Project 3: Capital Asset Pricing Model

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Dataset

Description : Chosen 10 risky assets

Asset: Stocks

Time Period: 11-17-2023 to 2-17-2024

Assets Chosen

We have chosen the following 10 risky assets (stocks) :
- RELIANCE
- TCS
- HDFCBANK
- INFY
- ICICIBANK
- HINDUNILVR
- MRF
- TATAMOTORS
- SBIN
- IRCTC

As per the requirements of the assignment we have chosen a time period of 3 months (as per the instructions of the project).

Calculating the simple returns for each asset

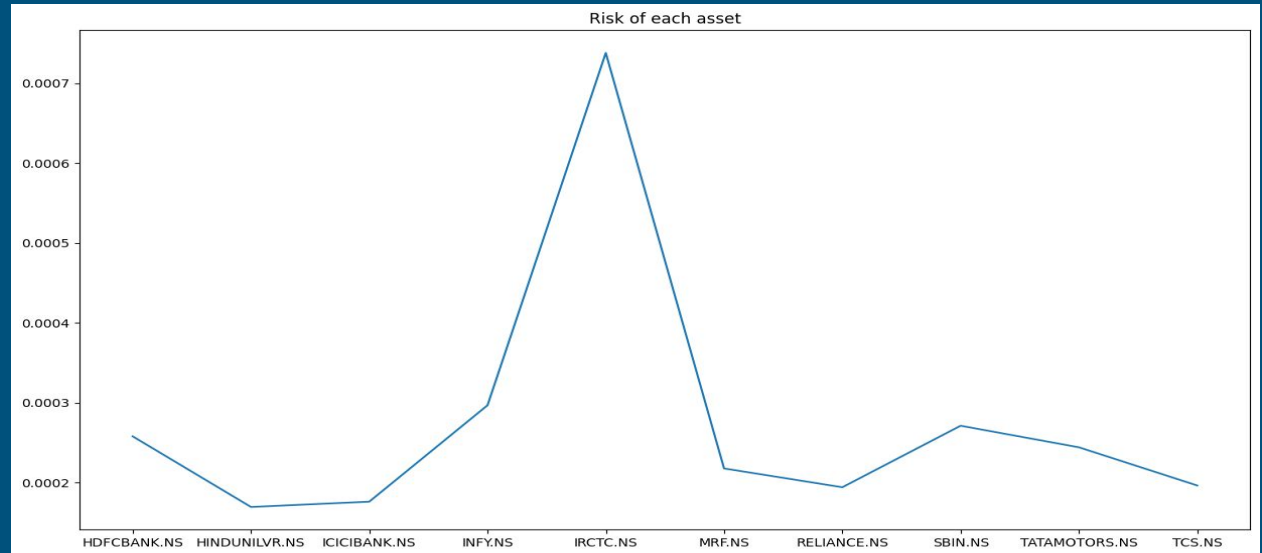Return is calculated by using below formula :

