Stock portfolio analysis report using R and Excel

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I. INTRODUCTION

In the context of researching the stock prices of five major companies in the technology industry, this report will focus on analyzing historical data on the stock prices of International Business Machines Corporation (IBM), Dell Technologies, Google, Microsoft, and Oracle Corporation from December 23, 2017, to December 23, 2022. The data, meticulously sourced from Yahoo Finance, provides a comprehensive view of the market journey of these companies, instilling confidence in its reliability.

In finance, stock price plays a crucial role, not just as a number, but as a reflection of investor sentiment and market dynamics. Fluctuations in stock prices serve as powerful indicators of a company's performance, vividly reflecting market perceptions of its success or disappointment. The closing price, a key metric in financial analysis, indicates the price at which a stock was last traded on a specific day, providing valuable information about daily market sentiment and trends.

However, to accurately assess the value of a stock, one needs to consider factors beyond market influences. The adjusted stock price, a refined indicator, calculates factors such as stock splits, additional stock issuances, and other adjustments that may affect the stock price. Therefore, the adjusted stock price provides a more accurate view of its true value, helping investors better understand its performance over time. With this comprehensive and meticulously analyzed financial data, we will explore and further analyze the stock price fluctuations of these leading technology companies to uncover trends and valuable insights behind the numbers.

TASK 1: Calculate the expected return and the volatility for each company and the correlations between the asset returns.

Expected return and volatility are fundamental financial concepts utilized to assess the risk-return trade-off of an investment. The "expected return" denotes the average amount of money an investor anticipates receiving from an investment over time. Typically expressed as a percentage, it can be determined by multiplying the probability of each potential return by the return itself. Expected returns can be estimated using historical returns or by forecasting future returns.

Volatility, conversely, measures the degree of variation or fluctuations in the returns of an investment. Often quantified by the standard deviation of the returns, it illustrates how much the returns are expected to deviate from the expected return. High volatility suggests that returns are likely to be widely dispersed and can encompass both positive and negative values. Conversely, low volatility indicates more consistent returns, closer to the expected return.

Now, let's delve into the dataset to gain a better understanding.

DAILY SHARE PRICES FOR 5 ASSETS					
Date	IBM	DELL	GOOG	MSFT	ORCL
26/12/2017	114.9685	22.28999	52.837002	80.422455	43.498119
27/12/2017	115.19419	22.25712	52.468498	80.714355	43.452251
28/12/2017	115.87876	22.19412	52.407001	80.723793	43.580654
29/12/2017	115.41235	22.2626	52.32	80.554283	43.360554
02/01/2018	116.03672	22.57759	53.25	80.940384	42.764435
03/01/2018	119.22632	22.81588	54.124001	81.31707	43.754898

Table 1: Overview about Stock data

1.1 Calculate Daily Expected Return and Annual Expected Return

To calculate the expected annual return from daily returns, the average daily returns over a period of time were calculated and then annualize it.

Here is the result:

Stock	Daily Expected Return	Daily Standard Dev	Annual Expected Return	Annual STDEV
IBM	0.050%	2.482%	12.704%	39.405%
DELL	0.037%	1.984%	9.245%	31.489%
GOOG	0.081%	1.969%	20.520%	31.263%
MSFT	0.042%	1.885%	10.705%	29.931%
ORCL	0.049%	1.869%	12.263%	29.664%

Table 2: Annual Expected Return

1.2 Calculate Correlations Between Five Stocks

Correlation is a statistical metric that quantifies the degree to which the prices of two investments move in relation to each other.

A positive correlation signifies that when one investment's price rises, the other's typically increases. Conversely, a negative correlation indicates that when one investment's price

rises, the other's tends to decrease. A correlation coefficient of 1 signifies a perfect positive correlation, while a coefficient of -1 denotes a perfect negative correlation. A coefficient of 0 suggests no correlation between the two investments.

To compute correlation, the following formula is employed:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

Where,

r = Pearson Correlation Coefficient

x_i = x variable samples

y_i = y variable sample

$\bar{x}$ = mean of values in x variable

$\bar{y}$ =mean of values in y variable

Here is the result:

Correlation between five stocks					
	IBM	*DELL*	*GOOG*	*MSFT*	*ORCL*
IBM	1				
DELL	0.47	1			
GOOG	0.46	0.487	1		
MSFT	0.5	0.52	0.81	1	
ORCL	0.51	0.43	0.52	0.61	1

Table 3: Correlations Between Five Stocks

The findings reveal a moderate-to-strong positive correlation among the stocks. Notably, GOOG and MSFT exhibit the highest correlation coefficient of 0.81, indicating a robust association. Conversely, the lowest correlation is observed between DELL and ORCL, with a coefficient of 0.43, signifying a moderate positive correlation.

The remaining correlations are as follows:

- IBM and DELL: 0.57
- IBM and GOOG: 0.46
- IBM and MSFT: 0.50
- IBM and ORCL: 0.51
- DELL and MSFT: 0.52

These correlations suggest that while the stocks generally move in the same direction, they may not do so with equal magnitude.

TASK 2: Using Solver Function and Draw Efficient Frontier

Variance - Corvariance Matrix					
	IBM	*DELL*	*GOOG*	*MSFT*	*ORCL*
IBM	0.07665	0.05153	0.04026	0.04315	0.04216
DELL	0.05153	0.15425	0.05990	0.06335	0.05012
GOOG	0.04026	0.05990	0.09818	0.07836	0.04788
MSFT	0.04315	0.06335	0.07836	0.09628	0.05594
ORCL	0.04216	0.05012	0.04788	0.05594	0.08792

Table 4: Variance – Covariance Matrix

All the highlight values in table 4 are the variance of 5 stocks, and other cells are covariance between 2 stocks.

