Project-1: Building a portfolio

Submitted by:

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1. A brief description of your chosen assets

Stocks: Stocks represent ownership in a company. When you buy a stock, you're buying a share of ownership in that company. Stockholders typically have voting rights and may receive dividends if the company distributes profits. Stock prices fluctuate based on factors such as company performance, market conditions, and investor sentiment.

We have chosen the following stocks to build the portfolio

IRFC.NS: Indian Railway Finance Corporation Limited -Risky due to potential exposure to economic downturns and government policy changes affecting railway infrastructure funding.

GPIL.NS: Godawari Power and Ispat Limited - Risky due to susceptibility to fluctuations in steel prices and energy markets.

HINDUNILVR.NS: Hindustan Unilever Limited- Risky due to exposure to consumer preferences, competitive market dynamics, and regulatory changes.

RBLBANK.NS: RBL Bank Limited- Risky due to exposure to credit risk, interest rate fluctuations, and regulatory changes in the banking sector.

LICI.NS: Life Insurance Corporation of India- Risky due to exposure to market volatility, interest rate fluctuations, and mortality risk.

ITC.NS: ITC Limited- Risky due to exposure to regulatory changes in the tobacco and FMCG sectors, as well as competitive pressures

WIPRO.NS: Wipro Limited- Risky due to exposure to global economic conditions, technological disruptions, and competition in the IT services industry.

TATAELXSI.NS: Tata Elxsi Limited- Risky due to dependency on client projects, technological obsolescence, and competition in the IT consulting and engineering services sector.

IOC.NS: Indian Oil Corporation Limited- Risky due to exposure to fluctuations in oil prices, government policies, and regulatory changes in the energy sector.

RELIANCE.NS: Reliance Industries Limited- Risky due to exposure to global oil prices, regulatory changes in various sectors, and the conglomerate's diverse business interests. why we have selected the stocks

Closing price of the Stocks:

We have used the 'yfinance' library to collect historical market data for ten stocks listed below from the National Stock Exchange (NSE) of India and have retrieved their closing prices each day for the past three months from the date that we have specified ('2024-02-19').

Date	IRFC.NS	GPIL.NS	HINDUNILVR.NS	RBLBANK.NS	LICI.NS
2023-11-21	76.849998	679.950012	2505.250000	236.149994	610.900024
2023-11-22	76.699997	663.400024	2521.899902	234.100006	608.750000
2023-11-23	76.500000	659.099976	2519.899902	238.850006	617.700012
2023-11-24	76.099998	657.349976	2515.199951	234.500000	677.650024
2023-11-28	75.599998	659.950012	2510.550049	237.750000	674.299988
...	...	...	...	...	...
2024-02-13	153.449997	736.950012	2394.000000	250.750000	1011.450012
2024-02-14	154.300003	754.799988	2387.949951	253.750000	1070.500000
2024-02-15	158.899994	779.900024	2350.850098	259.049988	1056.099976
2024-02-16	155.449997	768.799988	2375.250000	262.350006	1039.849976
2024-02-19	158.649994	794.849976	2387.149902	261.200012	1052.199951

Date	ITC.NS	WIPRO.NS	TATAELXSI.NS	IOC.NS	RELIANCE.NS
2023-11-21	436.250000	400.649994	8423.250000	101.050003	2378.899902
2023-11-22	439.700012	400.250000	8389.700195	101.250000	2388.199951
2023-11-23	440.350006	402.500000	8380.349609	103.800003	2395.500000
2023-11-24	437.799988	396.000000	8334.549805	103.449997	2393.899902
2023-11-28	435.250000	396.850006	8306.200195	108.199997	2394.399902
...	...	...	...	...	...
2024-02-13	406.750000	511.600006	7443.299805	174.449997	2930.199951
2024-02-14	411.549988	514.500000	7429.549805	183.550003	2962.750000
2024-02-15	403.899994	518.500000	7470.200195	189.850006	2941.199951
2024-02-16	404.600006	543.000000	7513.450195	187.000000	2921.149902
2024-02-19	409.250000	535.950012	7708.649902	188.500000	2948.000000

