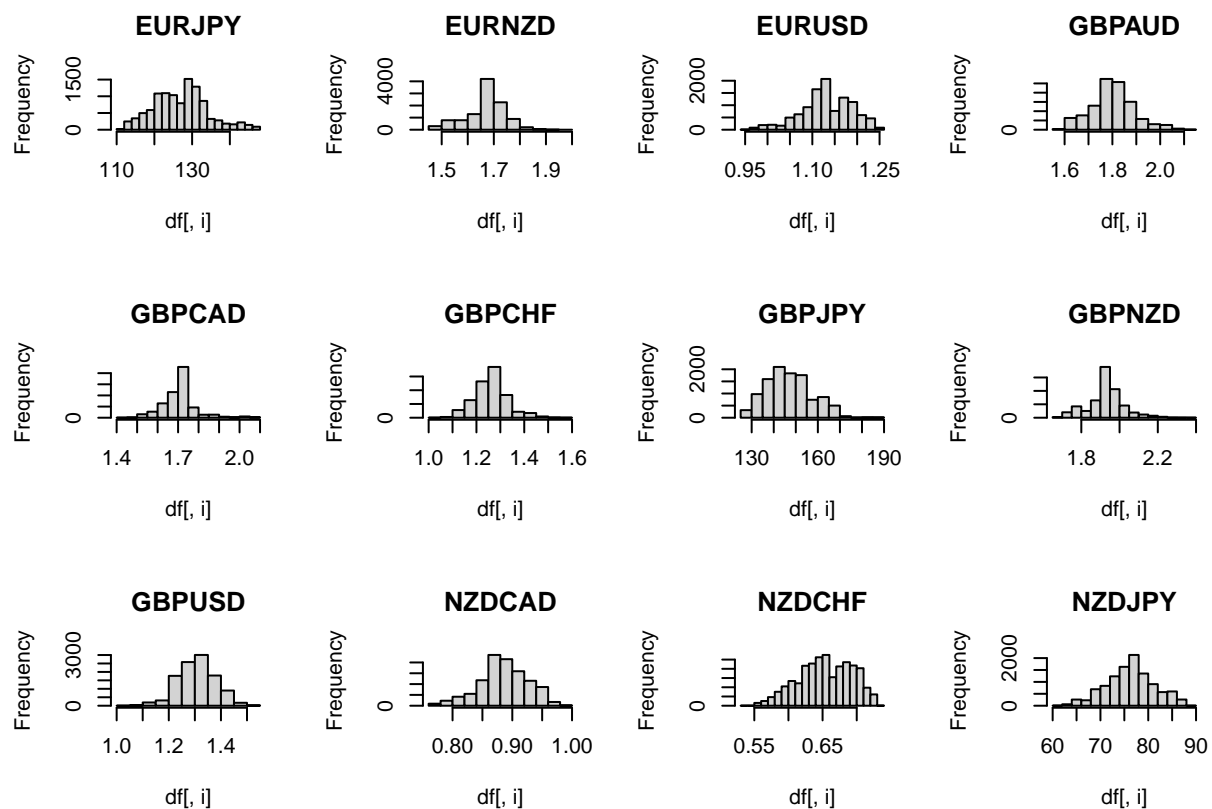


### Univariate analysis-histogram

```
library(e1071)
library(moments)
library(tidyr)
library(tibble)
library(tidyverse)
library(psych)
par(mfrow = c(3,4))
for(i in 1:12){
  hist(df[,i],main = colnames(df)[i])
}
```



```
par(mfrow = c(3,4))
for(i in 13:24){
  hist(df[,i],main = colnames(df)[i])
}
```

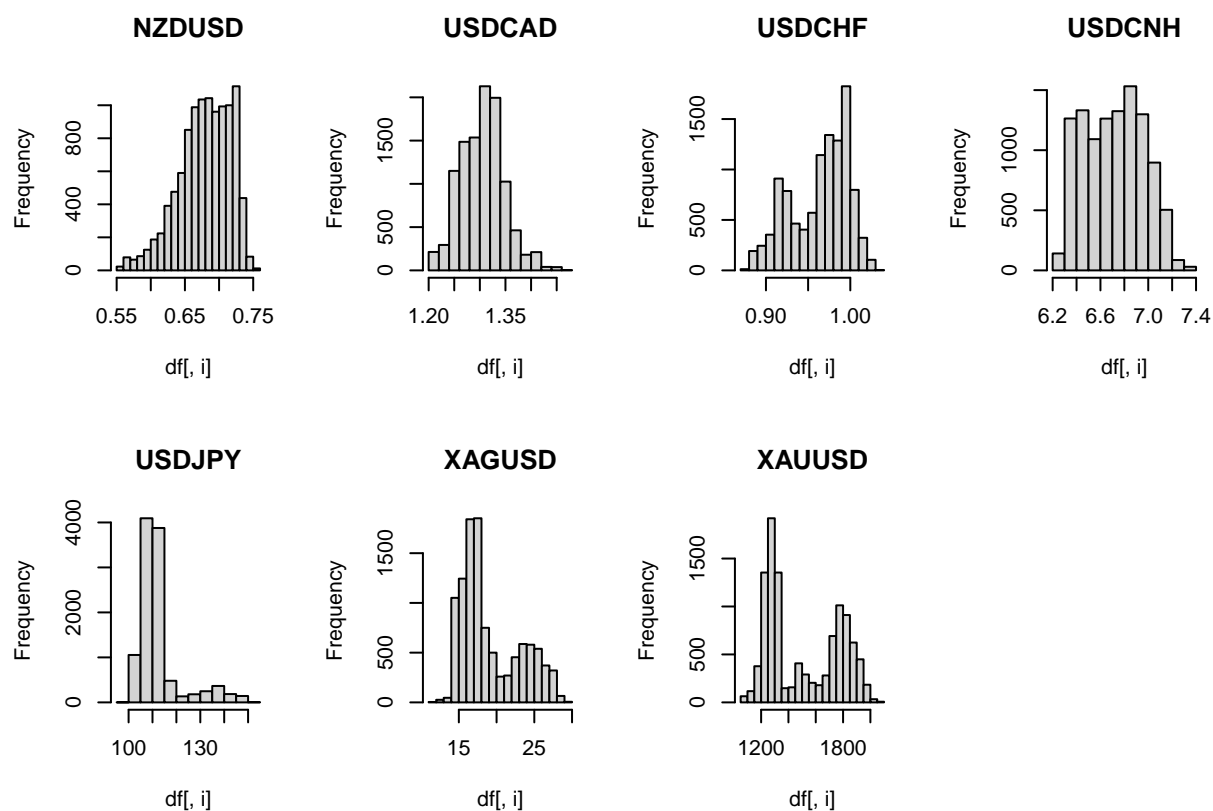


```

par(mfrow = c(2,4))
for(i in 25:31){
  hist(df[,i],main = colnames(df)[i])
}
par(mfrow = c(1,1))

```

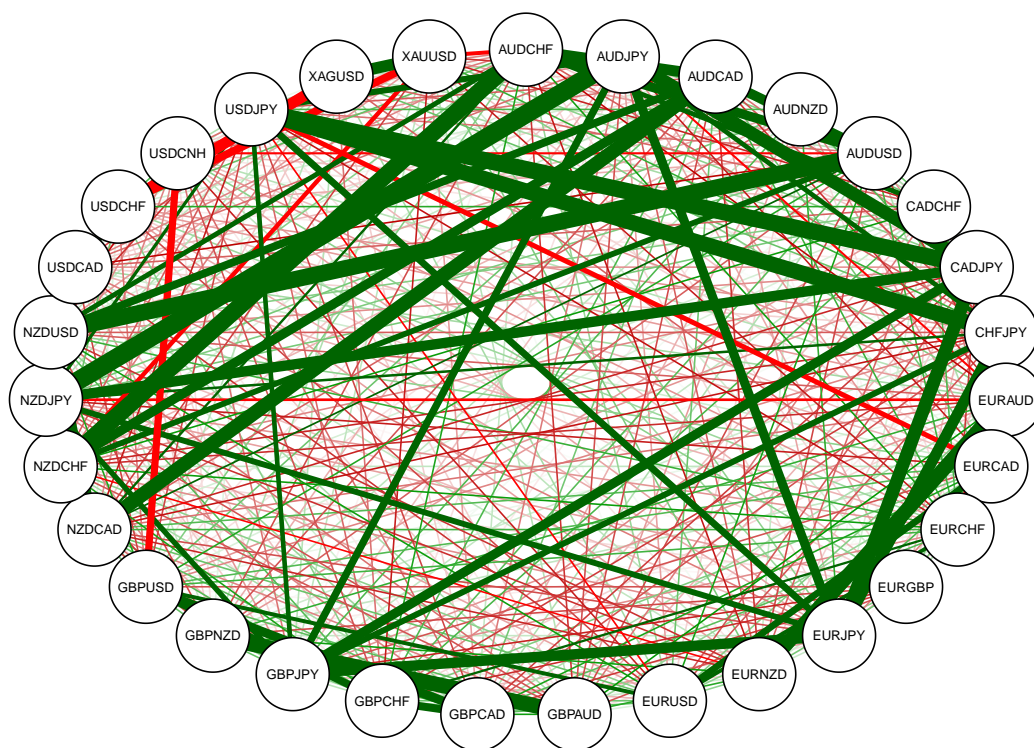




## Bi-variate analysis

This is a correlation graphic. It is easy to see the highest and lowest correlation between variables. For example, USDJPY is highly correlated with CADJPY and CHFJPY. NZDCAD is highly correlated with AUDCAD. NZDUSD is highly correlated with AUDUSD.

```
library(qgraph)
qgraph(cor(df), labels=colnames(df))
```



## Outlier treatment

I used IQR to find outlier values. After removing outliers, I have 7676 observations.

```
count(df)
```

```
##          n
## 1 10765
```

```
outliers=df[,]
for (i in 1:31) {
  q1=quantile(df[,i], .25)
  q3=quantile(df[,i], .75)
  IQR=IQR(df[,i])
  count_out<-subset(df, df[,i] > (q1 - 1.5*IQR) & df[,i] < (q3 + 1.5*IQR))
  add_out<-setdiff(df,count_out)
  outliers<-rbind(outliers,add_out)
  outliers<-unique(outliers)
}
df<-setdiff(df,outliers)
count(df)
```

```
##          n
## 1 7676
```

## Rotated PCA

### Train model

I trained rotated PCA model. Firstly, we have to normalize our data set. After it, we have to calculate covariance and eigen values. Then we trained rotated PCA using principal function with varimax rotation option. There is loadings for each factor. This loadings indicate correlation between currency pair and RC1, RC2. \* RC1 is highly positive correlated with AUDCHF,AUDCAD,CADCHF,EURCHF,NZDCHF. And RC1 is highly negative correlated with EURAUD,GBPAUD,GBPNZD, XAUUSD. \* RC2 is highly positive correlated with AUDJPY,CADJPY,CHFJPY,EURJPY,GBPJPY,GBPUSD,NZDJPY. And RC2 is highly negative correlated with USDCAD,USDCNH, USDCHF. \* Goodness of fit is 0,83 \* RC1 can explain 30 percent of 31 variables. \* RC2 can explain 60 percent of 31 variables. \*

```
library(psych)
library(clusterSim)
df.n<-data.Normalization(df, type="n1", normalization="column")
df.cov<-cov(df.n)
df.eigen<-eigen(df.cov)
pca4<-principal(df.cov, nfactors=2, rotate="varimax")
head(pca4)
```