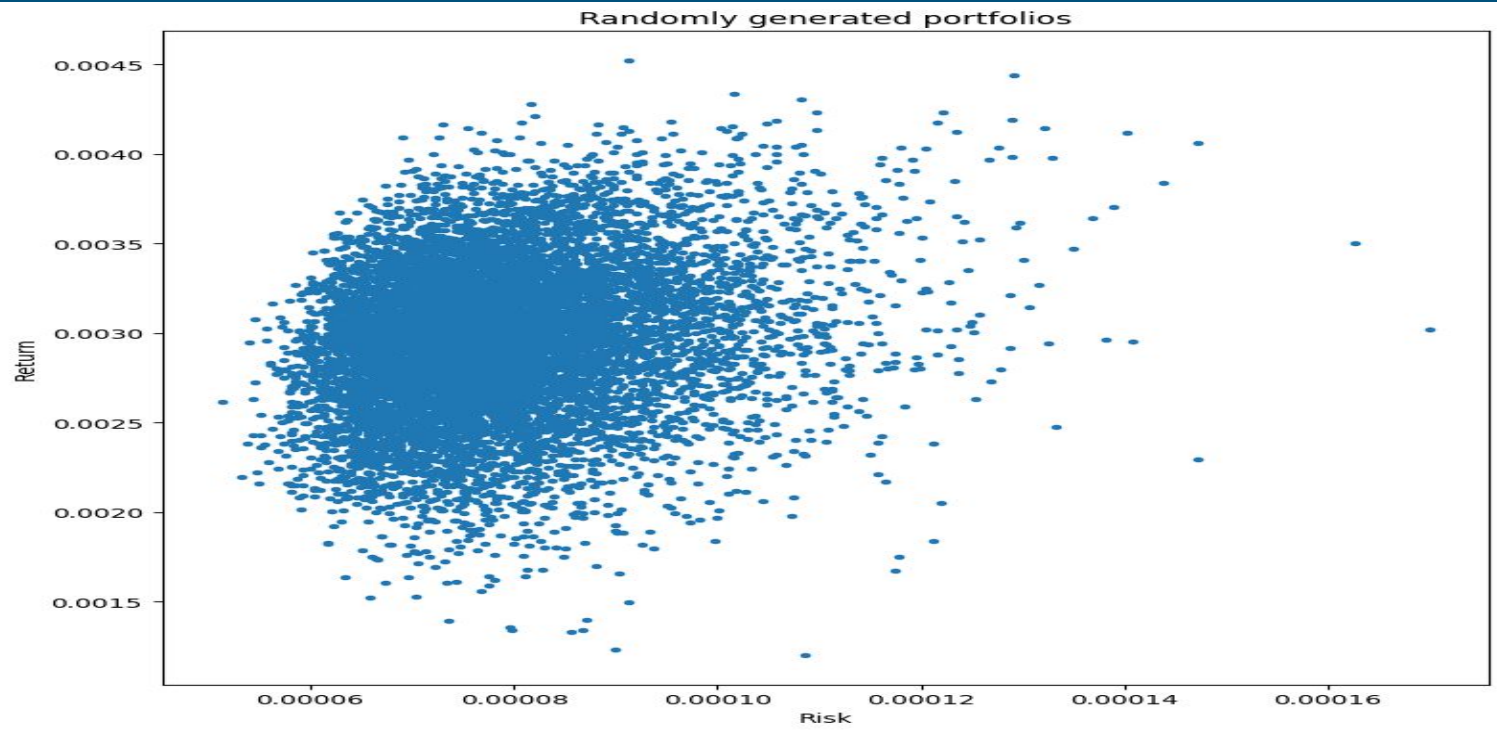$$r_j = \frac{P_{t+1} - P_t}{P_t} \equiv \frac{P_{t+1}}{P_t} - 1$$

Daily Returns
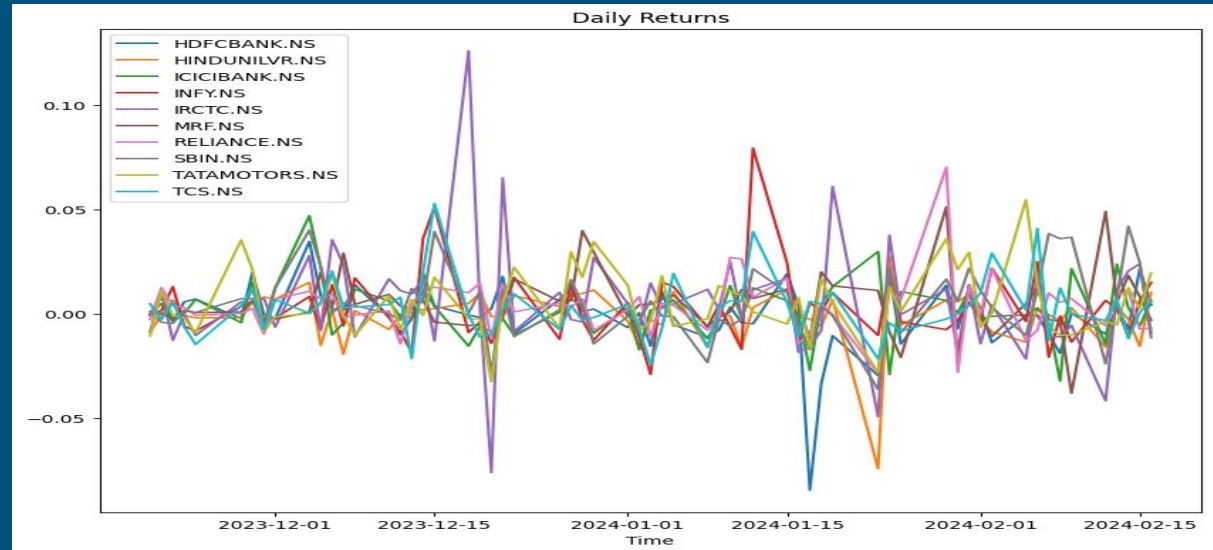
Calculating the risk for each asset

