

**BITS Pilani, Hyderabad Campus**

Department of Economics and Finance

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# **Modern Portfolio Theory**

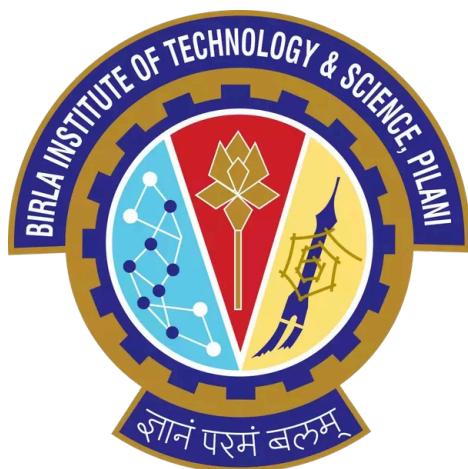
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**Group Number:** 14

**Course Name:** Securities Analysis and Portfolio Management

**Course Number:** ECON F412

**Instructors In-Charge:** Shreya Biswas



## **Group Number: 14**

<b>SR NO.</b>	<b>NAME</b>	<b>ID</b>	<b>SYMBOL</b>
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2	UTKARSH BHASKAR	2021B3A71610H	ASIANPAINT
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4	TANISHQ KURHADE	2022A7PS0208H	BORORENEW
5	PRAMUKH NANDAN REDDY KALLEM	2022A1PS0766H	ENGINEERSIN
6	RAJKUMAR SA	2022A8PS0851H	VBL
7	AROHI PORE	2022A1PS1678H	FIVESTAR

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## **Allotted Company Names**

- 1. BAJAJHLDNG (Bajaj Holdings)**
  - 2. ASIANPAINT (Asian Paints)**
  - 3. UJJIVANSFB (Ujjivan Small Finance Bank LTD.)**
  - 4. BORORENEW (Borosil Renewables)**
  - 5. ENGINERSIN (Engineering India LTD.)**
  - 6. VBL (Varun Beverages)**
  - 7. FIVESTAR (Five Star Business)**
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## **ACKNOWLEDGEMENT**

We would like to thank Dr. Shreya Biswas, for providing us this opportunity to work on this project, which helped us in applying the concepts and knowledge learned in the course in real life . We are deeply grateful for her timely guidance throughout the course of this project, which was crucial to the completion of this project. We shall remain indebted to her for her help and guidance throughout the course and this assignment. We are also thankful to the Economics Department, BITS Pilani Hyderabad Campus, for creating such provisions for students to participate in innovative, useful projects, while also giving us hands-on experience in applying our knowledge to real-world data. This project has certainly developed our skills and has given us the necessary tools to excel further in this field.

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## ABSTRACT

In the report, a detailed analysis and the development of a diversified portfolio of nine securities, including seven different firms, one international security and one cryptocurrency, for the period between April 1st, 2023 to March 31st, 2024 is done. The firm's raw returns were determined using the fundamental formula  $(P_t - P_{t-1})/P_{t-1}$ . To calculate the excess returns on the securities, the risk-free rate was deducted. Using the Nifty50 index as the market benchmark, we conducted a comparable examination of the market. These variables were used in the portfolio analysis to obtain the minimum variance and tangency portfolios using the Markowitz Model Portfolio. Finally, the same concept was used to generate the efficient frontier.

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## **PORTFOLIO OVERVIEW**

### **1. Bajaj Holdings**



Bajaj Holdings & Investment Ltd (BHIL) is the primary investment arm of the Bajaj Group, a prominent Indian conglomerate. Established in 1945 with its headquarters in Pune, it holds strategic stakes in various Bajaj subsidiaries including Bajaj Auto, Bajaj Finance, and Bajaj Finserv, with a focus on long-term capital appreciation and diversification of investments. Bajaj Holdings has a strong financial performance that has benefited greatly over the years, from the growth of its portfolio companies. It primarily aims to create shareholder value via strategic investments and portfolio management. Not only does BHIL play an important role in the Bajaj Group's strategy but it also provides investors with diversified exposure to a conglomerate with a wide range of business avenues.

### **2. Asian Paints**



Asian Paints, established in 1942, is one of India's leading paint companies. It holds a dominant position in the Indian market for decorative and industrial paints and also has significant international presence. A heavy focus on R&D for its own products, combined with digital initiatives to increase consumer engagement and enhance the buying experience has proved to be fruitful to the company, reflected in its strong financial performance (revenue growth and dividend payouts). The company continues to explore growth opportunities in both domestic and international markets and consistent innovation ensures that evolving consumer preferences are met.

### **3. Ujjivan Small Finance Bank**



Originally a microfinance company, Ujjivan Financial Services, established in 2005, obtained a banking licence from the Reserve Bank of India in 2016, forming Ujjivan Small Finance Bank in 2017. The bank primarily caters to low and middle income households, small businesses and the self employed (informal sector). The bank leverages its experience in microfinance to serve a strata of society which may not have access to traditional banking services. It has a wide network of branches with strong growth in deposits and loans, with a balanced loan product portfolio to mitigate risk. With further branch expansion planned, and a slew of digital offerings being released, we can appreciate the crucial role USFB plays in promoting financial inclusion in India.

### **4. Borosil Renewables**



Borosil Renewables is a subsidiary of the Borosil Group specializing in the manufacture of solar glass, which is a key component in the making of solar panels. The company aims to support the growing renewable energy sector in India. The company is headquartered in Mumbai with manufacturing facilities in Gujarat. Borosil Renewables is one of the leading makers of solar glass in India, leveraging its parent company's reputation for quality assurance, supplying both domestic and international clients. The company has seen strong growth owing to the increased adoption of renewable energy systems, with an increase in production capacity well underway.

## **5. Engineers India Ltd.**



**ENGINEERS INDIA LIMITED**

Engineers India Ltd is a leading engineering consultancy and contracting company based in New Delhi, founded in 1965. It is a public sector undertaking (PSU) with the Government of India holding a majority stake. EIL has been instrumental to the execution and completion of numerous projects in India and abroad, working in the oil and gas, infrastructure and renewable energy sectors. With projects in over 30 countries

## **6. Varun Beverages**



Varun Beverages is a major player in the Indian beverage industry, primarily known for being the bottling partner for PepsiCo in India and several other countries. Founded in 1995, the company produces soda, bottled water, fruit juices and other non-alcoholic beverages. With bottling plants in India, Sri Lanka, Morocco etc. it has the capacity to meet demand across various markets. Its relationship as a franchisee of PepsiCo contributes significantly to its revenue. It is also adapting to consumer preferences, with a shift towards healthier beverages and diet offerings. The company also demonstrates a commitment to sustainability and reducing its environmental impact.

## **7. Five Star**



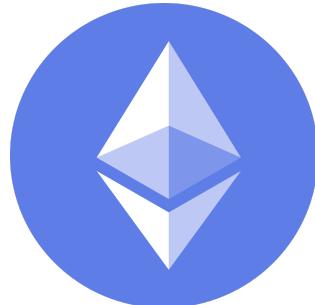
Five-Star Business Finance Limited is a prominent non-banking Financial Company( NBFC- ND- SI) registered with the Reserve Bank of India( RBI). With over 20 years of experience, the company helps small businesses and self-employed individuals get secure financial results. Five Star provides secured loans to micro-entrepreneurs and self-employed individuals for business purposes, as well as for asset creation such as home renovation or improvement, or for meeting expenses for significant economic events such as marriage, healthcare, and education.

## **8. Apple**



Apple is a technology company headquartered in Cupertino, California. With iconic products sold across the globe, Apple has become a household name. Founded in 1976, Apple has been making personal computers ever since, expanding into music players, cell phones and several other categories of electronics. Its business strategy over the years has proved to be sound, with high profit margins and revenue growth, maintaining substantial cash reserves and regularly paying investors dividends. Apple has shown consistent growth in its revenue base, engages with investor sentiments with its efforts towards carbon neutrality, and its ever increasing market capitalization is a solid metric to warrant investment.

## **9. Ethereum**



The cryptocurrency we've chosen to add to our portfolio is Ethereum. Launched in 2015, it introduced the concept of a programmable blockchain which lets developers deploy decentralized applications which can execute automatically when certain parameters are met. With the second largest market capitalization behind Bitcoin, Ethereum is one of the most widely traded cryptocurrencies. It has a strong community of developers and projects continuously evolving to address problems like scalability and transaction costs. The possibility for growth is endless, and a cryptocurrency could serve as valuable diversification for a portfolio primarily consisting of equity instruments.

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## **Markowitz Portfolio**

The Markowitz Portfolio Theory is a framework for constructing an investment portfolio with the goal of maximizing expected return for a given level of risk, or minimizing risk for a given level of expected return. It emphasizes diversification to reduce the overall risk of the portfolio.

Key concepts of Markowitz Portfolio Theory include:

### **1. Risk and Return**

Expected Return: The weighted average of the portfolio's expected returns of individual assets.

Risk (Standard Deviation): The portfolio's risk is influenced by the risk (standard deviation) of individual assets and how they correlate with each other.

### **2. Diversification**

Diversification reduces risk by combining assets that do not perfectly move together (i.e., low or negative correlation). By mixing such assets, the overall risk of the portfolio can be lower than the risk of any individual asset.

### **3. Efficient Frontier**

The efficient frontier is a set of optimal portfolios that offer the highest expected return for a given level of risk. Portfolios that lie on this frontier are considered efficient. Portfolios below the frontier are inefficient because they don't provide the best return for the level of risk taken.

### **4. Portfolio Optimization**

The goal is to find the portfolio that either:

Maximizes return for a given risk level or Minimizes risk for a given level of expected return.

### **5. Covariance and Correlation**

Covariance measures how two assets move together, and correlation standardizes this to a value between -1 and +1. These factors influence how diversification reduces risk. Lower or negative correlations between assets reduce portfolio risk.

### **6. Risk-Return Tradeoff**

Investors must choose where they want to be on the risk-return spectrum. By taking on more risk, investors can potentially achieve higher returns. Conservative investors may prefer lower-risk portfolios with more stable returns.

### **7. Capital Allocation Line (CAL)**

When a risk-free asset is introduced (e.g., Treasury bills), the Capital Allocation Line represents the risk-return combinations from holding a mix of the risk-free asset and a portfolio of risky assets. The portfolio with the highest Sharpe ratio (risk-adjusted return) is known as the tangency portfolio.

