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Portfolio Risk Assessment & 1-Day 95% VaR Calculation

1. What was the main goal of this project and how did you achieve it?

The project aims to assist investors in gauging the level of risk associated with a stock portfolio, particularly during periods of market instability, by estimating potential daily losses through the 1-Day 95% Value at Risk (VaR) and Conditional VaR (CVaR) metrics.

Steps Followed:
• Retrieved past stock price data for leading tech companies using the `yfinance` library.
• Processed and refined the dataset by addressing missing entries and synchronizing dates to compute returns.
• Performed data analysis by computing logarithmic returns, key statistical indicators, and risk parameters such as VaR and CVaR.
• Used techniques like bootstrapping, fitting probability distributions, conducting hypothesis tests, and backtesting to enhance the reliability of risk assessment.

2. Which tools and libraries did you use in this project, and what was the role of each?

1. pandas
• Organized and managed stock price datasets using DataFrames.
• Executed tasks such as time-shifting data, eliminating missing values, and summarizing statistics.

2. numpy
• Performed numerical computations including array manipulations and mathematical operations.
• Utilized for calculating portfolio weights, average returns, and standard deviations.

3. matplotlib.pyplot
• Created visual outputs like histograms, bar charts, and VaR-related graphs.
• Aided in visualizing data insights and interpreting risk-related findings.

4. yfinance
• Downloaded historical stock prices from Yahoo Finance seamlessly.
• Streamlined the process of acquiring data for several stock symbols over defined time spans.

5. datetime
• Handled date formatting and time range definitions for analysis periods.
• Enabled dynamic date usage, including retrieving the current date programmatically.

6. scipy.stats
• Applied to fit return data to theoretical distributions like normal and t-distributions.
• Carried out hypothesis testing, implemented bootstrapping, and computed probability density functions (PDFs).

7. time
• Tracked the duration of code execution where applicable.
• Used to monitor efficiency during extended calculations or repetitive loops.

3. How did you calculate Value at Risk (VaR), and what does it tell us about financial risk?

How I Estimated Value at Risk (VaR):
I used three different techniques to determine VaR:

1. **Historical Approach – Analyzed actual past returns and identified the 5th percentile (the fifth-worst return day).**
2. **Normal Distribution Approach – Assumed that returns follow a normal distribution and applied the mean and standard deviation to quantify risk.**
3. **Student's t-distribution Approach – Leveraged a distribution that captures heavy tails (extreme losses) more effectively, offering a more realistic risk estimate.**

Understanding What VaR Reveals About Risk:
Value at Risk (VaR) provides an estimate of the potential maximum loss over a specific period with a given confidence level.
For instance, a 1-Day 95% VaR implies:
"There's a 95% probability that losses won't exceed this amount in a single day, and a 5% probability that they could."

Practical Significance of VaR:
Investors rely on VaR to anticipate worst-case losses under typical market conditions. It supports decision-making by clarifying:
• The appropriate capital allocation
• The level of risk tolerance
• When adjustments or risk reductions are needed

Insights From My Results:
The computed VaR suggested that the portfolio has low daily volatility. However, results from the t-distribution method indicated a slightly higher chance of larger losses.
This emphasizes the critical role of selecting a suitable risk model to enhance the safety and reliability of investment strategies.

4. What challenges or errors did you face while completing this project, and how did you overcome them?

Challenges Encountered and How I Resolved Them:

• Comprehending Logarithmic Returns:
At first, I was unsure why log returns were used instead of simple returns. After some in-depth reading and hands-on testing, I discovered that log returns are time-consistent and offer advantages in mathematical modeling and statistical analysis.

• **Fitting Statistical Distributions (Normal and Student's t):**
I ran into issues when trying to fit the Student's t-distribution — the output parameters didn't initially behave as expected. I addressed this by reviewing official documentation and testing the function on smaller, controlled datasets to understand how `stats.t.fit()` operates.

• **Mastering Bootstrapping:**
The concept of bootstrapping was initially overwhelming, especially the correct procedure for resampling and estimating confidence intervals. I overcame this by breaking the process into simpler steps and carefully verifying results at each stage.

• **Understanding and Interpreting Hypothesis Testing:**
Interpreting statistical test results and grasping their real-world meaning was a challenge at first. I resolved this by studying various test types, practicing with example scenarios, and learning how to link p-values and test statistics to risk decisions.Interpreting the **t-test results** and **p-values** was tricky. I learned to clearly define the **null and alternative hypotheses** and rely on confidence levels to draw correct conclusions.

- **Plotting for Better Understanding:**
  My initial visualizations lacked clarity. I improved the graphs using **Seaborn**'s themes and careful labelling to make the results more understandable.

  What I Learned:
  Even though the data was clean and complete, this project helped me understand **financial statistics**, improve **coding logic**, and build confidence in using **Python for risk analysis**. Every challenge improved my understanding and problem-solving skills.

5. If you were to expand this project, what would you add or change?

• **Expand Stock Universe or Industry Coverage:**
Incorporate companies from a wider range of sectors such as healthcare, energy, and financial services to evaluate the impact of diversification on portfolio risk and returns.

• **Conduct Time-Based Comparisons:**
Examine data across different periods—such as before COVID, after COVID, and the most recent year—to identify how risk indicators like VaR vary with market conditions over time.

• **Integrate Advanced Risk Indicators:**
Enhance the analysis by introducing additional risk measures like the Sharpe Ratio, Sortino Ratio, and Maximum Drawdown to provide deeper insights into portfolio performance.

• **Leverage Machine Learning Models:**
Implement predictive techniques such as random forest or LSTM networks to forecast future returns and flag potential high-risk trading days using historical patterns and advanced analytics.

• **Create an Interactive Visualization Tool:**
Develop a dynamic, user-friendly dashboard using tools like Plotly Dash or Streamlit that enables users to input stock symbols and date ranges to receive instant risk evaluations.

• **Simulate Stress Test Scenarios:**
Perform scenario analysis to assess how the portfolio might react during extreme market events or economic downturns, offering a view into potential worst-case losses.

6. What are daily log returns, and how are they different from just looking at stock prices?

What Are Daily Log Returns?

Daily log returns tell us how much a stock's price has changed from one day to the next, using a special math function called the natural logarithm (ln).

The formula is:

log return = ln(today's price / yesterday's price)

This gives us a value that shows how much the stock moved, either up or down, in a smooth and consistent way.

How Are They Different from Just Looking at Prices?

- Looking at stock prices alone only tells you the **value**, not how much it changed from the previous day.
- Simple price changes or percent changes are helpful, but log returns give more accurate results, especially over time or for compounding returns.
- Log returns can be added across time, which makes them perfect for multi-day or long-term analysis.

Why Are Log Returns Useful in This Project?

- They allow us to measure daily performance and compare different stocks fairly, even if their prices are very different.
- They're better for statistical analysis, like calculating the mean, variance, or fitting distributions (like normal or t-distributions).
- They help in estimating financial risk, such as Value at Risk (VaR) and Expected Shortfall (CVaR).
- Because log returns behave nicely in models, they are widely used in portfolio analysis and financial simulations.

7. Why do we compare today's price to yesterday's price when calculating returns?

We compare today's price to yesterday's price to understand **how much the stock changed in one day**. This gives us the **daily return**, which tells us:

- Whether the stock **went up or down**
- By **how much** it moved
- How **risky or stable** it is from day to day

By looking at these daily changes, we can track the **stock's behavior over time**—whether it tends to rise steadily, stay flat, or jump around a lot.

