FincAssignement

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Introduction

Portfolio Optimization : Portfolio optimization is the manner of choosing the first-class portfolio (asset distribution), out of the set of all portfolios being considered, in keeping with a few goal. The goal usually maximizes elements which includes anticipated go back and minimizes fees like monetary risk.

This represents the creation of a balanced portfolio, which implies a desire to distribute investment capital across a variety of assets. We will then balance these assets to achieve the desired risk and reward outcomes.

Portfolio optimization lead to what investors call a "performance portfolio". This means you get the highest possible return for the amount of risk you set. (Although the term is less common, it can refer to a portfolio that has the least level of risk to the return it seeks.)

```
library(quantmod)

## Warning: package 'quantmod' was built under R version 4.1.3

## Loading required package: xts

## Warning: package 'xts' was built under R version 4.1.3

## Loading required package: zoo

## Warning: package 'zoo' was built under R version 4.1.3

##
## Attaching package: 'zoo'

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

## Loading required package: TTR

## Warning: package 'TTR' was built under R version 4.1.3

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

library(ggplot2)

## Warning: package 'ggplot2' was built under R version 4.1.3
```

```
library(dplyr)

## Warning: package 'dplyr' was built under R version 4.1.3

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:xts':
##
##     first, last

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

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

Scope

Portfolio management involves creating and overseeing investment choices that will meet an investor's long-term financial goals and risk tolerance. Aggressive portfolio management requires the strategic buying and selling of stocks and other assets to perform better in the wider market.

The portfolio optimization industry is a thriving multi-billion dollar industry that has grown rapidly and is expected to double in size.

It is an opportunity for growth. The goal of portfolio optimization is to increase the manageability and attractiveness of your project portfolio. Achieving this goal requires the development of project transformation standards.

Relevance

The optimal portfolio is said to have the highest Sharpe ratio. It measures the excess return per unit of risk taken. Portfolio optimization is based on the Modern Portfolio Theory (MPT). MPT is based on the principle that investors want maximum returns with minimum risk. To do this, you need to make your selections taking into account how the assets in your portfolio perform in relation to each other. That is, it should have a low correlation. An optimal portfolio based on MPT is well-diversified to avoid conflicts when a particular asset or class of assets does not perform well.

Major advantages of portfolio optimization are maximizing returns, diversification, Identifying market opportunities.

Major Limitations of portfolio optimization are Frictionless markets, normal distributions, dynamic coefficients.

Methods : Mean Variance Optimization using simulation

Optimization is based on monthly statistics on the profitability of selected portfolio assets over a given time period. Optimization results do not predict which distribution will perform best after a given time period, nor do they predict the actual performance of a portfolio built using optimized asset weights.

we start with time series data. For financial assets, data is typically represented as S4 timeSeries objects in R. Financial time series data mainly consists of prices, indices and derivatives such as volatility, decline and returns. Rmetrics provides functions for calculating these derived series.

pros

The benefits of portfolio optimization can be explained by the following points:

Portfolio optimization helps you maximize your return on investment. This is done using an efficient frontier graph that represents the point at which the portfolio’s risk-return is highest. This point returns the optimal portfolio. Maximum returns increase investor satisfaction. Portfolio optimization helps you diversify your portfolio. Portfolio managers choose diversified portfolios so that one inefficient asset does not affect the entire portfolio. To select the optimal portfolio, portfolio managers do a lot of market research that helps them identify market opportunities before others do, which ultimately benefits their clients or investors

cons

The disadvantages of portfolio optimization can be explained by the following points:

Some of the assumptions portfolio managers make when choosing the optimal portfolio, such as frictionless markets, are not true. There are frictions, such as transaction costs, and other constraints that complicate the portfolio optimization process.

Another assumption made in the portfolio optimization process according to modern portfolio theory is that returns follow a normal distribution, but in practice returns can be skewed, kurtosis, etc. These assumptions can lead to loss by returning incorrect results. . There is always a risk of over-diversifying an asset, which can result in a marginal loss of expected return that exceeds the marginal benefit of risk reduction. Ultimately, this will reduce the investor’s return from the expected return on investment.

In our case, the data we’re working with is represented by a matrix of numbers, where each column represents asset data. A string belongs to a specific timestamp.

Portfolio Type : Tickers Optimization goal : Mean variance - Maximize sharpe ratio Time period : Month-to-Month

We calculated The vector of stock means and covariance matrix, weights before normalization, sharpe ratio, optimum portfolio and minimum variance portfolio optimum portfolio sharpe ratio should be highest minimum portfolio In this case port sigma(variance)is considered as risk should be minimum.