**When short selling is allowed :**

$$\text{Min } \sigma_p^2 = \mathbf{w}' \boldsymbol{\Sigma} \mathbf{w}$$

Constraint:  $\mathbf{w}' \mathbf{1} = 1$

$w$ - vector of asset weights

$\boldsymbol{\Sigma}$  - variance-covariance matrix

**When short selling is not allowed**

$$\text{Min } \sigma^2 = \mathbf{w}' \boldsymbol{\Sigma} \mathbf{w}$$

Constraint:  $\mathbf{w}' \mathbf{1} = 1, \mathbf{w} > 0$

$w$ - vector of asset weights

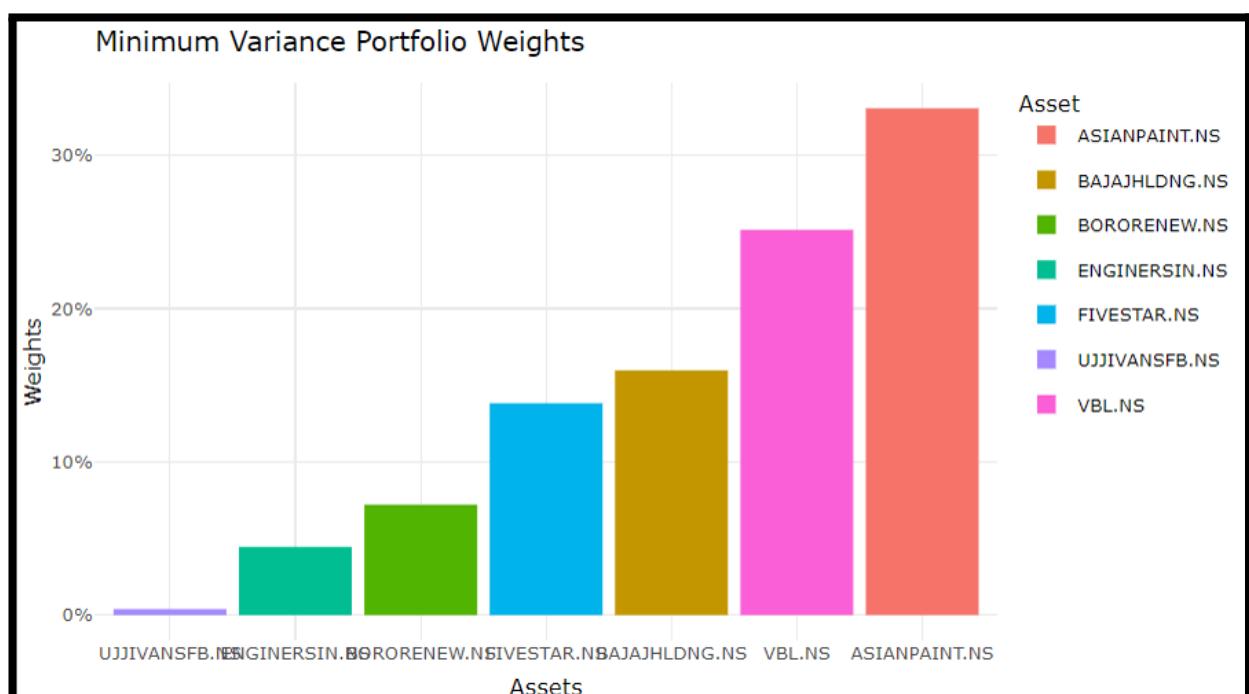
$\boldsymbol{\Sigma}$  - variance-covariance matrix

## Domestic Portfolio

### Minimum Variance Portfolio:

A minimum variance portfolio indicates a well-diversified portfolio that consists of individually risky assets, which are hedged when traded together, resulting in the lowest possible risk for the rate of expected return.

### Weights for Minimum Variance Portfolio (Without Shortselling):



### Security weights for Minimum Variance Portfolio (Without Shortselling):

ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
0.3305805	0.1596361	0.07197896	0.04443116	0.1382008	0.003857526	0.251315	0.4198346	0.1400941	2.497139

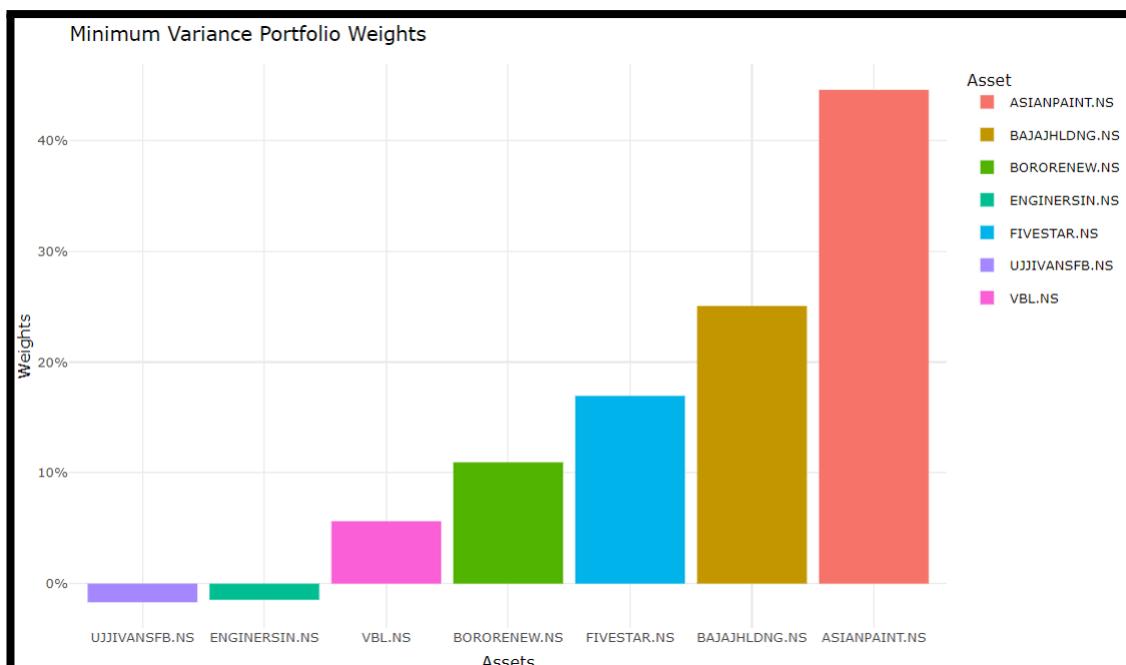
## Mean Return and Cov Matrix (Without Shortselling)

```

ASIANPAINT.NS BAJAJHLDNG.NS BORORENEW.NS ENGINERSIN.NS FIVESTAR.NS UJJIVANSFB.NS VBL.NS
 0.00014     0.00152      0.00070    0.00412     0.00112     0.00219     0.00282
>
> # Calculate the covariance matrix (annualized by multiplying with 252)
> cov_mat <- cov(log_ret_xts) * 252
> print(round(cov_mat, 4))
   ASIANPAINT.NS BAJAJHLDNG.NS BORORENEW.NS ENGINERSIN.NS FIVESTAR.NS UJJIVANSFB.NS VBL.NS
ASIANPAINT.NS     0.0273     0.0085     0.0079     0.0086     0.0024     0.0079 0.0018
BAJAJHLDNG.NS    0.0085     0.0656     0.0161     0.0296     0.0071     0.0109 0.0108
BORORENEW.NS     0.0079     0.0161     0.1738     0.0548     0.0195     0.0372 0.0110
ENGINERSIN.NS    0.0086     0.0296     0.0548     0.2733     0.0353     0.0611 0.0095
FIVESTAR.NS      0.0024     0.0071     0.0195     0.0353     0.1108     0.0266 0.0008
UJJIVANSFB.NS    0.0079     0.0109     0.0372     0.0611     0.0266     0.1443 0.0102
VBL.NS           0.0018     0.0108     0.0110     0.0095     0.0008     0.0102 0.0860
> |

```

## Weights for Minimum Variance Portfolio (With Shortselling):



## Security weights for Minimum Variance Portfolio (With Shortselling):

	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
1	0.3885189	0.1030166	0.02567187	-0.04208925	0.1137796	0.09073149	0.3203709	0.3813902	0.1415782	2.199422

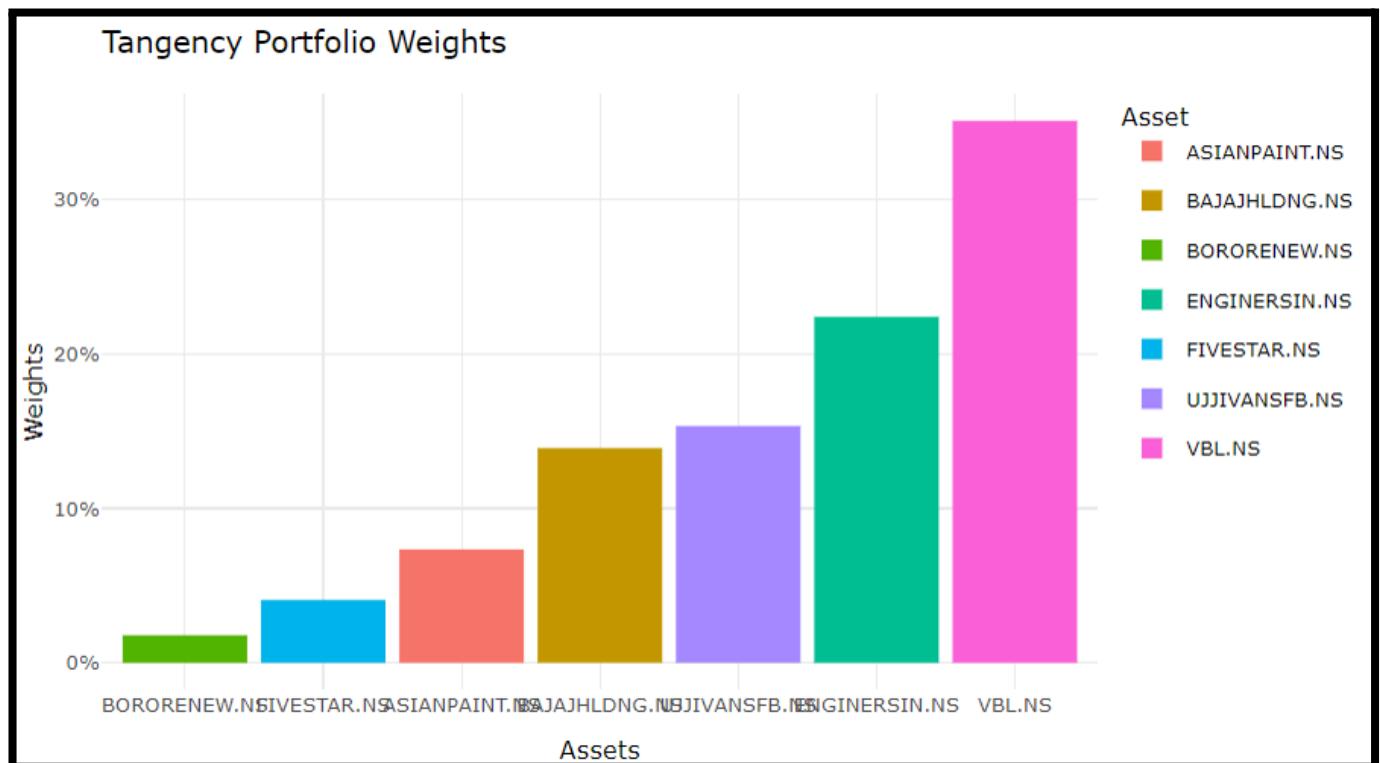
## **Inferences from the Minimum Variance Portfolio:**

The minimum variance portfolio allocates the largest weight to ASIANPAINTS (~30%), optimizing risk and return trade-offs. The portfolio's Sharpe ratio (0.261) reflects moderate risk-adjusted returns. The covariance matrix indicates how stock returns move together, helping reduce overall portfolio volatility. Positive covariances suggest mild correlations between assets, with the portfolio achieving diversification despite concentrating weight on lower-risk assets like ASIANPAINTS to minimize risk.

## Tangency Portfolio

The tangency point is the optimal portfolio of risky assets, known as the market portfolio. It is the portfolios with the best trade-off between expected returns and variance (risk) lie on this line.

