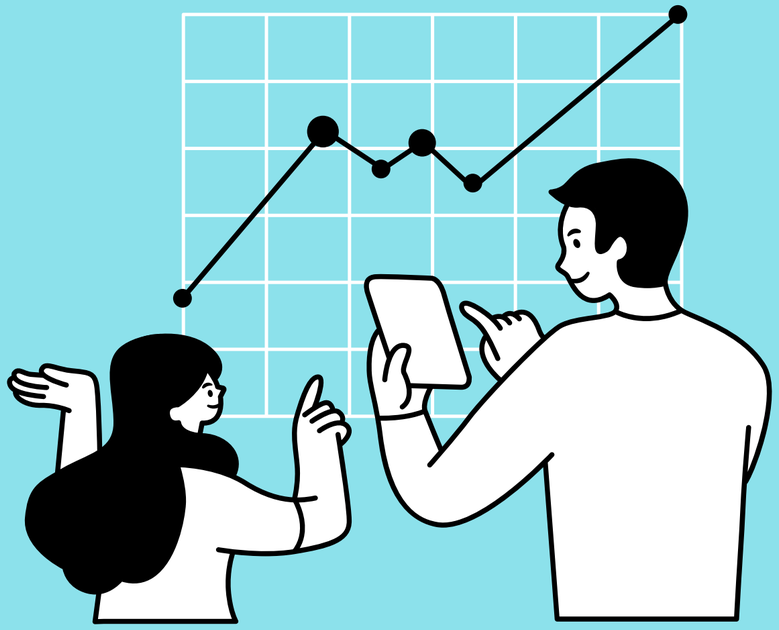
Introduction to Financial Engineering 2024

GROUP 23

Project 3: Capital Asset Pricing Model



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23,Feb 2024

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Historical Prices for Risky Assets:
Ticker            AAPL        AMZN        BND       GOOGL          GS
Date
2023-11-24  189.727905  146.740005  69.957222  136.690002  336.387756
2023-11-27  189.548126  147.729996  70.383553  136.410004  334.959503
2023-11-28  190.157349  147.029999  70.680992  137.199997  334.899994
2023-11-29  189.128662  146.320007  71.047836  134.990005  340.260010
2023-11-30  189.707916  146.089996  70.819794  132.529999  341.540009

Ticker            JD         JPM        MSFT        NFLX        TSLA
Date
2023-11-24  28.760000  152.599014  376.733307  479.559998  235.449997
2023-11-27  28.340000  152.251175  377.911133  479.170013  236.080002
2023-11-28  28.160000  152.599014  381.993622  479.000000  246.720001
2023-11-29  27.440001  153.374252  378.150696  477.190002  244.139999
2023-11-30  27.430000  155.123459  378.210602  473.970001  240.080002

Historical Prices for Risk-Free Asset (U.S. Treasury Bonds):
Date
2023-11-24    91.527992
2023-11-27    92.222366
2023-11-28    92.629066
2023-11-29    93.115128
2023-11-30    92.658829
Name: Adj Close, dtype: float64
```

BASIC INFORMATION

SOURCE yahoo! finance

ASSET: # 10 chosen assets

tickers = ["AAPL", "GOOGL", "MSFT", "AMZN", "TSLA", "NFLX", "JPM", "GS", "BND", "JD"] **STOCKS**

 # NON RISKY

U.S. Treasury bonds

TSLA (Tesla Inc.)

Tesla is an electric vehicle and clean energy company recognized for its innovation in automotive technology.

AMZN (Amazon.com Inc.)

Amazon is a major e-commerce company providing products and services, including cloud computing.

AAPL (Apple Inc.)

Known for its popular consumer electronics like iPhone and Mac.

GOOGL (Alphabet Inc. - Class A)

Alphabet is Google's parent company, operating in online advertising, cloud computing, and software development.

MSFT (Microsoft Corporation)

Microsoft is a top tech-firm offering software products, hardware devices, and cloud services.

>> These assets cover various sectors such as technology, finance, e-commerce, automotive, entertainment, and the broader market through bond and S&P 500 index exposure. The selection of assets should align with investment goals, risk tolerance, and market outlook.

NFLX (Netflix Inc.)

Netflix is a popular streaming service offering a vast library of TV shows, movies, and original content.

GS (The Goldman Sachs Group Inc.)

Goldman Sachs is a leading investment bank and financial services company.

JPM (JPMorgan Chase & Co.)

JPMorgan Chase is a global financial services firm providing banking and investment services.

BND

(Vanguard Total Bond Market ETF): BND is an ETF tracking the performance of the U.S. Aggregate Bond Index, offering exposure to investment-grade bonds.

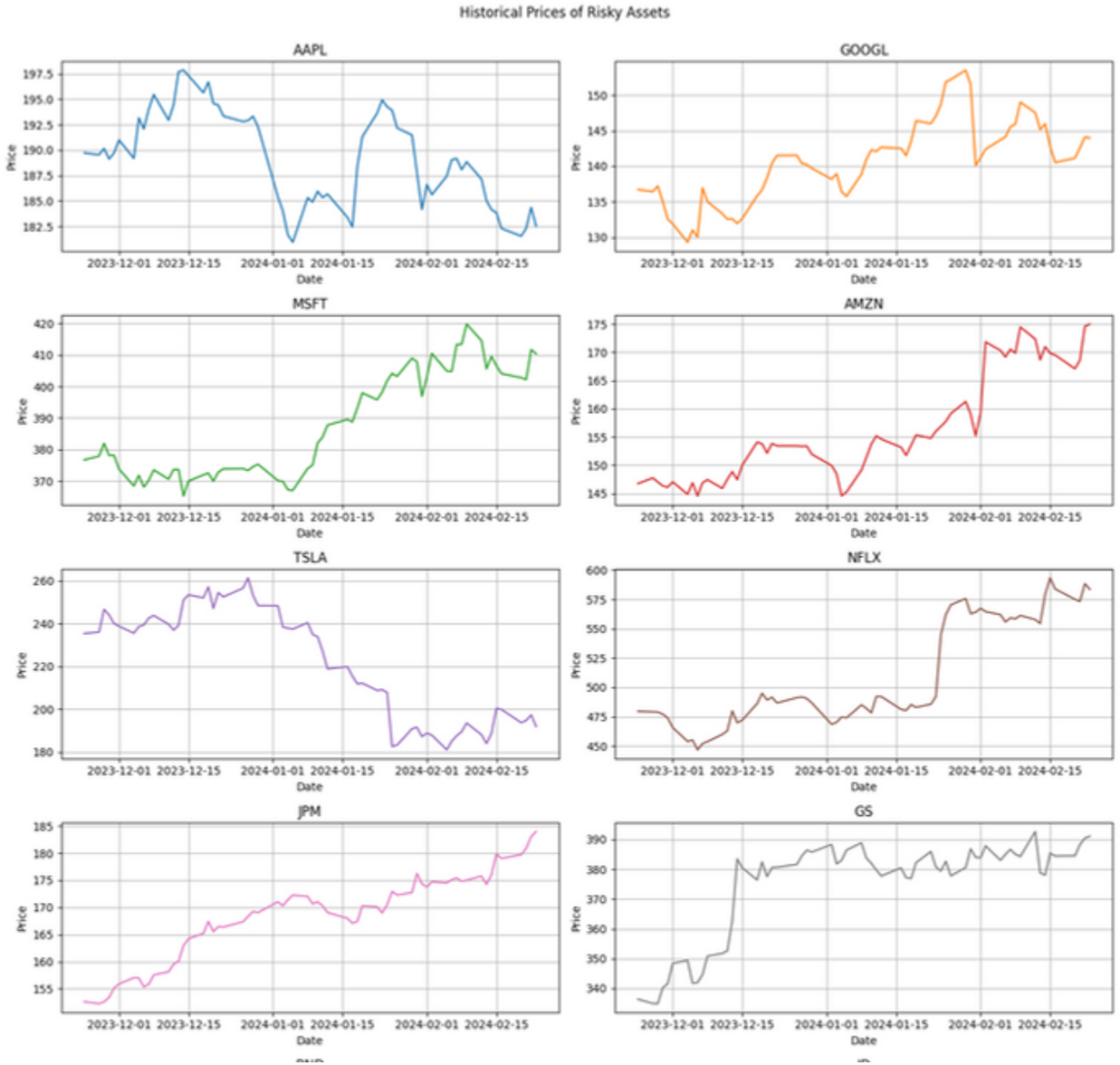
JD.com Inc

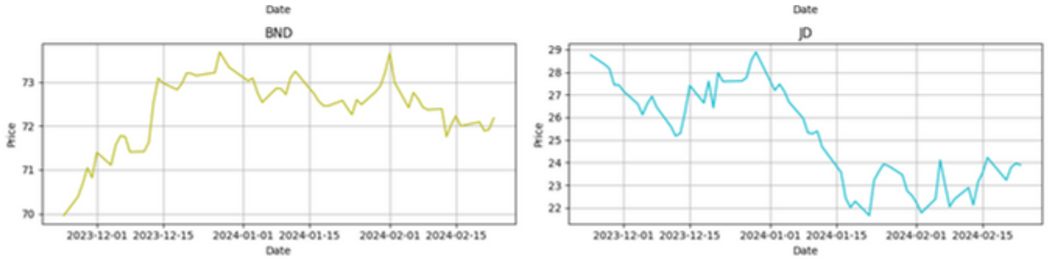
A Chinese e-commerce company : logistics network and delivery services,.

