PORTFOLIO OPTIMIZATION PROJECT

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Submitted to,
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Assignment 01

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Subject: AID – 562 AI for investment

Objective:

To analyze different stocks/bonds expost monthly returns to identify best combination which will yield optimum return in the future based on the data available.

Introduction:

In this study mainly bond market and stock market data is analyzed and analysis is mainly focused on the Indian scenario that is compared with the international market. Here, 10 years government bond is used as a Indian bond data, BSE data is used as a stock market index, US security bonds are used as a international bond and for international stock index NASDEQ data is used. The dataset contains data from 1st January, 2007 to 31st December,2021. Dataset is given in the attached zip file named "data.csv".

The main task in the given study is to create an optimum portfolio from given securities, and analyze the risk and return in the different situations.

Packages Used:

R programming language is used to analyze various portfolio. Some of the important packages namely **tseries, PortfolioAnalytics, quantmod, Quandl, DEoptim** and **stats** are used. You can directly access the dataset from Yahoo finance without downloading. For that use **IND10** ticker for Indian bond market data, **^BSESN** is used for Indian stock market data, **TLT** ticker for US/international bond market data and **^IXIC** ticker is used for US stock index data.

Analysis:

First of all, we are analyzing simple monthly return and risk of the four securities from 2007 to 2022.After analysis it has been seen that bonds have negative return in some small time period, where as stock market gives appreciable result of **10.04%** return at the risk of **22%.** Highest sharpe ratio is of international stock which gives **13.24%** return on just **17.60%** risk.

```
> comp1=cbind(mbonds,mbse,mibonds,mistocks)
> table.AnnualizedReturns(comp1)
                          mbonds   mbse monthly.returns mistocks
Annualized Return         -0.0116 0.1004          0.0657   0.1324
Annualized Std Dev         0.1360 0.2259          0.1361   0.1760
Annualized Sharpe (Rf=0%) -0.0853 0.4445          0.4829   0.7521
```