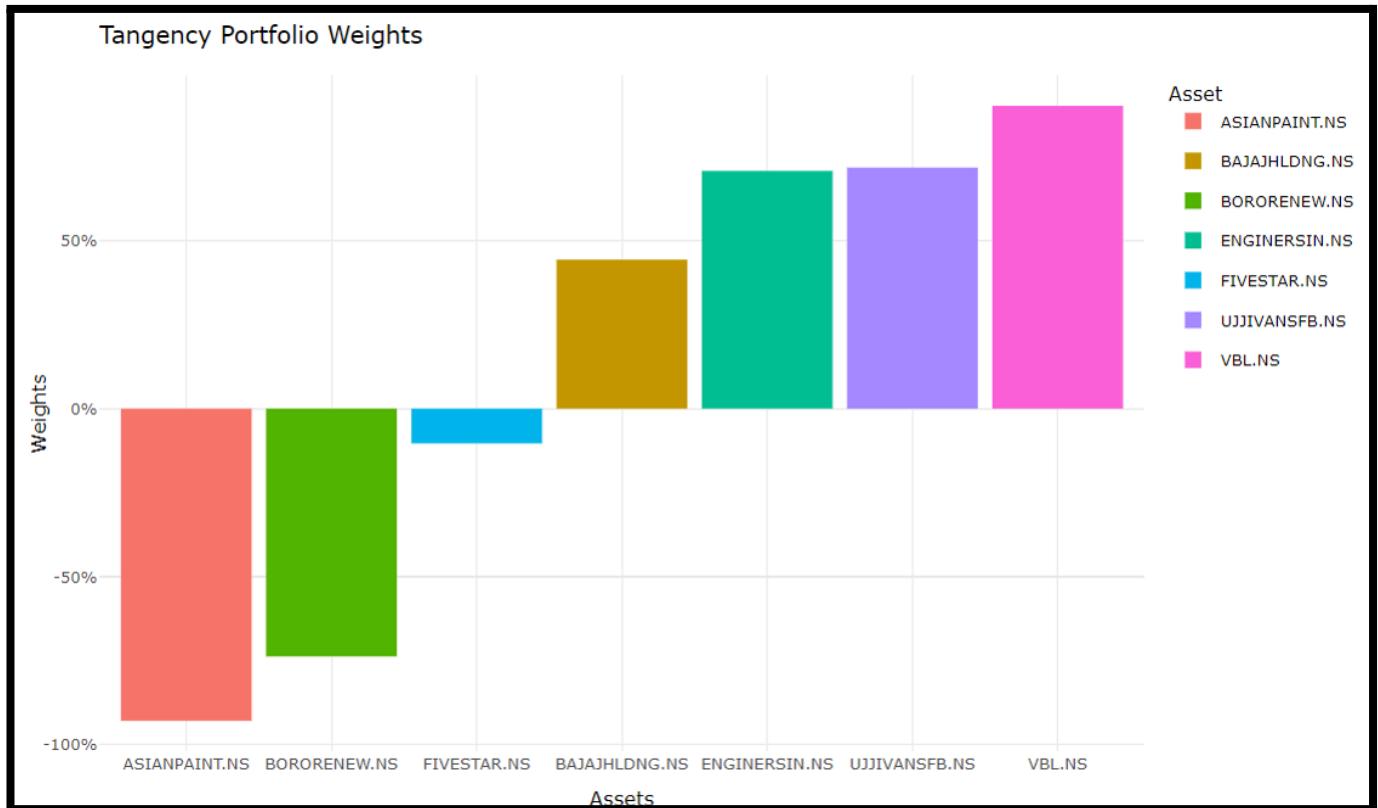
## Weights for Tangency Portfolio (Without Short Selling)



## Security weights for Tangency Portfolio (Without Short Selling):

ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio	
0.07343323	0.1391284	0.01779475	0.2242336	0.04069743	0.1534467	0.3512659	0.8894609	0.205668	3.984388	

## Weights for Tangency Portfolio (WithShortselling)



## Security weights for Tangency Portfolio(With Short Selling):

	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
1	-0.9670991	0.6503985	-0.2532046	0.987453	-0.3860564	0.03699956	0.9315091	4.827135	0.6361382	7.478147

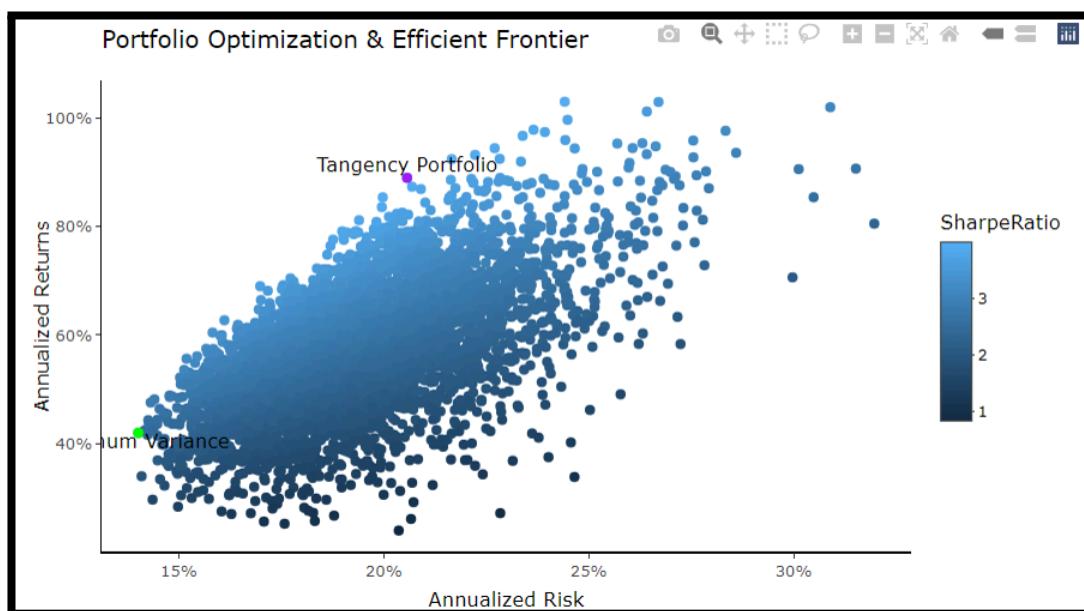
## Inference from tangency portfolio:

In a tangency portfolio our objective is to maximize the risk adjusted return i.e. maximize the sharpe ratio. The tangency portfolio maximizes risk-adjusted returns with the highest weight allocated to VBL.NS (~30%) due to its strong return-to-risk profile, followed by ENGINEERSIN.NS and UJJIVANSFB.NS. BORORENEW.NS has the smallest allocation. The portfolio achieves a Sharpe ratio of 0.546, indicating efficient risk management. This portfolio is ideal for investors aiming to optimize returns per unit of risk, leveraging the high return potential of VBL.NS and ENGINEERSIN.NS.

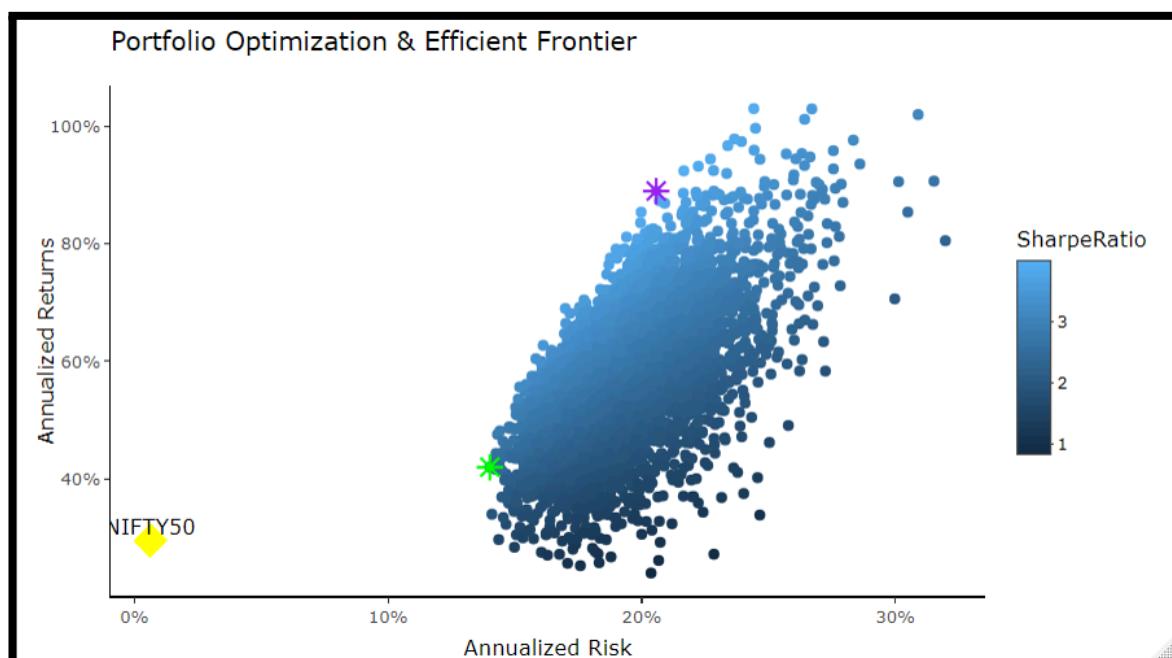
## Efficient Frontier:

The efficient frontier is a collection of optimum portfolios that provide the best anticipated return for a given level of risk or the least risk for a given level of expected return. Portfolios that are below the efficient frontier are sub-optimal because they do not generate enough return for the amount of risk they carry. Also, portfolios that cluster to the right of the efficient frontier have a greater degree of risk for the stated rate of return, making them sub-optimal.

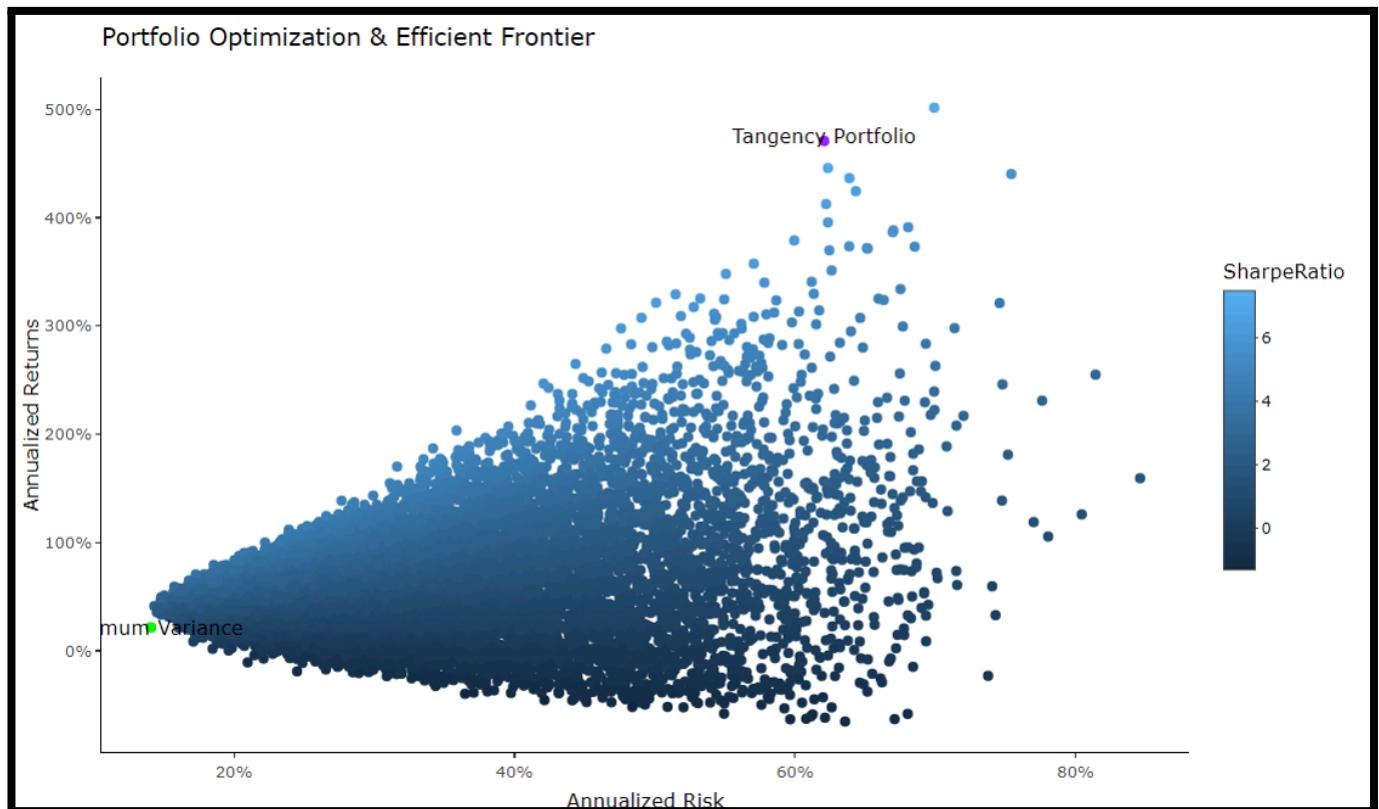
## Portfolio Optimization And Efficient Frontier (without short selling):



