Names: Adarsh Tiwari, Laldinpuia Hmar, Narendra Chatta, Kushal Shahi, Niall Pande
Financial Analytics and Artificial Intelligence
Tushar Jaruhar

Introduction

Portfolio management is the process of carefully selecting and overseeing a group of investments to achieve specific financial goals while balancing the reward and risk. Let's explain the concept of portfolio management using an example. Imagine you have a basket and you are in a supermarket. Now in that basket you can put various things like fruits, vegetables, stationary, or even toys. Each of these items have their own benefits – some of them are sweet, some are useful and some are fun to play with. In the same way, when we talk about investments like stocks, gold, bonds, or real estate, each of them offer different benefits and risks. So, a portfolio is like a basket and the investments are the things you can put in the basket. Portfolio management is the art of deciding what to put in that basket to ensure that the things in the basket grow (more reward) and stay safe (less risk).

Why do we need Portfolio Management?

In this rapidly changing world, we all want to save money and make it grow. However, putting all the money in one place is risky. For instance, if you invest only in one stock and the company does not do well, then you could lose all the money you invested. But if you spread your money across many different investments (just like in our basket example), then even if one of the things does not do well, the others might. This will help in protecting our overall savings. Thus, portfolio management helps you balance the reward (the chance of making money) and the risk (the chance of losing money) by spreading/investing your money across diverse types of investments.

In this project,

- **For NIFTY50 Stocks:** We are finding the optimal weights to get the maximum Sharpe ratio (i.e. Reward to risk ratio) for the NIFTY50 stocks and perform the risk analysis for these stocks using the VaR (Value at Risk).

- **For 5 Stocks:** We are only taking stocks from various sectors into consideration. We are taking note of the diversification principle and got stocks from different sectors whose correlation is very low among each other. This way even if one of the sectors have some drastic change, it would not affect the other sectors much, resulting in less portfolio risk. Apart from this, we choose stocks from different market caps. We also looked into the company fundamentals, their scope of international expansion, the industry trends, and factors like debt-to-equity ratio, P/E ratio, book value, and revenue growth. After all this research, we found the optimal weights which would give us the maximum Sharpe ratio and performed the risk analysis.

Methodology Used:

Markowitz model: It is a portfolio management model which assists in selecting the most efficient portfolio by calculating the optimized weights to maximize the overall with minimizing risks producing the highest sharpe ratio.

Monte Carlo Simulation: The Monte Carlo simulation is another method to assess portfolio returns which involves repeatedly sampling inputs allowing to assess performances like expected return, volatility and Sharpe ratio.

VaR Analysis: Value at Risk(VaR) is a risk management tool that quantifies the potential loss in value of a portfolio over a specified time period for a given confidence level. It helps understand the potential downside risk of investments.

Data and Risk free rate

The NIFTY50 stock data was collected from Yahoo Finance, using the 'yfinance' API. This API pulls the historical data for each of the selected stocks from NIFTY50. Additionally, our stock data includes only the daily adjusted closing prices over the time period of 3 years (from 11th October 2021 to 11th October 2024). Moreover, we got the risk free rate by referring to the 10-year Government Bond Yield. We referred to this data from an external website called Investing.com.

Rationale for Stock Selection:

Let us look at the different companies and the reason as to why we have selected them as part of our portfolio (what could potentially drive their future growth):

A. **Triveni Turbine Ltd.:** Triveni Turbine Ltd. accounts for 50% market share in the Indian market for the 0-30 MW steam turbine segment, and has a strong presence in over 70 countries globally. With 36% YoY revenue growth in FY 2024 and EBITDA margins above 23%, it has been focusing on technological innovation and expansion in aftermarket services, effectively striving for long-term growth, particularly in the renewable energy sector.