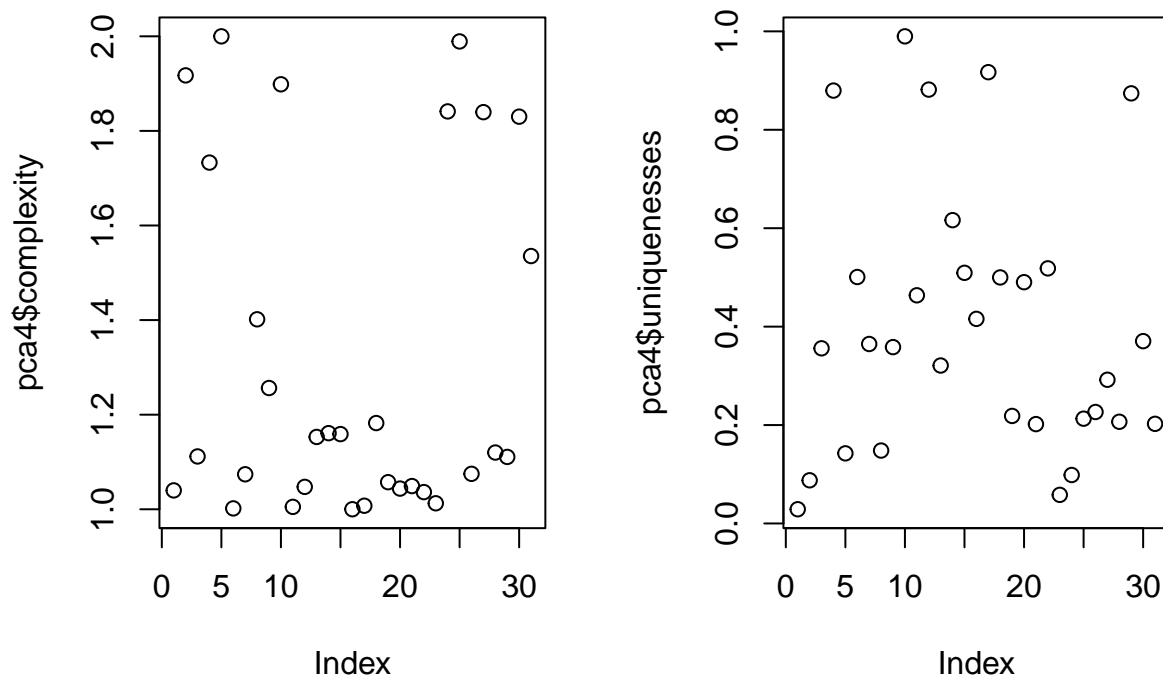
```
## $values
## [1] 1.153424e+01 7.013194e+00 4.227529e+00 3.325186e+00 2.530495e+00
## [6] 1.083625e+00 9.257916e-01 1.763606e-01 1.497849e-01 2.814249e-02
## [11] 2.208883e-03 8.228951e-04 6.140448e-04 4.677327e-04 2.889112e-04
## [16] 2.606984e-04 2.074183e-04 1.343327e-04 1.095265e-04 8.986632e-05
## [21] 8.667102e-05 7.411472e-05 6.505188e-05 5.017632e-05 4.758365e-05
## [26] 3.387957e-05 2.820202e-05 2.424263e-05 1.525483e-05 1.512176e-05
## [31] 6.242035e-06
##
## $rotation
## [1] "varimax"
##
## $n.obs
## [1] NA
##
## $communality
## AUDCHF AUDJPY AUDCAD AUDNZD AUDUSD CADCHF CADJPY
## 0.97107588 0.91222370 0.64407230 0.12034347 0.85751025 0.49917369 0.63527815
## CHFJPY EURAUD EURCAD EURCHF EURGBP EURJPY EURNZD
## 0.85182157 0.64160609 0.01013291 0.53635139 0.11833097 0.67902956 0.38361389
## EURUSD GBPAUD GBPCAD GBPCHF GBPJPY GBPNZD GBPUSD
## 0.49063212 0.58421915 0.08295683 0.50002343 0.78151519 0.50967441 0.79809508
## NZDCAD NZDCHF NZDJPY NZDUSD USDCAD USDCHF USDCNH
## 0.48160812 0.94184637 0.90152172 0.78704178 0.77346852 0.70795035 0.79332046
## USDJPY XAGUSD XAUUSD
## 0.12599037 0.62948029 0.79752677
##
## $loadings
##
## Loadings:
## RC1 RC2
## AUDCHF 0.976 0.138
## AUDJPY 0.601 0.742
```

```
## AUDCAD 0.781 0.185
## AUDNZD 0.289 0.191
## AUDUSD 0.653 0.657
## CADCHF 0.706
## CADJPY 0.151 0.783
## CHFJPY -0.384 0.839
## EURAUD -0.753 -0.272
## EURCAD
## EURCHF 0.731
## EURGBP -0.340
## EURJPY 0.220 0.794
## EURNZD -0.596 -0.170
## EURUSD 0.191 0.674
## GBPAUD -0.764
## GBPCAD 0.287
## GBPCHF 0.677 0.205
## GBPJPY 0.148 0.872
## GBPNZD -0.706 0.104
## GBPUSD 0.138 0.883
## NZDCAD 0.688
## NZDCHF 0.967
## NZDJPY 0.564 0.764
## NZDUSD 0.604 0.650
## USDCAD -0.167 -0.863
## USDCHF 0.499 -0.677
## USDCNH -0.212 -0.865
## USDJPY 0.345
## XAGUSD -0.468 0.641
## XAUUSD -0.786 0.424
##
##          RC1    RC2
## SS loadings 9.491 9.056
## Proportion Var 0.306 0.292
## Cumulative Var 0.306 0.598
##
## $fit
## [1] 0.8296409
```

## Quality measure of PCA

We can see the complexity and uniqueness of each variable from below plot. GBPCAD and EURCAD has the largest unique value, and they are higher than 0.9. It means that these variables are not strongly correlated with other variables. So I removed these variables from the dataset. I will use dataset without GBPCAD, and EURCAD from now on.

```
par(mfrow=c(1,2))
plot(pca4$complexity)
plot(pca4$uniquenesses)
```



```
par(mfrow=c(1,1))
set<-data.frame(complex=pca4$complexity, unique=pca4$uniqueness)
tail(set[order(set$unique),])
```

```
##          complex    unique
## EURNZD 1.160888 0.6163861
## USDJPY 1.110678 0.8740096
## AUDNZD 1.732998 0.8796565
## EURGBP 1.047349 0.8816690
## GBPCAD 1.007496 0.9170432
## EURCAD 1.898571 0.9898671
```

```
df=df[-c(10,17)]
```

## PCA model

The main goal of PCA is to minimize dimensions, preserving the covariance of data.

### Covariance and Eigenvalues

First, we have to normalize our dataset and calculate covariance, and eigenvalues.

```
library(clusterSim)
df.n<-data.Normalization(df, type="n1", normalization="column")
df.cov<-cov(df.n)
df.eigen<-eigen(df.cov)
df.eigen$values
```

```
## [1] 1.149570e+01 6.967749e+00 4.001713e+00 2.776378e+00 1.731421e+00
## [6] 8.840814e-01 7.870096e-01 1.742080e-01 1.484947e-01 2.812983e-02
## [11] 2.023660e-03 7.922386e-04 5.870671e-04 4.265750e-04 2.821831e-04
## [16] 2.266632e-04 1.438783e-04 1.094790e-04 1.046126e-04 8.680014e-05
## [21] 8.455184e-05 6.116234e-05 5.363028e-05 4.181169e-05 2.970704e-05
## [26] 2.520425e-05 1.682551e-05 1.525626e-05 6.312481e-06
```

```
head(df.eigen$vectors)
```

```
##          [,1]          [,2]          [,3]          [,4]          [,5]          [,6]
## [1,] -0.2418472 -0.20690172 -0.03620309 0.05377337 -0.0009332690 -0.126410299
## [2,] -0.2788675 0.05954315 -0.06682821 0.03116742 -0.1729461332 -0.002881992
## [3,] -0.2067416 -0.14462123 0.22467294 0.10362963 0.0003009108 -0.092385920
## [4,] -0.1025010 -0.01363566 -0.07371298 0.38557376 -0.2630455321 -0.576114685
## [5,] -0.2726095 0.02273398 0.15591842 0.09657977 0.0096725705 -0.131954883
## [6,] -0.1611763 -0.17182323 -0.29143874 -0.02543344 0.0004008112 -0.098748823
##          [,7]          [,8]          [,9]          [,10]          [,11]          [,12]
## [1,] -0.005085311 0.03250668 0.09345574 -0.081512388 -0.272133239 -0.16247136
## [2,] 0.101120385 0.04460306 -0.02273838 -0.079651276 -0.317751699 0.14981490
## [3,] 0.395499431 0.03824011 0.02508033 -0.007719497 0.006743843 -0.23860067
## [4,] 0.190694783 -0.09184302 -0.01999144 -0.025045572 -0.005023702 -0.03449304
## [5,] -0.025028510 0.01680702 -0.12593877 -0.081951333 -0.299430151 0.11394880
## [6,] -0.426201031 0.03336895 0.11795995 -0.050923140 -0.097350315 -0.03200442
##          [,13]          [,14]          [,15]          [,16]          [,17]          [,18]
## [1,] -0.042840241 -0.267322991 0.27834436 -0.18047177 0.11799701 -0.22318545
## [2,] 0.212501410 -0.178332865 0.08485833 0.23343029 -0.09684879 0.07954948
## [3,] 0.196554189 -0.055404762 0.08515234 0.04655495 0.28553324 0.09343488
## [4,] -0.021598678 -0.001426875 -0.06251512 0.03358411 0.05398519 0.06406016
## [5,] 0.207492503 0.148431745 -0.05322957 -0.19403715 -0.07088037 -0.13639614
## [6,] 0.005813667 0.099062743 -0.06913359 -0.05921741 0.22159979 0.29254502
##          [,19]          [,20]          [,21]          [,22]          [,23]          [,24]
## [1,] -0.080929863 0.02348370 0.01085808 -0.02980712 -0.024879859 0.08633724
## [2,] -0.003675145 -0.02425706 0.08996190 0.24866663 -0.085595972 -0.45941806
## [3,] -0.066443332 0.09107954 0.21357206 0.14971117 0.207137549 0.43971585
## [4,] 0.137238158 0.13065965 -0.16706954 -0.42377586 -0.155387995 -0.12445455
## [5,] 0.055635781 -0.40779870 0.13185635 0.08074011 0.227294998 -0.07882794
## [6,] 0.072351305 0.07720338 -0.02996395 0.02051265 0.009345844 -0.14593678
##          [,25]          [,26]          [,27]          [,28]          [,29]
## [1,] 0.2541039 0.24382658 -0.18250262 0.46987181 -0.34675591
## [2,] -0.2190590 0.12010472 0.23557324 0.24552348 0.34550896
## [3,] 0.1484908 -0.04862782 0.19473917 -0.17320980 0.31675100
## [4,] -0.1073862 -0.04338629 -0.22237608 -0.15663129 0.06406284
## [5,] -0.1132031 -0.17215276 0.09710166 -0.35223809 -0.43768635
## [6,] 0.4293274 -0.47236464 0.19736696 0.02891579 0.07370902
```

## Train model

In order to train PCA model, I used prcomp function. You can see rotation values from below table. \* We can reduce these 29 variables to at least 1 variable by performing dimensional reduction. PC1 can explain 63% of these variables. PC2 can explain 86% of these variables. If I reduce these 29 variables to three PC, it can explain 94 % of these variables.

```
pca1=prcomp(df.cov,center = F,scale. = F)
head(pca1)
```

```
## $sdev
## [1] 2.172483e+00 1.316781e+00 7.562526e-01 5.246862e-01 3.272077e-01
## [6] 1.670757e-01 1.487308e-01 3.292222e-02 2.806286e-02 5.316037e-03
## [11] 3.824359e-04 1.497190e-04 1.109453e-04 8.061509e-05 5.332759e-05
## [16] 4.283532e-05 2.719044e-05 2.068958e-05 1.976993e-05 1.640368e-05
## [21] 1.597880e-05 1.155860e-05 1.013517e-05 7.901667e-06 5.614102e-06
## [26] 4.763155e-06 3.179723e-06 2.883162e-06 1.192947e-06
##
## $rotation
##          PC1          PC2          PC3          PC4          PC5
## AUDCHF -0.24184718  0.20690172  0.036203090 -0.053773366  0.0009332690
## AUDJPY -0.27886755 -0.05954315  0.066828210 -0.031167416  0.1729461332
## AUDCAD -0.20674160  0.14462123 -0.224672944 -0.103629634 -0.0003009108
## AUDNZD -0.10250105  0.01363566  0.073712976 -0.385573761  0.2630455321
## AUDUSD -0.27260945 -0.02273398 -0.155918423 -0.096579773 -0.0096725705
## CADCHF -0.16117626  0.17182323  0.291438741  0.025433439 -0.0004008112
## CADJPY -0.18888266 -0.18475871  0.245832333  0.049027418  0.2111793206
## CHFJPY -0.08125036 -0.33555707  0.041583434  0.035106211  0.2292575053
## EURAUD  0.21989554 -0.11432851  0.106223031 -0.227881108 -0.2194676698
## EURCHF -0.15310046  0.19346916  0.164699426 -0.302758441 -0.2221125169
## EURGBP  0.05331912  0.09924908 -0.127470216 -0.490525191  0.1785236695
## EURJPY -0.20489858 -0.17157567  0.171581428 -0.217431072  0.0446858846
## EURNZD  0.16441111 -0.10633107  0.142082679 -0.430101146 -0.0801621034
## EURUSD -0.17358417 -0.14582963 -0.114563967 -0.352746676 -0.2291385006
## GBPAUD  0.17107871 -0.18536033  0.199735495  0.142382436 -0.3399309554
## GBPCHF -0.18715519  0.11863146  0.250987488  0.058633269 -0.3520801676
## GBPJPY -0.20310208 -0.20627139  0.215730754  0.069573734 -0.0487662623
## GBPNZD  0.13651582 -0.20364319  0.268038036 -0.061807016 -0.2369780748
## GBPUSD -0.20173788 -0.21086648 -0.019820526  0.006074295 -0.3413217881
## NZDCAD -0.16730521  0.15013545 -0.285589641  0.102558062 -0.1480394389
## NZDCHF -0.22756367  0.22406916  0.009633497  0.089413973 -0.1023605412
## NZDJPY -0.27459437 -0.07319487  0.047681020  0.102438628  0.1000096439
## NZDUSD -0.25996705 -0.03109450 -0.203806851  0.050598770 -0.1183512517
## USDCAD  0.20795558  0.20433961 -0.005500174  0.028488707  0.0132265856
## USDCHF  0.02298260  0.31925698  0.256605812  0.051741039  0.0061202689
## USDCNH  0.21574290  0.18941973  0.059248668 -0.036084988  0.1663532351
## USDJPY -0.08727972 -0.07693222  0.374964950  0.104535086  0.3334974706
## XAGUSD -0.02312166 -0.30010483 -0.241734908  0.044433906  0.0348350719
## XAUUSD  0.08959471 -0.31918676 -0.184225102  0.023480882  0.0455560618
##          PC6          PC7          PC8          PC9          PC10
## AUDCHF -0.126410299 -0.005085311 -0.032506680 -0.09345574  0.081512388
## AUDJPY -0.002881992  0.101120385 -0.044603058  0.02273838  0.079651276
## AUDCAD -0.092385920  0.395499431 -0.038240107 -0.02508033  0.007719497
## AUDNZD -0.576114685  0.190694783  0.091843021  0.01999144  0.025045572
```