VOO (Vanguard S&P 500 ETF)

VOO is an ETF mirroring the S&P 500 Index's performance, providing exposure to the largest U.S. publicly traded companies.

VISUALIZATION STOCK Price + 1 BOND OVER 3 months





Estimated Current Yield of U.S. Treasury Bonds: 2.126754551817291

Investors can expect to receive an annual return of around 2.13% of the bond's face value in the form of coupon payments.

SIMPLE RETURNS

Ticker	AAPL	AMZN	BND	GOOGL	GS	JD
Date						
2023-11-27	-0.000948	0.006747	0.006094	-0.002048	-0.004246	-0.014604
2023-11-28	0.003214	-0.004738	0.004226	0.005791	-0.000178	-0.006351
2023-11-29	-0.005410	-0.004829	0.005190	-0.016108	0.016005	-0.025568
2023-11-30	0.003063	-0.001572	-0.003210	-0.018224	0.003762	-0.000364
2023-12-01	0.006791	0.006434	0.008157	-0.005055	0.020173	-0.009843

Ticker	JPM	MSFT	NFLX	TSLA
Date				
2023-11-27	-0.002279	0.003126	-0.000813	0.002676
2023-11-28	0.002285	0.010803	-0.000355	0.045069
2023-11-29	0.005080	-0.010060	-0.003779	-0.010457
2023-11-30	0.011405	0.000158	-0.006748	-0.016630
2023-12-01	0.004869	-0.011612	-0.017364	-0.005207

Date	
2023-11-27	0.007586
2023-11-28	0.004410
2023-11-29	0.005247
2023-11-30	-0.004900
2023-12-01	0.009435

Name: Adj Close, dtype: float64

The formula for calculating simple returns R_t for a given time period t is

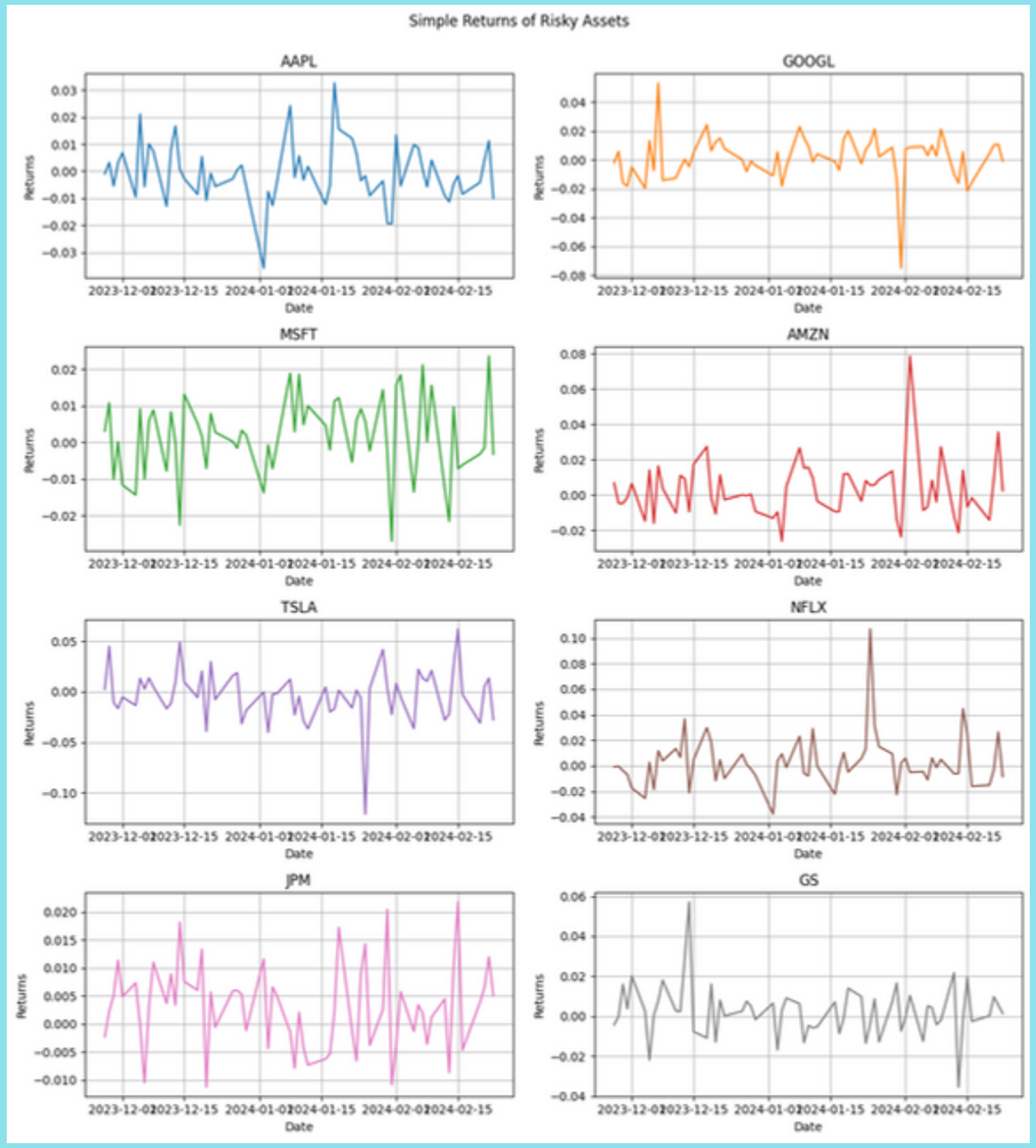
$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \times 100\%$$

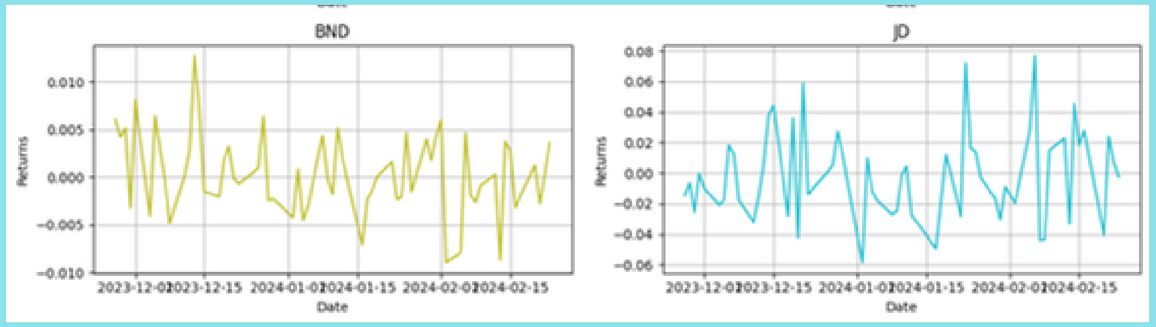
- P_t is the price of the asset at time t.
- P_{t-1} is the price of the asset at the previous time period $t - 1$.

