

# 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

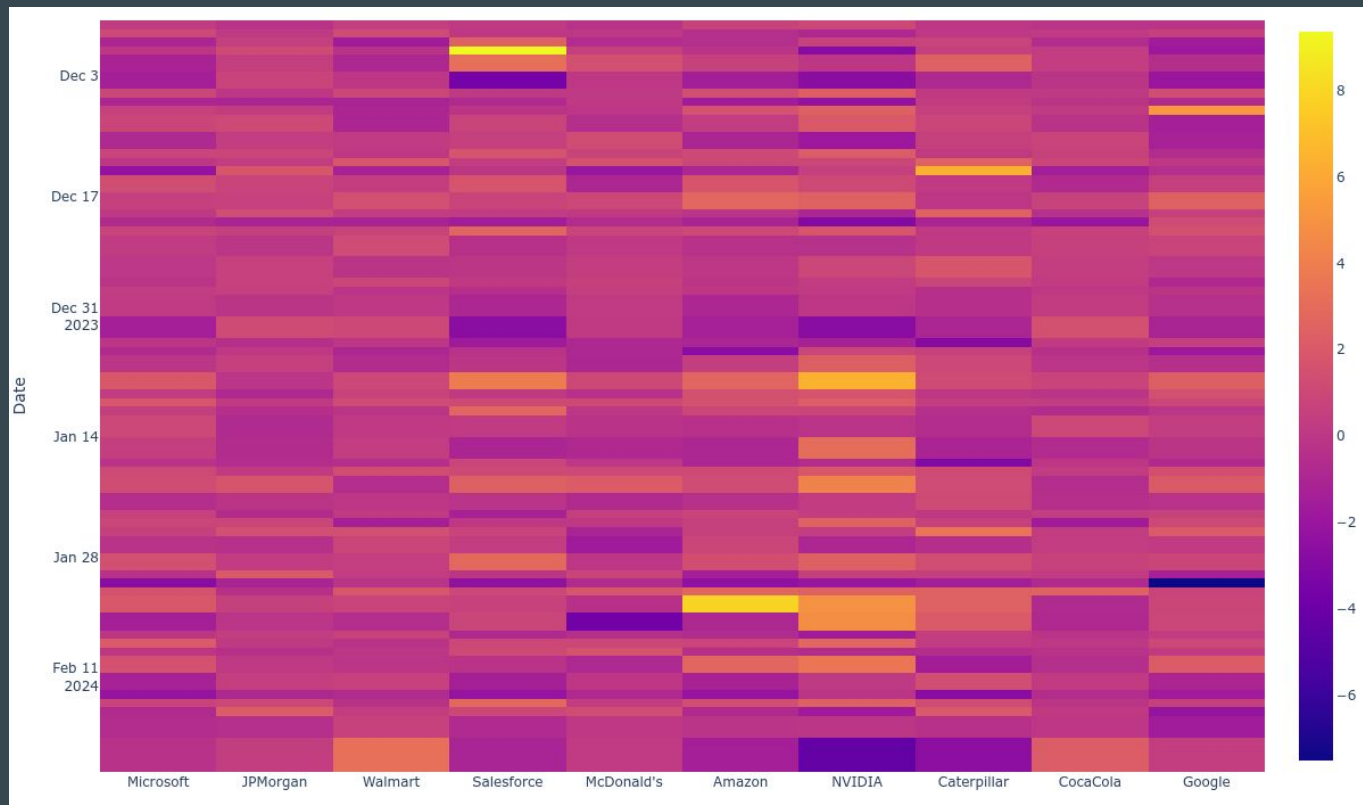
Ex-Date

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)

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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

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Nifty Bank  
(^NSEBANK)

## Market Return

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

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# Capital Asset Pricing Model (CAPM) Formula

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

where:

$\beta_i$  = beta of investment

$\mu_i$  = expected return of investment

$\mu_{rf}$  = risk-free rate

$\mu_m$  = expected return of market

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

where:

$\beta_i$  = 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

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# Capital Asset Pricing Model (CAPM)

