APPLICATION FOR QIP STRATEGIST

MANAGERIAL QUESTIONNAIRE

1) Design an AI-driven portfolio optimization tool

Objective: Empower users with insights based on live market conditions.
Execution: Use Python, machine learning, and APIs for real-time updates.
Sustainability: Automate updates and provide comprehensive documentation.

- First phase will be research and development phase, where our team identifies institutional needs and goals. Understanding different types of indicators, learning math, reading research papers and spending time trying different strategies and back testing will help team get insights about what works and what not.
- Run live testing and monitor performance.
- Update the model dynamically to reflect market changes.
- I prefer a team, where everyone has a basic idea about the thing, but strong in one sector. One might deal well with indicators, the other with machine learning, the combination will produce better results.

2)
- **Task Planning:**

Divide the project into sprints with clear deadlines.
Assign tasks based on members' strengths and their expertise.

- **Follow-Ups:**

Weekly progress reviews and realignment meetings.
Use tools like Trello/notion for task tracking

- **Documentation:**

Maintain a shared repository for all documents (Google Drive or GitHub).
Ensure proper versioning and accessibility for all team members.

- **Timely Delivery:**

Define KPIs to monitor progress.
Financial kpis are.. ROI, PE ratio, EPS, DE ratio, FCF.

Will make sure, to be strict in, early issue detection. We should spot data/model problems before they cause any delay.

Example lets say.. im live testing a strategy, then unexpected market behaviour occurred, fine tuning the model

So break project into mile stones and identify possible risks, plan solutions in advance, also review frequently to catch small issues(like missing data)

3) Host workshops and hackathons on quantitative finance.
Use social media to promote success stories. Its better to hire one who can do all this stuff, will recruit them based on their interest and past experiences.

4) Regular team meetups for identifying potential roadblocks, will strongly insist team members to inform their absence in prior, we will plan things in advance without effecting the workflow.
Establish clear communication channels to resolve issues quickly.

5) I work in Amogh and Aero-club, there wrt to time I understood, how much thinking in advance is important, after crossing several failures while testing, and debugging the issue.
I had a MEA por, where I learnt a little about how to manage ppl, and tasks.
My ability to learn fast and efficient, and multi task things, is what makes me suitable for this role, and more than anything, I started finance from scratch on jan 7 for zelta hackathon, literally 0 knowledge.. Now im happy to know, that I understood most of the terms, types of trading, pair trading, btc trading, what crypto currency is, etc.

6)   1)AMOGH MECHANICAL: tenure is almost getting finished, don't have much work starting from now.
2) aero-club project: its almost finished, im working on some non technical written stuff. So chill
3) Prof project under Mayank mittal: This one is serious, I just started working with him

Ill have more than sufficient time for this role. I also have plans about pursuing quant profile job, I want to dedicate as much time as possible…

TECHNICAL QUESTIONNAIRE

FUNDAMENTAL ANALYSIS

We are going to do financial analysis for ABREAL company. I didn't understand what order to follow, Ill start with company overview and jump to into order following the application.

COMPANY OVERVIEW

 ABREL operates as part of the Aditya Birla Group, one of India's leading. The company focuses on real estate development, including residential, commercial, and mixed-use properties. ABREL's operations are acquiring land, developing properties, and selling or leasing them to generate revenue.

So land acquisition, property development, revenue through sales, rental, capital appreciation, property management steps for their revenue.

Gross margin, ROE, D/E are some of the important metrics through which we evaluate company performances. Which we will discuss in coming slides.

1. Revenue and Profit Drivers

 Revenue Sources:

- Property Sales:

Residential and commercial units sold.

Profit Driver: Demand for real estate in urban areas, pricing strategy, and construction efficiency.

Pricing strategy can be market based, like price based on recent sale prices, Or cost based, how much it costed for company, how much profit it wants, or

psychology pricing, like setting 49.99 instead of 50, using marketing strategy like show initially some high price then reduce it, making it a good deal, auction pricing works at high demand areas.

- Leasing/Rental Income:

Income from leased properties like office spaces or shopping malls.

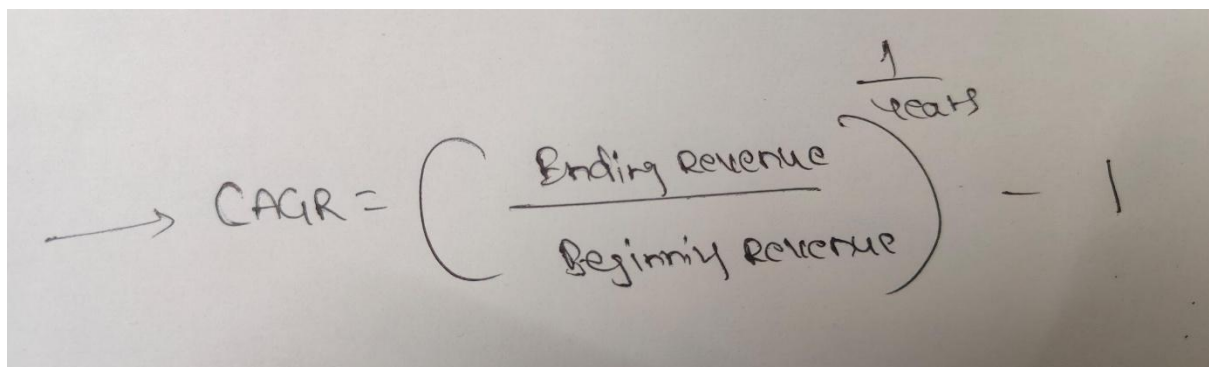Driver: Occupancy rates, rental yields, and long-term contracts.

- Management Services:

Revenue from maintaining developed properties.

Driver: Retention of customers post-sales or leasing.

Growth rate

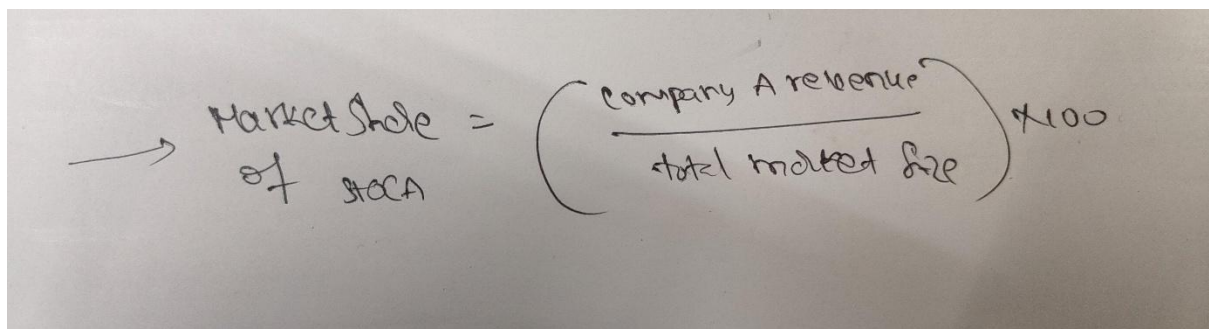**Revenue Growth**: If ABREL has disclosed figures, calculate CAGR

$$\rightarrow CAGR = \left(\frac{Ending\ Revenue}{Beginning\ Revenue} \right)^{\frac{1}{years}} - 1$$

Drivers: Urbanization, demand for affordable housing, and India's booming commercial real estate market.