```
myMeanVar = function(ticks, begin_date, end_date, riskFreeRate){
  retout <- NULL
  retout <- xts(retout)
  for(i in 1:length(ticks)){
    prices = getSymbols(ticks[i], auto.assign = F)
    returns <- periodReturn(prices, period = "monthly",
                            type = "arithmetic")
    retout <- merge.xts(retout, returns)
  }
  colnames(retout) <- ticks
  retout <- retout['2014/2017']
  retout <- na.omit(retout)
  head(retout)
  meanret <- colMeans(retout,na.rm = T)
  x1 = round(meanret, 5)
  cat("The mean vector :\n")
  print(x1)
  covar <- var(retout)
  x2 = round(covar, 8)
  cat("The covariance matrix: \n")
  print(x2)
  set.seed(12)
  niter <- length(ticks)*100   # Set the number of iterations here

  randomnums <- data.frame(replicate(length(ticks), runif(niter, 1, 10)))

  cat("Check the weights before normalization...")
  head(randomnums)

  wt_sim <- randomnums / rowSums(randomnums)
  cat("The weights after normalization are in wt_sim...")
  head(wt_sim)

  weight <- matrix(data = NA, nrow = length(ticks), ncol = 1)
  Results <- matrix(data = NA, nrow = niter, ncol = length(ticks)+2)

  # Loop: each i is a portfolio
  for (i in 1:niter){

    # inner loop places weights into Results
    for (k in 1:length(ticks)) {
      Results[i,k] = weight[k,1] = wt_sim[i,k]
    }

    Results[i,length(ticks)+1] <- t(weight) %*% meanret                #
portfolio mean
```

```
    Results[i,length(ticks)+2] <- sqrt(t(weight) %*% covar %*% weight) #
portfolio sigma
  }

  colnames(Results) <- c(ticks, "PortMean", "PortSigma")
  Results <- as.data.frame(Results)
  head(Results)
  minmret = min(Results$PortMean)
  maxmret = max(Results$PortMean)
  seqmret = seq(round(minmret,3)-.001, maxmret+.001, .001)