Financials:

- **Revenue Growth**: Revenues increased by **36% YoY** in FY 2024, reaching **₹11.96 billion**, indicating strong growth momentum.
- **EBITDA Margins**: The company maintained an **EBITDA margin above 23%**, reflecting strong operational efficiency.
- **Order Book**: The order book stood at a record **₹15.8 billion**, up by 28%, providing future revenue visibility and sustained demand
- **Cash Flow Stability**: A growing focus on **aftermarket services** ensures consistent, recurring revenue, adding to the company's sustainable cash flow even during slower turbine sales periods

Other Growth Drivers:

- **Market Leadership**: Triveni Turbine is one of the top two global players in the **0-30 MW steam turbine segment**, with **50% market share** and exports accounting for **51% of total revenue**, up from previous years
- **Global Expansion**: The company has a presence in over **70 countries**, reducing reliance on the domestic market and improving growth prospects internationally
- **Strategic Partnerships**: The joint venture with **GE Oil & Gas** boosted Triveni's technological expertise and reach, allowing it to serve high-growth sectors like **waste-to-energy** and **renewable energy**
- **Technological Innovation**: Triveni focuses on **R&D** and holds over **338 patents**, leading to cutting-edge energy-efficient turbines and sustainable solutions for renewable energy sectors like **biomass** and **waste heat recovery**.
- **Aftermarket Services**: The company's expansion into the **aftermarket repair and services** sector for external turbines provides an important revenue stream, stabilizing earnings even when sales slow down.

References:

- Triveni Turbines 2024 Annual Report: Triveni Turbines
- Forbes India on Triveni's global growth and strategy: Forbes India
- Screener

B. **Bharat Forge**: **Bharat Forge Ltd.** is a global leader in the automotive, defense, and aerospace sectors, known for its innovation and strategic collaborations. It plays a key role in defense modernization and self-reliance, while making use of the growing demand for electric vehicle components. With its strong market position and focus on high-growth industries, Bharat Forge is well-positioned for future expansion and long-term growth.

Qualitative Reasons:

- **Global Reach:** Bharat Forge has a diverse portfolio in automotive, defense, and aerospace, significantly focused on artillery systems.
- **Defense Growth:** Collaborations with AM General and Mandus Group enhance its defense capabilities, particularly in next-generation artillery platforms.
- **Market Leadership:** Accounts 80% of foreign contracts in the defense sector, becoming a global leader.
- **Self-Reliance Contribution:** Helps India's defense self-reliance under the Made in India strategy.
- **EV Market Adaptation:** Adjusting to new emission regulations and rising demand for electric vehicle components.

Financial Reasons:

- **P/E Ratio: High at 71.9**, suggesting expectations for **growth**.
- With a **Return on Equity (ROE) of 12.7%**, the **capital** was **used efficiently**.
- **12.9% Return on Capital Employed (ROCE)** is a **solid performance indicator.**
- With a **dividend yield of 0.60%**, investors should expect significant profits.
- **Growth Focus:** Excellent prospects for future expansion with its focus on electric vehicle components, defense modernization, and aerospace recovery.
- **Reasoning for Investment:** Attractive option for long-term investors in international industrial and defense sectors due to its strong foundations and strategic objectives.

References: Screener

C. **TATA ELXSI: Tata Elxsi** is a global leader in design-led technology services, and it presents a compelling investment opportunity due to its diversified business model, consistent growth, and strong financial performance. It has a strong presence in multiple sectors such as the automotive, media, communications, and healthcare, and since it can leverage its technology expertise, it is well-positioned to benefit from rapid digital transformation across industries.

Key Growth drivers and differentiators:

- Plays a key role in the development of **Software-Defined Vehicles (SDV)**, autonomous driving systems, and electric vehicle solutions.
- Partnered with global **OEMs** and **Tier-1 suppliers** in the automotive sector
- Secured a **$50 million multi-year deal** with European OEM to develop **Level 3+ autonomous driving systems**, strengthening its leadership in SDV and automotive technologies
- Partnerships with **Ateme** and **INVIDI Technologies** in media and communications, enabling access to innovative video services and addressable advertising solutions.
- Exploring the healthcare sector through **multi-year contracts** to develop **critical care device platforms** and next-gen hospital equipment.
- Leveraging **AI and machine learning** to enhance regulatory workflows and operational efficiencies in medical devices, driving breakthrough innovations in healthcare.