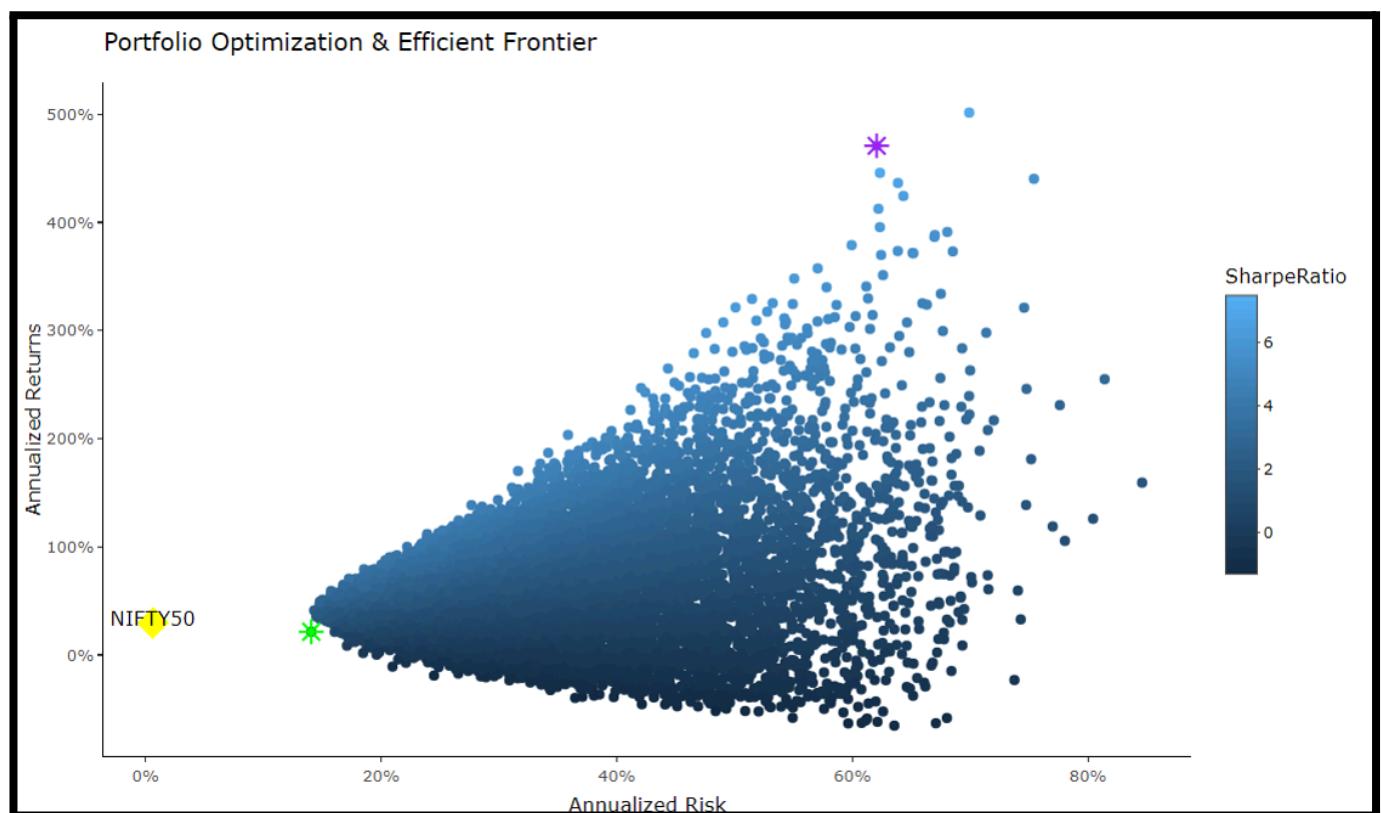
## Efficient Frontier (with NIFTY 50 for comparison):



## Portfolio Optimization And Efficient Frontier (with short selling):



## Efficient Frontier (with NIFTY 50 for comparison):



## Inference from efficient frontier

**NIFTY 50's position:** The NIFTY 50 is located below the efficient frontier, indicating that it may not be the most efficient portfolio for the given level of risk. Other portfolios on the frontier offer better returns for the same or even lower levels of risk.

**Tangency Portfolio:** In both graphs, the tangency portfolio stands out as a key optimized choice for maximizing returns per unit of risk.

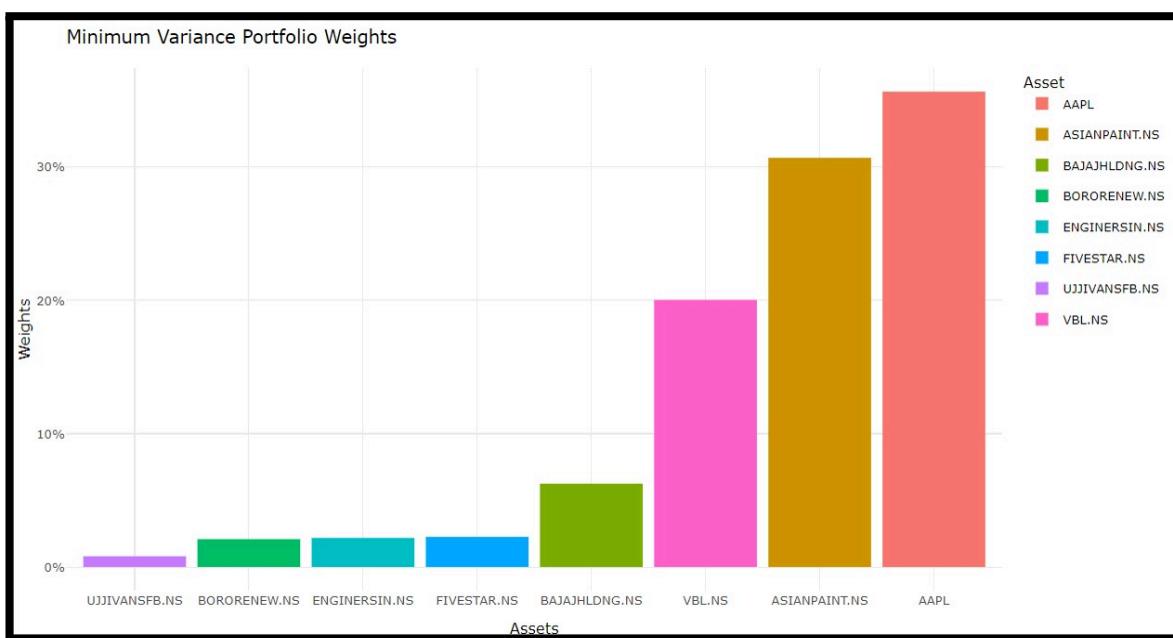
# International Portfolio

This portfolio includes an additional international security - Apple, along with the 7 securities used in the domestic security.

## Minimum Variance Portfolio:

A minimum variance portfolio indicates a well-diversified portfolio that consists of individually risky assets, which are hedged when traded together, resulting in the lowest possible risk for the rate of expected return.

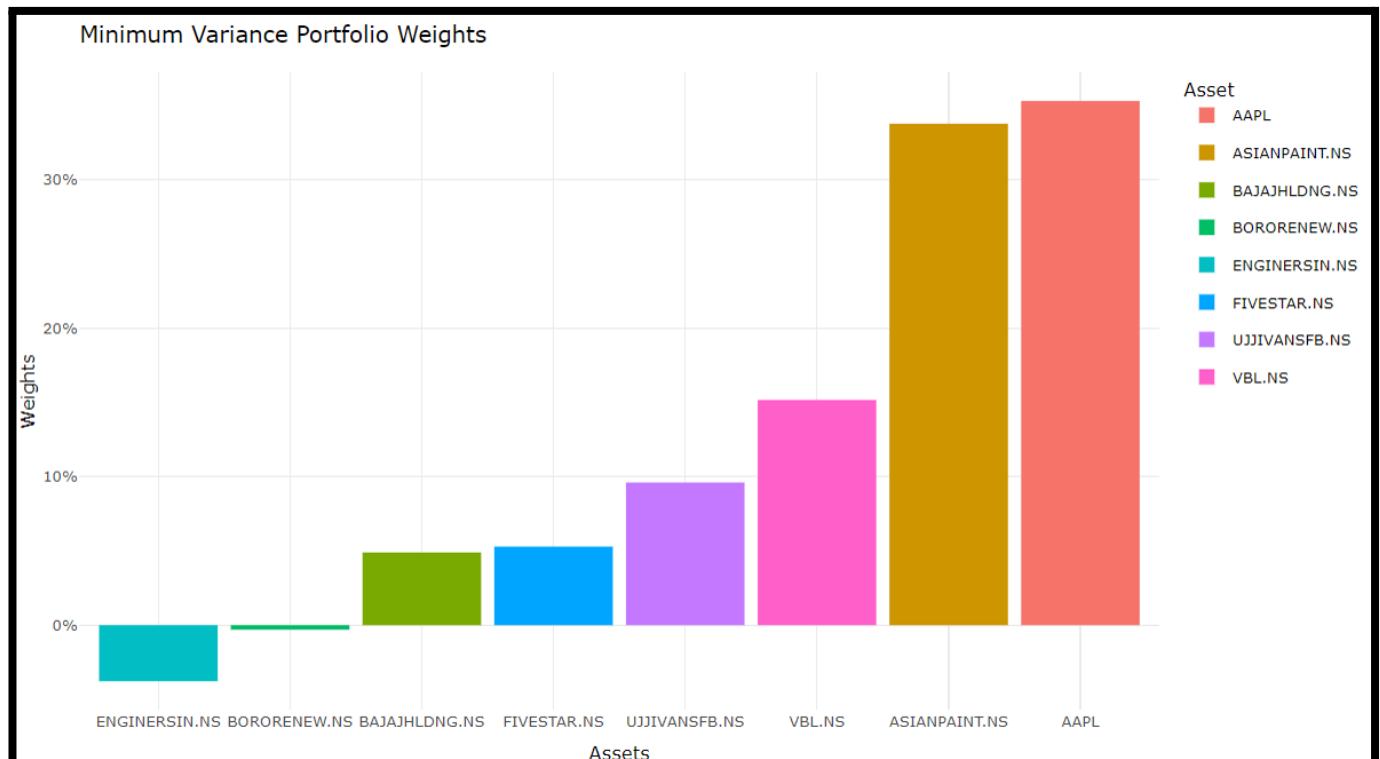
## Weights for Minimum Variance Portfolio without short selling:



## Security weights for Minimum Variance Portfolio without shortselling:

AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
0.2332032	0.2315399	0.1608336	0.01607205	0.02102663	0.07430694	0.0480294	0.2149882	0.3281764	0.1193607	2.162993

## Weights for Minimum Variance Portfolio with short selling:



## Security weights for Minimum Variance Portfolio with shortselling:

	AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
1	0.3531595	0.3377932	0.04897924	-0.003031129	-0.03773262	0.052953	0.09614006	0.1517387	0.2029326	0.1158534	1.147421

## Mean Return and Cov Matrix:

```
> head(portfolio_values)
# A tibble: 6 x 11
  AAPL ASIANPAINT.NS BAJAJHLDNG.NS BORORENEW.NS ENGINERSIN.NS FIVESTAR.NS UJJIVANSFB.NS VBL.NS Return
<dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 0.00165 0.175 0.113 0.0553 0.184 0.245 0.0835 0.142 0.496
2 0.0521 0.0802 0.0701 0.196 0.202 0.0802 0.101 0.217 0.553
3 0.128 0.00540 0.184 0.154 0.240 0.147 0.0985 0.0428 0.468
4 0.0292 0.254 0.135 0.154 0.113 0.110 0.0162 0.187 0.401
5 0.138 0.0384 0.108 0.152 0.0523 0.209 0.127 0.175 0.417
6 0.0971 0.0449 0.0852 0.0158 0.337 0.0788 0.0655 0.276 0.719
# i 2 more variables: Risk <dbl>, SharpeRatio <dbl>
>
```

