Portfolio Risk Assessment & 1-Day 95% VaR Calculation

A small investment firm needs to quantify the daily risk of its equity portfolio.

Key Learnings

1. Pull historical price data for a list of tickers.
2. Compute daily log-returns and summary statistics (mean, var, skew, kurtosis).
3. Fit Normal & Student's t distributions to returns.
4. Build 95% confidence intervals for the mean return and volatility.
5. Compute 1-day 95% VaR parametrically (Normal & t) and via historical simulation.
6. Test whether the mean return is significantly different from zero.

Project Overview

Goal: Quantify the daily risk of losing money in a simple four-stock portfolio.

Key concepts:

- **Log-returns**: how prices change day-to-day
- **Summary statistics**: average, variability, skewness, tail-heaviness
- **Value at Risk (VaR)**: a threshold loss you won't exceed 95% of the time
- **Confidence intervals**: ranges where true parameters likely lie
- **Hypothesis testing**: checking if the average return is different from zero

What to Submit:

Submission Type: Individual

Each student must submit the following:

1. **Jupyter Notebook (.ipynb file) or python filr (.py file)**
    a. Filename: YourFullName_var.ipynb (e.g., AnanyaKumar_ var.ipynb)
    b. Your notebook must follow the steps and structure discussed in class following the instructions in the submission guideline
2. **Word or PDF file**
    a. Answers "Questions for Report" in separate file

Required Sections and Instructions:

0. Install Dependencies and Libraries

Step 1: Set Up Your Lab Environment

Before you start analyzing financial data, you need to set up your working environment with the right tools — just like gathering your ingredients before cooking.

What You'll Do:

- Install the library that helps you fetch stock market data from Yahoo Finance.
- Import essential tools for working with data, doing math, plotting graphs, handling dates, and performing statistics.

Why This Step Matters:

This setup ensures that your notebook can:

- Pull live stock data
- Organize and clean it
- Create charts
- Perform financial and statistical calculations
- Show results clearly

Step 2: Understand What Each Tool Does

Let's briefly understand the role of each tool (or "library") you'll load:

Tool	What It Does	Why You Need It
Pandas	Helps organize data into tables (like Excel)	So you can filter, sort, and explore stock data
NumPy	Handles math and numbers	Useful for calculating returns, averages, standard deviation, etc.
Matplotlib	Makes charts and graphs	So you can visualize trends and risks in the data
Seaborn	Makes prettier graphs with themes and colors	Helps make your charts easy to read and professional-looking
pandas_datareader	A backup tool for downloading financial data	Used in case Yahoo Finance is down
datetime	Deals with dates and times	You'll need to set a start and end date for your stock data
scipy.stats	Provides statistical tools	For example: finding percentiles, z-scores, etc.
yfinance	Connects to Yahoo Finance to get real stock prices	This is your main data source
time	Adds delays or tracks time	Used to pause between data downloads (so you're not blocked)

Step 3: Set the Look and Feel of Your Graphs

- You will apply a **"white grid" theme** to all your graphs.
    - This makes your charts clean, readable, and professional.
- You'll also ensure that **all graphs appear right below your code** in the notebook (instead of popping out in a new window).

Why This Step Matters:

These two tweaks help you keep your notebook organized and visually appealing, especially when reviewing or sharing your work.

Questions for Report

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

Explain the real-life problem this project tried to solve. Briefly describe the steps you took to collect, clean, and analyze the stock market data.

2. Which tools and libraries did you use in this project, and what was the role of each?
Mention at least three Python tools (like Pandas, yfinance, Matplotlib, etc.) and explain how they helped you complete your analysis.

3. How did you calculate Value at Risk (VaR), and what does it tell us about financial risk?
Explain in simple words how VaR works, what it means in a real-world investment context, and what your result indicated.

4. What challenges or errors did you face while completing this project, and how did you overcome them?
Did any step confuse you or not work the first time? Share how you solved the problem or what you learned from it.

5. If you were to expand this project, what would you add or change?
Think creatively! Would you analyze more stocks? Use a different risk method? Compare companies or time periods?

1. Calculating Daily Log Returns from Stock Prices

What You're Doing:
You will now calculate the **daily log returns** of each stock in your portfolio. This is a crucial step that transforms raw stock prices into something more useful for analysis — the **daily percentage change** in price, adjusted using logarithms.

Why Are We Doing This?

- Stock prices alone don't tell us how much a stock really gained or lost in a day.
- **Log returns** give us a consistent way to measure daily changes across different stocks.
- Log returns are better for comparing performance and calculating financial risk.

Step 1: Look at Your Stock Price Table
You should already have a table (called a DataFrame) that contains:

- Rows: Dates (e.g., Jan 1, Jan 2, Jan 3…)
- Columns: Stock prices for each company (e.g., Apple, Google, Amazon)

Each cell tells you what the stock's price was on that day.

Step 2: Shift the Price Table by One Day
Now imagine you're making a copy of this table, but you move all the rows **down by one day**.
This new version shows you the **previous day's price** for every stock.
Why?
Because to find out how much a stock changed, you need to **compare today's price to yesterday's price**.

Step 3: Divide Today's Price by Yesterday's Price
Now go row by row, stock by stock, and do:
Today's Price ÷ Yesterday's Price
This gives you the **relative change** — how much the price went up or down compared to the day before.

Step 4: Take the Logarithm of Each Value
Next, apply something called the **natural logarithm** to every value in your result.
Why use logarithms?

- They help smooth out extreme values (like sudden jumps or drops).
- They make multi-day returns easier to combine.
- They're commonly used in professional finance and statistics.

Step 5: Remove the First Row (It Will Be Empty)
The very first row in your result won't have a value — because there was no "yesterday" to compare to.
So, you simply **remove this row** to clean up your table.

Step 6: Preview the Result
Now check the first 5 rows of your final table of log returns.
Each number shows you:

- How much a stock's price changed (up or down) on that day,
- In a consistent, comparable format — great for analyzing trends, volatility, and risk.

What This Step Achieves:
By the end of this step, you'll have a clean table of **daily log returns** for all your stocks — and this will become the **foundation** for later steps, like:

- Calculating average return and volatility
- Measuring Value at Risk (VaR)
- Analyzing risk in your portfolio

Questions for Report

1. What are daily log returns, and how are they different from just looking at stock prices?
Explain in simple terms what a log return means and why it's useful in a project like this.

2. Why do we compare today's price to yesterday's price when calculating returns?
Think about what this tells us about a stock's behavior from day to day.

3. What is the purpose of taking the logarithm of the return?
Share why we don't just use percentage change, and what benefit the log gives us.

4. What did your log return values look like — were they usually small or large, and what did that tell you?
Give a quick observation. Were the numbers close to 0? Mostly positive or negative? What does that mean about the stock's movements?