Closing Prices of the Top 10 Stocks:

Date	IRFC.NS	IOC.NS	LICI.NS	WIPRO.NS	RELIANCE.NS	\
2023-11-21	76.849998	101.050003	610.900024	400.649994	2378.899902	
2023-11-22	76.699997	101.250000	608.750000	400.250000	2388.199951	
2023-11-23	76.500000	103.800003	617.700012	402.500000	2395.500000	
2023-11-24	76.099998	103.449997	677.650024	396.000000	2393.899902	
2023-11-28	75.599998	108.199997	674.299988	396.850006	2394.399902	
...	...	...	...	...	...	
2024-02-13	153.449997	174.449997	1011.450012	511.600006	2930.199951	
2024-02-14	154.300003	183.550003	1070.500000	514.500000	2962.750000	
2024-02-15	158.899994	189.850006	1056.099976	518.500000	2941.199951	
2024-02-16	155.449997	187.000000	1039.849976	543.000000	2921.149902	
2024-02-19	158.649994	188.500000	1052.199951	535.950012	2948.000000	

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2023-11-21	679.950012	236.149994	2505.250000	436.250000	8423.250000
2023-11-22	663.400024	234.100006	2521.899902	439.700012	8389.700195
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...	...	...	...	...	...
2024-02-13	736.950012	250.750000	2394.000000	406.750000	7443.299805
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2024-02-19	794.849976	261.200012	2387.149902	409.250000	7708.649902

2.The calculated returns and risk measures for each asset.

Simple returns are calculated as the difference between the closing price of one day and the closing price of the previous day, divided by the closing price of the previous day.

$$Simple\ ri = \frac{Price_i - Price_{i-1}}{Price_{i-1}}$$

These are the simple return calculation for the chosen assets:

Simple Return	IRFC.NS	IOC.NS	LICI.NS	WIPRO.NS	RELIANCE.	GPIL.NS	RBLBANK.	HINDUNIL
0	-0.00195	0.001979	-0.00352	-0.001	0.003909	-0.02434	-0.00868	0.006646
1	-0.00261	0.025185	0.014702	0.005621	0.003057	-0.00648	0.02029	-0.00079
2	-0.00523	-0.00337	0.097054	-0.01615	-0.00067	-0.00266	-0.01821	-0.00187
3	-0.00657	0.045916	-0.00494	0.002146	0.000209	0.003955	0.013859	-0.00185
4	-0.00397	0.003235	0.009788	0.023687	0.002631	-0.01159	-0.00021	0.005776
5	-0.00863	0.029479	-0.00206	0.016738	-0.00968	0.052966	-0.01304	0.008119
6	0.010047	-0.00447	-0.01266	-0.01307	0.007087	-0.00946	-0.00639	0.00711
7	0.013263	0.041798	0.071695	-0.00049	0.010817	0.019843	0.040111	0.015076
8	-0.00327	0.015531	-0.00688	-0.00761	0.007251	-0.01391	0.017117	-0.01501
9	-0.0046	0.013594	0.044745	0.035613	0.009579	0.006504	0.025953	0.001717

Log returns are calculated as the natural logarithm of the ratio between the closing price of one day and the closing price of the previous day.

$$Log\ ri = ln\left(\frac{Price_i}{Price_{i-1}}\right)$$

These are the Log return calculation for the chosen assets:

	IRFC.NS	IOC.NS	LICI.NS	WIPRO.NS	RELIANCE.	GPIL.NS	RBLBANK.	HINDUNIL
0	-0.00195	0.001977	-0.00353	-0.001	0.003902	-0.02464	-0.00872	0.006624
1	-0.00261	0.024873	0.014595	0.005606	0.003052	-0.0065	0.020087	-0.00079
2	-0.00524	-0.00338	0.092628	-0.01628	-0.00067	-0.00266	-0.01838	-0.00187
3	-0.00659	0.044893	-0.00496	0.002144	0.000209	0.003948	0.013764	-0.00185
4	-0.00398	0.00323	0.00974	0.02341	0.002628	-0.01166	-0.00021	0.005759
5	-0.00867	0.029053	-0.00206	0.0166	-0.00973	0.051611	-0.01313	0.008086
6	0.009997	-0.00448	-0.01274	-0.01316	0.007062	-0.00951	-0.00641	0.007085
7	0.013175	0.040948	0.069241	-0.00049	0.010759	0.019648	0.039328	0.014964
8	-0.00328	0.015411	-0.00691	-0.00764	0.007225	-0.01401	0.016972	-0.01512

Mean return is calculated as the average rate of return of an investment over a specific period, computed by dividing the sum of returns by the number of observations.

IRFC	IOC	LICI	Wipro	Reliance	Gpil	RBLBank	Hindunilvr	Tataelxsi	ITC
0.013310	0.010859	0.009468	0.005360	0.003582	0.002356	0.002086	-0.000815	-0.00119	-0.00183

Volatility is calculated as the square root of the average squared standard deviation of daily returns from their mean

$$vol = \sigma\sqrt{T}$$

IRFC	IOC	LICI	Wipro	Reliance	Gpil	RBLBank	Hindunilvr	Tataelxsi	ITC
0.052918	0.027657	0.029293	0.020005	0.014093	0.023645	0.024621	0.013193	0.012723	0.014499

Construction of Efficient Frontier

Efficient Frontier: The efficient frontier is the set of optimal portfolios that offer the highest expected return for a defined level of risk or the lowest risk for a given level of expected return.

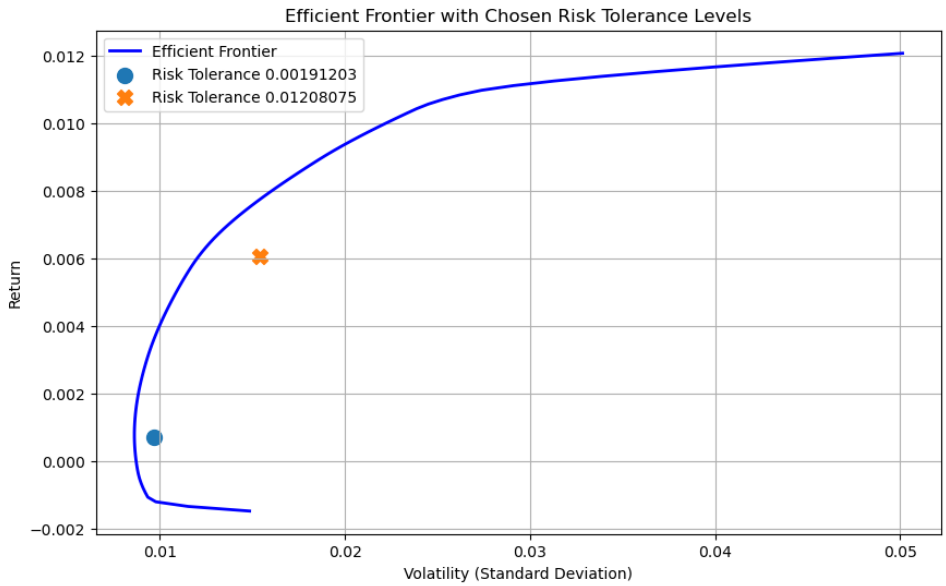
We also visualized the efficient frontier, which shows the best possible return you can get for any given level of risk. By adjusting our target return, we traced out this frontier, showing all the optimal portfolios on the risk-return spectrum.

The graph shows the efficient frontier, which visualizes the optimal trade-off between risk and return. Highlighting the optimal portfolio within this frontier pinpoints the ideal investment allocation that maximizes expected return for a chosen level of risk.