Risk is calculated by using below formula :

$$\sigma^2 = \frac{\sum_{i=1}^{n} \left(x_i - \overline{x} \right)^2}{N}$$

Risk of each asset

# Visualisations 10000 Random Portfolio

Randomly generated portfolios

Getting the Efficient Frontier

Initially, we obtain 10,000 randomly generated portfolios with random weights, risks, and returns. Next, we attempt to identify an optimal frontier for each of these risks. That is, there is no portfolio with less risk and the same return or the same risk and higher return if we choose any portfolio on the efficient frontier.To do this, we create an optimization problem with the constraint that the sum of the weights must equal one in order to maximize the returns associated with each sigma (risk). We are then left with a Markowitz efficient frontier.

Visualisation of Efficient Frontier
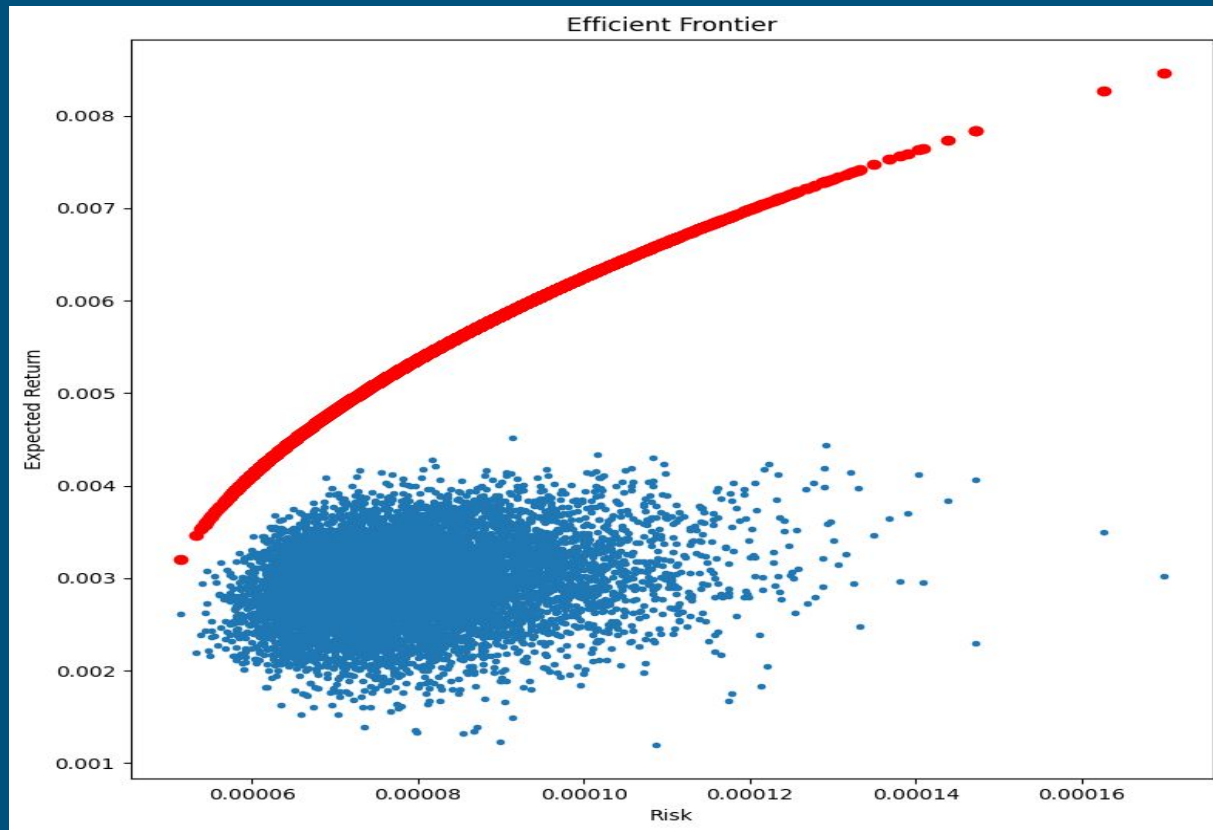
Treasury Bill (Risk Free Asset)

A Treasury Bill (T-Bill) in India is a short-term debt instrument issued by the Government of India to raise funds from the money market. T-Bills are considered one of the safest investment options because they are backed by the creditworthiness of the Indian government, making them virtually risk-free.