##	AUDUSD	-0.131954883	-0.025028510	-0.016807020	0.12593877	0.081951333
##	CADCHF	-0.098748823	-0.426201031	-0.033368947	-0.11795995	0.050923140
##	CADJPY	0.065222544	-0.167726845	-0.014552970	0.03999406	0.019863731
##	CHFJPY	0.147044196	0.145794286	0.018330365	0.11903553	-0.053094157
##	EURAUD	0.298678546	-0.026972348	-0.043876288	-0.04676741	-0.014337440
##	EURCHF	0.115845806	-0.039001898	-0.097242108	-0.20792842	0.016487303
##	EURGBP	0.321983021	-0.147821359	0.019295855	-0.09463988	-0.018738548
##	EURJPY	0.234786300	0.108628564	-0.093582864	-0.01931261	-0.027099838
##	EURNZD	-0.009411700	0.075052100	0.002524756	-0.03828039	-0.033056727
##	EURUSD	0.113247797	-0.056912209	-0.073660546	0.10250651	0.001091362
##	GBPAUD	0.052272618	0.076417773	-0.050390473	0.03866802	0.023121641
##	GBPCHF	-0.125121369	0.070133993	-0.117692283	-0.13246716	0.037566925
##	GBPJPY	0.038503038	0.170332585	-0.079483327	0.02528824	-0.009408660
##	GBPNZD	-0.278923633	0.201866663	-0.001447142	0.05324710	0.002088409
##	GBPUSD	-0.116432848	0.042560407	-0.080352736	0.16750132	0.010417838
##	NZDCAD	0.222592941	0.322453425	-0.095730811	-0.03915305	-0.029896754
##	NZDCHF	0.083011973	-0.076904316	-0.079915294	-0.11559293	0.052150800
##	NZDJPY	0.203788508	0.049525612	-0.087181585	0.01319436	0.053144592
##	NZDUSD	0.089497106	-0.103287616	-0.058718815	0.12799207	0.049595441
##	USDCAD	0.103258149	0.494829529	-0.018951044	-0.21162585	0.042326373
##	USDCHF	-0.002895945	0.015308973	-0.046908374	-0.28389538	-0.019206900
##	USDCNH	-0.045562745	-0.005952437	-0.841462879	0.40023130	0.111837754
##	USDJPY	0.207569207	0.235220225	-0.041371693	-0.15346784	-0.051418248
##	XAGUSD	-0.198169688	-0.111327261	-0.407781741	-0.53164392	-0.579988622
##	XAUUSD	-0.062312485	-0.048348182	-0.157435752	-0.45128967	0.778717727
##		PC11	PC12	PC13	PC14	PC15
##	AUDCHF	-0.272133239	0.162471360	-0.042840241	0.267322991	0.2783443594
##	AUDJPY	-0.317751699	-0.149814900	0.212501410	0.178332865	0.0848583269
##	AUDCAD	0.006743843	0.238600669	0.196554189	0.055404762	0.0851523393
##	AUDNZD	-0.005023702	0.034493036	-0.021598678	0.001426875	-0.0625151169
##	AUDUSD	-0.299430151	-0.113948803	0.207492503	-0.148431745	-0.0532295696
##	CADCHF	-0.097350315	0.032004419	0.005813667	-0.099062743	-0.0691335904
##	CADJPY	-0.099411016	-0.071963541	-0.184697822	-0.054155767	-0.0153204864
##	CHFJPY	0.102683180	0.145315389	-0.123967502	-0.096265408	-0.1043394551
##	EURAUD	-0.278105789	-0.053329502	0.030499422	0.135963365	0.2221574469
##	EURCHF	0.177775087	0.093887356	0.018251288	-0.139596540	0.0950738027
##	EURGBP	0.035435340	-0.024137613	0.146954369	0.404155937	-0.5689798888
##	EURJPY	0.079492936	0.031334800	-0.048016753	-0.050979295	0.3246685767
##	EURNZD	-0.143983836	0.008337963	-0.478195302	-0.163722977	0.0689996359
##	EURUSD	0.111181963	-0.020434491	0.276004191	-0.339565561	0.1016926789
##	GBPAUD	-0.362071193	0.299632241	0.368598505	0.113206369	-0.0595690404
##	GBPCHF	0.284632129	-0.030589867	-0.033876874	0.272380249	-0.0923074797
##	GBPJPY	0.208877812	-0.207306973	-0.094030575	0.274700077	-0.0382287844
##	GBPNZD	-0.191416333	0.174317140	-0.091209596	-0.106828932	-0.4481633532
##	GBPUSD	0.216187393	-0.367719245	0.033567142	0.104190730	-0.0884016030
##	NZDCAD	0.061072809	0.302531236	-0.179227404	-0.120145793	-0.1887351433
##	NZDCHF	-0.178688632	0.189465718	-0.406891363	0.106174270	-0.0719856629
##	NZDJPY	-0.238930534	-0.183221188	-0.035713184	0.046944717	-0.1799819995
##	NZDUSD	-0.208807097	-0.084860417	-0.151503244	-0.330850172	-0.2263878375
##	USDCAD	-0.225426052	-0.513298765	-0.103419886	-0.055076352	0.0263633202
##	USDCHF	0.035199745	-0.222403943	0.249640801	-0.391980024	-0.1779450709
##	USDCNH	0.033020381	0.017715236	-0.009156874	0.002655626	0.0016966140
##	USDJPY	0.107231900	0.236204600	0.202110868	-0.152639719	-0.0608527325
##	XAGUSD	-0.090807957	-0.022266348	0.010982535	0.024026271	-0.0005011362



##	XAUUSD	0.085868994	0.044651343	-0.006685626	-0.030350614	-0.0088145739
##		PC16	PC17	PC18	PC19	PC20
##	AUDCHF	-0.180471774	-0.117997014	-0.223185446	-0.080929863	-0.0234836963
##	AUDJPY	0.233430286	0.096848786	0.079549475	-0.003675145	0.0242570585
##	AUDCAD	0.046554946	-0.285533242	0.093434879	-0.066443332	-0.0910795377
##	AUDNZD	0.033584112	-0.053985190	0.064060159	0.137238158	-0.1306596539
##	AUDUSD	-0.194037147	0.070880367	-0.136396141	0.055635781	0.4077986959
##	CADCHF	-0.059217406	-0.221599789	0.292545020	0.072351305	-0.0772033756
##	CADJPY	-0.278418778	-0.175335724	0.461523328	0.239297793	-0.0139159645
##	CHFJPY	-0.208327952	-0.103389070	-0.419244453	0.384740669	-0.3058597104
##	EURAUD	0.187368646	-0.453299652	-0.038604341	0.050636741	0.1498502060
##	EURCHF	-0.041131402	0.416636962	0.078540079	-0.040042102	-0.0417894608
##	EURGBP	-0.167429718	0.005644595	-0.005794868	-0.013820157	0.0289794099
##	EURJPY	-0.258968123	0.265100429	0.052657406	-0.310201293	-0.1204364977
##	EURNZD	0.262937177	-0.085257954	-0.042071526	0.023876806	0.0991177250
##	EURUSD	0.003007966	-0.100569154	-0.033276295	0.235232743	-0.1534136350
##	GBPAUD	-0.201425441	0.109139533	0.063277985	0.138856774	-0.2033100624
##	GBPCHF	0.184381277	0.121512286	-0.053661614	0.512107754	0.1693069040
##	GBPJPY	-0.134896211	-0.201928037	0.053581127	-0.345120099	0.0234494389
##	GBPNZD	-0.042831878	0.107185021	0.026571412	-0.291194028	0.0119908308
##	GBPUSD	-0.065573298	-0.217534590	-0.091168055	-0.096694115	0.0410745649
##	NZDCAD	0.031197085	-0.206879247	0.410182571	0.014363105	-0.0069886971
##	NZDCHF	-0.153221422	-0.045543412	-0.381659664	-0.005222002	-0.0467861505
##	NZDJPY	0.551292840	0.183991823	-0.004184201	-0.024797436	-0.4033677141
##	NZDUSD	-0.015525117	0.077183639	-0.060882096	-0.042874233	0.2352815665
##	USDCAD	-0.314714634	0.132447674	0.102103405	0.253204015	0.0017528186
##	USDCHF	-0.017210947	-0.313555170	-0.253230988	-0.192802309	-0.2518400660
##	USDCNH	-0.011862262	-0.002130316	-0.012261963	0.006833159	-0.0012100679
##	USDJPY	0.139360611	-0.040000715	-0.116566273	0.017786803	0.5276078831
##	XAGUSD	-0.009200844	0.026492561	0.005178449	0.013597617	0.0101417101
##	XAUUSD	0.005106642	-0.028637842	-0.001213098	-0.027826725	0.0005252916
##		PC21	PC22	PC23	PC24	PC25
##	AUDCHF	-0.010858081	-0.029807117	-0.024879859	-0.0863372419	-0.254103853
##	AUDJPY	-0.089961899	0.248666628	-0.085595972	0.4594180632	0.219059010
##	AUDCAD	-0.213572055	0.149711171	0.207137549	-0.4397158483	-0.148490843
##	AUDNZD	0.167069544	-0.423775859	-0.155387995	0.1244545467	0.107386216
##	AUDUSD	-0.131856350	0.080740113	0.227294998	0.0788279373	0.113203104
##	CADCHF	0.029963953	0.020512651	0.009345844	0.1459367761	-0.429327384
##	CADJPY	-0.120664715	0.116713387	-0.026908834	-0.3018946270	0.224823898
##	CHFJPY	-0.329884017	-0.010218772	0.114509425	0.2422064842	-0.187659140
##	EURAUD	-0.153955270	-0.116234256	-0.020225732	0.1925434558	-0.113637498
##	EURCHF	-0.606239121	-0.152250904	-0.223620893	0.0066476721	0.074334678
##	EURGBP	0.077830206	-0.007990711	0.041990050	-0.0500299124	-0.037643507
##	EURJPY	0.412907449	-0.035862182	0.249337669	0.1528063416	-0.220473981
##	EURNZD	0.027337900	-0.021825938	0.181284311	-0.1434874379	0.147297755
##	EURUSD	0.294302786	0.341381202	-0.197356901	-0.1197236044	0.123089651
##	GBPAUD	0.115614440	-0.358094693	0.017592410	-0.1200985371	0.217626625
##	GBPCHF	0.153108053	0.079744117	0.369279454	0.0383617127	-0.035949772
##	GBPJPY	-0.116448921	-0.066949195	0.199580939	-0.0346502691	0.325603185
##	GBPNZD	-0.073271494	0.425096305	-0.048326308	0.0587108092	-0.221497794
##	GBPUSD	-0.002899446	-0.180843150	-0.439789890	-0.0278880050	-0.220533417
##	NZDCAD	0.085369442	-0.096518946	-0.060704995	0.4092591295	0.060837345
##	NZDCHF	0.193842938	0.147979965	-0.328757792	-0.0471178006	0.303156650
##	NZDJPY	0.024797956	-0.076693737	-0.032266372	-0.2453572877	-0.137512468

```

## NZDUSD 0.014218074 -0.396774855 0.209738610 -0.0993197301 -0.117473722
## USDCAD 0.048773135 0.049736216 -0.123841154 -0.0606231577 -0.171348923
## USDCHF 0.021157343 -0.048911254 0.213843684 0.0898579585 0.216428199
## USDCNH -0.018144675 -0.001442521 -0.001048886 0.0006640399 0.001227850
## USDJPY 0.129584613 -0.087172758 -0.288160258 -0.1566248588 -0.093566209
## XAGUSD -0.005603731 0.004515721 -0.005901805 -0.0057027768 -0.003172638
## XAUUSD 0.007142976 -0.007394332 0.007639558 0.0046496938 0.001262790
## PC26 PC27 PC28 PC29
## AUDCHF -0.243826579 -0.182502623 -0.469871808 -0.3467559060
## AUDJPY -0.120104722 0.235573243 -0.245523481 0.3455089635
## AUDCAD 0.048627821 0.194739173 0.173209803 0.3167510011
## AUDNZD 0.043386288 -0.222376083 0.156631289 0.0640628450
## AUDUSD 0.172152756 0.097101663 0.352238085 -0.4376863493
## CADCHF 0.472364638 0.197366957 -0.028915787 0.0737090161
## CADJPY -0.414272239 -0.060746443 0.101800907 -0.0288367040
## CHFJPY 0.060891582 0.065925635 -0.048524665 0.0115994944
## EURAUD -0.055931803 -0.340779375 0.314443954 0.1055712067
## EURCHF 0.011243580 -0.045232938 0.023958526 0.0007340277
## EURGBP -0.055519611 0.070325375 -0.062380259 -0.0010268036
## EURJPY -0.130817303 0.083249078 0.264324518 0.0692615650
## EURNZD 0.058739487 0.468636132 -0.230910700 -0.1393066160
## EURUSD 0.164955411 -0.249000389 -0.246023111 -0.0226080793
## GBPAUD 0.078196788 0.207038469 -0.068047720 -0.0011311584
## GBPCHF -0.145885436 -0.068781379 0.047138756 0.0397881164
## GBPJPY 0.457397920 -0.233424351 -0.203120901 -0.0313184070
## GBPNZD -0.114097194 -0.212539182 0.019423829 0.0248246336
## GBPUSD -0.210872178 0.386386633 0.057939927 -0.0503628008
## NZDCAD -0.060658910 0.012845634 -0.049311030 -0.2879030395
## NZDCHF 0.139099169 0.037272332 0.296043219 0.2254713352
## NZDJPY 0.074661246 -0.112166379 0.166567503 -0.2858255981
## NZDUSD -0.092647370 -0.198511439 -0.248862702 0.4422659316
## USDCAD 0.175745097 -0.037857193 -0.064329579 0.0447324986
## USDCHF -0.272499473 0.060022645 0.014243768 -0.0485773395
## USDCNH -0.001376357 -0.005168495 -0.003847927 -0.0024079166
## USDJPY 0.055952326 0.020085518 -0.060927867 -0.0315907217
## XAGUSD 0.004551657 -0.008713797 -0.004895806 0.0022271098
## XAUUSD -0.009712667 0.009826906 0.005940468 -0.0032260847
##
## $center
## [1] FALSE
##
## $scale
## [1] FALSE
##
## $x
## PC1 PC2 PC3 PC4 PC5
## AUDCHF -2.7802021 1.44163929 0.14487437 -0.14929520 0.0016158813
## AUDJPY -3.2057771 -0.41488172 0.26742731 -0.08653253 0.2994425088
## AUDCAD -2.3766390 1.00768447 -0.89907661 -0.28771505 -0.0005210032
## AUDNZD -1.1783211 0.09500988 0.29497817 -1.07049857 0.4554424698
## AUDUSD -3.1338359 -0.15840469 -0.62394076 -0.26814197 -0.0167472885
## CADCHF -1.8528336 1.19722114 1.16625416 0.07061285 -0.0006939727
## CADJPY -2.1713380 -1.28735233 0.98375041 0.13611865 0.3656402395
## CHFJPY -0.9340296 -2.33807752 0.16640496 0.09746812 0.3969411820

