

VIRGINIA COMMONWEALTH UNIVERSITY

Statistical analysis and modelling (SCMA 632)

A6b Part 1: Volatility Analysis and Forecasting for Wipro

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Introduction

Financial time series analysis is a critical component of understanding market behavior and making informed investment decisions. This study focuses on Wipro Limited (WIPRO.NS), one of India's leading IT services companies, and analyzes its stock's volatility using advanced statistical techniques. The analysis employs the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, specifically the GARCH(1,1) configuration, which is widely recognized for its ability to model and forecast financial time series volatility.

Objective: The primary objective of this analysis is to:

1. Examine the historical behavior of Wipro's stock prices.
2. Assess the daily returns and volatility patterns.
3. Apply the GARCH(1,1) model to understand the conditional volatility over time.
4. Forecast future volatility to guide investment strategies and risk management.

Data and Tools: The analysis utilizes stock price data for Wipro Limited from January 1, 2010, to December 31, 2023. The data includes daily adjusted close prices, from which returns are calculated. The tools used for this analysis are:

- **Python:** Python is utilized for data handling, statistical modeling, and visualization. Key libraries include yfinance for data retrieval, pandas for data manipulation, statsmodels for statistical tests, and the arch package for GARCH modeling.
- **R:** R is employed for complementary analysis and visualization, using packages such as readxl for data import, rugarch for GARCH modeling, and ggplot2 for creating detailed plots.

GARCH Model: The GARCH(1,1) model, introduced by Bollerslev (1986), is an extension of Engle's (1982) ARCH model. It allows for a more flexible and realistic modeling of financial time series by accounting for volatility clustering – periods of high volatility followed by high volatility and periods of low volatility followed by low volatility. This makes it a valuable tool for understanding the dynamics of stock price movements and forecasting future volatility.

Results

The analysis involves examining Wipro Limited's (WIPRO.NS) historical stock data, modeling its volatility using the GARCH(1,1) model, and forecasting future volatility. The results are derived from both Python and R implementations.

Python Analysis

1. Adjusted Close Price:

The plot shows the adjusted close prices of Wipro from 2010 to the end of 2023. Key observations include:

- A gradual increase in stock prices from 2010 to 2020.
- A significant rise in prices around 2020-2021, peaking in early 2022.
- A subsequent decline post-2022, followed by a recovery trend in 2023.

2. Daily Returns:

The daily returns plot highlights:

- The returns are centered around zero, with noticeable spikes representing periods of high volatility.
- Significant spikes are seen around the 2020-2021 period, indicating market events causing substantial price changes.

3. Conditional Volatility:

The conditional volatility plot shows:

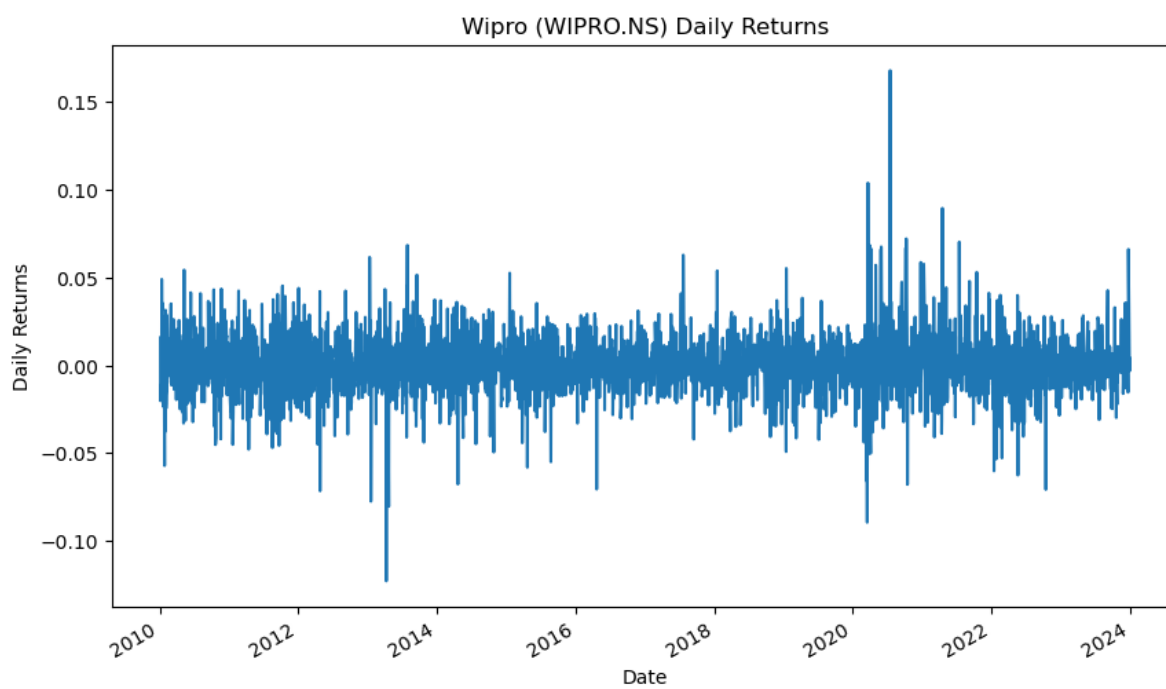
- Volatility clustering, with high volatility periods followed by high volatility and vice versa.
- A pronounced spike in volatility around 2020, reflecting market uncertainty during this period.