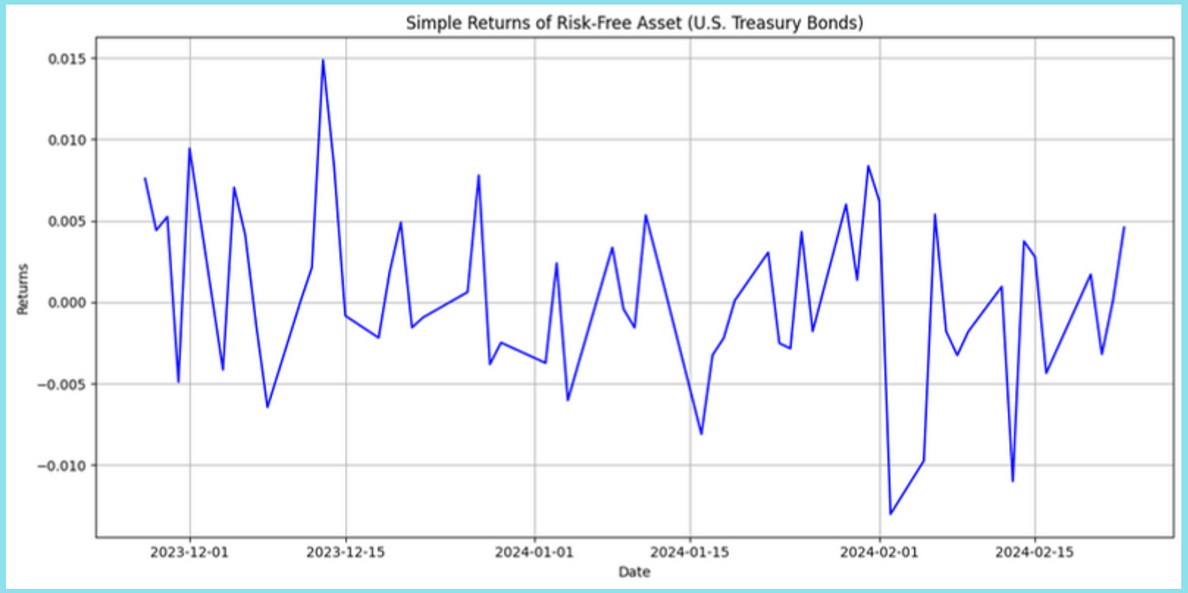
Simple returns are a common way to measure **the Relative change in the value of an asset over a period of time. It provide a straightforward measure of the percentage change in the asset's value from one period to the next, making them easy to interpret and compare across different assets and time periods.**

NORMALIZATION TO INTER CALACULATION RELATIONS WITH STOCKS AND BOND COMBINED

VISUALIZATION SIMPLE RETURN OVER 3 months







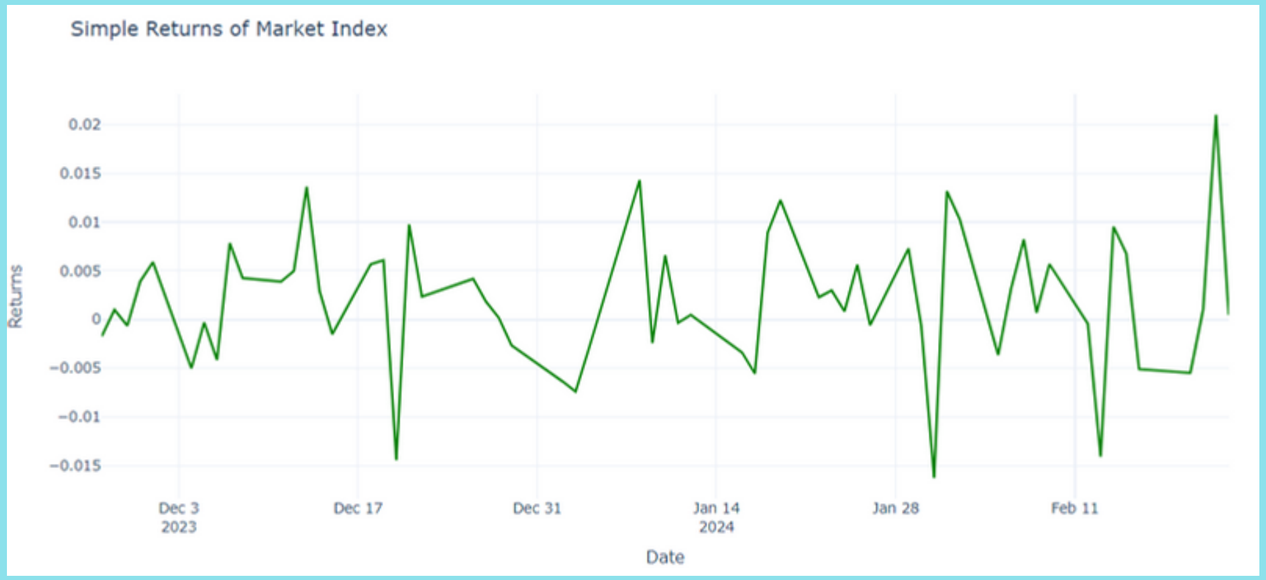
NORMALIZATION done TO INTER CALACULATION RELATIONS WITH STOCKS AND BOND COMBINED

WHY VOO (Vanguard S&P 500 ETF) ? AS MARKET INDEX

VOO tracks the performance of the S&P 500 Index, which is composed of 500 of the largest publicly traded companies in the United States to capture the performance of a broad section of the U.S. stock market, representing various sectors and industries.

The "market index" typically refers to a benchmark index that represents the overall performance of a specific financial market.
Market indices are constructed to track the performance of a group of assets or securities that are representative of the market they are designed to measure.

Vanguard S&P 500 ETF (VOO) as a proxy for market returns for the selected assets



3. Use the CAPM formula to calculate the expected return for each of your 10 risky assets.

The Capital Asset Pricing Model (CAPM) is a widely-used financial model that describes the relationship between the expected return of an asset, the risk-free rate, the asset's beta, and the expected market return. CAPM is based on the principle that investors require compensation for both the time value of money and the risk they undertake.

