Introduction to Financial Engineering

Capital Asset Pricing Model

Team Members

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Risky Asset Selection

The closing price data (over the past 3 months) of the following 10 selected risky assets was taken from **Yahoo Finance**.

Microsoft Corporation **(MSFT)**	JPMorgan Chase & Co. **(JPM)**	Walmart Inc. **(WMT)**	Salesforce, Inc. **(CRM)**	McDonald's Corporation **(MCD)**
Amazon.com, Inc. **(AMZN)**	NVIDIA Corporation **(NVDA)**	Caterpillar Inc. **(CAT)**	The Coca-Cola Company **(KO)**	Alphabet Inc. **(GOOGL)**

Risk-Free Asset Selection

Indian Railway Finance Corporation Ltd **(Bond)**	Current Yield **4.24%**

Indian Railway Finance Corporation Ltd 8.1% BUY SELL

ISIN: INE053F07538 | Rating: CRISIL AAA/Stable

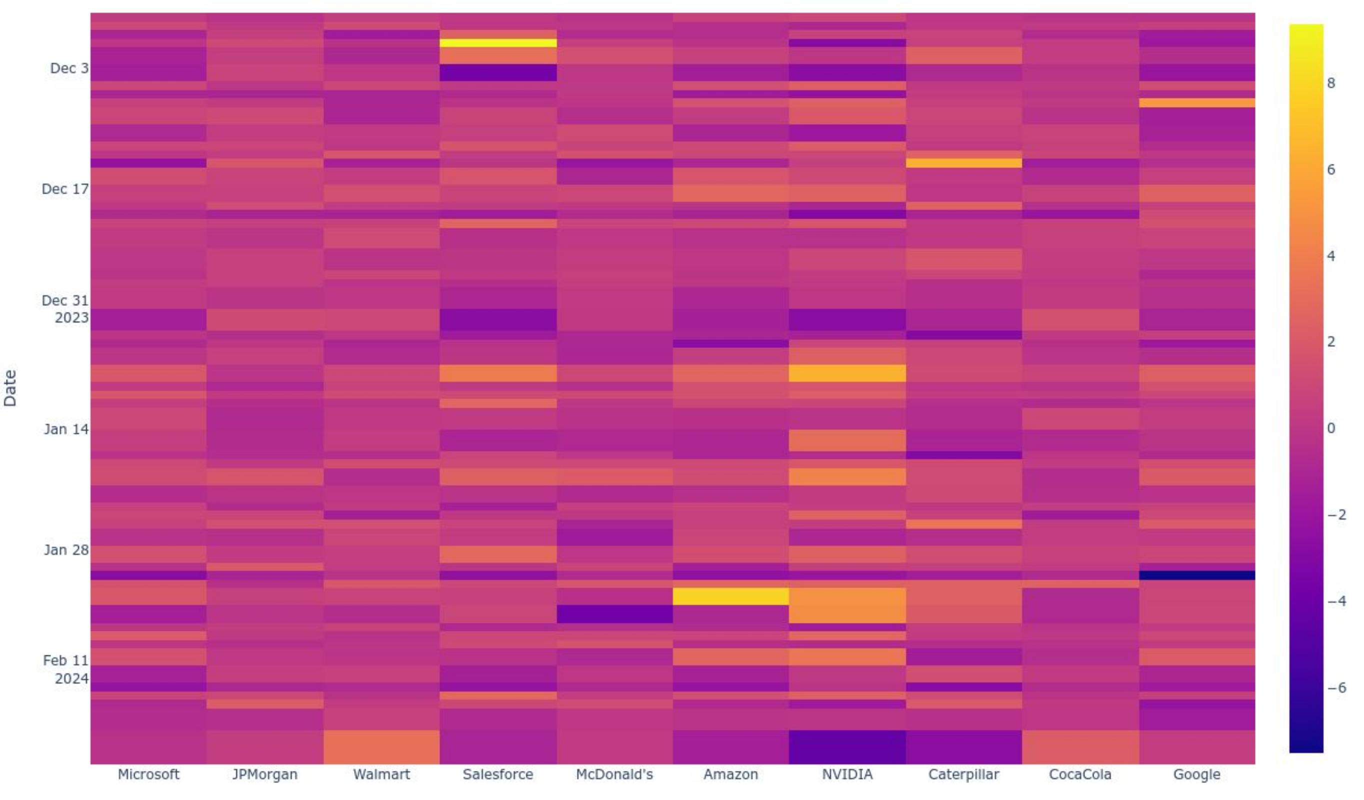
Overview

Yield: 4.24 %	Coupon rate: 8.1%	Face Value: ₹ 1,000
Maturity date: 23-Feb-2027	Last Traded Price: ₹ 1,105.15	Last Traded Date: 19-Feb-2024

Key Metrics

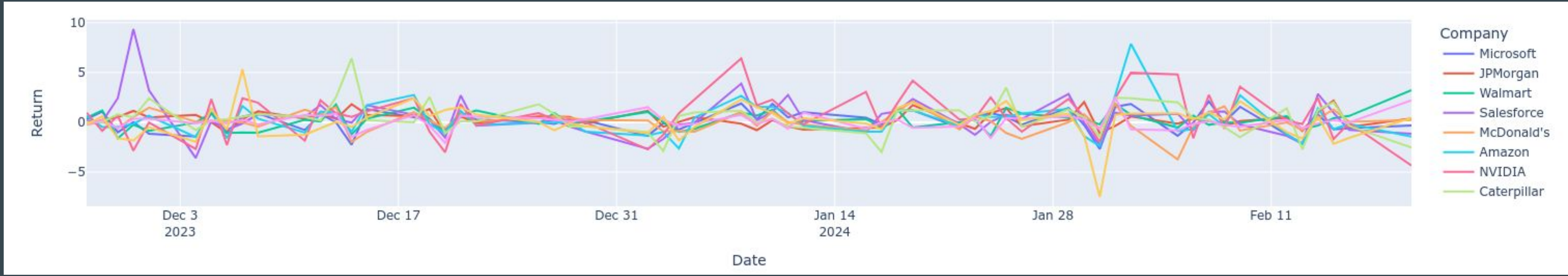
Nature of bond: Secured	Coupon Frequency: Yearly
Time till maturity: 3y 0m 5d	Ex-Date: 23-Feb-2024
Issue date: 23-Feb-2012	

Visualizations