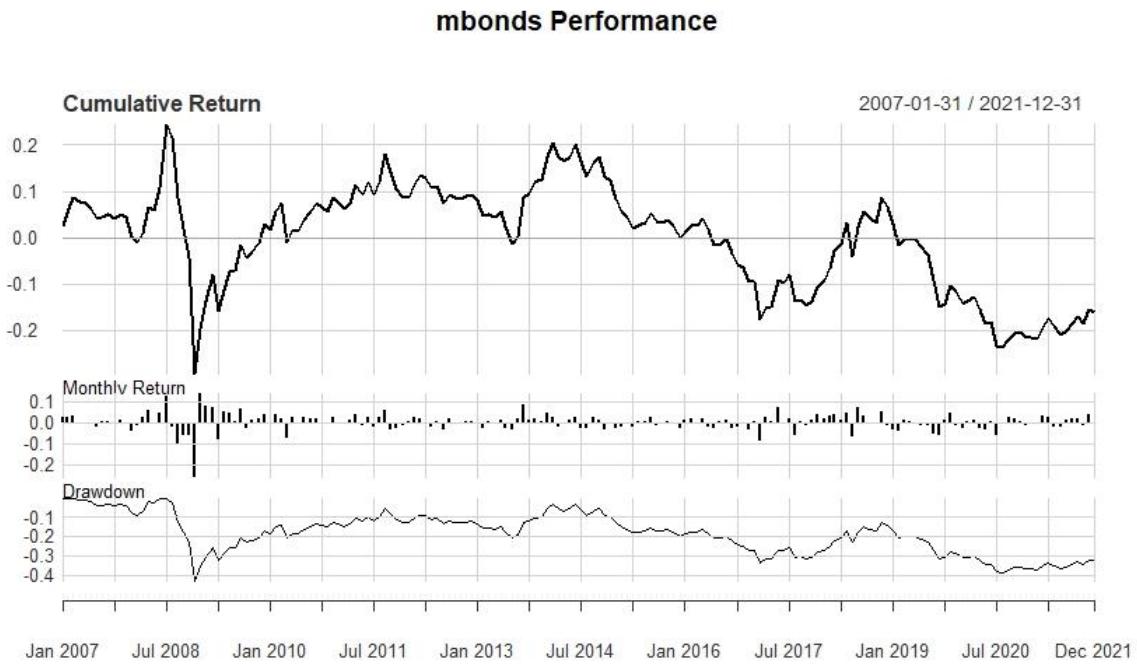

Figure 1 Indian bond market performance from year 2007 to 2021

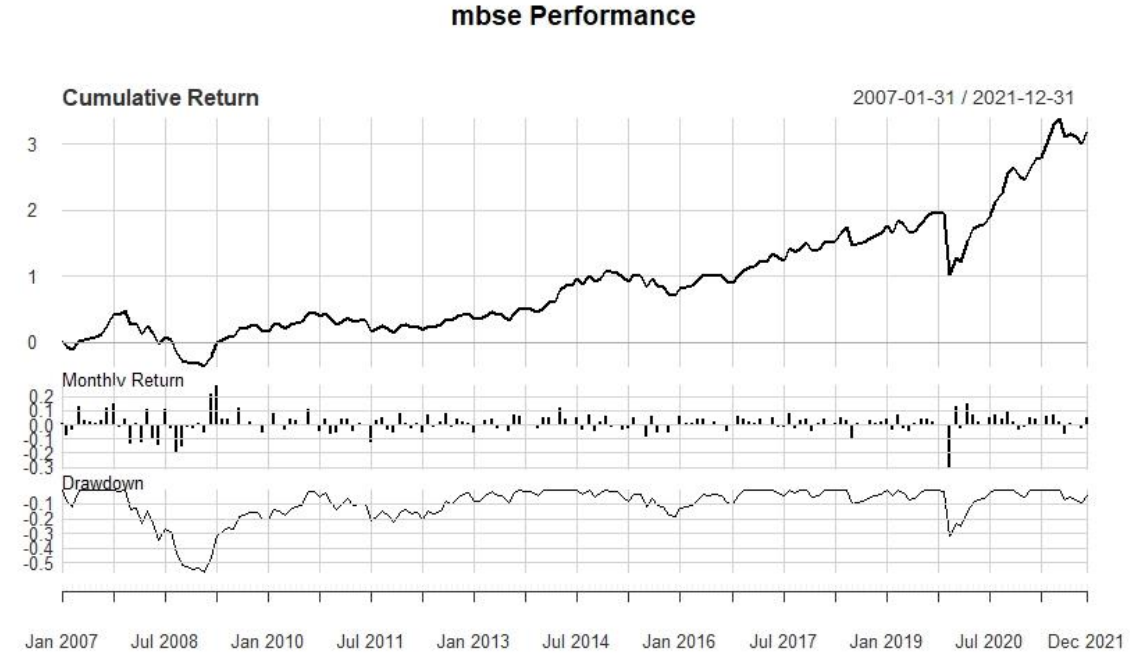

Figure 2 Indian Stock market (BSE) performance from year 2007 to 2021

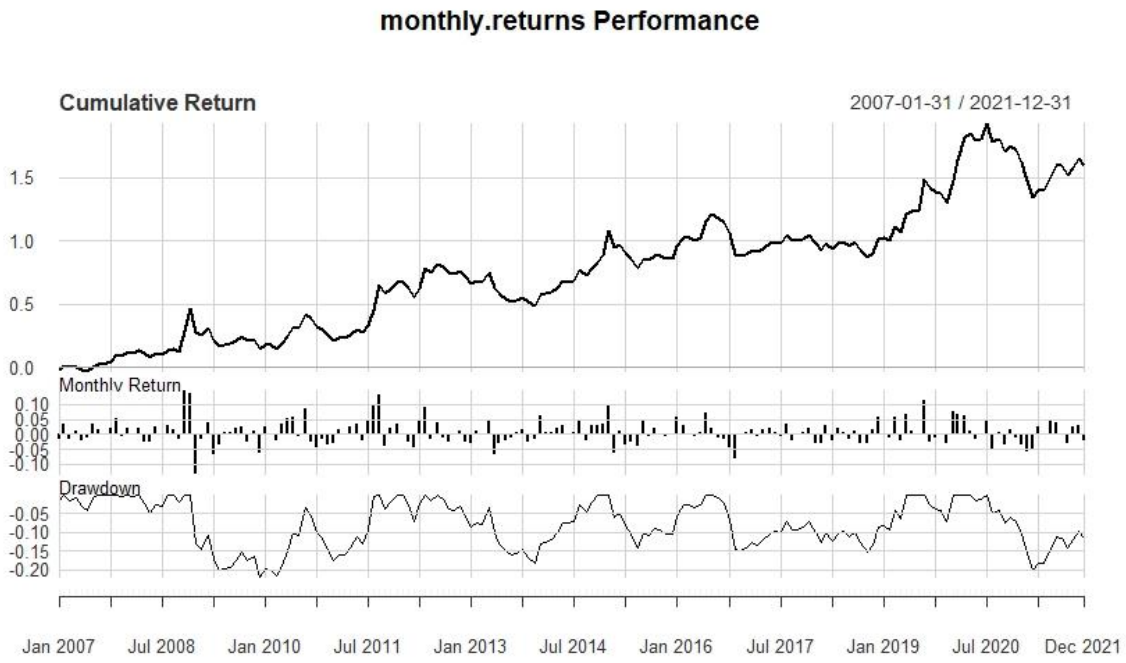

Figure 3 International bond market performance from year 2007 to 2021

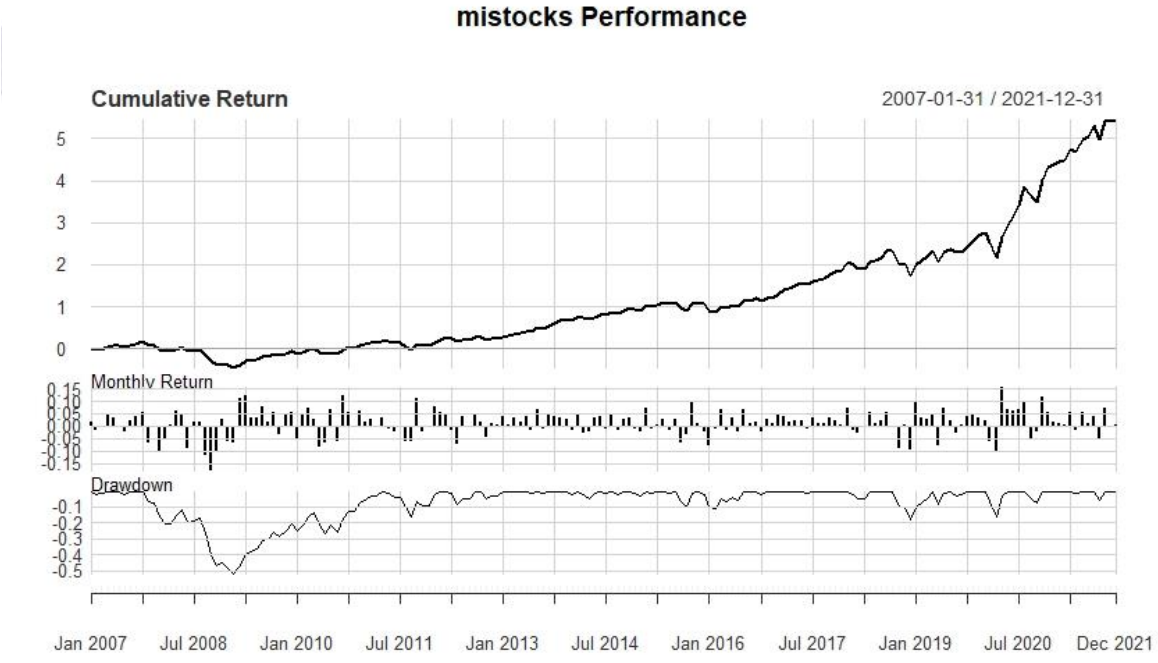

Figure 4 International stock market (US) performance from year 2007 to 2021

Above graph shown three result, cumulative return which gives trend of the price, monthly return and drawdown which indicates how much volatile a particular security is, high drawdown implies high volatile security. A drawdown refers to **how much an investment or trading account is down from the peak before it recovers back to the peak**.