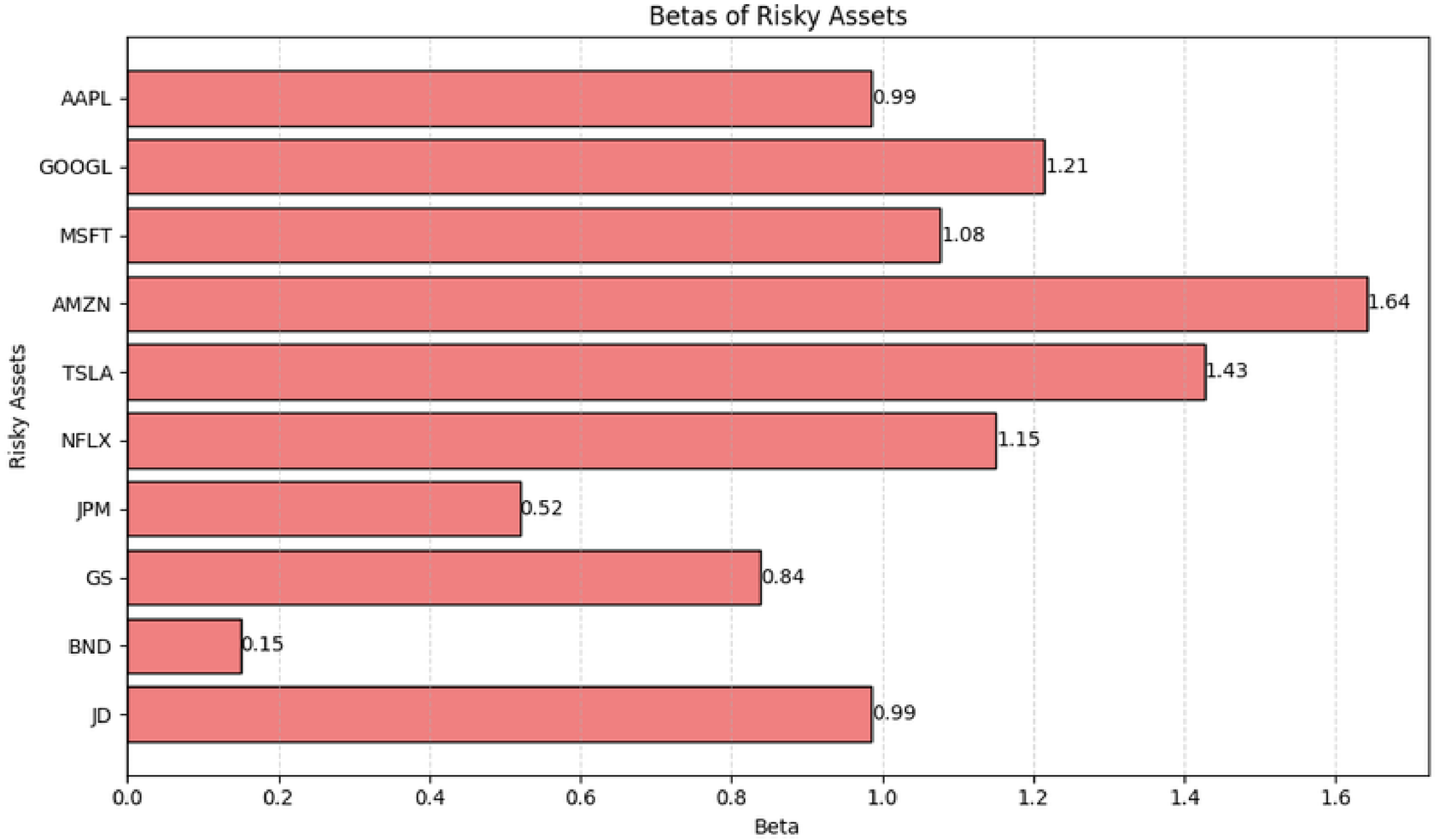
Mathematically, the CAPM formula is expressed as:

$$E(R_i) = R_f + \beta_i \times (E(R_m) - R_f)$$

Where:

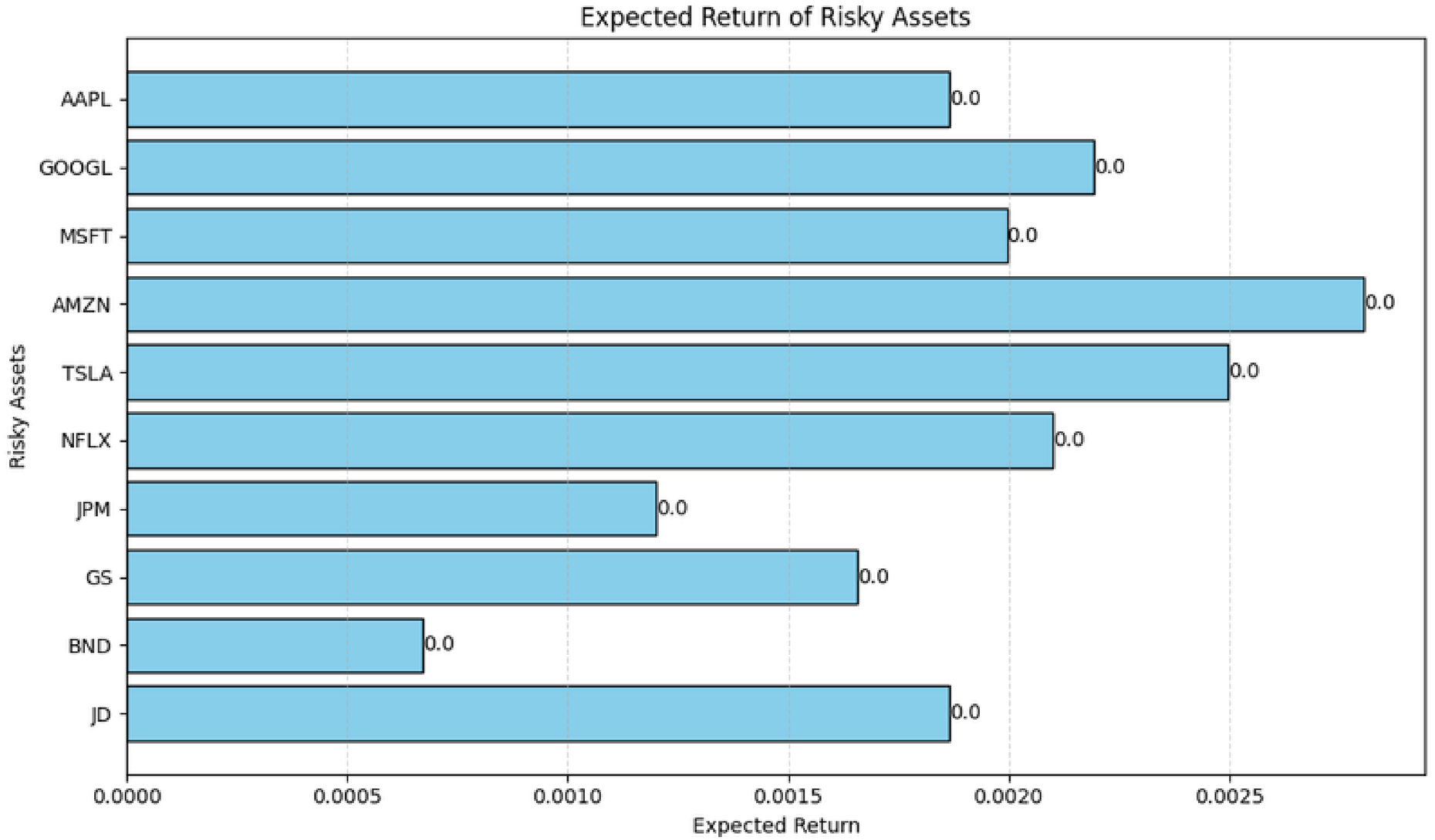
- $E(R_i)$ is the expected return of asset i.
- R_f is the risk-free rate (the return of a risk-free asset).
- β_i is the beta of asset i, representing the asset's sensitivity to market movements.
- $E(R_m)$ is the expected return of the market portfolio.

The term $(E(R_m) - R_f)$ represents the market risk premium, which is the excess return that investors expect from holding a risky asset over and above the risk-free rate.



In the context of the CAPM (Capital Asset Pricing Model), beta is a measure of a stock's volatility in relation to the overall market.

- Beta above 1: Indicates that the stock is more volatile than the market. If the market moves up or down by a certain percentage, stock w is expected to move by a larger percentage in the same direction.
- Beta below 1: Suggests that the stock is less volatile than the market. It may not react as strongly to market movements compared to a stock with a higher beta.
- Beta equal to 1: Implies that the stock's volatility matches that of the market. It moves in tandem with the market.

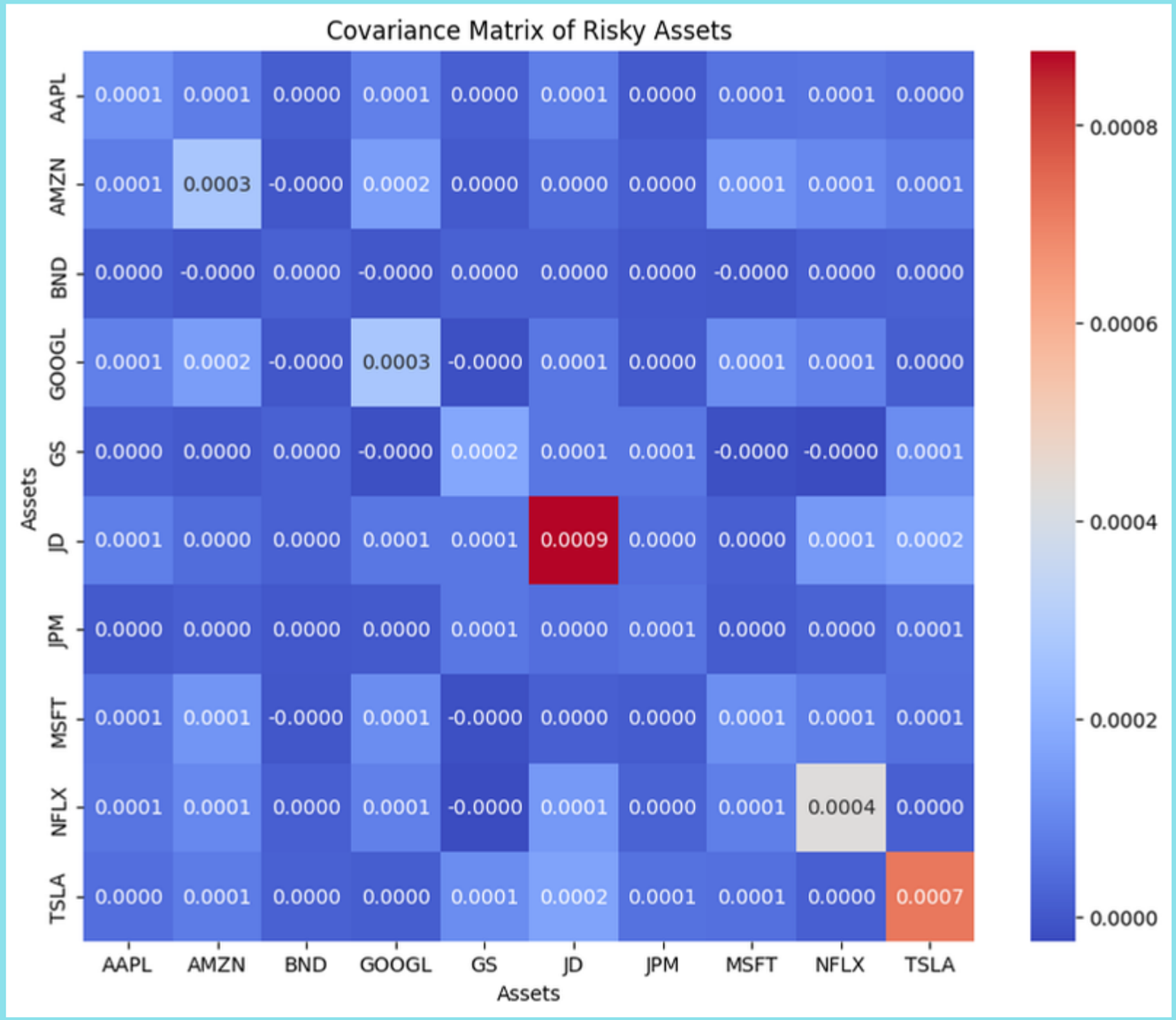


The expected return is the amount of profit or loss an investor can anticipate receiving on an investment. An expected return is calculated by multiplying potential outcomes by the odds of them occurring (BETAS) and then totaling these results.

