SHRI VILEPARLE KELAVANI MANDAL'S
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
(Autonomous College Affiliated to the University of Mumbai)
NAAC ACCREDITED with "A" GRADE (CGPA : 3.18)

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

Experiment 4

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Aim: Perform the Max Sharpe Ratio Portfolio on specified data source.

Objective:

- Understand the concept of maximum Sharpe ratio portfolio.
- Calculate the Sharpe ratio of a portfolio.
- Construct a maximum Sharpe ratio portfolio using a specified data source.

Theory:

The Sharpe ratio is a measure of the risk-adjusted return of a portfolio. It is calculated as the portfolio's excess return over the risk-free rate, divided by the portfolio's standard deviation. A higher Sharpe ratio indicates a portfolio with a higher return per unit of risk.

The formula for the Sharpe ratio is:

$$Sharpe\ Ratio\ =\ (R\_p\ -\ R\_f)\ /\ \sigma\_p$$

where:

- R_p is the portfolio's return
- R_f is the risk-free rate
- σ_p is the portfolio's standard deviation

The risk-free rate is the return of an investment that is considered to be free of risk. For example, the return of a US Treasury bill is often used as a proxy for the risk-free rate.

The standard deviation of a portfolio is a measure of its volatility. It tells us how much the portfolio's returns vary over time.

The maximum Sharpe ratio portfolio is the portfolio on the efficient frontier that has the highest Sharpe ratio. The efficient frontier is the set of portfolios that offer the highest expected return for a given level of risk.

To construct a maximum Sharpe ratio portfolio, we can use the following steps:

1. Calculate the Sharpe ratio of each asset in the data source.
2. Sort the assets by their Sharpe ratios.
3. Choose the assets with the highest Sharpe ratios until we reach the desired level of risk.

The resulting portfolio will be the maximum Sharpe ratio portfolio for that level of risk.

Here is an example of how to calculate the Sharpe ratio of a portfolio:

Let's say we have a portfolio that consists of two assets, A and B. The returns of the two assets are as follows:

- Asset A: 10%
- Asset B: 5%

The risk-free rate is 3%.

The standard deviation of Asset A is 15%. The standard deviation of Asset B is 10%.

The Sharpe ratio of Asset A is:

$$(10\% - 3\%) / 15\% = 0.4$$

The Sharpe ratio of Asset B is:

$$(5\% - 3\%) / 10\% = 0.2$$

Therefore, Asset A has a higher Sharpe ratio than Asset B.

If we want to construct a maximum Sharpe ratio portfolio with a risk of 10%, we would choose Asset A and Asset B in equal proportions. This would give us a Sharpe ratio of 0.333.

The maximum Sharpe ratio portfolio is a useful tool for investors who want to maximize their returns for a given level of risk. It can be used to construct portfolios that are more efficient than simply investing in a single asset.

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

1. Download a data source containing historical returns for a set of assets.
2. Calculate the Sharpe ratio of each asset in the data source.
3. Construct a maximum Sharpe ratio portfolio using the assets in the data source.
4. Plot the efficient frontier and the maximum Sharpe ratio portfolio.

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

In [7]:
```
def download_data(tickers, start_date, end_date):
    data = yf.download(tickers, start=start_date, end=end_dat
e)['Adj Close']
    return data
```

In [8]:
```
def calculate_daily_returns(data):
    return data.pct_change().dropna()
```

In [9]:
```
def calculate_annual_returns(daily_returns):
    return daily_returns.mean() * 252
```

In [10]:
```
def calculate_annual_volatility(daily_returns):
    return daily_returns.std() * np.sqrt(252)
```

In [11]:
```
def calculate_sharpe_ratio(returns, risk_free_rate=0.0):
    sharpe_ratio = (returns - risk_free_rate) / np.sqrt(252)
    return sharpe_ratio
```

In [12]:
```
def generate_random_weights(num_assets):
    weights = np.random.random(num_assets)
    weights /= np.sum(weights)
    return weights
```

In [13]:
```
def calculate_portfolio_return(weights, returns):
    return np.sum(weights * returns)
```

In [14]:
```
def calculate_portfolio_volatility(weights, cov_matrix):
    return np.sqrt(np.dot(weights.T, np.dot(cov_matrix, weight
s)))
```

In [15]:

```
def simulate_portfolios(returns, cov_matrix, num_portfolios=
00):
    results = np.zeros((3, num_portfolios))
    for i in range(num_portfolios):
        weights = generate_random_weights(len(returns))
        portfolio_return = calculate_portfolio_return(weights,
returns)
        portfolio_volatility = calculate_portfolio_volatility
(weights, cov_matrix)
        sharpe_ratio = portfolio_return / portfolio_volatility
        results[0, i] = portfolio_return
        results[1, i] = portfolio_volatility
        results[2, i] = sharpe_ratio
    return results
```

In [16]:

```
def plot_efficient_frontier(returns, cov_matrix, num_portfol
s=5000):
    results = simulate_portfolios(returns, cov_matrix, num_por
tfolios)
    max_sharpe_idx = np.argmax(results[2])
    max_sharpe_return = results[0, max_sharpe_idx]
    max_sharpe_volatility = results[1, max_sharpe_idx]
    plt.scatter(results[1, :], results[0, :], c=results[2, :],
cmap='viridis')
    plt.colorbar(label='Sharpe Ratio')
    plt.scatter(max_sharpe_volatility, max_sharpe_return, mark
er='*', color='r', s=200, label='Max Sharpe Ratio Portfolio')
    plt.xlabel('Volatility')
    plt.ylabel('Return')
    plt.title('Efficient Frontier')
    plt.legend()
    plt.show()
```

In [17]:
```
tickers = ['AAPL', 'GOOGL', 'MSFT', 'AMZN', 'TSLA']
start_date = '2020-01-01'
end_date = '2023-01-01'
data = download_data(tickers, start_date, end_date)

daily_returns = calculate_daily_returns(data)

annual_returns = calculate_annual_returns(daily_returns)
cov_matrix = daily_returns.cov()
sharpe_ratios = calculate_sharpe_ratio(annual_returns)

plot_efficient_frontier(annual_returns, cov_matrix)
```

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