After that, A equally weighted portfolio was build. Solver Function was applied to calculate Expected Return, Std dev and Shape R. In this report, the risk-free rate is 0.12%.

Equally weighted portfolio	
Stocks	Weights
IBM	0.2
DELL	0.2
GOOG	0.2
MSFT	0.2
ORCL	0.2
Sum	1
Expected Return	0.119355406
Standard Dev	0.251286107

Table 5: Equally weight portfolio

2.1 Option 1: Maximize the Expected Return

In this optimization scenario, the goal is to maximize the expected return. Several constraints were applied to ensure the integrity of the optimization process:

- The weight of all assets must be greater than 0.
- The total weight of all assets must equal 1.
- The objective function to be maximized is the "Expected Return," achieved by adjusting the weights of the five assets.

High Return Portfolio	
Stocks	Weights
IBM	0.0000
DELL	0.0000
GOOG	0.0000
MSFT	1.0000
ORCL	0.0000
Sum	1.0000
Expected Return	0.2177
Standard Dev	0.3103

Table 6: High Return Portfolio

The findings in Table 6 highlight that the portfolio yields the highest expected return when the investor allocates 100% of the capital to MSFT stock.

2.2 Option 2: Minimize the Standard Deviation

To minimize the standard deviation, the following constraints were applied:

- The weight of all assets must exceed 0.
- The total weight of all assets must sum to 1.
- The objective function to be minimized is the "Standard Deviation," achieved by adjusting the weights of the five assets.

Low Risk Portfolio	
Stocks	Weights
IBM	0.4317
DELL	0.0353
GOOG	0.2161
MSFT	0.0366
ORCL	0.2802
Sum	1.0000
Expected Return	0.0861
Standard Dev	0.2388

Table 7: Low Risk Portfolio

For achieving the lowest Standard Deviation, the optimal portfolio allocation would be to invest 43.17% in IBM, 3.53% in DELL, 21.61% in GOOG, 3.66% in MSFT, and 28.02% in ORCL stocks.

2.3 Draw the Efficient Frontier Curve

An efficient frontier curve represents the set of optimal portfolios that offer the highest expected return for a given level of risk. It is plotted with volatility on the x-axis and expected return on the y-axis, demonstrating the trade-off between risk and return.

Below are the portfolios that offer the minimum risk at a given expected portfolio return:

Efficient Frontier																		
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18
IBM's weight	0.8510	0.7187	0.5896	0.460	0.421	0.393	0.366	0.338	0.311	0.277	0.227	0.176	0.126	0.076	0.026	0	0	0
DELL's Weight	0.0000	0.0000	0.0011	0.032	0.035	0.035	0.035	0.034	0.032	0.032	0.028	0.023	0.018	0.013	0.008	0	0	0
GOOG's Weight	0.1490	0.1911	0.2197	0.236	0.200	0.158	0.115	0.073	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0
MSFT's Weight	0.0000	0.0000	0.0000	0.000	0.065	0.137	0.210	0.282	0.355	0.425	0.486	0.548	0.609	0.671	0.732	0.81	0.92	1
ORCL's Weight	0.0000	0.0902	0.1896	0.272	0.279	0.277	0.274	0.272	0.270	0.266	0.260	0.253	0.247	0.240	0.233	0.19	0.08	0
Volatility	0.261	0.249	0.2419	0.239	0.239	0.239	0.241	0.243	0.246	0.249	0.254	0.259	0.265	0.273	0.281	0.29	0.3	0.31
Exp Return	0.050	0.060	0.0700	0.080	0.090	0.100	0.110	0.120	0.130	0.140	0.150	0.160	0.170	0.180	0.190	0.2	0.21	0.218

Table 8: Different Weights by Solver Function

Here is the portfolio optimised weights chart:

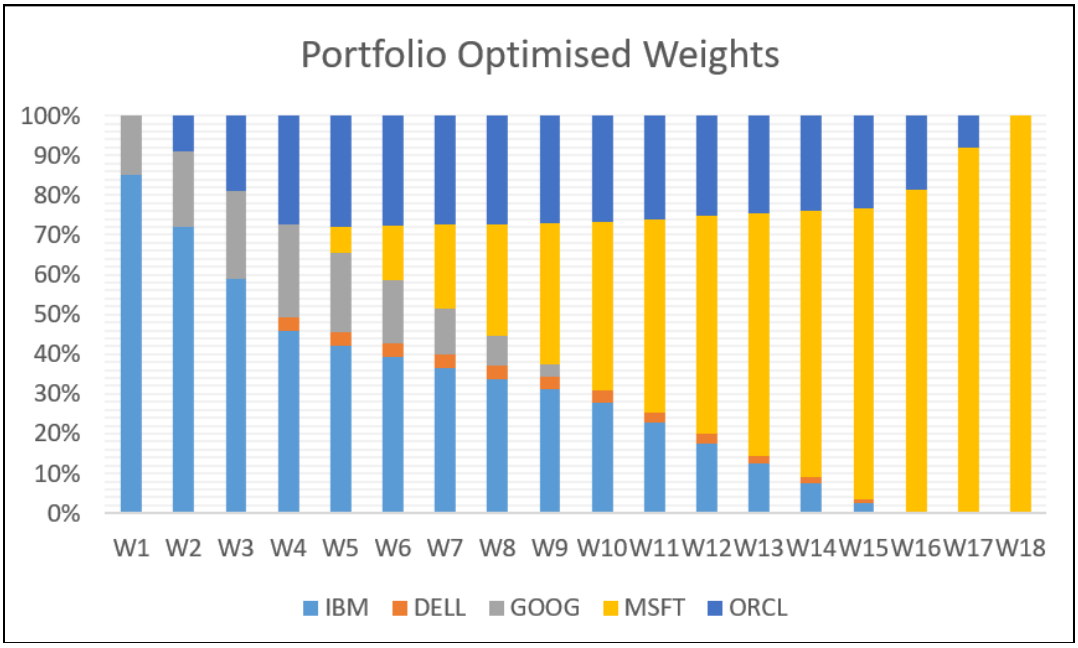

Figure 1: Portfoli Optimised Weights

The data shows that to achieve an increasing expected return (from W1 to W18), we should allocate more capital to MSFT stock while reducing investments in the remaining four stocks, particularly shares of IBM and GOOG. Notably, most portfolios have minimal exposure to DELL stock, indicating that the presence or absence of DELL stock has little impact on the expected return or volatility of the portfolio.