```

##	EURAUD	2.5278527	-0.79661235	0.42507407	-0.63268413	-0.3799908586
##	EURCHF	-1.7599966	1.34804455	0.65907981	-0.84057193	-0.3845702014
##	EURGBP	0.6129404	0.69154268	-0.51009920	-1.36188343	0.3090995704
##	EURJPY	-2.3554522	-1.19549624	0.68661961	-0.60367088	0.0773700640
##	EURNZD	1.8900204	-0.74088826	0.56857409	-1.19412343	-0.1387943222
##	EURUSD	-1.9954712	-1.01610430	-0.45845210	-0.97935817	-0.3967351349
##	GBPAUD	1.9666691	-1.29154425	0.79928410	0.39530749	-0.5885634804
##	GBPCHF	-2.1514795	0.82659426	1.00437986	0.16278813	-0.6095988776
##	GBPJPY	-2.3348001	-1.43724731	0.86329253	0.19316300	-0.0844349142
##	GBPNZD	1.5693446	-1.41893468	1.07261126	-0.17159965	-0.4103087355
##	GBPUUSD	-2.3191177	-1.46926477	-0.07931606	0.01686454	-0.5909715969
##	NZDCAD	-1.9232902	1.04610619	-1.14284774	0.28473996	-0.2563185436
##	NZDCHF	-2.6160032	1.56125772	0.03855049	0.24824700	-0.1772291562
##	NZDJPY	-3.1566540	-0.51000353	0.19080575	0.28440837	0.1731587641
##	NZDUSD	-2.9885027	-0.21665868	-0.81557650	0.14048132	-0.2049158028
##	USDCAD	2.3905945	1.42378717	-0.02201012	0.07909542	0.0229007836
##	USDCHF	0.2642011	2.22450258	1.02686278	0.14365269	0.0105967601
##	USDCNH	2.4801152	1.31982916	0.23709616	-0.10018557	0.2880274287
##	USDJPY	-1.0033413	-0.53604439	1.50050206	0.29022893	0.5774244119
##	XAGUSD	-0.2657996	-2.09105520	-0.96735369	0.12336533	0.0603141633
##	XAUUSD	1.0299537	-2.22401326	-0.73721596	0.06519181	0.0788767068
##		PC6	PC7	PC8	PC9	PC10
##	AUDCHF	-0.111757000	-0.004002188	-0.0056629234	-0.013877683	2.292929e-03
##	AUDJPY	-0.002547915	0.079582715	-0.0077702092	0.003376529	2.240576e-03
##	AUDCAD	-0.081676678	0.311261852	-0.0066617323	-0.003724296	2.171481e-04
##	AUDNZD	-0.509332305	0.150078626	0.0159997884	0.002968622	7.045276e-04
##	AUDUSD	-0.116658864	-0.019697677	-0.0029279172	0.018701240	2.305277e-03
##	CADCHF	-0.087302003	-0.335424306	-0.0058131373	-0.017516427	1.432459e-03
##	CADJPY	0.057662042	-0.132002639	-0.0025352437	0.005938906	5.587633e-04
##	CHFJPY	0.129999046	0.114741504	0.0031932961	0.017676146	-1.493529e-03
##	EURAUD	0.264056162	-0.021227497	-0.0076436000	-0.006944713	-4.033097e-04
##	EURCHF	0.102417128	-0.030694868	-0.0169403525	-0.030876268	4.637850e-04
##	EURGBP	0.284659216	-0.116336830	0.0033614923	-0.014053520	-5.271121e-04
##	EURJPY	0.207570213	0.085491724	-0.0163028829	-0.002867820	-7.623137e-04
##	EURNZD	-0.008320709	0.059066724	0.0004398327	-0.005684436	-9.298799e-04
##	EURUSD	0.100120276	-0.044790455	-0.0128322559	0.015221674	3.069981e-05
##	GBPAUD	0.046213252	0.060141521	-0.0087784231	0.005741996	6.504077e-04
##	GBPCHF	-0.110617481	0.055196127	-0.0205029364	-0.019670671	1.056751e-03
##	GBPJPY	0.034039822	0.134053381	-0.0138466308	0.003755169	-2.646640e-04
##	GBPNZD	-0.246591209	0.158871003	-0.0002521037	0.007906912	5.874659e-05
##	GBPUUSD	-0.102936120	0.033495449	-0.0139980889	0.024873058	2.930520e-04
##	NZDCAD	0.196790290	0.253773944	-0.0166770725	-0.005814020	-8.409905e-04
##	NZDCHF	0.073389345	-0.060524436	-0.0139218830	-0.017164938	1.466993e-03
##	NZDJPY	0.180165640	0.038977133	-0.0151877290	0.001959293	1.494948e-03
##	NZDUSD	0.079122731	-0.081288346	-0.0102292870	0.019006144	1.395111e-03
##	USDCAD	0.091288614	0.389435594	-0.0033014234	-0.031425317	1.190633e-03
##	USDCHF	-0.002560251	0.012048309	-0.0081718136	-0.042156959	-5.402867e-04
##	USDCNH	-0.040281177	-0.004684625	-0.1465895592	0.059432227	3.145976e-03
##	USDJPY	0.183508085	0.185120577	-0.0072072795	-0.022789160	-1.446386e-03
##	XAGUSD	-0.175198145	-0.087615624	-0.0710388386	-0.078946304	-1.631498e-02
##	XAUUSD	-0.055089312	-0.038050484	-0.0274265663	-0.067014124	2.190519e-02
##		PC11	PC12	PC13	PC14	PC15
##	AUDCHF	-5.507053e-04	1.287161e-04	-2.515010e-05	1.140333e-04	7.854407e-05
##	AUDJPY	-6.430215e-04	-1.186891e-04	1.247526e-04	7.607234e-05	2.394558e-05

##	AUDCAD	1.364725e-05	1.890287e-04	1.153905e-04	2.363429e-05	2.402855e-05
##	AUDNZD	-1.016627e-05	2.732671e-05	-1.267987e-05	6.086692e-07	-1.764071e-05
##	AUDUSD	-6.059449e-04	-9.027464e-05	1.218120e-04	-6.331727e-05	-1.502048e-05
##	CADCHF	-1.970040e-04	2.535514e-05	3.413013e-06	-4.225769e-05	-1.950833e-05
##	CADJPY	-2.011741e-04	-5.701230e-05	-1.084300e-04	-2.310150e-05	-4.323182e-06
##	CHFJPY	2.077959e-04	1.151245e-04	-7.277725e-05	-4.106441e-05	-2.944283e-05
##	EURAUD	-5.627917e-04	-4.224969e-05	1.790521e-05	5.799857e-05	6.268907e-05
##	EURCHF	3.597564e-04	7.438119e-05	1.071473e-05	-5.954839e-05	2.682822e-05
##	EURGBP	7.170909e-05	-1.912275e-05	8.627208e-05	1.724028e-04	-1.605565e-04
##	EURJPY	1.608667e-04	2.482464e-05	-2.818906e-05	-2.174649e-05	9.161598e-05
##	EURNZD	-2.913744e-04	6.605656e-06	-2.807327e-04	-6.984013e-05	1.947053e-05
##	EURUSD	2.249945e-04	-1.618899e-05	1.620330e-04	-1.448502e-04	2.869595e-05
##	GBPAUD	-7.327091e-04	2.373802e-04	2.163921e-04	4.829100e-05	-1.680938e-05
##	GBPCHF	5.759988e-04	-2.423447e-05	-1.988800e-05	1.161906e-04	-2.604761e-05
##	GBPJPY	4.226978e-04	-1.642366e-04	-5.520226e-05	1.171802e-04	-1.078752e-05
##	GBPNZD	-3.873617e-04	1.381008e-04	-5.354616e-05	-4.557055e-05	-1.264641e-04
##	GBPUSD	4.374899e-04	-2.913214e-04	1.970617e-05	4.444516e-05	-2.494544e-05
##	NZDCAD	1.235906e-04	2.396769e-04	-1.052185e-04	-5.125119e-05	-5.325787e-05
##	NZDCHF	-3.616051e-04	1.501021e-04	-2.388725e-04	4.529129e-05	-2.031314e-05
##	NZDJPY	-4.835143e-04	-1.451549e-04	-2.096604e-05	2.002544e-05	-5.078788e-05
##	NZDUSD	-4.225546e-04	-6.722970e-05	-8.894257e-05	-1.411324e-04	-6.388282e-05
##	USDCAD	-4.561858e-04	-4.066551e-04	-6.071442e-05	-2.349419e-05	7.439283e-06
##	USDCHF	7.123233e-05	-1.761970e-04	1.465559e-04	-1.672089e-04	-5.021309e-05
##	USDCNH	6.682204e-05	1.403469e-05	-5.375700e-06	1.132823e-06	4.787558e-07
##	USDJPY	2.170009e-04	1.871304e-04	1.186526e-04	-6.511228e-05	-1.717161e-05
##	XAGUSD	-1.837645e-04	-1.764026e-05	6.447486e-06	1.024901e-05	-1.414122e-07
##	XAUUSD	1.737697e-04	3.537452e-05	-3.924911e-06	-1.294681e-05	-2.487324e-06
##		PC16	PC17	PC18	PC19	PC20
##	AUDCHF	-4.090632e-05	-1.697721e-05	-2.443412e-05	-8.466285e-06	-2.038388e-06
##	AUDJPY	5.291006e-05	1.393444e-05	8.708996e-06	-3.844665e-07	2.105516e-06
##	AUDCAD	1.055229e-05	-4.108203e-05	1.022916e-05	-6.950811e-06	-7.905717e-06
##	AUDNZD	7.612283e-06	-7.767296e-06	7.013241e-06	1.435684e-05	-1.134128e-05
##	AUDUSD	-4.398109e-05	1.019815e-05	-1.493251e-05	5.820205e-06	3.539698e-05
##	CADCHF	-1.342241e-05	-3.188340e-05	3.202753e-05	7.568860e-06	-6.701264e-06
##	CADJPY	-6.310730e-05	-2.522700e-05	5.052711e-05	2.503357e-05	-1.207908e-06
##	CHFJPY	-4.722029e-05	-1.487544e-05	-4.589846e-05	4.024873e-05	-2.654867e-05
##	EURAUD	4.246958e-05	-6.521997e-05	-4.226364e-06	5.297242e-06	1.300702e-05
##	EURCHF	-9.322977e-06	5.994501e-05	8.598488e-06	-4.188909e-06	-3.627331e-06
##	EURGBP	-3.795016e-05	8.121347e-07	-6.344163e-07	-1.445763e-06	2.515417e-06
##	EURJPY	-5.869855e-05	3.814219e-05	5.764879e-06	-3.245097e-05	-1.045391e-05
##	EURNZD	5.959819e-05	-1.226677e-05	-4.605948e-06	2.497815e-06	8.603433e-06
##	EURUSD	6.817953e-07	-1.446972e-05	-3.643055e-06	2.460831e-05	-1.331633e-05
##	GBPAUD	-4.565574e-05	1.570281e-05	6.927610e-06	1.452617e-05	-1.764734e-05
##	GBPCHF	4.179246e-05	1.748298e-05	-5.874819e-06	5.357294e-05	1.469586e-05
##	GBPJPY	-3.057601e-05	-2.905306e-05	5.866008e-06	-3.610392e-05	2.035415e-06
##	GBPNZD	-9.708412e-06	1.542160e-05	2.909011e-06	-3.046257e-05	1.040806e-06
##	GBPUSD	-1.486306e-05	-3.129850e-05	-9.980986e-06	-1.011543e-05	3.565278e-06
##	NZDCAD	7.071232e-06	-2.976543e-05	4.490637e-05	1.502562e-06	-6.066199e-07
##	NZDCHF	-3.472966e-05	-6.552708e-06	-4.178371e-05	-5.462873e-07	-4.061045e-06
##	NZDJPY	1.249578e-04	2.647243e-05	-4.580821e-07	-2.594125e-06	-3.501237e-05
##	NZDUSD	-3.518973e-06	1.110505e-05	-6.665310e-06	-4.485186e-06	2.042247e-05
##	USDCAD	-7.133424e-05	1.905634e-05	1.117818e-05	2.648834e-05	1.521449e-07
##	USDCHF	-3.901089e-06	-4.511378e-05	-2.772347e-05	-2.016956e-05	-2.185975e-05
##	USDCNH	-2.688739e-06	-3.065062e-07	-1.342427e-06	7.148347e-07	-1.050341e-07