Challenges can increasing interest rates. Its makes borrowing more expensive, high loan costs etc

Market share:

$$\rightarrow Market\ Share = \left(\frac{Company\ A\ revenue}{total\ market\ size} \right) \times 100$$

ABREL operates in a competitive market with players like DLF, Godrej Properties, and Oberoi Realty.

Segment specific risks

Residential Segment:

Risk: Dependence on buyer financing.

Rising interest rates could lower demand for new homes.

Commercial Segment:

Risk: Volatile occupancy rates.

Remote work trends can reduce office space demand.

Retail Segment (shopping Malls):

Risk: Reduced footfall during economic downturns.

Shifts to online shopping impact retail property revenues.

Development Risks:

Construction Delays: Can lead to cost overruns and project delays.

Land Acquisition Issues: Regulatory hurdles or disputes.

Regulatory and policy changes can significantly impact **ABREL** by influencing demand, operational efficiency, and compliance requirements.

If ABREL delays project registration or fails to meet delivery timelines, it may face reputational damage, due to Real Estate Regulatory Authority (RERA)

Other thing is GST.

GST rates for under-construction residential properties are 5% without input tax credit (ITC). High pricing costs due to this.

Affordable housing attracts a reduced GST rate of 1%. Opporntiy for affordable housing segment.

Foreign Direct Investment (FDI) Policies, land acquisition policies, after going through them..

Opportunities for ABREL

a. Sustainability Regulations

Opportunity: ABREL can differentiate itself by offering eco-friendly, energy-efficient buildings.

Example: Marketing a LEED-certified project as a premium offering in metro cities.

b.Urbanization and Infrastructure Policies

Government investment in smart cities and metro projects enhances real estate demand in urban areas.

Opportunity: ABREL can strategically invest in projects near such infrastructure.

c. Tax Incentives

SEZs (Special Economic Zones) offer tax benefits for commercial properties.

Opportunity: Developing SEZ properties for IT parks or office spaces can boost ABREL's revenue.

d.Attracting foreign investment through FDI-friendly policies.

RERA non-compliance leading to penalties and policy reversals are major risks here.

Next objective..

Before that, I used tinker finology, and screener as my resource for this analysis. Ill attach respective screenshots/ graphs that will relate.

Capital structure
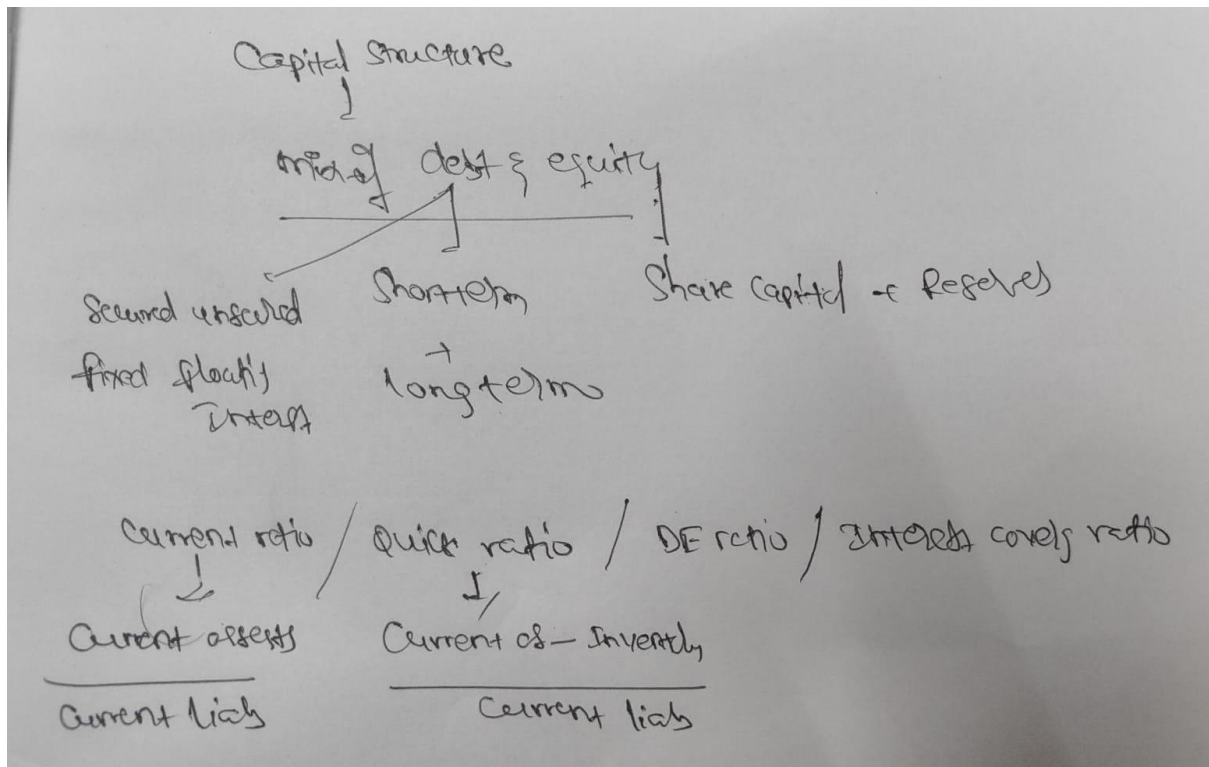
Understanding ratios/metrics in capital structure

Ex...interest coverage ratio of 3 means ABREL earns three times its interest obligations, indicating a comfortable margin to meet interest payments.

current ratio of 1.5 indicates that ABREL has ₹1.50 in current assets for every ₹1.00 of current liabilities, suggesting reasonable liquidity.

Types of cash flows

Operating Cash Flow: Cash generated from core business activities.

Investing Cash Flow: Cash used for or generated from investments in assets.

Financing Cash Flow: Cash flows related to borrowing, repaying debt, or equity transactions.

Other metric is **PE ratio**. Its how much investor willing to pay for each $1 of company earnings. Its ratio of stock price and earning per share(esp). high pe, stock is expensive, high growth is expected. Low pe, stock is cheap. Undervalued and risky.