Based on this Volatility and Expected Return dataset, an Efficient Frontier Curve was constructed to visualize the optimal trade-off between risk and return for different portfolio allocations.

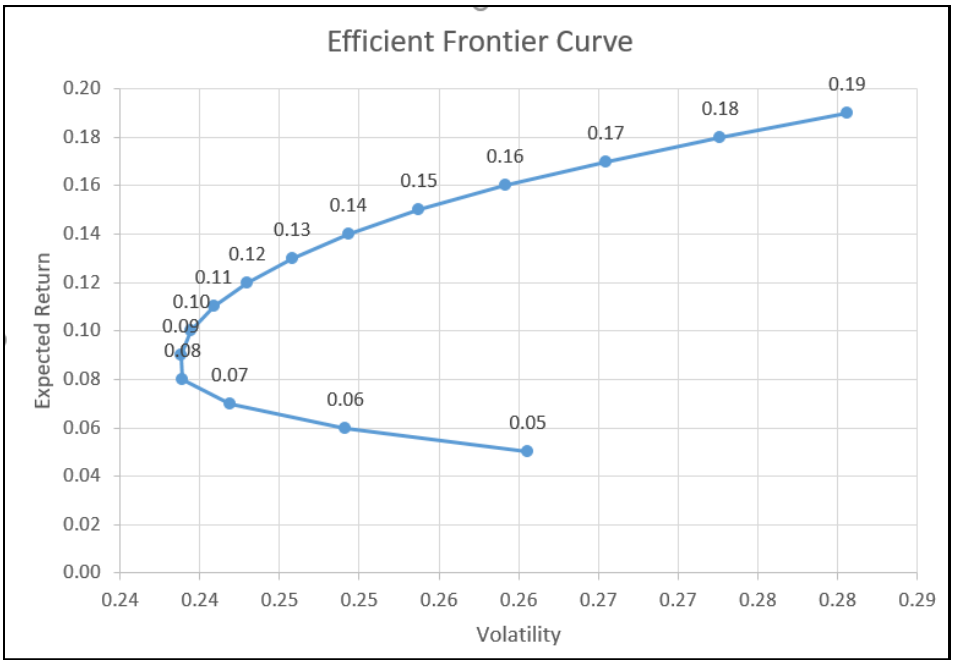

Figure 2: Efficient Frontier Curve

The slope of the efficient frontier appears shallow, indicating a weak trade-off between risk and return. Positioned in the lower-left corner, the curve suggests investments with high risk and low return. Notable points along the curve include the tangency portfolio, representing the highest Sharpe ratio, observed when the expected return equals 16%. Conversely, the minimum variance portfolio, characterized by the least risk, occurs when the expected return equals 8%.

Task 3: Calculate the Sharpe Ratios and Determine the Equation of the Capital Market Line

3.1 Calculate the Sharpe Ratios

The Sharpe ratio is a metric used to assess the risk-adjusted performance of a portfolio by comparing its return to that of a risk-free investment, while accounting for its volatility. A higher Sharpe ratio indicates a better risk-adjusted return for the portfolio. It is calculated using the following formula:

$$\text{Sharpe Ratio} = \frac{R_p - R_f}{\sigma_p}$$

- R_p Return of portfolio
- R_f Risk-free rate
- σ_p Standard deviation of portfolio's excess return

By calculating the Sharpe ratios for each portfolio, we can evaluate their risk-adjusted performance in financial mathematics.

By using the risk free rate is 1.5%, here is the result:

Efficient Frontier																		
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18
IBM's weight	0.8510	0.7187	0.5896	0.460	0.421	0.393	0.366	0.338	0.311	0.277	0.227	0.176	0.126	0.076	0.026	0	0	0
DELL's Weight	0.0000	0.0000	0.0011	0.032	0.035	0.035	0.035	0.034	0.032	0.032	0.028	0.023	0.018	0.013	0.008	0	0	0
GOOG's Weight	0.1490	0.1911	0.2197	0.236	0.200	0.158	0.115	0.073	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0
MSFT's Weight	0.0000	0.0000	0.0000	0.000	0.065	0.137	0.210	0.282	0.355	0.425	0.486	0.548	0.609	0.671	0.732	0.81	0.92	1
ORCL's Weight	0.0000	0.0902	0.1896	0.272	0.279	0.277	0.274	0.272	0.270	0.266	0.260	0.253	0.247	0.240	0.233	0.19	0.08	0
Volatility	0.261	0.249	0.2419	0.239	0.239	0.239	0.241	0.243	0.246	0.249	0.254	0.259	0.265	0.273	0.281	0.29	0.3	0.31
Exp Return	0.050	0.060	0.0700	0.080	0.090	0.100	0.110	0.120	0.130	0.140	0.150	0.160	0.170	0.180	0.190	0.2	0.21	0.218
Sharpe Ratio	0.13	0.24	0.29	0.33	0.38	0.42	0.46	0.49	0.53	0.56	0.59	0.62	0.64	0.66	0.68	0.69	0.70	0.70
Sharpe Ratio = (Expected Return - Risk_Free)/ Standard Dev																		

Table 9: Calculate the Sharpe Ratio

3.2 Determine the Equation of the Capital Market Line

The Capital Market Line (CML) is a graphical depiction illustrating the connection between the expected returns and the risk of a portfolio. It showcases the efficient frontier, representing the set of portfolios offering the highest expected returns for a given level of risk, alongside the risk-free asset, which presents the investment with the lowest possible risk.

