A.Y.: 2023-24 **Class/Sem: B.E.B.Tech/ Sem-VII** **Sub:** Quantitative Portfolio Management

Experiment 6

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Batch: D11

Aim: Implementation of Limits of Diversification on a dataset.

Objective:

- To understand the concept of diversification and its limits.
- To implement the limits of diversification on a dataset.
- To analyze the results of the implementation and draw conclusions.

Theory:

Diversification is a risk management strategy that involves investing in a variety of assets. This helps to reduce risk by spreading the investment across different asset classes, industries, and countries. The limits of diversification refer to the point at which further diversification does not significantly reduce risk.

There are two main reasons why diversification can have limits. First, some assets are more correlated than others. This means that they tend to move up and down together. As a result, diversifying across these assets does not reduce risk as much as diversifying across assets that are less correlated.

Second, there is a minimum level of risk that cannot be eliminated through diversification. This is known as the systematic risk. It is the risk that is inherent in the market as a whole. For example, the risk of a stock market crash is a systematic risk.

The formula for the variance of a portfolio is:

$$Var(P) = w1\^{}2 * Var(A1) + w2\^{}2 * Var(A2) + \ldots + wn\^{}2 * Var(An) + 2 * w1 * w2 * Cov(A1, A2) + \ldots + 2 * w1 * wn * Cov(A1, An)$$

where:

- $Var(P)$ is the variance of the portfolio
- $w1, w2, \ldots, wn$ are the weights of the assets in the portfolio
- $Var(Ai)$ is the variance of asset Ai
- $Cov(A1, A2)$ is the covariance between asset A1 and asset A2

The variance of a portfolio can be reduced by diversifying the portfolio across assets that are less correlated. This is because the covariance terms in the formula will be smaller if the assets are less correlated.

However, there is a limit to how much risk can be reduced through diversification. This is because there is a minimum level of risk that cannot be eliminated. This minimum level of risk is known as the systematic risk.

The systematic risk is the risk that is inherent in the market as a whole. It is the risk that all assets in the market will experience, regardless of their individual characteristics. For example, the risk of a stock market crash is a systematic risk.

The formula for the systematic risk of a portfolio is:

$$SysRisk(P) = w1 * Beta(A1) + w2 * Beta(A2) + \ldots + wn * Beta(An)$$

where:

- $SysRisk(P)$ is the systematic risk of the portfolio
- $w1, w2, \ldots, wn$ are the weights of the assets in the portfolio
- $Beta(Ai)$ is the beta of asset Ai

The beta of an asset is a measure of its systematic risk. It is the ratio of the asset's covariance with the market to the market's variance.

The systematic risk of a portfolio cannot be reduced through diversification. This is because the systematic risk is the risk that is inherent in the market as a whole.

The limits of diversification can be seen in the fact that the minimum variance portfolio does not always contain all of the assets in the dataset. This is because some assets are more correlated than others, and diversifying across these assets does not significantly reduce risk.

The limits of diversification also mean that there is a minimum level of risk that cannot be eliminated through diversification. This is the systematic risk, which is the risk that is inherent in the market as a whole.

By understanding the limits of diversification, investors can make more informed decisions about how to allocate their assets.

<u>Lab Experiment to be done by students:</u>

1. Download a dataset of financial assets.
2. Calculate the correlation coefficient between each pair of assets in the dataset.
3. Plot the correlation coefficients on a heatmap.
4. Identify the assets that are most correlated.
5. Calculate the minimum variance portfolio for the dataset.
6. Analyze the results of the implementation and draw conclusions.