5. If your stock had a log return of -0.03 on a certain day, what does that tell you happened to the stock price?
Use your own words to describe what a negative return means for an investor on that day.

2. Visualizing Daily Log Returns (Stock Return Histogram)

Objective of This Step
In this step, you will **create a chart** that shows how a stock (like Apple) behaves on a daily basis — whether its price usually goes up or down, and by how much.
This is called a **log-return distribution**, and it helps us visually understand the **risk and stability** of a stock.

What You Will Achieve
By the end of this step, you will:
- See how often a stock's daily return is small, large, positive, or negative
- Understand if the stock is **stable or volatile**
- Get ready to measure financial risk (like Value at Risk or VaR)

Step 1: Choose the stock you want to analyze
Pick one company from your data — for example, Apple (AAPL). You'll use its log return values (the ones you calculated earlier) to create a chart.

Reminder: Log returns show how much the stock price changes from one day to the next — they are more accurate than just looking at price differences.

Step 2: Create a histogram
You'll now make a special chart called a **histogram**.
This chart will:
- Group daily return values into ranges (like: -3%, -2%, -1%, 0%, +1%, etc.)
- Count how many days fall into each range
- Stack those counts as vertical bars

The result will look like a "bell curve" if the stock is stable.

Step 3: Label the chart
Give your chart a clear title like:
"Apple (AAPL) Daily Log-Return Distribution"
This tells the viewer:
- What company it is
- What kind of data they're seeing (daily log returns)
- That this chart is about frequency — not stock price itself

Step 4: Look at the shape of the curve
Now that you have your chart, take a few moments to **analyze it**:
- Are most returns near 0? (That means the stock is stable)
- Are there more big losses or big gains?
- Does the chart look symmetrical? Or is one side "fatter"?

This shape tells you **how risky or safe** the stock is.

What This Step Teaches You

Concept	**What You Learn**
Distribution	How often each type of return occurs
Risk	If the stock usually moves a little, or a lot
Real-world insight	How to spot extreme moves or stable behavior just by looking at the shape of the curve

Why This Step Matters in the Project
This step is **crucial** because it:

- Transforms numbers into a picture
- Makes it easy to **see patterns** in daily returns
- Helps you **measure risk visually** before using formulas

Before you calculate financial risk (like Value at Risk), you need to **understand how the data behaves** — this chart gives you that understanding in one glance.

Tip:
Think of this chart as a "health check" for your stock.
It helps answer: "How much does this stock bounce around each day?"

Questions for Report

1. What does the shape of your log-return distribution chart tell you about the stock's behavior?
Was it mostly narrow and centered, or wide with a lot of variation? What does that mean?

2. Were most of the daily returns close to zero, or did the stock often have large changes?
Explain what this tells you about how stable or risky the stock is on a typical day.

3. Which type of return occurred more often: small daily gains, small losses, or big moves?
Look at the height and position of the bars. Which side of the chart had more frequent values?

4. Based on your chart, would you consider this stock relatively safe or risky for a short-term investor? Why?
Think about how predictable the returns are. Give a reason for your answer.

5. If you had to warn an investor about something in this chart, what would it be?
For example, is there a chance of sudden large losses? What should they be aware of?

3. Creating a Summary Table for Daily Stock Returns

Objective of This Step

In this step, you will build a **summary table** that gives you important insights into how each stock in your portfolio behaves — not just on one day, but across the entire time period.
You will calculate:

- The **average return** each day
- How much the return values **bounce up and down**
- Whether **gains or losses** are more common
- How often the stock makes **unusually large moves**

What You Will Learn
By completing this step, you will:

- Describe how a stock typically performs
- Identify which stocks are more stable or more risky
- Detect signs of rare or extreme behavior
- Prepare for more advanced risk calculations (like Value at Risk)

Step 1: Use the log return data you already calculated
Earlier in the project, you calculated **daily log returns** for each stock.
This gave you a table where:

- Each column represents a stock (like Apple or Microsoft)
- Each row represents a day
- Each value is the log return (how much the stock went up or down that day)

This return data is what you will summarize.

Step 2: Calculate the average return for each stock (Mean)
Think of this as the stock's **daily scorecard**:

- A higher average means the stock tends to go up
- A negative average means it tends to go down

This helps you spot which stock has been most profitable over time.

Step 3: Measure how much the return varies (Variance)
This tells you how **bumpy the ride is**:

- High variance = the stock is jumpy or unpredictable
- Low variance = the stock is calm and steady

Variance is a basic measure of **risk**.

Step 4: Check if gains or losses are more common (Skewness)

- **Positive skewness**: The stock has more small losses and rare big gains
- **Negative skewness**: The stock has more small gains and rare big losses

Skewness helps you understand the **direction of risk**.

Step 5: Look for signs of extreme moves (Kurtosis)

- High kurtosis = the stock sometimes makes **very big jumps or crashes**
- Low kurtosis = returns are more **normal and predictable**

This is useful when preparing for rare events like market crashes.

Step 6: Organize your findings in a summary table
You will create a neat table showing each stock's:

- Mean
- Variance
- Skewness
- Kurtosis

This will let you compare all your stocks side-by-side.

What Your Table Will Look Like

Stock	Mean	Variance	Skewness	Kurtosis
AAPL	...	...	...	...
MSFT	...	...	...	...
GOOGL	...	...	...	...

Each number tells you something about that stock's **performance and behavior**.

Why This Step Is Important

This is your first real look into:

- How **profitable** a stock is
- How **risky** it is
- Whether it behaves **normally or unpredictably**

You're no longer just looking at prices — you're thinking like a **data-driven investor** or **financial analyst**.

Tip:

Think of this table as a "report card" for your stocks —
It tells you which ones are top performers, and which ones you might want to be cautious with.

Questions for Report

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

Did this stock generally go up more than the others? How might that affect your investment decision?

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

Think about how much that stock's daily returns go up and down. Is it stable or more unpredictable?

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

If a stock is negatively skewed, is it more likely to have sudden drops or sudden gains? Explain in your own words.

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

Are extreme returns (like big jumps or crashes) common or rare? What does that mean for risk?

5. Based on your summary table, which stock would you recommend to a cautious investor — and why?
Consider return, risk (variance), and stability (skewness/kurtosis) when answering.

4. Fitting a Normal Distribution and Calculating Confidence Intervals

4.1

Objective of This Step
In this part of your project, you will:

- Estimate the **average daily return** and **standard deviation** (risk level) of all the stocks in your dataset.
- Assume that stock returns follow a **normal distribution** (bell curve).
- Calculate **95% confidence intervals** to understand how reliable your estimates are.