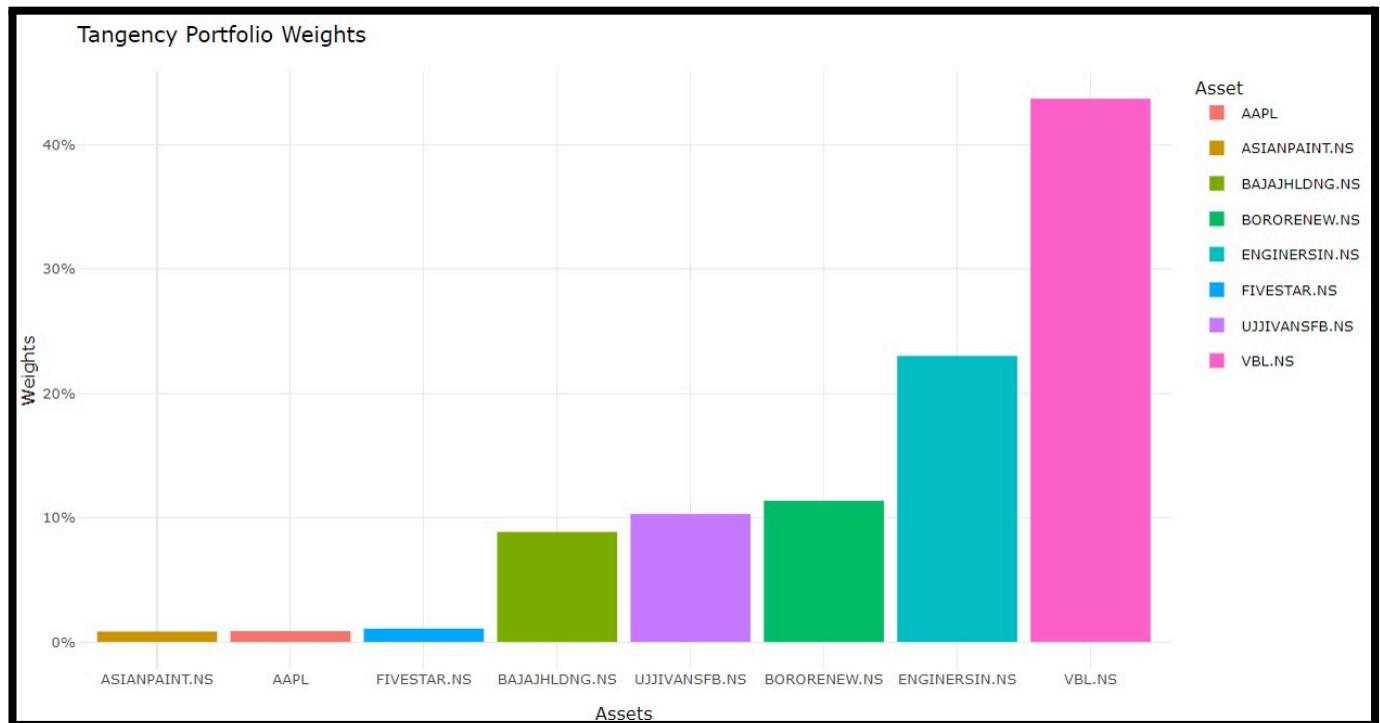
## **Inference from minimum variance portfolio:**

The portfolio's risk is minimized through careful allocation to assets with low variance and low correlation. Higher weights are given to stable stocks like AAPL and ASIANPAINT.NS, while riskier assets like UJJIVANSMFB.NS have smaller allocations. By focusing on the covariance matrix, the portfolio reduces overall volatility, aiming for steady returns with less exposure to large fluctuations, thus achieving the goal of a minimum variance portfolio.

## Tangency Portfolio

The tangency point is the optimal portfolio of risky assets, known as the market portfolio. It is the portfolios with the best trade-off between expected returns and variance (risk) lie on this line.

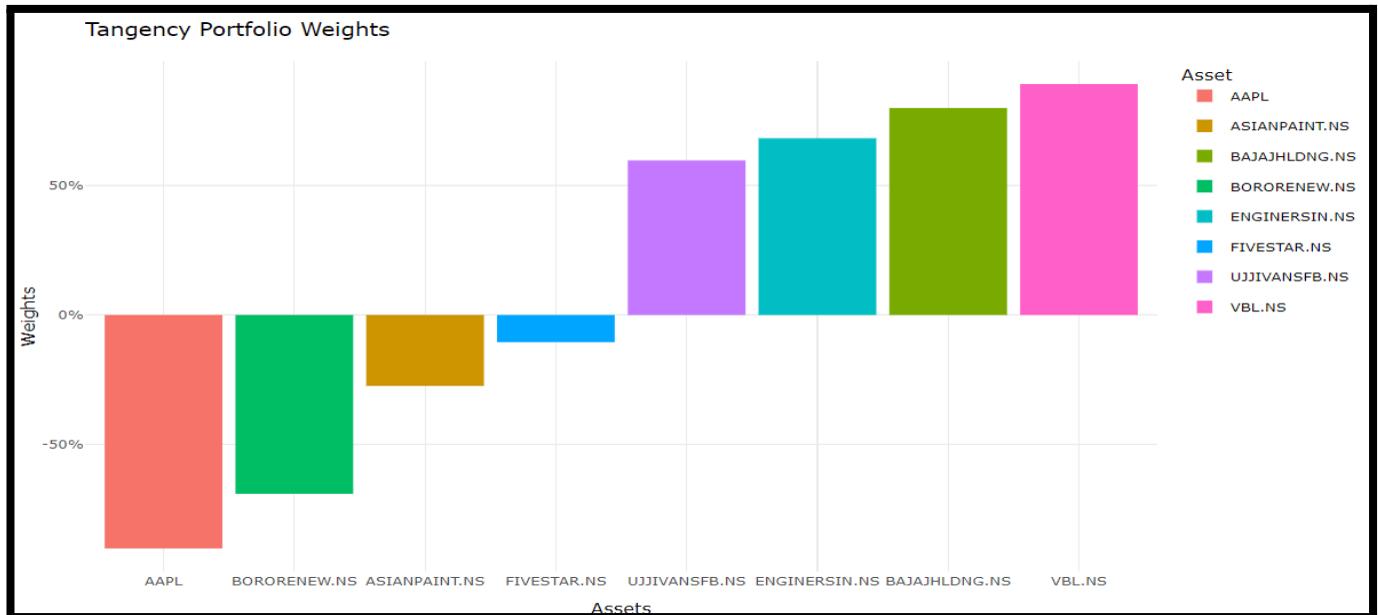
### Weights for Tangency Portfolio (without short selling):



### Security weights for Tangency Portfolio (without short selling):

	AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
1	0.004606597	0.008890876	0.2830164	0.002325863	0.03059738	0.05958768	0.2196609	0.3913143	0.6941728	0.1878885	3.322039

## Weights for Tangency Portfolio (with short selling):



## Security weights for Tangency Portfolio (with short selling):

AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
-0.9022399	-0.2739467	0.7998059	-0.6906854	0.6827776	-0.1050251	0.5972001	0.8921136	3.79055	0.6373188	5.837816

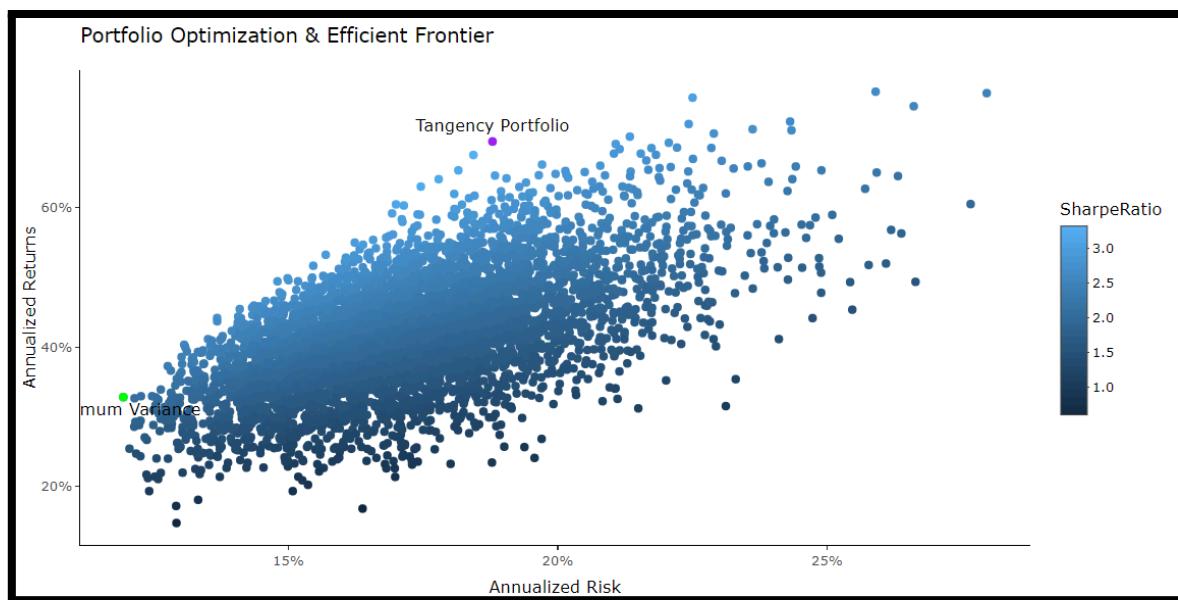
## Inference from tangency portfolio:

The Tangency Portfolio maximizes the Sharpe ratio by balancing higher-risk, high-return assets like VBL.NS and ENGINERSIN.NS with lower-risk assets such as AAPL and ASIANPAINT.NS. The portfolio aims for the best risk-adjusted return, allocating more to volatile stocks for potential gains while maintaining stability through smaller allocations to safer assets. This results in a higher-risk portfolio designed for investors seeking optimal returns relative to risk.

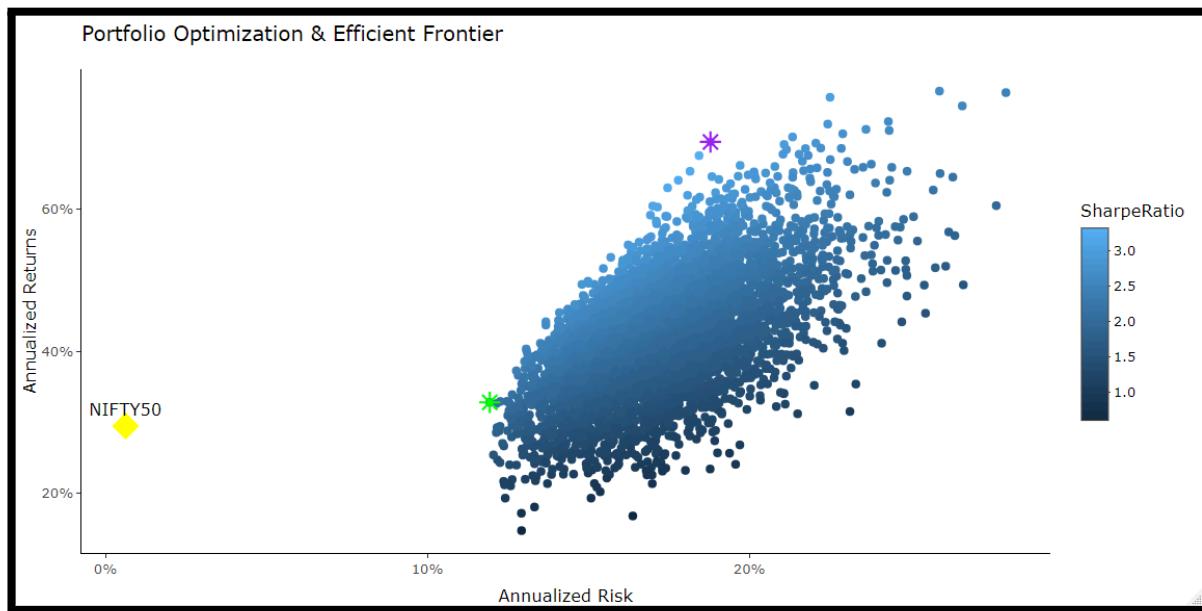
## Efficient Frontier:

The efficient frontier is a collection of optimum portfolios that provide the best anticipated return for a given level of risk or the least risk for a given level of expected return. Portfolios that are below the efficient frontier are sub-optimal because they do not generate enough return for the amount of risk they carry. Also, portfolios that cluster to the right of the efficient frontier have a greater degree of risk for the stated rate of return, making them sub-optimal.