Returns for each company (asset)

Visualizations



Returns for companies (assets) over time

Capital Asset Pricing Model (CAPM)

Capital Asset Pricing Model (CAPM)

It is a financial model that calculates the expected rate of return for an asset or investment.

It achieves this by utilizing the expected return on both the market and a risk-free asset, along with the asset's correlation or sensitivity to the market (beta).

Market Data

Nifty Bank
(^NSEBANK)

Market Return

Calculated using the percentage change between consecutive data points in the market data.

Capital Asset Pricing Model (CAPM) Formula

$$\mu_i = \mu_{rf} + \beta_i\,(\,\mu_m - \mu_{rf}\,)$$

where:

β_i = beta of investment
μ_i = expected return of investment
μ_{rf} = risk-free rate
μ_m = expected return of market

$$\beta_i = Cov(R_i\,, R_m)\ /\ Var(R_m)$$

where:

β_i = beta of investment
R_i = return on investment
R_m = return on market

CAPM Expected Returns (Risky Assets)

Microsoft	0.027500
JPMorgan	0.056402
Walmart	0.036176
Salesforce	0.024740
McDonald's	0.029928
Amazon	0.029128
NVIDIA	0.027721
Caterpillar	0.057252
CocaCola	0.038329
Google	0.005993

Capital Asset Pricing Model (CAPM)