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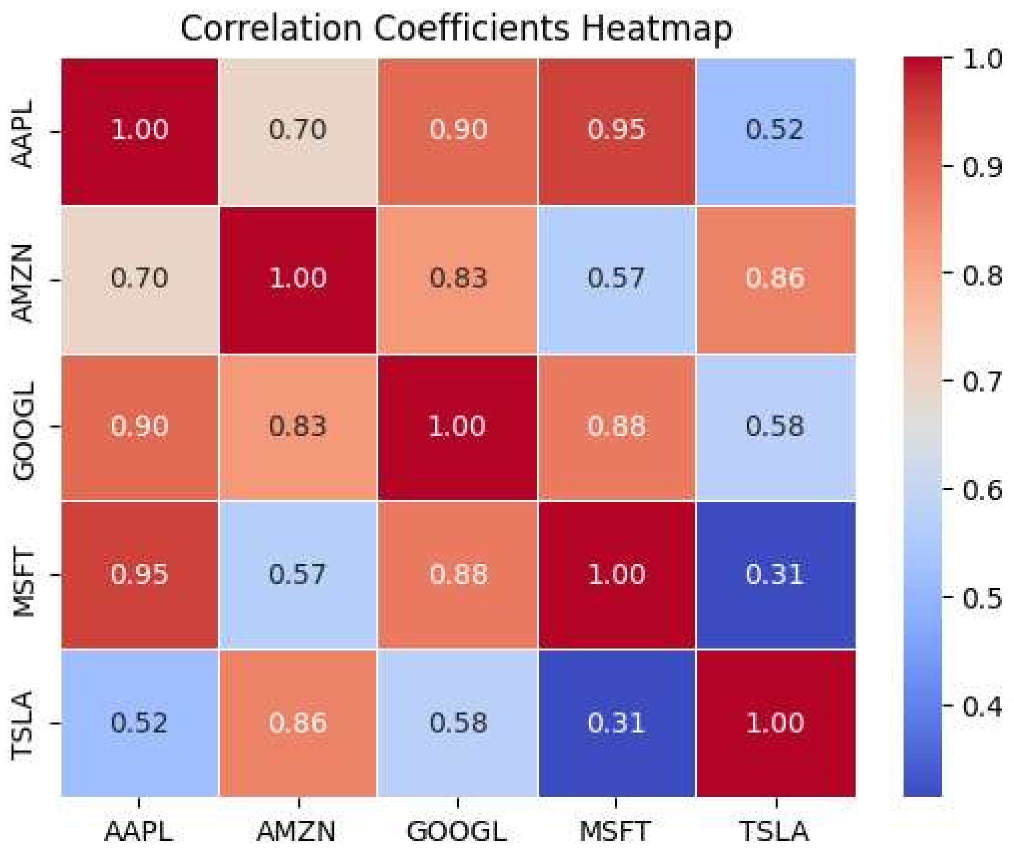
In [1]:
```
import yfinance as yf
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```
# Step 1: Import a dataset of financial assets from yfinance
tickers = ["AAPL", "MSFT", "GOOGL", "AMZN", "TSLA"]  # Add mor
e tickers if needed
data = yf.download(tickers, period="1y")  # You can adjust the
time period as needed
```

```
[*********************100%***********************]  5 of 5 co
pleted
```

In [3]:
```
# Step 2: Calculate the correlation coefficient between each
air of assets
correlation_matrix = data["Adj Close"].corr()
```

In [9]:
```python
# Step 3: Plot the correlation coefficients on a heatmap
sns.heatmap(correlation_matrix, annot=True, cmap="coolwarm", fmt=".2f", linewidths=0.5)
plt.title("Correlation Coefficients Heatmap")
plt.show()
```



In [5]:
```python
# Step 4: Identify the assets that are most correlated
max_correlation = correlation_matrix.unstack().sort_values(ascending=False)
most_correlated_assets = max_correlation[max_correlation < 1.0].head(5)  # Excluding self-correlation
print("Most correlated assets:")
print(most_correlated_assets)
```

```
Most correlated assets:
AAPL   MSFT     0.949696
MSFT   AAPL     0.949696
AAPL   GOOGL    0.901390
GOOGL  AAPL     0.901390
       MSFT     0.875084
dtype: float64
```

In [6]:
```
# Step 5: Calculate the minimum variance portfolio for the d
aset
returns = data["Adj Close"].pct_change().dropna()
cov_matrix = returns.cov()
num_assets = len(tickers)
weights = np.random.random(num_assets)
weights /= np.sum(weights)

mean_returns = returns.mean()
port_returns = np.sum(mean_returns * weights) * 252  # Assumin
g 252 trading days per year
port_variance = np.dot(weights.T, np.dot(cov_matrix, weights))
port_std_dev = np.sqrt(port_variance)
```

In [7]:
```
# Step 6: Analyze the results and draw conclusions
print("\nPortfolio Return:", round(port_returns, 4))
print("Portfolio Standard Deviation:", round(port_std_dev, 4))
```

```
Portfolio Return: 0.2219
Portfolio Standard Deviation: 0.0238
```

