| | Markowitz Portfolio Selection

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Introduction

Portfolio optimization with broad defination can be described as the process of selecting proportions of various assets to include in a portfolio. However, Markowitz portfolio model allows investors to construct a portfolio that gives the best risk/return trade off available.

In this project, an optimal portfolio is created for 5 different stocks from 5 different sectors by Markowitz portfolio model.

Data

Data set consists of 5-year, daily closing prices of 5 different stocks between May 2014 and May 2019. "AKBNK", "MGROS", "NETAS", "BJKAS" and "AKSEN" stocks belong to banking, market chain, telecommunication, sports club and energy sector respectively.

```
require(readxl)
```

```
## Loading required package: readxl
```

```
akbnk<-read_excel("C:/Users/Veli/Documents/R/markowitz/Portfolio.project/AKBNK2.xlsx")
aksen<-read_excel("C:/Users/Veli/Documents/R/markowitz/Portfolio.project/AKSEN2.xlsx")
bjkas<-read_excel("C:/Users/Veli/Documents/R/markowitz/Portfolio.project/BJKAS2.xlsx")
mgros<-read_excel("C:/Users/Veli/Documents/R/markowitz/Portfolio.project/MGROS2.xlsx")
netas<-read_excel("C:/Users/Veli/Documents/R/markowitz/Portfolio.project/NETAS2.xlsx")
stock_prices<-cbind(akbnk[,c(1,2)],aksen[,2],bjkas[,2],mgros[,2],netas[,2])
colnames(stock_prices)<-c("Date","AKBNK","AKSEN","BJKAS","MGROS","NETAS")
head(stock_prices)
```

```
##         Date AKBNK AKSEN BJKAS MGROS NETAS
## 1 2019-05-13   548  2240  1570  1195   601
## 2 2019-05-10   561  2210  1750  1247   635
## 3 2019-05-09   566  2180  1650  1252   650
## 4 2019-05-08   583  2230  1700  1299   673
## 5 2019-05-07   580  2270  1650  1289   684
## 6 2019-05-06   595  2220  1660  1314   695
```

```
require(tseries)
```

```
## Loading required package: tseries
```

```
## Registered S3 method overwritten by 'xts':
##   method     from
##   as.zoo.xts zoo
```

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

```
require(timeSeries)
```

```
## Loading required package: timeSeries
```

```
## Loading required package: timeDate
```