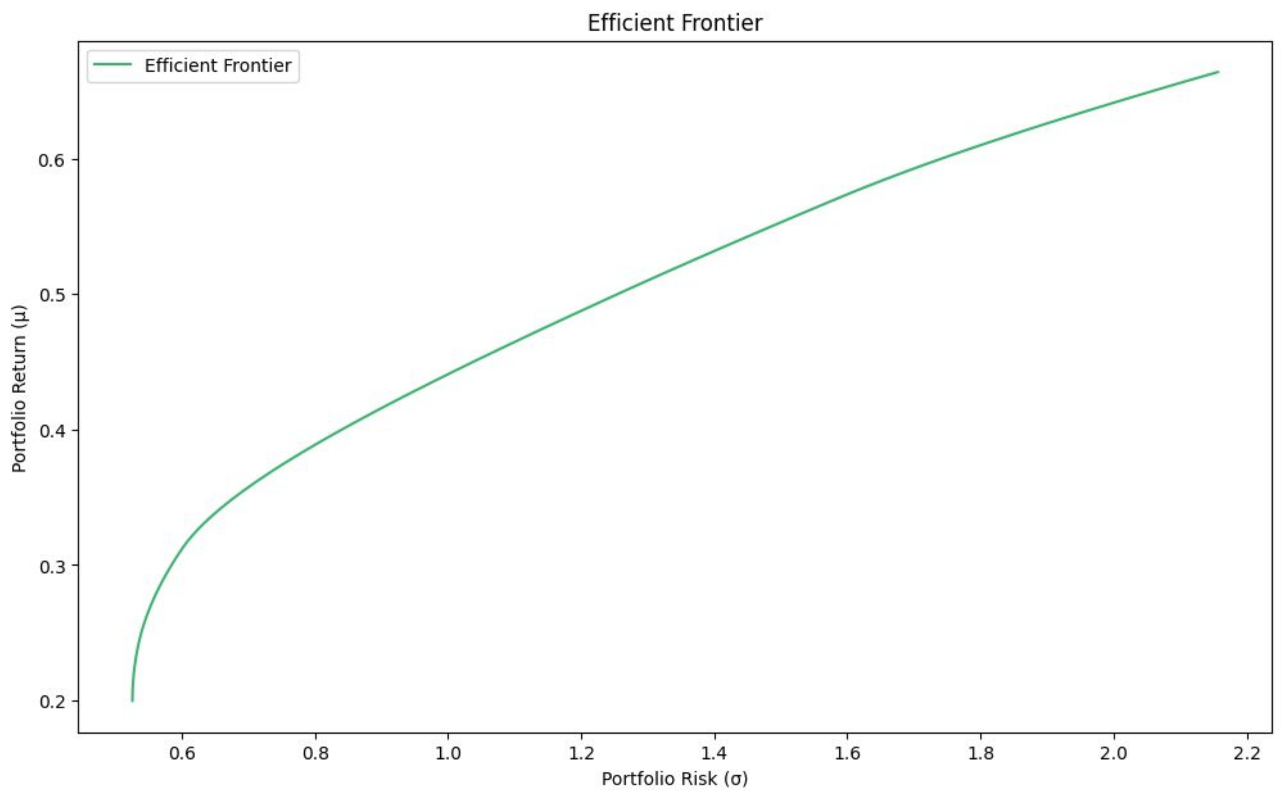
$$\underbrace{\text{Risky Assets}}_{\text{Markowitz Portfolio Optimization}} \; + \; \text{Risk-Free Assets}$$

$$\left(\begin{array}{lrcl} \text{minimize} & \mathbf{x}^\top \boldsymbol{\Sigma} \mathbf{x} & & \\ \text{subject to} & \boldsymbol{\mu}^\top \mathbf{x} & \geq & r_{\min}, \\ & \mathbf{1}^\top \mathbf{x} & = & 1. \end{array} \right)$$

$$\downarrow$$

Efficient Frontier

Efficient Frontier



Capital Market Line (CML)

