ISDS 570 Group Project
MV Portfolio Optimization

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Executive Summary

This report briefly overviews how to optimize Mean-Variance (MV) for selected tickers. The tickers are based on the Last Name and first spelling of all the team members of Group 1. The primary purpose of conducting this process is to check ticker performance against the standard SP500TR index. The selected time frame is five years, i.e., from 12-31-2016 to 03-26-2021. We backtest the portfolio in the final section using available data from the quarter of 2021.

To estimate stock performance, we have calculated cumulative return. The cumulative return provides a concise measure of the overall profitability of an investment or portfolio over a specific period, representing the total percentage gain or loss during that time. It serves as a critical indicator of performance, allowing investors to assess the success of their investments and compare them to market benchmarks.

Using the ROI method (Risk-Optimized Investment), we have accurately calculated the optimal weight for each ticker to minimize risk and maximize returns. The weight assigned to each stock precisely represents the proportion of the total investment strategically allocated within the portfolio.

In our conclusion, our optimized portfolio closely tracked the SP500TR index from the selected timeframe with only slight variations. While our portfolio demonstrated consistent outperformance in the early months, the SP500TR index performed better last month, resulting in a temporary overlap. Our portfolio exhibited lower volatility and more excellent stability, with a lower standard deviation and annualized return than the SP500TR index. These findings suggest the potential value of utilizing our portfolio's results for future enhancements and developing effective investment strategies.

Introduction

This project aims to optimize Mean-Variance (MV) portfolio for selected tickers. Tickers selected are based on criteria that tickers have to start with the first letter of the last name of group members (Exhibit 1).

We consider three scopes to perform the operations. The first scope we consider to calculate cumulative return is based on five years. I.e., 2016 to 2020. The second scope of the project is to calculate the optimal weight for the portfolio. I.e., from 2016 to 03-26-2021. The final scope of the project is the first quarter of 2021. The reason to do this is to compare the SP500TR (Standard and Poor Index of Top 500 Companies in the USA) performance from 5 years to the latest 2021 first quarter.

Our goal is to offer a cumulative return chart for chosen tickers, an optimized weight for each portfolio, and to present cumulative return and annualized data for the optimized portfolio and SP500TR index for 2021.

Background

The project involves extracting, processing, and loading data from 2016 through 2021 (until March 26) using PostgreSQL, pgAdmin, and RStudio. Historical data is extracted from the Yahoo Finance Platform (Yahoo! (n.d.)) and uploaded to specific tables in the stock market database. We then created a custom calendar for the specified period, including the last day of 2015. The calendar we've designed marks trading days with a "1," while non-trading days, encompassing weekends and holidays, are flagged with a "0". Various R packages, including reshape2, zoo, and PerformanceAnalytics, are used in our analysis. The MV portfolio optimization hinges on the selection of 15 stock tickers. In our data evaluation, the SP500TR Index has been utilized.

Objective

The main objective of this project is to understand the Extract, Transform, and Load (ETL) process to help the industry to make better-informed decisions. Through this process, we aim to optimize Mean-Variance (MV) portfolio for selected tickers and spread/ minimize risk by calculating the optimal weight of all our portfolios.

Technical Analysis

Tools

RStudio: RStudio is a unified development platform for R, a programming language specifically designed for statistical analysis and graphical representation (Aleshunas, n.d.).

PostgreSQL: PostgreSQL is a powerful, open-source object-relational database system with over 35 years of active development that has earned it a strong reputation for reliability, feature robustness, and performance (Group, 2023).

Excel: A spreadsheet tool used for data manipulation, calculations, and visualization (Gillis, 2021).

ETL Process

Data Extraction: The initial phase of our ETL process involves extracting data from diverse sources. In this project, the data sources are Yahoo Finance and Quandl, providing us with stock-related information from the last day of 2015 (December 31) to March 26, 2021. To sort through this data successfully, we developed a unique calendar system that clearly demarcates trading days from non-trading days, including weekends and public holidays.

To ensure a smooth and effective extraction, we used RStudio packages such as "PortfolioAnalytics" and "PerformanceAnalytics". These tools allowed us to extract the data set from our custom calendar, preparing it for the next stages of the ETL process.

Data Transformation: Transformation is the second key stage in the ETL process, where the raw data undergoes a series of alterations to meet our specific requirements. This stage involved two primary activities: data cleansing and data enrichment.

The data cleansing activity ensured the removal of any inaccuracies or inconsistencies within the data, eliminating duplicates and filling in any gaps in the data.

During the data enrichment activity, we expanded our dataset by incorporating an additional "SP500TR" column in the ticker segment, with its volume preset at '0'. This ticker column represents the Standard and Poor's Index of Top 500 Companies in the USA, which served as our benchmark for later assessments. Furthermore, we designed two vectors, one for the custom calendar and the other for the SP500TR data, to aid our subsequent data handling and analysis.