- High pe is also a limitation. It suggest stock is overvalued, its also relying on future growth expectations. Growth expectations may not be met, also industry comparisons matter, if we compare competitors having low pe.

- A high P/E often means the stock is priced for perfection—if anything goes wrong (slower growth, market downturn), the stock price may drop sharply
- Price to Earnings ratio, which indicates how much an investor is willing to pay for a share for every rupee of earning as I already wrote above. rule of thumb is that shares trading at a low P/E are undervalued (it depends on other factors too). Abrel has a PE ratio of **94.38** which is **high** and comparatively **overvalued**. It can be considered as limitation as some of its peers have pe in the range of 15-50 too.
- The current share price of Aditya Birla Real is **Rs 1,860.45**. One can use valuation calculators of ticker to know if Aditya Birla Real share price is undervalued or overvalued.
  I tried to use online valuation calculators. Its saying stock is too overvalued.
- It tells us how much profit is allocated to to each outstanding share of a common stock. The latest EPS of Aditya Birla Real is Rs 19.71 . The higher the EPS, the better it is for investors.

- The company has a good cash flow management; CFO/PAT stands at 1.47.
- The company has a high promoter holding of 50.21%.
- The company is trading at a high EV/EBITDA of 37.07. it's a red flag. Stock is expensive, overvalued, more than it competitors. high ev/ebitda, also says low return on investment and high debt burden.
- The company has shown a poor revenue growth of 14.12% for the Past 3 years.
- The company has a high promoter holding of 50.21. That too it stayed like that for consecutive years
- Return on Assets measures how effectively a company can earn a return on its investment in assets. In other words, ROA shows how efficiently a company can convert the money used to purchase assets into net income or profits. Aditya Birla Real has ROA of 4.98 % which is a bad sign for future performance. (higher values are desirable

Price Chart

CAGR Return :   **30.0%**

Company has good cagr from past 3 years. A consistent increase in stock price.

The following picture shows, high pe value of this stock, proving to be a overvalued stock. High pe may reduce the volume of the trade.

Company Essentials

MARKET CAP ℹ️	ENTERPRISE VALUE ℹ️	NO. OF SHARES ℹ️
₹ 20,887.09 Cr.	₹ 22,018.43 Cr.	11.17 Cr.
P/E ℹ️	P/B ℹ️	FACE VALUE ℹ️
94.87	4.64	₹ 10
DIV. YIELD ℹ️	BOOK VALUE (TTM) ℹ️	CASH ℹ️
0.27 %	₹ 403.19	₹ 212.78 Cr.
DEBT ℹ️	PROMOTER HOLDING ℹ️	EPS (TTM) ℹ️
₹ 1,344.12 Cr.	50.21 %	₹ 19.71
SALES GROWTH ℹ️	ROE ℹ️	ROCE ℹ️
1.25%	9.29 %	12.61%
PROFIT GROWTH ℹ️	Add Your Ratio	
-6.71 %		

Profit growth is calculated for a particular time frame till present date.

Negative value proves, profits have declined by 6%compared to previous period. Earnings are shrinking, stock price may also get impact due to this, reducing investor confidence leading to fallin stock prices.

I cant understand it's a one time drop or its trend. If it's a trend then its surely a red flag.

Debt/Equity ℹ️	Price to Cash Flow ℹ️
0.31	35.45
Interest Cover Ratio ℹ️	CFO/PAT (5 Yr. Avg.) ℹ️
7.07	1.47

1. Debt/Equity (0.31) – This indicates that the company has low debt compared to its equity, suggesting financial stability and lower risk. A ratio below 1 is generally considered safe.

2. Price to Cash Flow (35.45) – A high ratio means the stock is expensive relative to its cash flow, indicating overvaluation. Investors may see this as a red flag unless future growth justifies it.

3. Interest Cover Ratio (7.07) – This measures how easily the company can pay its interest expenses. A ratio above 3 is considered good, meaning ABREAL is not struggling with debt

4. CFO/PAT (1.47, – A ratio above 1 means the company generates more cash from operations than its reported profit, which is a positive sign for cash flow.

Study about digital transformation objective…

 ABREL is likely adopting digital transformation strategies from the broader Aditya Birla Group, especially from Aditya Birla Capital.

 initiatives include AI-driven customer engagement (e.g., chatbots), digital onboarding (e-KYC), and automation (e.g., email bots) to enhance efficiency and customer experience. Through Birla Estates, ABREL focuses on innovative, luxurious real estate projects with smart home technologies and sustainable practices, aiming to stay competitive and deliver exceptional experiences.

Study about diversification objective..

ABREAL's operations are categorized into three primary segments:

Pulp and Paper: This segment encompasses the production of pulp, writing and printing paper, tissue paper, and multilayer packaging boards.

Real Estate: This includes the development of residential projects, management of leased properties, and holding of investment properties.

As of the quarter of the fiscal year 2024, the revenue distribution was as follows:

Pulp and Paper: 73%

Textiles: 22%

Real Estate Business: 4%

Others: 1% ///info from chat gpt only.

Noteworthy point here is real state 4%. But now abrel taking active plans and projects, birla estates which comes under abrel. So in coming years, real state revenue distribution going to increase broadly.

Studying other objective

Interest Rate Fluctuations, commodity prices, Foreign Exchange Rates, Trade Policies and Tariffs, Regulatory Changes.. they significantly influences its operations and profitability..

By expanding its portfolio across various geographies and real estate segments, ABREAL mitigates risks associated with economic downturns or geopolitical tensions in specific areas.. as its already doing.

Implementing financial instruments to hedge against currency and commodity price volatility helps stabilize costs and protect profit margins..

Financial model

Building a financial model for ABREAL involves:

Data collection.

Spreadsheet or Python-based computation.

Forecasting and valuation.

I got stuck at data collection itself, if I had csv files then, we can do python coding, calculating each of the valuation metrics using their respective formulas. I could have tried further. There are no csv files available, only pdfs and annual reports. May be I couldn't find them.

Oh-oh.. maybe its too late(12am), there is website known as money control, which have data that can be copied to excel. It also consists of so much data that can evaluated and considered for analysis, and also for making financial model.

INDUSTRY RESEARCH

1. Real Estate Market Overview

- **Global Trends**:

Urbanization and increasing housing demand.

Adoption of sustainable and green building practices.

Rise of PropTech in digitizing real estate services.

- **Indian Real Estate Trends**:

Residential real estate recovery post-COVID.

Demand for office spaces due to hybrid work models.

Growth in Tier-2 and Tier-3 cities due to rising disposable incomes.

Increased government focus on affordable housing

2. Segment-Specific Analysis

- **Residential**:

Examine price appreciation and sales growth in key cities.

Rising preference for mid-to-high-income housing.

- **Commercial**:

Growth in demand for co-working spaces.