By determining the equation of the Capital Market Line, we can mathematically represent this relationship, providing valuable insights into portfolio optimization and risk management strategies.

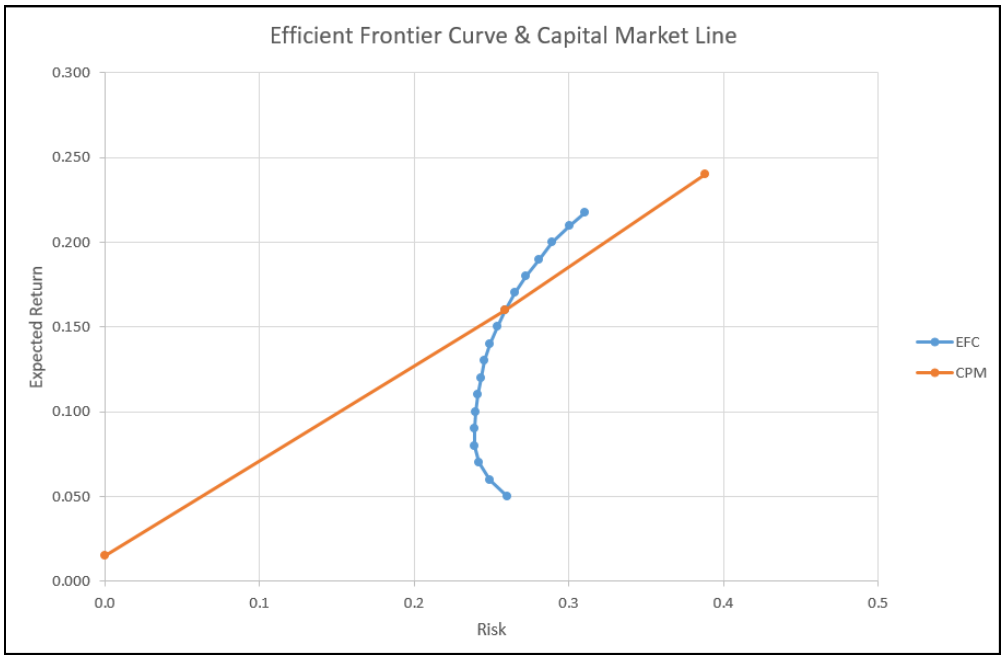

Figure 3: Efficient Frontier Curve and Capital Market Line

The CML is vital to the economy because it helps investors and financial managers make intelligent choices about their portfolios, understand the trade-off between risk and return, and compare the risk and return of a portfolio to the market.

TASK 4: Calculate the beta for each asset and provide discussion. Calculate how much each asset contributes to estimated VaR 5%.

First step, we will look at the overal view of stocks prices over time.

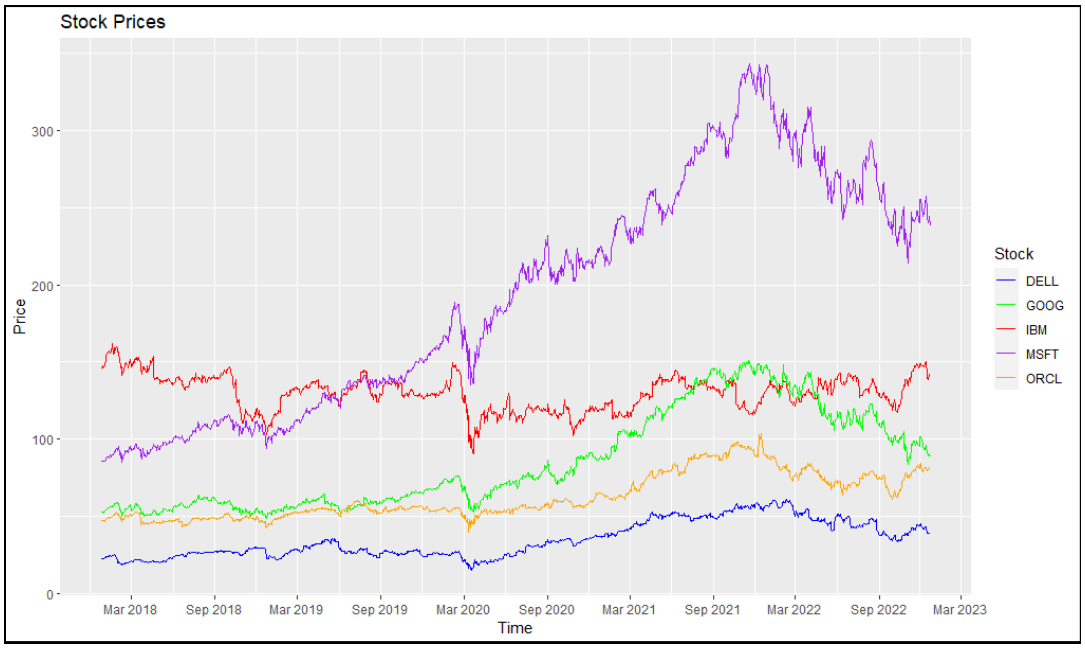

Figure 4: Stocks Prices over time

In December 2018, stock DELL was priced at $25, stock GOOG at $52, stock IBM at $145, stock MSFT at 80$, and stock ORCL at $48. Over the next five years, stock MSFT experienced the most fluctuation in price, reaching as high as $340 in December 2021 before dropping down to $250 in 2022. On the other hand, stock DELL had the least fluctuation and saw steady growth, ending at $45 in December 2022. Stock IBM had moderate fluctuation and ended at $140 in December 2022, while stock GOOG and ORCL had a similar trend and ended at $80 and $75 respectively.