8. What is the purpose of taking the logarithm of the return?

We use the **logarithm of the return (log return)** instead of just percentage change because it gives several important benefits:

- **Additivity Over Time:**
  Log returns can be added across days to get total return over a period. This isn't true for regular percentage changes.
- **Better for Modelling:**
  Log returns work better with **statistical tools** and are more accurate in financial models, especially for volatility and risk analysis.
- **Handles Large Changes Smoothly:**
  For big price jumps, log returns give a more consistent and accurate measure than simple percentage changes.
- **Symmetry:**

Log returns treat gains and losses more evenly, which helps in modeling returns using distributions like the normal or t-distribution.

9. What did your log return values look like — were they usually small or large, and what did that tell you?

The log return values tended to be small and hovered around zero, commonly falling within the range of -0.02 to 0.02. While most returns were mildly positive, there were occasional negative ones as well.

This indicates:
• The stocks underwent minor daily fluctuations, which is typical for stable, large-cap companies.
• The absence of extreme values shows that the stocks were not subject to high short-term volatility.
• The slight positive bias in returns points to a gradual upward momentum over the observed period.

In summary, the stock prices demonstrated consistent and modest movements, with infrequent small losses or gains—reflecting a relatively stable and balanced market behavior.

10. If your stock had a log return of -0.03 on a certain day, what does that tell you happened to the stock price?

If a stock has a **log return of -0.03** on a certain day, it means the stock's price **dropped** on that day — about **3% lower** than the previous day.

For an investor, this means:

- The stock **lost value** that day.
- If you were holding the stock, your investment **decreased** by roughly 3%.
- It was a **negative day** for returns, which might be due to market news, earnings results, or overall investor sentiment.

In short, a log return of -0.03 means the investor would have faced a **noticeable loss** on that day.

11. What does the shape of your log-return distribution chart tell you about the stock's behavior?

The log-return distribution chart was mostly **narrow and centered around 0**, with a few **longer tails** on either side.

This means:

- Most of the time, the stock had **small daily changes**, either positive or negative.
- The **centered peak** near 0 shows that returns were usually close to zero — indicating **stability**.
- The **longer tails** suggest that **large price moves** (both gains and losses) happened, but **rarely**.

In short, the stock behaved **steadily on most days**, but there were **some days with big movements**, which reflects normal market behavior.

12. Were most of the daily returns close to zero, or did the stock often have large changes?

Most of the daily log returns were **close to zero**, meaning the stock usually had **small daily changes** in price.

This tells us that:

- The stock is generally **stable** on a typical day.

- It does **not show high risk or wild fluctuations** most of the time.
- While large changes can happen occasionally, the overall pattern suggests a **low to moderate level of risk** for short-term investing.

  In simple terms, the stock tends to move in **small steps**, not big jumps, making it **more predictable and less risky** for daily movements.

13. Which type of return occurred more often: small daily gains, small losses, or big moves?

Most of the bars in the log-return distribution chart were **tall and close to zero**, slightly more on the **positive side**.

This means:

- **Small daily gains** occurred more often than losses or big moves.
- The chart showed a **higher frequency of small positive returns**, meaning the stock tended to go up a little bit on most days.
- **Big moves**, whether gains or losses, were **less frequent** and appeared at the edges of the chart (the tails).

  In short, the stock mostly showed **small, steady gains**, with fewer days of large movement — suggesting a **gradual upward trend** and relatively **low daily risk**.

14. Based on your chart, would you consider this stock relatively safe or risky for a short-term investor? Why?

Based on the chart, the stock appears to be relatively safe for a short-term investor.

- Most of the daily returns were small and close to zero, with only a few large spikes. This means the returns were fairly predictable, and the stock did not show frequent sharp ups or downs.
- Since the distribution is narrow and centered, it suggests low daily volatility, which is a sign of lower short-term risk. That makes it more suitable for investors looking for stability over short periods.

15. If you had to warn an investor about something in this chart, what would it be?

If I had to warn an investor about something in this chart, I would say:

Even though most returns are small and stable, the **long tails** in the chart show that there is a **chance of sudden large losses** (and gains).

This means:

- On rare days, the stock can **drop sharply**, which could lead to **unexpected losses**.
- These extreme movements may be caused by **market news, earnings reports, or global events**.

  So, while the stock is generally stable, investors should be aware that **big swings can still happen**, and it's important to be prepared for such **occasional risks**.

16. Which stock had the highest average return, and what does that tell you about its performance over time?

- MSFT had the highest average return with a mean of 0.000839, slightly more than AAPL and GOOGL.
- This tells us that Microsoft's stock provided the best average daily gains over the given period.
- Yes, this stock generally went up more than the others, indicating better overall performance.
- For an investor, this could mean that MSFT may offer better long-term growth potential, assuming similar risk levels.
- However, it's still important to compare this return with its risk (variance)—MSFT also has the lowest variance, suggesting more stable returns along with higher average gains, which is an attractive

combination for many investors.

17. Which stock had the highest variance, and what does that say about its risk?

- **AMZN (Amazon)** had the **highest variance** among the four stocks.
- A **higher variance** means that AMZN's **daily returns fluctuated more** than the others.
- This makes it **more unpredictable or volatile**, indicating **higher risk**.
- While it may offer **higher potential returns on some days**, it also carries a **greater chance of large losses**.
- For investors, this suggests AMZN is **less stable** and may be **better suited for those with higher risk tolerance**.

18. Did any of your stocks show negative skewness? What could that mean for an investor?

- **Yes, AMZN**, **GOOGL**, and **MSFT** all show **negative skewness**.
- **Negative skewness** means that the stock's returns have a **longer left tail** — in simpler terms, there's a **higher chance of experiencing sudden large drops** than big gains.
- This suggests that while most of the returns might be small and positive or near zero, **there's a greater risk of rare but sharp losses**.
- For an investor, this is important because it means the stock might **appear stable most days**, but can still lead to **unexpected steep losses**, so **caution and risk management are needed**.

19. What does high kurtosis tell you about a stock's behavior? Did any stock have a high kurtosis value?

What High Kurtosis Tells About a Stock's Behavior:

- **High kurtosis** means the stock's returns have **fat tails** — in other words, **extreme returns (big gains or losses)** happen **more often** than in a normal distribution.
- This indicates the stock is **more prone to sudden spikes or crashes**, making it **riskier and less predictable**.

Based on the Output:

- **AAPL (4.88)** and **AMZN (4.65)** have **high kurtosis** values.
- These values suggest that both stocks **experience more frequent extreme price movements**, compared to others like **MSFT (2.62)**, which has lower kurtosis.

What This Means for Risk:

- Stocks with **high kurtosis** can be **more volatile and riskier** even if their average daily movements seem small.
- **Investors should be prepared for unexpected large changes**, which can impact portfolio performance — both positively and negatively.

20. Based on your summary table, which stock would you recommend to a cautious investor — and why?

For a **cautious investor**, **Microsoft (MSFT)** would be the most suitable choice.

Reason:

- It has the **highest average return**, meaning it performed well over time.
- It shows the **lowest variance**, indicating **lower daily price fluctuations** and more **consistent returns**.
- Its **skewness is only slightly negative**, so the risk of sudden large drops is **less severe** compared to others.
- **Kurtosis is moderate**, suggesting it experiences **fewer extreme returns**, which makes it **more stable**.

In short, MSFT offers a good balance of **decent returns with relatively low risk and better stability**, which aligns well with a cautious investor's goals.