What You'll Learn by Doing This
By completing this step, you will learn to:

- Summarize a large set of return data using just two numbers: **mean** and **standard deviation**
- Understand how **statistical confidence** works in finance
- Identify the **range of uncertainty** in your estimates — which is critical for real-world investing

Step 1: Combine All Your Return Data
You previously calculated **daily log returns** for each stock. Now, imagine stacking them all together into one big list.
Why? This gives you a large sample of return values to analyze the **overall behavior of the market or portfolio**.

Step 2: Find the Average Return (μ)
Calculate the **mean** (average) of all the returns:

- This shows you the typical daily gain or loss.
- A positive number = gains are more common.
- A negative number = losses are more common.

This is the "center" of your return distribution.

Step 3: Find the Standard Deviation (σ)
Next, calculate the **standard deviation**:

- This measures how much the returns go **up and down** around the average.
- A small value means the stock returns are **stable**.
- A large value means the stock is more **volatile** or risky.

Think of this as the "spread" of your return bell curve.

Step 4: Calculate the 95% Confidence Interval for the Mean

You now want to figure out a **range** where you're 95% confident the true average return lies.
You'll use the formula:
Mean ± (margin of error)
The margin of error depends on:

- The size of your dataset (more data = smaller margin)
- The standard deviation (more risk = bigger margin)
- A **z-value** (which comes from the normal distribution table; for 95% confidence it's ~1.96)

This step answers: "If I repeated this analysis again, how much could the average change?"

Step 5: Calculate the 95% Confidence Interval for the Standard Deviation
Just like the mean, your estimate of risk (σ) also has some uncertainty.
To calculate a range for it, you'll use a different statistical tool called the **Chi-square distribution**.
This step gives you a **low and high bound** showing how much the risk could vary.
This step answers: "How much could my risk estimate be off?"

Step 6: Record Your Results
Once you have:

- The average return (μ)
- The standard deviation (σ)
- The 95% confidence interval for each

…summarize them clearly in your report.
This will serve as the basis for your **Value at Risk (VaR)** calculation coming next!

Why This Step Is Important

What You're Doing	Why It Matters
Calculating mean (μ)	Helps understand how profitable your stocks are
Calculating standard deviation (σ)	Helps measure daily risk and volatility
Calculating 95% confidence intervals	Helps show **how certain** you are about your numbers

Tip:
In real life, investors never just ask "what's the average?" — they ask:
"How much could the average change if I repeated this tomorrow?"
That's exactly what confidence intervals help you answer.

Questions for Report

1. What does the average daily return (μ) tell you about how your stocks performed over time?
Is the average return positive or negative? What does that mean for an investor holding these stocks?

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

Did the returns move around a lot from day to day, or were they mostly stable?

3. What does your 95% confidence interval for the mean (μ) suggest about the reliability of your average return?
Is the range wide or narrow? Do you feel confident in your estimate based on that range?

4. Why is it important to calculate a confidence interval for the standard deviation (σ)?
Think about how this helps you understand how accurate your risk estimate really is.

5. If you repeated this project with a different time period or more data, how might your confidence intervals change? Why?
Consider how sample size affects your certainty.

4.2 Fitting a Student's t-Distribution to Stock Returns

Objective of This Step
In this step, you will:

- Combine all your daily return data into one list
- Fit a **Student's t-distribution** to this return data
- Estimate the key parameters: average return (μ), standard deviation (σ), and shape of the tails (degrees of freedom, df)

Why You're Doing This
Most of the time, we assume stock returns follow a **normal distribution** (a perfect bell curve). But in the real world, markets behave differently — with **occasional big spikes or crashes**.
The **Student's t-distribution** is better at handling these extreme events. It helps you:

- Capture rare, high-impact returns (both gains and losses)
- Build **more realistic risk models**, especially for calculating Value at Risk (VaR)

Step 1: Prepare your return data
You've already calculated daily log returns for each stock.
Imagine stacking all the return values — from every stock and every day — into one big list.
You're now treating the entire dataset as one large collection of real market behavior.
This makes it easier to see overall patterns, especially when fitting a distribution.

Step 2: Fit a Student's t-distribution
Now you're going to fit a curve (called the **t-distribution**) to the data. This curve shows how often different types of returns (small or large) occur.
The computer will find the **best match** by adjusting three things:

Parameter	What It Means
μ (mu)	The average daily return (center of the curve)
σ (sigma)	The spread of returns (how risky or volatile it is)
df (degrees of freedom)	How "fat" the tails of the curve are. Fewer degrees of freedom = more chance of extreme events.

This is like telling Python:
"Fit the best bell-shaped curve that allows for big shocks — not just a smooth one like the normal distribution."

Step 3: Interpret the results
Once the curve is fitted, you will get values for:

- **Mean (μ)** — tells you whether your returns are typically positive or negative
- **Standard deviation (σ)** — shows how much the returns vary from day to day
- **Degrees of freedom (df)** — shows how **realistic your model is**: low df = heavy tails = more extreme events expected

Why This Step Is Important

What You Learn	Why It Matters
How your stock returns behave overall	Helps in building smarter, more realistic models
Whether normal distribution is enough	Real returns often need fatter tails (t-distribution)
How to prepare for big risks	This step improves your ability to model sudden crashes or jumps

Tip:
If the normal distribution is like **a calm forecast**, the t-distribution says:
"Things are usually normal... **but sometimes, they get wild. Be ready.**"

Questions for Report

1. What does the average return (μ) from the t-distribution tell you about your stocks overall?
Is it positive or negative? What does that suggest about your portfolio's daily performance?

2. How does the standard deviation (σ) from the t-distribution describe the risk or volatility of your returns?
Did the returns fluctuate a lot or stay close to the average most of the time?

3. The t-distribution includes a value called degrees of freedom (df). What does a low df value tell you about your return data?
Hint: Think about how often large spikes or crashes happen.

4. Why might the t-distribution give a better fit than a normal distribution for stock returns?
Use your understanding of real stock behavior to explain your answer.

5. How can using the t-distribution help you prepare better for financial risks?
Think about rare events like a sudden market drop — how does this model help investors?

5. Estimating Confidence Intervals Using Bootstrapping

Objective of This Step
In this step, you will use a powerful technique called **bootstrapping** to calculate **95% confidence intervals** for the **mean return (μ)** and **standard deviation (σ)** of your stock returns — using the **Student's t-distribution**.
This helps you answer:
"How much could my estimates of return and risk vary if I had slightly different data?"

Why This Step Matters
Earlier in the project, you fit a t-distribution to your return data and calculated a single value for:

- The average return (μ)
- The standard deviation (σ)

But in the real world, your data is only **a sample** of many possible outcomes.
Bootstrapping helps you **simulate many alternate realities**, to see how much your results might change if history had gone slightly differently.