##	USDJPY	3.158793e-05	-5.755234e-06	-1.276156e-05	1.860724e-06	4.579644e-05
##	XAGUSD	-2.085493e-06	3.811704e-06	5.669313e-07	1.422482e-06	8.803019e-07
##	XAUUSD	1.157488e-06	-4.120363e-06	-1.328087e-07	-2.911027e-06	4.559538e-08
##		PC21	PC22	PC23	PC24	PC25
##	AUDCHF	-9.180707e-07	-1.823073e-06	-1.334314e-06	-3.609906e-06	-7.548673e-06
##	AUDJPY	-7.606444e-06	1.520903e-05	-4.590536e-06	1.920905e-05	6.507594e-06
##	AUDCAD	-1.805791e-05	9.156686e-06	1.110885e-05	-1.838526e-05	-4.411223e-06
##	AUDNZD	1.412604e-05	-2.591913e-05	-8.333502e-06	5.203655e-06	3.190126e-06
##	AUDUSD	-1.114870e-05	4.938255e-06	1.218990e-05	3.295929e-06	3.362929e-06
##	CADCHF	2.533507e-06	1.254602e-06	5.012202e-07	6.101863e-06	-1.275404e-05
##	CADJPY	-1.020242e-05	7.138464e-06	-1.443128e-06	-1.262272e-05	6.678852e-06
##	CHFJPY	-2.789230e-05	-6.250041e-07	6.141173e-06	1.012706e-05	-5.574797e-06
##	EURAUD	-1.301720e-05	-7.109160e-06	-1.084712e-06	8.050567e-06	-3.375833e-06
##	EURCHF	-5.125864e-05	-9.312022e-06	-1.199285e-05	2.779504e-07	2.208263e-06
##	EURGBP	6.580687e-06	-4.887306e-07	2.251938e-06	-2.091835e-06	-1.118277e-06
##	EURJPY	3.491209e-05	-2.193415e-06	1.337205e-05	6.389091e-06	-6.549629e-06
##	EURNZD	2.311470e-06	-1.334926e-06	9.722329e-06	-5.999452e-06	4.375780e-06
##	EURUSD	2.488384e-05	2.087967e-05	-1.058431e-05	-5.005846e-06	3.656629e-06
##	GBPAUD	9.775414e-06	-2.190191e-05	9.434859e-07	-5.021523e-06	6.465042e-06
##	GBPCHF	1.294557e-05	4.877337e-06	1.980456e-05	1.603968e-06	-1.067961e-06
##	GBPJPY	-9.845971e-06	-4.094770e-06	1.070358e-05	-1.448786e-06	9.672706e-06
##	GBPNZD	-6.195240e-06	2.599989e-05	-2.591754e-06	2.454798e-06	-6.580043e-06
##	GBPUSD	-2.451535e-07	-1.106079e-05	-2.358606e-05	-1.166045e-06	-6.551395e-06
##	NZDCAD	7.218144e-06	-5.903325e-06	-3.255626e-06	1.711182e-05	1.807297e-06
##	NZDCHF	1.638978e-05	9.050802e-06	-1.763137e-05	-1.970075e-06	9.005886e-06
##	NZDJPY	2.096713e-06	-4.690769e-06	-1.730455e-06	-1.025880e-05	-4.085088e-06
##	NZDUSD	1.202164e-06	-2.426768e-05	1.124834e-05	-4.152726e-06	-3.489796e-06
##	USDCAD	4.123858e-06	3.041984e-06	-6.641636e-06	-2.534757e-06	-5.090269e-06
##	USDCHF	1.788892e-06	-2.991527e-06	1.146850e-05	3.757113e-06	6.429441e-06
##	USDCNH	-1.534166e-06	-8.822794e-08	-5.625205e-08	2.776463e-08	3.647580e-08
##	USDJPY	1.095662e-05	-5.331690e-06	-1.545412e-05	-6.548750e-06	-2.779575e-06
##	XAGUSD	-4.738058e-07	2.761921e-07	-3.165155e-07	-2.384427e-07	-9.424967e-08
##	XAUUSD	6.039518e-07	-4.522547e-07	4.097117e-07	1.944116e-07	3.751375e-08
##		PC26	PC27	PC28	PC29	
##	AUDCHF	-6.145465e-06	-3.070700e-06	-7.168486e-06	-2.188890e-06	
##	AUDJPY	-3.027149e-06	3.963640e-06	-3.745770e-06	2.181019e-06	
##	AUDCAD	1.225628e-06	3.276586e-06	2.642534e-06	1.999485e-06	
##	AUDNZD	1.093519e-06	-3.741591e-06	2.389608e-06	4.043955e-07	
##	AUDUSD	4.338981e-06	1.633785e-06	5.373835e-06	-2.762887e-06	
##	CADCHF	1.190559e-05	3.320800e-06	-4.411467e-07	4.652867e-07	
##	CADJPY	-1.044142e-05	-1.022090e-06	1.553101e-06	-1.820311e-07	
##	CHFJPY	1.534726e-06	1.109233e-06	-7.403049e-07	7.322159e-08	
##	EURAUD	-1.409719e-06	-5.733787e-06	4.797238e-06	6.664162e-07	
##	EURCHF	2.833860e-07	-7.610673e-07	3.655175e-07	4.633536e-09	
##	EURGBP	-1.399330e-06	1.183260e-06	-9.516894e-07	-6.481678e-09	
##	EURJPY	-3.297152e-06	1.400708e-06	4.032603e-06	4.372123e-07	
##	EURNZD	1.480485e-06	7.885043e-06	-3.522833e-06	-8.793703e-07	
##	EURUSD	4.157577e-06	-4.189559e-06	-3.753392e-06	-1.427131e-07	
##	GBPAUD	1.970891e-06	3.483528e-06	-1.038154e-06	-7.140415e-09	
##	GBPCHF	-3.676933e-06	-1.157282e-06	7.191611e-07	2.511617e-07	
##	GBPJPY	1.152837e-05	-3.927484e-06	-3.098865e-06	-1.976968e-07	
##	GBPNZD	-2.875734e-06	-3.576080e-06	2.963350e-07	1.567050e-07	
##	GBPUSD	-5.314874e-06	6.501153e-06	8.839465e-07	-3.179142e-07	
##	NZDCAD	-1.528862e-06	2.161344e-07	-7.523018e-07	-1.817382e-06	

```
## NZDCHF 3.505890e-06 6.271261e-07 4.516512e-06 1.423283e-06
## NZDJPY 1.881780e-06 -1.887257e-06 2.541197e-06 -1.804269e-06
## NZDUSD -2.335107e-06 -3.340057e-06 -3.796714e-06 2.791795e-06
## USDCAD 4.429523e-06 -6.369666e-07 -9.814287e-07 2.823730e-07
## USDCHEF -6.868144e-06 1.009912e-06 2.173066e-07 -3.066435e-07
## USDCNH -3.469004e-08 -8.696257e-08 -5.870497e-08 -1.519993e-08
## USDJPY 1.410236e-06 3.379491e-07 -9.295313e-07 -1.994158e-07
## XAGUSD 1.147211e-07 -1.466141e-07 -7.469169e-08 1.405859e-08
## XAUUSD -2.448005e-07 1.653427e-07 9.062932e-08 -2.036460e-08
```

```
summary(pca1)
```

```
## Importance of components:
```

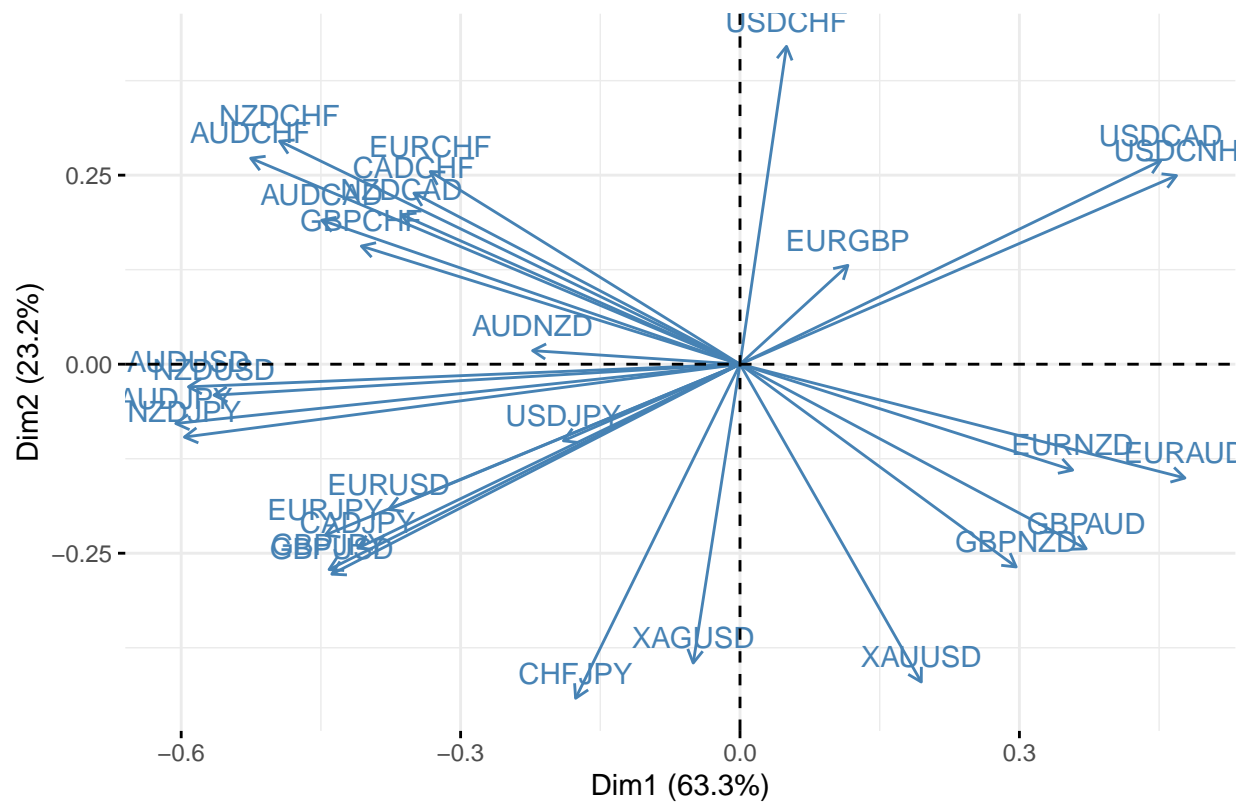
```
##          PC1      PC2      PC3      PC4      PC5      PC6      PC7
## Standard deviation 2.1725 1.3168 0.75625 0.5247 0.32721 0.16708 0.14873
## Proportion of Variance 0.6327 0.2324 0.07667 0.0369 0.01435 0.00374 0.00297
## Cumulative Proportion 0.6327 0.8651 0.94178 0.9787 0.99304 0.99678 0.99975
##          PC8      PC9      PC10      PC11      PC12      PC13
## Standard deviation 0.03292 0.02806 0.005316 0.0003824 0.0001497 0.0001109
## Proportion of Variance 0.00015 0.00011 0.000000 0.0000000 0.0000000 0.0000000
## Cumulative Proportion 0.99989 1.00000 1.000000 1.0000000 1.0000000 1.0000000
##          PC14      PC15      PC16      PC17      PC18
## Standard deviation 8.062e-05 5.333e-05 4.284e-05 2.719e-05 2.069e-05
## Proportion of Variance 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
## Cumulative Proportion 1.000e+00 1.000e+00 1.000e+00 1.000e+00 1.000e+00
##          PC19      PC20      PC21      PC22      PC23
## Standard deviation 1.977e-05 1.64e-05 1.598e-05 1.156e-05 1.014e-05
## Proportion of Variance 0.000e+00 0.00e+00 0.000e+00 0.000e+00 0.000e+00
## Cumulative Proportion 1.000e+00 1.00e+00 1.000e+00 1.000e+00 1.000e+00
##          PC24      PC25      PC26      PC27      PC28
## Standard deviation 7.902e-06 5.614e-06 4.763e-06 3.18e-06 2.883e-06
## Proportion of Variance 0.000e+00 0.000e+00 0.000e+00 0.00e+00 0.000e+00
## Cumulative Proportion 1.000e+00 1.000e+00 1.000e+00 1.00e+00 1.000e+00
##          PC29
## Standard deviation 1.193e-06
## Proportion of Variance 0.000e+00
## Cumulative Proportion 1.000e+00
```