21. What does the average daily return (μ) tell you about how your stocks performed over time?

- The average daily return (μ) shown here is positive, which means that, on average, the portfolio or stocks have been gaining value over time.
- For an investor, this indicates a potential for profit if the trend continues. Although the return is small on a daily basis, consistent small gains can add up to a significant return in the long run. The confidence interval also suggests that we can be fairly sure the average return is above zero, reinforcing the idea of a generally upward trend in stock performance.

22. What does the standard deviation (σ) tell you about the risk or volatility of your returns?

- The standard deviation (σ) measures the volatility or risk of the daily returns — in other words, how much the returns fluctuate from day to day.
- In this case, the standard deviation is fairly low, which means the returns were mostly stable with small daily movements. For an investor, this suggests the portfolio is less risky and does not experience large swings in value very often. Lower volatility is generally preferred by cautious or risk-averse investors.

23. What does your 95% confidence interval for the mean (μ) suggest about the reliability of your average return?

- The 95% confidence interval for the mean (μ) gives a range in which we believe the true average daily return is likely to fall, with 95% certainty.
- In this case, the interval is fairly narrow, which means the estimate is reliable and there isn't a lot of uncertainty. Since the entire interval is above zero, it also suggests that the portfolio has a consistently small positive return, giving more confidence to investors about its potential to grow steadily over time.

24. Why is it important to calculate a confidence interval for the standard deviation (σ)?

Calculating a **confidence interval for the standard deviation (σ)** is important because it helps you understand how **reliable and accurate** your risk estimate really is. Here's why it matters:

- A **standard deviation** tells us how much returns tend to fluctuate — it's a measure of **risk or volatility**.
- But a single number doesn't tell the full story — it's only an **estimate** based on sample data.

Why use a confidence interval?

- It provides a **range** where the true volatility is likely to fall (e.g., with 95% confidence).
- A **narrow range** suggests the estimate is **precise and reliable**.
- A **wider range** means there's **more uncertainty**, so actual risk might be higher or lower than expected.

Conclusion:

The confidence interval helps investors judge how **trustworthy** their risk estimate is — which is crucial when making financial decisions under uncertainty.

25. If you repeated this project with a different time period or more data, how might your confidence intervals change? Why?

If this project were repeated with a **different time period** or **more data**, the **confidence intervals** would likely become **narrower** and more **reliable**. Here's why:

- A **larger sample size** (i.e., more days of data) gives a **better estimate** of the true mean and standard deviation.
- More data helps **reduce random noise** and improves the **stability** of statistical calculations.
- As a result:
    - The **confidence interval for the mean (μ)** would become **tighter**, making the average return estimate more precise.
    - The **confidence interval for the standard deviation (σ)** would also be **more accurate**, improving our understanding of risk.

In short, **more data increases certainty** and gives more confidence in both return and risk estimates.

26. What does the average return (μ) from the t-distribution tell you about your stocks overall?

The average return (μ) from the **Student's t-distribution fit** appears to be **positive**, as the peak of both fitted curves (red and blue) is centered slightly to the **right of zero**.

This suggests:

- On average, the portfolio had **small positive daily returns**.
- The stock portfolio tended to **gain slightly each day**, even though individual daily returns could vary.
- A positive μ implies that, over time, the portfolio may **grow in value**, making it a **potentially good investment** assuming the trend continues.

The Student's t-distribution also fits the **extreme values (tails)** better than the normal curve, making this average more robust to outliers.

27. How does the standard deviation (σ) from the t-distribution describe the risk or volatility of your returns?

The **standard deviation (σ)** from the Student's t-distribution is **0.01426**, or about **1.43%**.

This tells us:

- The **daily returns usually stayed fairly close to the average** (μ = 0.00106), meaning the portfolio had **moderate volatility**.
- Since σ is not too high, it suggests the investment was **relatively stable**, with **small day-to-day fluctuations**.
- However, because the t-distribution accounts for **occasional large changes**, this value still reflects **some risk** in extreme situations.

In short, the portfolio didn't fluctuate wildly most of the time, but **investors should still be aware of possible sudden moves**.

28. The t-distribution includes a value called degrees of freedom (df). What does a low df value tell you about your return data?

A **low degrees of freedom (df)** value in the **t-distribution** indicates that your return data has **heavy tails**, meaning:

- **Extreme events** (like sudden spikes or crashes) happen **more often** than they would under a normal distribution.
- The returns are **less predictable** and **more volatile**, especially in the **extreme ends**.
- The data is **not tightly clustered around the mean**, showing **more risk of large, unexpected moves**.

In simple terms, a low df suggests your portfolio might experience **occasional big jumps or drops**, so **risk is higher than it appears from average values alone**.

29. Why might the t-distribution give a better fit than a normal distribution for stock returns?

The **Student's t-distribution** often gives a better fit than the **normal distribution** for stock returns because real financial markets do not behave in a perfectly predictable or smooth way. Here's why:

- In real markets, **extreme price movements** (like sudden gains or crashes) occur **more often** than the normal distribution assumes.
- The t-distribution has **heavier tails**, which means it accounts for a **higher probability of large gains or losses**.
- Stock returns often show **volatility clustering**—calm periods followed by bursts of high movement—which the normal distribution doesn't model well.
- The **t-distribution** adapts better to **uncertainty and risk** in financial data, making it more reliable for risk management tasks like Value at Risk (VaR) calculations.

Overall, the t-distribution provides a **more realistic model of stock behavior**, especially when dealing with financial risk.

30. How can using the t-distribution help you prepare better for financial risks?

Using the **t-distribution** helps prepare better for financial risks because it more accurately reflects the real-world behavior of stock returns, especially during rare or extreme events. Here's how it helps investors:

- It gives **more realistic risk estimates** by accounting for **heavy tails**, meaning it predicts that **extreme losses or gains** are more likely than the normal distribution assumes.
- It allows investors to **anticipate sudden market drops**, crashes, or spikes better, helping them avoid being caught off guard.
- By using the t-distribution, investors can calculate **Value at Risk (VaR)** more conservatively, which means **building stronger risk buffers** during uncertain times.
- It improves **decision-making under uncertainty**, especially in volatile markets where standard models might underestimate risk.

31. What does a 95% confidence interval for the mean (μ) tell you about your average return?

A **95% confidence interval for the mean (μ)** tells you the range within which the **true average return** is likely to fall with **95% certainty**, based on your sample data.

- If the interval is **narrow**, it means your average return estimate is **more reliable and precise**.

- If the interval is **wide**, it suggests there is **more uncertainty** in the estimate, possibly due to high volatility or limited data.
- This range helps you **gauge how confident** you can be in using the estimated return for planning or making investment decisions.

  In short, the 95% CI shows the **trustworthiness of your return estimate** and how much it might vary in reality.

32. What did your confidence interval for the standard deviation (σ) look like? Was it narrow or wide, and what does that tell you about the risk in your returns?

The confidence interval for the standard deviation (σ) in your bootstrap output is **wide**.

What this tells you about the risk:

A wide confidence interval for σ indicates that there's **a lot of uncertainty** in your estimate of volatility or risk in the returns. This means the actual variability in returns could be much lower or much higher than your estimated average.

How the range affects confidence:

- A **wide** range makes you **less confident** in your result because it shows that the estimate could vary a lot depending on the sample.
- A **narrow** confidence interval would make you feel **more confident**, suggesting that most of your bootstrap samples agree on the estimate.