Office space absorption rates and rental trends.

PEER ANALYSIS

To evaluate ABREAL's competitors, focus on their financial metrics, business models.

 Identify Peers

- Competitors include real estate players with a similar focus on residential, commercial, or mixed-use developments.
  Key Peers:

DLF Limited: Market leader in residential and commercial real estate.

Godrej Properties: Focuses on sustainability and premium housing.

Prestige Group: Strong presence in South India.

Oberoi Realty: Known for high-end luxury projects.

2. Financial Comparisons

- Metrics to Compare:

Revenue growth rates.

EBITDA margins.

Debt-to-equity ratio.

ROE/ROCE.

Pre-sales and project pipeline size.

Example (Hypothetical):

- DLF's EBITDA Margin: 31%
- Godrej Properties' EBITDA Margin: 25%
- ABREAL's EBITDA Margin: 28% (Indicates competitive positioning)

3. Business Strategy Comparisons

- DLF: Focus on high-end office spaces and large-scale residential townships.
- Godrej Properties: Asset-light model leveraging joint ventures.
- Prestige Group: Diversified portfolio including hospitality and malls.
- ABREAL: Focus on sustainability, mid-income housing, and urban projects.
- Compare ESG scores and green building certifications among peers.

5. Market Positioning

Use data on market share in residential and commercial spaces.

How do we do this, download financial statements, csv files or load into excel or into python, then plot, then do valuation using metrics. Finally we wil just compare numericals. Which is high which is low, which is better.

Swot analysis

SWOT (Strengths, Weaknesses, Opportunities, Threats)

After going through all, asking several questions on gpt...

Simplied analysis is as follows..

Strengths

- Backed by Aditya Birla Group, ensuring financial stability and brand credibility.

- Emphasis on sustainability and green building practices aligns with global ESG trends.

- Diverse portfolio across residential, commercial, and mixed-use developments.

Weaknesses

- Limited geographical presence compared to major competitors.

- Low revenue contribution (~4%) to Aditya Birla Group indicates reduced focus.

- High debt levels in some projects increase financial vulnerability.

- Faces stiff competition from established players like DLF and Godrej Properties.

Opportunities

- Rising demand for mid-income and premium housing fueled by urbanization.

- Potential growth in Tier-2/3 cities and commercial real estate segments.

- Digital transformation through PropTech for enhanced customer experiences.

- Increased FDI inflows and demand for green-certified buildings.

Threats

- Economic uncertainty, inflation, and rising interest rates may dampen demand.

- High construction costs and regulatory compliance can impact margins.

- Intense competition and stronger brand recall of rivals.

- Failure to meet ESG benchmarks risks reputational and financial losses.

Discounted Cash Flow (DCF) is a financial modeling technique used to estimate a company's intrinsic value by forecasting its future cash flows and discounting them to present value. This method relies on assumptions about revenue growth, expenses, capital expenditures, and discount rates.

It's like a judge for overvalued or undervalued stock..

A code for dcf visualization…

Before that we have to take some assumptions, I included them in code..

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

# Define assumptions
years = 5
revenue_growth = [0.10, 0.10, 0.10, 0.08, 0.08]  # Revenue growth rates
ebit_margin = 0.15  # EBIT as % of Revenue
tax_rate = 0.25  # Corporate tax rate
capex_percent = 0.08  # CapEx as % of Revenue
wc_percent = 0.02  # Working Capital change as % of Revenue
discount_rate = 0.12  # WACC
terminal_growth_rate = 0.03  # Long-term growth rate

# Starting values
revenue = 1000  # Starting revenue in ₹ crores
fcf_list = []  # List to store Free Cash Flows

# Project revenues and FCFs
for i in range(years):
    revenue *= (1 + revenue_growth[i])
    ebit = revenue * ebit_margin
    tax = ebit * tax_rate
    capex = revenue * capex_percent
    wc_change = revenue * wc_percent
    fcf = ebit - tax - capex - wc_change
    fcf_list.append(fcf)

# Calculate terminal value
terminal_value = fcf_list[-1] * (1 + terminal_growth_rate) / (discount_rate - terminal_growth_rate)

# Discount FCFs to present value
discount_factors = [(1 / (1 + discount_rate) ** (i + 1)) for i in range(years)]
discounted_fcf = [fcf_list[i] * discount_factors[i] for i in range(years)]
discounted_terminal_value = terminal_value * discount_factors[-1]

# Sum up to calculate NPV
```

```python
# Discount FCFs to present value
discount_factors = [(1 / (1 + discount_rate) ** (i + 1)) for i in range(years)]
discounted_fcf = [fcf_list[i] * discount_factors[i] for i in range(years)]
discounted_terminal_value = terminal_value * discount_factors[-1]

# Sum up to calculate NPV
npv = sum(discounted_fcf) + discounted_terminal_value

# Create DataFrame for visualization
df = pd.DataFrame({
    "Year": [f"Year {i+1}" for i in range(years)],
    "Revenue (₹ Cr)": [revenue / (1 + revenue_growth[i]) for i in range(years)],
    "Free Cash Flow (₹ Cr)": fcf_list,
    "Discounted FCF (₹ Cr)": discounted_fcf
})
df.loc["Terminal"] = ["Terminal Value", "-", "-", discounted_terminal_value]

# Print results
print("Discounted Cash Flow Analysis")
print(df)
print(f"\nNet Present Value (Intrinsic Value): ₹{npv:.2f} crores")

# Visualize the results
plt.figure(figsize=(10, 6))
plt.bar(df.index[:-1], fcf_list, color="blue", alpha=0.7, label="FCF")
plt.plot(df.index[:-1], discounted_fcf, color="green", linestyle="--", marker="o", label="Discounted FCF")
plt.axhline(0, color="black", linewidth=0.8, linestyle="--")
plt.title("Free Cash Flow and Discounted Cash Flow Over Time")
plt.xlabel("Year")
plt.ylabel("₹ Crores")
plt.legend()
plt.show()
```

```
Discounted Cash Flow Analysis
                Year  Revenue (₹ Cr)  Free Cash Flow (₹ Cr)   \
0              Year 1       1411.344                  13.75
1              Year 2       1411.344                  15.125
2              Year 3       1411.344                  16.6375
3              Year 4        1437.48                  17.9685
4              Year 5        1437.48                  19.40598
Terminal   Terminal Value          -                        -

          Discounted FCF (₹ Cr)
0                  12.276786
1                  12.057557
2                  11.842244
3                  11.419307
4                  11.011474
Terminal          126.020205