## Plots

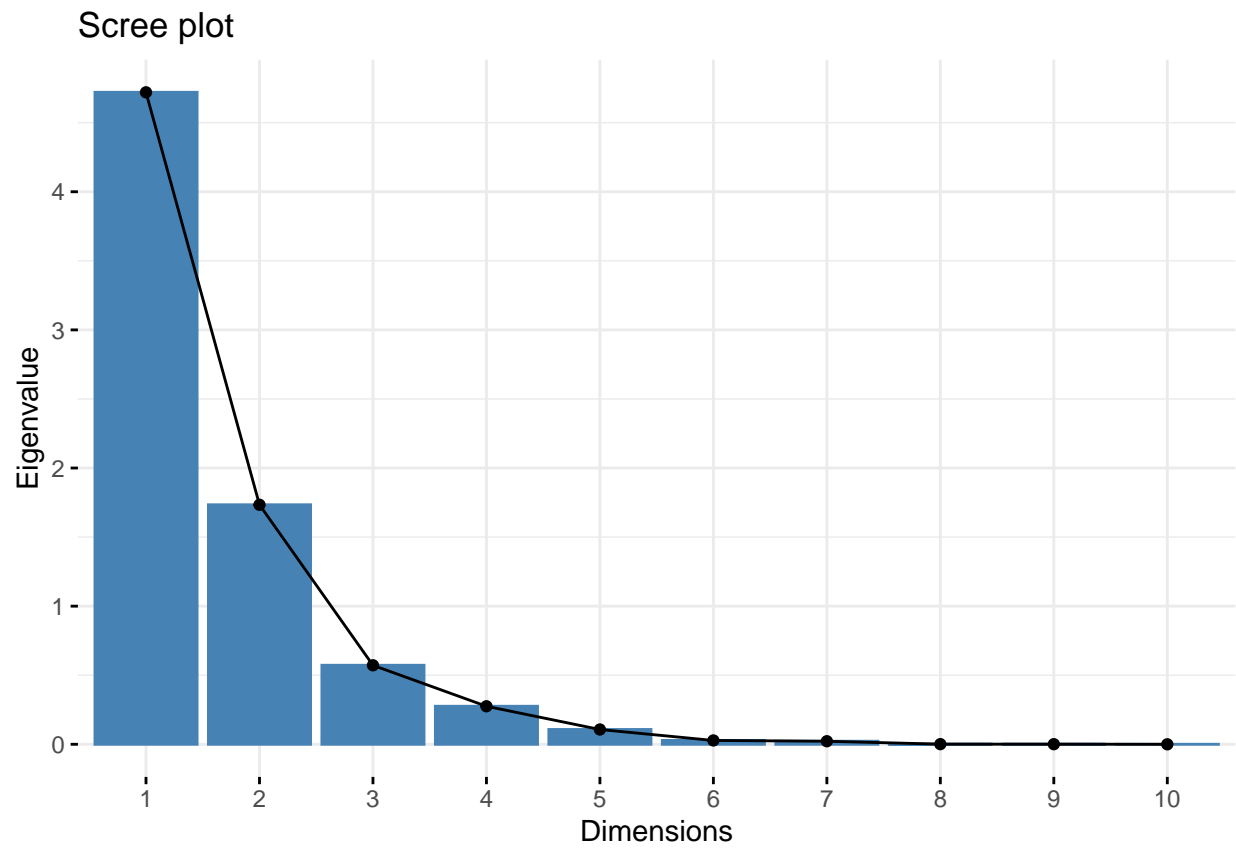
You can see each dimensional is highly positive and negative correlated with what variables. For example:  
 \* Dim1 is highly positive correlated with USDCAD,USDCNH,EURAUD,EURNZD,GBPNZD,GBPAUD. \* Dim1 is highly negative correlated with AUDUSD,NZDUSD,AUDJPY,NZDJPY. \* Dim2 is highly positive correlated with USDCHEF,NZDCHF,AUDCHF,USDCAD,USDCNH. \* Dim2 is highly negative correlated with CHFJPY,XAGUSD,XAUUSD.

```
library(factoextra)
fviz_pca_var(pca1, col.var="steelblue")
```

## Variables – PCA

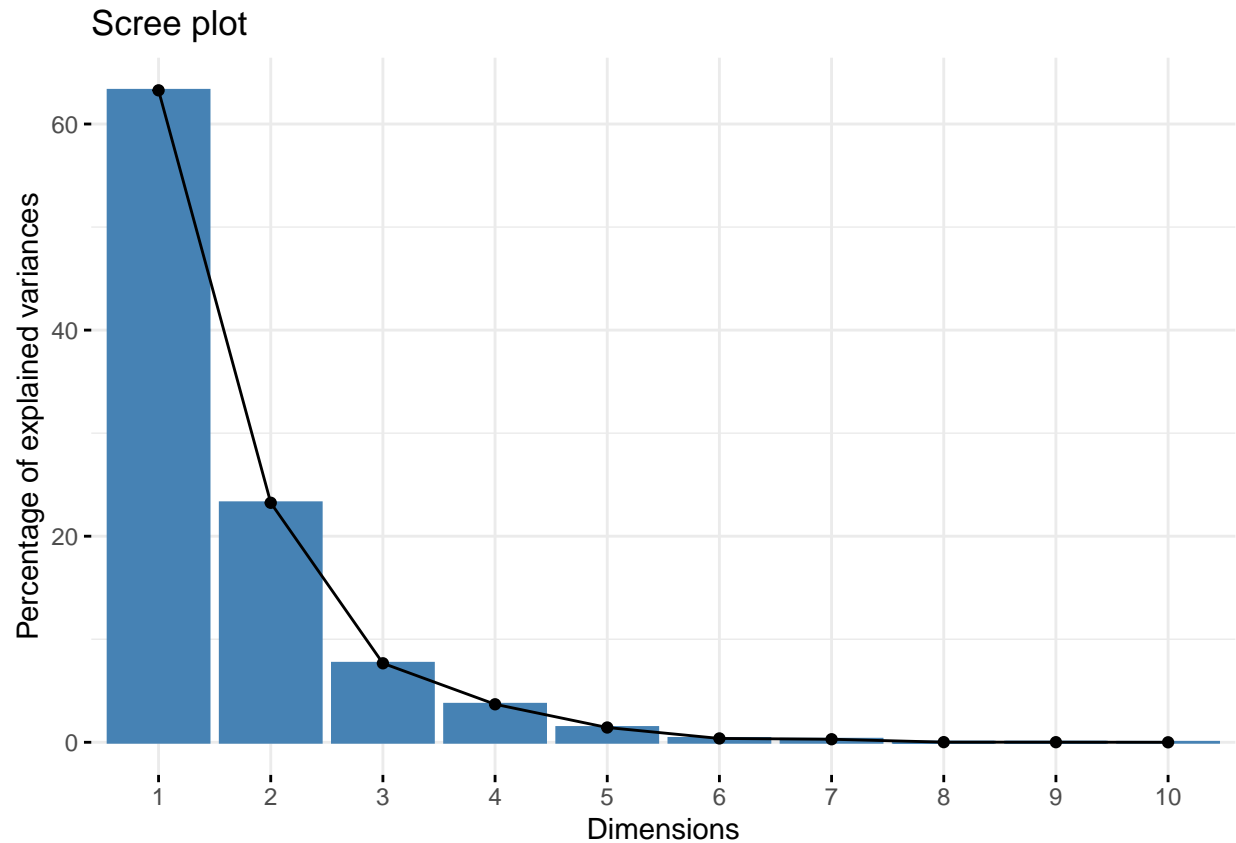


```
fviz_eig(pca1, choice='eigenvalue')
```



```
fviz_eig(pca1) # percentage of explained variance on y-axis
```



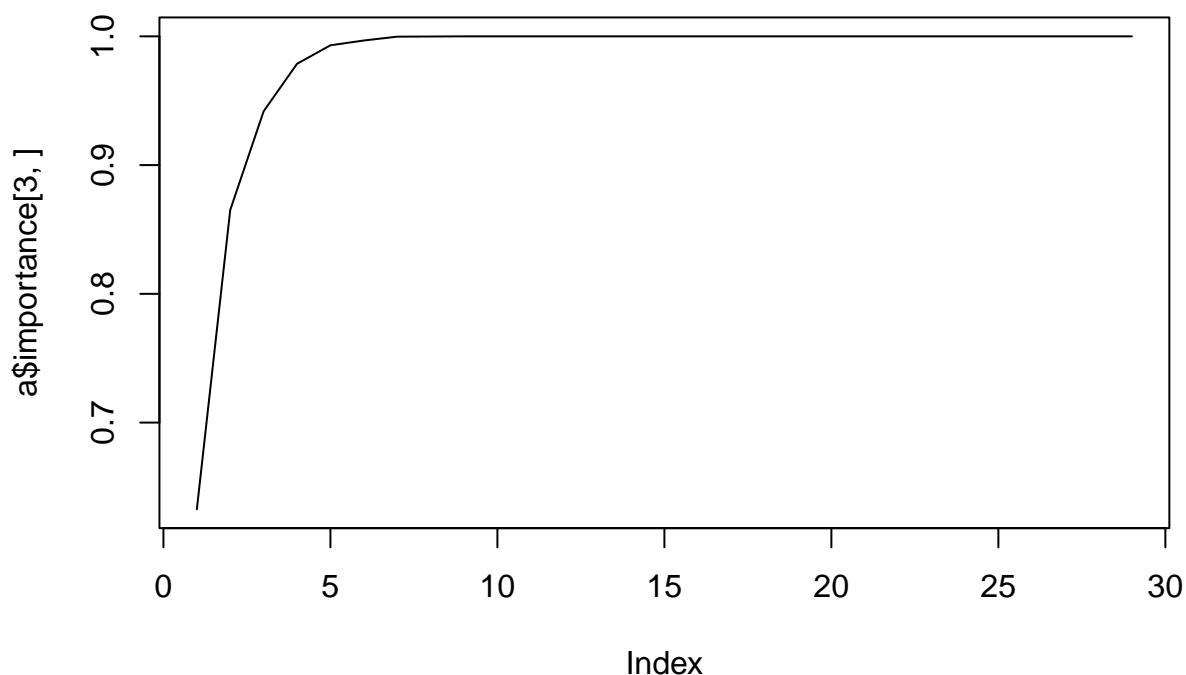


```
eig.val<-get_eigenvalue(pca1)
```

### Cumulative variance

It shows optimal number of PC. I think 5 PC is optimal number. In other words, PC1 PC2 PC3 PC4 and PC5 can explain 98% of these variables.

```
a<-summary(pca1)  
plot(a$importance[3,],type="l")
```



