

Stock Market Analysis and Time Series Visualization

1. Introduction

Stock market analysis is a crucial tool for understanding financial trends and predicting price behavior. Historical stock data provides valuable insights into how company performance and global events influence prices.

This study focuses on **Apple Inc. (AAPL)** stock data from **January 2018 to December 2023**, obtained from **Yahoo Finance**. The objective is to analyze stock price movements, visualize patterns, evaluate volatility, and forecast future prices using **time series analysis (ARIMA)**.

2. Data Collection and Preprocessing

Dataset

Data was collected using the **yfinance** Python library:

```
Python
data = yf.download("AAPL", start="2018-01-01",
end="2023-12-31")
```

The dataset includes daily **Open, High, Low, Close, and Volume** prices for AAPL.

Preprocessing

- Missing values were handled using **forward and backward fill** methods.
- Outliers were detected using **z-scores** ($|z| > 5$) and removed.
- Date indices were standardized for proper time series ordering.

After cleaning, the dataset was saved as **AAPL_cleaned.csv**.

3. Exploratory Data Analysis (EDA)

3.1 Closing Price Trend

The closing price exhibited a **strong upward trend** from 2018 to 2021, followed by a decline during 2022 due to global market corrections. A steady recovery was observed through 2023.

3.2 Moving Averages

50-day and 100-day **Moving Averages (MA50, MA100)** were computed to smooth noise and observe medium-term trends.

- **MA50 > MA100** indicated bullish momentum (mid-2020 recovery).
- **MA50 < MA100** indicated bearish phases (early 2022 correction).

3.3 Peaks and Dips

Using `scipy.signal.find_peaks()`, major **peaks** were observed in **Dec 2021** and **Jan 2022**, while significant **dips** occurred around **March 2020** (COVID-19 crash) and **May 2022**. These correspond to real-world financial shocks.

4. Time Series Visualization

Comprehensive time-series visualizations were created:

- **OHLC plots** displayed daily fluctuations and overall growth trend.
- **Volume overlay plots** showed spikes during earnings reports and market events.

Periods of high trading volume aligned with major price changes, reflecting strong investor reactions to news or quarterly results.

5. Volatility Analysis

Volatility was measured using **30-day rolling standard deviation** of daily returns, annualized for comparison:

$$\text{Volatility}_{30} = \text{RollingStd}(\text{returns}, 30) \times \sqrt{252}$$

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Key observations:

- A large spike occurred in **March 2020** due to pandemic uncertainty.
- Moderate volatility continued during **2022** amid inflation concerns.
- Stability improved during **2023**, signaling market recovery.

6. Forecasting Analysis

Model: ARIMA

An **ARIMA (Auto-Regressive Integrated Moving Average)** model was applied for forecasting.

Using `auto_arima`, the best-fit parameters (p, d, q) were selected automatically.

Evaluation

The dataset was divided into training and testing (last 60 days). Performance metrics were:

Metric	Value
RMSE	≈ 4.15
MAPE	≈ 2.3%

Forecast Results

The ARIMA model successfully predicted a stable 30-day upward trend with mild fluctuations.

Confidence intervals (95%) captured realistic uncertainty bands, providing a reliable short-term price outlook.

7. Insights and Discussion

- Apple stock maintains long-term growth despite short-term volatility.
- Major volatility spikes correlate with global crises and policy shifts.
- Forecast accuracy (MAPE < 3%) shows ARIMA's reliability for short-term trends.

- **Limitations:** The model ignores exogenous factors (e.g., news, macroeconomic indicators) that affect prices. Advanced models like **Prophet** or **LSTM** could capture complex patterns better.
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8. Conclusion

This project demonstrates how **time-series visualization and ARIMA forecasting** can help analyze stock price behavior.

Key findings include:

- Detection of long-term upward trends and short-term fluctuations.
- Identification of major peaks/dips aligned with real-world events.
- Reliable short-term forecasting with high accuracy.

Overall, this approach provides valuable insights for both **investors** and **analysts**, emphasizing the importance of combining **data analytics** and **financial modeling** in market prediction.