3.A graph showing the Markowitz efficient frontier and the two chosen points.

1. **First Chosen Point:**
    - Portfolio Volatility: 0.00862
    - Portfolio Mean Return: 0.000780
2. **Second Chosen Point:**
    - Portfolio Volatility: 0.00862
    - Portfolio Mean Return: 0.000780

These data points represent the specific portfolios selected for the two chosen risk tolerance levels on the Markowitz efficient frontier graph. They illustrate the risk (volatility) and return characteristics of the portfolios chosen to align with the specified risk tolerance levels.



CAPM: It is a financial model which gives the linear relation between systematic risk and the expected returns for assets. It is used for pricing risky securities and generating expected returns for assets, given the risk of those assets and cost of capital.

Here we have calculated the expected return for a portfolio of assets using the Capital Asset Pricing Model (CAPM) framework. CAPM estimates the expected return of an asset based on its beta, representing its sensitivity to market movements. By incorporating the risk-free rate and the market return, CAPM enables investors to gauge the expected returns of assets within the context of systematic market risk. In this scenario, with given beta values for 10 assets and predefined risk-free rate and market return and computed the expected returns for each asset using the CAPM formula.

The expected returns obtained through CAPM provide valuable insights into the potential performance of the assets within the portfolio. These returns are crucial for investors in making informed investment decisions, as they reflect the compensation expected for bearing systematic risk relative to the market. By analyzing the expected returns derived from CAPM, investors can assess the attractiveness of individual assets and allocate their investments strategically to optimize risk-adjusted returns.

Beta Values:

We have taken that from market data as data is for 3 months we have taken the beta value for respective stocks.

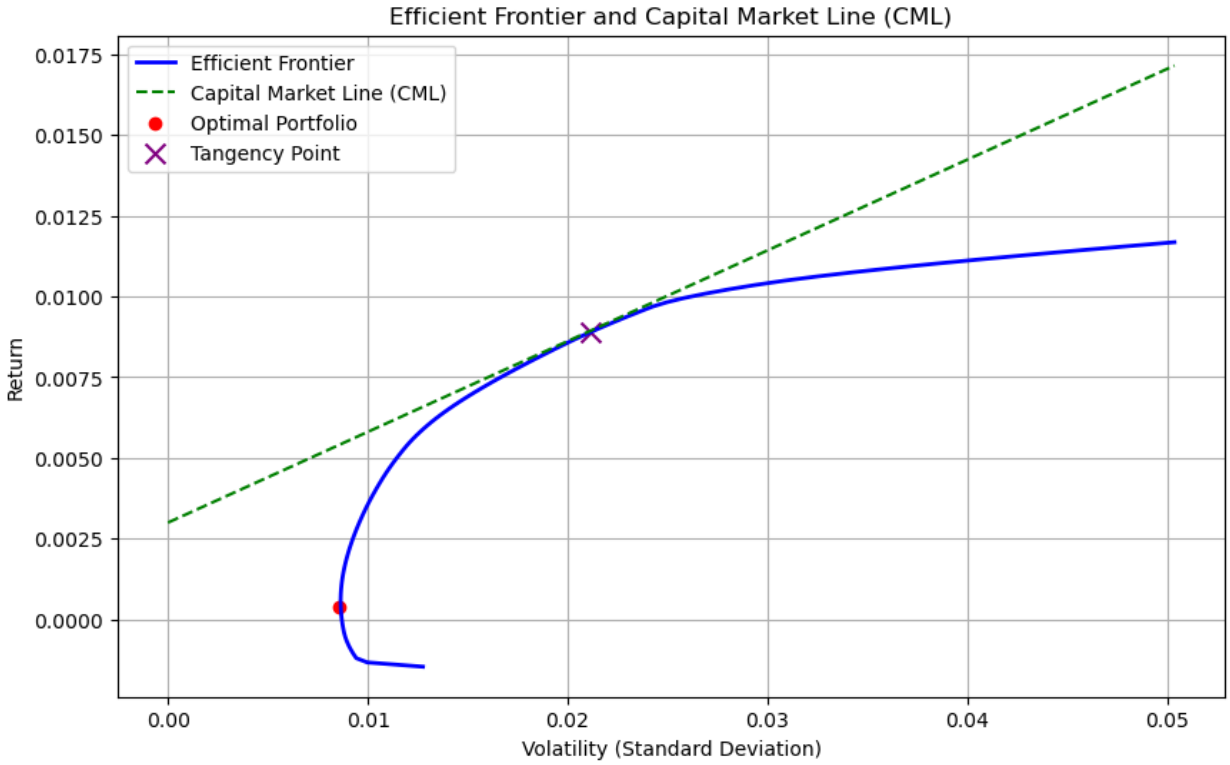
Asset Name	Beta value
IRFC.NS	2.22
GPIL.NS	0.872
HINDUNILVR.NS	0.722
RBLBANK.NS	1.76
LICI.NS	0.945
ITC.NS	0.719
WIPRO.NS	1.23
TATAELXSI.NS	0.467
IOC.NS	1.17
RELIANCE.NS	1.1