Data Loading: The final stage of the ETL process is data loading, which involves integrating the refined data into a designated system for subsequent analysis. We chose R as this system for our project, given its superior statistical analysis abilities.

Once we compiled all the necessary information, such as the daily returns, we fed this data into R for further analysis. This marked the culmination of the ETL process, setting the groundwork for the comprehensive analysis that would follow and enabling us to derive meaningful insights from the MV portfolio optimization.

Minimum Acceptable Return (MAR)

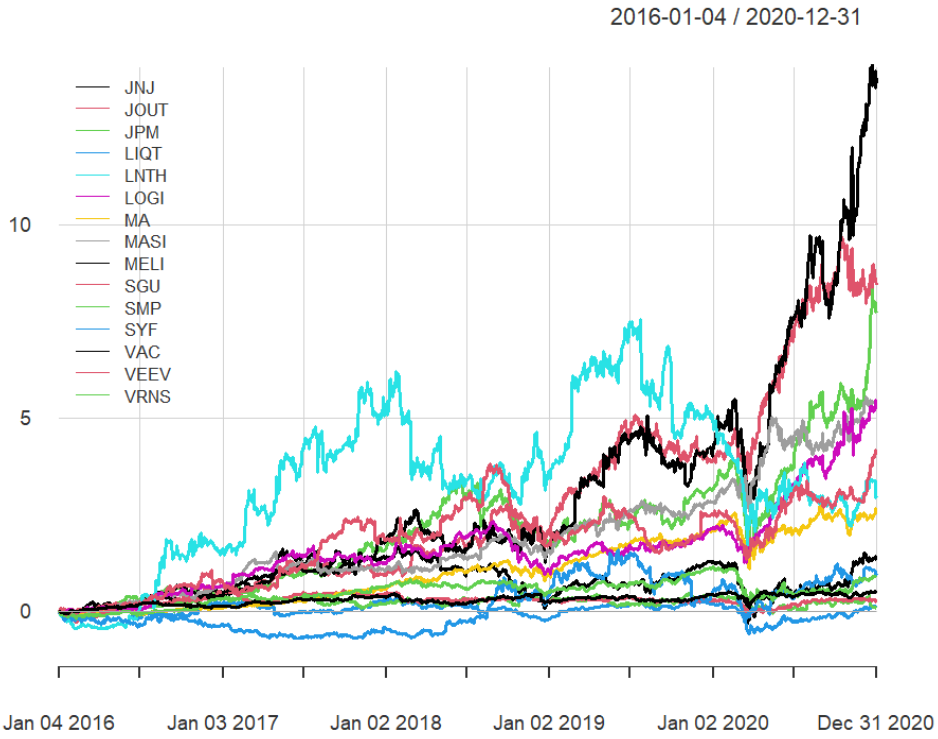
MAR is the daily return the portfolio aims to achieve at a minimum as part of the portfolio optimization process. If the portfolio's expected return falls below this level, the optimization algorithm will adjust the portfolio weights until this target return is met. If the daily return of any stock in the portfolio consistently falls below this value (0.06365513%), the portfolio manager or investor might seek to adjust the portfolio. The adjustment could be reducing the allocation of the underperforming stocks or even removing them entirely. The specific action would depend on the portfolio strategy and the risk tolerance of the investor or portfolio manager.

Cumulative return chart(2016-2020)

When calculating the return on investment, we calculate the aggregate amount the investment has lost or gained within the defined period. We visualize the time series data using a chart to show how much the investment has grown or lessened.

Higher returns suggest stocks are usually associated with higher risk, so a stock with a very high return may also have experienced significant volatility. Also, past performance is not necessarily indicative of future results.

Chat 1: Cumulative return chart for selected tickers



*Please Refer to Exhibit 1.

Stocks like Johnson & Johnson (JNJ), JPMorgan Chase & Co (JPM), and Marriott Vacations Worldwide Corp (VAC) have cumulative returns ranging from around 0.5321 to 1.4095, meaning they have increased in value by approximately 53.21% to 140.95% over the period in 2016 to 2020.

Other stocks like Mastercard Incorporated (MA), Logitech International S.A. (LOGI), Masimo Corporation (MASI), MercadoLibre Inc (MELI), Veeva Systems Inc (VEEV), and Varonis Systems Inc (VRNS) have seen substantial increases, with cumulative returns ranging from about 2.6662 to 13.6512, or a 26.67% to 1365.12% increase.