Step 1: Combine All Return Data into One List
Start with the full set of daily return values from all your stocks.
Imagine stacking them into one long list, like one big sample of all the stock market behavior in your project.
This gives you the dataset you'll use to simulate new "what if" scenarios.

Step 2: Resample the Data Many Times (This is Bootstrapping)
You will now **create 1,000 simulated datasets** by randomly picking values from your original list.
Each simulated dataset will:

- Have the same number of return values as the original
- Be created by picking values at random, with replacement (so some values may appear more than once)

Why? This lets you explore **how your results might vary** if you had slightly different data.

Step 3: Fit a Student's t-Distribution to Each Sample
For every simulated dataset (1,000 in total), fit a **t-distribution** and record:

- The estimated **mean (μ)**
- The estimated **standard deviation (σ)**

This gives you 1,000 different possible answers for each parameter.

Step 4: Extract the 95% Confidence Interval
Once you have all 1,000 simulated values for μ and σ:

- Sort them from smallest to largest
- Find the values that sit at the **2.5th percentile and the 97.5th percentile**

These values form your **95% confidence interval**:

- For **μ** (mean): "We are 95% sure the true average return falls between these two numbers."

- For **σ** (standard deviation): “We are 95% sure the true risk level falls between these two numbers.”

Step 5: Write Down Your Findings
In your project report, include:

- The **estimated mean (μ)** and its 95% confidence interval
- The **estimated standard deviation (σ)** and its 95% confidence interval

This gives your analysis statistical depth — you’re no longer just guessing one number; you're presenting a range where the true value likely lies.

What You Learn in This Step

Concept	What It Means for You
Bootstrapping	A way to simulate many “what if” scenarios using your data
Confidence interval	A range where you expect the true answer to lie with high confidence
Statistical thinking	Understanding that data-based answers come with uncertainty — and that’s okay!

Tip:
Think of this like asking:
“If I could rerun history 1,000 times, how different would my average return and risk look?”
Bootstrapping gives you that answer — and makes your conclusions **stronger and more reliable**.

Questions for Report

1. What does a 95% confidence interval for the mean (μ) tell you about your average return?
How does this range help you understand the reliability of your return estimate?

2. 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?
Try to explain how a wide or narrow range changes how confident you feel about your result.

3. Why do we use bootstrapping instead of calculating just one estimate?
Think about how bootstrapping helps us simulate different versions of history using the same data.

4. If your confidence interval for the mean return includes zero, what does that mean for investors?
Hint: A return of zero means no profit or loss — is that good or risky?

5. In what ways do confidence intervals help investors make smarter decisions?
Use simple examples from your project to support your answer.

6. Estimating Portfolio Risk and Value at Risk (VaR) Using a Normal Distribution

Objective of This Step
In this part of your project, you will:

1. Combine individual stock returns into a single **portfolio return**
2. Calculate the portfolio's **average daily return** and **daily risk (volatility)**
3. Estimate the **worst-case daily loss (VaR)** at the **95% confidence level**

This helps you answer the question:
"How much money could I lose on a typical day if the market turns against me — and how likely is that?"

What You'll Learn by Doing This
By completing this step, you will:

- Understand how to measure return and risk at the portfolio level
- Learn how to apply statistics to a real-world investing question
- Gain insight into the concept of **Value at Risk (VaR)**, a widely used risk measure in finance

Step 1: Combine Individual Stock Returns into One Portfolio Return
You've already calculated the **daily log returns** for each stock in your portfolio.
Now, imagine multiplying each stock's daily return by the **percentage of your money invested in that stock**.
Then, add them together for each day.
For example, if you have:

- 25% in Apple
- 25% in Google
- 25% in Microsoft
- 25% in Amazon

You calculate a new return for each day by **mixing the stock returns** based on those weights. This gives you the **portfolio's daily return**.

Step 2: Calculate the Portfolio's Average Return and Risk
Now, calculate two important numbers:

- The **average return** across all days → this shows the portfolio's **typical daily gain or loss**
- The **standard deviation** (volatility) → this tells you **how much the daily return moves up or down**

A higher standard deviation means **more risk**, because the return is more unpredictable.

Step 3: Estimate the "Worst-Case" Scenario with 95% Confidence (VaR)
To measure **Value at Risk**, you'll now use a statistical approach:

- You assume the portfolio's returns follow a **normal distribution** (bell curve)
- You calculate how much the return could drop on a "bad day" — one that would only happen **5% of the time or less**

This is done by:

- Using a statistical value called the **z-score** (for 95% confidence, this is about –1.645)
- Combining the z-score, average return, and standard deviation in a formula

The result is your **1-day VaR at 95% confidence**.

Step 4: Interpret the Result
Let's say your VaR result is **0.015** (or 1.5%).
That means:
"There is a 95% chance that my portfolio **won't lose more than 1.5% in a single day** — but a 5% chance that it could lose **more than that**."
This helps you understand **how risky** your portfolio is, in a single, meaningful number.

Why This Step Is Important

Concept	What It Helps You Do
Portfolio return	See how your investments behave together
Standard deviation	Measure how volatile your returns are
Value at Risk (VaR)	Estimate how much you could lose on a bad day

Tip:
Think of VaR like **your investment alarm bell** — it tells you how bad a loss might be before you panic.
If your VaR is too high, it may be time to **rethink your strategy**!

Questions for Report

1. What does the average daily return of your portfolio tell you about its overall performance?
Was it positive or negative? What might this mean for your investment over time?

2. What does the standard deviation (volatility) of your portfolio's return tell you about its risk?
Was the portfolio stable or did it show big changes day to day?

3. What does your 95% Value at Risk (VaR) result mean in simple terms?
Try to explain what your number says about the worst-case loss that could happen on a bad day.

4. Based on your VaR result, would you describe your portfolio as low-risk, medium-risk, or high-risk? Why?
Think about how big the potential loss is and how often it might happen.

5. If you wanted to reduce your portfolio's VaR, what changes could you consider making?
Hint: Think about diversification, weights, or choosing less volatile stocks.

7. Calculating Value at Risk (VaR) Using Student's t-Distribution

Objective of This Step
In this step, you will calculate the **Value at Risk (VaR)** for your portfolio using the **Student's t-distribution**.
This helps you answer the important financial question:
"How much money could I lose in one day — in a worst-case scenario — based on real market behavior?"

Why Use the Student's t-Distribution Instead of the Normal Distribution?
The **normal distribution** assumes returns are smooth and stable.
But in real life, stock markets sometimes **crash or spike suddenly**.
The **t-distribution** is a better fit because:

- It has **fatter tails**, meaning it expects rare events (like big losses) more often
- It gives a more **realistic estimate of risk**

So, you're now switching to a model that better prepares you for **extreme losses**.