Conclusion:

Since the interval is wide, it reflects **greater uncertainty in risk** and suggests you should be **cautious when interpreting the stability or predictability** of your returns.

33. Why do we use bootstrapping instead of calculating just one estimate?

We use bootstrapping instead of calculating just one estimate because it helps us understand the uncertainty and variability in our estimates — something a single value can't provide.

Why bootstrapping is useful:

1. Simulates many possible outcomes:

Bootstrapping involves resampling your data (with replacement) to generate many alternative "histories." Each of these is a possible version of what could have happened, assuming the original data is representative.

2. Captures variability:

Instead of getting just one estimate (like a single mean or standard deviation), bootstrapping gives us a distribution of estimates. This helps us see how much the estimate could vary due to random chance.

3. Provides confidence intervals:

Bootstrapping lets us construct confidence intervals around our estimates, which show the range within which the true value is likely to lie. A single estimate gives no sense of how confident we should be.

4. Works without strong assumptions:

Traditional methods often assume things like normality. Bootstrapping is non-parametric — it doesn't require those assumptions and works directly with the data.

34. If your confidence interval for the mean return includes zero, what does that mean for investors?

If your confidence interval for the mean return includes zero, it means there's a real possibility that the average return could be zero — or even negative.

What this means for investors:
1. Uncertain profitability:
Since zero is within the range, investors can't be confident the asset will generate a profit over time. It might not return anything, or worse, it might produce a loss.

2. Risk of no gain or loss:
A return of zero means the investment might not grow at all. For investors, this could be a warning sign, especially if they are looking for positive growth or income.

3. Higher investment risk:
Including zero in the confidence interval shows greater uncertainty about the expected return. It means the asset's performance is not reliably positive, which increases the risk.

4. Not a strong signal to invest:
For most investors, especially risk-averse ones, an investment with an uncertain or possibly zero return is not attractive. They may prefer alternatives with a more consistently positive expected return.

35. In what ways do confidence intervals help investors make smarter decisions?

Show range of returns

- CI for mean return includes zero → possible no profit or even loss.
- Helps investors assess potential downside.

Reveal uncertainty in risk

- Wide CI for standard deviation shows high variability in risk.
- Alerts investors to possible high volatility.

Avoid overreliance on single values

- One estimate (like average return) can be misleading.
- CI shows how much that estimate might vary.

Support better decision-making

- CI gives a fuller picture of return and risk.
- Helps investors choose safer or more suitable investments.

36. What does the average daily return of your portfolio tell you about its overall performance?

- The average daily return is positive, indicating the portfolio has shown gains on average each day.
- This suggests good overall performance, with the portfolio tending to grow in value over time.
- A positive average daily return points to the potential for long-term profit if trends continue.
- However, the presence of VaR reminds us there is still risk — losses can occur, especially during downturns.
- If returns remain consistently positive, your investment is likely to appreciate over time, but risk management remains important.

37. What does the standard deviation (volatility) of your portfolio's return tell you about its risk?

The standard deviation (σ) represents the **volatility** or **risk** in the portfolio's daily returns.
Based on the output:

- The Value at Risk (VaR) was relatively **small**, and since VaR depends directly on σ, this suggests that the **standard deviation is not very high**.
- This means the portfolio does **not experience large day-to-day swings** in returns.
- The portfolio is therefore considered to be **relatively stable**, with **moderate risk**.

Conclusion:
The standard deviation indicates that the portfolio shows **controlled, moderate daily fluctuations**, suggesting it is **stable rather than highly volatile**. This reflects a **reasonable level of risk**, suitable for investors seeking **balanced performance**.

38. What does your 95% Value at Risk (VaR) result mean in simple terms?

The 95% Value at Risk (VaR) result represents the **maximum expected loss** for the portfolio on a single day, with **95% confidence**.
Interpretation:

- This means that on **95% of trading days**, the portfolio is **not expected to lose more than the VaR amount**.
- There is a **5% chance** that the portfolio could experience a **larger loss** than this on a particularly bad day.
- It reflects a **worst-case daily loss under normal market conditions**, not accounting for extreme events.

Conclusion:
The 95% VaR indicates that the portfolio is expected to **lose no more than the calculated amount** on most days. However, in rare cases (5% of days), **losses could exceed this threshold**, highlighting the importance of risk awareness.

39. Based on your VaR result, would you describe your portfolio as low-risk, medium-risk, or high-risk? Why?

Based on the Value at Risk (VaR) result, the portfolio would be described as **low-risk to medium-risk**.
Reasoning:

- The VaR value is **relatively small**, indicating that the **potential loss on a bad day is limited**.
- Since this is a **95% VaR**, such a loss is expected to be **exceeded only 5% of the time**, meaning that **larger losses are rare**.
- The **standard deviation** used in the VaR calculation was also **moderate**, suggesting that **daily fluctuations in returns are not extreme**.

Conclusion:

The portfolio shows a **controlled level of risk**, with **limited potential losses occurring rarely**, which places it in the **low to medium-risk category**. This makes it suitable for investors who prefer **steady performance with moderate downside exposure**.

40. If you wanted to reduce your portfolio's VaR, what changes could you consider making?

To reduce the portfolio's Value at Risk (VaR), several changes can be considered:

1. Increase Diversification

- Add a wider variety of assets (e.g., stocks from different sectors or asset classes).
- This spreads risk and can lower overall portfolio volatility.

2. Adjust Portfolio Weights

- Reduce the weight of more volatile or high-risk assets.
- Increase the weight of more stable, lower-risk assets to reduce overall exposure.

3. Choose Less Volatile Stocks

- Replace highly volatile stocks with those that have more consistent, stable returns.
- This lowers the standard deviation, which directly reduces VaR.

4. Include Low-Correlation Assets

- Add assets that do not move in the same direction as the rest of the portfolio.
- This reduces the overall risk through diversification, as losses in one asset may be offset by gains in another.

5. Shorten Holding Periods or Monitor More Frequently

- Actively managing the portfolio and adjusting based on market trends can help limit exposure during volatile periods.

41. What is the purpose of calculating Value at Risk (VaR), and how does it help in investment decision-making?

The main purpose of calculating **Value at Risk (VaR)** is to **quantify the potential loss** an investment portfolio could face **over a specific time period**, with a given level of confidence (e.g., 95%).

How VaR Helps in Investment Decision-Making:

1. **Measures Potential Loss**
    - VaR provides a clear estimate of the **worst expected loss** under normal market conditions.
    - For example, a 95% VaR tells how much the portfolio could lose in a day, with only a 5% chance of a greater loss.
2. **Helps Compare Risk**
    - Investors can use VaR to compare the **riskiness of different portfolios or assets**, making it easier to choose safer options.
3. **Supports Risk Management**
    - By knowing how much could be lost, investors or fund managers can **adjust asset allocations** or apply hedging strategies to reduce exposure.

4. **Informs Capital Allocation**
    - VaR helps decide **how much capital to set aside** as a cushion against potential losses, especially in institutional investing.

42. Why did we use the Student's t-distribution instead of the normal distribution in this step?

We use the **Student's t-distribution** instead of the **normal distribution** in this step because **financial markets do not always behave in smooth, predictable ways**.

Reasons:

1. **Real-world returns have "fat tails"**
    - Financial market returns often show **extreme changes** (large gains or losses) more often than a normal distribution predicts.
    - The **t-distribution captures this better** by allowing for **heavier tails**, meaning it accounts for **more frequent extreme events**.
2. **Smaller sample sizes**
    - When using a **limited amount of data**, the t-distribution provides a more **accurate reflection of uncertainty** compared to the normal distribution.
3. **More realistic risk estimates**
    - The t-distribution leads to **higher Value at Risk (VaR)** values, making it a **more conservative and safer estimate of risk**.
    - This is useful when preparing for **rare but severe market events**, which normal distributions tend to underestimate.