4.Calculate the Capital market line (CML) equation using CAPM model.

Step 1: To Calculate Covariance and Variance

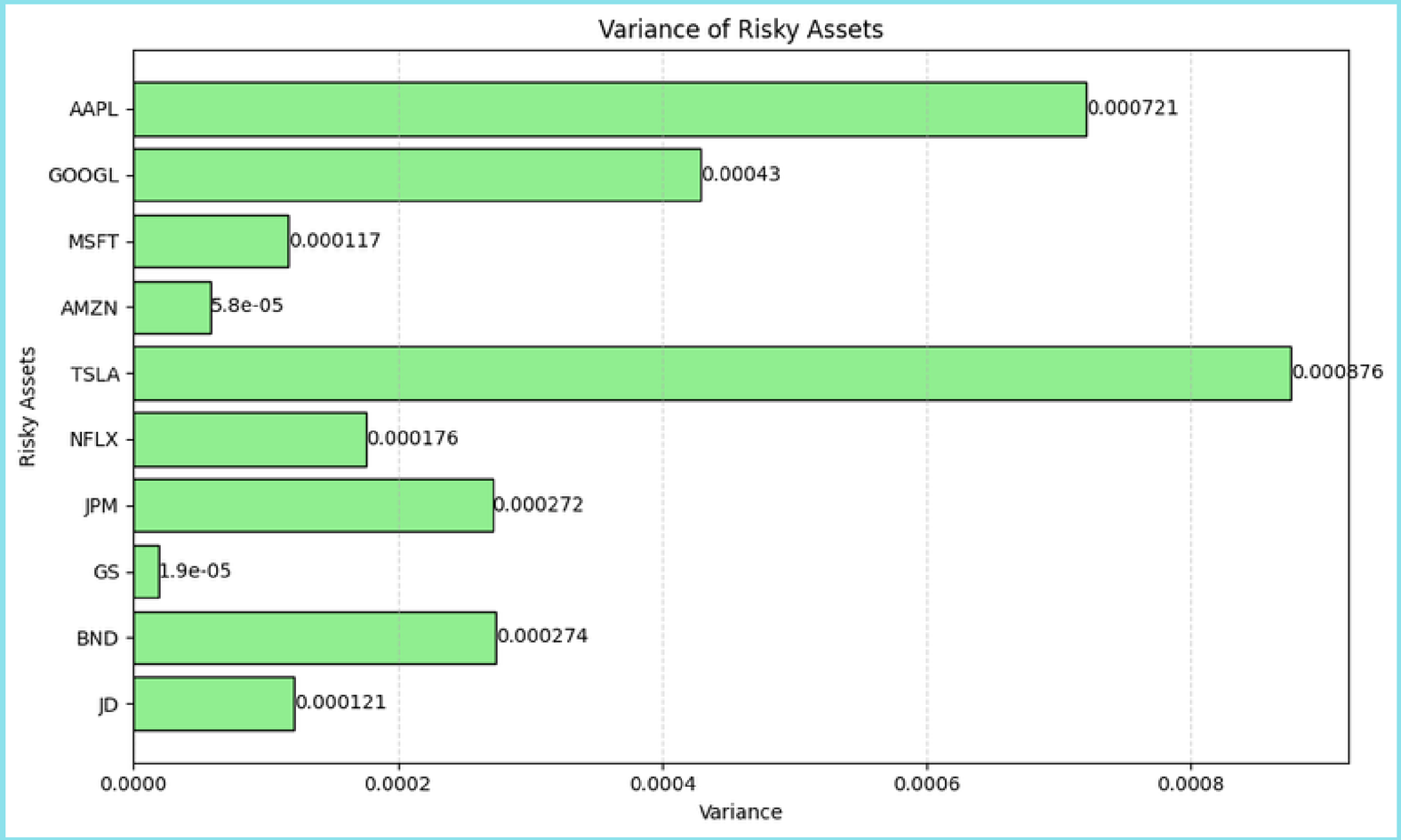
Each element in the covariance matrix represents the covariance between the returns of two assets. A positive covariance indicates that the returns of the two assets move together, while a negative covariance implies that they move in opposite directions.



4.Calculate the Capital market line (CML) equation using CAPM model.

Step 1: To Calculate Covariance and Variance

The variance of each asset represents the spread or dispersion of its returns around the mean return. It is a measure of the asset's riskiness. Higher variance indicates greater volatility.

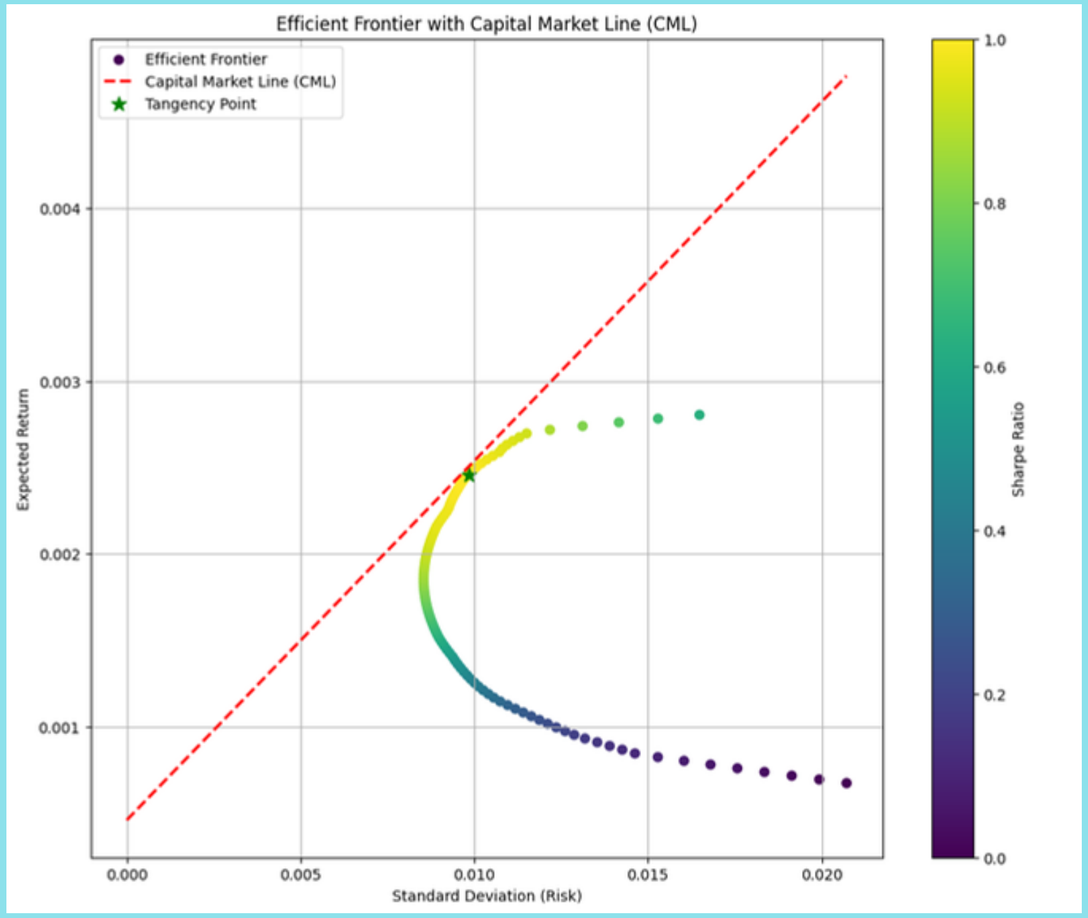


4.Calculate the Capital market line (CML) equation using CAPM model.