CML: The Capital Market Line is a graphical representation of all the portfolios that optimally combine risk and return.

- The slope of the Capital Market Line (CML) is the Sharpe Ratio of the market portfolio.

- The efficient frontier represents combinations of risky assets.
- If we draw a line from the risk-free rate of return, which is tangential to the efficient frontier, we get the Capital Market Line. The point of tangency is the most efficient portfolio.

We have created a graph which states the relationship between risk and return through the efficient frontier and the Capital Market Line (CML). The efficient frontier represents the set of portfolios that offer the highest expected return for a given level of risk or the lowest risk for a given level of return. On the other hand, the CML depicts the linear relationship between expected return and volatility, incorporating the risk-free rate and the market return.



4.The optimal portfolio weights for each chosen point on the efficient frontier.

Point 1:
Risk Tolerance: 0.00191203
Optimal Portfolio Weights:
IRFC.NS: 0.021827149679035006
IOC.NS: 0.025505254849478076
LICI.NS: 0.02698419297830272
WIPRO.NS: 0.04545982868168762
RELIANCE.NS: 0.05366769836987275
GPIL.NS: 0.06182871283411437
RBLBANK.NS: 0.08480327153525567
HINDUNILVR.NS: 0.15458039892499292
TATAELXSI.NS: 0.20844739784183866
ITC.NS: 0.31689609430542215

Point 2:
Risk Tolerance: 0.01208075
Optimal Portfolio Weights:
IRFC.NS: 0.1669352056809928
IOC.NS: 0.1462679272215161
LICI.NS: 0.14001626080214544
WIPRO.NS: 0.10307255507827279
RELIANCE.NS: 0.09552874536337919
GPIL.NS: 0.08987158066992454
RBLBANK.NS: 0.07900431477314881
HINDUNILVR.NS: 0.06292539123775881
TATAELXSI.NS: 0.05876091653691127
ITC.NS: 0.057617102635948714

5. A brief discussion of the trade-off between risk and return in your portfolio choices.

the trade-off between risk and return in portfolio choices involves selecting portfolios along the Efficient Frontier that align with an investor's risk tolerance and investment objectives while considering the relationship between expected return and systematic risk captured by the SML.

Risk and Return Relationship: A positive relationship is observed between risk and returns. If higher level of returns are associated with the higher levels of risks. Investors demand compensation for taking on additional risk, and this compensation comes in the form of higher potential returns.

Trade-off Analysis: We observed that as the Sharpe ratio becomes more negative, the risk-adjusted performance worsens. This implies that while the returns may increase, they do not increase enough to compensate for the higher level of risk associated with the portfolio.