Conclusion:

The Student's t-distribution is used because **financial returns are not perfectly normal**. Markets can be **volatile and unpredictable**, and the t-distribution does a better job of capturing that reality — making it a **more reliable choice for risk assessment**.

43. What does your 95% 1-day VaR result mean in simple terms?

A **95% 1-day VaR of 2.65%** means that, under normal market conditions, there is a **95% chance** that the portfolio **will not lose more than 2.65% of its value in a single day**.

What this says about potential losses:

- On **most days (95 out of 100)**, losses are expected to be **less than 2.65%**.
- On the **remaining 5% of days**, the portfolio **could lose more than 2.65%**, indicating the potential for **larger, less frequent losses**.
- It shows that while the **day-to-day risk is limited**, **rare but significant losses** are still possible.

Conclusion:

The 2.65% VaR indicates a **moderate level of daily risk** — losses are generally contained, but investors should be prepared for occasional **larger drops in portfolio value**.

44. How does using a distribution with “fatter tails” (like the t-distribution) affect the risk estimate?

Using a distribution with **fatter tails** like the **Student’s t-distribution** makes the **risk estimate larger** compared to the normal distribution.

Why the risk looks larger:

- **Fatter tails** mean the distribution accounts for **more extreme outcomes** — such as large gains or losses — that occur more often than predicted by a normal distribution.
- As a result, the calculated **Value at Risk (VaR)** becomes **higher**, reflecting a **greater chance of rare, severe losses**.

Why this is good for cautious investors:

1. **More realistic risk assessment**
    - Financial markets often show **unexpected, extreme movements**. The t-distribution captures this better than the normal distribution.
2. **Safer decision-making**
    - A larger risk estimate encourages **conservative strategies**, which help investors **avoid overexposure**.
3. **Better preparation for worst-case scenarios**
    - By not underestimating the chance of extreme losses, investors can **set aside enough capital** or build in **risk buffers**.

Conclusion:

Using a t-distribution **increases the estimated risk**, which helps **cautious investors better prepare for market shocks** and make more **informed, protective investment decisions**.

45. If your VaR is too high, what changes could you make to reduce the risk in your portfolio?

If the Value at Risk (VaR) is too high, it means the portfolio is exposed to **potentially large losses**, and steps should be taken to reduce risk. Here are some changes that could help:

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1. Increase Portfolio Diversification

- Add more assets from **different sectors or asset classes**.
- Diversification helps reduce overall risk by **spreading exposure**, so poor performance in one area can be offset by gains in another.

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2. Reduce Weights of Risky Assets

- Lower the investment in **high-volatility or high-risk stocks**.
- Reallocate more weight to **stable or defensive stocks** with lower price fluctuations.

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3. Choose Less Volatile Stocks

- Replace highly volatile stocks with ones that have **more consistent and predictable returns**.
- This helps lower the overall **standard deviation** of the portfolio, which directly reduces VaR.

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4. Review and Adjust Correlations

- Combine assets that have **low or negative correlations** with each other.
- This helps reduce the portfolio's overall sensitivity to market movements.

46. What does your Historical Value at Risk (VaR) tell you about the potential losses in your portfolio?

The **Historical Value at Risk (VaR)** of **2.71%** tells us that, based on **actual past returns**, the portfolio would not be expected to lose **more than 2.71% in a single day**, **95% of the time**.

What this means about potential losses:

- The **worst 5% of past daily returns** were greater than a **2.71% loss**.
- This tells the investor that under conditions similar to the past, **daily losses beyond 2.71% are rare but possible**.
- It provides a **real-world, data-based estimate** of how much the portfolio might drop on a bad day.

What it means for an investor:

- The Historical VaR gives a **practical, experience-based view of risk** by using actual return data rather than relying on theoretical distributions.
- A VaR of 2.71% means the investor should be prepared for occasional **small to moderate daily losses**, but also that **extreme losses have been rare** historically.
- It helps investors **set expectations**, manage risk, and decide whether the portfolio fits their **risk tolerance**.

47. Why do you think Historical VaR is a useful way to measure risk?

Historical VaR is a useful way to measure risk because it is based on **actual past return data** rather than assumptions from a theoretical model.

Reasons why it's useful:

1. **Reflects real market behavior**
    - It uses the portfolio's own **historical performance**, capturing how it actually responded to market conditions, including volatility and shocks.
2. **No assumptions about distribution**
    - Unlike models that assume returns follow a normal or t-distribution, Historical VaR does **not require any assumptions** about the shape of the return distribution.
    - This is important because financial returns often **don't follow ideal, predictable patterns**.
3. **Captures rare and extreme events**
    - It can account for **unusual past events**, making it more accurate in identifying **actual worst-case scenarios**.
4. **Easy to understand and communicate**
    - It gives a **clear, data-backed estimate** of potential losses, which makes it more **intuitive and practical** for decision-makers.

48. How does Historical VaR compare to the Normal or t-distribution VaR you calculated earlier?

- The **Student's t-distribution VaR** gave the **highest risk estimate**.
- The **Historical VaR** was slightly higher than the Normal VaR but lower than the t-distribution VaR.

Reason for the differences:

1. **Student's t-distribution (Highest VaR):**
    - Accounts for **fatter tails** and **more extreme outcomes** than the normal distribution.
    - Reflects a **more conservative estimate of risk**, useful for capturing rare, severe losses.
2. **Historical VaR (Middle):**
    - Based on **actual return data**, it includes **real-world volatility and past shocks**.
    - Reflects how the portfolio has actually behaved, without relying on theoretical assumptions.
3. **Normal VaR (Lowest):**
    - Assumes returns are **normally distributed**, which often **underestimates the probability of extreme losses**.
    - Gives a more optimistic view that may not reflect actual market behavior.

Conclusion:

The **Student's t-distribution VaR** gave the highest risk estimate because it assumes **greater probability of extreme losses**. This makes it a **more cautious and realistic measure** for investors, especially in volatile markets. The **Historical VaR** also provided a realistic estimate, while the **Normal VaR** may have slightly **underestimated the true risk**.

49. If your VaR is large (e.g., more than 3%), what does that say about your portfolio's risk level?

If the Value at Risk (VaR) is large—**for example, more than 3%**—it indicates that the portfolio is exposed to **significant potential losses** on a bad day.

What it says about the portfolio's risk level:

- A high VaR means the portfolio could **lose more than 3% of its value in a single day**, with a 5% chance of even worse losses.
- This level of potential loss suggests the portfolio is **high-risk**, especially for short-term investors or those with low risk tolerance because:
    1. The expected worst-case daily loss is relatively large.
    2. It indicates higher volatility or exposure to riskier assets.
    3. It shows that the portfolio is more likely to experience sharp declines, which could be a concern for cautious investors.

50. Based on your VaR result, what advice would you give to someone thinking about investing in this portfolio?

- **Big losses are possible:**
  The portfolio could lose more than the VaR amount on about **5% of days**.
- **Not suitable for all investors:**
  Might be **too risky for short-term or risk-averse investors**.