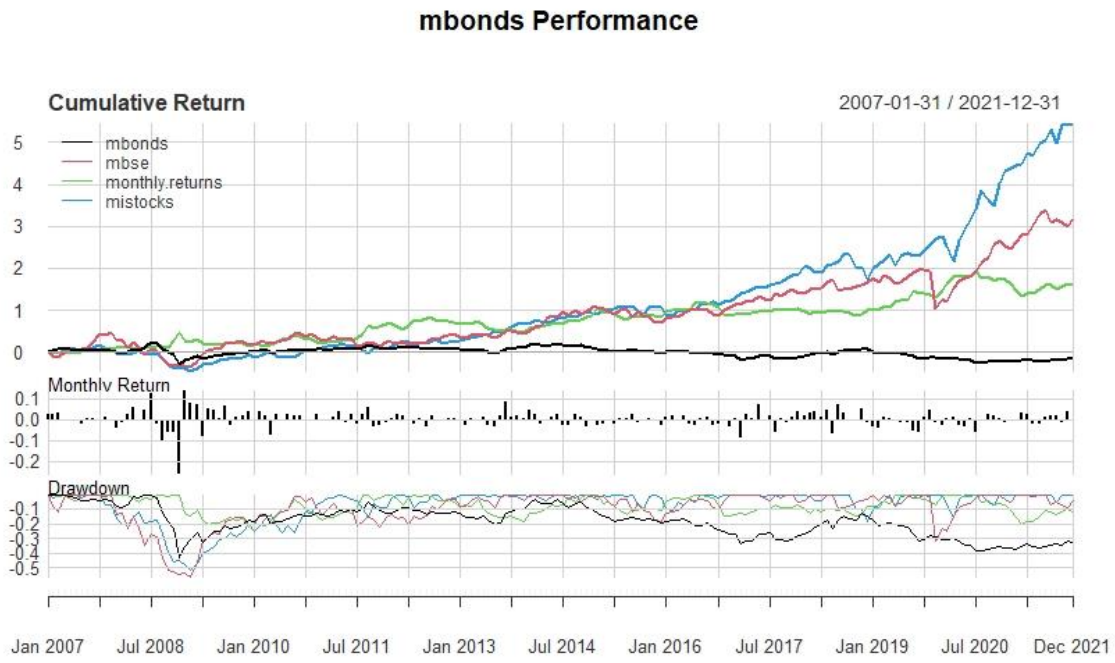

Figure 5 Performance comparison of all four securities from year 2007 to 2021

Normality test:

We have assume that all the data are normaly distributed and analyse it but in the actual position, it is not true in every case. To test whether our data is normally distribued or not we may use some of the basic statistics, such as mean, median, skewness, kurtosis etc or we can use statistical test such as Jarqubera test.

```
> print(df)
                   Factor         value
1           skewness-bond -1.380820e+00
2          skewness-stock -3.967606e-01
3       skewness_int-bond  5.663646e-01
4      skewness_int-stock -4.578356e-01
5          kurtosis-bonds  1.071921e+01
6          kurtosis_stock  4.627369e+00
7       kurtosis_int-bond  1.787947e+00
8      kurtosis_int-stock  8.253708e-01
9    p-value_JBtest_bonds  0.000000e+00
10  p-value_JBtest_stocks  0.000000e+00
11  p-value_JBtest_ibonds  5.059733e-08
12 p-value_JBtest_istocks  3.349847e-03
```

All the values indicate that data is not normally distributed, that can be seen in the distribution graph also.