Step 2: To Calculate the standard deviation to get CML

Standard Deviation of the Market Portfolio:
0.00687
Slope of the CML (Sharpe ratio): 0.208
Intercept of the CML: 0.000457

The Capital Market Line (CML) is a graphical representation of the relationship between risk and return for efficient portfolios in the capital market. It is derived from the Capital Asset Pricing Model (CAPM) and is used to evaluate investment opportunities in terms of their risk-return trade-off.



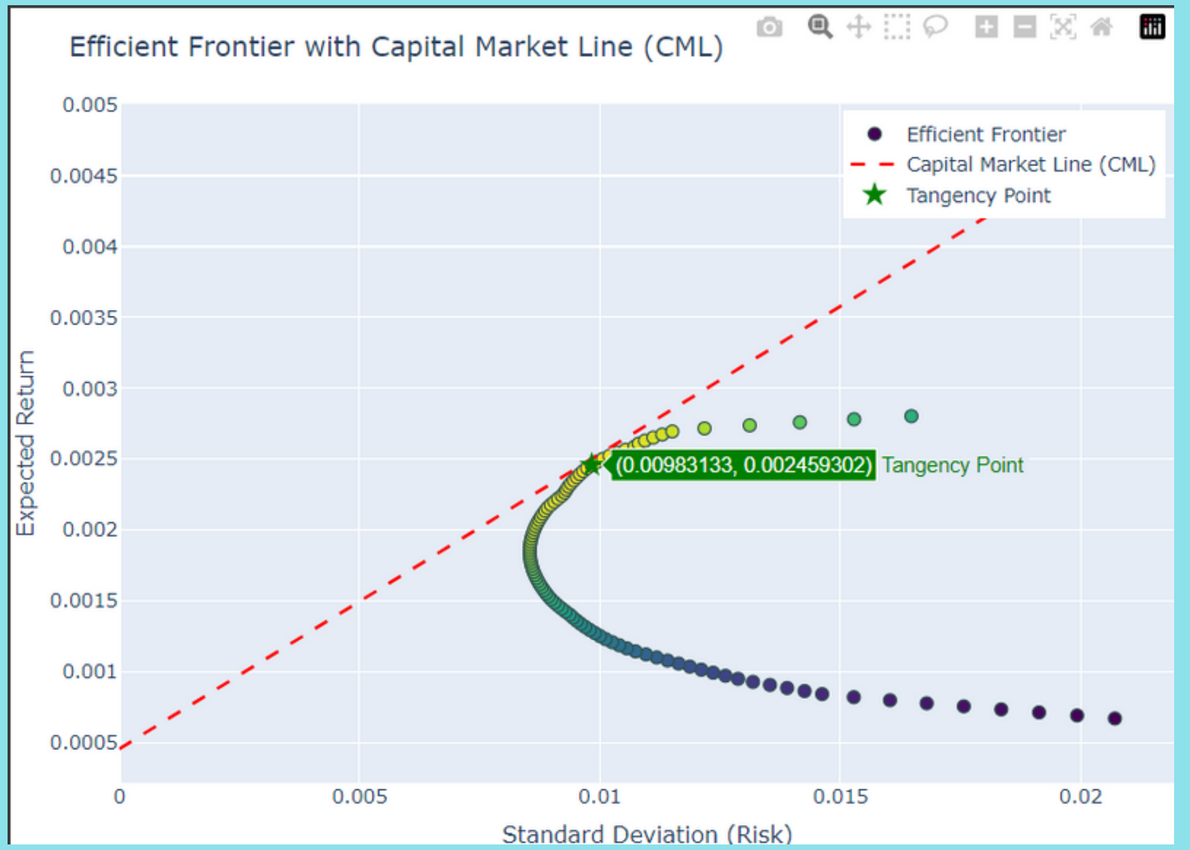
5. Identify the tangency point on efficient frontier where CML touches it. Discuss what this point represents and its significance.

The tangency point on the efficient frontier where the Capital Market Line (CML) touches it represents the optimal portfolio allocation for an investor seeking to maximize their risk-adjusted return.

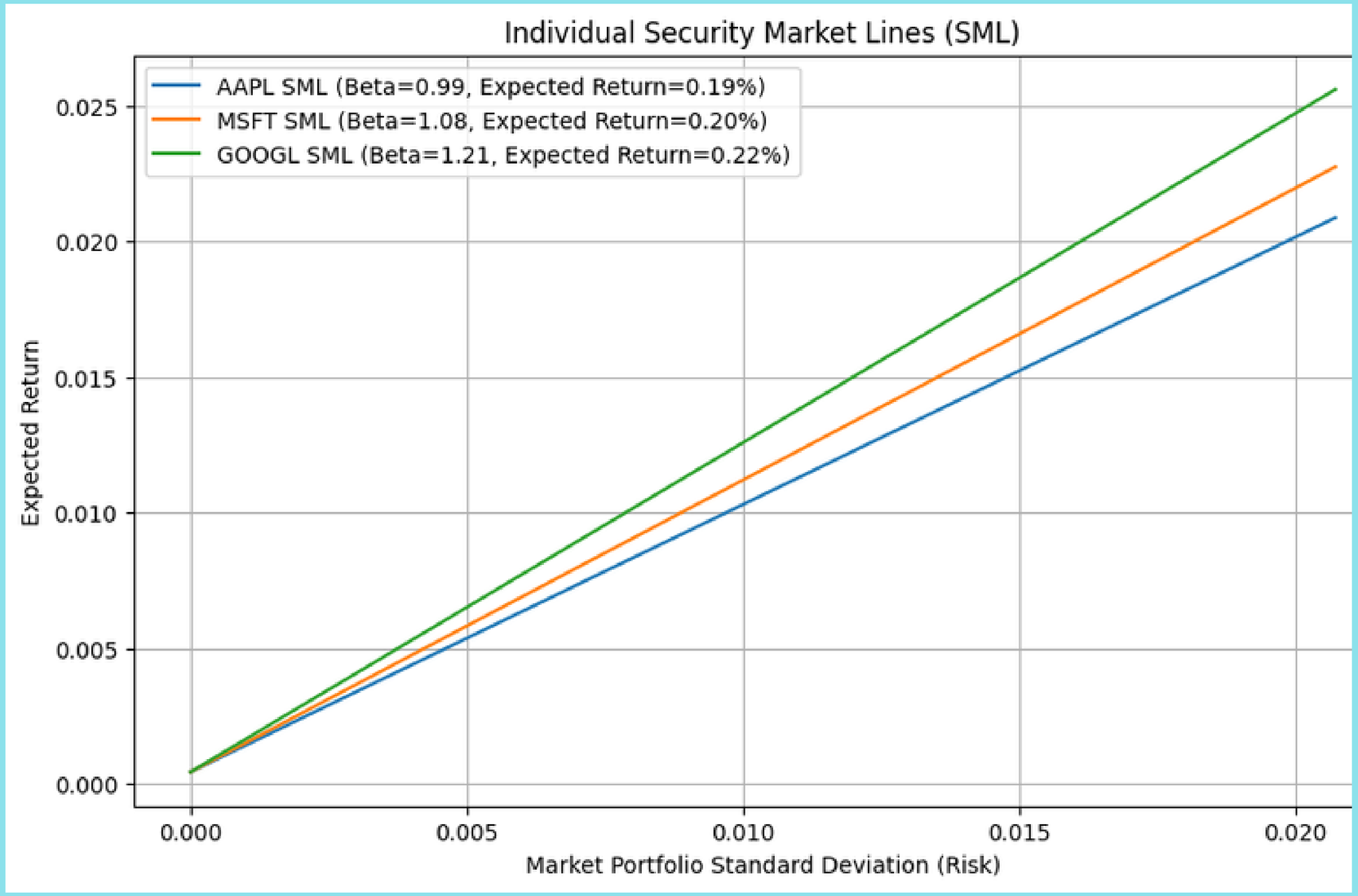
>>This point is significant because it indicates the portfolio composition that offers the highest Sharpe ratio, which is a measure of risk-adjusted return.

>> In this case, the tangency point coordinate is approximately (0.0099, 0.0025)

Investors aiming to maximize their risk-adjusted returns should allocate their investment funds according to the weights of assets in the tangency portfolio. By doing so, they achieve the highest possible return for a given level of risk or the lowest possible risk for a given level of return, depending on their risk preferences.



6. 3 of our risky assets to calculate individual security market lines.



By plotting the SML for each individual asset, investors can visually assess how the expected return of each asset varies with its level of systematic risk (measured by beta) and compare it to the expected return of the market.