Strong Financial Performance:

- Reported a **24% YoY increase** in net profit for Q2 FY25.
- Operating margins expanded to **27.9%**.
- Delivered a **22.4% CAGR in profit growth** over the last 5 years.
- Maintained an ROE of **37.4%** over the past 3 years.
- Operates with **minimal debt**, enhancing financial stability and reducing risk.
- **Strong profitability** allows reinvestment into innovation and expansion while consistently providing returns to stakeholders.

References:

- The Tata group. Leadership with Trust.
- Business Upturn
- Screener

D. **State Bank of India:** State Bank of India (SBI) is one of the very safe investment propositions where stability and growth go hand in hand. Being India's oldest and largest bank, SBI has spread its reach well through a diversified business model.

Main Strengths:

- **Market Leadership**: SBI holds a 22.84% share in deposits and 19.69% in advances. Its well-diversified loan book spans retail, corporate, SME, and agriculture, minimizing risk.
- **Sound Balance Sheet**: SBI maintains a strong Capital Adequacy Ratio of 14.50%, a Net Interest Margin of 3.34%, and has reduced Net NPAs to 1.23%.
- **Broad-based Network**: With over 22,000 branches, 62,617 ATMs, and 71,968 business correspondents, SBI's extensive network supports growth in both urban and rural markets.

Growth Catalysts:

- **Subsidiary Contributions**: SBI's subsidiaries, such as SBI Life Insurance and SBI Cards, drive growth and diversify revenue streams.
- **Digital Growth**: SBI's YONO platform processes 67% of all transactions, with digital penetration increasing by 10%.
- **International Business**: SBI operates in 32 countries, contributing to 13% of its advances, diversifying its revenue base.
- **Financial Performance**: SBI has delivered a 98% CAGR profit growth over the last five years and maintained a healthy dividend payout of 18.1%, reflecting consistent profitability.

References:

- About SBI
- Annual Report
- PPT
- Screener

E. **Deepak Nitrite Ltd.:** Deepak Nitrite Ltd. is one of the important investment recommendations combining strong financials, strategic market positioning, and growth potential within the chemical sector. Investing in Deepak Nitrite is a smart move because:

Strong Financial Performance:

- **Debt Status**: Deepak Nitrite has nearly zero debt, showing financial stability and growth potential.
- **High ROE**: Great three-year Return on Equity of 23.9%, providing effective capital allocation and strong profitability.
- **Consistent Profit Growth**: Net profit has grown five times recently, driven particularly by the phenolics business.

Key Growth drivers and differentiators:

- **Market Leadership:** Deepak Nitrite accounts for 75% market share in sodium nitrite, sodium nitrate, and nitrotoluenes, and 50% in phenol and acetone, reducing India's import dependence.
- **Strategic Investments:** Sets to invest ₹300 crore in eco-friendly technologies and ₹700 crore in high-value solvents to guide revenue growth.
- **R&D Focus:** New R&D center in Vadodara enhances innovation in specialty chemicals and green production methods.
- **Revenue Growth:** Strong sales growth with a near monopoly in the domestic market; exports account for 22% of revenues, primarily to Europe, the US, and Asia.
- **Global Strategy:** Connecting with the 'China Plus One' strategy, Deepak Nitrite is advantageous to attract global firms diversifying supply chains.

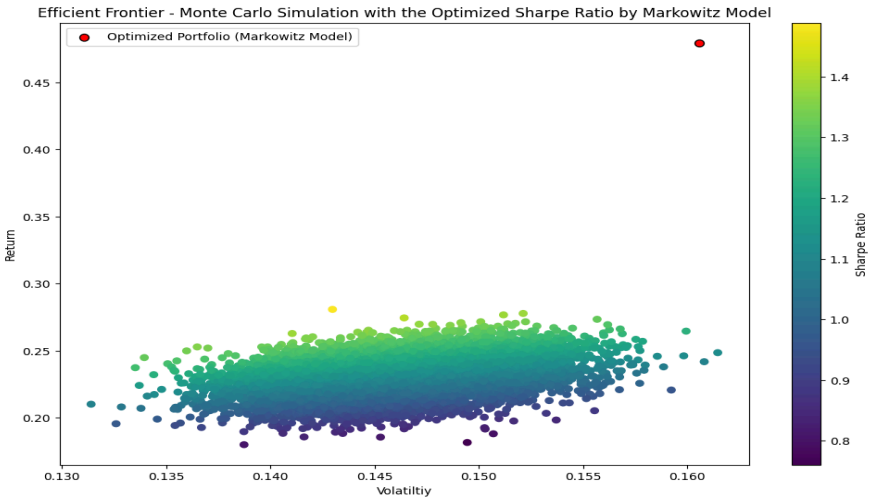
- **Strategic Partnerships:** Long-term agreements with Petronet LNG enhance raw material supply for new projects in high-demand sectors like automotive and consumer electronics.
- **Investment:** Strong financial health, nearly debt-free status, high ROE of 23.9%, and sustainable practices make Deepak Nitrite a potential long-term investment.