Sharpe Ratio Interpretation: We know that the Sharpe ratio measures the risk-adjusted return of a portfolio. It indicates how much excess return an investor receives for the level of volatility or risk taken on by holding that portfolio. A higher Sharpe ratio suggests better risk-adjusted performance.

6.Discussion of the limitations of Markowitz optimization and its real-world applications.

Markowitz optimization, also known as Modern Portfolio Theory (MPT), is a cornerstone of portfolio management that aims to construct portfolios that maximize expected return for a given level of risk or minimize risk for a desired level of return. While Markowitz optimization has been widely used and has contributed significantly to the field of finance, it also has several limitations and challenges, as well as various real-world applications. Let's discuss these aspects:

Limitations of Markowitz Optimization:

1. **Assumption of Normality:** Markowitz optimization assumes that asset returns follow a normal distribution. However, asset returns often exhibit non-normal behavior, such as fat tails or skewness, which can lead to inaccurate estimates of risk and returns.

2. **Estimation Error:** The accuracy of portfolio optimization depends heavily on the accuracy of inputs, such as expected returns, volatilities, and correlations. Estimating these parameters based on historical data introduces estimation error, which can lead to suboptimal portfolio allocations.

3. **Sensitivity to Inputs:** Markowitz optimization is sensitive to changes in input parameters, such as expected returns and correlations. Small changes in these inputs can lead to significant changes in the optimal portfolio allocation, making the optimization process unstable.

4. **Diversification Benefits:** While Markowitz optimization emphasizes diversification to reduce portfolio risk, it may not always provide effective diversification benefits during periods of market stress or financial crises when correlations between assets tend to increase.

5. **Transaction Costs and Constraints:** Markowitz optimization does not explicitly consider transaction costs or constraints, such as short-selling restrictions or minimum investment requirements. Ignoring these factors can lead to impractical or costly portfolio allocations.

Real-World Applications of Markowitz Optimization:

1. Asset Allocation: Markowitz optimization is commonly used by investors and portfolio managers to determine the optimal allocation of assets across different asset classes, such as stocks, bonds, and alternative investments, based on their risk-return profiles.

2. Portfolio Management: Institutional investors, such as pension funds and endowments, use Markowitz optimization to construct and rebalance their investment portfolios, aiming to achieve specific investment objectives while managing risk.

3. Risk Management: Markowitz optimization plays a crucial role in risk management by identifying diversified portfolios that offer superior risk-adjusted returns. It helps investors quantify and manage portfolio risk through efficient diversification strategies.

4. Quantitative Finance: In quantitative finance, Markowitz optimization serves as a foundational framework for developing more sophisticated portfolio optimization techniques, such as Black-Litterman model, risk parity strategies, and factor-based investing approaches.

5. Robo-Advisors: Robo-advisors and algorithmic trading platforms often employ Markowitz optimization algorithms to provide automated portfolio management services to retail investors, offering personalized investment solutions based on individual risk preferences and investment goals.

In conclusion, while Markowitz optimization has several limitations and challenges, it remains a valuable tool in portfolio management and investment decision-making, with various real-world applications across different sectors of the financial industry. Despite its limitations, Markowitz optimization provides valuable insights into portfolio construction, risk management, and asset allocation, helping investors navigate the complex landscape of financial markets.

SML Construction:

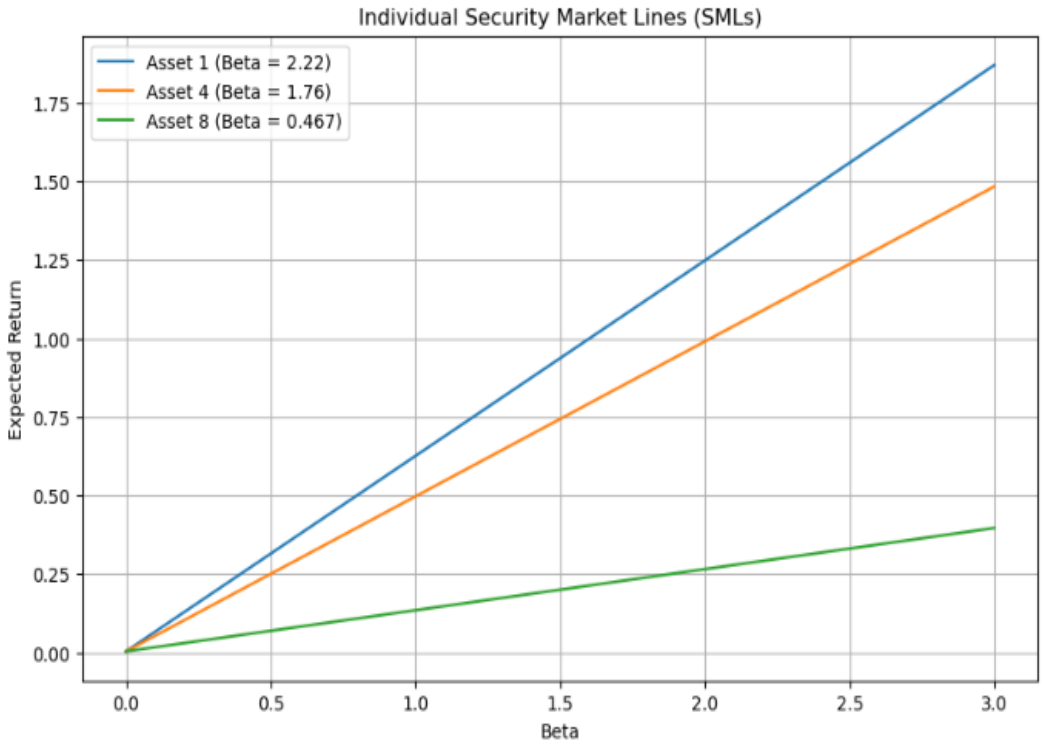
SML: The Security Market Line is another graphical representation that gives the relationship between the expected return and the systematic risk (beta) of individual securities or portfolios.

The SML is derived from the Capital Asset Pricing Model (CAPM), which computes the expected return of an asset based on its risk as measured by beta.

The SML is a straight line that starts from the risk-free rate and has a positive slope equal to the market risk premium (the excess return of the market over the risk-free rate) multiplied by beta.

Each SML illustrates how the expected return of an asset varies with changes in its beta, assuming a linear relationship based on CAPM. As beta increases, the expected return also increases, reflecting higher systematic risk and thus higher expected compensation for investors.

The plot provides a visual comparison of the risk-return profiles of the chosen assets, aiding in investment decision-making and portfolio management.



Sharpe Ratio:

Portfolio Sharpe Ratio Calculation:

The Sharpe ratio compares the return of an investment with its risk. It's a mathematical expression of the insight that excess returns over a period of time may signify more volatility and risk, rather than investing skill.

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

where:

R_p = return of portfolio

R_f = risk-free rate

σ_p = standard deviation of the portfolio's excess return

The Sharpe Ratio assesses the risk-adjusted return of an investment portfolio by comparing the excess return to the volatility of returns

For portfolios, the Sharpe Ratio based on the expected returns and volatility of portfolios derived from the efficient frontier analysis.

For individual assets, the Sharpe Ratio and Treynor Ratio using the expected returns derived from the Capital Asset Pricing Model (CAPM) and the historical standard deviation of returns.

We have calculated the Sharpe ratios for each portfolio on the efficient frontier, incorporating the risk-free rate as a measure of risk-adjusted return. The Sharpe ratio is a widely used metric for evaluating the performance of an investment by assessing the excess return earned per unit of risk.

We have marked the tangency point on the efficient frontier.The tangency point is the portfolio with the highest Sharpe ratio, indicating the most efficient tradeoff between risk and return. By maximizing the Sharpe ratio, investors achieve the optimal balance between seeking higher returns and minimizing risk, considering the risk-free rate and the market return.