  optim <- Results %>% mutate(portnumber = index(Results)) %>%
    mutate(ints = cut(PortMean ,breaks = seqmret),
           lower = as.numeric( sub("\\((.+),.*", "\\1", ints) )) %>%
    group_by(ints) %>%
    summarise( lowerval = min(lower),
               sig_optim = min(PortSigma),
               retn_optim = PortMean[which.min(PortSigma)],
               numb = length(PortSigma),
               portID=portnumber[which.min(PortSigma)])
  Sharpe_ratio = (optim$retn_optim-riskFreeRate)/optim$sig_optim
  optim$Sharpe_ratio <- Sharpe_ratio
  print(optim)
  Sp = (Results$PortMean-riskFreeRate)/Results$PortSigma #using Sharpe ratio
formula
  Results$Sp <- Sp #creating new column for sharpe ratio of each portfolio
  print(head(Results))
  w <- which.max(Results$Sp) #finding row with max value of Sharpe ratio
  max(Results$Sp)
  print("Optimum portfolio")
  print(Results[w,]) # Printing row with max sharpe ratio
  x <- which.min(Results$PortSigma)
  print("Min Variance Portfolio")
  print(Results[which.min(x),])
  return(list(Results, optim))
}
```

Data sets used in our report:

GE - General motors XOM - Exxon mobil corporation GBX - Greenbrier companies, Inc SBUX - Starbucks corporation PFE - Pfizer, Inc HMC - Honda motor company, LTd NVDA - NIVDIA corporation

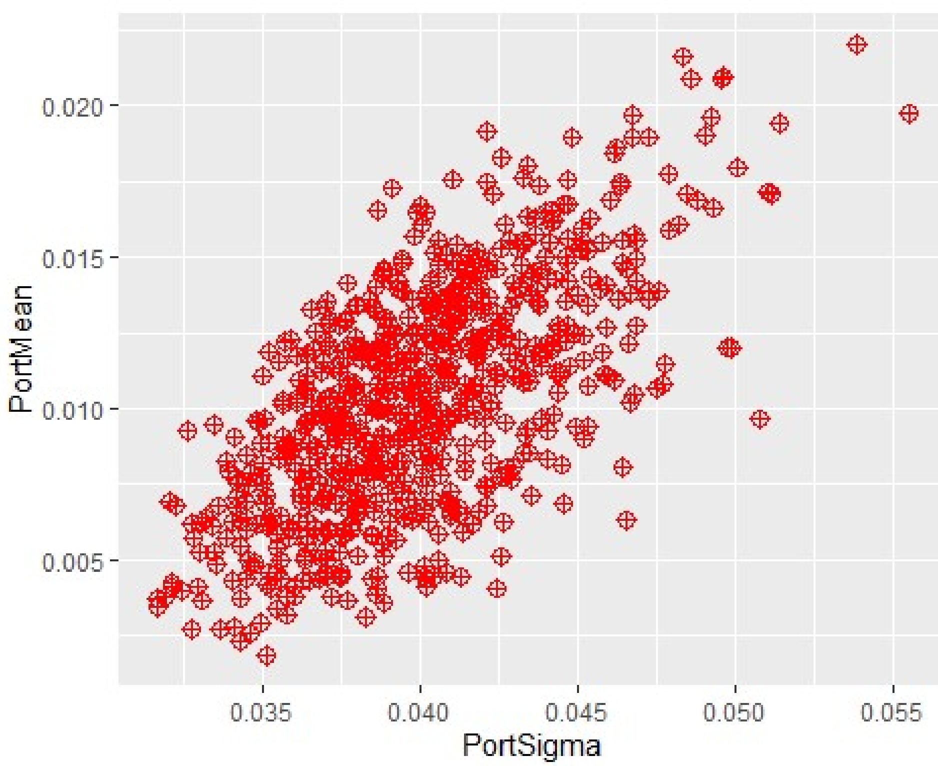
```
ticks <- c( "GE", "XOM", "GBX", "SBUX", "PFE", "HMC", "NVDA")
begin_date <- 20140101
end_date <- 20171231
riskFreeRate <- 0.02
final <- myMeanVar(ticks, begin_date, end_date, riskFreeRate)
```