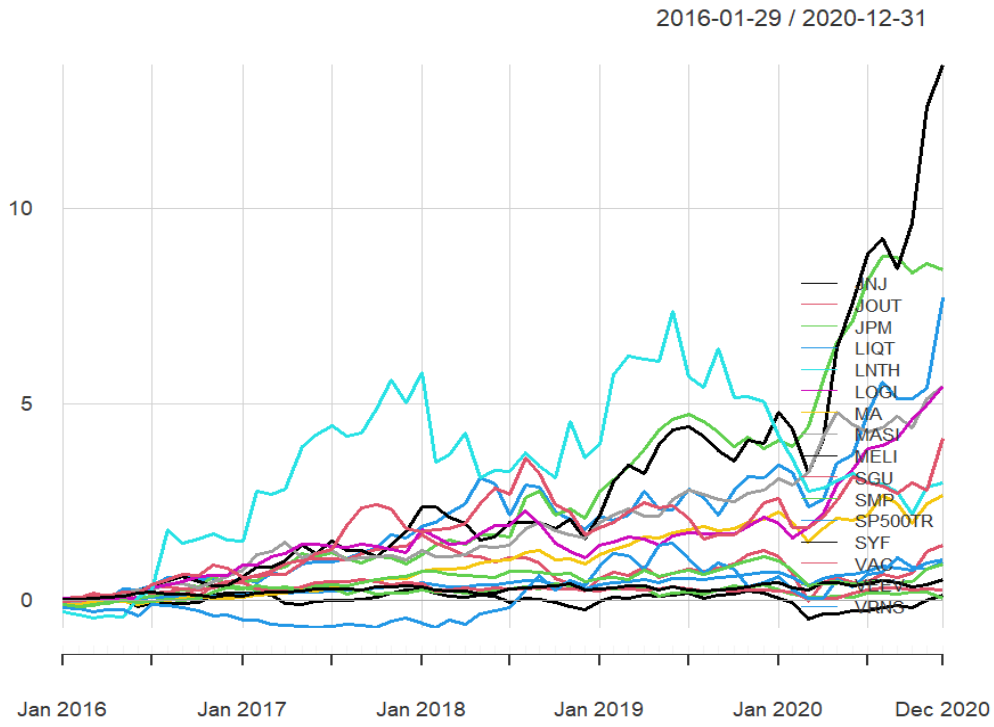
Some stocks, such as Standard Motor Products, Inc. (SMP), Synchrony Financial (SYF), and Star Group LP (SGU), have seen less growth or even decreased in value, as indicated by their lower cumulative returns, ranging from approximately 0.0633 to 0.2647, or a 6.33% to 26.48% increase.

Chat 2: Cumulative return chart SP500TR

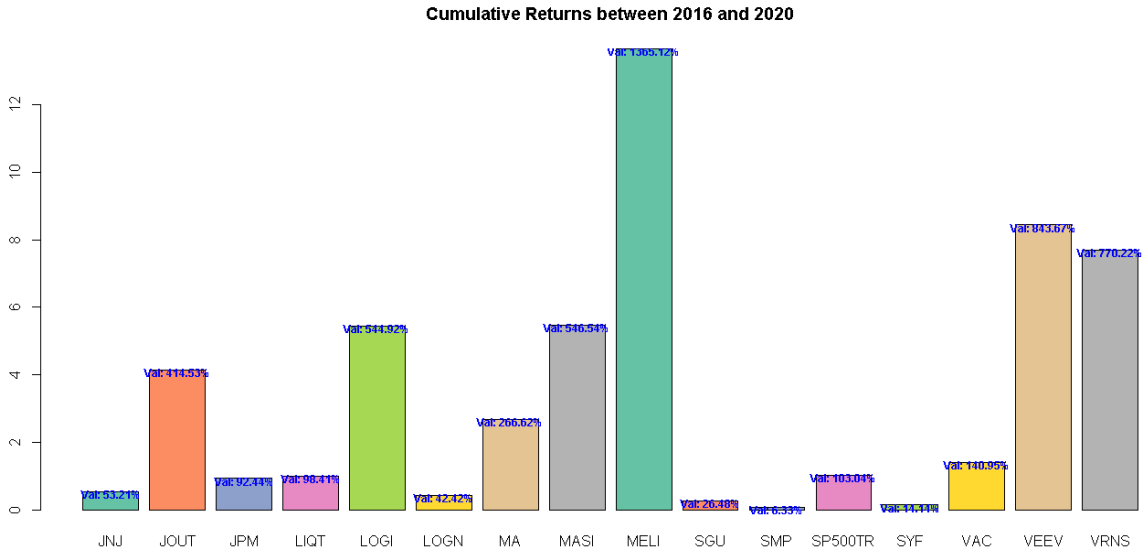
*Please Refer to Exhibit 1.

