Analyzing Key Factors Influencing Volatility in Major Technology Stocks: AAPL, MSFT, NVDA, TSLA and AMZN

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Project Overview

This project analyzes volatility differences among five major technology stocks AAPL, MSFT, NVDA, TSLA, and AMZN using historical daily market data. By analyzing price movements, return distributions, rolling and annualized volatility, and cross-stock correlations, the study identifies each stock's distinct risk profile and examines how volatility evolves over time. The purpose is to understand the drivers of instability in tech equities and provide insights useful for financial decision-making and portfolio risk management.

Research Question

What underlying factors explain the differences in volatility among major technology stocks, and how do these volatility patterns evolve over time?

Hypothesis

Major technology stocks exhibit different volatility patterns due to varying business models, market sensitivity, and investor behavior. These differences should be observable through return distributions, volatility measures, and correlation structures.

Data Collection

1. **Data Sources:** Historical daily price data for AAPL, MSFT, NVDA, TSLA, and AMZN (Jan 2021–Dec 2025) were retrieved programmatically via the yfinance API, using a custom script (get_data.py). Data were downloaded as CSV files into data/raw/.
2. **Number of Data Samples:** Each stock contained 1,007 trading-day observations, totaling 5,035 samples prior to cleaning.

Data Cleaning

A preprocessing script (clean_data.py) standardized and validated the datasets. Key steps included:

1. **Date Standardization:** Converted the date column to a unified datetime format and removed rows with invalid or unparseable dates.
2. **Column Selection & Renaming:** Retained only relevant fields (Date and Close price). Ensured all files followed a consistent Date–Close structure.

3. **Data Alignment:** Merged datasets by matching trading days across all stocks. This ensured equal-length time series for comparative analysis.
4. **Export of Cleaned Data:** Processed datasets were saved to data/processed/ for analysis.

Analysis Techniques

The cleaned datasets were used to conduct several analyses:

- **Daily Returns Calculation:** Computed percent changes in closing prices to measure day-to-day movement.
- **30-Day Rolling Volatility:** Captured short-term risk dynamics using rolling standard deviations.
- **Annualized Volatility:** Converted daily return variability into a yearly risk measure.
- **Distribution of Daily Returns:** Examined the shape and spread of return distributions to assess return variability, tail behavior, and short-term risk differences across stocks.
- **Correlation Analysis:** Produced a correlation matrix to examine how similarly stocks move.

Visualizations and Findings

Several figures were constructed to communicate findings clearly

1. **Stock Price History (2021–2025):** Shows trends and volatility in closing prices over time.

   This chart compares daily closing prices for AAPL, AMZN, MSFT, NVDA, and TSLA from 2021–2025. Time is on the x-axis, price on the y-axis, with each stock shown as a separate line. These trends establish each stock's baseline behavior and help explain differences in volatility observed later.

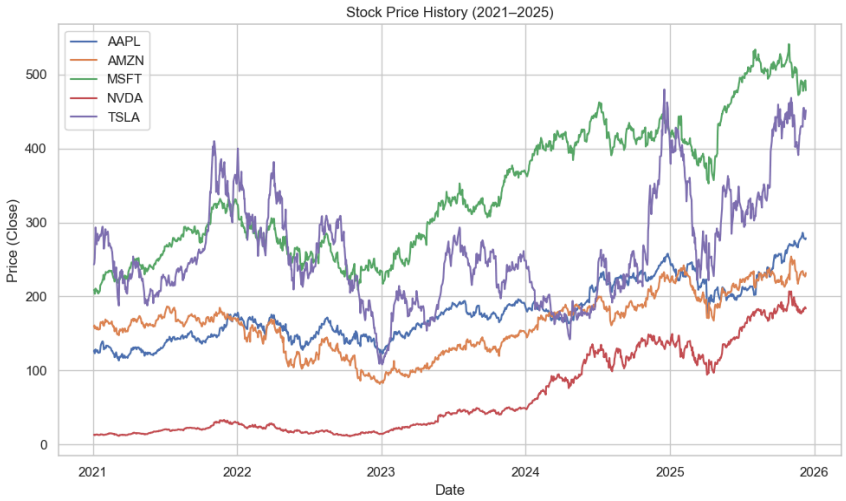

Figure 1. Stock Price History (2021–2025)

Conclusion: MSFT shows the strongest, steady upward trend; AAPL and AMZN grow moderately; NVDA rises with noticeable volatility; TSLA shows the largest fluctuations.

2. **30-Day Rolling Volatility (Daily Returns):** Displays how risk evolves for each stock using a 30-day moving window.

   This chart shows 30-day rolling volatility for each stock from 2021–2025. The x-axis represents time, the y-axis represents volatility, and each line reflects one stock's short-term risk pattern. These patterns clearly distinguish high-risk from stable stocks and help identify periods of elevated risk for better timing and diversification decisions.