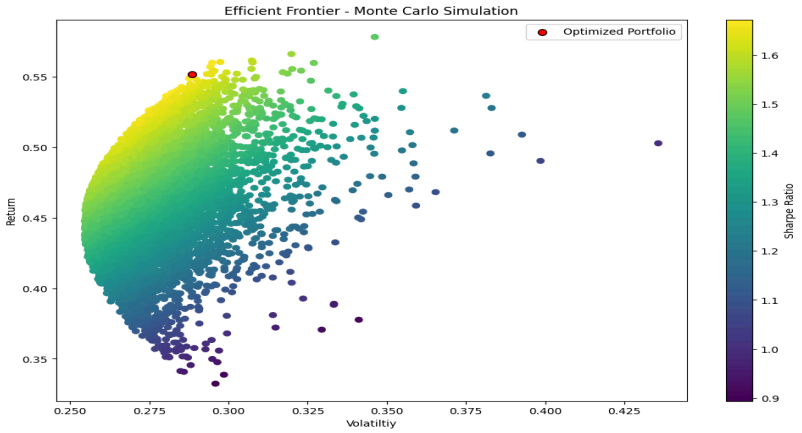
Reference: Screener

Optimization and Simulation

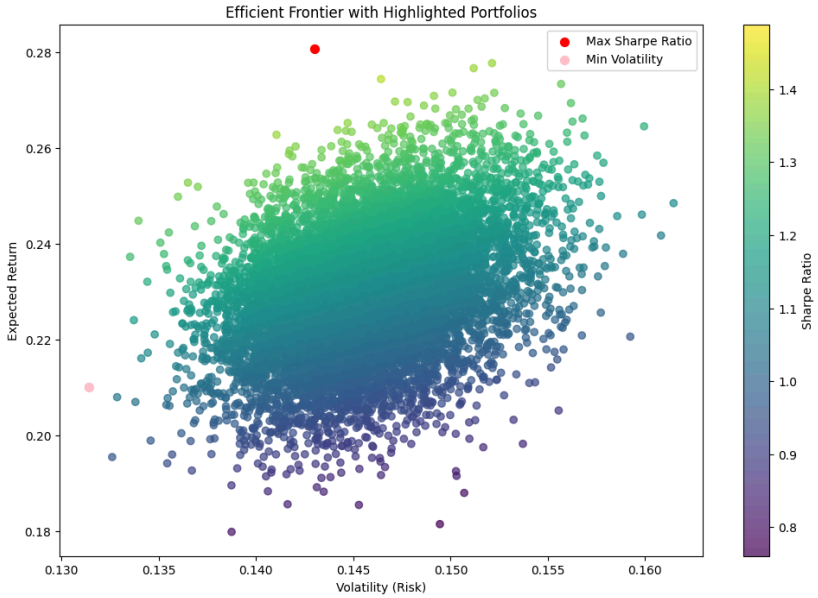
Optimization Process: The aim of our optimization is to increase the Shape Ratio while maximizing the Return and minimizing the Risk. The weights are modified in a way that they are constrained between 0 and 1 and their sum equals 1. The weights are then optimized and we optimized standard deviation and optimized return. The resulting optimized standard deviation and return gives the optimized Sharpe Ratio.