Net Present Value (Intrinsic Value): ₹184.63 crores
```

So above 184.63. stock is overvalued. Below that undervalued.

Free Cash Flow and Discounted Cash Flow Over Time
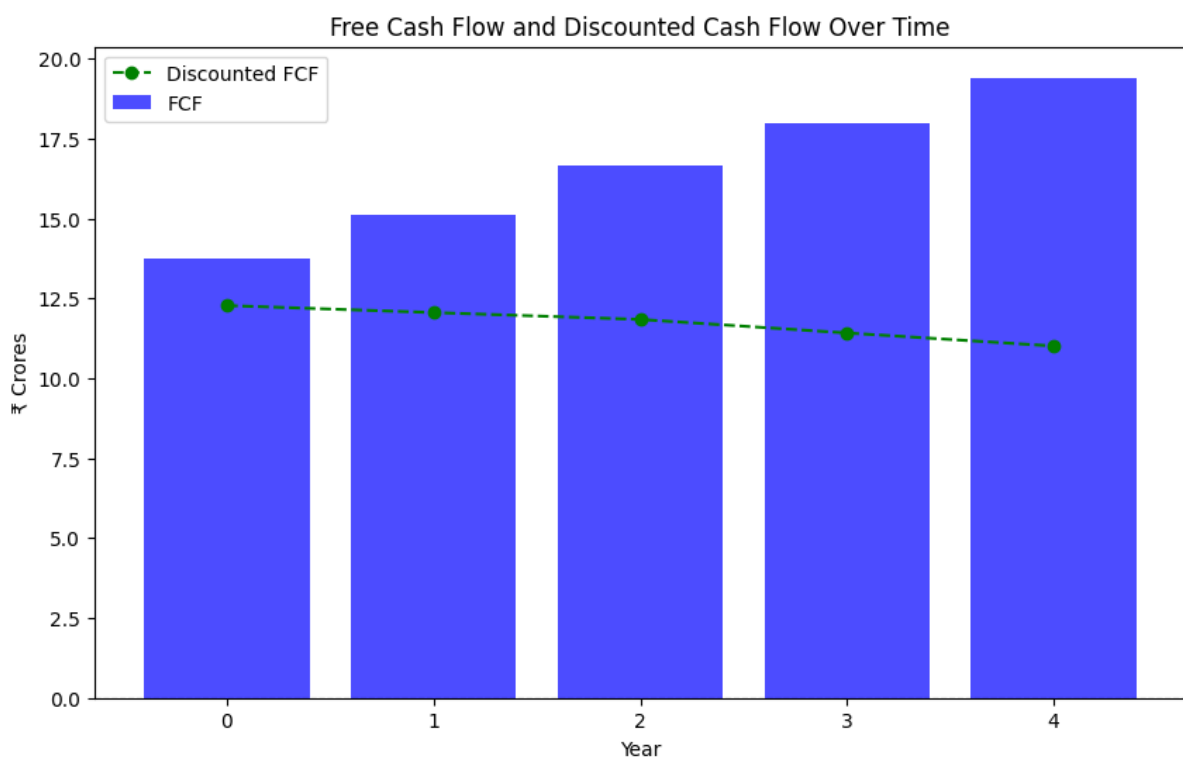
Scenario analysis and **stress testing** are tools used to assess how potential risks can impact a company's valuation

We'll model three scenarios—**Base Case**, **Optimistic Case**, and **Pessimistic Case**—to assess their impact on ABREL's valuation..

 Optimistic Case:

- Higher growth and improved margins result in a significantly higher valuation.

- Indicates strong operational efficiency and favorable market conditions.

Base Case:

- Reflects a realistic scenario based on historical performance and conservative assumptions.

- Serves as a benchmark for comparison.

Pessimistic Case:

- Highlights vulnerabilities in the business, such as higher costs and slower growth.

- May indicate areas for risk mitigation, like cost control or revenue diversification.

The above is how we intrepet each case..

Assumptions are taken for each scenario, and then incorporate them in the code..

```python
def dcf_scenario(revenue, revenue_growth, ebit_margin, tax_rate, capex_percent, wc_percent, discount_rate, terminal_
    years = 5
    fcf_list = []

    for i in range(years):
        revenue *= (1 + revenue_growth[i])
        ebit = revenue * ebit_margin
        tax = ebit * tax_rate
        capex = revenue * capex_percent
        wc_change = revenue * wc_percent
        fcf = ebit - tax - capex - wc_change
        fcf_list.append(fcf)

    # Terminal Value
    terminal_value = fcf_list[-1] * (1 + terminal_growth_rate) / (discount_rate - terminal_growth_rate)

    # Discount FCFs
    discount_factors = [(1 / (1 + discount_rate) ** (i + 1)) for i in range(years)]
    discounted_fcf = [fcf_list[i] * discount_factors[i] for i in range(years)]
    discounted_terminal_value = terminal_value * discount_factors[-1]

    npv = sum(discounted_fcf) + discounted_terminal_value
    return npv

# Scenario Inputs
base_case = {
    "revenue": 1000,
    "revenue_growth": [0.10, 0.10, 0.10, 0.08, 0.08],
    "ebit_margin": 0.15,
    "tax_rate": 0.25,
    "capex_percent": 0.08,
    "wc_percent": 0.02,
    "discount_rate": 0.12,
    "terminal_growth_rate": 0.03
}
```

```python
    "discount_rate": 0.12,
    "terminal_growth_rate": 0.03
}

optimistic_case = {
    "revenue": 1000,
    "revenue_growth": [0.12, 0.12, 0.12, 0.10, 0.10],
    "ebit_margin": 0.17,
    "tax_rate": 0.25,
    "capex_percent": 0.06,
    "wc_percent": 0.01,
    "discount_rate": 0.10,
    "terminal_growth_rate": 0.04
}

pessimistic_case = {
    "revenue": 1000,
    "revenue_growth": [0.07, 0.07, 0.07, 0.05, 0.05],
    "ebit_margin": 0.12,
    "tax_rate": 0.25,
    "capex_percent": 0.10,
    "wc_percent": 0.03,
    "discount_rate": 0.14,
    "terminal_growth_rate": 0.02
}

# Calculate NPV for each scenario
scenarios = {
    "Base Case": base_case,
    "Optimistic Case": optimistic_case,
    "Pessimistic Case": pessimistic_case
}

for name, params in scenarios.items():
    npv = dcf_scenario(**params)
    print(f"{name} NPV: ₹{npv:.2f} crores")
```

