

# Question 7: Portfolio Construction

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2022-11-26

```
knitr::opts_chunk$set(echo = FALSE, message = FALSE, warning = FALSE, fig.width = 6, fig.height = 5, fig.cap = " ")
# Note: Include = FALSE implies the code is executed, but not printed in your pdf.
# warning and message = FALSE implies ugly messages and warnings are removed from your pdf.
# These should be picked up when you execute the command chunks (code sections below) in your rmd, not in the pdf.

# load packages
pacman::p_load("tidyverse", "devtools", "rugarch", "rmgarch",
               "forecast", "tbl2xts", "lubridate", "PerformanceAnalytics",
               "ggthemes", "ks")
library(PortfolioAnalytics)

## Warning: package 'PortfolioAnalytics' was built under R version 4.2.2

## Loading required package: foreach

##
## Attaching package: 'foreach'

## The following objects are masked from 'package:purrr':
##
##   accumulate, when

library(TTR)
pacman::p_load("DEoptim", "ROI", "ROI.plugin.glpk", "ROI.plugin.quadprog")

# load functions
list.files('code/', full.names = T, recursive = T) %>% .[grepl('.R', .)] %>% as.list() %>% walk(~source(., encoding = "UTF-8"))

# load data, and see how this can be stored and later called from your 'data' folder.
MAA <- read_rds("data/MAA.rds")
MAA$Ticker <- gsub(" Index", "", MAA$Ticker)
msci <- read_rds("data/msci.rds") %>%
  filter(Name %in% c("MSCI_ACWI", "MSCI_USA", "MSCI_RE", "MSCI_Jap"))
```

## Introduction

To construct the portfolio using the PortfolioAnalytics package. I take into consideration the constraints on and requirements of the portfolio. I follow the vignette called 'Introduction to PortfolioAnalytics' by Ross Bennett, one of the package authors, and the package documentation to optimize this portfolio.

## Data

I then use the 'TTR' package to calculate returns for the combined data and filter the data for the last 20 years. I pad the data by looking back a maximum of 5 days to fill in missing values, this adds to ensure that each asset included has at least 3 years' of returns data.

I begin by join the two data sets and select tickers in order of asset class.

Col 1-3: Equity Col 4-5: Currency col 6-11: Bonds and Credit Col 12: Commodity

## Creating the Portfolio Object

I optimize each portfolio subject to the constraints below.

Requirements: Long-only strategy When using covariance and mean forecasts, use a look-back of less than 3 years Do not hold any assets with less than 3 years' returns data Apply Quarterly Re-balancing Limit exposure to Bonds and credit instruments at 25% Limit exposure to Equities at 60% Limit single asset exposure at 40%

## Setting up the portfolio

Initially I use the random sample method to optimize the portfolio. However, this produced different results each time the same code was run, even after using 'set.seed()'. I then opted for the ROI optimization method to solve each portfolio.

I create three different portfolios, the first two subject to asset exposure constraints and the last without asset exposure constraints. I proceed to run optimization on the four portfolios to Minimize Risk, Maximize Return and then Minimize Rijs without constraints. All positions in each portfolio is long only and all funds are invested (no cash holdings). Each portfolio is re-balance quartely and makes use of a rolling window = 90 days periods to calculate annulized returns.

## Minimize Risk

```
## *****  
## PortfolioAnalytics Optimization with Rebalancing  
## *****  
##  
## Call:  
## optimize.portfolio.rebalancing(R = q7_returns_data, portfolio = minrisk,  
##   optimize_method = "ROI", search_size = 100, trace = T, rp = NULL,  
##   rebalance_on = "quarters", training_period = NULL, rolling_window = 90)  
##  
## Number of rebalancing dates: 76  
## First rebalance date:
```

```
## [1] "2003-03-31"
## Last rebalance date:
## [1] "2021-10-29"
##
## Annualized Portfolio Rebalancing Return:
## [1] 0.01668808
##
## Annualized Portfolio Standard Deviation:
## [1] 0.022795
```

## Maximise Return

```
## *****
## PortfolioAnalytics Optimization with Rebalancing
## *****
##
## Call:
## optimize.portfolio.rebalancing(R = q7_returns_data, portfolio = maxret,
##   optimize_method = "ROI", search_size = 100, trace = T, rp = NULL,
##   rebalance_on = "quarters", training_period = NULL, rolling_window = 90)
##
## Number of rebalancing dates: 76
## First rebalance date:
## [1] "2003-03-31"
## Last rebalance date:
## [1] "2021-10-29"
##
## Annualized Portfolio Rebalancing Return:
## [1] 0.06223531
##
## Annualized Portfolio Standard Deviation:
## [1] 0.1020928
```

## Minimize Risk without Asset Exposure Constraints

```
## *****
## PortfolioAnalytics Optimization with Rebalancing
## *****
##
## Call:
## optimize.portfolio.rebalancing(R = q7_returns_data, portfolio = pspec_4,
##   optimize_method = "ROI", search_size = 100, trace = T, rp = NULL,
##   rebalance_on = "quarters", training_period = NULL, rolling_window = 90)
##
## Number of rebalancing dates: 76
## First rebalance date:
## [1] "2003-03-31"
## Last rebalance date:
## [1] "2021-10-29"
##
## Annualized Portfolio Rebalancing Return:
```

```
## [1] 0.02433584
##
## Annualized Portfolio Standard Deviation:
## [1] 0.04374746
```

## Discussion of Annualized Portfolio Results

### Minimize Risk

Asset exposure constraints with the objective of minimize risk, led to lower returns than if were to both minimize risk and maximize return, but a similar degree of risk.