## Individual results

```
library(factoextra)
ind<-get_pca_ind(pca1)
print(ind)
```

```
## Principal Component Analysis Results for individuals
## =====
##   Name      Description
## 1 "$coord"  "Coordinates for the individuals"
## 2 "$cos2"   "Cos2 for the individuals"
## 3 "$contrib" "contributions of the individuals"
```

```
head(ind$coord) # coordinates of variables
```

```
##           Dim.1      Dim.2      Dim.3      Dim.4      Dim.5      Dim.6
## AUDCHF -2.780202  1.44163929  0.1448744 -0.14929520  0.0016158813 -0.111757000
## AUDJPY -3.205777 -0.41488172  0.2674273 -0.08653253  0.2994425088 -0.002547915
## AUDCAD -2.376639  1.00768447 -0.8990766 -0.28771505 -0.0005210032 -0.081676678
## AUDNZD -1.178321  0.09500988  0.2949782 -1.07049857  0.4554424698 -0.509332305
## AUDUSD -3.133836 -0.15840469 -0.6239408 -0.26814197 -0.0167472885 -0.116658864
## CADCHF -1.852834  1.19722114  1.1662542  0.07061285 -0.0006939727 -0.087302003
##           Dim.7      Dim.8      Dim.9      Dim.10      Dim.11
```

```
## AUDCHF -0.004002188 -0.005662923 -0.013877683 0.0022929292 -5.507053e-04
## AUDJPY 0.079582715 -0.007770209 0.003376529 0.0022405765 -6.430215e-04
## AUDCAD 0.311261852 -0.006661732 -0.003724296 0.0002171481 1.364725e-05
## AUDNZD 0.150078626 0.015999788 0.002968622 0.0007045276 -1.016627e-05
## AUDUSD -0.019697677 -0.002927917 0.018701240 0.0023052767 -6.059449e-04
## CADCHF -0.335424306 -0.005813137 -0.017516427 0.0014324590 -1.970040e-04
##          Dim.12      Dim.13      Dim.14      Dim.15      Dim.16
## AUDCHF 1.287161e-04 -2.515010e-05 1.140333e-04 7.854407e-05 -4.090632e-05
## AUDJPY -1.186891e-04 1.247526e-04 7.607234e-05 2.394558e-05 5.291006e-05
## AUDCAD 1.890287e-04 1.153905e-04 2.363429e-05 2.402855e-05 1.055229e-05
## AUDNZD 2.732671e-05 -1.267987e-05 6.086692e-07 -1.764071e-05 7.612283e-06
## AUDUSD -9.027464e-05 1.218120e-04 -6.331727e-05 -1.502048e-05 -4.398109e-05
## CADCHF 2.535514e-05 3.413013e-06 -4.225769e-05 -1.950833e-05 -1.342241e-05
##          Dim.17      Dim.18      Dim.19      Dim.20      Dim.21
## AUDCHF -1.697721e-05 -2.443412e-05 -8.466285e-06 -2.038388e-06 -9.180707e-07
## AUDJPY 1.393444e-05 8.708996e-06 -3.844665e-07 2.105516e-06 -7.606444e-06
## AUDCAD -4.108203e-05 1.022916e-05 -6.950811e-06 -7.905717e-06 -1.805791e-05
## AUDNZD -7.767296e-06 7.013241e-06 1.435684e-05 -1.134128e-05 1.412604e-05
## AUDUSD 1.019815e-05 -1.493251e-05 5.820205e-06 3.539698e-05 -1.114870e-05
## CADCHF -3.188340e-05 3.202753e-05 7.568860e-06 -6.701264e-06 2.533507e-06
##          Dim.22      Dim.23      Dim.24      Dim.25      Dim.26
## AUDCHF -1.823073e-06 -1.334314e-06 -3.609906e-06 -7.548673e-06 -6.145465e-06
## AUDJPY 1.520903e-05 -4.590536e-06 1.920905e-05 6.507594e-06 -3.027149e-06
## AUDCAD 9.156686e-06 1.110885e-05 -1.838526e-05 -4.411223e-06 1.225628e-06
## AUDNZD -2.591913e-05 -8.333502e-06 5.203655e-06 3.190126e-06 1.093519e-06
## AUDUSD 4.938255e-06 1.218990e-05 3.295929e-06 3.362929e-06 4.338981e-06
## CADCHF 1.254602e-06 5.012202e-07 6.101863e-06 -1.275404e-05 1.190559e-05
##          Dim.27      Dim.28      Dim.29
## AUDCHF -3.070700e-06 -7.168486e-06 -2.188890e-06
## AUDJPY 3.963640e-06 -3.745770e-06 2.181019e-06
## AUDCAD 3.276586e-06 2.642534e-06 1.999485e-06
## AUDNZD -3.741591e-06 2.389608e-06 4.043955e-07
## AUDUSD 1.633785e-06 5.373835e-06 -2.762887e-06
## CADCHF 3.320800e-06 -4.411467e-07 4.652867e-07
```

```
head(ind$contrib) # contributions of individuals to PC
```

```
##          Dim.1      Dim.2      Dim.3      Dim.4      Dim.5      Dim.6
## AUDCHF 5.647316 4.13321730 0.1265468 0.27918654 8.409569e-05 1.542854e+00
## AUDJPY 7.508548 0.34231317 0.4312009 0.09379110 2.887897e+00 8.019466e-04
## AUDCAD 4.126822 2.01940835 4.8737313 1.03687872 8.742500e-06 8.240842e-01
## AUDNZD 1.014417 0.01795199 0.5246237 14.35406725 6.680699e+00 3.204630e+01
## AUDUSD 7.175330 0.04990121 2.3472260 0.90060093 9.033246e-03 1.681167e+00
## CADCHF 2.508200 2.85051790 8.2007694 0.06245543 1.551099e-05 9.415077e-01
##          Dim.7      Dim.8      Dim.9      Dim.10      Dim.11      Dim.12
## AUDCHF 0.002496865 0.10202468 0.84328045 0.641515667 7.150282732 2.54867035
## AUDJPY 0.987273464 0.19208316 0.04992052 0.612555590 9.748455099 2.16705558
## AUDCAD 15.102601384 0.14118814 0.06073324 0.005753578 0.004391116 5.49671663
## AUDNZD 3.511055186 0.81442736 0.03858763 0.060565032 0.002436732 0.11487430
## AUDUSD 0.060482538 0.02727354 1.53136578 0.648443407 8.656674577 1.25365943
## CADCHF 17.538361785 0.10750905 1.34347367 0.250374664 0.915028792 0.09889628
##          Dim.13      Dim.14      Dim.15      Dim.16      Dim.17      Dim.18
## AUDCHF 0.177200049 6.8997389107 7.4804011 3.1446956 1.3443182 4.8094097
## AUDJPY 4.359971665 3.0705968904 0.6952628 5.2610743 0.9056250 0.6109908
```

```
## AUDCAD 3.730135776 0.2963836350 0.7000889 0.2092626 7.8717880 0.8429039
## AUDNZD 0.045041659 0.0001965766 0.3773376 0.1089000 0.2813904 0.3962197
## AUDUSD 4.156854766 2.1272259281 0.2735684 3.6352124 0.4850784 1.7962393
## CADCHF 0.003263326 0.9475033088 0.4614645 0.3385780 4.7413140 8.2631465
##          Dim.19      Dim.20      Dim.21      Dim.22      Dim.23      Dim.24
## AUDCHF 0.632379292 0.05324673 0.01138325 0.08578275 0.05976623 0.7197081
## AUDJPY 0.001304094 0.05681151 0.78140694 5.97028475 0.70740267 20.3786855
## AUDCAD 0.426248471 0.80094311 4.40401599 2.16405575 4.14264481 18.6682785
## AUDNZD 1.818485291 1.64832574 2.69497418 17.33933587 2.33128278 1.4954833
## AUDUSD 0.298860430 16.05653014 1.67865763 0.62941739 4.98815327 0.5999573
## CADCHF 0.505420410 0.57548315 0.08668785 0.04062596 0.00843329 2.0563145
##          Dim.25      Dim.26      Dim.27      Dim.28      Dim.29
## AUDCHF 6.234226 5.7401352 3.2158683 21.31664288 11.6093463
## AUDJPY 4.633213 1.3927725 5.3581141 5.82030975 11.5260015
## AUDCAD 2.128920 0.2283125 3.6615644 2.89670969 9.6871500
## AUDNZD 1.113415 0.1817461 4.7745911 2.36873828 0.3962529
## AUDUSD 1.237305 2.8614621 0.9103604 11.97933354 18.4963501
## CADCHF 17.796607 21.5434270 3.7610484 0.08072909 0.5245674
```

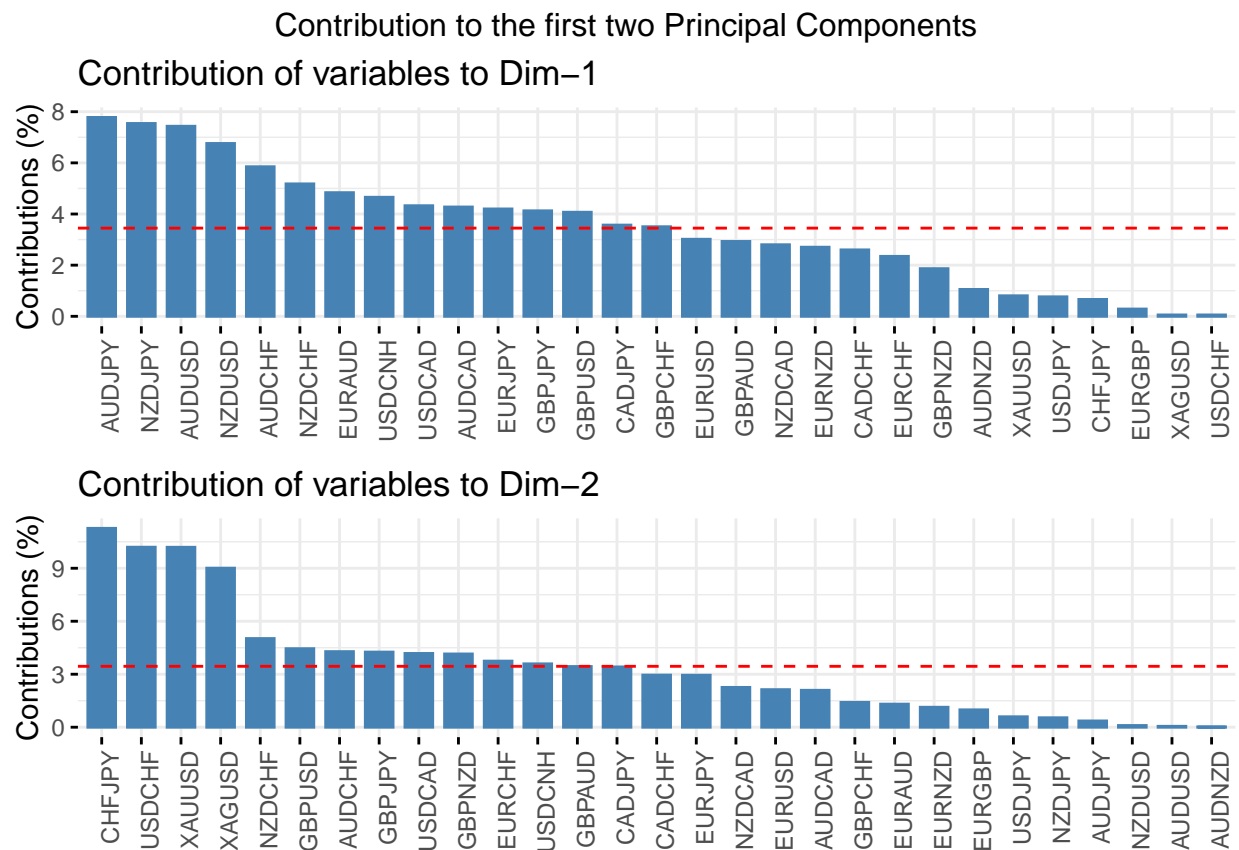
`head(ind$cos2)` *# represents the quality of representation for variables on the factor map*

```
##          Dim.1      Dim.2      Dim.3      Dim.4      Dim.5      Dim.6
## AUDCHF 0.7836203 0.210700787 0.002127826 0.0022596679 2.647109e-07 1.266200e-03
## AUDJPY 0.9673185 0.016201360 0.006731539 0.0007047932 8.439754e-03 6.110445e-07
## AUDCAD 0.7375281 0.132587097 0.105546912 0.0108087956 3.544320e-08 8.710604e-04
## AUDNZD 0.4450012 0.002893153 0.027887759 0.3672874213 6.648152e-02 8.314503e-02
## AUDUSD 0.9514685 0.002430961 0.037716258 0.0069658077 2.717258e-05 1.318492e-03
## CADCHF 0.5404636 0.225653646 0.214131231 0.0007849844 7.581906e-08 1.199892e-03
##          Dim.7      Dim.8      Dim.9      Dim.10      Dim.11
## AUDCHF 1.623858e-06 3.251130e-06 1.952481e-05 5.330086e-07 3.074620e-08
## AUDJPY 5.961292e-04 5.682877e-06 1.073109e-06 4.725224e-07 3.891830e-08
## AUDCAD 1.265039e-02 5.794640e-06 1.811092e-06 6.156929e-09 2.431881e-11
## AUDNZD 7.218909e-03 8.204693e-05 2.824515e-06 1.590852e-07 3.312507e-11
## AUDUSD 3.758997e-05 8.305379e-07 3.388306e-05 5.148586e-07 3.557199e-08
## CADCHF 1.771261e-02 5.320038e-06 4.830417e-05 3.230413e-07 6.110033e-09
##          Dim.12      Dim.13      Dim.14      Dim.15      Dim.16
## AUDCHF 1.679649e-09 6.412572e-11 1.318306e-09 6.254315e-10 1.696421e-10
## AUDJPY 1.325943e-09 1.464880e-09 5.446988e-10 5.397017e-11 2.634993e-10
## AUDCAD 4.665600e-09 1.738570e-09 7.293518e-11 7.538888e-11 1.453938e-11
## AUDNZD 2.393364e-10 5.153043e-11 1.187398e-13 9.973921e-11 1.857222e-11
## AUDUSD 7.895387e-10 1.437548e-09 3.884063e-10 2.185797e-11 1.874018e-10
## CADCHF 1.012105e-10 1.833874e-12 2.811286e-10 5.991476e-11 2.836315e-11
##          Dim.17      Dim.18      Dim.19      Dim.20      Dim.21
## AUDCHF 2.922035e-11 6.052659e-11 7.266725e-12 4.212372e-13 8.544865e-14
## AUDJPY 1.827602e-11 7.139027e-12 1.391297e-14 4.172727e-13 5.445857e-12
## AUDCAD 2.203718e-10 1.366255e-11 6.308457e-12 8.160836e-12 4.257819e-11
## AUDNZD 1.933631e-11 1.576418e-11 6.606202e-11 4.122472e-11 6.395502e-11
## AUDUSD 1.007591e-11 2.160268e-11 3.281848e-12 1.213876e-10 1.204176e-11
## CADCHF 1.600379e-10 1.614881e-10 9.018920e-12 7.069799e-12 1.010504e-12
##          Dim.22      Dim.23      Dim.24      Dim.25      Dim.26
## AUDCHF 3.369466e-13 1.804966e-13 1.321127e-12 5.776891e-12 3.828798e-12
## AUDJPY 2.177239e-11 1.983489e-12 3.473077e-11 3.986060e-12 8.625226e-13
## AUDCAD 1.094785e-11 1.611350e-11 4.413588e-11 2.540798e-12 1.961414e-13
## AUDNZD 2.153151e-10 2.225815e-11 8.678623e-12 3.261742e-12 3.832537e-13
```

```
## AUDUSD 2.362593e-12 1.439600e-11 1.052441e-12 1.095664e-12 1.823968e-12
## CADCHF 2.478024e-13 3.955039e-14 5.861632e-12 2.560882e-11 2.231494e-11
##          Dim.27      Dim.28      Dim.29
## AUDCHF 9.559336e-13 5.209641e-12 4.857366e-13
## AUDJPY 1.478738e-12 1.320642e-12 4.477356e-13
## AUDCAD 1.401830e-12 9.117865e-13 5.220213e-13
## AUDNZD 4.486902e-12 1.830151e-12 5.241390e-14
## AUDUSD 2.586019e-13 2.797761e-12 7.395508e-13
## CADCHF 1.736117e-12 3.063795e-14 3.408278e-14
```