The SP500TR index is a benchmark of the overall U.S. stock market. Results indicate SP500TR index has a cumulative return of approximately 1.0304 or a 103.04% increase over the same period.

Charts 3 & 4: Cumulative return chart



*Please Refer to Exhibit 1.



*Please Refer to Exhibit 1.

The cumulative returns of the tickers compared to the S&P 500 Total Return (SP500TR) index indicates how each stock has performed relative to the overall market.

Based on results, Tickers such as Johnson & Johnson (JNJ), JPMorgan Chase & Co (JPM), and Marriott Vacations Worldwide Corp (VAC) have performed positively but at a lower level compared to the overall market represented by the index.

Stocks like Logitech International SA (LOGI), Masimo Corporation(MASI), and MercadoLibre Inc (MELI) have significantly higher cumulative returns suggesting that these stocks have experienced substantial growth and have outperformed the SP500TR index over the given period.

Extra Assessment on Cumulative Return (Based on Inflation Rate)

The best assessment method for investment is to compare its earnings with the inflation rate. Excluding inflation from the earnings will show the actual return on investment.

The cumulative US inflation rate between 2016 and 2020: 9.18% (Exhibit 2). The cumulative US interest (average yield) rate between 2016 and 2020: 5.82% (Exhibit 3).

Another instrument is to compare the earnings with the cumulative average yielded interest rate of FED within the defined period. This number shows the minimum percentage of earnings per investment in the safest way possible. As this interest rate indicates borrowing costs between banks, your earnings must be significantly above this percentage according to the level of risk you have taken.

The other pivotal instrument to evaluate stock exchange earnings is comparing it with general stock indexes like SP500TR. These indexes show us the general positioning of the market.

JNJ (Johnson & Johnson) has generated a solid 60.87% earnings for its investors. This return significantly surpasses the cumulative inflation rate during the period from 2016 to 2020. However, when compared to the performance of the SP500TR ns are relatively lower. Nonetheless, investors earned a respectable profit with this stock.

JOUT (Johnson Outdoors Inc) has created an outstanding 221.12% earnings for its investors. This exceptional return far surpasses the cumulative inflation rate over the same period. However, it is essential to note that JOUT's performance is still below that of the SP500TR index. Despite this, investors have earned a substantial profit with JOUT.

JPM (JPMorgan Chase & Co) has delivered a remarkable 87.59% earnings for its investors. This return is significantly higher than the cumulative inflation rate, demonstrating the value generated by this stock. While JPM's performance falls slightly below that of the SP500TR index, investors have substantially profited from this investment.

LIQT (LiqTech International, Inc) has created a modest 32.21% earnings for its investors. Although this return nearly tripled the cumulative inflation rate, it is approximately a quarter of the income generated by the SP500TR index. Investors in LIQT have earned a reasonable profit, but more lucrative options may have been available.

LNTH (Lantheus Holdings, Inc) has produced a solid 58.33% earnings for its investors. This return outperforms the cumulative inflation rate, indicating a positive real money value. However, it falls short compared to the performance of the SP500TR index. Despite this, investors in LNTH have achieved a respectable profit.

LOGI (Logitech International S.A) has generated an impressive 156.85% earnings for its investors. This return significantly exceeds the cumulative inflation rate and reflects a substantial profit. Although LOGI's performance is slightly lower than that of the SP500TR index, investors have earned a notable profit with this stock.

MA (Mastercard Incorporated) has delivered an exceptional 269.95% earnings for its investors. This outstanding return surpasses the cumulative inflation rate by a significant margin. However, it is important to note that MA's performance is slightly below that of the SP500TR index. Despite this, investors in MA have earned a substantial profit.

MASI (Masimo Corporation) has created an impressive 110.61% earnings for its investors. This return significantly exceeds the cumulative inflation rate, indicating a substantial profit. Although MASI's performance is slightly below that of the SP500TR index, investors have earned a significant profit with this stock.

MELI (MercadoLibre, Inc) has delivered its investors an outstanding 239.35% earnings. This exceptional return significantly surpasses the cumulative inflation rate, indicating a substantial profit. However, it falls slightly below the performance of the SP500TR index. Nonetheless, investors in MELI have achieved a remarkable profit.

SGU (Star Group, L.P) has created a modest 26.48% earnings for its investors. Even though the generated income percentage has almost tripled the cumulative inflation rate between 2016 and 2020, it is approximately a quarter of the income generated by the SP500TR. The investors of SGU have earned a modest profit, but the market performed much better than this stock.

SMP (Standard Motor Products, Inc) has generated a disappointing 6.33% earnings for its investors. This return is even worse than the cumulative inflation rate, indicating a loss in real money value. By comparing it with the cumulative interest rate of 5.82%, we can easily understand that SMP was a very poor investment decision for its investors. By investing in SMP, they have lost 2.85% in real money value (9.18% - 6.33%).