Annualized Portfolio Rebalancing Return: 0.01790729 Annualized Portfolio Standard Deviation: 0.04286854

### Maximize Return

Asset exposure constraints with the objective of maximize return, led to higher returns compared to any of the other portfolio objectives. However, this type of optimization leads to a more than double increase in the risk calculated by standard deviation.

Annualized Portfolio Rebalancing Return: 0.06223531 Annualized Portfolio Standard Deviation: 0.1020928

### Minimize Risk without Asset Exposure Constraints

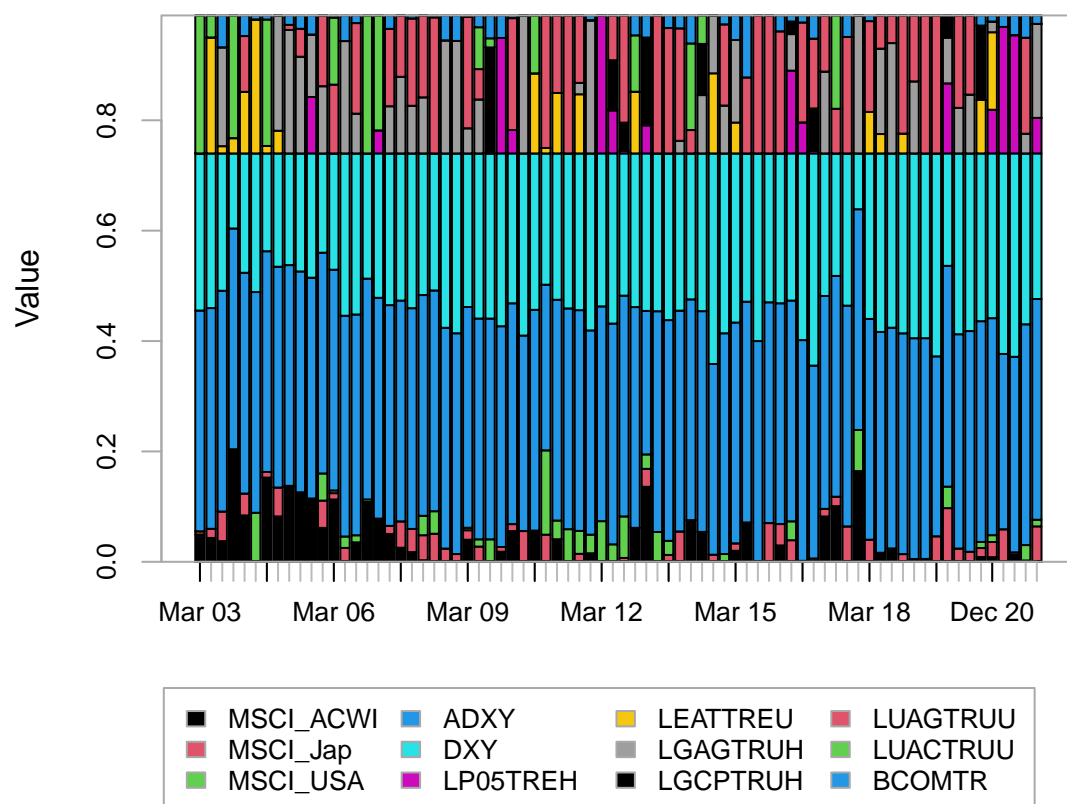
The portfolio with no asset exposure constraints that where I minimize risk, provides higher returns than the same portfolio subject to constraints but with a very similar level of risk.

Annualized Portfolio Rebalancing Return: 0.02433584 Annualized Portfolio Standard Deviation: 0.04374746

## Visualisation of Portfolios

For the risk minimized and return maximized portfolios with asset exposure constraints, the graphs below show the breakdown of weights as they adjust over time. For the risk minimized portfolio we can see large exposure to Asian and American currencies, this makes sense as the currencies of the two largest trading countries by GDP would be very stable given that many assets are Dollar denominated. Whereas the return maximizing Portfolio is weights equities and bonds exposure more heavily to achieve higher returns.

## Risk Minimized Portfolio: Rebalancing Weights



## Return Maximizing Portfolio: Rebalancing Weights