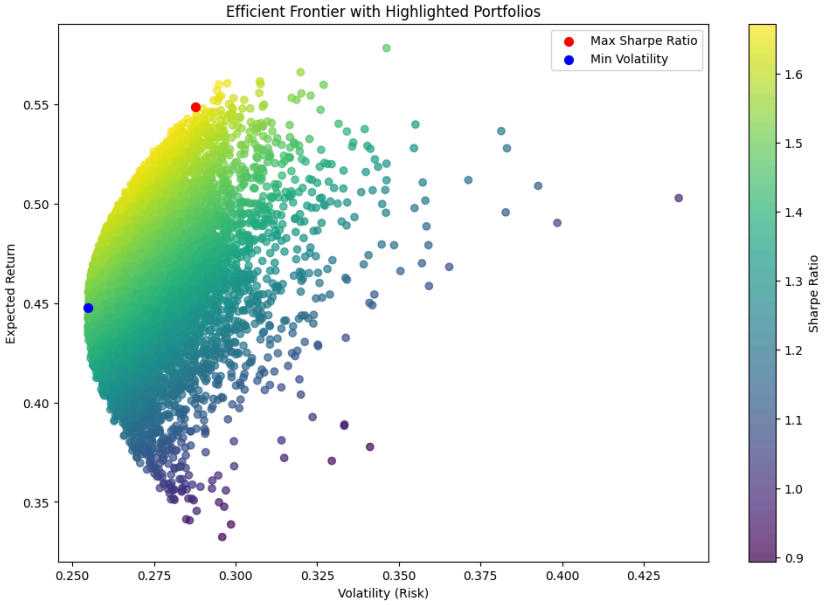
Monte Carlo Simulation: Monte Carlo simulations involve two optimizations: one without the Markowitz Model and with it. In both cases, we generate 10000 random portfolios to stimulate potential performances. We iterate through the random portfolio and assign random weights which are normalized to sum 1 as in the optimization process discussed above.
In Monte Carlo Simulation by Markowitz Model, we optimize the weights by Markowitz method and for each portfolio, we calculate return, volatility and Sharpe ratio. We then plot a graph to show the efficient frontier representing the volatility and expected return and we highlighted the maximum sharpe ratio. (First graph represents the NIFTY 50 stocks and the second graph represents the 5 stocks)





Whereas in Monte Carlo simulations without Markowitz method, it finds the highest Sharpe ratio by manually locating it and we did it similarly for finding the lowest volatility again. We then plot graphically to show the risk-expected return graph to show where the maximum Sharpe Ratio and minimum volatility lies. (First graph represents the NIFTY 50 stocks and the second graph represents the 5 stocks)



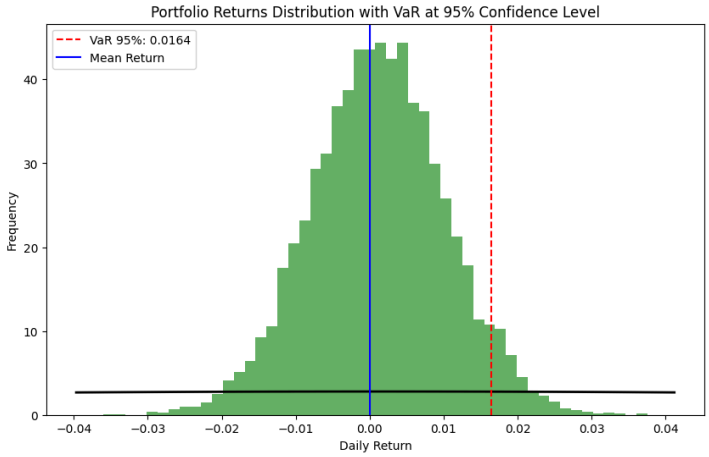


Risk Analysis

1. **NIFTY 50:**

- **Volatility (Risk):** The Monte Carlo Simulation with Markowitz Model has a risk of 0.16058980843599716 or 16.06%. Our Portfolio of Monte Carlo Simulation with maximum Sharpe ratio has a risk of 0.14 or 14% while our Portfolio with Minimum Volatility has 0.13 or 13%.