Equation

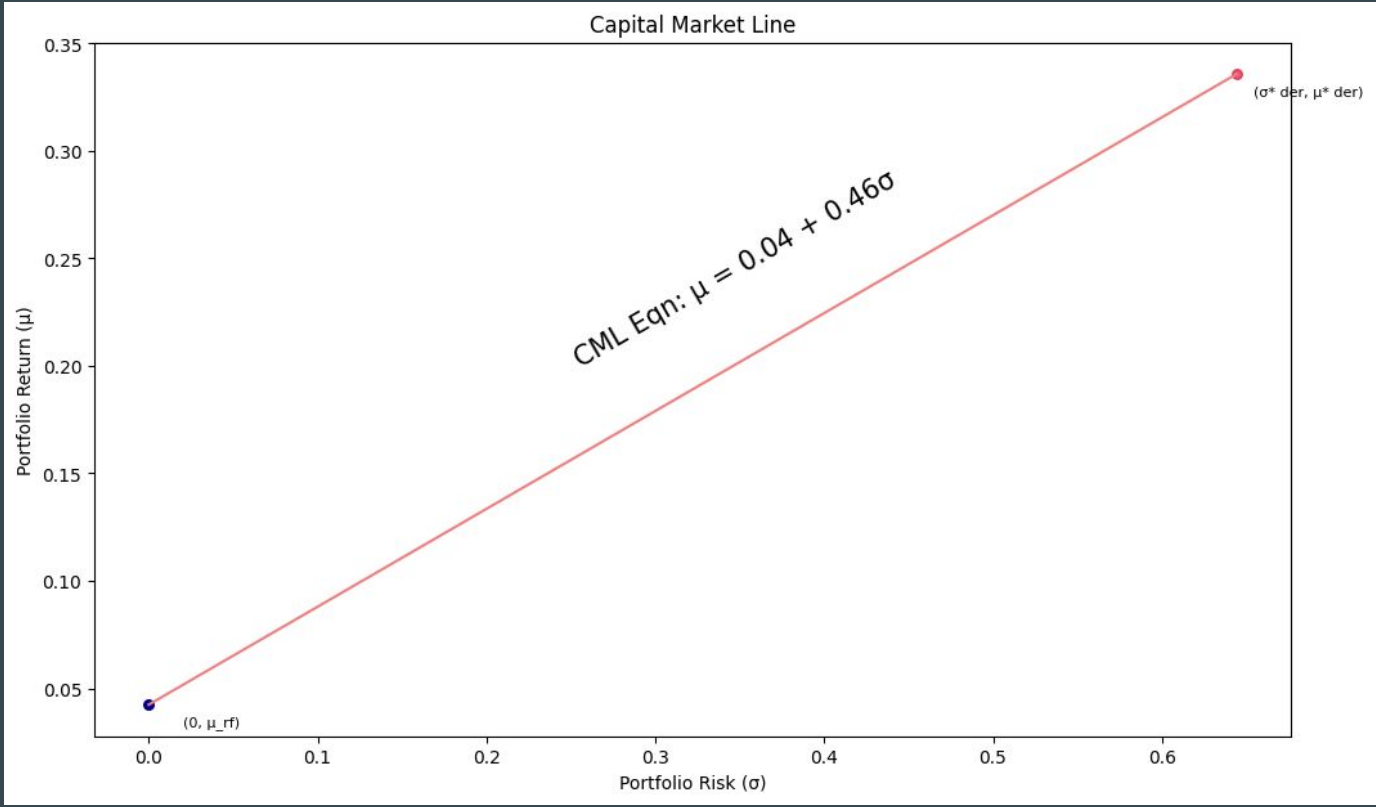
$\mu = \mu_{rf} + \sigma\,(\,\mu_{der} - \mu_{rf}\,)\,/\,\sigma_{der}$

where:

$$\mu_{der} = \boldsymbol{\mu}.W^{*}$$
$$\sigma_{der} = W^{*}.\Sigma.W^{*T}$$

(W^* is calculated by maximizing the Sharpe ratio in a feasible region, i.e., within the efficient frontier)

Capital Market Line (CML)