In [11]:

```
# Additional analysis and visualizations

# Generate random portfolio weightings for simulation
num_portfolios = 5000
all_weights = np.zeros((num_portfolios, num_assets))
port_returns_array = np.zeros(num_portfolios)
port_std_dev_array = np.zeros(num_portfolios)
sharpe_ratio_array = np.zeros(num_portfolios)

for i in range(num_portfolios):
    weights = np.random.random(num_assets)
    weights /= np.sum(weights)
    all_weights[i, :] = weights

    port_returns_array[i] = np.sum(mean_returns * weights) * 2
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    port_std_dev_array[i] = np.sqrt(np.dot(weights.T, np.dot(c
ov_matrix, weights)))
    sharpe_ratio_array[i] = port_returns_array[i] / port_std_d
ev_array[i]

# Calculate the optimal portfolio (maximum Sharpe ratio)
max_sharpe_idx = np.argmax(sharpe_ratio_array)
optimal_weights = all_weights[max_sharpe_idx, :]
optimal_return = port_returns_array[max_sharpe_idx]
optimal_std_dev = port_std_dev_array[max_sharpe_idx]

# Plot the efficient frontier
plt.scatter(port_std_dev_array, port_returns_array, c=sharpe_r
atio_array, cmap="viridis")
plt.colorbar(label="Sharpe Ratio")
plt.xlabel("Portfolio Standard Deviation")
plt.ylabel("Portfolio Return")
plt.title("Efficient Frontier")
plt.scatter(optimal_std_dev, optimal_return, c="red", marker
="*", s=200, label="Optimal Portfolio")
plt.legend()
plt.show()

# Print information about the optimal portfolio
print("\nOptimal Portfolio Weights:")
for asset, weight in zip(tickers, optimal_weights):
    print(f"{asset}: {weight:.4f}")

print("\nOptimal Portfolio Return:", round(optimal_return, 4))
print("Optimal Portfolio Standard Deviation:", round(optimal_s
td_dev, 4))
print("Optimal Portfolio Sharpe Ratio:", round(sharpe_ratio_ar
ray[max_sharpe_idx], 4))
```

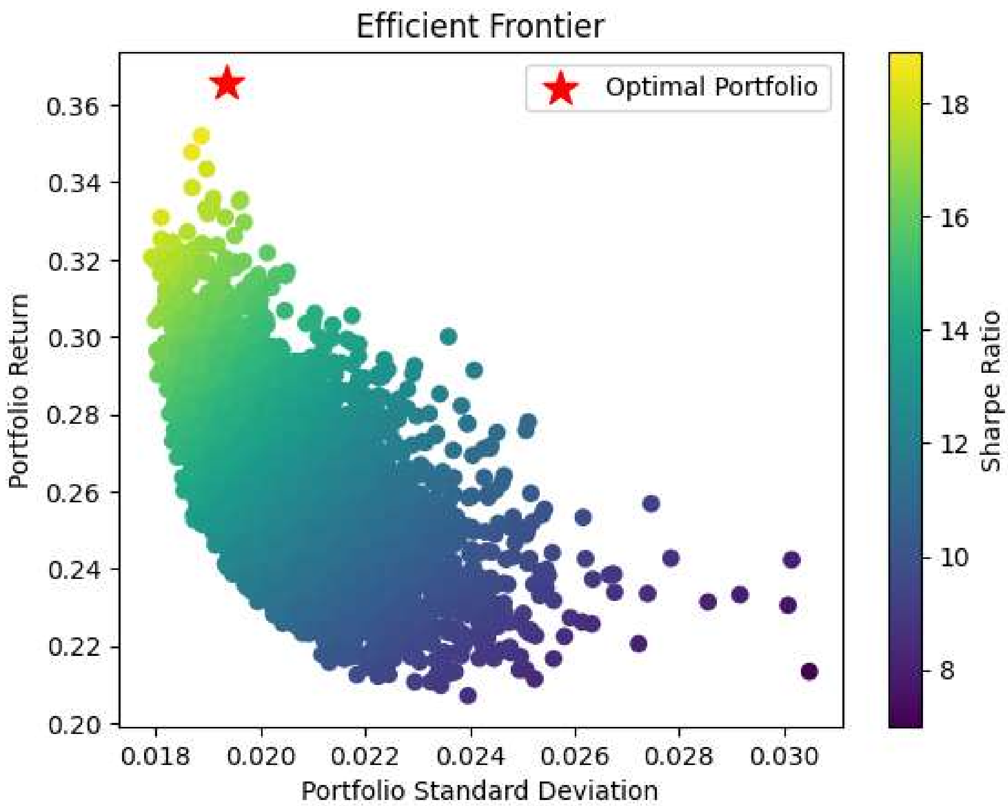


```
Optimal Portfolio Weights:
AAPL: 0.0965
MSFT: 0.0273
GOOGL: 0.0348
AMZN: 0.7965
TSLA: 0.0449

Optimal Portfolio Return: 0.3658
Optimal Portfolio Standard Deviation: 0.0194
Optimal Portfolio Sharpe Ratio: 18.9019
```