```
## The mean vector :
##       GE      XOM      GBX     SBUX      PFE      HMC     NVDA
## -0.00837 -0.00314  0.01536  0.00902  0.00442 -0.00246  0.05817
## The covariance matrix:
##              GE        XOM        GBX       SBUX        PFE        HMC
## GE   0.00294255 0.00103470 0.00121121 0.00080728 0.00064653 0.00062168
## XOM  0.00103470 0.00168517 0.00162533 0.00023608 0.00053446 0.00020432
## GBX  0.00121121 0.00162533 0.01036163 0.00006399 0.00157675 0.00212741
## SBUX 0.00080728 0.00023608 0.00006399 0.00211533 0.00052364 0.00068028
## PFE  0.00064653 0.00053446 0.00157675 0.00052364 0.00188741 0.00083543
## HMC  0.00062168 0.00020432 0.00212741 0.00068028 0.00083543 0.00316065
## NVDA 0.00135432 0.00109161 0.00318265 0.00036711 0.00036748 0.00116384
##            NVDA
## GE   0.00135432
## XOM  0.00109161
## GBX  0.00318265
## SBUX 0.00036711
## PFE  0.00036748
## HMC  0.00116384
## NVDA 0.01112564
## Check the weights before normalization...The weights after normalization
are in wt_sim...# A tibble: 22 x 7
##    ints          lowerval sig_optim retn_optim  numb portID Sharpe_ratio
##    <fct>            <dbl>     <dbl>      <dbl> <int>  <int>        <dbl>
##  1 (0.001,0.002]    0.001    0.0351    0.00185     1    350       -0.517
##  2 (0.002,0.003]    0.002    0.0328    0.00272     6     76       -0.528
##  3 (0.003,0.004]    0.003    0.0317    0.00370    15    331       -0.515
##  4 (0.004,0.005]    0.004    0.0322    0.00411    38    309       -0.494
##  5 (0.005,0.006]    0.005    0.0328    0.00571    31    553       -0.435
##  6 (0.006,0.007]    0.006    0.0320    0.00695    58    190       -0.407
##  7 (0.007,0.008]    0.007    0.0339    0.00791    52    488       -0.356
##  8 (0.008,0.009]    0.008    0.0339    0.00825    57    195       -0.347
##  9 (0.009,0.01]     0.009    0.0326    0.00925    68    401       -0.329
## 10 (0.01,0.011]     0.01     0.0356    0.0102     61    682       -0.274
## # ... with 12 more rows
##            GE        XOM        GBX       SBUX       PFE        HMC
NVDA
## 1 0.04591352 0.12500521 0.11204062 0.14103162 0.2409166 0.20463972
0.1304527
## 2 0.17032874 0.09825230 0.16522497 0.17753802 0.1241027 0.19185299
0.0727003
## 3 0.22918285 0.03894855 0.24130303 0.05836888 0.1482585 0.11881530
0.1651229
## 4 0.09390609 0.21051359 0.07800949 0.03641164 0.2498903 0.08883252
0.2424364
## 5 0.07590857 0.19030177 0.25140423 0.10023674 0.1593137 0.08202033
0.1408146
## 6 0.03183638 0.12317640 0.22950334 0.17884515 0.1092784 0.11006486
0.2172955
##      PortMean  PortSigma          Sp
```