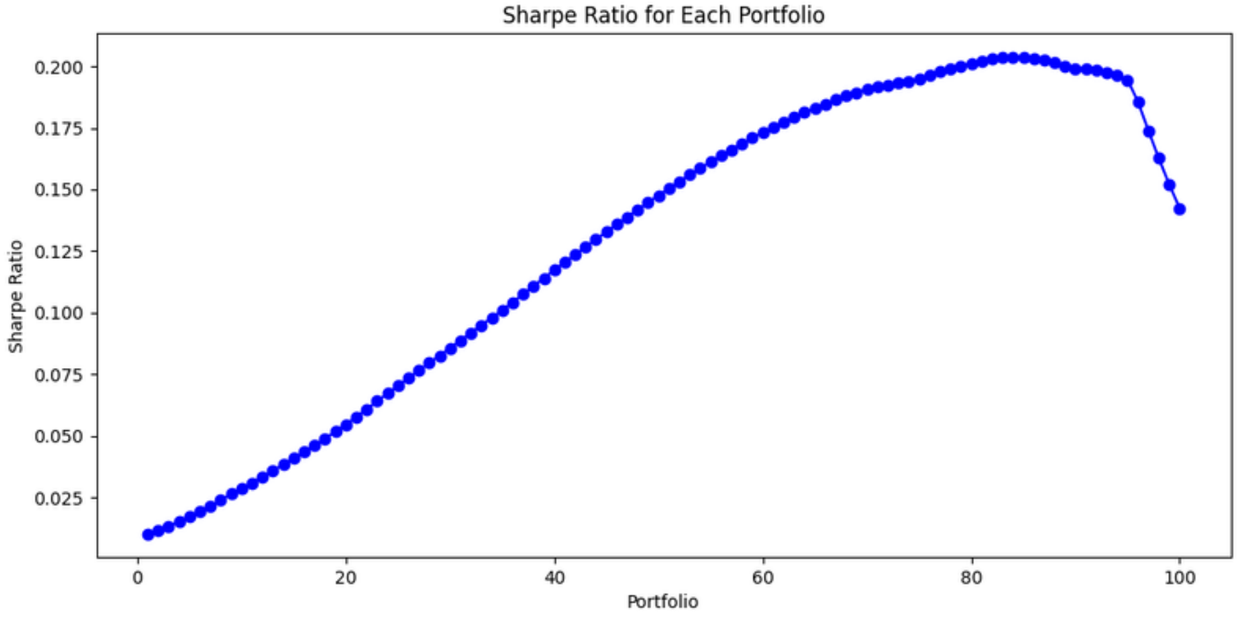
7.a Calculate relevant performance measures (Sharpe Ratio, Treynor Ratio) for each of our optimized portfolios .

1. **Sharpe Ratio**: Measures the risk-adjusted return of a portfolio by comparing the excess return over the risk-free rate to the portfolio's standard deviation.

$$SharpeRatio = \frac{R_p - R_f}{\sigma_p}$$

Where:

- R_p is the expected return of the portfolio,
- R_f is the risk-free rate,
- σ_p is the standard deviation of the portfolio's returns.

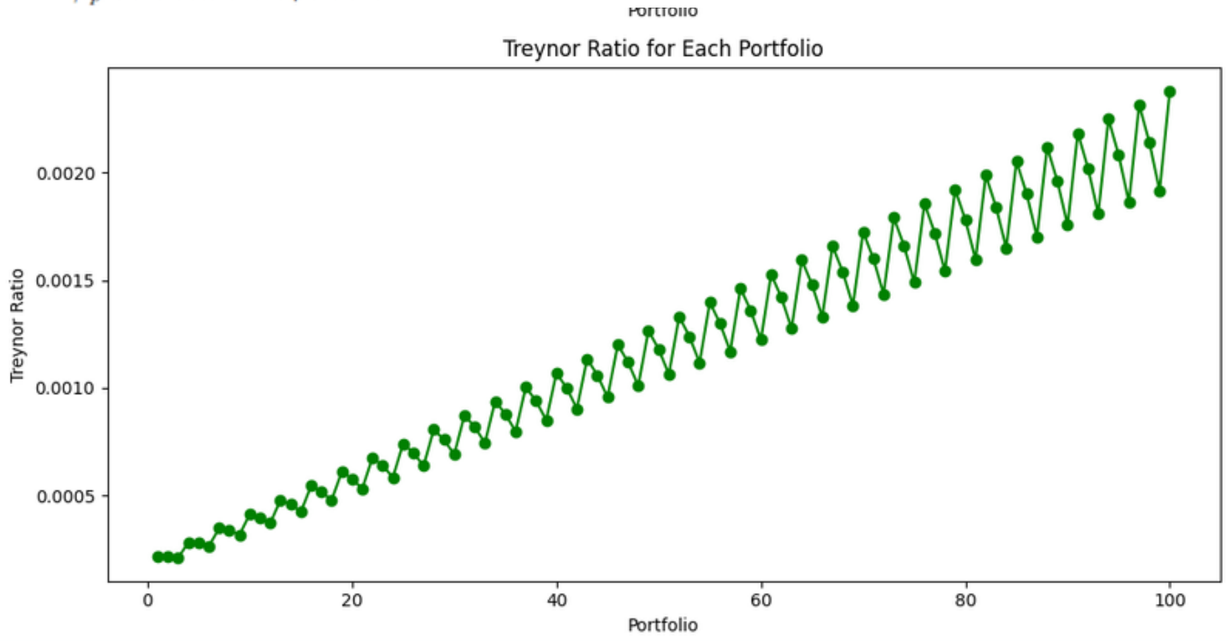


2. **Treynor Ratio**: Measures the risk-adjusted return of a portfolio by comparing the excess return over the risk-free rate to the portfolio's beta, which represents systematic risk.

$$TreynorRatio = \frac{R_p - R_f}{\beta_p}$$

Where:

- R_p is the expected return of the portfolio,
- R_f is the risk-free rate,
- β_p is the beta of the portfolio.



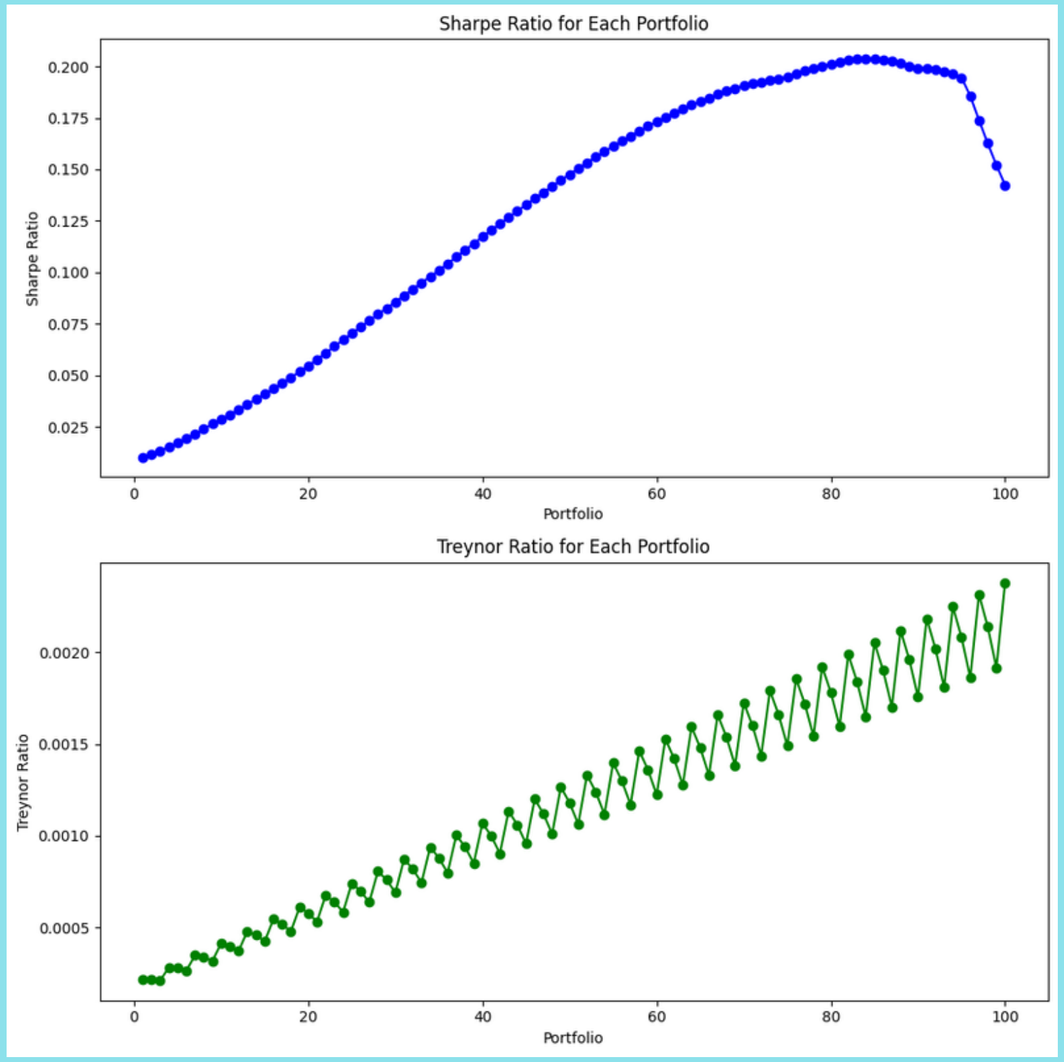
7.b Sharpe Ratio, Treynor Ratio) Discuss the implications of these measures in evaluating portfolio performance.