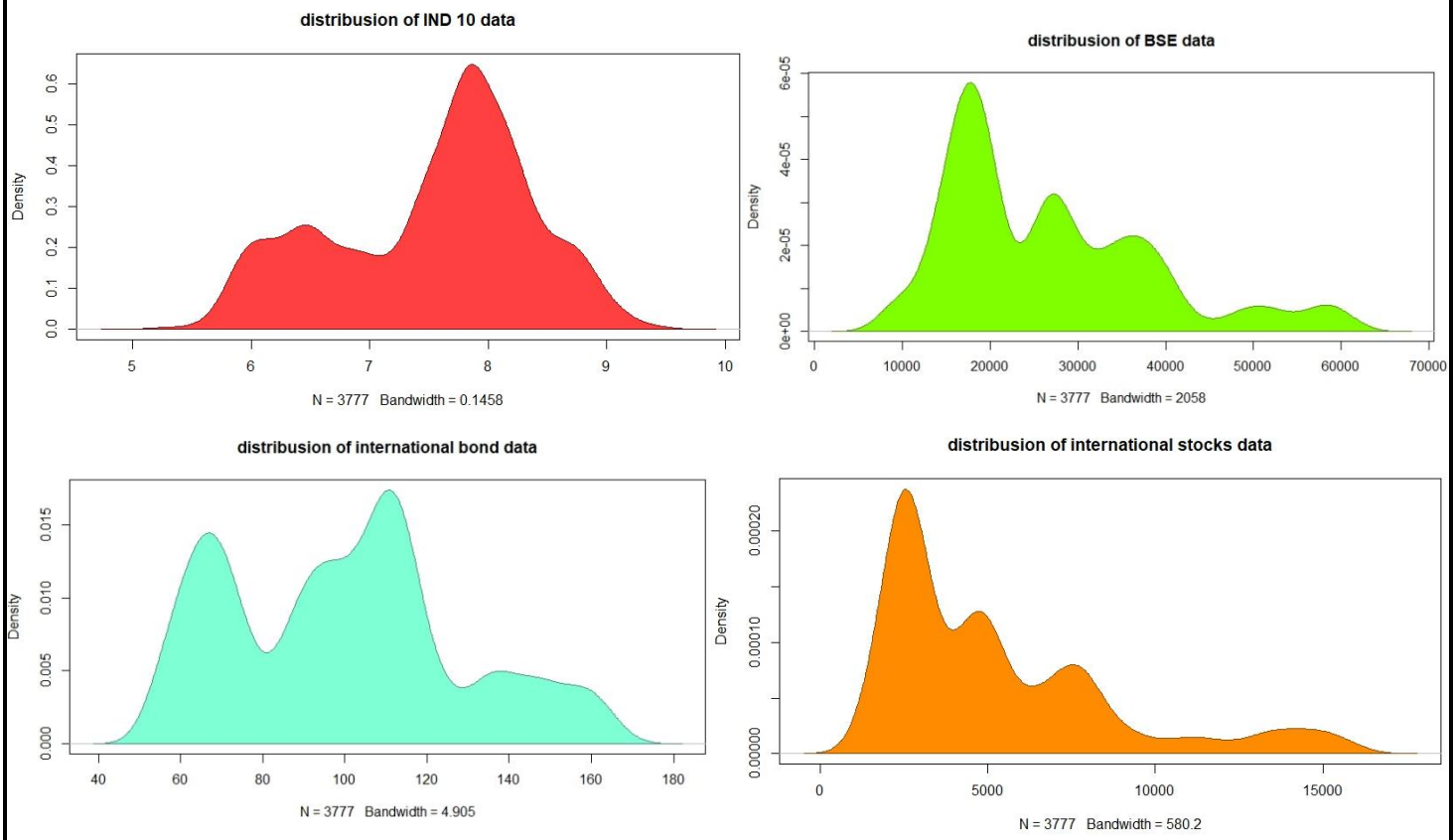

Figure 6 Distribution of data given

```
> mmain = cbind(mbonds,mbse,mibonds,mistocks)
> macov = cov(mmain)
> macov
                    mbonds         mbse monthly.returns      mistocks
mbonds          0.0015409560 0.0003191533   -0.0003775518  0.0000399808
mbse            0.0003191533 0.0042520112    0.0001803319  0.0006167001
monthly.returns -0.0003775518 0.0001803319    0.0015438724 -0.0006183174
mistocks        0.0000399808 0.0006167001   -0.0006183174  0.0025826227
>
> #corr
> macor=cor(mmain)
> macor
                   mbonds       mbse monthly.returns   mistocks
mbonds          1.0000000 0.12468292     -0.24477988  0.0200413
mbse            0.1246829 1.00000000      0.07038331  0.1861000
monthly.returns -0.2447799 0.07038331      1.00000000 -0.3096530
mistocks        0.0200413 0.18609998     -0.30965298  1.0000000
```