```
Base Case NPV: ₹184.63 crores
Optimistic Case NPV: ₹1352.26 crores
Pessimistic Case NPV: ₹-402.88 crores
```

THE END FOR FIRST QUESTION.

Pair trading

This is what I learnt most of the time in last 2 days, since I started my application.

the selection of the pair of stocks is critical for a successful pair trading strategy

I used mean reversion strategy, I took pair which is highly correlated, and the price ratio is fluctuating about the mean, reverting to the mean.

We also need to select companies of same industry, or else they don't have correlation at all.

Understanding the diff between correlation and cointegration is very important. Correlation means they both moving together. That's all it focuses about, but cointegration is like how much they being tied together, its like even the divergence occur, they should revert to the mean.

Correlation = moving together in short term, but can drift apart.

Cointegration = moving together in the long term with tendency to return..

- Considering some facts, I thought best pairs will infy and tcs, as they both are big players under the similar niche. They must be correlated and cointegrated as well. But later on when I applied my strategy results are suboptimal. So checked for p values for cointegration, correlation, it doesn't seemed to be too good between them.
- So, I thought about making a heatmap, then consider which is the best pair.

  Below are the heat maps, and there code..

Correlation Matrix

Cointegration P-value Matrix
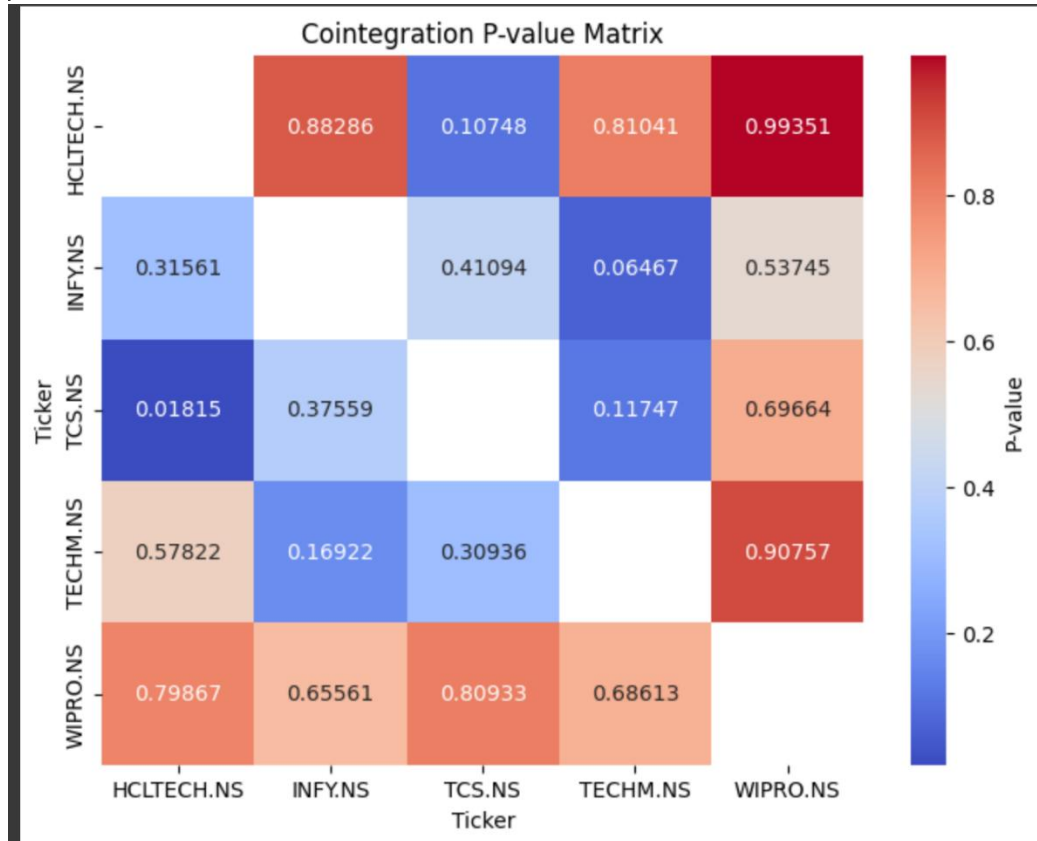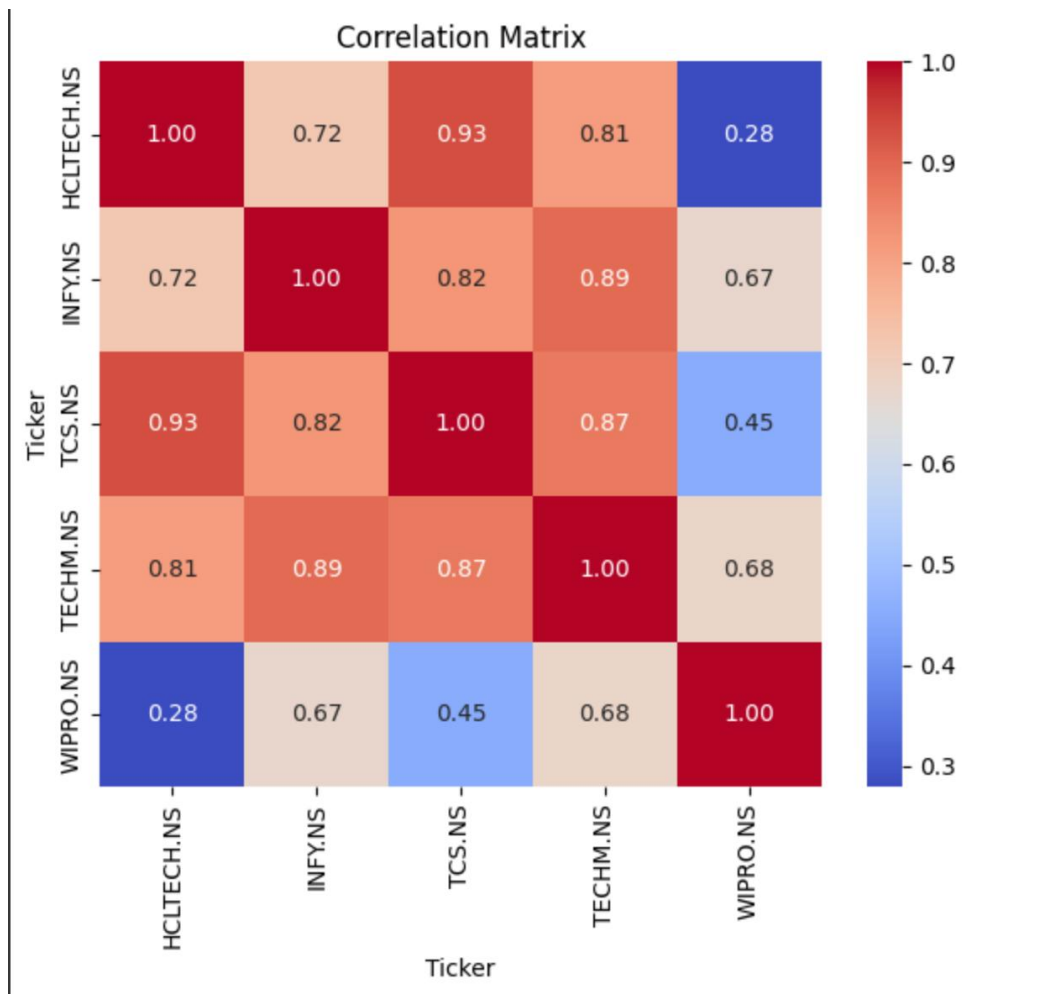
```python
import yfinance as yf
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from statsmodels.tsa.stattools import coint