SYF (Synchrony Financial) has created a modest 14.14% earnings for its investors. While this return is higher than the cumulative inflation rate within the period, it falls significantly short when compared to the performance of the SP500TR index. Even from the cumulative interest rate perspective, SYF's performance is unsatisfactory. Investors in SYF have earned a modest profit, but better-performing options were available in the market.

Weights of optimized portfolio

The weights represent the proportion of the total investment allocated to each stock in the portfolio to achieve optimal returns while minimizing risk. We have provided optimized weights

for each stock in the portfolio with a precision of 4 decimal places. These weights are calculated through the portfolio optimization process using the 'ROI' (Risk-Optimized Investment) method.

The positive portfolio weight corresponds to a greater portfolio weight. The negative weights indicate that the optimization process has determined that a short position should be taken for these stocks, meaning selling the stocks with the expectation that their prices will decrease. This strategy allows investors to profit from the anticipated decline in stock prices and contributes to the overall risk-adjusted returns of the portfolio.

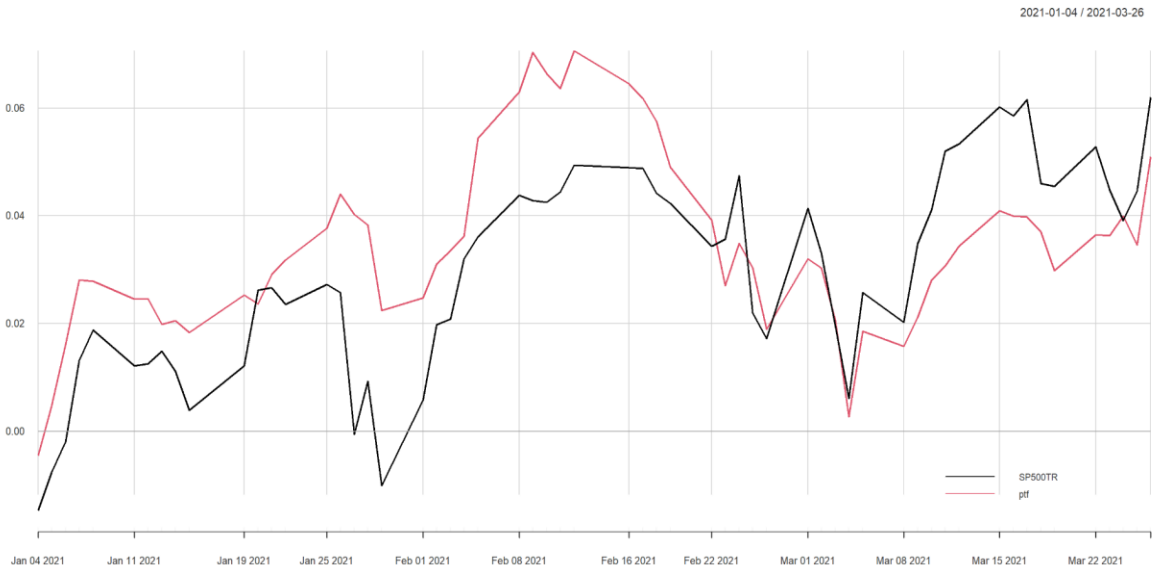
Our analysis reveals a diverse range of performances across our selected tickers. Specifically, Johnson & Johnson (JNJ) and Johnson Outdoors Inc (JOUT) have performed superior. JNJ, with a high portfolio allocation at a weight of 0.4435, has demonstrated exceptional returns. Meanwhile, JOUT's performance is strong, reflected by a moderate allocation weight of 0.0447.

Tickers demonstrating neutral performance include JPMorgan Chase & Co (JPM) with a fair weight of 0.0638, LiqTech International, Inc (LIQT) with a moderate weight of 0.0180, and Lantheus Holdings, Inc (LNTH) with a minimal weight of 0.0003. Logitech International S.A (LOGI) holds a moderate weight of 0.0593, and Masimo Corporation (MASI) has a significant weight of 0.1393. Star Group, L.P (SGU) holds a substantial weight of 0.2570, while Standard Motor Products, Inc (SMP) has a fair weight of 0.0893. Lastly, Varonis Systems, Inc (VRNS) has a minor allocation with a weight of 0.0069.

We also noticed that a few tickers underperformed, leading to lower weights or potential short positions. These include Mastercard Incorporated (MA) with a weight of -0.0172, MercadoLibre, Inc (MELI) with a weight of -0.0223, and Synchrony Financial (SYF) with a weight of -0.0389. Marriott Vacations Worldwide Corporation (VAC) weights -0.0397, and Veeva Systems Inc (VEEV) have a minor negative weight of -0.0040. These negative weights reflect their relative underperformance within the portfolio.