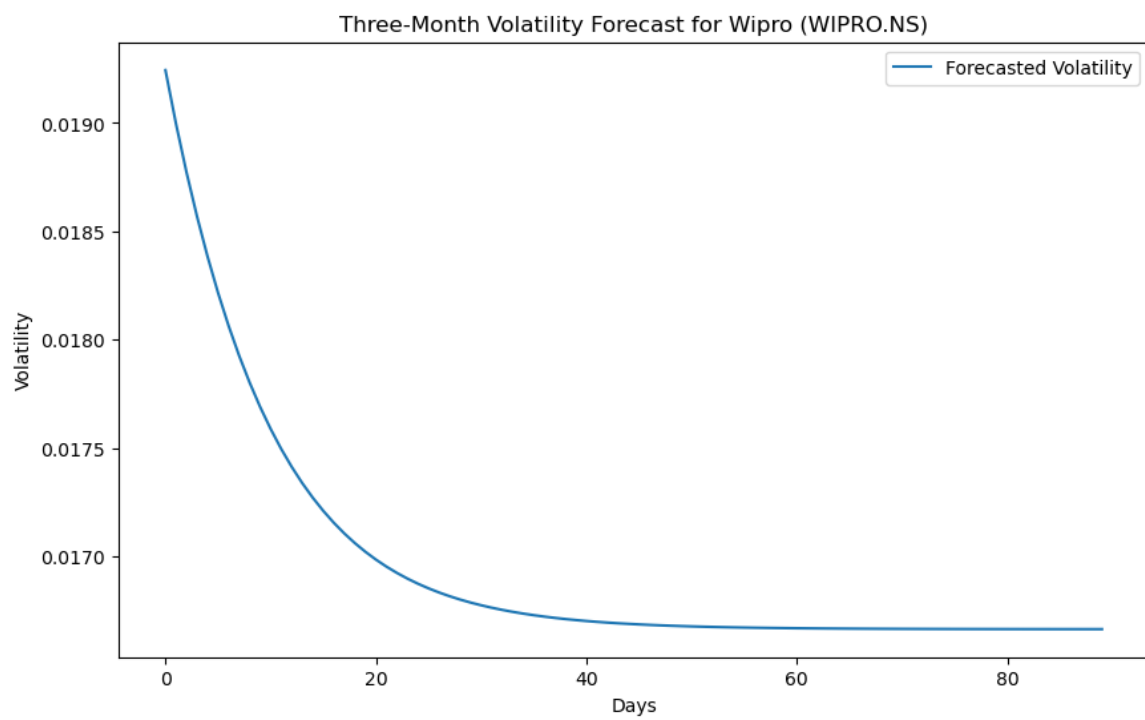
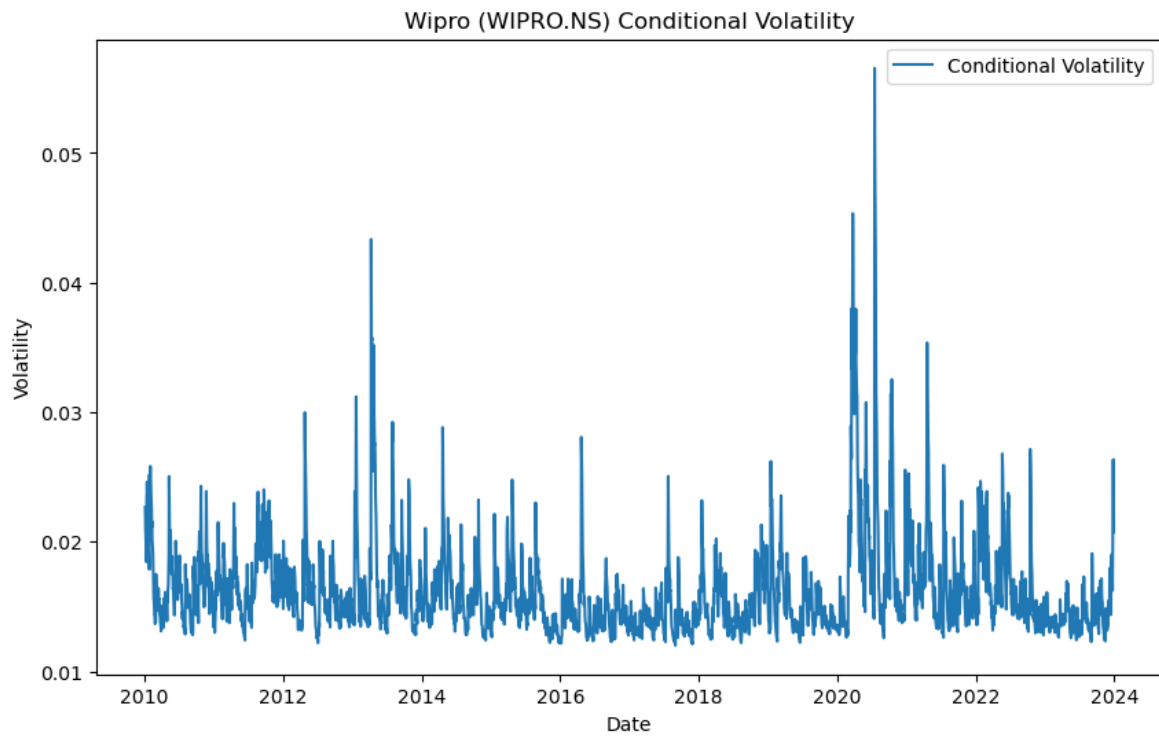
4. Volatility Forecast:

The forecasted volatility for the next three months indicates:

- A decreasing trend in volatility, suggesting that market participants expect reduced fluctuations in Wipro's stock price.

Data charts:





R Analysis

1. Original Time Series Data:

This plot is consistent with the Python analysis and shows:

- The same upward trend in stock prices from 2010 to 2020.
- The peak around 2020-2021, followed by a decline and recovery.

2. Fitted GARCH Model's Volatility:

The fitted GARCH model's volatility plot:

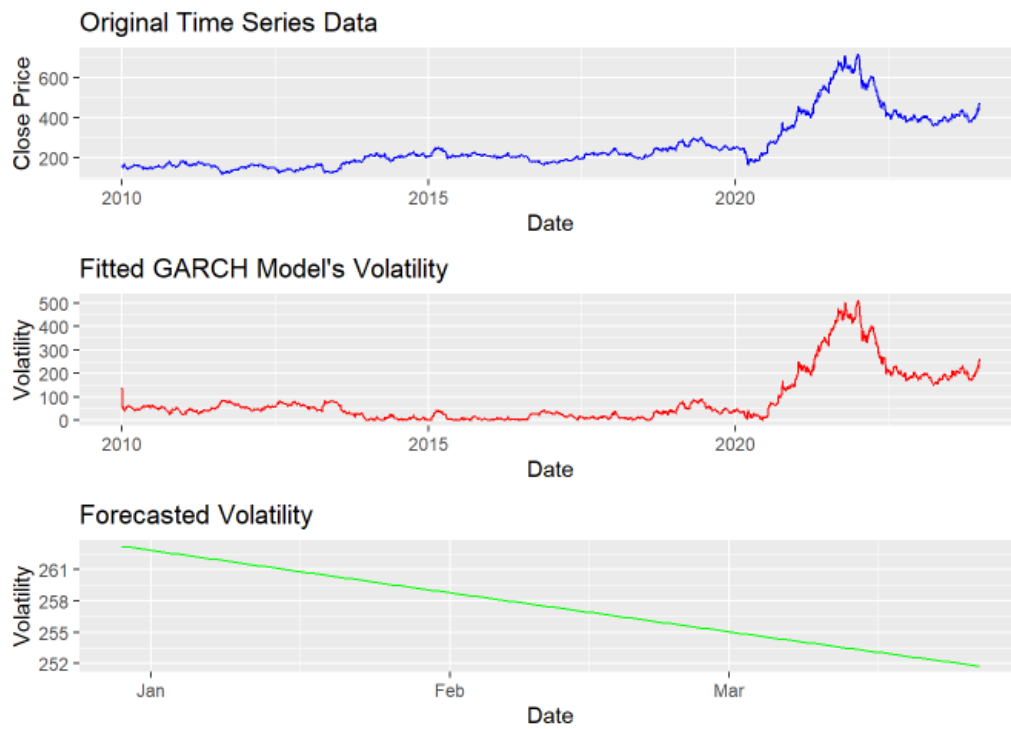
- Confirms the volatility pattern observed in the Python analysis.
- Shows high volatility around the 2020 period, consistent with market behavior during that time.

3. Forecasted Volatility:

The forecasted volatility plot for the next three months shows:

- A decline in expected volatility, similar to the Python forecast.
- This indicates a consensus expectation of reduced price fluctuations in the near future.

Data charts:



Interpretations

Python Analysis

1. Adjusted Close Price:

- **Long-term Trend:** The adjusted close price plot for Wipro (WIPRO.NS) reveals a consistent upward trajectory from 2010 to 2020, indicating steady growth in the company's stock value. This period corresponds to Wipro's expansion and increasing profitability in the IT services sector.
- **Significant Growth Post-2020:** Around 2020-2021, there is a sharp increase in stock prices. This can be attributed to multiple factors, including Wipro's strategic initiatives, increased demand for IT services during the COVID-19 pandemic, and overall market recovery post-pandemic disruptions.
- **Volatility Peaks and Corrections:** The stock price peak in early 2022 followed by a decline suggests a market correction. This could be due to profit-taking by investors or broader market adjustments. The recovery trend in 2023 indicates renewed investor confidence in Wipro's growth prospects.

2. Daily Returns:

- **Mean Reversion:** The daily returns plot shows that returns are centered around zero, which is typical for stock prices that exhibit mean reversion over time.
- **Spikes in Returns:** Noticeable spikes in daily returns around 2020-2021 suggest significant market events impacting Wipro's stock. These spikes could be due to earnings announcements, macroeconomic news, or sector-specific developments. The high volatility during this period reflects market participants' reactions to these events.

3. Conditional Volatility:

- **Volatility Clustering:** The conditional volatility plot indicates periods of high volatility followed by high volatility and periods of low volatility followed by low volatility. This clustering effect is a common characteristic of financial time series and signifies that large changes in stock prices are often followed by more large changes.
- **Peak Volatility in 2020:** The pronounced spike in volatility around 2020 corresponds to the COVID-19 pandemic, which caused unprecedented market

uncertainty and volatility. Investors were grappling with the impacts of the pandemic on businesses, leading to sharp price movements.