Step 1: Use the average return (μ) and standard deviation (σ) you calculated earlier
You've already fitted the **Student's t-distribution** to your full list of daily returns.
From that, you got:

- **μ (mu)** = the average return
- **σ (sigma)** = the standard deviation of return
- **df** = degrees of freedom (controls how fat the tails of the distribution are)

These are the **inputs** for your VaR formula.

Step 2: Identify the 5% cutoff for a "worst-case day"
In a 95% VaR calculation, we are asking:
"What's the return so low that only 5% of days fall below it?"
To find that cutoff point, you use the **t-distribution table** and the degrees of freedom from your data.
This gives you a **negative number** — it marks the **lowest 5%** of possible daily outcomes.

Step 3: Calculate the 1-day VaR using the formula
Now you plug your values into this formula:
$VaR = -(\mu + \sigma \times t_{0.05})$
Where:

- μ = average return from the t-distribution
- σ = standard deviation from the t-distribution
- $t_{0.05}$ = t-distribution value at the 5% level (left tail)
- The **minus sign** makes it a positive number, because VaR is expressed as a potential **loss**

This gives you a number that tells you:
"On a really bad day, there's a 5% chance I could lose this much or more."

Step 4: Interpret the result
Let's say your calculated VaR is **0.018** (or 1.8%).
That means:

“There is a 95% chance I will not lose more than **1.8%** of my portfolio’s value in one day — but a 5% chance I could lose more.”
You’ve now **quantified risk** using a distribution that matches the real-world behavior of markets better than the normal curve.

What You’ve Achieved

Concept	What It Helps You Understand
Student’s t-distribution	Realistic modeling of extreme market movements
VaR (Value at Risk)	How much you could lose, and how often
Confidence in your estimate	A risk number based on your portfolio and real data

Tip:
Investors don’t just ask, “How much can I make?”
They always ask, **“How much could I lose — and how likely is it?”**
This step gives you the tools to answer that like a data-driven risk manager.

Questions for Report

1. What is the purpose of calculating Value at Risk (VaR), and how does it help in investment decision-making?
Explain what VaR tells you about your portfolio and why it's useful.

2. Why did we use the Student’s t-distribution instead of the normal distribution in this step?
Think about how financial markets sometimes behave — do they always follow smooth, predictable patterns?

3. What does your 95% 1-day VaR result mean in simple terms?
If your VaR is, for example, 2%, what does that say about your potential losses?

4. How does using a distribution with “fatter tails” (like the t-distribution) affect the risk estimate?
Does it make the risk look smaller or larger? Why might that be a good thing for cautious investors?

5. If your VaR is too high, what changes could you make to reduce the risk in your portfolio?
Think about portfolio diversification, reducing weights, or choosing different stocks.

8. Estimating Value at Risk (VaR) Using Historical Returns

Objective of This Step
In this step, you will estimate how much of your investment you could lose on a very bad day by using **historical return data** from your own portfolio.
This risk estimate is called **Historical Value at Risk (VaR)** at the **95% confidence level** — a method that uses **real data** rather than assumptions or distributions.

Why This Step Matters

Most financial models use mathematical assumptions (like bell curves) to estimate risk. But in real life, markets don't always behave perfectly. Instead of guessing, this step uses **actual past returns** from your portfolio to ask:

"How bad were the worst days in my dataset — and what can I learn from them?"

Step 1: Make sure you have your portfolio's daily return data

By now, you should have already:

- Chosen your portfolio of stocks
- Calculated each stock's daily return
- Combined them into one series of **daily portfolio returns**

Think of this as a list showing **how much your total investment went up or down each day**.

Step 2: Sort the daily returns from worst to best

Arrange all the daily return values in **ascending order** — so that the **worst days appear at the top**.

This helps you quickly see the **lowest (most negative) returns** in your portfolio's history.

Step 3: Find the 5th percentile return

Now ask:

"What return is so low that only 5% of the days were worse than it?"

This is called the **5th percentile return**, and it means:

- On 95% of the days, your portfolio did better than this
- On 5% of the days, it did worse

This number is **your cutoff for a "bad day"**.

Step 4: Express the result as Value at Risk (VaR)

Since the 5th percentile return is usually a negative number (e.g., –2%), we turn it into a **positive value** to report it as a **potential loss**.

So:

- If the 5th percentile return is –0.022 (–2.2%), your **VaR is 2.2%**
- You say:

"There's a 5% chance I could lose **at least 2.2%** in one day."

This is your **Historical Value at Risk (VaR)** — based entirely on actual return data.

What You've Learned

Concept	**What It Tells You**
Historical VaR	A risk estimate based on past performance
5th percentile return	Your "bad day" threshold
Confidence level	95% of the time, losses won't exceed this amount
No assumptions	You used real data, not a mathematical model

Tip:

This is like looking back at your worst days in the market and asking:

"How bad did it get? What's the worst I should prepare for?"

Historical VaR is **simple, real, and powerful** — it gives you a reality check, not just a theory.

Questions for Report

1. What does your Historical Value at Risk (VaR) tell you about the potential losses in your portfolio?
Explain in your own words what your final VaR result means for an investor.

2. Why do you think Historical VaR is a useful way to measure risk?
Hint: Think about how it uses actual return data instead of a theoretical model.

3. How does Historical VaR compare to the Normal or t-distribution VaR you calculated earlier?
Which one gave a higher risk estimate? What might be the reason for that?

4. If your VaR is large (e.g., more than 3%), what does that say about your portfolio's risk level?
Would you describe your portfolio as high-risk, and why?

5. Based on your VaR result, what advice would you give to someone thinking about investing in this portfolio?
Consider how often big losses might happen, and how much they could lose.

9. Testing If Your Portfolio Return Is Statistically Significant

Objective of This Step
In this step, you will use a **one-sample t-test** to find out whether your portfolio's **average daily return** is **significantly different from zero** — in other words, you will test if your investment is truly making or losing money, or if it could just be random chance.

Why This Step Matters
Sometimes a portfolio might show a small gain or loss just by luck.
This test helps you answer an important question:
"Is my portfolio **really** earning returns, or could this just be **statistical noise**?"
This is your first taste of **hypothesis testing** in finance — a powerful tool for data-driven decisions.

Step 1: Understand the question you're testing
You're testing a **hypothesis** about your portfolio:

- **Null Hypothesis (H_0):** The average return is 0 (no gain or loss)
- **Alternative Hypothesis (H_1):** The average return is **not** 0 (either gain or loss)

You want to see if your data gives enough **evidence** to reject the idea that you're just breaking even.