Cumulative Return Chart (SP500TR and Portfolio)

The following graph showcases a cumulative return chart that compares the performance of our optimized portfolio with the SP500TR index, encompassing the period from January 1, 2021, to March 26, 2021. The analysis focuses explicitly on the first three months of 2021.



The graph illustrates the overall smooth performance of our portfolio, closely aligning with the trend line of the SP500TR index but with some minor variations. Our portfolio generally outperforms the SP500TR index for most of January and February. However, in March, the SP500TR index surpassed our portfolio.

Annualized and cumulative returns of the portfolio

The annualized and cumulative returns of our portfolio are presented below.

	SP500TR	PTF
Annualized return	0.2987	0.2412
Annualized Standard Deviation	0.1623	0.1188
Annualized Sharpe (Rf = 0%)	1.8399	2.0312
Cumulative Return	0.06199359	0.05098071

By examining the annualized returns table, we can observe that our portfolio exhibits a 19.25% decrease in annualized return compared to that of SP500TR. Additionally, our portfolio's cumulative returns are 17.76% lower than SP500TR.

Conclusion

Based on our analysis of the performance of our optimized portfolio compared to the SP500TR index from January 1, 2021, to March 26, 2021, it is evident that our portfolio closely tracked the benchmark's trend with only slight variations. Throughout the majority of January and February, our portfolio consistently outperformed the SP500TR index, demonstrating a smooth trajectory of success. However, the SP500TR index performed better in March, surpassing our portfolio. Notably, there was a brief overlap period between our portfolio and the SP500TR index during the initial week of March. Additionally, upon further examination of the annualized returns, we discovered that our portfolio displayed a 26.80% lower standard deviation and a 19.25% lower annualized return compared to the SP500TR index. Our portfolio's cumulative returns were also 17.76% lower than the SP500TR. These findings indicate that while our portfolio followed a similar trend to the SP500TR index, demonstrating superior performance in the early months but declining towards the end, it exhibited lower volatility and more excellent stability.

Recommendation

Based on the findings and conclusions of our analysis, we highly recommend utilizing the results obtained for future enhancements and the development of more effective investment strategies. The close tracking of our optimized portfolio with the SP500TR index and its consistent outperformance during the initial months demonstrates the potential value of our approach. We can refine our investment strategies by leveraging these insights to capitalize on market trends and optimize returns. Additionally, our portfolio's lower volatility and excellent stability highlight the potential for risk mitigation and for creating more resilient investment portfolios. Therefore, we strongly encourage using our results as a foundation for future enhancements in investment strategies, aiming to achieve improved performance and better risk management.

Exhibits

Exhibit 1: Selected Stock Ticker, Optimal Weight, and Cumulative Return.

Team Member Name	Tickers	Company Name	Optimal Weight	Cumulative Return
Sairaj Prakash Jadhav	JNJ	Johnson & Johnson.	0.4435	53.21%
	JOUT	Johnson Outdoors Inc.	0.0447	414.53%
	JPM	JPMorgan Chase & Co.	0.0638	92.44%
Ray Lien	LIQT	LiqTech International, Inc.	0.0180	98.41%
	LNTH	Lantheus Holdings, Inc.	0.0003	299.11%
	LOGI	Logitech International S.A.	0.0593	544.92%
Queeny Mathayas	MA	Mastercard Incorporated.	-0.0172	266.62%
	MASI	Masimo Corporation.	0.1393	546.54%
	MELI	MercadoLibre, Inc.	-0.0223	1365.12%
Mine Salman	SGU	Star Group, L.P.	0.2570	26.48%
	SMP	Standard Motor Products, Inc.	0.0893	6.33%
	SYF	Synchrony Financial.	-0.0389	14.14%
Adrian Vasquez	VAC	Marriott Vacations Worldwide Corporation.	-0.0397	140.95%
	VEEV	Veeva Systems Inc.	-0.0040	843.67%

	VRNS	Varonis Systems, Inc.	0.0069	770.23%

Exhibit 2: U.S. Inflation Data for Time Period.

U.S. Inflation Rate - Historical Data		
Year	**Inflation Rate (%)**	**Annual Change**
2021	4.70%	3.46%
2020	1.23%	-0.58%
2019	1.81%	-0.63%
2018	2.44%	0.31%
2017	2.13%	0.87%
2016	1.26%	1.14%

Source: MacroTrends. (n.d.).

Exhibit 3: U.S. Inflation Data for Time Period.