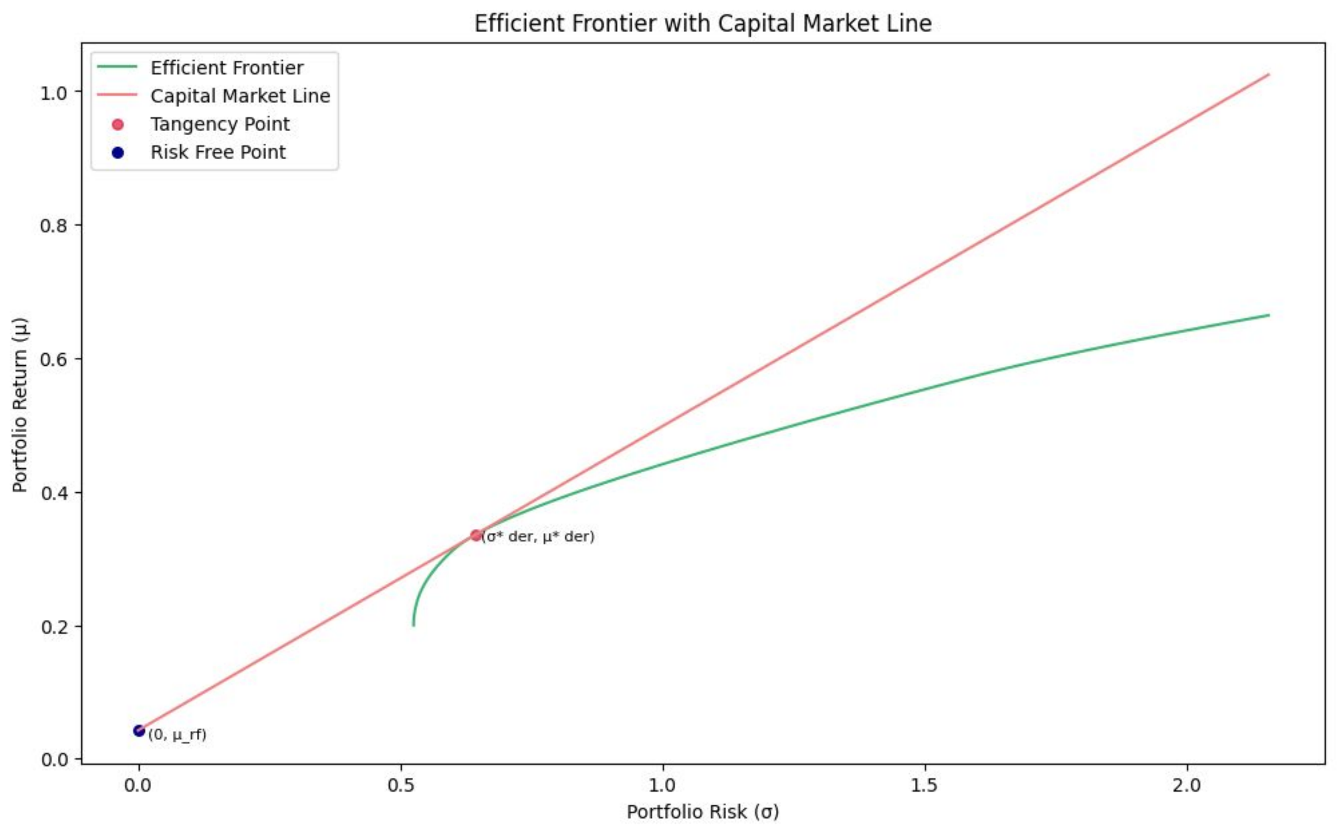


Tangency Point of CML on Efficient Frontier

The tangency point on the efficient frontier where the Capital Market Line (CML) touches it represents the optimal portfolio of risky assets, known as the market portfolio.

This point indicates the **highest Sharpe ratio**, signifying the best risk-adjusted return among all possible portfolios.

Tangency Point of CML on Efficient Frontier



Security Market Line (SML)

Security Market Line (SML)

It is a line drawn on a chart that serves as a graphical representation of the capital asset pricing model (CAPM).

It can help to determine whether an investment product would offer a favorable expected return compared to its level of risk.