Next we will have the look at the Portfolio Return Performance:

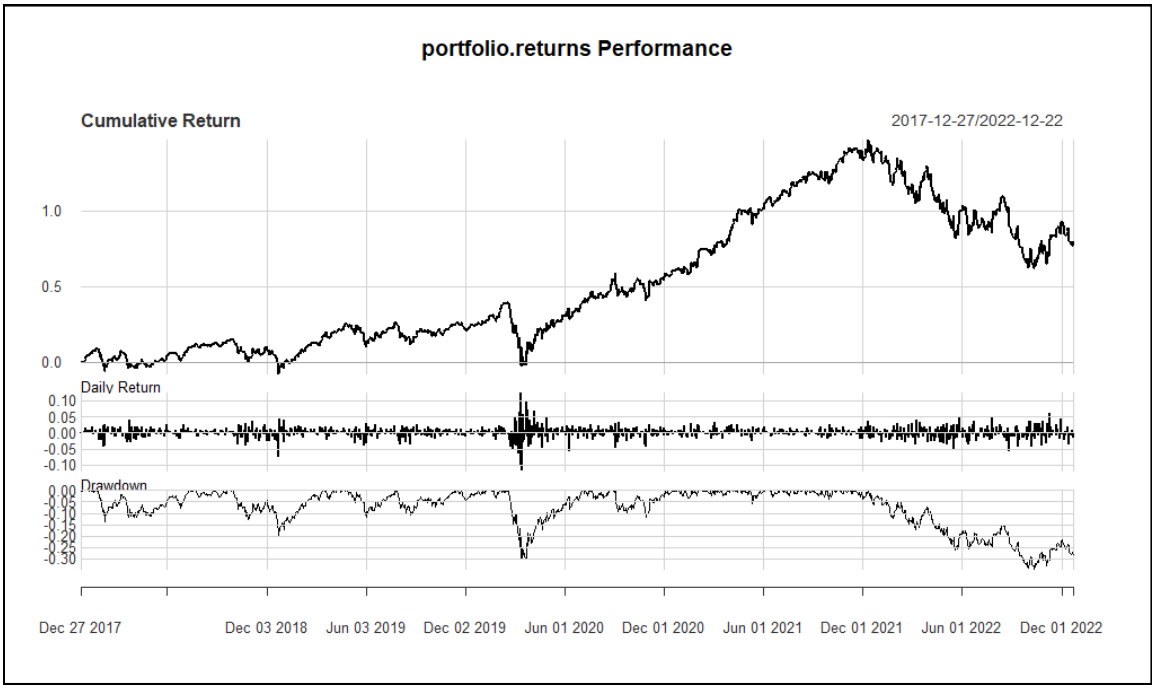

Figure 5: Portfolio Return Performance Chart

The visualization comprises multiple elements, including a cumulative returns line chart, a drawdown line chart, and a series of bar charts depicting return distribution.

The primary line chart presents the portfolio's cumulative returns spanning five years, from December 2017 to December 2022. It illustrates the cumulative return on the y-axis against time on the x-axis. A value of 0 signifies no returns, while 0.5 indicates a 50% return and 1 denotes a 100% return. The cumulative return trended moderately upward until March 2020, followed by a sharp decline to 0 due to market volatility. Subsequently, it rebounded to a peak of 1.5 in December 2021 before slightly decreasing to 0.8 by December 2022. This chart aids in identifying overall trends, peak and trough periods, and assessing the portfolio's risk-return profile.

The bar chart illustrates the portfolio's daily returns from December 2017 to December 2022, showing stable returns mostly within the range of -0.05 to 0.05. However, heightened volatility occurred in March and April 2020, with returns fluctuating between -0.1 and 0.12.

The drawdown line chart depicts fluctuations in the portfolio's drawdown, representing the percentage loss from its peak. The drawdown primarily fluctuated between 0 and -0.1, except for a significant drop to -0.3 in March and April 2020. Subsequently, it gradually increased, remaining around 0 for nearly two years before slightly dropping to -0.2 in December 2022. This chart provides insights into the portfolio's performance, highlighting significant drawdown declines in 2020 and a minor drop in December 2022, with relatively stable performance in between.

4.1 Calculate the BETA

Moving forward, we will proceed to calculate the BETA using R.

```
> #Calculate Metrics with the risk-free rate =1.5% per year
> # CAPM.beta function is used to calculate beta
> CAPM.beta(portfolioReturn, benchmarkReturns, .015/252)
[1] 1.09106
>
> # CAPM.beta.bull function is used to calculate beta during bullish market
> CAPM.beta.bull(portfolioReturn, benchmarkReturns, .015/252)
[1] 1.134165
>
> # CAPM.beta.bear function is used to calculate beta during bearish market
> CAPM.beta.bear(portfolioReturn, benchmarkReturns, .015/252)
[1] 1.055519
```

Figure 6: Result of Caculation of Beta (See Appendix)

Beta serves as a metric for assessing a portfolio's volatility compared to the market, with a beta of 1 suggesting that the portfolio's volatility aligns with the market's, a beta greater than 1 implying higher volatility than the market, and a beta less than 1 indicating lower volatility than the market.