# Define stock symbols
companies = ['TCS.NS', 'HCLTECH.NS', 'INFY.NS', 'WIPRO.NS', 'TECHM.NS']

# Fetch data from Yahoo Finance
data = yf.download(companies, start="2021-01-01", end="2024-12-31")['Close']

# Function to calculate cointegration p-values
def calculate_cointegration_matrix(data):
    n = data.shape[1]
    p_values = np.zeros((n, n))
    for i in range(n):
        for j in range(n):
            if i != j:  # Skip diagonal
                _, p_value, _ = coint(data.iloc[:, i], data.iloc[:, j])
                p_values[i, j] = p_value
            else:
                p_values[i, j] = np.nan  # Diagonal remains NaN for clarity
    return pd.DataFrame(p_values, index=data.columns, columns=data.columns)

# Calculate cointegration p-values
cointegration_matrix = calculate_cointegration_matrix(data)

# Plot the cointegration p-value matrix as a heatmap
plt.figure(figsize=(8, 6))
sns.heatmap(cointegration_matrix, annot=True, cmap="coolwarm", fmt=".5f", cbar_kws={'label': 'P-value'})
plt.title("Cointegration P-value Matrix")
plt.show()

# Suggest best pairs based on cointegration p-values
threshold = 0.05  # Cointegration significance level
best_pairs = []
```

```python
    plt.show()

    # Suggest best pairs based on cointegration p-values
    threshold = 0.05  # Cointegration significance level
    best_pairs = []
    for i in range(len(companies)):
        for j in range(i + 1, len(companies)):
            p_value = cointegration_matrix.iloc[i, j]
            if p_value < threshold:
                best_pairs.append((companies[i], companies[j], p_value))

    # Display the best pairs
    print("Best pairs based on cointegration p-value threshold:")
    if best_pairs:
        for pair in best_pairs:
            print(f"{pair[0]} and {pair[1]} - P-value: {pair[2]:.5f}")
    else:
        print("No significant pairs found.")
```

So from the two heat maps, we can see that..

TCS and HCLTECH are best pair. Correaltion 0.93 and cointegration 0.01(p value) it is expected to be less than 0.05 right, according to one famous test.

So im proceeding with these two.

Im showing some graphs for data visualization,As you can see price ratio, its reverting to the mean.. showing high co integration.

Closing Price Trends: TCS vs HCL Tech

Price Spread: TCS vs HCL Tech
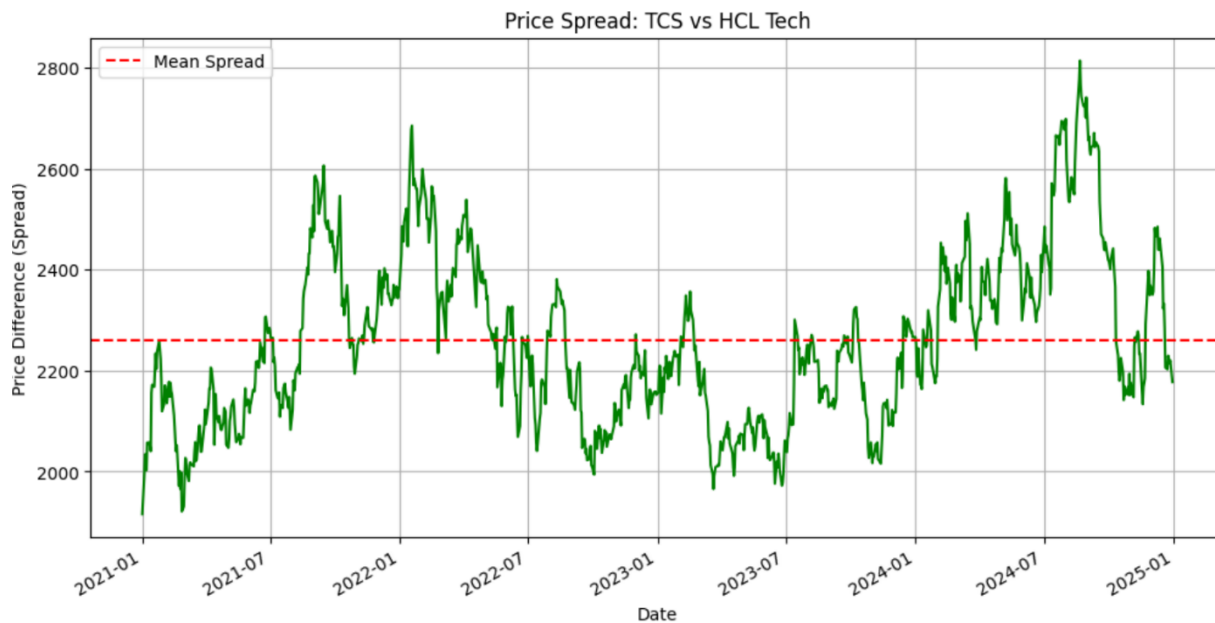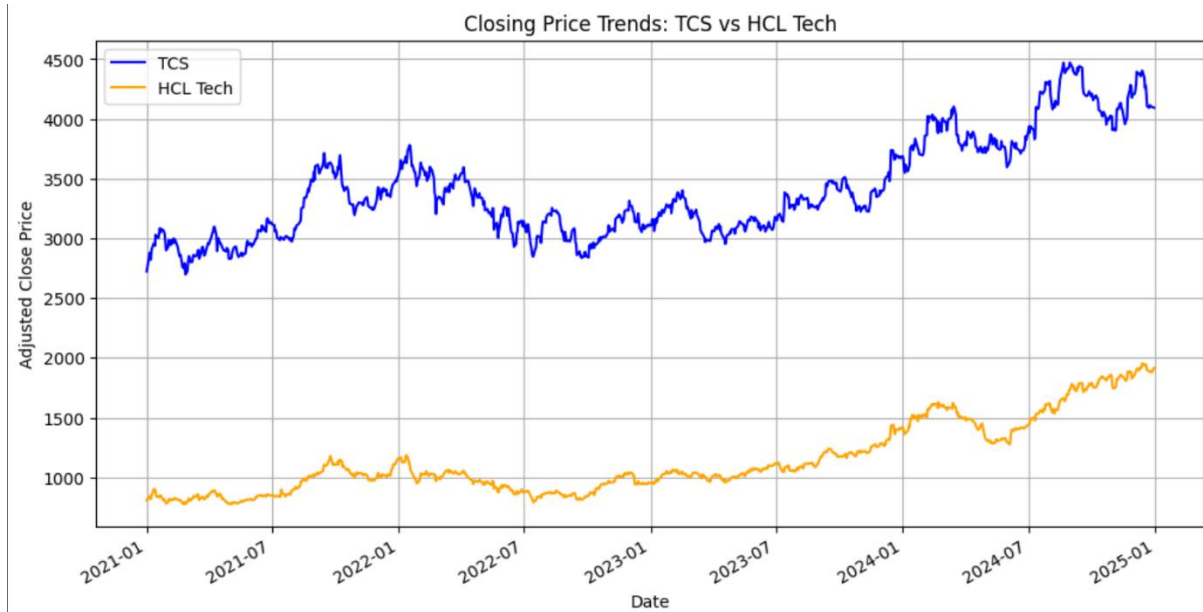
These graphs are obtained by python code. Im displaying the code here.

So this proves to be a good pair for pair trading..

So lets implement our mean reversion strategy and backtest it, to get performance metrics, returns, sharpe ratio, max drawdown..

Code in next page..