```
## 1 0.010364394 0.03713120 -0.25950161
## 2 0.006709984 0.03799179 -0.34981282
## 3 0.012159533 0.04662683 -0.16815356
## 4 0.015065803 0.04154418 -0.11876987
## 5 0.012226077 0.04463796 -0.17415499
## 6 0.017337207 0.04636429 -0.05743198
## [1] "Optimum portfolio"
##             GE         XOM        GBX       SBUX         PFE        HMC
NVDA
## 665 0.1029453 0.04604356 0.1778672 0.0452899 0.09125947 0.1931936
0.3434009
##       PortMean  PortSigma         Sp
## 665 0.02203604 0.05384175 0.03781531
## [1] "Min Variance Portfolio"
##            GE        XOM        GBX       SBUX        PFE        HMC       NVDA
## 1 0.04591352 0.1250052 0.1120406 0.1410316 0.2409166 0.2046397 0.1304527
##     PortMean PortSigma         Sp
## 1 0.01036439 0.0371312 -0.2595016
```

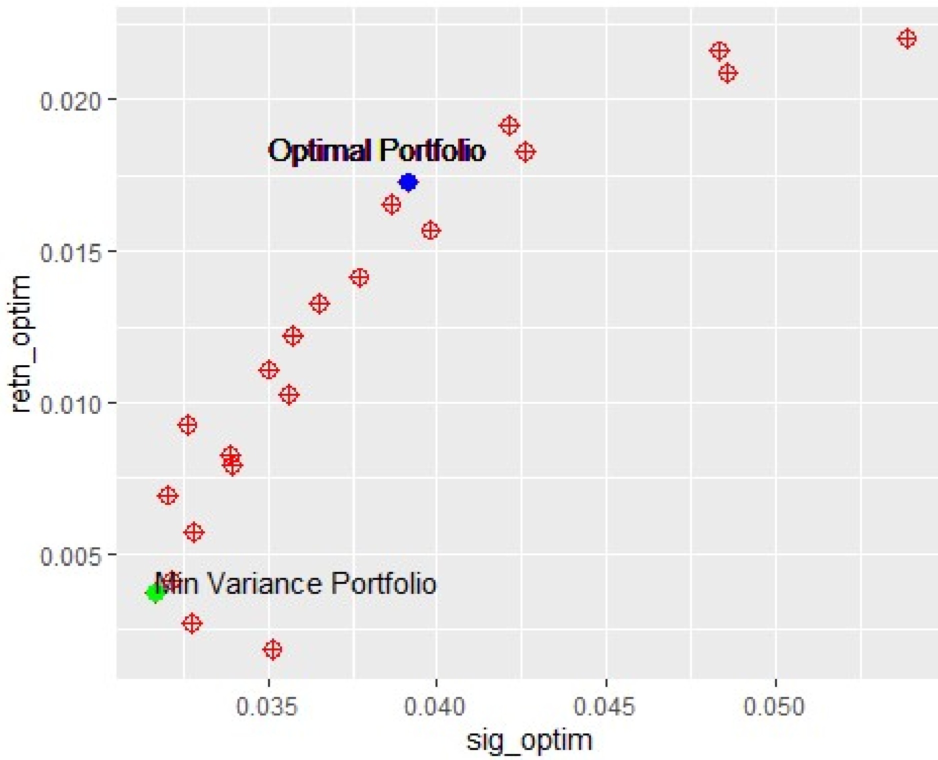
The below picture depicts all the portfolios Before optimization in a graph. Each point represents risk and return of a portfolio at that level

```
Results = data.frame(final[1])
Optimum = data.frame(final[2])
ggplot(data = Results , aes(x = PortSigma, y = PortMean)) +
  geom_point(pch = 10, colour = "red", size = 3)
```



An optimal portfolio is one that minimizes risk for a given level of return or maximizes return for a given level of risk. This means that risk and return cannot be considered separately. To get a higher return, you have to take a higher risk

```
ggplot(data = Optimum , aes(x = sig_optim, y = retn_optim)) +
  geom_point(pch = 10, colour = "red", size = 3) +
  geom_point(data=Optimum[which.min(Optimum$sig_optim),],
aes(x=sig_optim,y=retn_optim), color='Green',
size=3)+geom_text(data=Optimum[which.min(Optimum$sig_optim),], label="Min
Variance Portfolio", vjust=0,hjust=0)+
  geom_point(aes(x=0.03915,y=0.01725), color='Blue',
size=3)+geom_text(x=0.035,y=0.018, label="Optimal Portfolio",
vjust=0,hjust=0)
```



Looking at the chart above, we can see that there is a clear positive relationship between risk and return. The higher the risk you take, the higher the expected return and the lower the risk you take. it will be less your expectations of returns.

Conclusion

Portfolio optimization is a great tool for investors looking to maximize their risk/reward ratio. They can achieve this with the help of a good portfolio manager who can help them choose the best combination of high-risk and low-risk asset classes to reach a compromise. The choice is always based on risk appetite and the investor's expected return. Also, in conclusion, it's worth saying that each model or theory has its pros and cons, and with diligence, portfolio managers can get maximum benefit from portfolio maximization methods

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