Security Market Line (SML)

Equation

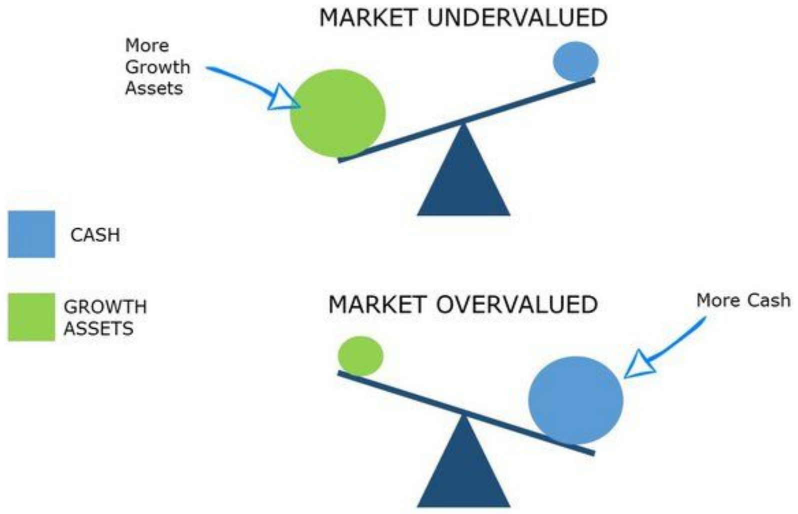
$$\mu = \mu_{rf} + \beta * (\mu_m - \mu_{rf})$$

where:

β = beta of the market

μ_{rf} = risk-free rate

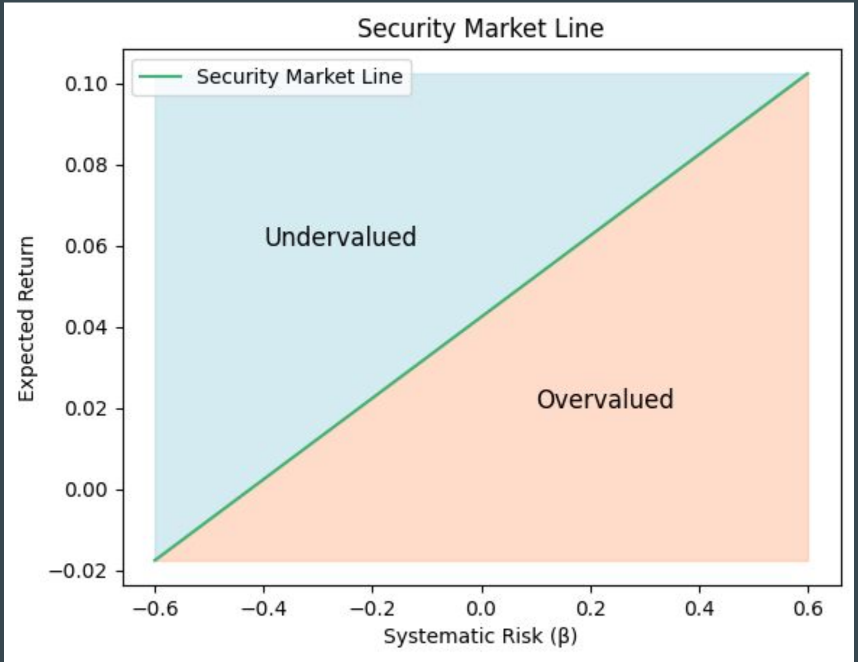
μ_m = expected return of market

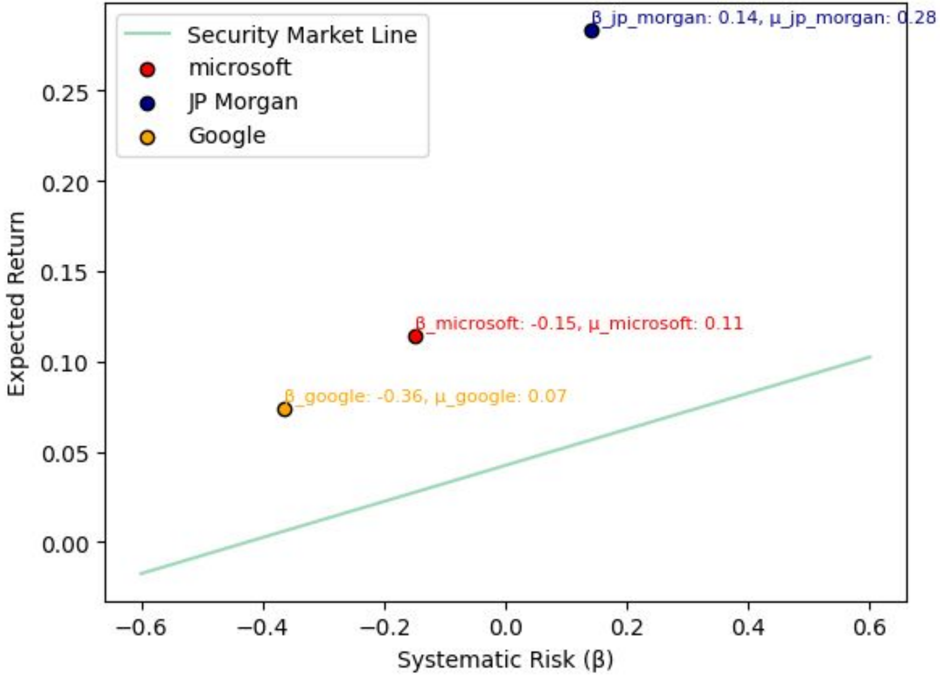


Selected Risky Assets
(Individual Security Market Lines)

- Microsoft Corporation (MSFT)
- JPMorgan Chase & Co. (JPM)
- Alphabet Inc. (GOOGL)

Visualizations





Evaluating **Portfolio** Performance

Sharpe Ratio

A measure of an investment's risk-adjusted performance, calculated by comparing its return to that of a risk-free asset.

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

where:

$R_p =$ return of portfolio

$R_f =$ risk-free rate

$\sigma_p =$ standard deviation of the portfolio's excess return

Sharpe Ratio (Optimized Portfolio)

Asset	**Weights** (Optimized Portfolio)	**Sharpe Ratio**
Microsoft	0	0.066834
JPMorgan	0.176	0.311536
Walmart	0.106	0.176869
Salesforce	0.018	0.209705
McDonald's	0	0.028528
Amazon	0	0.113065
NVIDIA	0.062	0.288253
Caterpillar	0.004	0.243791
CocaCola	0	0.03428
Google	0	0.018559
Risk Free Asset	0.633	

<

Optimized Portfolio Sharpe Ratio
0.4553845331574839

Note: *Desired return is assumed to be 0.15 for demonstration.*

Sharpe Ratio (Optimized Portfolio)

The Sharpe ratio compares a fund's returns to a benchmark and considers the volatility of those returns, helping to assess whether excess returns are attributable to smart decisions or luck. **A higher ratio suggests better risk-adjusted performance.**

The Sharpe ratio of the optimized portfolio surpassed that of individual assets, indicating that the portfolio has achieved superior risk-adjusted performance through diversification and effective risk management strategies, i.e., CAPM in this case.

Markowitz Portfolio Optimization
V/S
Capital Asset Pricing Model

(BONUS)

Comparing risk for the same desired return

	Markowitz Portfolio Optimization	Capital Asset Pricing Model
Risk	0.539039374810739	0.236283826448688 6

lower risk
(for same return)

Note: *Desired return is assumed to be 0.15 for demonstration.*

Comparing risk for the same desired return

Risk (CAPM Portfolio) < Risk (MPO Portfolio)

CAPM assumes rational, risk-averse investors needing compensation for additional risk. This leads to a conservative portfolio with minimized risk for a given return.

Lower risk in CAPM suggests significant allocation to risk-free asset, indicating conservative risk management.

Comparing risk for the same desired return

MPO maximizes return for given risk or minimizes risk for given return. It emphasizes diversification and asset correlation for optimal portfolio construction.

Higher risk in MPO suggests allocation to assets with higher risk-return ratios for desired returns.

- CAPM suits risk-averse investors prioritizing stability over returns, ideal for long-term investments.
- MPO is for investors with higher risk tolerance seeking short-term gains.

Both models are valuable in portfolio management, so investors should weigh their options based on individual preferences, financial goals, and risk tolerance.

References

Learning about Capital Asset Pricing Model
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Learning about MPO, CAPM
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Python library for handling optimization
https://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.minimize.html

THANK YOU!