## Contributions of individual variables to PC

```
library(gridExtra)
var<-get_pca_var(pca1)
a<-fviz_contrib(pca1, "var", axes=1, xtickslab.rt=90) # default angle=45°
b<-fviz_contrib(pca1, "var", axes=2, xtickslab.rt=90)
grid.arrange(a,b,top='Contribution to the first two Principal Components')
```

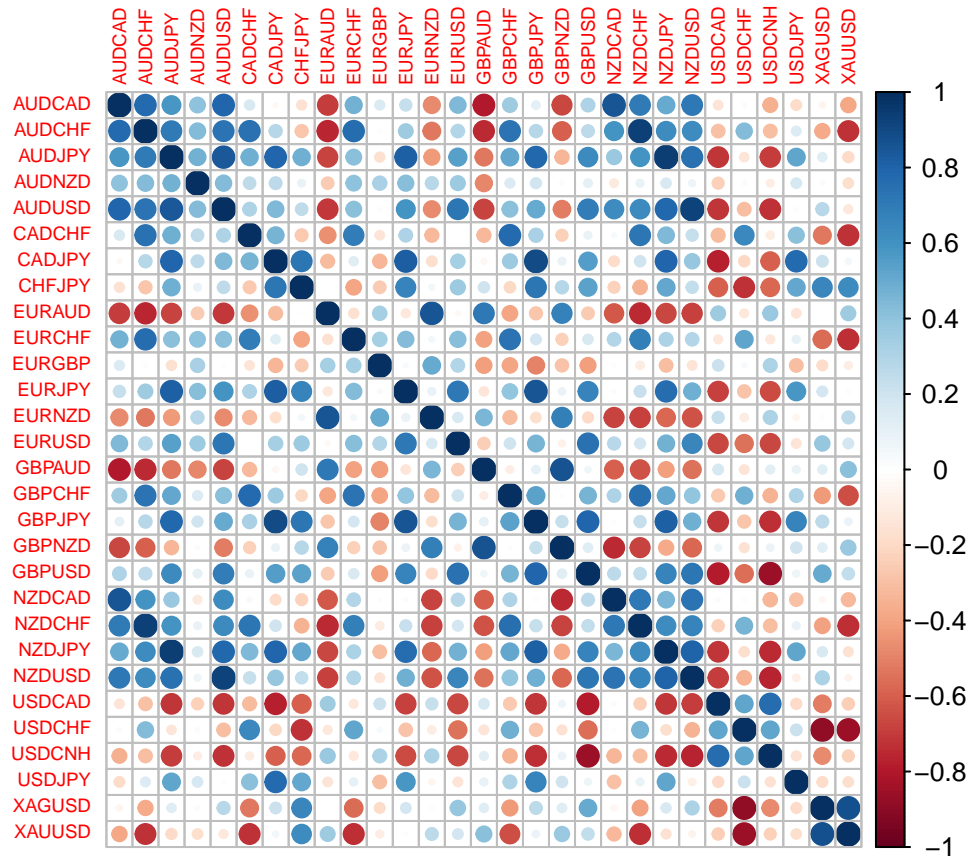


## MDS model

The main goal of MDS is minimizing dimensions, preserving distance between data points.

## Standardize datasets

```
library(tidyverse)
library(corrplot)
library(clusterSim)
df.norm<-data.Normalization(df, type="n1",normalization="column")
df.norm.plot<-cor(df.norm, method="pearson")
corrplot(df.norm.plot, order ="alphabet", tl.cex=0.6)
```



## Training model

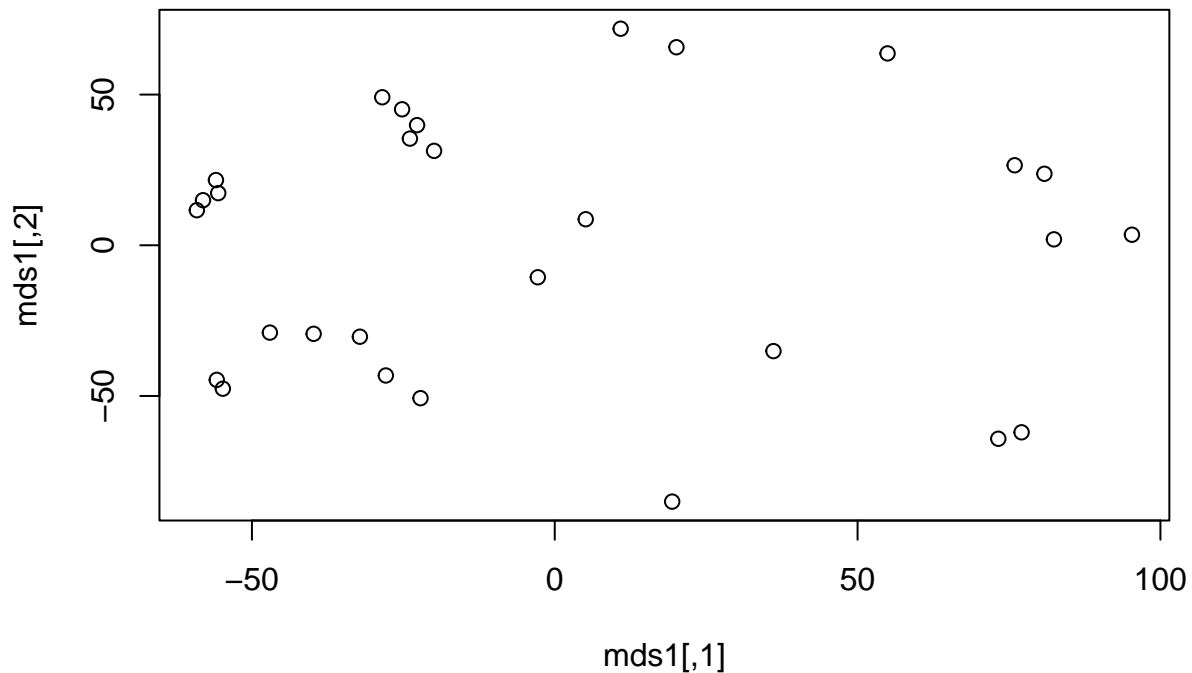
```
dist_df<-dist(t(df.norm))
as.matrix(dist_df)[1:5, 1:5] # let's see the distance matrix
```

```
##          AUDCHF  AUDJPY  AUDCAD  AUDNZD  AUDUSD
## AUDCHF  0.00000  67.37418  58.69585  93.03029  64.32286
## AUDJPY  67.37418   0.00000  79.95874  90.12655  48.55428
## AUDCAD  58.69585  79.95874   0.00000  95.35919  56.01423
## AUDNZD  93.03029  90.12655  95.35919   0.00000  93.07366
## AUDUSD  64.32286  48.55428  56.01423  93.07366   0.00000
```

```
mds1<-cmdscale(dist_df, k=2) #k - the maximum dimension of the space
summary(mds1)
```

```
##           V1           V2
## Min.      :-59.09  Min.    :-85.06
## 1st Qu.   :-39.81  1st Qu. :-35.12
## Median    :-22.16  Median   : 8.64
## Mean      :  0.00  Mean     : 0.00
## 3rd Qu.   : 36.11  3rd Qu. : 31.33
## Max.      : 95.30  Max.     : 71.86
```

```
plot(mds1)
```



## Similarity and Dissimilarity matrix

Similarity - it shows a positive correlation between variables. Dissimilarity - it shows a negative correlation between variables.

```
### Similarity and Dissimilarity matrix
sim<-cor(df.norm) # similarity matrix
dis.t<-dist(t(df.norm)) # dissimilarity matrix
library(smaccf)
dis2<-sim2diss(sim, method=1, to.dist = TRUE)
head(sim)
```

```
##          AUDCHF    AUDJPY    AUDCAD    AUDNZD    AUDUSD    CADCHF    CADJPY
## AUDCHF 1.0000000 0.7042814 0.7755569 0.4361802 0.7304605 0.7489569 0.28041340
## AUDJPY 0.7042814 1.0000000 0.5834918 0.4708277 0.8464157 0.4873813 0.79371358
## AUDCAD 0.7755569 0.5834918 1.0000000 0.4075977 0.7955965 0.1629495 -0.03011594
## AUDNZD 0.4361802 0.4708277 0.4075977 1.0000000 0.4356543 0.2502926 0.26273199
## AUDUSD 0.7304605 0.8464157 0.7955965 0.4356543 1.0000000 0.3072117 0.44770993
## CADCHF 0.7489569 0.4873813 0.1629495 0.2502926 0.3072117 1.0000000 0.46880326
##          CHFJPY    EURAUD    EURCHF    EURGBP    EURJPY    EURNZD
## AUDCHF -0.2756359 -0.7593473 0.7638475 0.01564967 0.3537505 -0.5244581
## AUDJPY 0.4876679 -0.6776433 0.4108405 -0.16338143 0.8147020 -0.4259333
## AUDCAD -0.1598355 -0.6999549 0.4778026 0.15685226 0.2376629 -0.4776496
## AUDNZD 0.0905585 -0.2516660 0.4032833 0.32925447 0.4239972 0.2779589
## AUDUSD 0.2505331 -0.7074345 0.4148729 -0.01127155 0.5900626 -0.4715231
## CADCHF -0.2643930 -0.4522829 0.6933101 -0.14041195 0.3028410 -0.3202533
##          EURUSD    GBPAUD    GBPCHF    GBPJPY    GBPNZD    GBPUSD
## AUDCHF 0.294529340 -0.7418321 0.7345366 0.2830734 -0.5957209 0.26339455
## AUDJPY 0.544291853 -0.5254762 0.5136758 0.7877748 -0.3300341 0.63098252
## AUDCAD 0.443376516 -0.7939430 0.3553265 0.1111700 -0.6673029 0.30583393
## AUDNZD 0.363044360 -0.4833282 0.1547223 0.1914080 0.0295884 0.11477894
## AUDUSD 0.727012463 -0.6703275 0.4122796 0.5094286 -0.5125858 0.69810332
## CADCHF -0.003494861 -0.3261343 0.7762797 0.3253657 -0.2325759 0.09227028
##          NZDCAD    NZDCHF    NZDJPY    NZDUSD    USDCAD    USDCHF
## AUDCHF 0.59948124 0.93693826 0.6272194 0.62980029 -0.2989188 0.43014244
## AUDJPY 0.37001294 0.59479820 0.9489451 0.74461391 -0.7125934 -0.13956858
## AUDCAD 0.85924502 0.70252994 0.5057336 0.71566702 -0.1451947 0.02784396
## AUDNZD -0.11667581 0.09454288 0.1688873 0.07358324 -0.2309610 0.02850358
## AUDUSD 0.62076941 0.63944804 0.7892297 0.92961814 -0.7139071 -0.30180839
## CADCHF 0.03764082 0.72865559 0.4499015 0.23546534 -0.3161523 0.64289650
##          USDCNH    USDJPY    XAGUSD    XAUUSD
## AUDCHF -0.3079255 0.14905180 -0.37895964 -0.7233128
## AUDJPY -0.6936721 0.52060678 0.13235378 -0.1947619
## AUDCAD -0.3588304 -0.18030693 -0.05682365 -0.3827726
## AUDNZD -0.0942304 0.17455482 -0.02856079 -0.1734553
## AUDUSD -0.7205687 -0.01362342 0.27361129 -0.1203454
## CADCHF -0.1025139 0.41988622 -0.52975165 -0.7297891
```

```
as.matrix(dis2)[1:5,1:5]
```

```
##          AUDCHF    AUDJPY    AUDCAD    AUDNZD    AUDUSD
## AUDCHF 0.0000000 0.2957186 0.2244431 0.5638198 0.2695395
## AUDJPY 0.2957186 0.0000000 0.4165082 0.5291723 0.1535843
## AUDCAD 0.2244431 0.4165082 0.0000000 0.5924023 0.2044035
## AUDNZD 0.5638198 0.5291723 0.5924023 0.0000000 0.5643457
## AUDUSD 0.2695395 0.1535843 0.2044035 0.5643457 0.0000000
```

## Mantel test

P value of mantel-test is 0,001. It means our dataset is non-random pattern, interpreted as a similarity of the matrices.

```
### Mantel test
library(ape)
mantel.test(as.matrix(sim), as.matrix(dis2))
```



```
## $z.stat
## [1] -58.36825
##
## $p
## [1] 0.001
##
## $alternative
## [1] "two.sided"
```