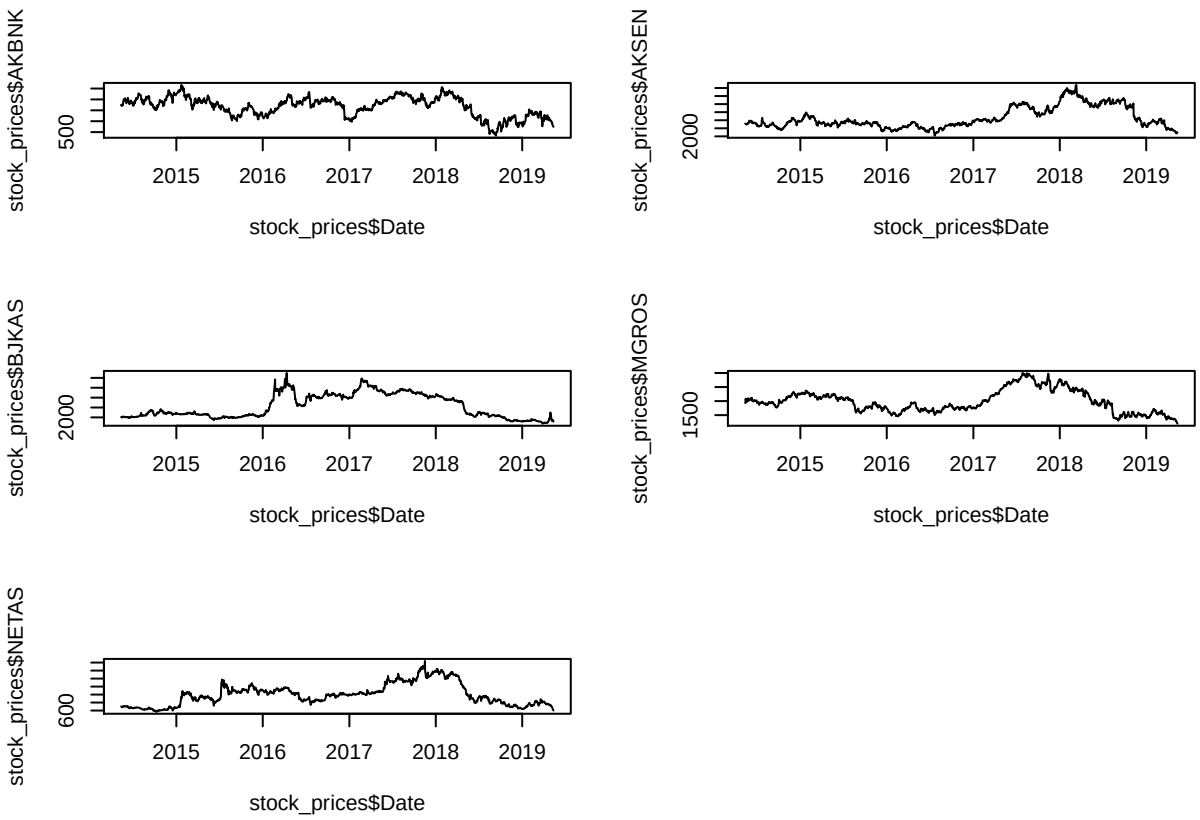
```
stock_returns<-cbind.data.frame((stock_prices$Date[-1]),apply(stock_prices[,-1],2,function(x) diff(x)/h
head(stock_returns)
```

```
##   (stock_prices$Date[-1])        AKBNK       AKSEN        BJKAS
## 1              2019-05-10  0.023722628 -0.01339286  0.114649682
## 2              2019-05-09  0.008912656 -0.01357466 -0.057142857
## 3              2019-05-08  0.030035336  0.02293578  0.030303030
## 4              2019-05-07 -0.005145798  0.01793722 -0.029411765
## 5              2019-05-06  0.025862069 -0.02202643  0.006060606
## 6              2019-05-03  0.005042017  0.04504505  0.246987952
##          MGROS      NETAS
## 1  0.043514644 0.05657238
## 2  0.004009623 0.02362205
## 3  0.037539936 0.03538462
## 4 -0.007698229 0.01634473
## 5  0.019394880 0.01608187
## 6  0.028158295 0.03884892
```

```
stock_returns2 <- as.timeSeries(stock_returns)
```

Daily returns are calculated by taking into consideration the prices that changed according to the previous day.

```
par(mfrow=c(3,2))
plot(stock_prices$Date,stock_prices$AKBNK,type="l")
plot(stock_prices$Date,stock_prices$AKSEN,type="l")
plot(stock_prices$Date,stock_prices$BJKAS,type="l")
plot(stock_prices$Date,stock_prices$MGROS,type="l")
plot(stock_prices$Date,stock_prices$NETAS,type="l")
```



The graphs show the daily price changes of the stocks mentioned during the 5-year period.

```
returns.portfolio<-stock_returns2
meanReturns <- colMeans(returns.portfolio[,-1])
covMat <- cov(returns.portfolio[,-1])
meanReturns
```

```
##        AKSEN        BJKAS        MGROS        NETAS
## 0.0004045834 0.0006509721 0.0005856500 0.0005012458
```

```
covMat
```

```
##               AKSEN        BJKAS        MGROS        NETAS
## AKSEN 0.0004698523 0.0001370893 0.0001730924 0.0001803566
## BJKAS 0.0001370893 0.0008782400 0.0001743226 0.0002141664
## MGROS 0.0001730924 0.0001743226 0.0004139203 0.0002087852
## NETAS 0.0001803566 0.0002141664 0.0002087852 0.0007452057
```

According to the average mean return vector, while the stock of *BJKAS* has the most mean return, the stock of *AKSEN* has the least mean return.