From the variance co-variance matrix, it has been seen that Indian bonds returns and US bonds returns are negatively corelated with each other. Not only that US bonds and stocks are also negatively correlated with each other. As per the Marcowitz methods, for reducing the diversifiable risk negatively correlated securities should be added. So, this combination will give a batter result as compare to another portfolio.

Portfolio optimization:

For efficient portfolio we have to allocate funds in such a manner that it can either give maximum return or minimize risk or both. So, we have to calculate the weights with different constrains of maximum return, minimum risk.

Initially we have assigned equal weights to all the assets, which is known as naïve approach of weight allocation. Different standardized methods such as **Roche global** and **Bogle** method are applied in which a predefined weights for four securities are mentioned. Results indicates that in our case naïve and roche method work similarly whereas bogle method gives very volatile and gives lower return as compare to rest of the methods.

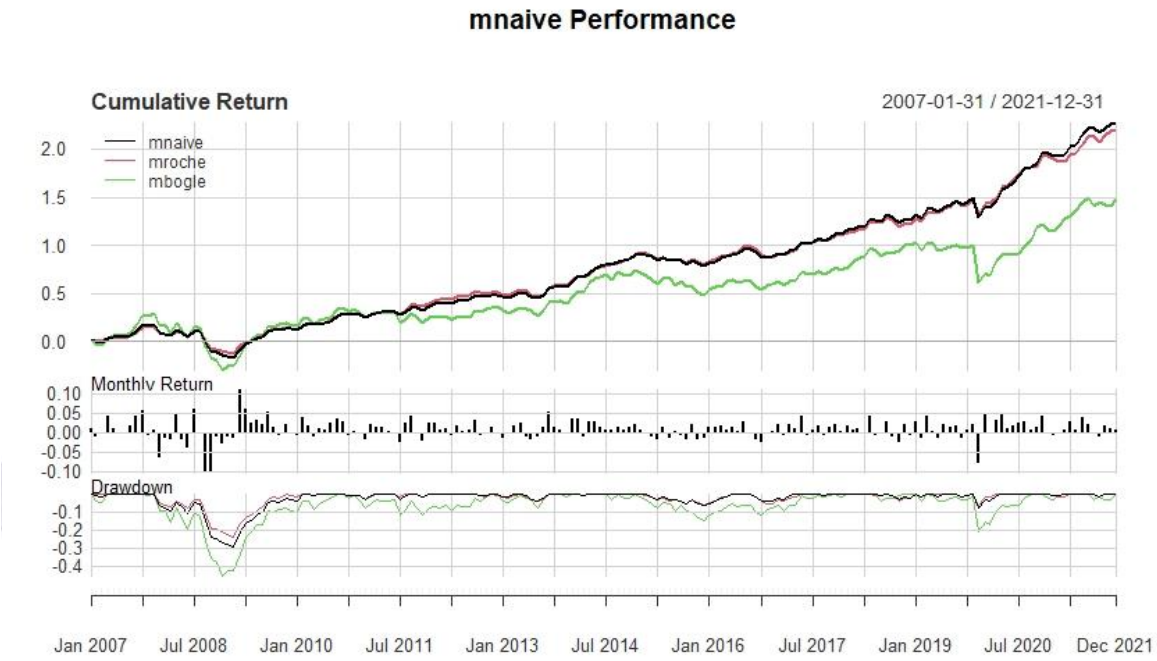

Figure 7 Performance comparison of naive, roche and bogle method

We can also determine the optimal weights by simulation with different constrains. Here we have used for constrains including min variance, max return, min variance with max return and min VaR with max return and compare the result with naïve approach. Results indicates that max return constrain gives best result in the long run, but it is high volatile in nature. Naïve gives slow and steady returns