Risky Assets + Risk-Free Assets



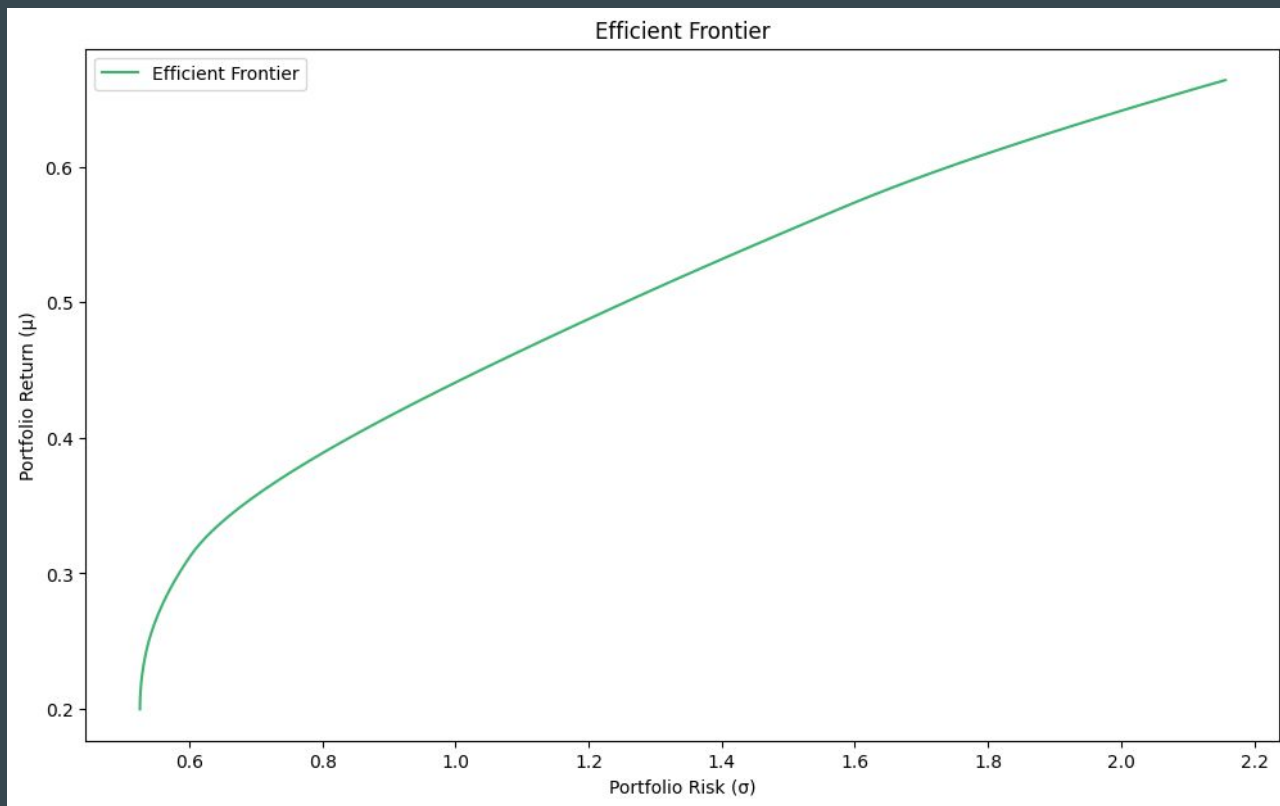
Markowitz Portfolio Optimization

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



Efficient Frontier

# Efficient Frontier



# Capital Market Line (CML)

Equation