- **Better for long-term or high-risk investors:**
  Suitable for those who can **handle short-term losses** in exchange for **higher potential returns**.
- **Risk awareness is important:**
  Investors should be prepared for occasional sharp drops in value.
- **Consider adjustments if needed:**
  To lower risk, consider diversifying or reducing exposure to volatile assets.

51. What was the goal of the t-test you performed on your portfolio's returns?

- The **goal** of the one-sample t-test was to check whether the **average daily return** of the portfolio is **significantly different from zero**.

What the test is trying to find out:

- It tests the **null hypothesis**: that the portfolio's **true mean return is zero** (no profit or loss on average).
- If the p-value is **low (typically < 0.05)**, we **reject the null** and say the average return is **statistically significant** (either positive or negative).
- If the p-value is **high**, we **fail to reject** the null, meaning we **don't have strong evidence** that the average return is different from zero.

52. What did your p-value indicate about your portfolio's performance?

- The **p-value was 0.117**, which is **above 0.05**.

What this means:

- Since the p-value is **greater than 0.05**, it means there is **not enough evidence** to say the portfolio's average return is **statistically different from zero**.
- In other words, the observed return could be due to **random chance**, rather than a consistent or reliable pattern.

Conclusion:

- The portfolio's performance is **not statistically significant**.
- There is a **high likelihood** that the return is just **due to random fluctuations**, not a guaranteed trend.

53. Did you reject or fail to reject the null hypothesis? What does that tell you about the average return?

- **You failed to reject the null hypothesis**
  (Because the p-value was **greater than 0.05**)

What this tells us:

- The **average return is not significantly different from zero**.
- This means there's **no strong evidence** that the portfolio is truly generating consistent gains (or losses).
- The return could simply be due to **random chance**.

In simple terms:
The test results show that the portfolio's **average daily return is not significantly different from zero**, so we **can't confidently say it's performing better than break-even**.

54. Why is it useful to test whether the return is statistically significant, instead of just looking at the average?

- **Averages can be misleading:**
  A small positive average return might look good, but it could have happened **just by chance** — especially if the returns vary a lot.
- **Statistical significance shows confidence:**
  Testing tells us whether the return is **consistently different from zero**, or if it's likely just **random noise**.
- **Helps avoid false conclusions:**
  Without testing, one might **mistakenly believe** the portfolio is performing well, when the return isn't **reliably positive**.
- **Adds evidence to decision-making:**
  A significant result gives **stronger support** for investing decisions. It means the return is **more likely real**, not random.

55. If you failed to reject the null hypothesis, what changes could you consider for your portfolio?

If the null hypothesis is not rejected, here are some changes to consider:

- **1. Re-evaluate current assets**
  - Look at which stocks or assets are **underperforming** or showing **high volatility with low return**.
  - Consider **replacing** or reducing them.
- **2. Adjust portfolio weights**
  - Shift more weight toward assets with **better historical performance or stronger fundamentals**.
- **3. Increase diversification**
  - Add assets from **different sectors or markets** to reduce risk and improve the chance of consistent returns.
- **4. Review strategy and time horizon**
  - If the current strategy is short-term, consider **longer-term investments** for more stable performance.
- **5. Monitor and test regularly**
  - Keep testing the portfolio's performance periodically to check for improvements or further adjustments.

56. Looking at the heatmap, which pairs of stocks have the highest correlation? What does this mean about how they move together?

From the heatmap, the pair with the **highest correlation** is:

- **AAPL (Apple)** and **MSFT (Microsoft)** with a correlation of **0.67**

What does this mean?

- A correlation of **0.67** means these two stocks have a **strong positive relationship**.
- When **AAPL's price goes up or down**, **MSFT's price tends to move in the same direction** on the same day.
- However, it's not a perfect correlation (which would be 1), so they don't move identically — just **similarly most of the time**.

In simple terms:

- AAPL and MSFT are **closely connected in their daily movements**.
- Their prices often **rise or fall together**, likely due to being in the **same sector (technology)** and responding to similar market news or trends.

57. Were there any stocks in your portfolio that had low correlation with others? Why might this be helpful for diversification?

Yes, some pairs in the portfolio show moderate to lower correlations — for example:

- GOOGL and AAPL: Correlation of 0.58
- GOOGL and AMZN: Also, around 0.58

Why is this helpful for diversification?

- Low correlation means the stocks don't always move in the same direction.
- When one stock goes down, another might stay stable or even go up.
- This helps to smooth out the portfolio's overall returns, reducing the total risk.

58. What is the difference between the weighted average risk (σ) and the actual portfolio risk (σ)?

- Weighted average σ: 0.0193
- Actual portfolio σ: 0.0166
- Difference (Diversification benefit): 0.0028

What this tells us:

- The actual portfolio risk is lower than the weighted average of individual asset risks.
- This difference of 0.0028 represents the diversification benefit.
- It shows that combining assets with less-than-perfect correlation helps to reduce total portfolio volatility.

59. What does the diversification benefit value mean for your portfolio? Was it large or small? What could you do to increase it?

- The diversification benefit value of 0.0028 shows how much risk was reduced in the portfolio due to diversification.
- It represents the difference between the weighted average risk of the individual assets and the actual portfolio risk.

Was the benefit large or small?

- The benefit is small, but still positive.
- This means the portfolio has some level of diversification, but it's not highly diversified.

How to increase the diversification benefit:

- Add stocks from different sectors (e.g., healthcare, energy, finance) instead of just tech stocks.
- Include assets with lower or negative correlations, like bonds, commodities, or ETFs.
- Consider international stocks to reduce exposure to local market movements.
- Avoid adding assets that move similarly to current holdings.

60. Based on your analysis, how well-diversified is your portfolio? What changes (if any) would you suggest to improve it?

- The portfolio is moderately diversified — there is a small diversification benefit, meaning some risk reduction is happening.
- However, many of the assets are from similar sectors (e.g., tech) and show moderate to high correlations, limiting the full benefit of diversification.

What changes could improve it?

- Add stocks from different sectors (e.g., healthcare, utilities, consumer goods) to reduce sector concentration.
- Include lower-risk or less-correlated assets like bonds, index funds, or international stocks.
- Rebalance portfolio weights to avoid overexposure to any single stock or sector.

61. What does your cumulative return chart tell you about the overall growth of your portfolio?

- The portfolio showed strong overall growth, especially in the early and later periods.
- There was a significant decline between December 2021 and January 2023, with a maximum drawdown of approximately -44%, indicating a major loss from peak to trough.
- This period reflects high volatility and risk, possibly caused by market corrections or external economic factors.
- After the drawdown, the portfolio recovered well, reaching new highs by 2024, which shows its ability to rebound.
- Another smaller drop occurred in early 2025, but the portfolio began to recover again.

62. How much was your portfolio's maximum drawdown, and what does that number mean for an investor?

- The portfolio's maximum drawdown was -43.98%.
- This means the portfolio lost nearly 44% of its value from its peak before recovering.
- It shows the largest decline in portfolio value over the investment period.
- For an investor, this highlights the worst-case scenario — how much their investment could drop during a downturn.
- A drawdown of this size suggests the portfolio is highly volatile and may not be suitable for those with low risk tolerance.

63. How long did the drawdown last — from peak to recovery — and how might that affect an investor emotionally?

- The drawdown lasted from **December 10, 2021 to January 5, 2023**.
- That's approximately **13 months** from peak to recovery.

Emotional Impact on an Investor:

- Watching a portfolio lose nearly **44% of its value over a year** can cause **stress, fear, and uncertainty**.
- Many investors may feel the urge to **panic sell**, especially if they don't understand that markets can recover.
- A long recovery period can **test patience** and **shake confidence**, even if the portfolio eventually rebounds.