```
> #####
> #Comparision
> comp3 = cbind(mnaivew,mport1w,mport2w,mport3w,mport4w)
> comp3
         mnaivew mport1w mport2w mport3w mport4w
mbonds      0.25   0.004   0.262   0.218   0.332
mstocks     0.25   0.972   0.002   0.000   0.096
mibonds     0.25   0.014   0.468   0.508   0.536
mistocks    0.25   0.016   0.266   0.264   0.040
>
> # 4.3.5. Optimized Portfolios Backtesting Comparison
> mportcomp = cbind(mnaive["2015-01-31::"],mport1,mport2,mport3,mport4)
> table.AnnualizedReturns(mportcomp)
                          mnaive mport1 mport2 mport3 mport4
Annualized Return         0.0810 0.1097 0.0605 0.0628 0.0277
Annualized Std Dev        0.0696 0.1889 0.0663 0.0683 0.0735
Annualized Sharpe (Rf=0%) 1.1631 0.5808 0.9127 0.9192 0.3773
> charts.PerformanceSummary(mportcomp)
```

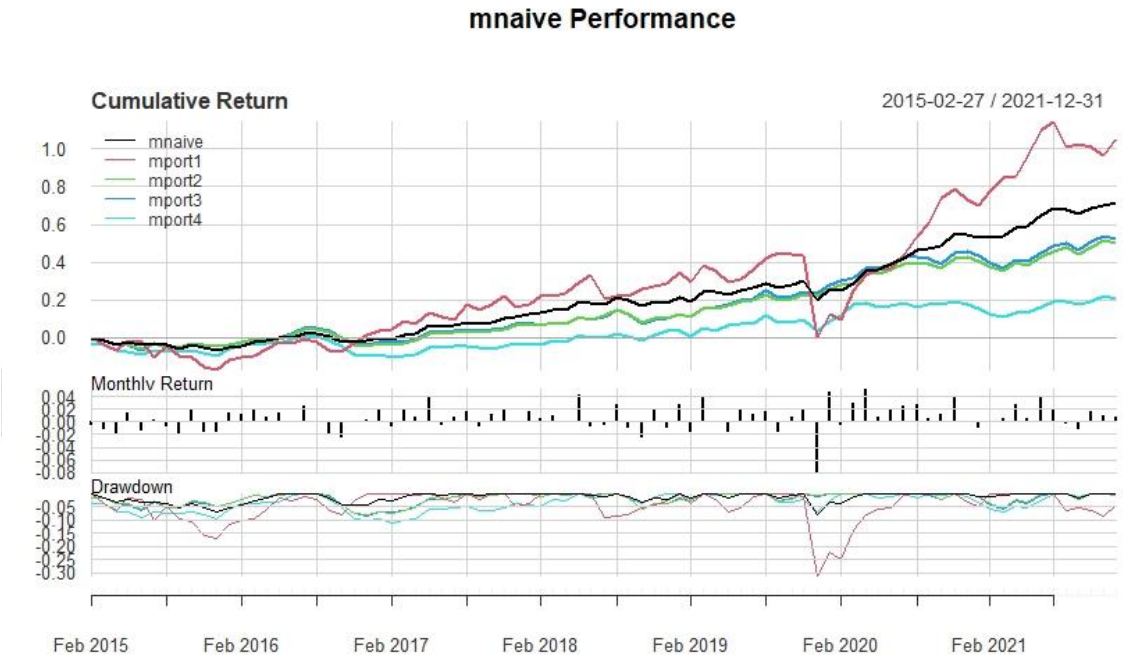

Figure 8 Performance comparison of different conditions with naive approach

Conclusion:

BSE index gives highest return in context of Indian stock market analysis whereas international is included then US stocks will dominate the results and gives considerable higher return with tolerable risk. If an efficient portfolio is made using the given four asset, then best and easy way which gives very good return is to allocate the money equally to all four assets i.e., the naïve approach but if you are a risk-taking person than you can go with the weight allocation mentioned in the first portfolio optimization method.