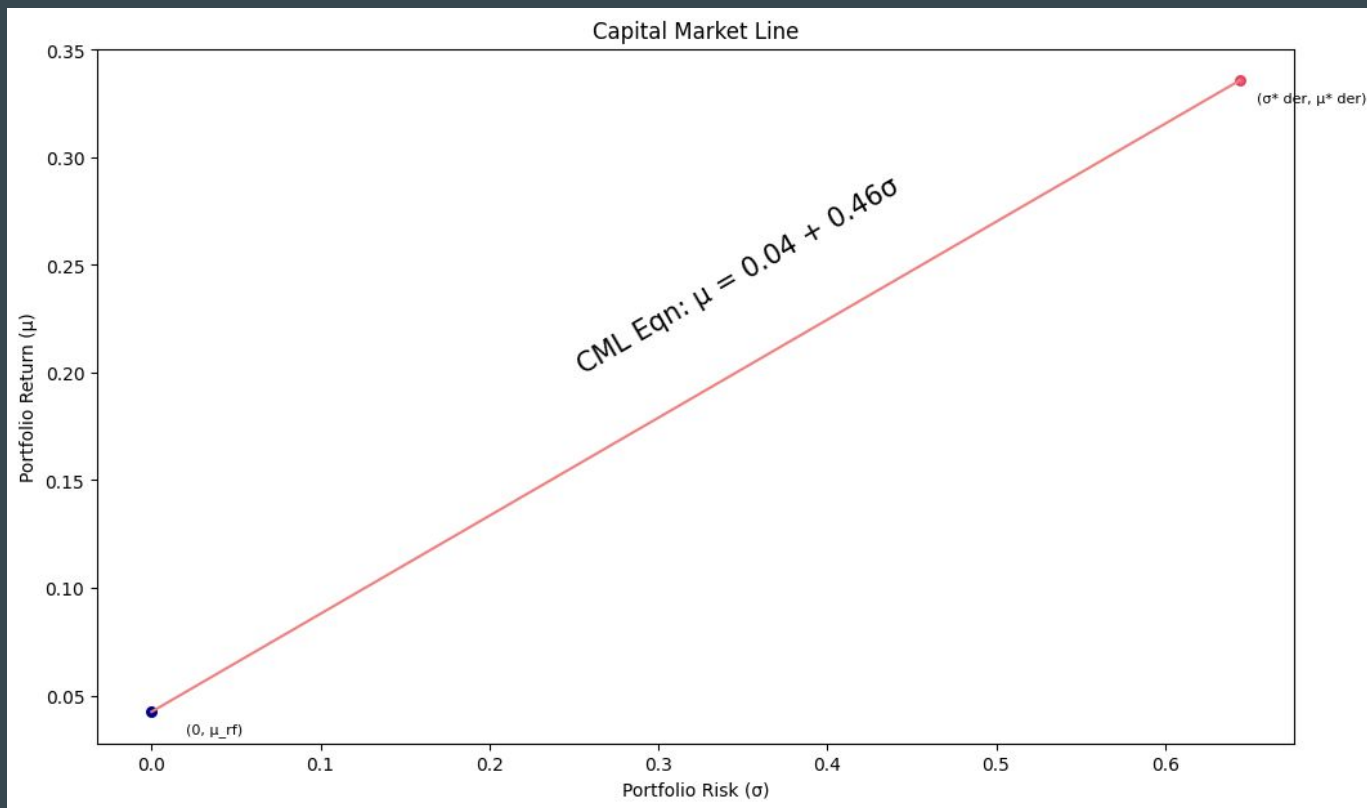
$$\mu = \mu_{rf} + \sigma (\mu_{der} - \mu_{rf}) / \sigma_{der}$$

where:

$$\begin{aligned}\mu_{der} &= \mu \cdot W^* \\ \sigma_{der} &= W^* \cdot \Sigma \cdot W^{*T}\end{aligned}$$