U.S. Inflation Rate - Historical Data		
Year	**Inflation Rate (%)**	**Annual Change**
2021	4.70%	3.46%
2020	1.23%	-0.58%
2019	1.81%	-0.63%
2018	2.44%	0.31%
2017	2.13%	0.87%
2016	1.26%	1.14%

Source: MacroTrends. (n.d.).

Exhibit 4: U.S. Interest Rates Data for Time Period

Federal Funds Rate - Historical Annual Yield Data						
Year	Average Yield	Year Open	Year High	Year Low	Year Close	Annual % Change
2023	4.58%	4.33%	4.83%	4.33%	4.83%	11.55%
2022	1.68%	0.08%	4.33%	0.08%	4.33%	6085.71%
2021	0.08%	0.09%	0.10%	0.05%	0.07%	-22.22%
2020	0.36%	1.55%	1.60%	0.04%	0.09%	-94.19%
2019	2.16%	2.40%	2.45%	1.55%	1.55%	-35.42%
2018	1.79%	1.42%	2.40%	1.34%	2.40%	80.45%

2017	1.00%	0.55%	1.42%	0.55%	1.33%	141.82%
2016	0.39%	0.20%	0.66%	0.20%	0.55%	175.00%

Source: MacroTrends. (n.d.).

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APPENDIX

Code:

```
require(RPostgres)
require(DBI)
conn <- dbConnect(RPostgres::Postgres()
                  ,user="stockmarketreader"
                  ,password="read123"
                  ,host="localhost"
                  ,port=5432
                  ,dbname="stockmarket"
)

#Custom calendar
qry<-"SELECT * FROM custom_calendar WHERE date BETWEEN '2015-12-31' AND '2021-
03-26' ORDER by date"
ccal<-dbGetQuery(conn,qry)

#Eod Prices and Indices
qry1="SELECT symbol,date,adj_close FROM eod_indices WHERE date BETWEEN '2015-12-
31' AND '2021-03-26'"
qry2="SELECT ticker,date,adj_close FROM eod_quotes WHERE date BETWEEN '2015-12-31'
AND '2021-03-26'  and ticker in ('JNJ', 'JOUT',
'JPM','LIQT','LNTH','LOGI','MA','MASI','MELI','SGU','SMP','SYF','VAC','VEEV','VRNS')"
eod<-dbGetQuery(conn,paste(qry1,'UNION',qry2))
```

```
dbDisconnect(conn)
rm(conn)

# Explore
head(ccal)
tail(ccal)
nrow(ccal)

head(eod)
tail(eod)
nrow(eod)

head(eod[which(eod$symbol=='SP500TR'),])

# Use Calendar ----------------------------------------------------
tdays<-ccal[which(ccal$trading==1),,drop=F]
head(tdays)
nrow(tdays)-1 #trading days between 2015 and 2020

# Completeness ----------------------------------------------------
# Percentage of Completeness
pct<-table(eod$symbol)/(nrow(tdays)-1)
selected_symbols_daily<-names(pct)[which(pct>=0.99)]
eod_complete<-eod[which(eod$symbol %in% selected_symbols_daily),,drop=F]

# Check
head(eod_complete)
tail(eod_complete)
nrow(eod_complete)

# Transform (Pivot) -----------------------------------------------
require(reshape2) #did you install this package?
eod_pvt<-dcast(eod_complete, date ~ symbol,value.var='adj_close',fun.aggregate = mean,
fill=NULL)
#check
eod_pvt[1:10,1:5] #first 10 rows and first 5 columns
ncol(eod_pvt) # column count
nrow(eod_pvt)

# Merge with Calendar ---------------------------------------------
eod_pvt_complete<-merge.data.frame(x=tdays[,'date',drop=F],y=eod_pvt,by='date',all.x=T)

# Check
eod_pvt_complete[1:10,1:5] #first 10 rows and first 5 columns
ncol(eod_pvt_complete)
nrow(eod_pvt_complete)
```

```
# Use Dates As Row Names and Remove The Date Column
rownames(eod_pvt_complete)<-eod_pvt_complete$date
eod_pvt_complete$date<-NULL #remove the "date" column

#Re-Check
eod_pvt_complete[1:10,1:5] #First 10 Rows and First 5 Columns
ncol(eod_pvt_complete)
nrow(eod_pvt_complete)

# Missing Data Imputation ----------------------------------------------------
require(zoo)
eod_pvt_complete<-na.locf(eod_pvt_complete,na.rm=F,fromLast=F,maxgap=3)
#re-check
eod_pvt_complete[1:10,1:5] #First 10 rows and First 5 columns
ncol(eod_pvt_complete)
nrow(eod_pvt_complete)

# Calculating Returns --------------------------------------------------------
require(PerformanceAnalytics)