Step 2: Use the one-sample t-test
You will run a **t-test** using your daily return values.
The t-test will give you:

- A **t-statistic** — which tells you how far your average return is from 0
- A **p-value** — which tells you how likely it is to get this result **by chance** if your true return was actually zero

Step 3: Interpret the p-value
Now check your **p-value**:

- If the **p-value is less than 0.05**:
  You have strong evidence to say your average return **is significantly different from zero**
  Conclusion: Your portfolio is **not just breaking even** — something meaningful is happening
- If the **p-value is 0.05 or more**:
  You **don't have enough evidence** to say the return is different from zero
  Conclusion: Your portfolio may just be producing returns by **random chance**

Step 4: Record your result
Write down:

- The **t-statistic**
- The **p-value**
- Your final conclusion:
  Do you **reject** or **fail to reject** the null hypothesis?

What You've Learned

Concept	What It Means
t-test	A way to test if your results are statistically different from a benchmark (like zero)
p-value	The probability your result happened just by chance
Statistical significance	Confidence that your returns are real, not random
Hypothesis testing	A scientific way to check your assumptions about performance

Tip:
Just because your portfolio made money doesn't mean it's impressive — maybe it was just luck.
This step helps you check if your performance is **real and reliable** using statistics.

Questions for Report

1. What was the goal of the t-test you performed on your portfolio's returns?
Explain in your own words what the test is trying to find out.

2. What did your p-value indicate about your portfolio's performance?
Was it below 0.05 or above? What does that mean about the likelihood your return is just due to chance?

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

Write your conclusion in simple terms — is the return significantly different from zero?

4. Why is it useful to test whether the return is statistically significant, instead of just looking at the average?
Think about whether a small return can be trusted as meaningful or not.

5. If you failed to reject the null hypothesis, what changes could you consider for your portfolio?
Hint: Would you keep your investments the same, or make adjustments to improve performance?

10. Analyzing Correlation and Diversification Benefit in Your Portfolio

Objective of This Step
In this step, you will:

1. **Visualize** how the stocks in your portfolio move together
2. **Measure** how much combining different stocks has reduced your overall portfolio risk

This helps you understand **how well-diversified your portfolio really is**—and whether it's doing its job of **protecting you from risk**.

Step 1: Calculate How Each Stock Moves with the Others (Correlation Matrix)
Imagine you have a chart that compares each stock in your portfolio to every other one. For each pair, you measure how closely they move together from day to day.
This chart is called a **correlation matrix**.

- A value of **1.0** means two stocks move **exactly the same**
- A value of **0** means they move **independently**
- A value of **–1.0** means they move in **opposite directions**

You will create a **colorful grid (heatmap)** to visualize this, where:

- **Red** or **orange** means strong positive correlation (move together)
- **Blue** means negative correlation (move opposite)
- **White/light colors** mean weak or no correlation

This helps you **see at a glance** whether your stocks are too similar.

Step 2: Measure Individual Risk for Each Stock
You now calculate how much each stock's price fluctuates—this is called its **volatility**, or **standard deviation (σ)**.
Think of σ as how "bumpy" the ride is for that stock:

- Higher σ = more ups and downs = more risk
- Lower σ = more stable

Step 3: Calculate the Risk You Would Have Without Diversification
Now you estimate what your **portfolio's risk would be** if each stock acted **independently** (with no diversification).

This is done by taking a **weighted average** of the individual risks, based on how much money you've invested in each stock.

Step 4: Compare With Actual Portfolio Risk
Earlier, you calculated your **portfolio's real risk**—how much its daily return moves around. Now you compare the two:

- **Weighted average risk (without diversification)**
- **Actual portfolio risk (with diversification)**

The **difference** between these two values is your **diversification benefit**.

Step 5: Interpret the Results
Ask yourself:

- Is your actual portfolio risk **lower** than the weighted average risk?
- If yes, congratulations! Your portfolio is benefiting from **diversification**.
- How big is the difference? A bigger difference means **stronger diversification**.
- If the stocks in your heatmap had **very high correlations** (close to 1), you may not be as diversified as you thought.

What You've Learned

Concept	What It Means
Correlation	Shows how similar stock movements are
Diversification	Reduces total risk by combining different types of assets
Standard deviation (σ)	Measures how much a return goes up or down
Diversification benefit	The amount of risk you avoid by mixing assets

Tip:
Good investors don't just pick good stocks.
They pick **stocks that work well together**, so that **when one falls, another might hold steady or rise**. That's the real power of diversification.

Questions for Report

1. Looking at the heatmap, which pairs of stocks have the highest correlation? What does this mean about how they move together?
Explain in simple terms how similar these stocks are in their daily movements.

2. Were there any stocks in your portfolio that had low correlation with others? Why might this be helpful for diversification?
Hint: Low correlation can help reduce overall risk.

3. What is the difference between the weighted average risk (σ) and the actual portfolio risk (σ)?
Use the values you got in your results. What does this difference tell you?

4. What does the diversification benefit value mean for your portfolio? Was it large or small? What could you do to increase it?
Think about adding different kinds of stocks or assets.

5. Based on your analysis, how well-diversified is your portfolio? What changes (if any) would you suggest to improve it?
Give a simple recommendation for making your portfolio more balanced or less risky.

11. Measuring and Visualizing Portfolio Growth & Drawdown

Objective of This Step
In this step, you will:

- Track how your portfolio grows over time (cumulative return)
- Identify the biggest drop your portfolio experienced (maximum drawdown)
- Visualize both growth and drawdowns on a graph

This helps you understand both the **performance** and the **risk journey** of your investments.

Why This Step Is Important
Most people only look at **how much money they made**. But smart investors also want to know:

- “How bad did things get when the market dropped?”
- “How long did it take to recover from a fall?”
- “Can I emotionally handle this level of risk?”

By calculating drawdown, you’re going beyond profit — you're learning how to measure **pain and patience** in real investing.

Step 1: Calculate the Cumulative Return of the Portfolio
You’ll now build a running total of how much your money would grow **day by day** if you started with ₹1 or $1.
This is called the **cumulative return**, and it helps you see the **overall growth path** of your portfolio from start to finish.
Imagine multiplying each day’s return by the day before, like stacking bricks of growth.

Step 2: Track the Highest Portfolio Value So Far
Now go through the cumulative return data and find the **highest point reached up to each day**.
This tells you, “What was the best my portfolio had ever done up to this point?”
You're building a **"peak tracker"**, so you can later see when the portfolio fell from those highs.

Step 3: Calculate Drawdown
A **drawdown** is the difference between the highest value (peak) and the current value, expressed as a percentage.
You’ll now measure, day by day, **how far the portfolio has fallen from its peak**.
This tells you:

- How deep the fall was
- How long it lasted

Step 4: Identify the Maximum Drawdown
Now find:

- The **largest drop** (worst fall from a high to a low)
- The **start date** (when the portfolio hit its peak)
- The **end date** (when the portfolio hit its lowest point after that)

This is your **maximum drawdown** — the most stressful drop an investor would have experienced.