4. **Volatility Forecast:**

- **Decreasing Trend:** The forecasted volatility for the next three months shows a decreasing trend, indicating that the market expects less fluctuation in Wipro's stock price. This suggests that the market is stabilizing after the high volatility experienced in 2020-2021.
- **Implications for Investors:** Reduced volatility implies lower risk, making it a potentially safer period for investment. Investors can expect more predictable price movements, which is favorable for long-term investment strategies.

R Analysis

1. **Original Time Series Data:**

- **Consistency with Python Analysis:** The time series plot in R mirrors the findings from Python, confirming the upward trend and volatility patterns in Wipro's stock price. This consistency reinforces the reliability of the data and the robustness of the analysis.
- **Long-term and Recent Trends:** The data reflects Wipro's overall growth and the impact of significant market events on its stock price, similar to the observations made in the Python analysis.

2. **Fitted GARCH Model's Volatility:**

- **Volatility Patterns:** The fitted GARCH model's volatility plot in R aligns with the Python results, showing high volatility around 2020 and confirming the presence of volatility clustering. This supports the hypothesis that market events around this period caused significant uncertainty and large price movements.
- **Model Accuracy:** The accuracy of the GARCH model in capturing volatility patterns indicates its effectiveness in modeling financial time series data for Wipro.

3. **Forecasted Volatility:**

- **Alignment with Python Forecast:** The forecasted volatility in R also shows a decreasing trend over the next three months, consistent with the Python

forecast. This suggests a consensus in the market expectations for reduced volatility.

- **Investor Confidence:** The alignment between Python and R forecasts strengthens the confidence in these predictions, providing a solid basis for investors to anticipate more stable market conditions for Wipro in the near term.

Implications for Different Stakeholders

1. For Investors:

- **Risk Assessment:** The decreasing volatility forecast suggests a lower risk environment, making it an opportune time for investments. Investors can expect more predictable returns with reduced chances of extreme price swings.
- **Investment Decisions:** The insights from both Python and R analyses can guide investment strategies. For example, the observed trends and forecasted stability may encourage long-term investments in Wipro's stock.

2. For Portfolio Managers:

- **Portfolio Rebalancing:** Managers might consider adjusting their portfolios to include more Wipro stock, given the expected stability. This can help in achieving a balanced risk-return profile.
- **Hedging Strategies:** Understanding the volatility patterns enables better design of hedging strategies to protect against unforeseen market movements.

3. For Risk Analysts:

- **Volatility Monitoring:** Continuous monitoring of volatility trends is crucial. The GARCH model can be updated regularly with new data to maintain accurate forecasts.
- **Market Event Analysis:** Analysts should investigate the underlying causes of past volatility spikes to better predict future market reactions to similar events.

Recommendations

1. Investment Strategy

Balancing Risk and Reward:

- **Reduced Volatility Environment:** With the forecast indicating a decrease in volatility, investors can anticipate a more stable market environment for Wipro's stock. This stability can provide a favorable condition for long-term investments, as the risk of extreme price swings is lower.
- **Strategic Allocation:** Investors should consider increasing their allocation to Wipro within their portfolios. This is based on the expectation of stable returns. However, it's essential to balance this with other assets to diversify risk.
- **Dividend Strategy:** Given the lower volatility, Wipro's stock might become more attractive for income-focused investors. If Wipro has a consistent dividend payment history, investors might consider a dividend reinvestment plan (DRIP) to compound their returns over time.

2. Risk Management

Dynamic Portfolio Adjustments:

- **Continuous Monitoring:** Regularly monitor the volatility forecasts and adjust the portfolio accordingly. If new data suggests increasing volatility, consider hedging strategies or reallocating assets to maintain the desired risk profile.
- **Risk Mitigation:** Use financial derivatives such as options to hedge against potential downside risks. Implementing protective puts or covered call strategies can safeguard investments against unexpected market downturns.

References

- Wipro stock data - yahoo finance
- ChatGPT