Top DJIA Assets by Sharpe Ratio

- **Sharpe Ratio** = (Return−Risk-free Rate)/Volatility It quantifies the risk-adjusted return, with higher values indicating better performance.
- Interpretation:
    - Top 3: AAPL (0.059), UNH (0.051), MSFT (0.047) contribute the most risk-adjusted return.
    - Lower Sharpe ratios (e.g., WMT at 0.035) indicate less effective risk-adjusted performance.

Optimal Weights

- **Weights**: Proportions of capital allocated to each stock.
    - E.g., AAPL gets ~23.3%, UNH ~15.4%, while WMT gets only ~2.3%.
    - Stocks with higher Sharpe ratios (better risk-adjusted returns) are prioritized in allocation.

Portfolio Statistics

1. **Expected Portfolio Return**:
    - Daily return: ~0.001 (0.1%).
    - Annualized return: $0.001 \times 252 = 0.252$ (~25.2%).
    - Indicates strong performance compared to traditional benchmarks (e.g., S&P 500 annualized return ~8-10%).
2. **Portfolio Variance and Volatility**:
    - Variance: ~0.00024.
    - Annualized volatility: ~24.6% ($\sqrt{\text{variance} \times 252}$).
    - Moderate risk level for a portfolio with high expected return.
3. **Sharpe Ratio**:
    - 0.982 indicates excellent risk-adjusted return (closer to or above 1 is desirable).

Risk Management

1. **Max Drawdown**:
    - −31.66%-: Maximum observed loss from a portfolio's peak to its trough.

○ Indicates potential vulnerability during adverse market conditions but is acceptable for a high-return portfolio.

Risk-Free Return

- **Definition**: The theoretical return on an investment with **zero risk** of financial loss.
- **Example**: Returns from U.S. Treasury bills are often used as the risk-free rate because they are backed by the government and considered extremely safe.
- **Role in Finance**: It sets the baseline for evaluating other investments. Any asset should ideally offer a higher return than the risk-free rate to compensate for the risk involved.

Risk-Adjusted Return

- **Definition**: A measure of the return on an investment after accounting for the risk taken to achieve it.
- **Formula**: Risk-adjusted return=Return−Risk-free return/Volatility
    - **Return**: Average or expected return of the asset or portfolio.
    - **Volatility**: Standard deviation of returns, representing the risk.
- **Purpose**: To compare investments with varying risk levels. An investment with a high return might seem attractive, but if it carries excessive risk, its risk-adjusted return might be lower than a safer investment.

Sharpe Ratio and Risk-Adjusted Return

- The **Sharpe Ratio** is a commonly used metric for risk-adjusted return: Sharpe Ratio=Return−Risk-free returnVolatility\text{Sharpe Ratio} = \frac{\text{Return} - \text{Risk-free return}}{\text{Volatility}}Sharpe Ratio=VolatilityReturn−Risk-free return
- **Interpretation**:
    - A Sharpe ratio > 1 indicates strong risk-adjusted returns (i.e., the investment rewards risk well).
    - A Sharpe ratio < 1 indicates that the returns may not justify the risk.

Example for Context

1. **Risk-Free Return**: Assume a Treasury bill offers an annual return of **2%**.
2. **Investment A**: Offers a return of **10%** but with high volatility (risk).

3. **Investment B**: Offers a return of **8%** with lower volatility.
   Using the Sharpe Ratio:
   - Investment A: (10%−2%)/Volatility of A(10\% - 2\%) / \text{Volatility of A}(10%−2%)/Volatility of A
   - Investment B: (8%−2%)/Volatility of B(8\% - 2\%) / \text{Volatility of B}(8%−2%)/Volatility of B
4. Even if Investment A has a higher raw return, Investment B might have a higher Sharpe Ratio if its volatility is much lower, making it a better risk-adjusted choice.

Summary

- **Risk-Free Return**: A baseline for no-risk investments.
- **Risk-Adjusted Return**: Evaluates how well an investment rewards the risk taken

Cumulative Returns Plot

- **Observation**:
  - This plot shows the cumulative return for the top DJIA assets identified by Sharpe ratio over the selected period.
  - **AAPL** (Apple) has outperformed other stocks significantly, with the highest cumulative return.
  - Other stocks such as **UNH**, **MSFT**, and **CAT** show consistent growth but at lower levels compared to AAPL.
  - Stocks such as **WMT** and **KO** have had relatively lower performance over time, indicating more stable or defensive growth.
- **Insights**:
  - The portfolio might benefit from emphasizing AAPL and other high-growth stocks (e.g., MSFT, UNH), depending on risk tolerance.
  - Stocks with lower growth (e.g., WMT, KO) might be suitable for stability and diversification.