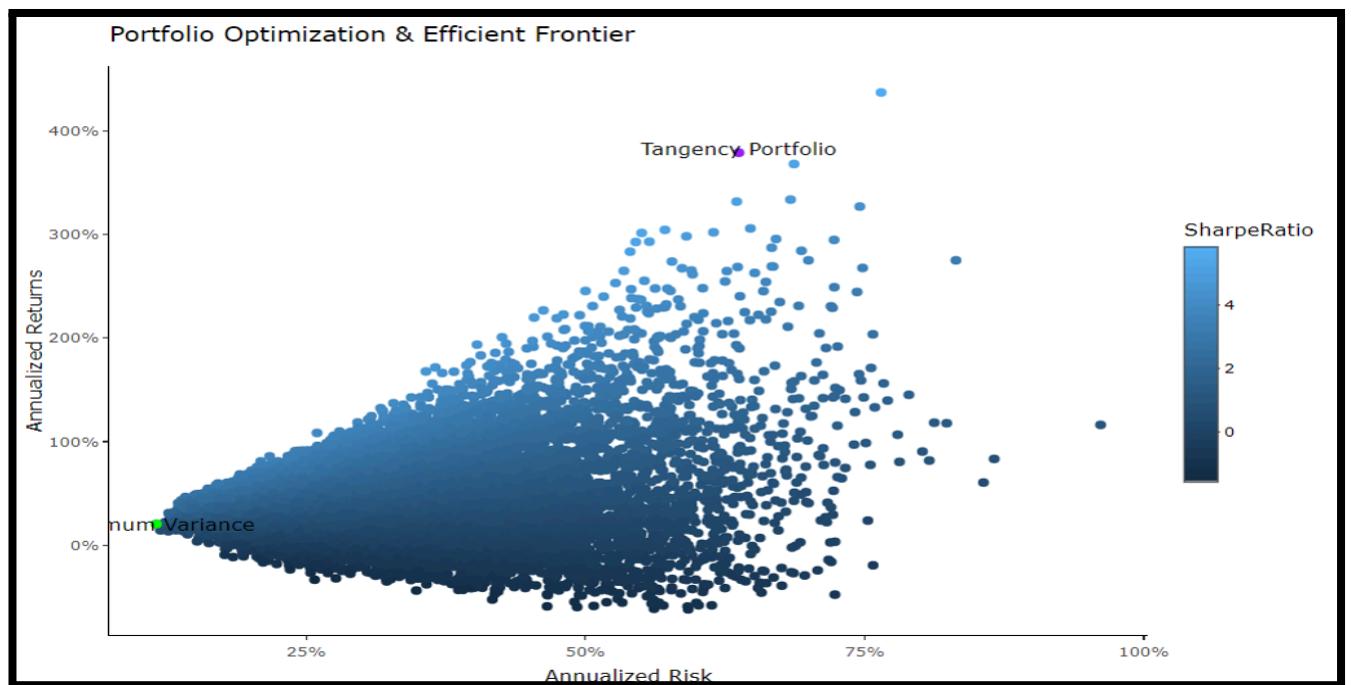
## Portfolio Optimization and Efficient Frontier (without short selling):



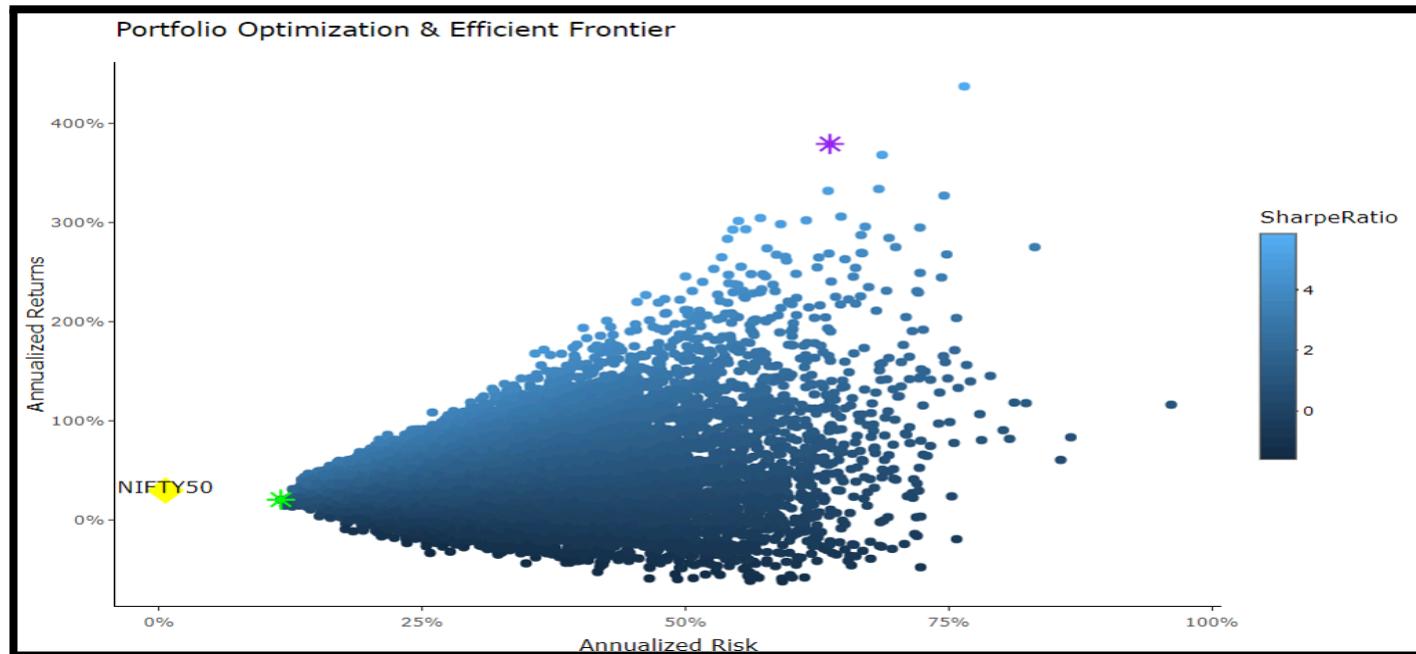
## Efficient Frontier with NIFTY 50 for comparison:



## Portfolio Optimization and Efficient Frontier (with shortselling):



## Efficient Frontier with NIFTY 50 for comparison:



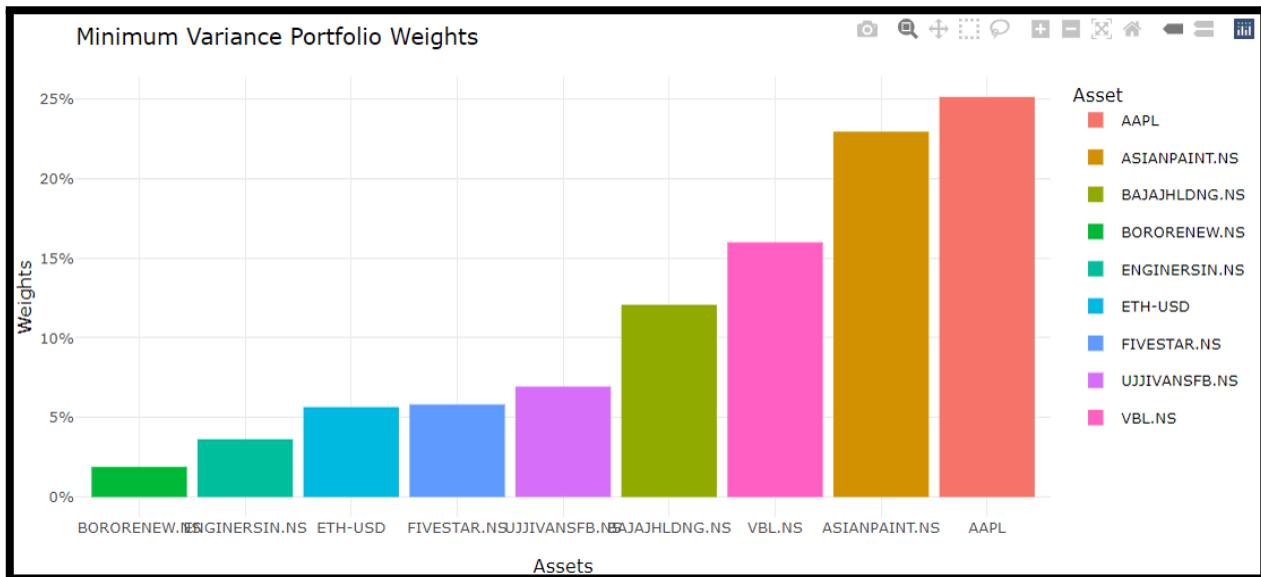
# **International & Cryptocurrency Portfolio:**

This portfolio goes beyond the international portfolio and adds a cryptocurrency to the portfolio as well to test for its impact. The cryptocurrency being used in this portfolio is Ethereum.

## **Minimum Variance Portfolio:**

A minimum variance portfolio indicates a well-diversified portfolio that consists of individually risky assets, which are hedged when traded together, resulting in the lowest possible risk for the rate of expected return.

## **Weights for Minimum Variance Portfolio (without short selling):**



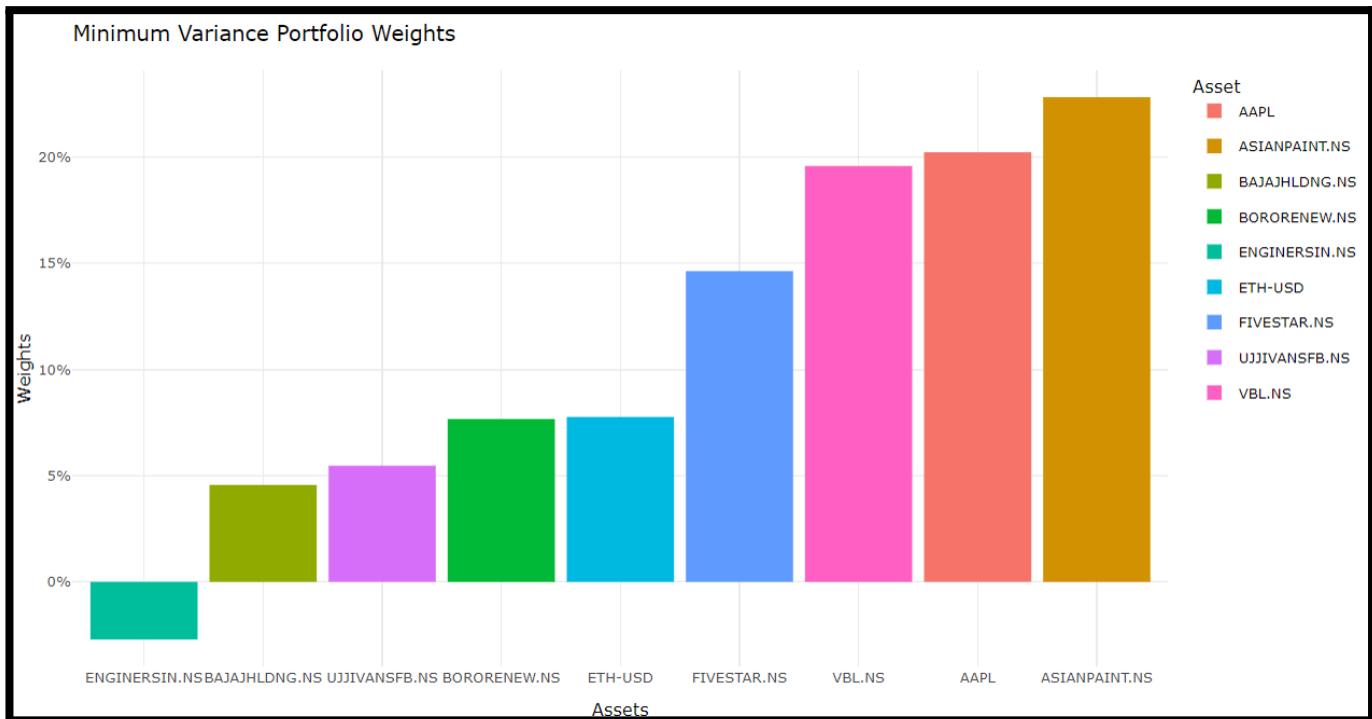
## **Security weights for Minimum Variance Portfolio (without short selling):**

	AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINEERSIN.NS	ETH-USD	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
0.251156	0.2293723	0.1206293	0.01886403	0.03628909	0.05642505	0.05806692	0.06934119	0.1598561	0.3318952	0.1120571	2.337157	

## Mean Return and Cov Matrix

```
> print(round(mean_rets, 3))
  AAPL ASIANPAINT.NS BAJAJHLDNG.NS BORORENEW.NS ENGINERSIN.NS   ETH-USD  FIVESTAR.NS UJJIVANSFB.NS
0.00005      0.00022      0.00120      0.00059      0.00299      0.00251      0.00103      0.00214
  VBL.NS
  0.00288
>
> # Calculate the covariance matrix (annualized by multiplying with 252)
> cov_mat <- cov(log_ret_xts) * 252
> print(round(cov_mat, 4))
          AAPL ASIANPAINT.NS BAJAJHLDNG.NS BORORENEW.NS ENGINERSIN.NS ETH-USD FIVESTAR.NS UJJIVANSFB.NS
AAPL      0.0386      0.0010     -0.0019     -0.0054     -0.0013      0.0063      0.0023     -0.0027
ASIANPAINT.NS  0.0010      0.0281      0.0089      0.0083      0.0094      0.0014      0.0026      0.0081
BAJAJHLDNG.NS -0.0019      0.0089      0.0660      0.0168      0.0281      0.0051      0.0077      0.0102
BORORENEW.NS   -0.0054      0.0083      0.0168      0.1771      0.0567     -0.0433      0.0174      0.0394
ENGINERSIN.NS  -0.0013      0.0094      0.0281      0.0567      0.2675     -0.0252      0.0375      0.0645
ETH-USD        0.0063      0.0014      0.0051     -0.0433     -0.0252      0.2040     -0.0176     -0.0131
FIVESTAR.NS    0.0023      0.0026      0.0077      0.0174      0.0375     -0.0176      0.1048      0.0280
UJJIVANSFB.NS -0.0027      0.0081      0.0102      0.0394      0.0645     -0.0131      0.0280      0.1475
VBL.NS         0.0008      0.0019      0.0121      0.0123      0.0090     -0.0097      0.0027      0.0115
VBL.NS
  AAPL      0.0008
  ASIANPAINT.NS  0.0019
  BAJAJHLDNG.NS  0.0121
  BORORENEW.NS   0.0123
  ENGINERSIN.NS  0.0090
  ETH-USD       -0.0097
  FIVESTAR.NS    0.0027
  UJJIVANSFB.NS  0.0115
  VBL.NS        0.0870
```

## Weights for Minimum Variance Portfolio (with shortselling):



## Security weights for Minimum Variance Portfolio with (short selling):

	AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	ETH-USD	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
1	-0.6753724	-0.04928374	-0.9276887	-0.309075	0.4936916	0.7863195	0.03004544	0.7467275	0.9046358	3.929029	0.6091833	6.334758

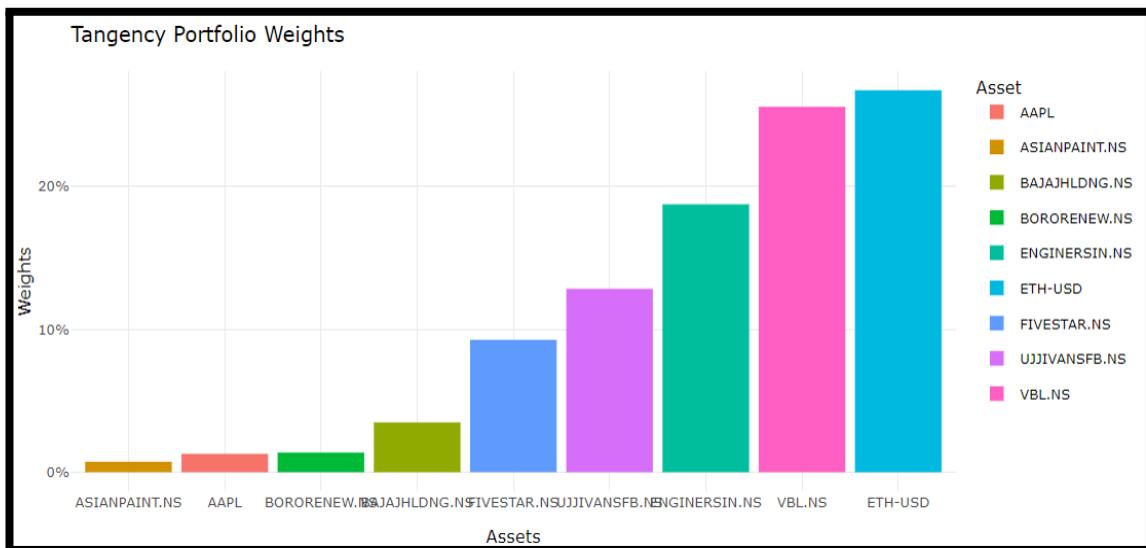
### Interpretation for minimum variance:

The table for minimum shows the weights required for achieving minimum variance portfolio when short selling is allowed. According to this table, When we analyze the table for minimum variance portfolio when short selling is not allowed we see that weights are given to all stocks except for Borosil Renewables because all other stocks are comparatively less risky than Borosil Renewables

### Tangency Portfolio

The tangency point is the optimal portfolio of risky assets, known as the market portfolio. It is the portfolios with the best trade-off between expected returns and variance (risk) lie on this line.

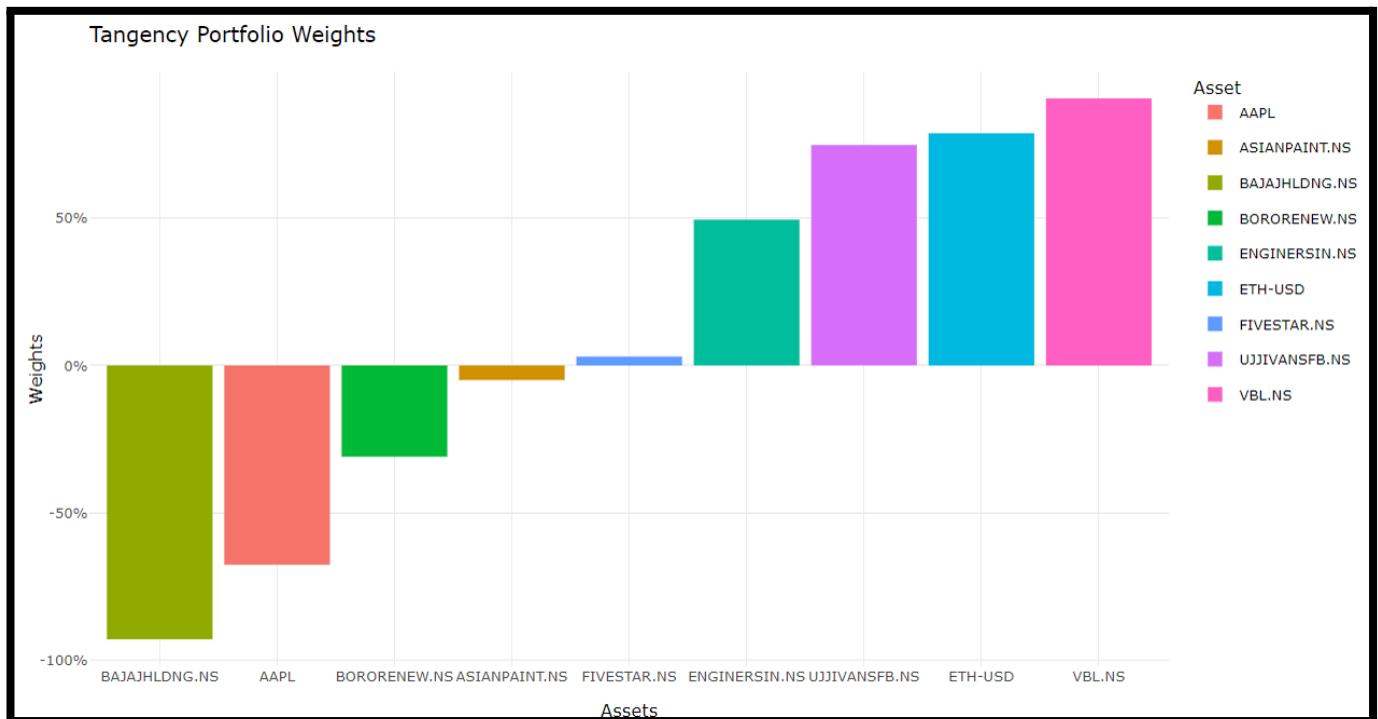
### Weights for Tangency Portfolio Without short selling



## Security weights for Tangency Portfolio (without shortselling):

AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	ETH-USD	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
0.012864	0.007315534	0.03482203	0.01373541	0.1874257	0.267247	0.09260707	0.128346	0.2556372	0.8253963	0.18834	4.010812

## Weights for Tangency Portfolio (with short selling):



## Stock prices for Tangency Portfolio (with short selling):

AAPL	ASIANPAINT.NS	BAJAJHLDNG.NS	BORORENEW.NS	ENGINERSIN.NS	ETH-USD	FIVESTAR.NS	UJJIVANSFB.NS	VBL.NS	Return	Risk	SharpeRatio
1 -0.6753724	-0.04928374	-0.9276887	-0.309075	0.4936916	0.7863195	0.03004544	0.7467275	0.9046358	3.929029	0.6091833	6.334758

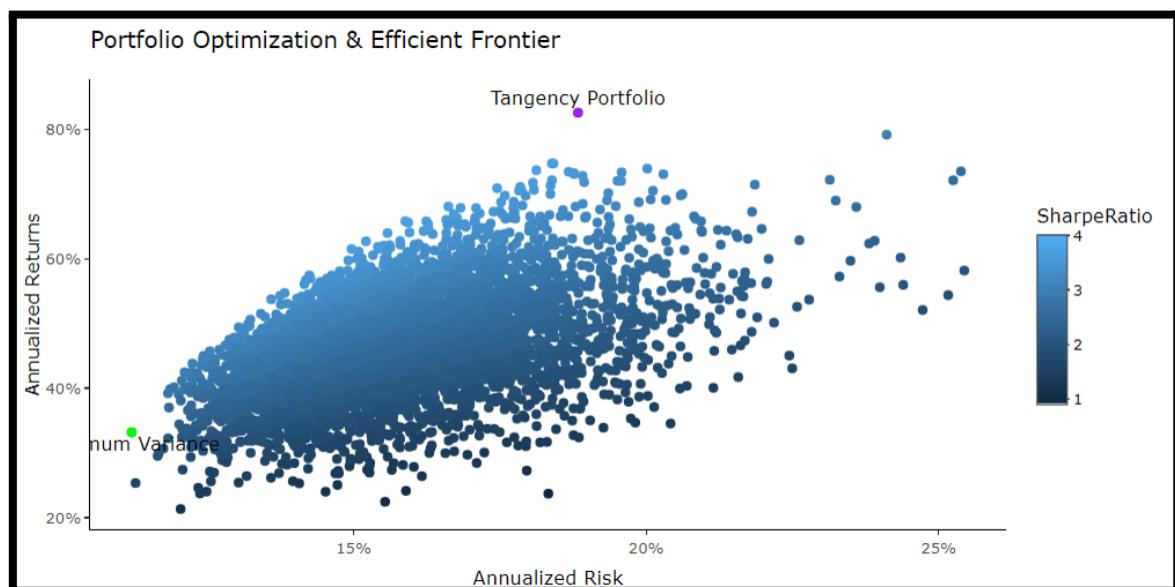
## Inference from the Tangency Portfolio:

In a tangency portfolio our objective is to maximize the risk adjusted return i.e. maximize the sharpe ratio. When short selling is banned all the weight is given to FiveStar,Ujjivain Small Finance Bank LTD,Engineering LTD,Varun Beverages and Ethurium as we are not allowed to short sell the other securities to maximize the risk adjusted return and in turn sharpe ratio will be less than that of when short selling is allowed. Also we can compare that although in minimum variance portfolio, risk is comparatively less but sharpe ratio is much less than the tangency portfolio.