- Emotionally, such a decline can make investors **doubt their strategy**, especially if they're not prepared for high volatility.

64. What could you do to reduce the size or frequency of drawdowns in a portfolio like this?

Increase Diversification

- Invest in a wider range of sectors (not just tech) to spread risk across different industries.

Add More Stable Assets

- Include **low-volatility assets** like bonds, gold, or defensive stocks to cushion against sharp drops.

Reduce Exposure to High-Risk Stocks

- Lower the weights of volatile stocks that tend to amplify losses during downturns.

Include International Assets

- Investing in global markets can reduce the impact of region-specific downturns.

Rebalance Regularly

- Adjust portfolio weights over time to maintain a consistent risk level and avoid overconcentration.

Use Risk Management Tools

- Apply stop-loss limits or hedging strategies to reduce large losses during market drops.

65. If you were to present your drawdown chart to a new investor, what advice would you give them based on your results?

- Expect ups and downs:

The chart shows that even a growing portfolio can face sharp and extended losses.

- Don't panic during downturns:

The biggest drop lasted over a year, but the portfolio eventually recovered — this highlights the importance of staying invested during tough times.

- One tip learned:

Patience is key. Short-term losses can feel discouraging, but long-term performance often rewards those who stay calm and committed to their strategy.

66. In your own words, what does Expected Shortfall (ES) tell us about a portfolio's risk?

Expected Shortfall (ES), also known as **Conditional VaR**, tells us the **average loss** we might face on the **worst days**—specifically, when losses go **beyond the Value at Risk (VaR)** level.

- While **VaR** shows the minimum loss expected in the worst 5% of cases, **ES shows how bad those worst losses can actually get on average**.
- It gives a clearer picture of **extreme downside risk**, especially during **highly volatile or crisis periods**.

How ES is different from average returns:

- **Average return** looks at the **overall performance**, including good and bad days.
- **ES focuses only on the worst-case scenarios**, helping investors understand **how much they could lose when things go really wrong**.

67. Compare your Historical ES and Parametric ES values. Which one is higher, and what might that tell you about real-world risk?

The **Historical ES is higher** than the Parametric ES.

What does this tell us about real-world risk?

- The **historical data showed worse losses** during extreme events than what the **normal model predicted**.
- This suggests that **real market behavior** includes **more severe downside risk** than the normal distribution assumes.
- The normal model tends to **underestimate risk** because it doesn't account well for **extreme market movements** (it assumes "thin tails").

Did the portfolio perform worse than the model predicted?

- **Yes.**
  The portfolio experienced **larger average losses in real-world worst-case scenarios** than what the theoretical model estimated.

68. Why might a historical method give a different result than a theoretical (normal distribution) method?

Real markets are not perfectly smooth:

- In real life, markets often experience **sudden shocks, crashes, or unexpected news**.
- These events cause **large and irregular price movements**, which a **normal distribution can't fully capture**.

The normal model assumes symmetry and stability:

- It expects returns to follow a **bell-shaped curve** with **rare extreme losses**.
- But actual market returns often have **"fat tails"**, meaning **extreme losses happen more often** than the model expects.

Historical method uses actual data:

- It reflects how the portfolio has really behaved during **good and bad times**.
- It includes **real-world volatility**, making it better at capturing **true downside risk**.

Theoretical models simplify reality:

- Normal distributions are easier to use and understand, but they **miss out on rare but important market behavior**.

69. If your Expected Shortfall is too high for your comfort, what changes could you make to reduce it?

If Expected Shortfall (ES) Is Too High — Ways to Reduce It:

1. **Increase Diversification**
   - Add assets from **different sectors or asset classes** (e.g., bonds, commodities, international stocks) to spread risk.
2. **Choose Lower-Risk Assets**
   - Replace highly volatile stocks with **more stable or defensive assets** (like utilities or dividend-paying stocks).
3. **Reduce Exposure to Risky Holdings**
   - **Lower the weight** of assets that contribute most to large losses during downturns.
4. **Use Risk Management Tools**
   - Apply strategies like **stop-loss orders** or **hedging** to limit extreme losses.

5. **Reassess Risk Tolerance**
    - Align the portfolio with your **comfort level and investment goals**—if ES feels too high, it may be time to shift to a **more conservative approach**.

70. What is one lesson you've learned about risk by comparing VaR and ES in this project?

One key lesson is that **knowing how likely a loss is (VaR)** isn't enough — it's also important to know **how severe that loss could be (ES)** if it happens.

Why this matters:

- **VaR** tells you the threshold loss you might expect on a bad day (e.g., 5% worst-case scenario), but it **doesn't show how bad things can get beyond that point**.
- **ES** goes a step further by showing the **average loss** on those worst days — giving a **more complete picture** of the potential damage during extreme events.

71. What does it mean when a portfolio return is lower than the Value at Risk (VaR) threshold?

- It means the portfolio lost more than expected on that day — it went beyond the 95% confidence limit.
- This kind of loss is rare but possible, and it shows up in the worst 5% of outcomes.
- An **exception** happens when the **actual return is worse than the VaR estimate**.
- In simple terms, it means the **model underestimated the risk** for that day.
- It's like saying, "The loss today was so bad, it fell into the **extreme range** the model didn't expect."

72. How many exceptions did you find in your data, and what percentage of total days was that?

Number of exceptions: 71
Total trading days: 1294
Percentage of exceptions: 5.49%

What this percentage tells you:

- The percentage of exceptions (**5.49%**) is **very close to the expected rate** of around **5%**, based on a 95% confidence level.
- This means the **VaR model is working reasonably well** — it's accurately predicting the number of extreme loss days.
- A small difference like this is **acceptable** and suggests the model is **reliable** for estimating risk.

73. Was your exception rate close to the expected 5%? What does that say about your VaR model's accuracy?

- **Yes**, the exception rate was **5.49%**, which is **very close to the expected 5%**.
- The **VaR model is accurate** — it correctly estimated how often extreme losses would occur.

- The model is **realistic**, not overly conservative or aggressive.
- It captures the **true level of risk** without over- or underestimating potential losses.

74. If your model had too many exceptions, what could that mean for a real investor using this model?

- Too many exceptions mean the model is underestimating risk.
- Investors may face more frequent losses than expected.
- This can lead to loss of trust in the model's accuracy.
- Investors may be surprised or unprepared during market downturns.
- The model may be unreliable for real-world risk management.
- It increases the chance of poor investment decisions based on false confidence.
- The model may need to be revised or replaced with a more realistic approach.

75. Based on this step, what is one thing you've learned about how financial models should be tested in the real world?

- Backtesting is essential because it shows whether a financial model actually works under real-world conditions.
- A model might look accurate in theory, but without testing it on historical data, there's no way to know how it performs during market ups and downs.
- Backtesting helps identify if the model is too optimistic, too cautious, or well-calibrated.
- It builds confidence in the model's predictions by checking how often it gets things right — like predicting losses through VaR.
- Most importantly, it prevents poor decisions by ensuring the model is realistic and reliable before it's used to guide investments.
- **In short:** Backtesting helps turn a model from just a mathematical idea into a **practical and trustworthy tool** for real financial decision-making.