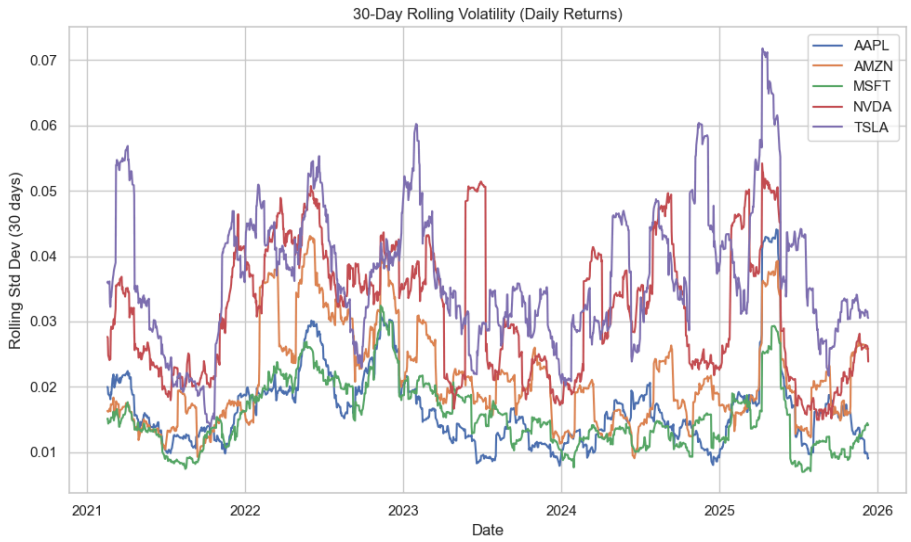

Figure 2. 30-Day Rolling Volatility

Conclusion: TSLA shows the highest and most frequent volatility spikes, NVDA also fluctuates sharply, AMZN is moderate, and AAPL/MSFT remain the most stable.

3. **Annualized Volatility by Stock:** Provides a comparative long-term risk ranking among the five stocks.

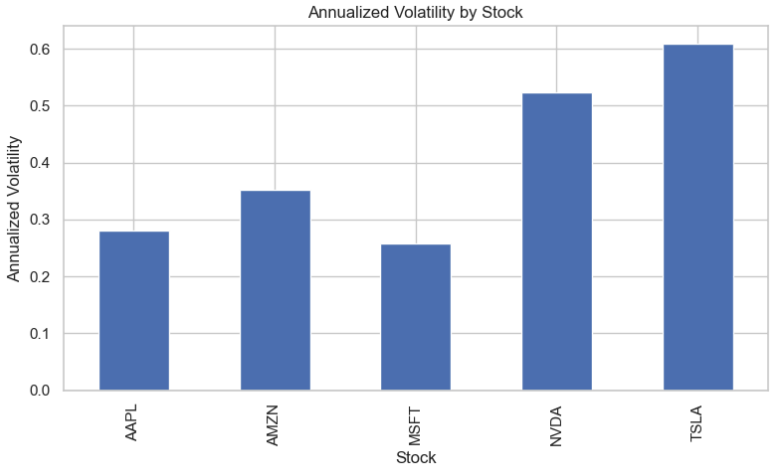

Figure 3. Annualized Volatility by Stock

This bar chart shows the annualized standard deviation of daily returns, comparing long-term volatility across the five stocks. This provides a straightforward comparison of long-term risk across companies, helping identify which stocks carry greater uncertainty over the full 2021–2025 period.

Conclusion: TSLA is the most volatile, followed by NVDA; AMZN is moderate, while AAPL and MSFT show the lowest long-term risk.

4. **Distribution of Daily Returns:** Illustrates differences in return shape, spread, and tail behavior.

   The histogram with KDE curves shows how daily returns are distributed across the five stocks. Returns cluster around zero, but the spreads differ: MSFT and AAPL have the narrowest distributions, AMZN is moderate, and NVDA and TSLA show the widest tails, indicating more frequent large swings. These differences highlight each stock's inherent risk profile useful for comparing short-term stability, choosing lower-risk assets, and building diversification strategies.

