



A.Y.: 2024-25 Class/Sem: B.Tech/ Sem-VII

Sub: Quantitative Portfolio Management

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Experiment 1

Aim: Analysis of returns and risk adjusted returns on a given dataset

Objective:

- Understand the concept of risk-adjusted returns.
- Calculate risk-adjusted returns using different methods.
- Analyze the returns and risk-adjusted returns of a given dataset.

Theory:

- Risk is the uncertainty of future returns. It is often measured by the standard deviation of returns.
- Return is the income or profit that an investment generates. It is often measured by the average return over a period of time.
- Risk-adjusted returns are a measure of how well an investment has performed relative to its risk. They consider both the return and the risk of an investment.

There are a number of different methods for calculating risk-adjusted returns, but some of the most common include:

1. Sharpe ratio: The Sharpe ratio is the most common ratio for comparing reward (return on investment) to risk (standard deviation). This allows us to adjust the returns on an investment by the amount of risk that was taken in order to achieve it. The Sharpe ratio also provides a useful metric to compare investments. The calculations are as follows:

$$\text{Sharpe ratio} = \frac{\bar{R} - R_f}{\sigma}$$

\bar{R} : annual expected return of the asset in question.

R_f : annual risk-free rate. Think of this like a deposit in the bank earning x% per annum.

σ : annualized standard deviation of returns

Since our data frequency is daily, we need to annualize the expected return and standard deviation. This can be achieved by multiplying the daily average return by 255. And multiplying the daily standard deviation by $\sqrt{255}$. For simplicity we will assume that the

risk-free rate $R_f = 1\%$ throughout the 7-year period.

2. Sortino Ratio: The Sortino ratio is very similar to the Sharpe ratio, the only difference being that where the Sharpe ratio uses all the observations for calculating the standard deviation the Sortino ratio only considers the harmful variance. So in the plot below, we are only considering the deviations colored red. The rationale for this is that we aren't too worried about positive deviations, however, the negative deviations are of great concern, since they represent loss of our money.

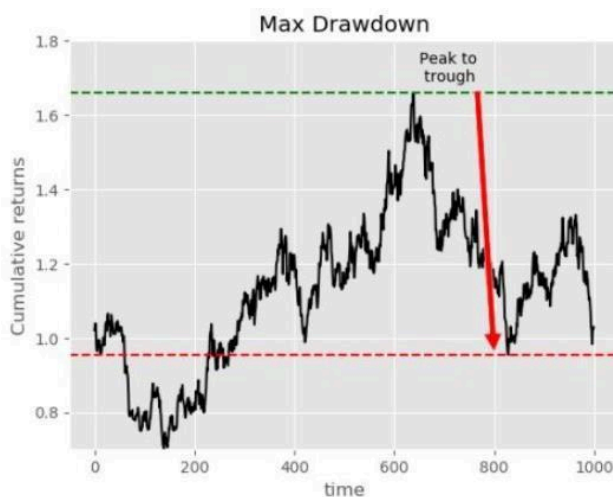
$$\text{Sortino ratio} = \frac{\bar{R} - R_f}{\sigma^-}$$

Everything in the ratio above is the same as the Sharpe ratio except σ^- represents the annualized down-side standard deviation.

3. Max Drawdown Ratio: Max drawdown quantifies the steepest decline from peak to trough observed for an investment. This is useful for a number of reasons, mainly the fact that it doesn't rely on the underlying returns being normally distributed. It also gives us an indication of conditionality amongst the returns increments. Whereas in the previous ratios, we only considered the overall reward relative to risk, however, it may be that consecutive returns are not independent leading to unacceptably high losses of a given period of time. To calculate max drawdown first we need to calculate a series of drawdowns as follows:

$$\text{drawdowns} = \frac{\text{peak} - \text{trough}}{\text{peak}}$$

We then take the minimum of this value throughout the period of analysis.





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4. Calmar Ratio: The final risk/reward ratio we will consider is the Calmar ratio. This is similar to the other ratios, with the key difference being that the Calmar ratio uses max drawdown in the denominator as opposed to standard deviation.

$$\text{Calmar ratio} = \frac{\bar{R}}{\text{max drawdown}}$$

Lab Experiment to be done by students:

1. Download a dataset of historical stock returns.
2. Calculate the risk-adjusted returns of the stocks in the dataset using Sharpe ratio, Sortino ratio, Max Drawdown Ratio, and Calmer Ratio.
3. Plot the risk-adjusted returns of the stocks on a chart.
4. Analyze the returns and risk-adjusted returns of the stocks in the dataset.

```
[1] import yfinance as yf
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

[2] tickers = ['AAPL', 'MSFT', 'GOOGL', 'AMZN', 'TSLA']

[3] data = yf.download(tickers, start="2019-01-01", end="2024-01-01")['Adj Close']
[*****100%*****] 5 of 5 completed

[4] returns = data.pct_change().dropna()

[5] rf = 0.02

[6] sharpe_ratio = (returns.mean() - rf/252) / returns.std() * np.sqrt(252)

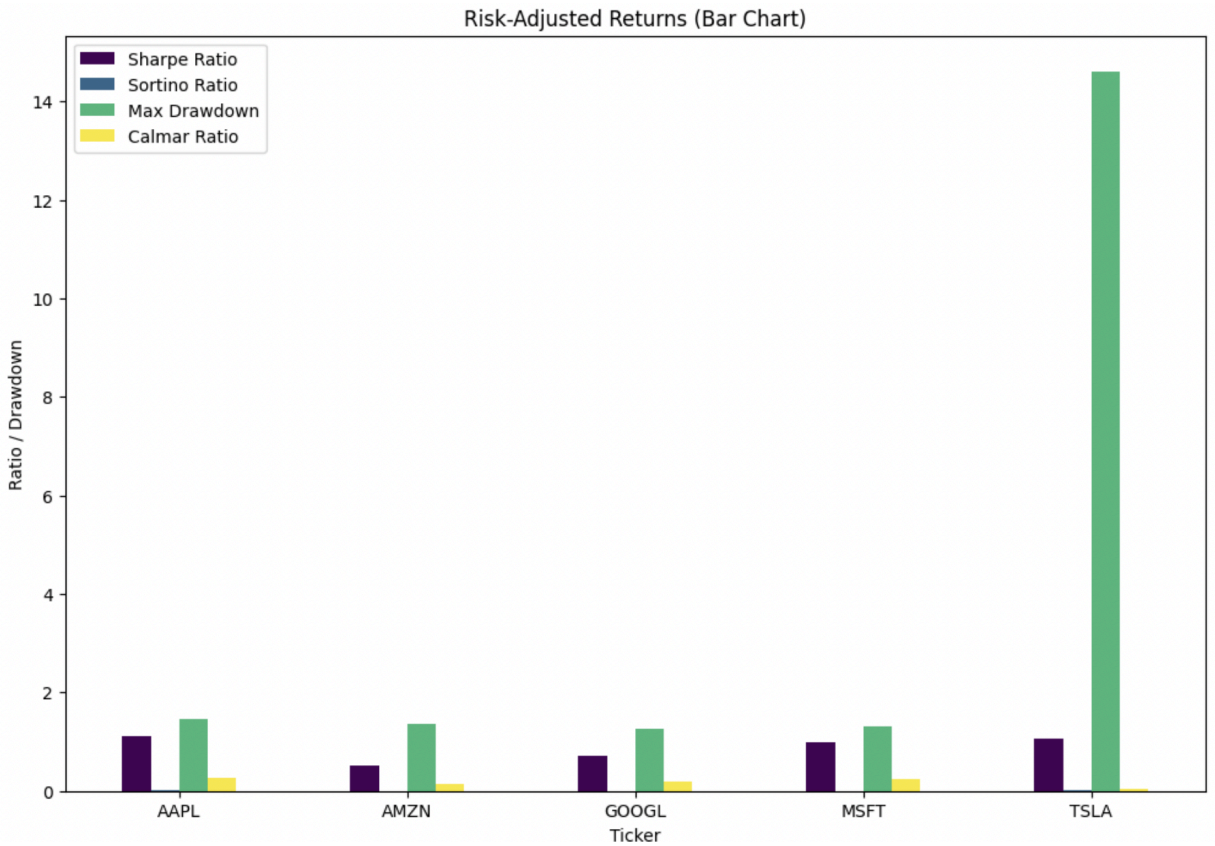
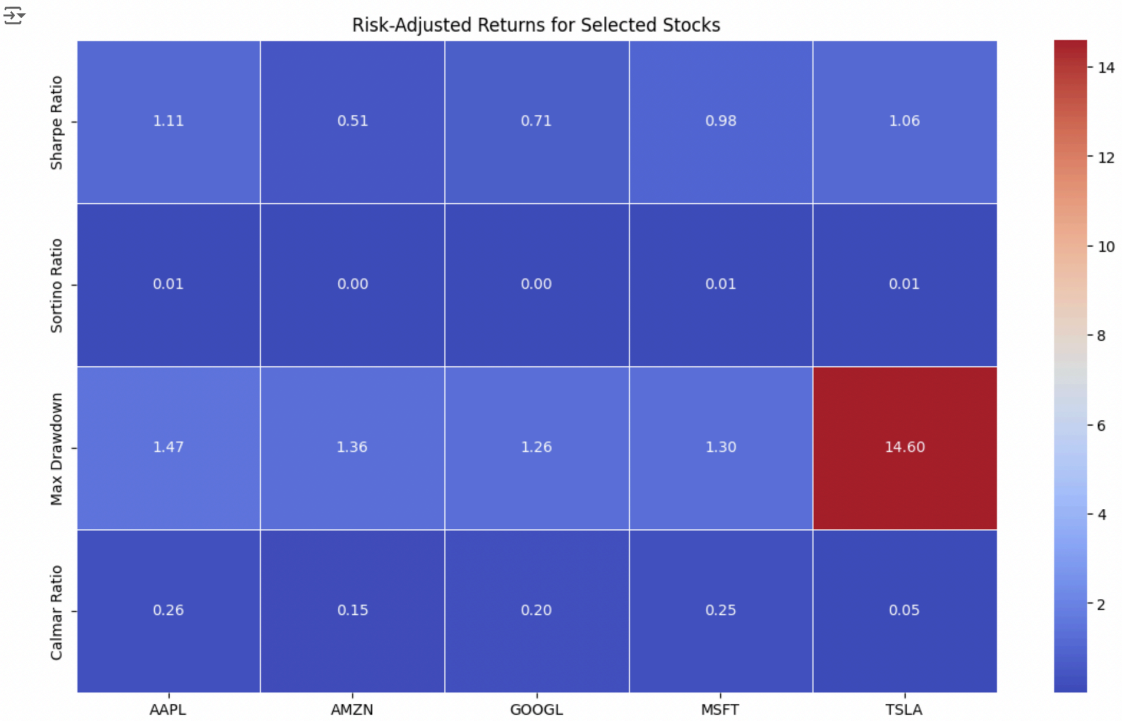
[7] downside_risk = returns[returns < 0].std() * np.sqrt(252)
sortino_ratio = (returns.mean() - rf/252) / downside_risk

[8] cumulative_returns = (1 + returns).cumprod()
max_drawdown = (cumulative_returns.cummax() - cumulative_returns).max()

[9] calmar_ratio = returns.mean() * 252 / max_drawdown

risk_adjusted_returns = pd.DataFrame({
    'Sharpe Ratio': sharpe_ratio,
    'Sortino Ratio': sortino_ratio,
    'Max Drawdown': max_drawdown,
    'Calmar Ratio': calmar_ratio
})
```