T-Bills have short-term maturities, typically ranging from 91 days, 182 days, and 364 days. Investors can choose to invest in T-Bills with different maturities based on their investment horizon and liquidity needs. Expected return rate for 91, 182, 364 days are 7.04, 7.18 and 7.15 percent respectively as per 2024.

CAPM

The Capital Asset Pricing Model (CAPM) is a model that describes the relationship between the expected return and risk of investing in a security. It shows that the expected return on a security is equal to the risk-free return plus a risk premium, which is based on the beta of that security.

Expected Return = Risk Free Rate + (Beta x Market Risk Premium)

where Market Risk Premium = Expected return of the market - Risk-free rate

Returns from CAPM
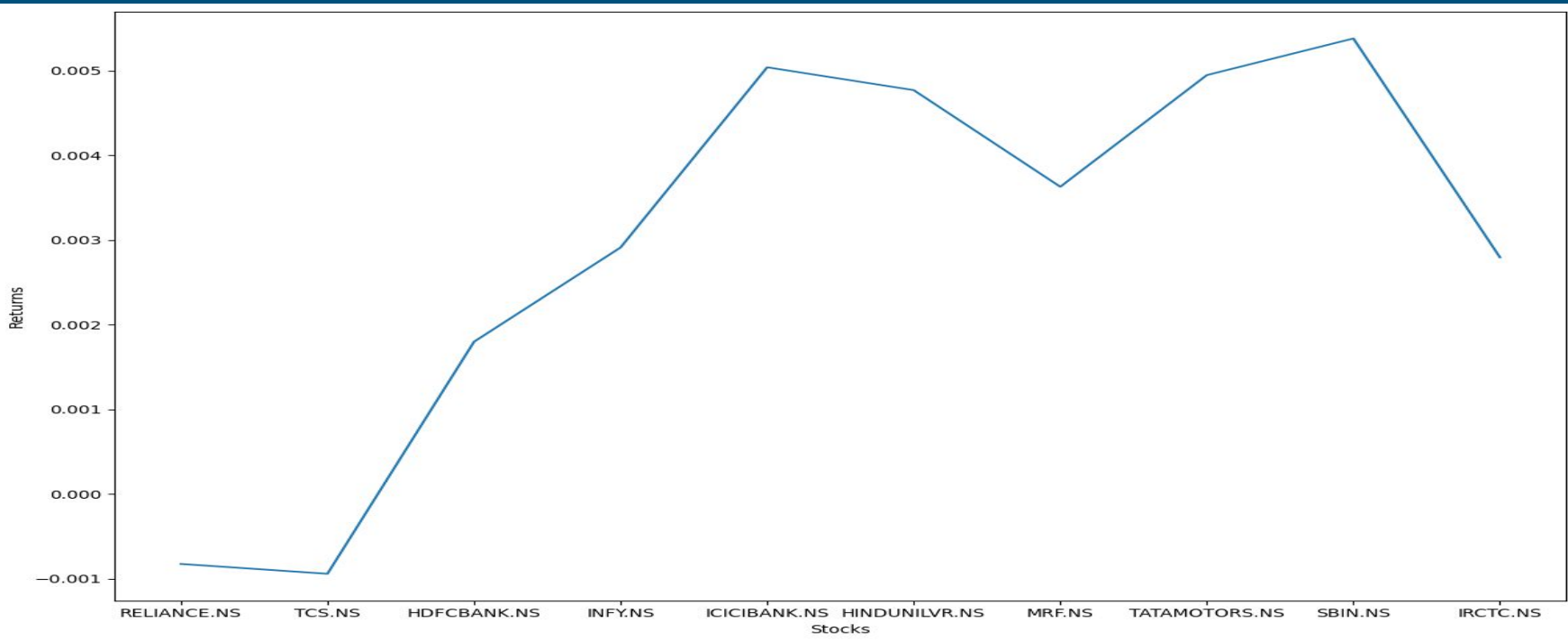
CML

The capital market line (CML) represents portfolios that optimally combine risk and return. It is a theoretical concept that represents all the portfolios that optimally combine the risk-free rate of return and the market portfolio of risky assets.