```python
import yfinance as yf
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from statsmodels.tsa.stattools import coint
from scipy.stats import zscore

# Fetch historical data
def fetch_data(ticker1, ticker2, start_date="2017-01-01", end_date="2024-01-01"):
    stock1 = yf.download(ticker1, start=start_date, end=end_date)['Close']
    stock2 = yf.download(ticker2, start=start_date, end=end_date)['Close']

    # Ensure single column (Series) is extracted
    if isinstance(stock1, pd.DataFrame):
        stock1 = stock1.squeeze("columns")
    if isinstance(stock2, pd.DataFrame):
        stock2 = stock2.squeeze("columns")

    return pd.DataFrame({'TCS': stock1, 'HCL': stock2}).dropna()

# ... (rest of the code remains the same) ...


    plt.plot(stock_data['TCS'], label='TCS', alpha=0.75)
    plt.plot(stock_data['HCL'], label='HCL', alpha=0.75)
    plt.legend()
    plt.title('Closing Prices')
# Calculate correlation and cointegration
def check_pair(stock_data):
    stock1 = stock_data['TCS']
    stock2 = stock_data['HCL']

    # Correlation
    correlation = stock1.corr(stock2)

    # Cointegration
    score, p_value, _ = coint(stock1, stock2)
    score, p_value, _ = coint(stock1, stock2)

    return correlation, p_value

# Visualize prices, ratios, and z-scores
def visualize_pair(stock_data):
    stock_data['Price Ratio'] = stock_data['TCS'] / stock_data['HCL']
    stock_data['Z Score'] = zscore(stock_data['Price Ratio'])

    plt.figure(figsize=(12, 8))

    plt.subplot(3, 1, 1)
    plt.subplot(3, 1, 2)
    plt.plot(stock_data['Price Ratio'], label='Price Ratio', color='orange')
    plt.axhline(stock_data['Price Ratio'].mean(), color='red', linestyle='--', label='Mean')
    plt.legend()
    plt.title('Price Ratio')

    plt.subplot(3, 1, 3)
    plt.plot(stock_data['Z Score'], label='Z Score', color='green')
    plt.axhline(1, color='red', linestyle='--')
    plt.axhline(-1, color='red', linestyle='--')
    plt.legend()
    plt.title('Z Scores')

    plt.tight_layout()
    plt.show()

# Mean Reversion Strategy
def mean_reversion_strategy(stock_data, z_entry_threshold=1.5, z_exit_threshold=0):
    stock_data['Price Ratio'] = stock_data['TCS'] / stock_data['HCL']
    stock_data['Z Score'] = zscore(stock_data['Price Ratio'])
    stock_data['Signal'] = 0

    # Entry conditions
    stock_data.loc[stock_data['Z Score'] > z_entry_threshold, 'Signal'] = -1  # Short TCS, Long HCL
```

```python
        stock_data.loc[stock_data['Z Score'] > z_entry_threshold, 'Signal'] = -1  # Short TCS, Long HCL
        stock_data.loc[stock_data['Z Score'] < -z_entry_threshold, 'Signal'] = 1  # Long TCS, Short HCL

        # Exit conditions
        stock_data.loc[abs(stock_data['Z Score']) < z_exit_threshold, 'Signal'] = 0

        # Calculate returns
        stock_data['Position'] = stock_data['Signal'].shift()
        stock_data['Strategy Return'] = stock_data['Position'] * (stock_data['TCS'].pct_change() - stock_data['HCL'].pct

        return stock_data

    # Backtesting metrics
    def backtest_metrics(stock_data):
        strategy_cum_returns = (1 + stock_data['Strategy Return'].fillna(0)).cumprod()
        total_return = strategy_cum_returns.iloc[-1] - 1
        max_drawdown = (strategy_cum_returns / strategy_cum_returns.cummax() - 1).min()
        sharpe_ratio = stock_data['Strategy Return'].mean() / stock_data['Strategy Return'].std() * np.sqrt(252)

        print(f"Total Return: {total_return * 100:.2f}%")
        print(f"Max Drawdown: {max_drawdown * 100:.2f}%")
        print(f"Sharpe Ratio: {sharpe_ratio:.2f}")

        # Plot strategy performance
        plt.figure(figsize=(10, 6))
        plt.plot(strategy_cum_returns, label='Strategy Cumulative Returns')
        plt.title('Strategy Performance')
        plt.legend()
        plt.show()

    # Main execution
    if __name__ == "__main__":
        # Fetch data
        data = fetch_data('TCS.NS', 'HCLTECH.NS')

        # Check correlation and cointegration
        corr, p_value = check_pair(data)
        print(f"Correlation: {corr:.2f}")
```

```python
    # Main execution
    if __name__ == "__main__":
        # Fetch data
        data = fetch_data('TCS.NS', 'HCLTECH.NS')

        # Check correlation and cointegration
        corr, p_value = check_pair(data)
        print(f"Correlation: {corr:.2f}")
        print(f"Cointegration p-value: {p_value:.5f}")

        # Visualize the data
        visualize_pair(data)

        # Implement mean reversion strategy
        strategy_data = mean_reversion_strategy(data)

        # Backtest and show metrics
        backtest_metrics(strategy_data)
```

Code for correlation calculation, strategy, and backtesting..

The results and outputs are..

Price Ratio

Z Scores

```
Total Return: 82.32%
Max Drawdown: -10.82%
Sharpe Ratio: 1.10
```

I also tried to incorporate AI but , as im still a newbie nothing much more than enthusiasm for finance, that one failed, I got -ve returns. So rather than overcomplicating things and wasting time, I restricted myself to mean reversion strategy. I kept those things for upcoming days.

THE END