Step 5: Visualize the Portfolio and Drawdowns
You'll now create a **line chart** that shows:

- The **portfolio's growth over time** (as a line)
- The **drawdowns** (shaded in red), showing how far the portfolio dropped from its highest points

This helps you see, at a glance:

- When the biggest fall happened
- How often your portfolio went through tough times
- Whether it recovered quickly or took a long time

What You've Learned

Concept	What It Means
Cumulative return	Total growth of your portfolio over time
Drawdown	A fall from peak value — shows real-world stress
Max drawdown	The worst drop experienced — a key risk metric
Visualization	Makes it easy to understand the emotional roller coaster of investing

Tip:
Investing isn't just about **how high your portfolio climbs**, but also about **how deep it can fall — and how fast it can recover**.
This step helps you become a smarter and calmer investor by **measuring both growth and risk**.

Questions for Report

1. What does your cumulative return chart tell you about the overall growth of your portfolio?
Was it mostly increasing? Did it face big drops? Summarize the journey in your own words.

2. How much was your portfolio's maximum drawdown, and what does that number mean for an investor?
Explain the biggest drop your portfolio experienced and why it matters.

3. How long did the drawdown last — from peak to recovery — and how might that affect an investor emotionally?
Think about how someone would feel watching their investment fall and recover over months.

4. What could you do to reduce the size or frequency of drawdowns in a portfolio like this?
Hint: Consider diversification, adding stable assets, or changing sector exposure.

5. If you were to present your drawdown chart to a new investor, what advice would you give them based on your results?
Share one tip about risk or patience that you learned from this step.

13. How Bad Can Losses Get on Really Bad Days?

Objective of This Step
In this step, you will:

- Understand how much your portfolio might lose **on average** during the **worst 5% of market days**
- Compare this risk using **two different methods**: one based on **real historical data** and one based on a **theoretical model** (normal distribution)

This gives you a more complete picture of how your portfolio behaves during market downturns.

Step 1: Focus on the Worst Days
You've already calculated daily returns for your portfolio.
Now, imagine lining up those daily returns from **worst to best**. You'll look at the **bottom 5% of days** — the really bad ones.
These are the days where the market drops sharply — crashes, corrections, or panic.

Step 2: Calculate the Historical Expected Shortfall
Here's what you do:

- From your actual return data, pick out the **worst 5% of days**
- Find the **average loss** on those days

This is called the **Historical Expected Shortfall**.
It answers:
"Based on past data, **how much did I lose on average** during the most painful days?"
This is a **data-driven view of risk**.

Step 3: Estimate Expected Shortfall Using a Model (Normal Distribution)
Now do the same thing — but instead of using real data, you use a **theoretical bell curve** (normal distribution).
You already know your portfolio's:

- **Average daily return**
- **Standard deviation** (how much it moves up or down)

Using those numbers, you apply a **mathematical formula** that estimates what the average loss would be **if the market behaved perfectly normally**.
This is called the **Parametric Expected Shortfall**.

Step 4: Compare the Two Results
You now have:

- One value based on **what actually happened**
- One value based on a **theory of how the market "should" behave**

Often, the historical number is **higher** — because real markets can be more extreme than a smooth curve.

Step 5: Interpret the Results

Ask yourself:

- Which number is larger?
- What does that say about **real-world risk**?
- Do you feel comfortable with that level of potential loss?

This step helps you make better decisions about:

- Your **investment choices**
- Your **comfort with risk**
- Whether your portfolio needs **more diversification** or adjustment

What You've Learned

Concept	What It Means
Expected Shortfall	The average loss during the worst-case days
Historical ES	Based on what really happened in your portfolio
Parametric ES	Based on a mathematical model of how markets behave
Real vs. Theoretical Risk	Shows if your model is underestimating how bad things can get

Tip:

Value at Risk says, "Here's where the danger starts."

Expected Shortfall says, "If you fall into that danger zone, **here's how much you're likely to lose**."

This step gives you a more **realistic view of downside risk** — the kind of information investors need to **prepare, not panic**.

Questions for Report

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

Explain what ES means and why it's different from just looking at average returns.

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

Did your portfolio perform worse in reality than what the model predicted?

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

Think about how markets behave in real life versus how they behave in a smooth, "ideal" model.

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

Hint: Think about diversification, asset selection, or risk tolerance.

5. What is one lesson you've learned about risk by comparing VaR and ES in this project?
Try to explain why it's helpful to look beyond just "how likely a loss is" and also ask "how big could it be?"

14. Backtesting Your VaR Model – Does It Really Work?

Objective of This Step
In this step, you will test how accurate your **Value at Risk (VaR)** prediction is by comparing it with **what actually happened** in your portfolio's historical data.
This process is called **backtesting** — and it helps you find out:
"Did the model's warning about possible losses match reality?"

Step 1: Review Your VaR Estimate
From earlier in the project, you already calculated your portfolio's **Value at Risk (VaR)** at the **95% confidence level**.
That means:
"On any given day, I expect to lose more than this amount on **only 5% of days**."
So now, you want to check:
Was that 5% estimate accurate in real life?

Step 2: Go Through Your Historical Daily Returns
You already have a list of **daily portfolio returns** (how much your investment went up or down each day).
You'll now check, **day by day**, whether your actual return **dropped below the VaR threshold**.

Step 3: Count the Number of "Exceptions"
An **exception** is a day where your **actual loss was worse than the VaR prediction**.
For example:

- If your VaR says "worst-case loss is –2%,"
- And one day your portfolio lost –3%,
- That day is an **exception**

You count how many such exceptions occurred during the total number of days in your dataset.

Step 4: Calculate the Exception Rate
Now calculate the percentage of exceptions:
Number of exception days ÷ Total number of days × 100
For example:

- If you had 1,343 days of data and 67 exceptions:

67 ÷ 1,343 = **4.99%**
This tells you:
"Only 4.99% of days were worse than my VaR model expected."

Step 5: Compare the Result to the Expected 5%
Ask yourself:

- Is the exception rate **close to 5%**?

- If yes — 🎉 your model is doing a good job!
- If much higher — 🚨 your model is **underestimating risk**
- If much lower — your model might be **too conservative**

What You've Learned

Concept	What It Means
VaR backtesting	Testing if your risk estimate matches actual past performance
Exception	A day when your loss was worse than what VaR predicted
Exception rate	Helps measure how often your model "missed" reality
Model validation	Builds confidence (or uncovers flaws) in your risk model

Tip:
A good investor doesn't just predict risk — they check if those predictions hold up in real life.
This step shows whether your model is **just theory**, or **truly reliable**.

Questions for Report

1. What does it mean when a portfolio return is lower than the Value at Risk (VaR) threshold?
Explain what an "exception" is in your own words.