Mathematically, the equation of the CML can be expressed as:

$$Rp = r_f + ((R_M - r_f) / \sigma_M) * \sigma_P$$

where R_p = portfolio return, r_f = risk-free rate, R_M = market return, σ_M = S.D of market returns, σ_P = S.D of portfolio returns.

CML
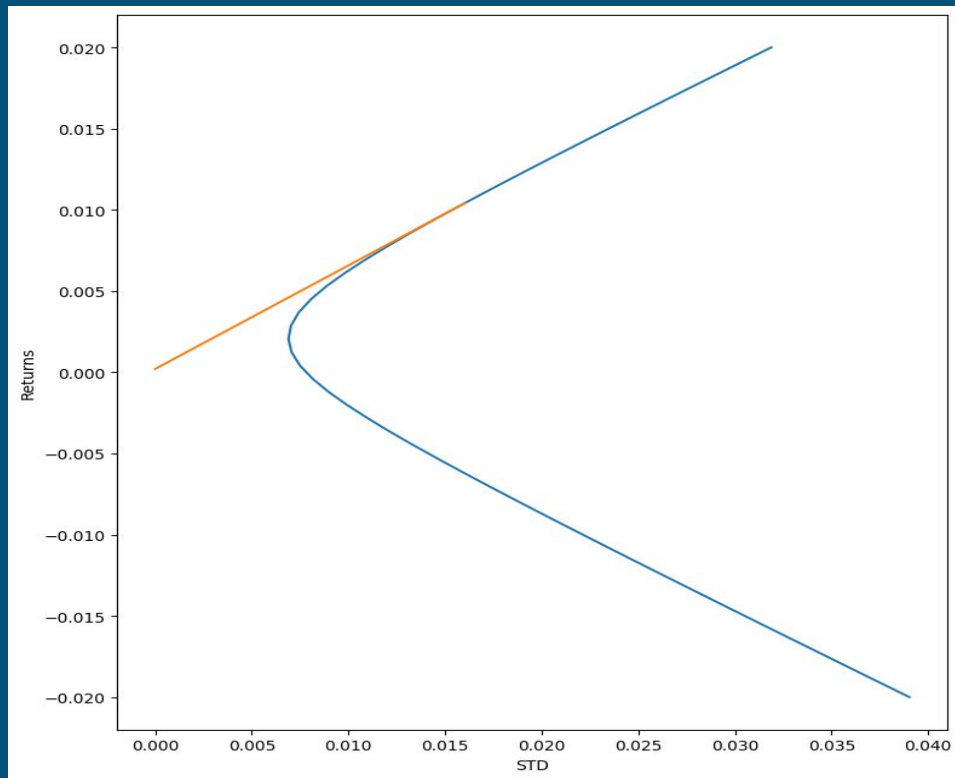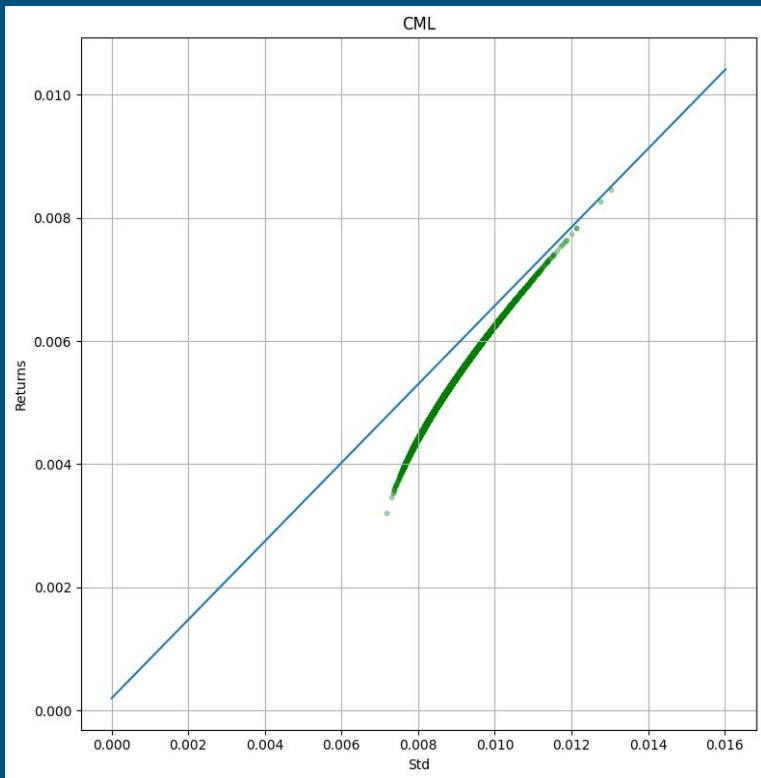
Significance of point of tangency on efficient frontier where CML touches it