2. Correlation Matrix

- **Observation**:
  - The heatmap shows the correlation coefficients between the selected stocks.
  - Highly correlated pairs are shown in red, while low correlations are shown in blue.
  - For example:
    - **AAPL** and **MSFT** appear to have a moderate-to-high correlation.
    - **CAT** and **GS** or **MRK** and **WMT** show lower correlation, which can aid in diversification.

- **Insights**:
  - To reduce risk, the portfolio should include assets with low or negative correlations (e.g., MRK vs. WMT).
  - High correlation among tech stocks (e.g., AAPL, MSFT) indicates a potential risk if the tech sector faces a downturn.

3. Hierarchical Clustering Dendrogram

- **Observation**:
  - The dendrogram groups stocks based on similarity (measured by their correlation).
  - **MSFT** and **AAPL** are closely clustered, indicating similar behavior.
  - **UNH**, **MRK**, and **KO** form another group, which might reflect a more defensive or healthcare-oriented cluster.
  - **HD**, **CAT**, and **GS** cluster separately, representing industrial or financial diversity.
- **Insights**:
  - The clustering supports a diversified strategy:
    - Allocate some weights to tech-heavy stocks (**AAPL**, **MSFT**) for growth.
    - Include defensive or uncorrelated stocks (**MRK**, **KO**, **WMT**) to hedge against volatility.
    - Consider industrials (**CAT**, **HD**) for balanced exposure.

Summary:

- The **cumulative returns** highlight growth leaders like AAPL and MSFT, while others provide diversification.
- The **correlation matrix** emphasizes pairing low-correlation stocks for risk mitigation.
- The **dendrogram** suggests diversification across tech, defensive, and industrial clusters for optimal balance.

Hierarchical Clustering Dendrogram

- **Purpose:** This dendrogram shows the clustering of the selected DJIA stocks based on their similarity (correlation of returns).
- **Observations:**
  - Stocks like **MSFT (Microsoft)** and **AAPL (Apple)** form a close cluster, indicating that they have similar return patterns.
  - **HD (Home Depot)** and **GS (Goldman Sachs)** form another cluster, which suggests a correlation in their behavior.
  - The dendrogram provides a hierarchical grouping of stocks that can be useful for diversification—selecting assets from different clusters reduces portfolio risk.

- **Implications:**
  - Clustering supports better diversification strategies in portfolio optimization by showing which stocks are more correlated and which are distinct.

2. Correlation Matrix of Selected Assets

- **Purpose:** This heatmap displays the correlation between the returns of the top DJIA stocks.
- **Observations:**
  - **Dark red cells** indicate strong positive correlations between the corresponding stocks (e.g., **AAPL and MSFT**).
  - **Blue cells** represent lower correlations, indicating less similar behavior between those stocks.
- **Implications:**
  - For portfolio optimization, selecting assets with lower correlations (blue cells) reduces overall portfolio risk. The matrix helps identify such pairs, complementing the dendrogram analysis.

3. Cumulative Returns of Optimized Portfolio

- **Purpose:** This plot shows how the optimized portfolio's cumulative returns have evolved over time.
- **Observations:**
  - The portfolio exhibits steady growth over the analyzed period, with minor dips during market downturns (e.g., early 2020 during the COVID-19 pandemic).
  - The cumulative return remains positive, reflecting the effectiveness of the optimization strategy in achieving growth while managing risk.
- **Implications:**
  - The portfolio optimization strategy successfully balances risk and return, demonstrating the practical application of concepts like Sharpe ratio maximization, risk minimization, and diversification.

How These Graphs Support the Project

- **Integration with the Code:**
  - The dendrogram and correlation matrix are outputs of the **data analysis stage**, which involves analyzing stock return data to identify patterns and relationships.
  - The cumulative return plot reflects the performance of the portfolio weights derived from **quadratic programming optimization**.
- **Relevance to Class Scope:**
  - These graphs provide insights into key financial and statistical principles like correlation, diversification, portfolio risk management, and Sharpe ratio optimization.

- They visually reinforce the outcomes of the project, showing the practical utility of data science and machine learning concepts in financial decision-making.