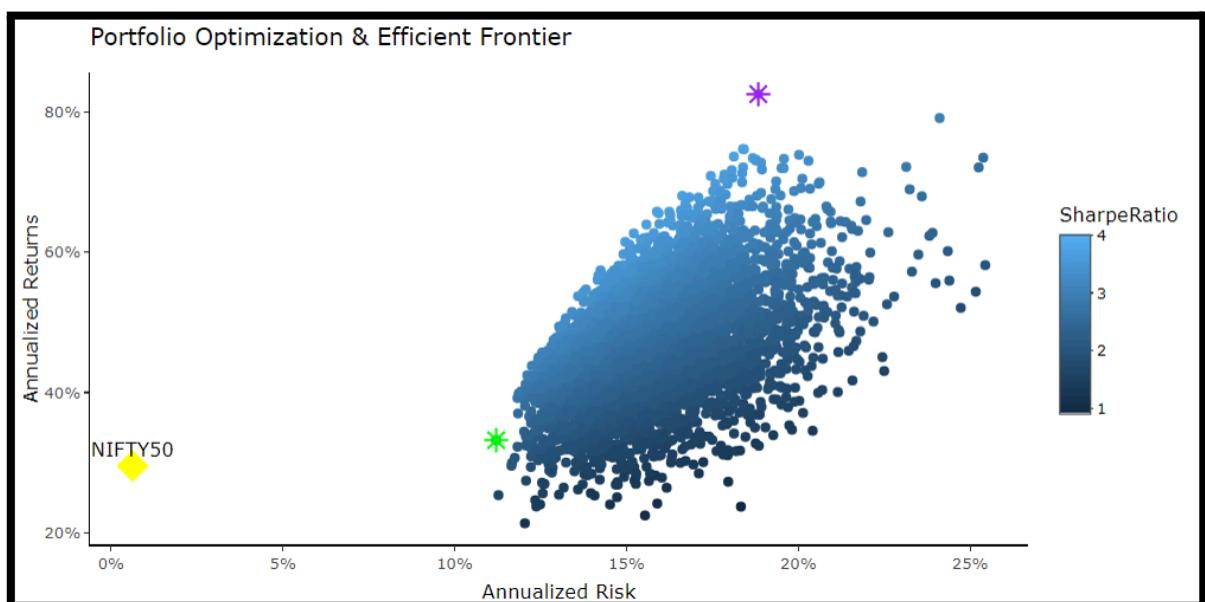
## **Efficient Frontier:**

The efficient frontier is a collection of optimum portfolios that provide the best anticipated return for a given level of risk or the least risk for a given level of expected return. Portfolios that are below the efficient frontier are sub-optimal because they do not generate enough return for the amount of risk they carry. Also, portfolios that cluster to the right of the efficient frontier have a greater degree of risk for the stated rate of return, making them sub-optimal.

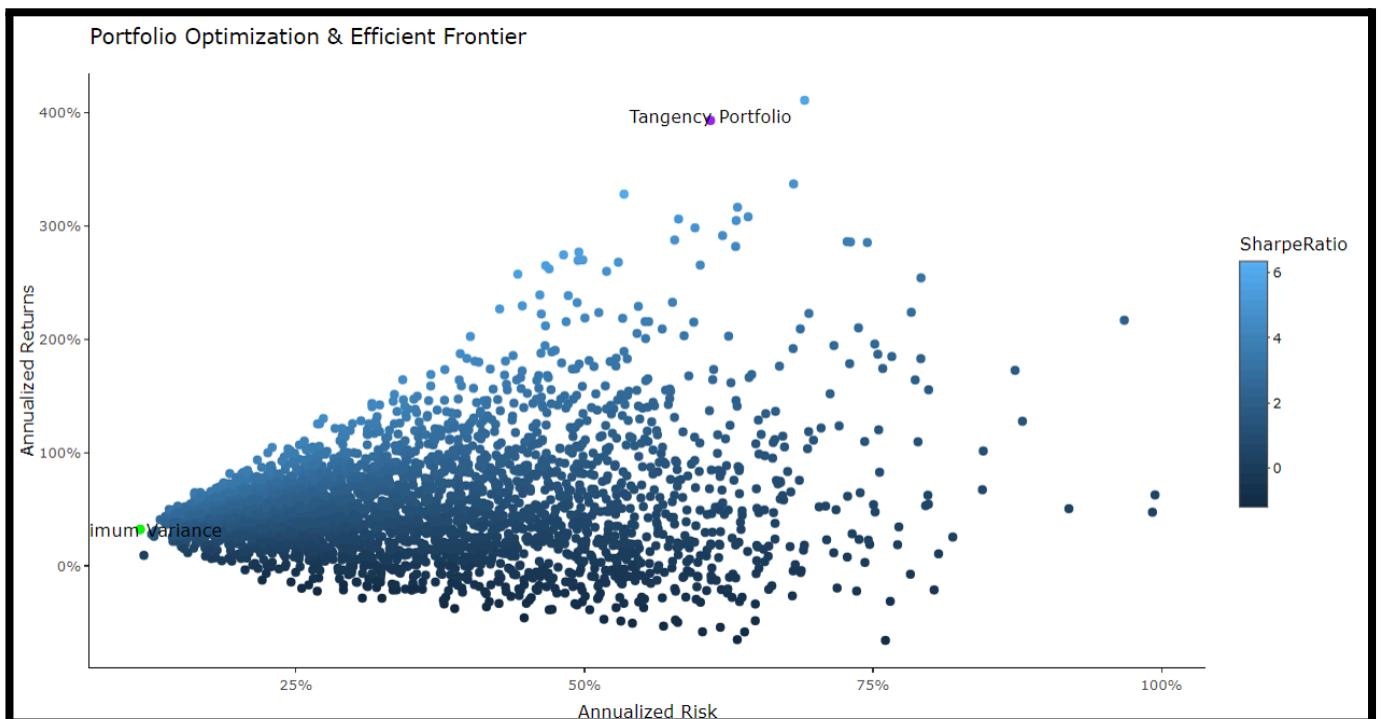
## **Portfolio Optimization And Efficient Frontier (without short selling):**



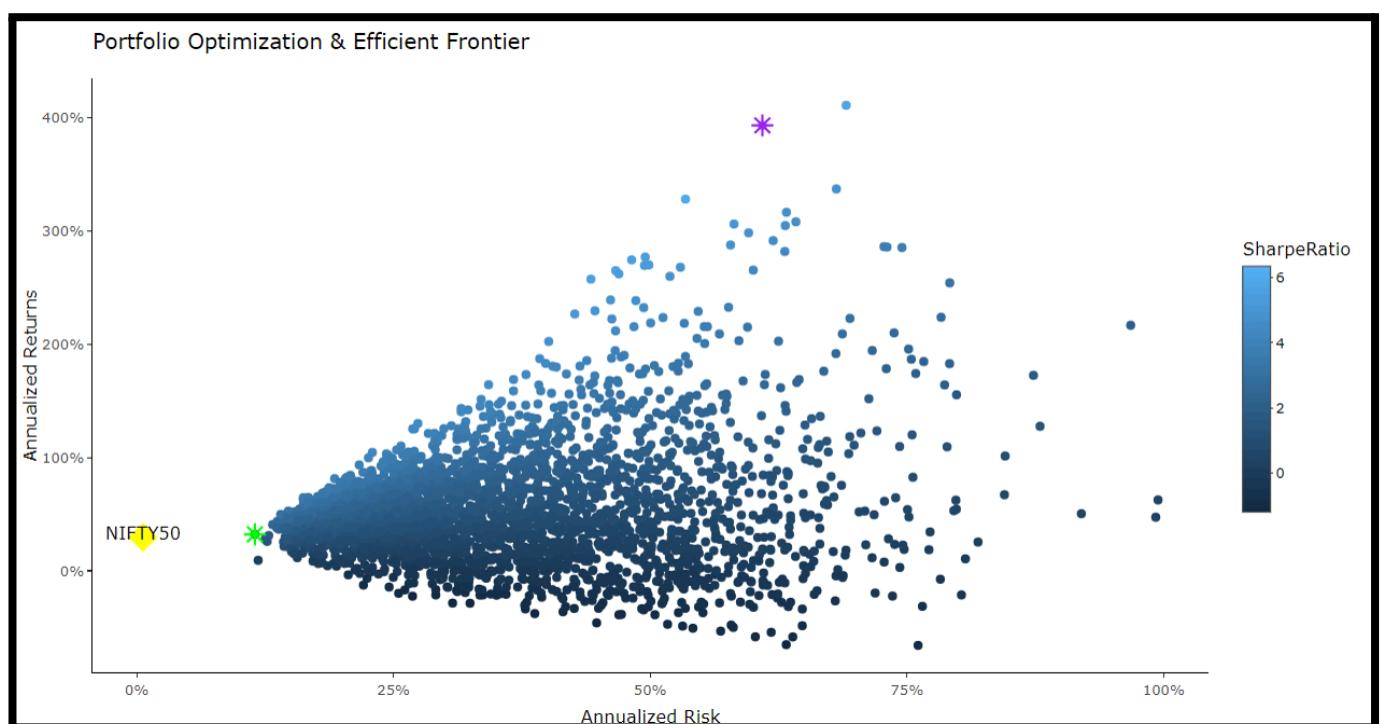
## **Efficient Frontier with NIFTY 50 for comparison:**



## Portfolio Optimization And Efficient Frontier (with short selling):



## Efficient Frontier With NIFTY 50 (with short selling):



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## **Comparisons:**

### **Domestic versus International Portfolios:**

Domestic Portfolio had return of 41.93% for 14.009% risk whereas International Portfolio had return of 32.804% for 11.9334% risk which shows that as soon as we added the one securities to domestic portfolio ,risk decreased and therefore return decreased due to risk return trade-off.

### **Domestic versus International & Cryptocurrency Portfolio:**

Domestic Portfolio had a return of 41.93% for 14.009% risk whereas Index had return of 33.18% for 10.205% which means Domestic Portfolio has superior risk adjusted performance.

### **International versus International & Cryptocurrency Portfolio:**

International Portfolio had a return of 32.804% for 11.9334% risk whereas International & cryptocurrency portfolio had return of 33.18% for 10.205% which means International Portfolio has superior risk adjusted performance.

**Thank You**