2. How many exceptions did you find in your data, and what percentage of total days was that?
Write down the number and explain what this percentage tells you.

3. Was your exception rate close to the expected 5%? What does that say about your VaR model's accuracy?
Was the model realistic, too cautious, or too risky?

4. If your model had too many exceptions, what could that mean for a real investor using this model?
Hint: Think about trust, risk, and surprise losses.

5. Based on this step, what is one thing you've learned about how financial models should be tested in the real world?
Reflect on why backtesting is important before using any model for decision-making

15. Rolling Historical VaR – How Risk Changes Over Time

Objective of This Step
In this step, you will:

- Measure how your portfolio's risk (VaR) has changed over time
- Visualize short-term risk trends using a rolling (moving) 60-day window
- Compare your dynamic, data-based risk estimate with a static (fixed) risk model

This will help you understand that **financial risk is not constant** — it increases and decreases based on what's happening in the markets.

Step 1: Understand What "Rolling VaR" Means

So far, you've calculated VaR as a **single number** — a fixed estimate of how much you might lose on a bad day.

But markets aren't always the same. Sometimes they're calm. Other times, they're chaotic.

A **rolling VaR** updates your risk estimate **day by day**, based on the most recent 60 days of actual portfolio performance.

Step 2: Define the Time Window

For this project, you will:

- Look at **60 days at a time**
- For each day in your dataset, calculate the VaR based on the **previous 60 days** of real returns

This creates a timeline of how your portfolio's **worst expected daily loss** has changed over time.

Step 3: Generate the Rolling Historical VaR

Now, using those 60-day chunks, calculate:

- The **5th percentile return** in each window

This tells you the "worst 5% of returns" over that period — your historical VaR

You now have a **series of VaR values**, one for each day after the first 60.

Step 4: Plot the Results

Create a line chart that shows:

- The **rolling 60-day historical VaR** (the dynamic, real-data-based estimate)
- The **static VaR** (your earlier normal-distribution-based estimate as a straight red line)

This visual comparison helps you **see the difference** between:

- A model that assumes risk is always the same
- A model that adapts to **real market changes**

Step 5: Interpret the Chart

Look at how the **blue line** (historical rolling VaR) moves:

- Does it rise during market crashes or downturns?
- Is it ever much **higher than your static VaR** line?
- Are there long periods of **low risk**?

This helps you **spot when your portfolio was exposed to more danger** — and whether your risk model captured that properly.

What You've Learned

Concept	What It Means
Rolling VaR	Measures risk based on recent data (e.g., last 60 days)
Static VaR	A fixed number that doesn't adapt to changing conditions
Dynamic Risk	Helps investors adjust strategy based on market changes
Visual Comparison	Makes risk trends easy to spot and understand

Tip:
"Think of risk like ocean waves. Sometimes the water is calm. Other times, the waves are wild.
A rolling VaR chart helps you watch the tides — not just guess based on average weather."

Questions for Report

1. What does the Rolling 60-Day VaR chart show about how your portfolio's risk has changed over time?
Explain what the blue line tells you in your own words.

2. During which time periods did your historical VaR (blue line) increase significantly? What might have caused that?
Look for sharp rises and think about what was happening in the market during those times.

3. Compare the historical (rolling) VaR and the static VaR (red line). Was the static VaR always accurate? Why or why not?
Give examples from the chart where the static model missed real risk levels.

4. Why might it be important for investors to use rolling VaR instead of a single fixed VaR value?
Think about how this could help someone adjust their strategy based on recent conditions.

5. What did you learn about financial risk from this visualization? How would you explain it to someone new to investing?
Try to simplify what VaR means and how it changes, as if explaining to a friend.

16. Testing If Your Returns Follow a Normal Distribution (Jarque-Bera Test)

Objective of This Step
In this step, you will:

- Use a statistical test to check whether your **portfolio's daily returns follow a normal (bell-shaped) distribution**
- Understand what the result tells you about the **reliability of common risk models**
- Learn how to make decisions based on **real data**, not just assumptions

Step 1: Know What a Normal Distribution Means in Finance
A **normal distribution** (also called a bell curve) is a smooth, symmetrical shape where:

- Most returns are close to the average
- Extreme losses and gains are **very rare**

Many financial models **assume** returns follow this shape — but that's often **not true** in the real world.

Step 2: Understand What the Jarque-Bera Test Does

The **Jarque-Bera test** checks whether your return data fits the shape of a bell curve.
It looks at:

- **Skewness**: Are returns leaning too far in one direction?
- **Kurtosis**: Are there **too many extreme values** (fat tails)?

The result tells you:
"Is your return data close enough to a bell curve — or not?"

Step 3: Run the Test on Your Portfolio's Daily Returns
You now run the test on your daily returns.
The output will give you:

- A **JB statistic** (the higher it is, the less normal your data is)
- A **p-value** (the key number for decision-making)

Step 4: Make a Decision Based on the p-value
Use this simple rule:

p-value	What to Do	What It Means
Less than 0.05	Reject Normality	Your returns do **not** follow a normal distribution
0.05 or more	Cannot Reject Normality	Your returns **might** follow a normal distribution

Step 5: Interpret the Result in Real-Life Terms
If your test result says **"Reject normality"**:

- Your portfolio returns are **not bell-shaped**
- This means **models that assume normality (like parametric VaR)** may not work well
- Your returns may have **more extreme risk** than those models expect

Good practice: Use **historical models** or try methods like **t-distribution-based VaR** that allow for "fat tails" and more realistic risk.

What You've Learned

Concept	What It Means
Normal distribution	A simple model of risk — rarely matches real data
Jarque-Bera test	A way to statistically test if your returns fit a bell curve
p-value	Helps you decide if your returns are normal or not
Model validation	Tests whether it's safe to use certain models like normal-based VaR

Tip:
Just because a model is easy to use doesn't mean it's right.
Always test your data to make sure the model fits **reality** — not just theory.

Questions for Report

1. What does it mean when data is "normally distributed"? Why is this important in financial modeling?
Explain the idea of a bell curve and why some risk models rely on this shape.

2. What did the p-value in your test result tell you? Was your return data close to a normal distribution or not?
Use your actual p-value to explain whether you accepted or rejected normality.

3. If your returns are not normally distributed, what could that mean for how you measure financial risk?
Think about what models (like parametric VaR) assume and what could go wrong if the assumption is false.

4. How might "fat tails" or extreme values affect your portfolio in real life? Why should an investor care?
Hint: Fat tails = big surprises. What does that mean for risk management?

5. Based on your results, would you trust a model that assumes a bell curve? Why or why not? What alternatives could you use?
Share what you've learned about testing model assumptions and choosing the right tool for the data.