When the sample covariance matrix is examined,diagonal elements imply the variance of stocks,and the off diagonal elements mean covariances between all possible pairs of stocks.

When the stock of *MGROS* has the minimum variance as the least risky stock, the stock of *BJKAS* has the maximum variance as the most risky stock. The optimal portfolio is not dependent of the initial weights of stocks.

Constraints

```
require(PortfolioAnalytics)
```

```
## Loading required package: PortfolioAnalytics
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following object is masked from 'package:timeSeries':
##
##     time<-
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
## Loading required package: xts
```

```
## Loading required package: foreach
```

```
## Loading required package: PerformanceAnalytics
```

```
##
## Attaching package: 'PerformanceAnalytics'
```

```
## The following objects are masked from 'package:timeDate':
##
##     kurtosis, skewness
```

```
## The following object is masked from 'package:graphics':
##
##     legend
```

```
p <- portfolio.spec(assets = colnames(returns.portfolio))
p
```

```
## **************************************************
## PortfolioAnalytics Portfolio Specification
## **************************************************
##
## Call:
## portfolio.spec(assets = colnames(returns.portfolio))
##
## Number of assets: 5
## Asset Names
## [1] "AKBNK" "AKSEN" "BJKAS" "MGROS" "NETAS"
```

Markowitz Optimization requires minimizing the variance of returns and maximizing returns of stocks.

```
p <- add.objective(portfolio = p, type = "risk", name = "var")
p <- add.constraint(portfolio = p, type = "full_investment")
```

In financial literature, *the full investment part* sets a constraint on the sum of the portfolio weights such that they always sum up to 1. This shows how much the investor cares about importance to the risk of the portfolio. Therefore, the optimization model returns portfolio weights that achieve the lowest possible portfolio variance. An additional constraint may be added to the optimization model.

```
p <- add.constraint(portfolio=p, type = "return",     return_target= 0.0005)
```

The return target is set to approximately 0.0005, which represents the total return average.

Modelling and Conclusion

```
require(ROI)
```

```
## Loading required package: ROI
```

```
## Registered S3 method overwritten by 'ROI':
##   method           from
##   print.constraint PortfolioAnalytics
```

```
## ROI: R Optimization Infrastructure
```

```
## Registered solver plugins: nlminb, glpk, quadprog.
```

```
## Default solver: auto.
```

```
##
## Attaching package: 'ROI'
```

```
## The following objects are masked from 'package:PortfolioAnalytics':
##
##     is.constraint, objective
```

```
require(ROI.plugin.quadprog)
```

```
## Loading required package: ROI.plugin.quadprog
```

```
require(ROI.plugin.glpk)
```

```
## Loading required package: ROI.plugin.glpk
```

```
optimize.portfolio(R=returns.portfolio, portfolio = p,
          optimize_method = "ROI", trace = TRUE)
```

```
## ***********************************
## PortfolioAnalytics Optimization
## ***********************************
##
## Call:
## optimize.portfolio(R = returns.portfolio, portfolio = p, optimize_method = "ROI",
##     trace = TRUE)
##
## Optimal Weights:
##  AKBNK  AKSEN  BJKAS  MGROS  NETAS
## 0.2032 0.3492 0.1041 0.2414 0.1022
##
## Objective Measure:
##  StdDev
## 0.01618
```

The optimal weights of stocks (AKBNK,AKSEN,BJKAS,MGROS,NETAS) under specified conditions are 0.2032, 0.3492, 0.1041, 0.2414, 0.1022 respectively.