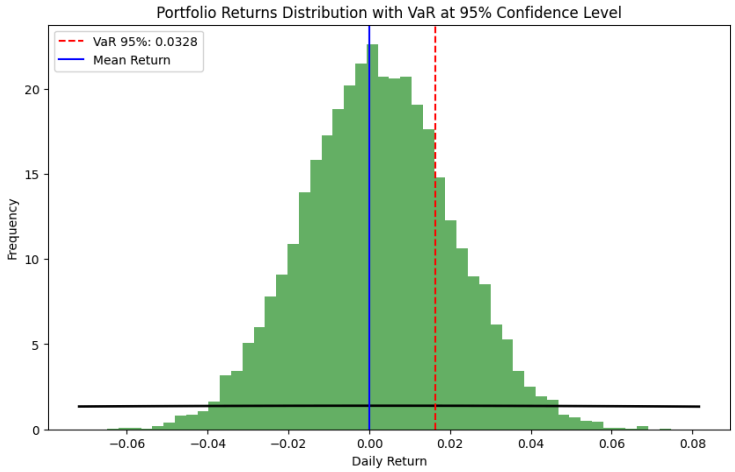
- **Value at Risk (VaR):** At a 95% confidence level, we have a VaR at 0.015920.01592 or 1.592% meaning that in a single day, there is a 5% chance of losing more than 1.592. When simulating it 10000 times, we have a VaR at 0.016443324891963533 or 1.644% which is higher than the previous theoretical calculation reflecting that there are potential market fluctuations and volatility not captured in the original model.



2. **5 STOCKS:**

- **Volatility(Risk):** The Monte Carlo Simulation with Markowitz Model has a risk of 0.2885921112796737 or 28.86%. Our Portfolio of Monte Carlo Simulation with maximum Sharpe ratio has a risk of 0.29 or 29% while our Portfolio with Minimum Volatility has 0.25 or 25%.

- **Value at Risk(VaR):** At a 95% confidence level, we have a VaR at 0.03198298198436844 or 3.198% meaning that in a single day, there is a 5% chance of losing more than 3.198. When simulating it 10000 times, we have a VaR at 0.03276730629186926 or 3.2767% which is slightly higher than the previous theoretical calculation reflecting that there are potential market fluctuations and volatility not captured in the original model.



Results

1. **For NIFTY50 Stocks:**

- After applying the Markowitz model, we are able to compute the optimal portfolio allocation weights for the NIFTY50 stocks. However, the Sharpe ratio from this solution is coming out to be anomalously high, and does not bear a close resemblance to what should be reflected in the efficient frontier. This is because the mathematical optimality of the Markowitz model may leave out practical realities like market constraints, liquidity, and several other external factors that might impact stock performance. As such, the model is giving too much weight to one stock or a few stocks, thereby unbalancing the portfolio and generating very unrealistic outcomes, which could evidently be seen in the figure above.

- To tackle this problem, we used a Monte Carlo simulation, where we assigned weights to the 50 stocks randomly with the intention of generating vast spread portfolios. Then, we

simulated 10,000 different portfolios to capture the broad nature of potential outcomes. From the large sample, we traced portfolios that met following two criteria:

a. **Highest Sharpe Ratio:** We traced the portfolio with the highest return in terms of every unit of risk taken. This portfolio provides a more efficient, risk-adjusted performance. The following is the more detailed information with the individual weights -

```
Portfolio with Maximum Sharpe Ratio:
Return: 0.28, Volatility: 0.14, Sharpe Ratio: 1.49
Optimal Weights: [0.03957569 0.01915219 0.02386162 0.00603159 0.00010591 0.01832246
 0.00124979 0.00467094 0.03956537 0.03680137 0.00960374 0.03517902
 0.03861938 0.02032001 0.03616567 0.00113243 0.01275677 0.03771763
 0.00428626 0.00136822 0.00593312 0.00475643 0.0134076  0.01647413
 0.00462398 0.01127798 0.04677232 0.00756022 0.01921496 0.00923524
 0.02092022 0.00215756 0.03562037 0.03271307 0.04736092 0.01752835
 0.00191239 0.00970943 0.03375574 0.01036932 0.03915988 0.00134194
 0.02942082 0.0343747  0.03883272 0.02423168 0.03177445 0.03070219
 0.02801474 0.00435744]
```