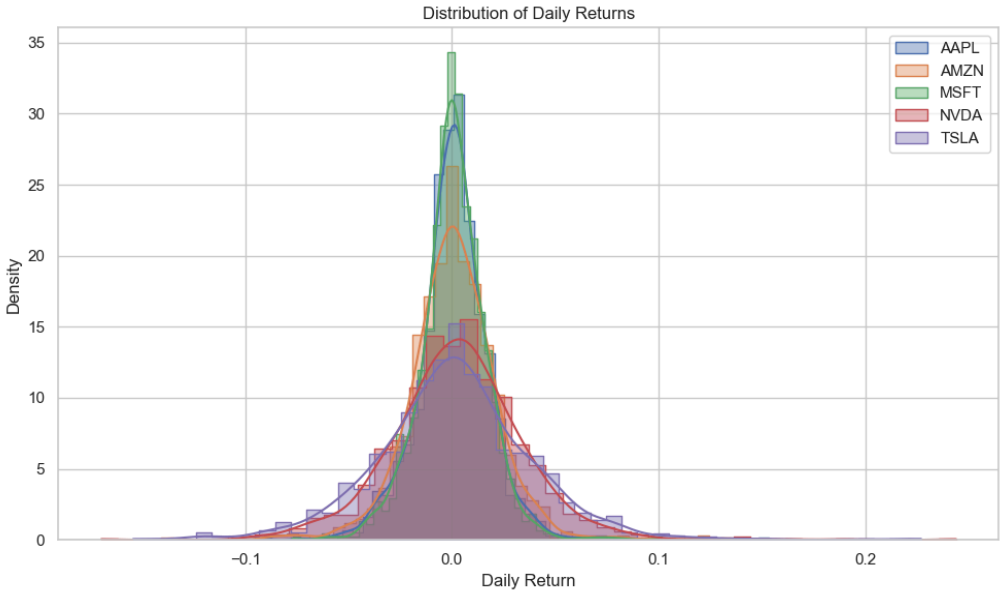

Figure 4. Correlation Heatmap of Daily Returns

Conclusion: MSFT and AAPL exhibit the most stable daily behavior, while NVDA and TSLA experience significantly higher short-term volatility.

5. **Correlation Heatmap of Daily Returns:** Summarizes co-movement strength across all stock pairs.

   The correlation matrix measures how closely the stocks move together, with values ranging from 0.42 to 0.65, indicating moderate positive relationships. The heatmap shows each pairwise correlation, where lighter colors represent stronger co-movement. These results highlight

diversification potential TSLA provides the most diversification benefit, whereas MSFT behaves most similarly to the overall tech group.

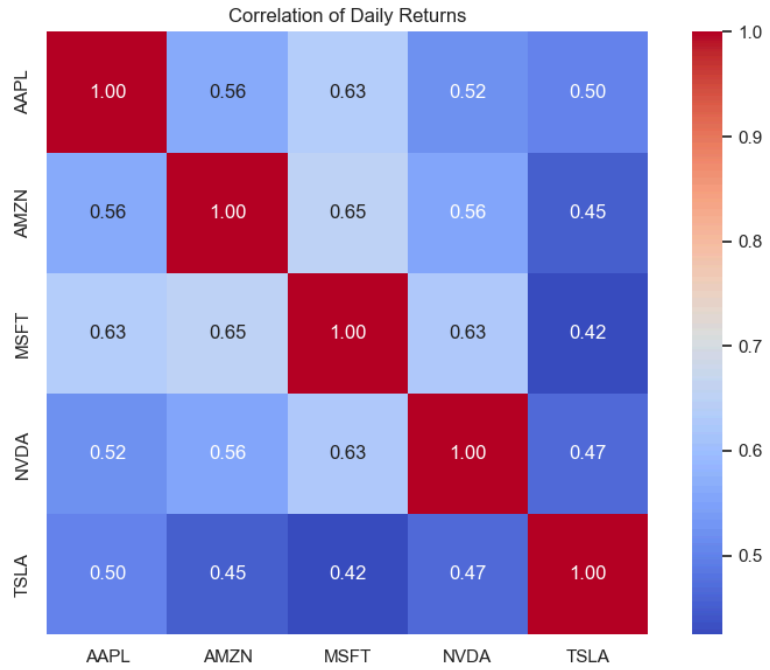

Figure 5. Distribution of Daily Returns

Conclusion: MSFT shows the strongest correlations with others (~0.63–0.65), while TSLA has the weakest (~0.42–0.50), indicating it moves more independently.

Conclusions

TSLA and NVDA display consistently high volatility; MSFT and AAPL remain the most stable; AMZN occupies a mid-range position. Most stocks exhibit moderate correlations, indicating shared responses to market conditions.

Changes from the Original Proposal

The original plan to process JSON responses was revised because yfinance delivers structured DataFrames, making CSV storage more efficient. A secondary challenge involved date formatting inconsistencies in raw files, resolved through explicit date parsing and standardized output formatting.

Future Work

Future extensions could include adding more financial indicators (e.g., volume, moving averages, macro factors) and expanding the dataset to other sectors or global markets to provide broader volatility insights. Additionally, applying predictive models such as ARIMA, GARCH, or LSTM would enable forecasting of future volatility and returns, making the analysis more forward-looking.