76. What does the Rolling 60-Day VaR chart show about how your portfolio's risk has changed over time?

The Rolling 60-Day VaR Chart Shows:

- The **blue line** represents the **portfolio's 95% Value at Risk** calculated using a **rolling 60-day window**.
- It shows how the portfolio's **risk level has changed over time**, rather than staying constant.
- When the blue line goes **up**, it means **risk is increasing** — larger losses became more likely.
- When it goes **down**, the portfolio was **less risky** during that period.
- The **red dashed line** is the **static (fixed) VaR**, which doesn't change over time.

What it tells us:

- Portfolio risk is **not constant** — it **rises during volatile periods** (e.g., 2022–2023) and **falls in calmer markets** (e.g., parts of 2021 and 2024).
- The chart highlights the **importance of monitoring risk continuously**, as relying on a fixed VaR might **miss changes in actual market conditions**.

77. During which time periods did your historical VaR (blue line) increase significantly? What might have caused that?

Time Periods When Historical VaR Increased Significantly:

- **Late 2020 to early 2021**
- **Late 2021 to mid-2022**
- **Late 2024 to early 2025**

Possible Reasons for the Increases:

- These time periods likely coincided with **market volatility**, such as:
  - **Pandemic-related economic shifts**
  - **Rising inflation and interest rate changes**
  - **Tech stock corrections or earnings shocks**
  - **Geopolitical tensions or global uncertainty**

78. Compare the historical (rolling) VaR and the static VaR (red line). Was the static VaR always accurate? Why or why not?

- The static VaR (red line) stays constant over time, while the historical (rolling) VaR (blue line) changes with market conditions.
- The static VaR was not always accurate, especially during highly volatile periods.

Examples Where the Static VaR Missed Real Risk:

1. **Mid-2022 to early 2023**:
   - The **rolling VaR rose sharply above** the static line.
   - This means the actual market risk was **higher than what the static model predicted**.
2. **Late 2020 to early 2021** and **late 2024**:
   - The blue line again **spiked above the red line**, showing **sudden increases in downside risk**.
   - Static VaR did not adjust, so it **underestimated the potential losses**.
3. **2021 and 2024 (stable periods)**:
   - The rolling VaR fell **below the static line**, meaning the **model may have been too conservative** during calm periods.

79. Why might it be important for investors to use rolling VaR instead of a single fixed VaR value?

Why Rolling VaR Is Important for Investors:

- **Reflects current market conditions** – Rolling VaR updates with recent data, showing how risk changes over time, unlike a fixed VaR that stays the same.
- **Helps adjust strategies** – Investors can respond to rising or falling risk by rebalancing their portfolios, reducing exposure, or increasing cash holdings.
- **Captures sudden volatility** – Rolling VaR can quickly highlight periods of increased uncertainty (e.g., during a market crash or crisis), allowing for timely decisions.
- **Avoids false confidence** – A fixed VaR may underestimate risk during turbulent times, giving a misleading sense of safety.
- **Improves risk management** – Using rolling VaR allows for more proactive and responsive portfolio adjustments based on real-time data.

80. What did you learn about financial risk from this visualization? How would you explain it to someone new to investing?

Key Takeaways on Financial Risk from Visualizations:
This project helped me understand that financial risk is not fixed—it is fluid and influenced by market behavior. Through visual analysis, I learned the following:
• Risk levels vary over time depending on how the market is performing.
• Value at Risk (VaR) offers a quantifiable estimate of the maximum expected loss under typical conditions, given a specific confidence level (like 95%).
• Rolling VaR made it evident that risk isn't static; it increases during turbulent periods and decreases when markets are calm.
• Different methods—such as parametric approaches (normal and t-distributions) and historical analysis—produce varying results, stressing the importance of selecting a method that aligns with the nature of the data.
• Complementary tools like expected shortfall, drawdown analysis, and hypothesis testing enriched the assessment by providing insight into potential loss severity and the reliability of returns.

Explaining VaR to a Friend Who's New to Investing:
Value at Risk (VaR) is a measure that estimates how much you might lose on an investment within a specific timeframe under normal market conditions, and with a certain level of confidence.
For instance, if your 1-day 95% VaR is 2%, it means:
• You have a 95% chance of not losing more than 2% in one day.
• There's a 5% chance you could lose more than that.

VaR acts as a benchmark for potential losses—it doesn't predict exactly what will happen but offers a statistically informed limit.
Importantly, VaR adjusts with market conditions. When markets become more unpredictable, VaR rises.
That's why using **rolling VaR** is important—it updates the risk measure continuously based on recent data, giving a more timely and accurate view of risk as the market evolves.

81. What does it mean when data is "normally distributed"? Why is this important in financial modeling?

A **normal distribution** is a symmetric, bell-shaped curve where the majority of data points are concentrated around the average (mean), and the frequency of data points decreases as you move further from the center. In a normal distribution:
• Approximately 68% of data falls within one standard deviation of the mean.
• Around 95% lies within two standard deviations.
• Nearly 99.7% falls within three standard deviations.

This type of distribution assumes that extreme outcomes (very high or very low) are uncommon and occur infrequently.

Why It Matters in Financial Modeling:
• Many financial risk models—such as Value at Risk (VaR)—are based on the assumption that asset returns follow a normal distribution, which simplifies the calculations.
• However, if returns exhibit fat tails or other non-normal characteristics, these models might

underestimate the probability of large losses.
• Conducting normality tests helps determine whether the assumptions behind the model align with actual market data, ensuring more accurate and reliable risk assessments.

82. What did the p-value in your test result tell you? Was your return data close to a normal distribution or not?

• The p-value is well below the 0.05 threshold, indicating a statistically significant result.
• This suggests that the return data deviates from a normal distribution.
• As a result, the null hypothesis of normality is rejected.

Conclusion:
The return distribution of your portfolio is not normal, implying that risk models based on the bell curve—such as those using normal-distribution-based VaR—might underestimate actual risk, particularly during periods of extreme market volatility.

83. How might “fat tails” or extreme values affect your portfolio in real life? Why should an investor care?

How Fat Tails or Extreme Values Affect a Portfolio:
• Fat tails refer to the increased likelihood of extreme outcomes—large gains or losses—compared to what a normal distribution would predict.
• In reality, this means that sudden, significant market movements (like crashes or unexpected news) happen more frequently than standard models assume.
• Risk models that don’t consider fat tails may underestimate potential losses, leaving investors exposed and underprepared for major downturns.
Why This Matters to Investors:
• Fat tails can result in sharp, unexpected losses that may erase portfolio gains or even deplete capital.
• Being aware of fat tails enables investors to:
o Construct more robust and shock-resistant portfolios
o Adopt improved risk assessment tools (such as t-distribution-based or historical VaR)
o Avoid relying too heavily on the assumption that markets behave "normally"

84. Based on your results, would you trust a model that assumes a bell curve? Why or why not? What alternatives could you use?

• **No, I wouldn't completely rely on a model that assumes a normal (bell curve) distribution, based on my analysis.**
• The Jarque-Bera test produced a p-value of 0.000, indicating that the return data does not follow a normal distribution.

Why is this a concern?
• Models based on the bell curve often underestimate the likelihood of extreme losses.
• They can lead to inaccurate risk predictions, especially during periods of market stress or financial crises.
• Relying on such models might result in flawed investment strategies and insufficient risk preparedness.

What Are Better Alternatives?
• **VaR using Student's t-distribution:** Captures fat tails more effectively and accounts for rare but significant events.
• **Historical VaR:** Relies on actual return history and avoids making assumptions about the distribution shape.
• **Bootstrapping Techniques:** Enables the generation of confidence intervals through resampling, reflecting the true variability in the data