The overall beta for the portfolio stands at 1.09106, signifying that the portfolio's volatility surpasses the market's by 9.106%. Under bullish market conditions, the portfolio's beta elevates to 1.134165, indicating 13.4165% higher volatility than the market. Conversely, during bearish market phases, the portfolio's beta decreases to 1.055519, suggesting 5.5519% higher volatility than the market. These findings offer crucial insights into the portfolio's risk profile relative to the market, aiding in informed investment decision-making.

```
> #CAPM.alpha(portfolioReturn, benchmarkReturns, .015/252)
> CAPM.jensenAlpha(portfolioReturn, benchmarkReturns, .015/252)
[1] 0.04061959
>
> SharpeRatio(portfolioReturn, Rf = .015/252, p = 0.95, FUN = "StdDev",
+             weights = NULL, annualize = FALSE)
                                portfolio.returns
StdDev Sharpe (Rf=0%, p=95%):        0.03226752
>
> table.AnnualizedReturns(portfolioReturn, Rf=.015/252, geometric=TRUE)
                              portfolio.returns
Annualized Return                        0.1209
Annualized Std Dev                       0.2593
Annualized Sharpe (Rf=1.5%)              0.4018
```

Figure 7: CAPM Alpha and tables of sumary result.(See Appendix 2)

The portfolio performance was analyzed using various metrics, including the Jensen Alpha, Sharpe Ratio, and annualized returns. The Jensen Alpha, a measure of a portfolio's excess return compared to the market, was found to be 0.04. The Sharpe Ratio, a measure of risk-adjusted return, was 0.03. The annualized return for the portfolio was 0.12, with an annualized standard deviation of 0.26 and an annualized Sharpe Ratio of 0.40. Overall, the portfolio shows a positive excess return compared to the market, but with a low risk-adjusted return.

4.2 Estimate Value at Risk (5%) for the portfolio and discuss how much each asset contributes to the estimated VaR.

In financial context, Value at Risk (VaR) is a measure of the potential loss of an investment portfolio over a given time period, such as a day or a week, with a certain level of confidence. VaR is typically expressed as a dollar amount or a percentage of the portfolio's value. In this part, the VaR is calculated with a probability level of 5%.

```
> # Print the VaR results
> print(PorVaR.Gaus)
$VaR
[1] 0.02564755

$contribution
  IBM.Close  DELL.Close  GOOG.Close  MSFT.Close  ORCL.Close
0.004214758 0.006161184 0.005272163 0.005405277 0.004594173

$pct_contrib_VaR
 IBM.Close DELL.Close GOOG.Close MSFT.Close ORCL.Close
 0.1643337  0.2402250  0.2055620  0.2107521  0.1791271
```

Figure 8: Result of Contribution of each asset (See Appendix 3)

The initial output line, denoted as $VaR, presents the Value-at-Risk (VaR) of the portfolio, computed utilizing the Gaussian method, a widely adopted approach for VaR determination. This figure signifies the potential loss of the portfolio within a specified confidence level, set at 5% in this instance.

The subsequent line, labelled as $contribution, delineates the monetary contribution to VaR attributed to each individual component within the portfolio. It encapsulates the estimated loss of each portfolio component during the most adverse 5% of scenarios.

Following that, the line designated as $pct_contrib_VaR illustrates the percentage contribution of VaR attributable to each portfolio component. It elucidates the proportionate loss expectation associated with each element within the portfolio during the most unfavourable 5% of scenarios.

The report furnishes insights into the Value at Risk (VaR) for a portfolio comprising five stocks: IBM, DELL, GOOG, MSFT, and ORCL. VaR is determined using the Gaussian method, assuming an equal weighting among the five stocks. The computed VaR for the portfolio amounts to 0.02564755, denoting a 5% likelihood that the portfolio may incur losses exceeding this threshold on any given day.