The tangency point lies in its representation of the optimal portfolio allocation that balances risk and return effectively.

Observations from the computed Sharpe ratios:

Based on the Sharpe Ratios provided for the 100 portfolios:

Negative Sharpe Ratios for Portfolios 1 to 41: We observed negative Sharpe Ratios for these portfolios which indicates that they have underperformed the risk-free rate, for the amount of the risk assumed. Since they are not paying investors enough for the amount of risk, this points to poor performance.

Portfolio 28	-0.2213
Portfolio 29	-0.2041
Portfolio 30	-0.1871
Portfolio 31	-0.1702
Portfolio 32	-0.1535
Portfolio 33	-0.1370
Portfolio 34	-0.1207
Portfolio 35	-0.1046
Portfolio 36	-0.0887
Portfolio 37	-0.0731
Portfolio 38	-0.0577
Portfolio 39	-0.0426
Portfolio 40	-0.0278
Portfolio 41	-0.0132
Portfolio 42	0.0010
Portfolio 43	0.0149
Portfolio 44	0.0285
Portfolio 45	0.0418
Portfolio 46	0.0548
Portfolio 47	0.0675

Positive Sharpe Ratios for Portfolios 42 to 100: Starting from Portfolio 40, the Sharpe Ratios become positive and gradually increase, reaching the highest value at Portfolio 82. This indicates that these portfolios have outperformed the risk-free rate, considering the risk means that these portfolios have performed better than the risk-free rate. When we go from Portfolio 40 to Portfolio 82, the positive and rising Sharpe Ratios point to better performance and more effective risk management. They also suggest improved risk-adjusted returns.

Portfolio 72	0.2628
Portfolio 73	0.2656
Portfolio 74	0.2681
Portfolio 75	0.2704
Portfolio 76	0.2725
Portfolio 77	0.2744
Portfolio 78	0.2761
Portfolio 79	0.2773
Portfolio 80	0.2782
Portfolio 81	0.2787
Portfolio 82	0.2790
Portfolio 83	0.2790
Portfolio 84	0.2788
Portfolio 85	0.2784
Portfolio 86	0.2779
Portfolio 87	0.2772
Portfolio 88	0.2764
Portfolio 89	0.2755
Portfolio 90	0.2741
Portfolio 91	0.2712

Peak at Portfolio 82: Portfolio 82 has the highest Sharpe Ratio at 0.2790, which suggests it offers the best risk-adjusted return among all the portfolios listed. This portfolio is thus the most desirable investment option based on this metric, as it effectively balances return and risk.

Decline after Portfolio 83: After reaching a peak at Portfolio 83, the Sharpe Ratios begin to decrease slightly, indicating a decline in the risk-adjusted performance. The efficiency of these

returns (taking risk into account) is gradually declining, even though these portfolios continue to offer positive excess returns in relation to their risk.

Individual Assets		Sharpe Ratio	Treynor Ratio
Asset 1	12.4092	0.2802	
Asset 2	8.9975	0.2802	
Asset 3	7.1005	0.2802	
Asset 4	25.2213	0.2802	
Asset 5	19.1992	0.2802	
Asset 6	8.6559	0.2802	
Asset 7	14.0253	0.2802	
Asset 8	9.8000	0.2802	
Asset 9	25.8900	0.2802	
Asset 10	21.3923	0.2802	

Conclusion: Based on these Sharpe Ratios, investors looking for the best risk-adjusted returns should think about Portfolio 82, which offers the ideal ratio of return to risk. Additionally, portfolios 42 through 82 provide favorable and increasing risk-adjusted returns, which could make them appealing choices. Portfolios 1 through 41 perform poorly when adjusted for risk and might not be as appealing as they could be from an investment perspective. The efficiency of risk-adjusted returns starts to slightly decrease after Portfolio 83, indicating that portfolios beyond this point should carefully weigh risk against return.