eod_ret<-CalculateReturns(eod_pvt_complete)

#Check
eod_ret[1:10,1:3] #First 10 Rows and First 3 Columns
ncol(eod_ret)
nrow(eod_ret)

#Remove The First Row
eod_ret<-tail(eod_ret,-1) #Use Tail With a Negative Value
#check
eod_ret[1:10,1:3] #First 10 Rows and First 3 Columns
ncol(eod_ret)
nrow(eod_ret)

# Check for Extreme Returns --------------------------------------------------
# There is colSums, colMeans but no colMax so we need to create it
colMax <- function(data) sapply(data, max, na.rm = TRUE)
# Apply it
max_daily_ret<-colMax(eod_ret)
max_daily_ret[1:10] #first 10 max returns
# And proceed just like we did with percentage (completeness)
selected_symbols_daily<-names(max_daily_ret)[which(max_daily_ret<=1.00)]
length(selected_symbols_daily)

# Subset eod_ret
eod_ret<-eod_ret[,which(colnames(eod_ret) %in% selected_symbols_daily),drop=F]
```

```
# Check
eod_ret[1:10,1:3] #first 10 rows and first 3 columns
ncol(eod_ret)
nrow(eod_ret)

# Export Data From R to CSV ------------------------------------------------
write.csv(eod_ret,'C:/Temp/eod_ret2.csv')

# Tabular Return Data Analytics ----------------------------------------------
# We will select 'SP500TR' and 15 ASSINGED TICKERS
selectedtickers <- c('JNJ', 'JOUT',
'JPM','LIQT','LNTH','LOGI','MA','MASI','MELI','SGU','SMP','SYF','VAC','VEEV','VRNS')
# We need To Convert Data Frames to xts (extensible time series)
Ra<-as.xts(eod_ret[,selectedtickers,drop=F])
Rb<-as.xts(eod_ret[,'SP500TR',drop=F]) # Benchmark

# Filter the Data Up to December 31, 2020
Ra <- Ra[index(Ra) <= as.Date("2020-12-31")]
Rb <- Rb[index(Rb) <= as.Date("2020-12-31")]

ncol(eod_ret)
str(eod_ret)

head(Ra)
head(Rb)

# Stats
table.Stats(Ra)

# Distributions
table.Distributions(Ra)

# Returns
table.AnnualizedReturns(cbind(Rb,Ra),scale=252) # note for monthly use scale=12

# Accumulate Returns
acc_Ra<-Return.cumulative(Ra)
acc_Rb<-Return.cumulative(Rb)

# Capital Assets Pricing Model
table.CAPM(Ra,Rb)

# Graphical Return Data Analytics --------------------------------------------
# Cumulative returns chart
chart.CumReturns(Ra,legend.loc = 'topleft')
chart.CumReturns(Rb,legend.loc = 'topleft')
```

```
#Box plots
chart.Boxplot(cbind(Rb,Ra))

chart.Drawdown(Ra,legend.loc = 'bottomleft')

# MV Portfolio Optimization ----------------------------------------------
Ra<-as.xts(eod_ret[,selectedtickers,drop=F])
Rb<-as.xts(eod_ret[,'SP500TR',drop=F]) #benchmark

# Withhold the Last 58 Trading Days
Ra_training<-head(Ra,-58)
Rb_training<-head(Rb,-58)

# Use the Last 58 Trading Days for Testing
Ra_testing<-tail(Ra,58)
Rb_testing<-tail(Rb,58)

# Optimize the MV (Markowitz 1950s) Portfolio Weights Based on Training
table.AnnualizedReturns(Rb_training)
mar<-mean(Rb_training) # We Need Daily Minimum Acceptable Return

require(PortfolioAnalytics)
require(ROI)
require(ROI.plugin.quadprog)
pspec<-portfolio.spec(assets=colnames(Ra_training))
pspec<-add.objective(portfolio=pspec,type="risk",name='StdDev')
pspec<-add.constraint(portfolio=pspec,type="full_investment")
pspec<-add.constraint(portfolio=pspec,type="return",return_target=mar)

# Optimize Portfolio
opt_p<-optimize.portfolio(R=Ra_training,portfolio=pspec,optimize_method = 'ROI')

# Extract Weights (Negative Weights Means Shorting)
opt_w<-round(opt_p$weights,digits = 4)

Rp<-Rb_testing
Rp$ptf<-Ra_testing %*% opt_w

# Check
head(Rp)
tail(Rp)

#Compare Basic Metrics
table.AnnualizedReturns(Rp)
Return.cumulative(Rp)
```

```
# Chart Hypothetical Portfolio Returns ----------------------------------
chart.CumReturns(Rp,legend.loc = 'bottomright')

# End of Stock Market Case Study
```