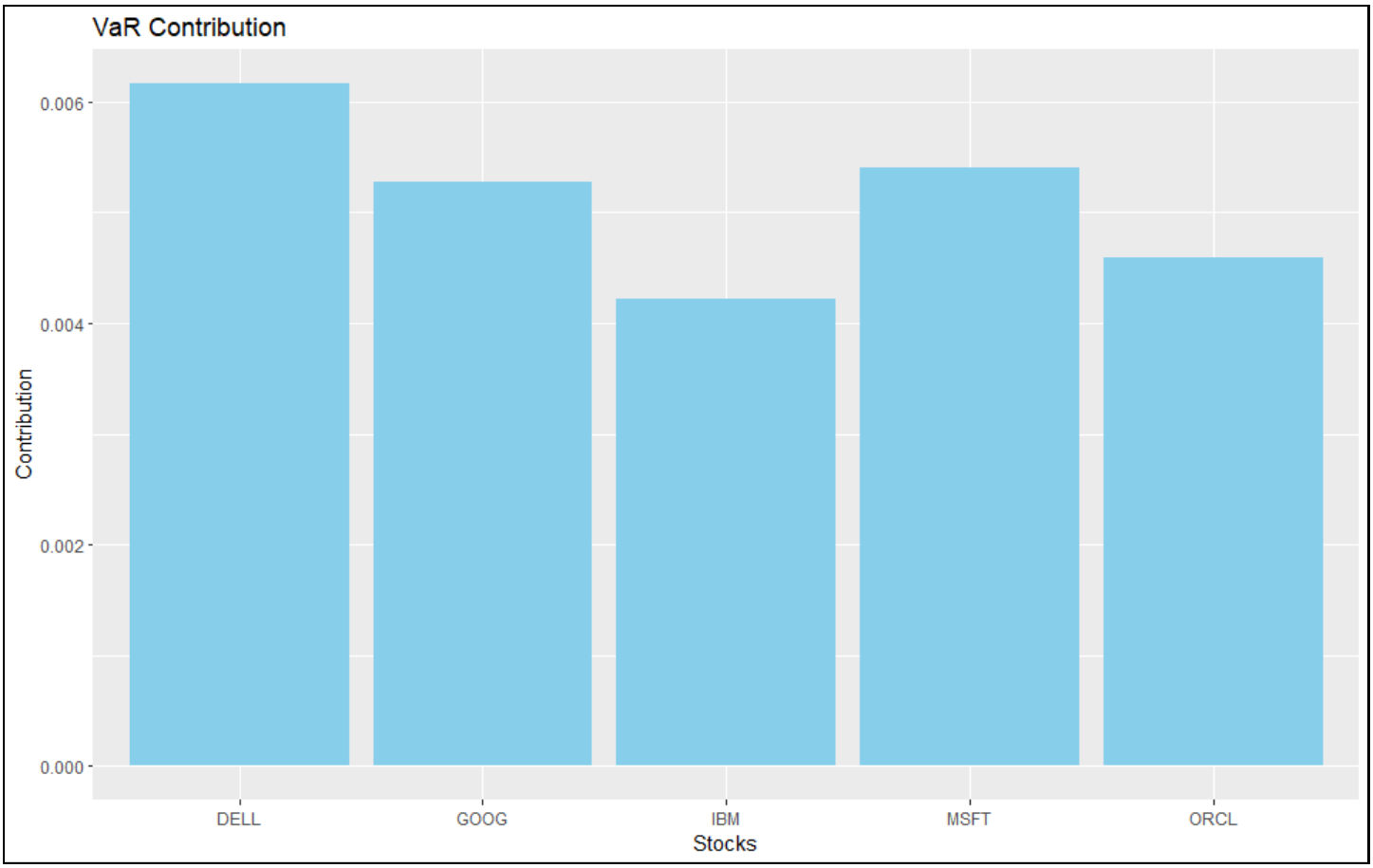

Figure 9: Graph of Contribution of each stocks

The report also shows the contribution of each stock to the overall VaR of the portfolio. IBM has the lowest contribution with 0.004214758 and DELL has the highest contribution with 0.00616.

In terms of percentage contribution, IBM has the lowest percentage contribution with 16.43337% while DELL has the highest percentage contribution with 24.02250%. This indicates that DELL contributes more to the overall risk of the portfolio than the other stocks.

In the financial context, the VaR is an important measure of risk and the contributions of individual stocks to the overall VaR can be used to identify the riskiest stocks in the portfolio.

This information can be used to make informed investment decisions and to construct a more diversified portfolio. Additionally, the percentage contributions to VaR can be used to determine how much of the portfolio's overall risk is due to each individual stock.

Task 5: Estimate the volatility of a single asset in the portfolio using ARCH/GARCH. Choosing the best model.

This task is to figure out how volatile a single asset in a portfolio is by using the ARCH/GARCH model and its extensions. The purpose of this task is to better understand the level of risk associated with the asset and make more informed investment decisions.

For this analysis, the daily closing prices of Microsoft (MSFT) stock from the past were used.

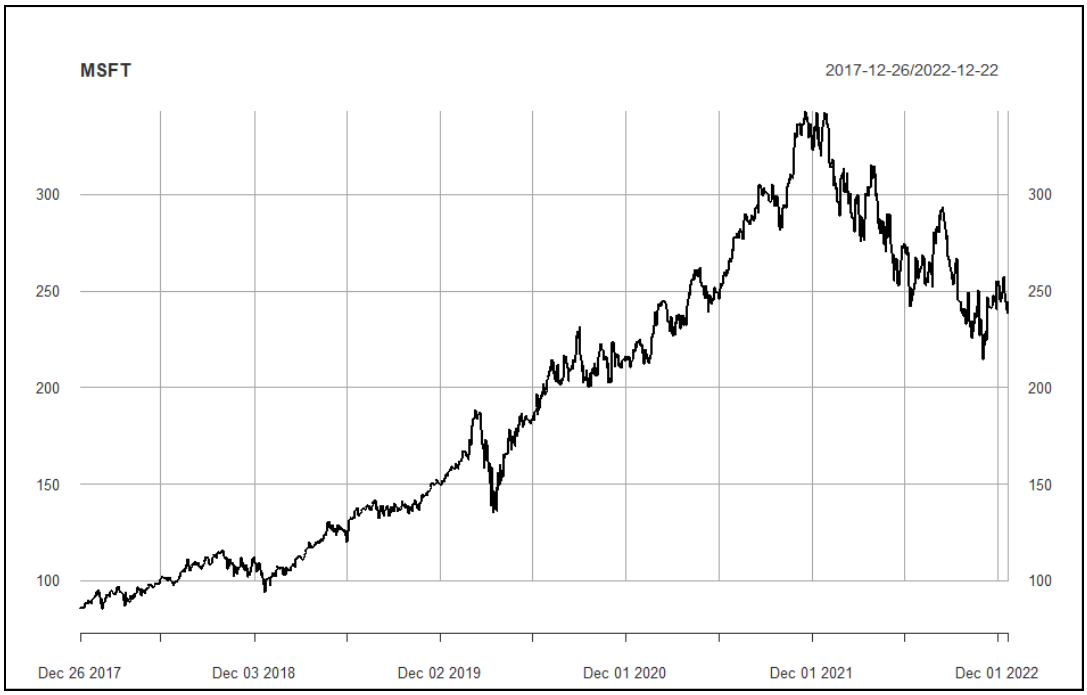

Figure 10: MSFT stock prices

And here is the graph about MSFT stocks's risk over time.