b. **Lowest Volatility**: We also traced the portfolio which minimizes the risk.

```
Portfolio with Minimum Volatility (Risk):
Return: 0.21, Volatility: 0.13, Sharpe Ratio: 1.08
Optimal Weights: [0.00822836 0.00313276 0.03578471 0.02307493 0.00222017 0.03047484
 0.01630189 0.0112997  0.02400575 0.03565615 0.03474328 0.03604858
 0.0200275  0.00406887 0.02744119 0.02693316 0.02680749 0.03893671
 0.02017891 0.0062234  0.02473547 0.0150351  0.03034874 0.03625696
 0.00219758 0.03710444 0.02434079 0.01712552 0.02776371 0.0308777
 0.01806546 0.00424394 0.0166892  0.00407412 0.03745135 0.0213015
 0.03355437 0.03784678 0.00829402 0.00161993 0.03250414 0.02240946
 0.00012334 0.0006562  0.03183898 0.00025058 0.01843543 0.00602845
 0.01988269 0.0073557 ]
```

- Now, using the critical analysis of the Monte Carlo simulation, we determined the best weights for each of these 50 stocks by the above criteria aimed at the highest Sharpe ratio and lowest volatility.

- **Value at Risk for NIFTY50:** The NIFTY50 stocks portfolio shows a VaR of 0.015929555104677782 at a 95% confidence level. This means that in 95% of the cases, on any given day, the NIFTY50 portfolio will not lose more than 1.59% of its value. In other words, there is only a 5% chance that the portfolio could lose more than 1.59% in a single day. This is based on historical volatility and the assumptions of normal distribution of returns. (In the figure above)

2. For 5 stocks that we chose:

- For the 5 stocks: ‘"TRITURBINE.NS', 'SBIN.NS', 'DEEPAKNTR.NS', 'BHARATFORG.NS', 'TATAELXSI.NS', we were able to compute the optimal portfolio allocation weights for these stocks such that we gain the highest reward with least risk. The optimization algorithm adjusted the portfolio weights to achieve this balance, resulting in a portfolio that lies on the efficient frontier.

- We then used a Monte Carlo simulation, where we assigned weights to the 5 stocks randomly with the intention of generating vast spread portfolios. Then, we simulated 10,000 different portfolios to capture the broad nature of potential outcomes. From the large sample, we traced portfolios that met following two criteria:

1. **Highest Sharpe Ratio:** We traced the portfolio with the highest return in terms of every unit of risk taken.

```
Portfolio with Maximum Sharpe Ratio:
Return: 0.55, Volatility: 0.29, Sharpe Ratio: 1.67
Optimal Weights: [0.00359377 0.24679053 0.05820626 0.46813406 0.22327538]
```

2. **Lowest Volatility**: We also traced the portfolio which minimizes the risk.

```
Portfolio with Minimum Volatility (Risk):
Return: 0.45, Volatility: 0.25, Sharpe Ratio: 1.49
Optimal Weights: [0.16348131 0.15358627 0.30831583 0.26830032 0.10631627]
```

- **Value at Risk for NIFTY50:** The NIFTY50 stocks portfolio shows a VaR of 0.01592955510467782 at a 95% confidence level. This means that in 95% of the cases, on any given day, the NIFTY50 portfolio will not lose more than 1.59% of its value. In other words, there is only a 5% chance that the portfolio could lose more than 1.59% in a single day. This is based on historical volatility and the assumptions of normal distribution of returns. (In the figure above)

Conclusion

In conclusion, this project applied the Markowitz model and Monte Carlo simulation to optimize the portfolio allocation for NIFTY50 and the selected five diversified stocks. The choice of five stocks of Triveni Turbine, Bharat Forge, Tata Elxsi, SBI, and Deepak Nitrite have strong financials, market leadership, and growth scopes in various sectors. The Sharpe Ratio is also pretty good for investors to invest in. Moreover, the VaR for the portfolio highlighted the risk exposure of the portfolio. Overall, it averaged a very balanced portfolio with the highest Sharpe ratio and minimal volatility, so it was a very robust investment strategy.

Works cited:

https://www.investopedia.com/articles/investing/112514/monte-carlo-simulation-basics.asp