Sharpe Ratio Graph Analysis:

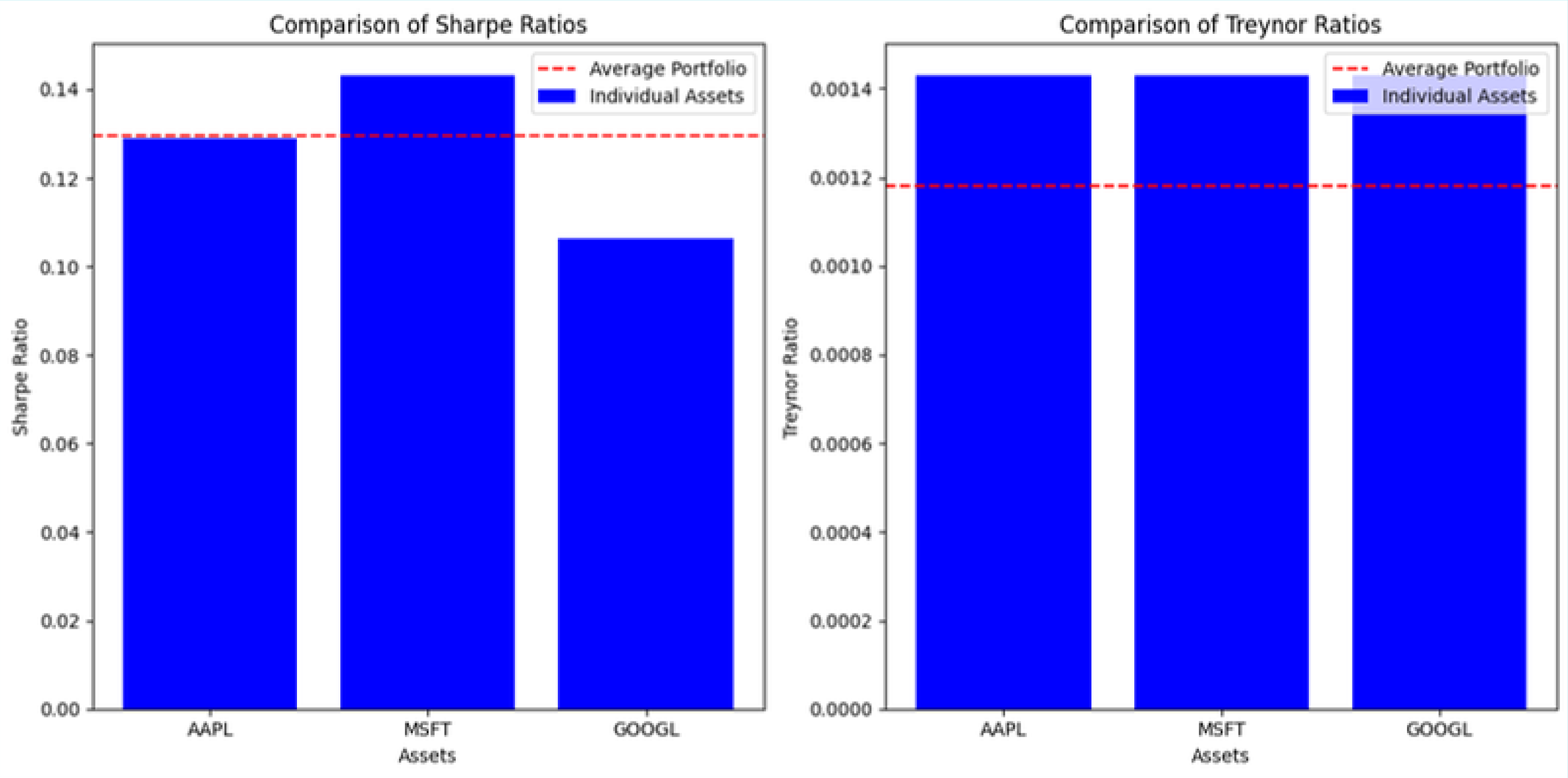
- The Sharpe Ratio measures the risk-adjusted return of a portfolio, with higher values indicating better risk-adjusted returns.
- Around portfolios 80-90, the Sharpe Ratio peaks and becomes saturated. This suggests that within this range, the portfolios are achieving optimal risk-adjusted returns given the level of risk.
- Beyond portfolio 95, there is a noticeable dip in the Sharpe Ratio. This could indicate diminishing returns or increased risk beyond this point.

Treynor Ratio Graph Analysis:

- The Treynor Ratio measures the excess return per unit of systematic risk (beta), with higher values indicating better performance per unit of systematic risk.
- The Treynor Ratio shows a zigzag pattern with three frequencies: up, mid, and down.
- Despite the zigzag pattern, the overall trend of the Treynor Ratio is increasing. This suggests that as portfolios are optimized, they are generating higher returns relative to their systematic risk.



7.c Sharpe Ratio, Treynor Ratio) Compare them to individual assets.



A higher Sharpe Ratio indicates better risk-adjusted returns, while a higher Treynor Ratio suggests superior returns relative to systematic risk. By analyzing these measures, investors can identify portfolios that offer optimal returns given their risk tolerance, helping them make informed decisions and construct well-balanced investment portfolios.

BONUS : Compare and contrast the portfolios constructed using Markowitz and CAPM approaches. What are the key insights gained from each method?

1. **Markowitz Approach:**
    - **Objective:** The main goal of the Markowitz approach is to create a portfolio that gives you the best possible return for a given level of risk, or the least amount of risk for a desired level of return.
    - **How It Works:** Imagine you're trying to make a mix of investments in different assets like stocks and bonds. The Markowitz approach helps you decide how much of each asset to include in your portfolio to minimize the risk while maximizing returns. It's like finding the perfect balance between risk and reward.
    - **Key Insight:** This approach helps you spread your investments across different types of assets to reduce the chance of losing money if one investment performs poorly. It's like not putting all your eggs in one basket.
2. **CAPM (Capital Asset Pricing Model) Approach:**
    - **Objective:** The CAPM approach focuses on creating a portfolio that mimics the overall market's performance while aiming for the best return adjusted for the level of risk.
    - **How It Works:** Instead of picking investments based on how they individually perform, CAPM looks at how they relate to the entire market's movements. It assigns each investment a "beta" value, which tells you how much it moves compared to the overall market. If an investment has a beta of 1, it moves exactly like the market. If it's higher than 1, it moves more than the market, and if it's less than 1, it moves less than the market.
    - **Key Insight:** CAPM helps you choose investments that match the market's behavior. If you're okay with taking on the same amount of risk as the overall market, CAPM suggests investing in assets with a beta of 1. If you want to take on more risk for potentially higher returns, you might invest in assets with a higher beta.

BONUS : Compare and contrast the portfolios constructed using Markowitz and CAPM approaches. What are the key insights gained from each method?

Comparison:

- **Diversification:** Markowitz helps you diversify across different assets to spread risk, while CAPM focuses on how each investment relates to the overall market.
- **Risk and Return:** Markowitz aims to balance risk and return for your entire portfolio, while CAPM looks at how investments perform compared to the market.
- **Complexity:** Markowitz considers individual asset performance and correlations, making it more complex. CAPM simplifies things by focusing on market movements and beta values.

Example:

- Let's say you want to invest some money. With Markowitz, you might choose a mix of stocks, bonds, and maybe some real estate to spread your risk. With CAPM, you might focus more on stocks that move similarly to the overall market because you believe in the market's long-term growth.

In short, Markowitz helps you create a balanced portfolio by diversifying across different assets, while CAPM guides you towards investments that behave similarly to the overall market. It's like choosing between a diverse mix of investments or ones that move in sync with the market's ups and downs.

Thank You!

HOPE YOU LIKED THE PRESENTATION