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

# Capital Market Line (CML)



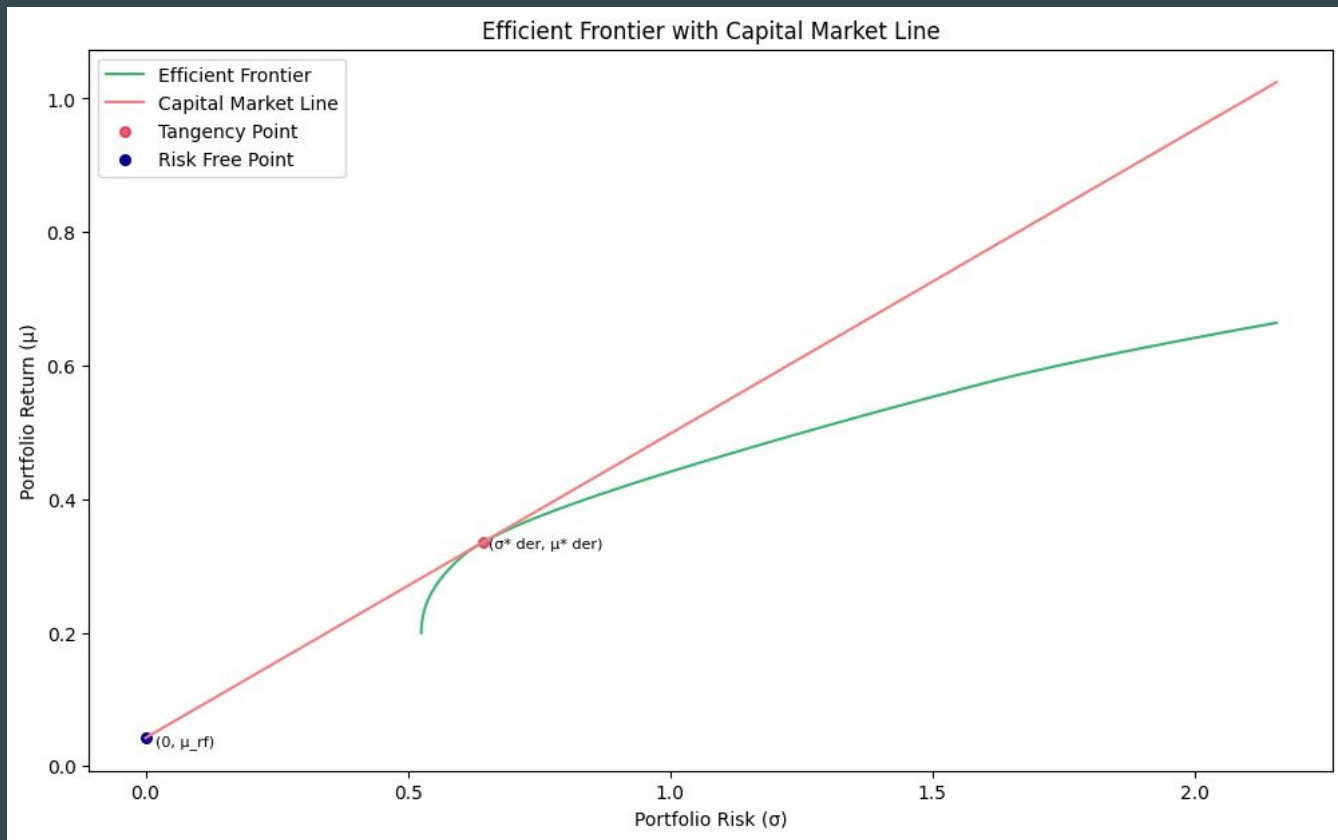
# Tangency Point of CML on Efficient Frontier

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:

$\beta$  = beta of the market

$\mu_{rf}$  = risk-free rate

$\mu_m$  = expected return of market

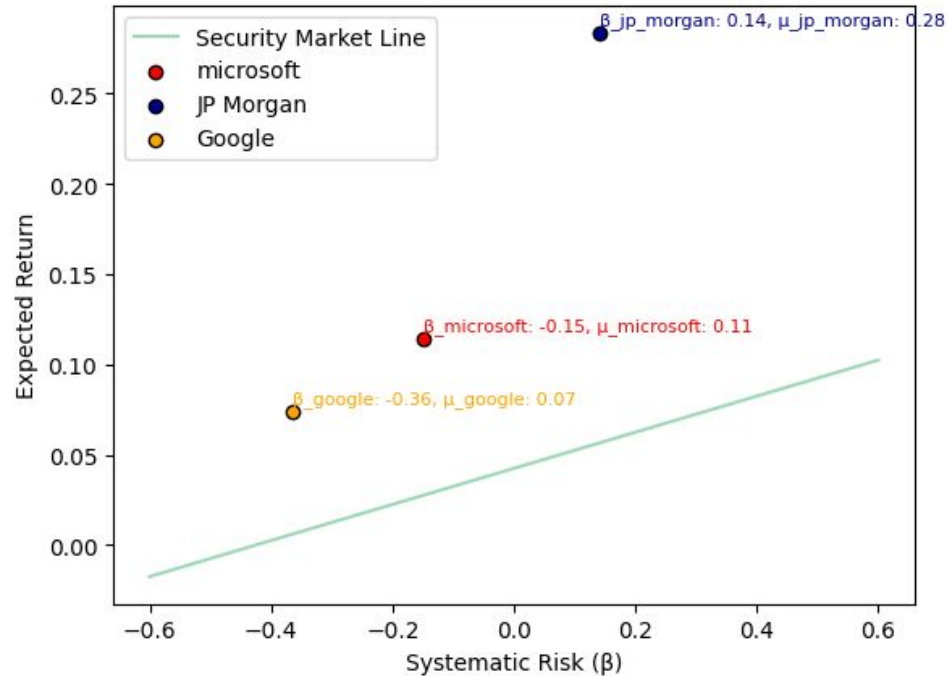
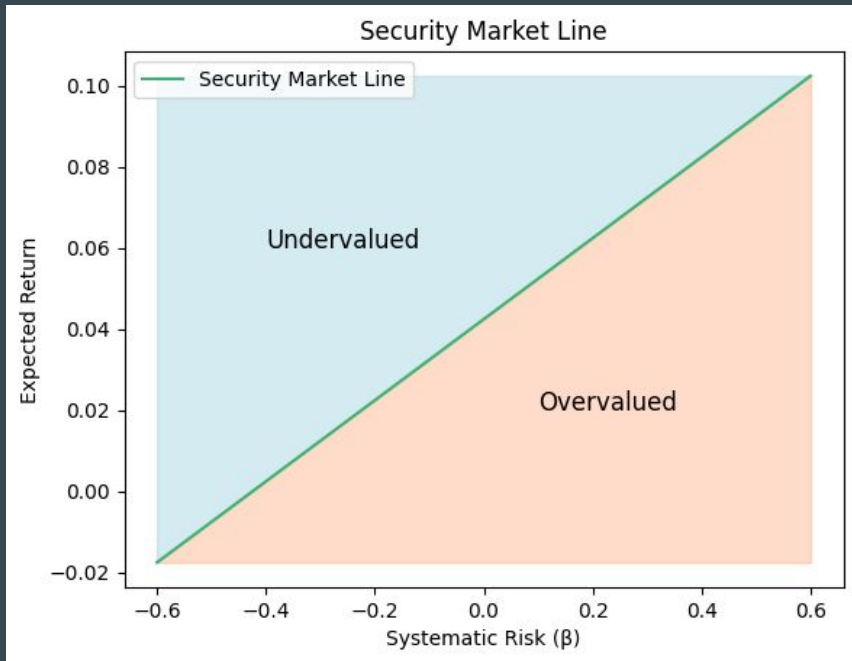


# **Selected Risky Assets**

## **(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.

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

**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	0.2362838264486886



lower risk  
(for same return)

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

# Comparing risk for the same desired return

$$\text{Risk (CAPM Portfolio)} < \text{Risk (MPO Portfolio)}$$

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

<https://www.investopedia.com/terms/c/capm.asp>

<https://obrianbl.github.io/CAPM AAPL TSLA MSFT INTL/>

<https://www.accaglobal.com/gb/en/student/exam-support-resources/fundamentals-exams-study-resources/f9/technical-articles/CAPM-theory.html>

<https://www.learnsignal.com/blog/capital-market-line/>

Learning about Capital Market Line

<https://www.wallstreetmojo.com/capital-market-line/>

Learning about Security Market Line

<https://www.investopedia.com/terms/s/sml.asp>

Learning about Sharpe ratio

<https://www.investopedia.com/terms/s/sharperatio.asp>

Learning about MPO, CAPM

<https://fastercapital.com/content/CAPM-and-Markowitz-Efficient-Set--Unveiling-the-Relationship.html>

Python library for handling optimization

<https://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.minimize.html>



**THANK YOU!**