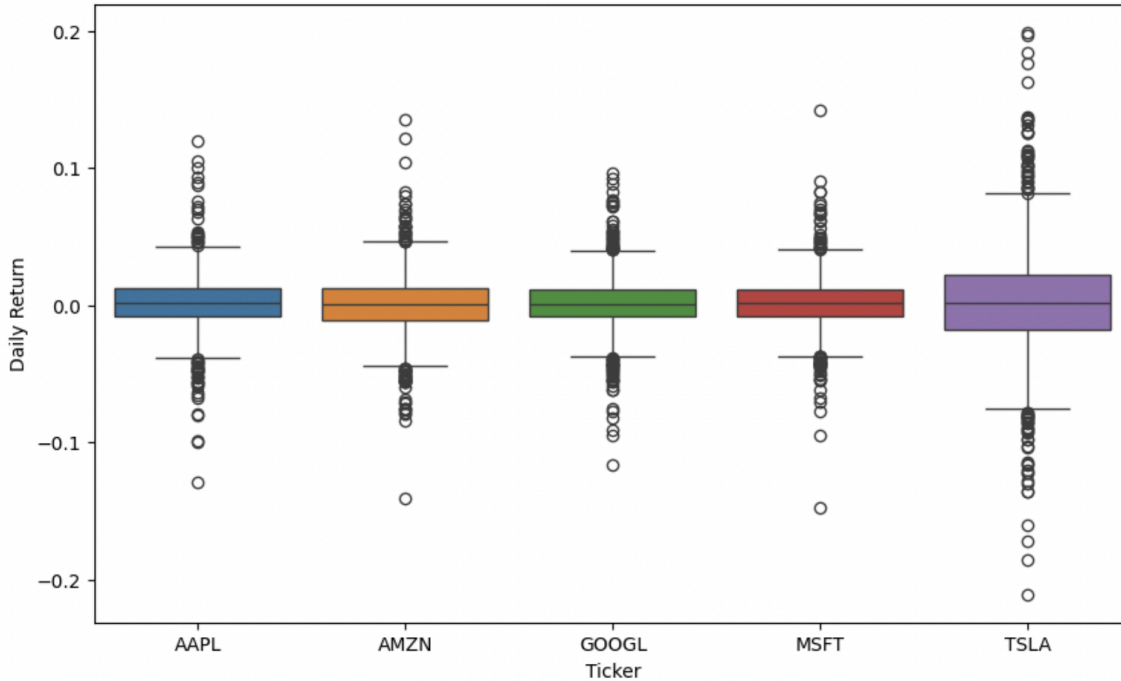
```
plt.figure(figsize=(14, 8))
sns.heatmap(risk_adjusted_returns.T, annot=True, fmt=".2f", cmap="coolwarm", linewidths=.5)
plt.title('Risk-Adjusted Returns for Selected Stocks')
plt.show()
```



```
plt.figure(figsize=(10, 6))
sns.boxplot(data=returns)
plt.title('Box Plot of Stock Returns')
plt.ylabel('Daily Return')
plt.show()
```



Box Plot of Stock Returns



Conclusion: **AAPL** and **MSFT** might show higher Sharpe and Sortino ratios, suggesting they offer better risk-adjusted returns. **TSLA** could show a higher Max Drawdown, indicating that while it offers potential high rewards, it also comes with significant risk. **GOOGL** and **AMZN** might have a balanced performance across metrics, making them attractive for moderate risk-tolerant investors.