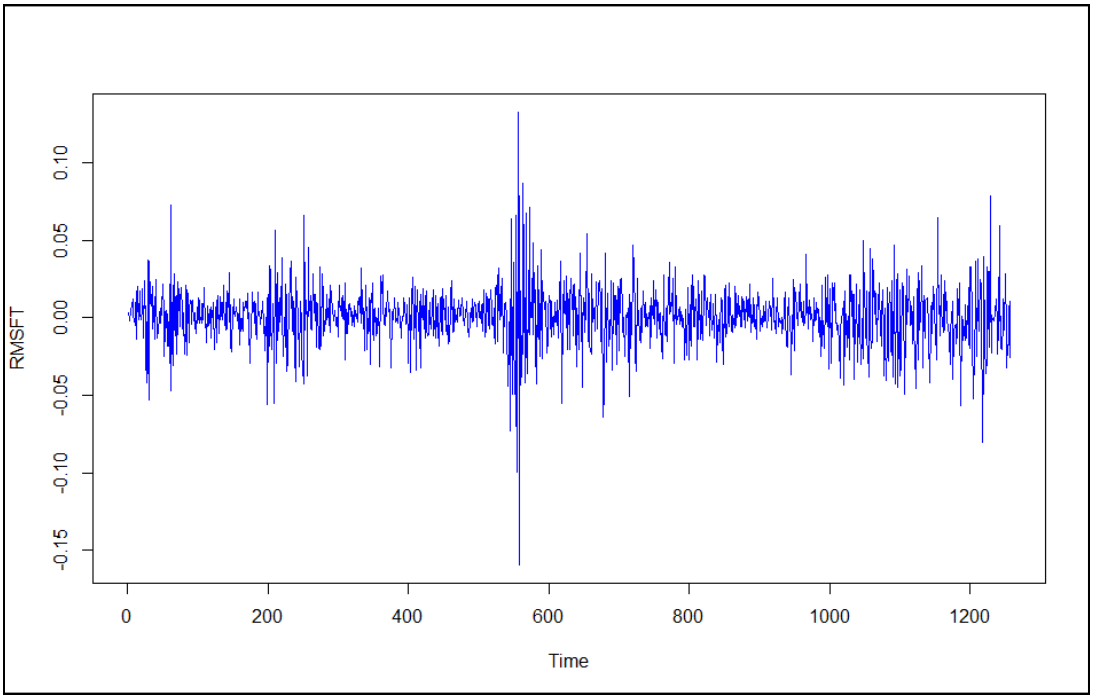

Figure 11 : MSFT stock's risk over time series

```
> print((best_model))

Call:
garch(x = RMSFT, order = c(1, 1), trace = FALSE)

Coefficient(s):
       a0         a1         b1
1.199e-05  1.595e-01  8.153e-01
```

Figure 13: The best GARCH model(See Appendix 4)

The result indicates that the p-value is lower than 0.05 and “alternative hypothesis”: stationary means data of MSFT stock can be used for ARCH/GARCH models.

Several GARCH models were fitted to the time series RMSFT using imported packages in R. The different models are specified by their orders: c(1,0), c(1,1), c(2,0), c(2,1), c(2,2), c(0,2), and c(1,2), respectively. It creates a list of these GARCH models and then extracts the AIC values from the models using the sapply() function and the AIC function. After that, it finds the model's index with the lowest AIC value using the which.min() function. Then, it selects the best model using the best_model_index and prints the best model's AIC value using the print() function. And then the best model is GARCH(1,1) because its AIC is lowest.

Subsequently, predictions were made regarding the Microsoft (MSFT) stock for the next five days. The data analysis revealed that there is a 99% probability that the MSFT stock will not decrease more than 2.076% on day T+1, 2.09% on the day T+2, 2.116% on the day T+3 and similar probabilities were calculated for the remaining days.

```
0-roll forecast [T0=1257-01-01]:
      Series   Sigma
T+1 0.001412 0.02076
T+2 0.001412 0.02096
T+3 0.001412 0.02116
T+4 0.001412 0.02136
T+5 0.001412 0.02156
```

Figure 17 : Forecast Volitality of MSFT in next 5 days

TASK 6: Summary of findings and discuss the implication of other relevant performance measurements.

Let's dive into the heart of our analysis, exploring the dynamics of our investment portfolio. Picture this: a carefully curated blend of tech giants, including IBM, Dell Technologies, Google, Microsoft, and Oracle. Over five years, from December 23rd, 2017, to December 23rd, 2022, we've delved into their historical stock prices, sourced diligently from Yahoo Finance.

Our journey begins with uncovering each company's expected returns and volatilities, alongside the intricate dance of correlations between their returns. These figures paint a vivid picture: annual expected returns ranging from a steady 9.245% for Dell Technologies to a robust 20.52% for Google. Yet, amidst this diverse landscape, we find volatility fluctuating from 29.664% for Oracle to a slightly more turbulent 39.405% for IBM. We've also untangled the web of correlations through meticulous analysis, spanning from 0.43 for Dell Technologies and Oracle to a striking 0.81 for Google and Microsoft.

But our story continues beyond there. We've charted the course of the efficient frontier, a visual representation of our portfolio's risk and return for different target levels. What unfolds before us is a tale of cautious optimism: a gentle slope hinting at a delicate balance between risk and return. As we navigate this terrain, we encounter pivotal landmarks—the tangency and minimum variance portfolios—guiding us towards optimal portfolio construction.

Venturing more profoundly, we've harnessed the power of Sharpe ratios, unravelling a spectrum of values from 0.13 to 0.7, each offering insight into risk-adjusted returns. The Capital Market Line (CML) emerges as our guiding star, with its equation—0.16—illuminating the path to risk-adjusted returns.

And what of our portfolio's resilience amidst market fluctuations? With beta as our compass, we discover an overall volatility of 9.106% greater than the market's. Yet, in the ebb and flow of bullish and bearish tides, we find nuances—13.4165% more volatile in bullish times and a slightly more tempered 5.5519% in bearish conditions.

Our narrative reaches its zenith with the Value at Risk (VaR) estimation. Each asset reveals its contribution: from IBM, the stalwart with the lowest contribution, to Dell Technologies, commanding the lion's share. These revelations echoed in percentages—16.43337% for IBM and a formidable 24.02250% for Dell Technologies—hold the key to unlocking the portfolio's risk landscape.

Our journey through the labyrinth of data unveils a tapestry of insights. It's a narrative of calculated risks, strategic manoeuvres, and informed decisions—a testament to the power of data-driven storytelling in shaping our investment journey.