The tangency point on the Efficient Frontier where the Capital Market Line (CML) touches it represents the optimal portfolio for an investor seeking the highest return for a given level of risk or the lowest risk for a given level of return(point of tangency is $\sigma_{derived}$ and $\mu_{derived}$). This point is of great significance in portfolio theory and investment management for several reasons:

- **Maximum Sharpe Ratio :** The tangency point portfolio has the maximum Sharpe ratio among all possible portfolios on the Efficient Frontier.
- **Optimal Asset Allocation :** The weights of assets in the tangency portfolio determine how an investor should allocate their investments across different assets to achieve their desired risk-return trade-off.
- **Efficient Diversification :** The tangency portfolio achieves efficient diversification by combining the risk-free asset with the risky portfolio in such a way that it maximizes return for a given level of risk or minimizes risk for a given level of return.

SML (Security Market Line)

The Security Market Line (SML) is a graphical representation of the Capital Asset Pricing Model (CAPM), which illustrates the relationship between the expected return and systematic risk (beta) of individual securities or portfolios.
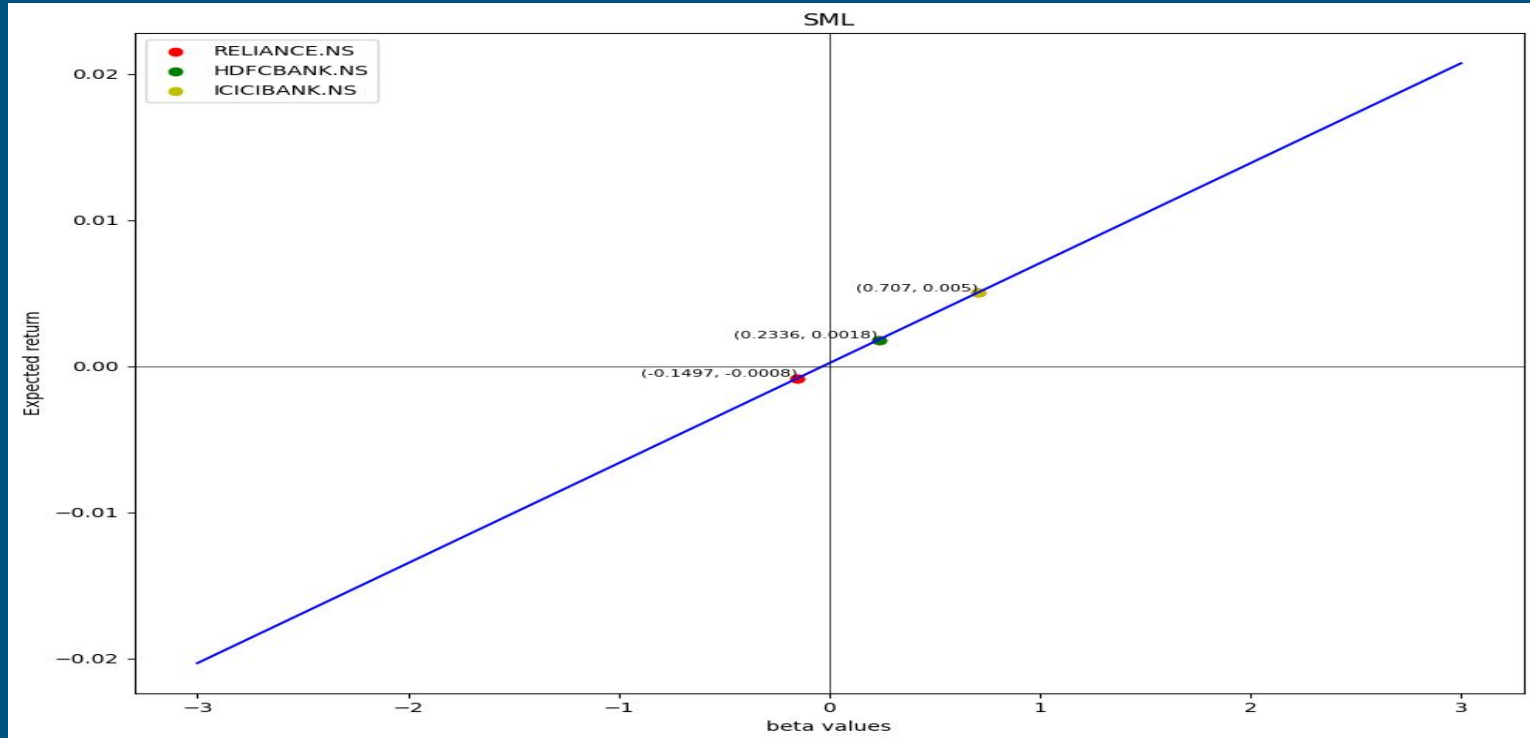
SML is a straight line that starts at the risk-free rate (R_f) on the y-axis and has a slope equal to the market risk premium ($E(R_M) - R_f$).
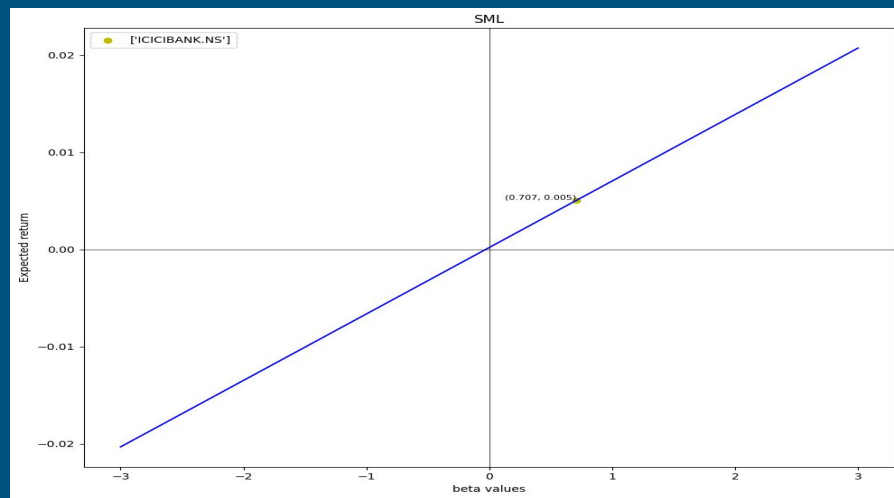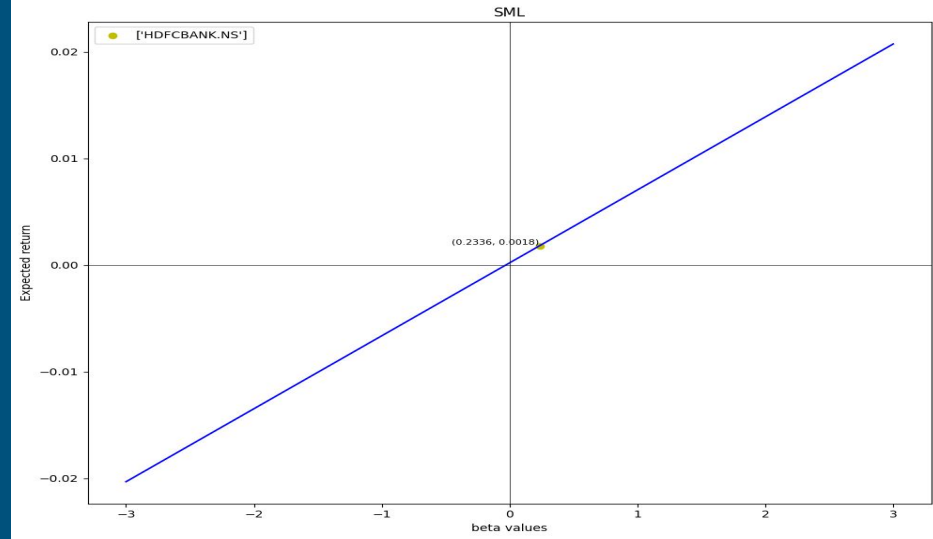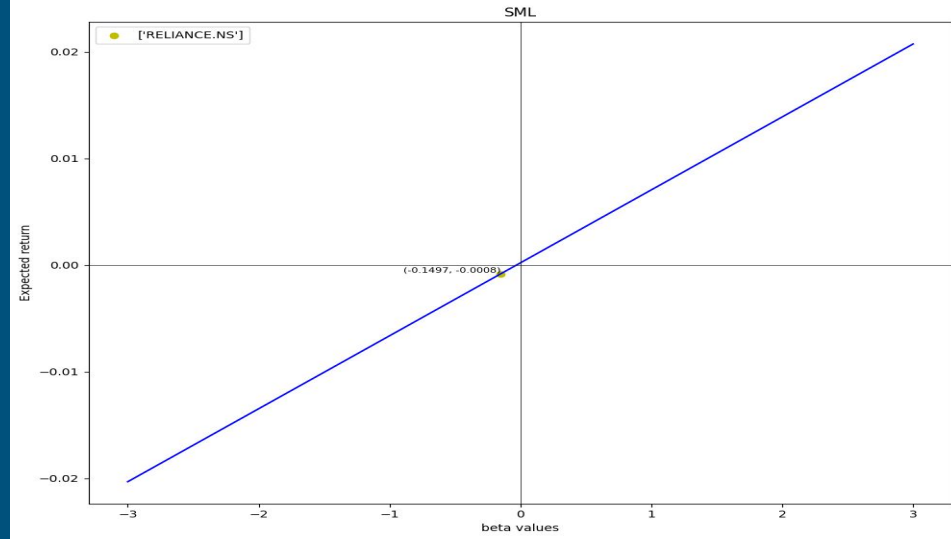
The equation of SML is:

$$E(R_i) = r_f + \beta_i \times (E(R_M) - r_f)$$

Beta is the slope of the regression line between the changes in market return and the corresponding response of the asset return.

Visualization of SML lines for 3 chosen assets

Portfolio Performance Measures:

- Sharpe Ratio - Calculated the Sharpe Ratio for each portfolio using the formula:

$$\text{Sharpe Ratio} = (E(R_P) - r_f) / \sigma_P$$

- Treynor Ratio - Calculated the Treynor Ratio for each portfolio using the formula:

$$\text{Treynor Ratio} = (E(R_P) - r_f) / \beta_P$$

where $E(R_p)$ is the expected return of the portfolio, r_f is the risk-free rate, σ_p is the standard deviation (risk) of the portfolio and β_P is the beta of the portfolio.

Sharpe Ratio

- The sharpe ratio of the portfolio is 0.637 .
- The sharpe ratio for each asset is given below:

Stock	Sharpe Ratio
RELIANCE.NS	-0.0638
TCS.NS	-0.0877
HDFCBANK.NS	0.1205
INFY.NS	0.1574
ICICIBANK.NS	0.1781
HINDUNILVR.NS	0.3098
MRF.NS	0.2461
TATAMOTORS.NS	0.2883
SBIN.NS	0.3315
IRCTC.NS	0.1852

Treynor Ratio

- The Treynor ratio of the portfolio is 0.010213378862396155 .
- The Treynor ratio for each asset is also 0.010213378862396155.
- If the Treynor ratio of each stock in a portfolio is the same, it could indicate that the stocks in the portfolio have similar betas or systematic risk exposures relative to the market.
- The Treynor ratio is calculated as the excess return of an investment (or portfolio) over the risk-free rate, divided by the investment's beta.
- If all the stocks in the portfolio have similar betas, then the excess return relative to the risk-free rate would be the primary factor determining the Treynor ratio. This could happen if the stocks in the portfolio belong to the same industry or have similar risk profiles.

Implications of measures in evaluating portfolio performance:

- Sharpe Ratio: A higher Sharpe Ratio indicates better risk-adjusted returns. Portfolios or assets with higher Sharpe Ratios are more efficient in generating returns relative to the risk taken.
- Treynor Ratio: The Treynor Ratio considers only systematic risk (beta) and evaluates the excess return per unit of systematic risk. It helps investors assess whether the portfolio's returns adequately compensate for its systematic risk.

Comparison between Markowitz Portfolio Theory and CAPM Approach

- Markowitz emphasizes diversification's role in reducing portfolio risk by selecting uncorrelated assets.

- CAPM focuses on the relationship between systematic risk (beta) and expected return, incorporating the risk-free rate and market risk premium.

- While Markowitz provides insights into portfolio diversification benefits, CAPM offers a framework for understanding the relationship between risk and return in the broader market context.

Thanks

References

https://www.investopedia.com/

https://finance.yahoo.com/