Investing with the Giants: A Comprehensive Stock Performance Analysis of Leading Tech Giants (2016-2024)

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Abstract

This report presents a comprehensive data analysis of the stock performance of five major technology companies: Apple (AAPL), Amazon (AMZN), Google (GOOGL), Microsoft (MSFT), and Nvidia (NVDA), spanning from early 2016 to late 2024. Leveraging historical daily stock data, this study explores their individual growth trajectories, quantifies their risk-reward profiles, and investigates the profound impact of the COVID-19 pandemic on their financial volatility. Furthermore, it delves into the interconnectedness of these tech giants and presents an attempt to forecast their future stock trajectories using time series models. The findings reveal distinct narratives of growth, resilience, and adaptability within the tech sector, highlighting Nvidia's explosive ascent and Microsoft's consistent stability, while also underscoring the market's dramatic shifts in response to global events.

Contents

1 Introduction: The Tech Titans' Arena

This section introduces the significance of the selected tech giants in the modern economy and outlines the project's primary objectives.

- Contextualization of Apple, Amazon, Google, Microsoft, and Nvidia as global economic powerhouses.
- Importance of understanding their historical stock performance for investors and market analysts.
- Stated objectives of the data-driven journey:
  1. Visualize growth trajectories.
  2. Analyze risk and reward profiles.
  3. Quantify the impact of the COVID-19 pandemic on stock behavior.
  4. Uncover correlations between their market movements.
  5. Explore the realm of predicting future stock trajectories.

2 The Landscape of Growth: Price Trajectories

This section details the stock price performance, distinguishing between raw and normalized prices for a truly comparable analysis of growth.

- Initial examination of raw closing prices and the misleading nature of absolute values.
- Methodology for normalizing all stock prices to a common starting point (base of 100 on January 2, 2016).
- Analysis of normalized percentage growth trajectories, highlighting:
  - Nvidia's undisputed champion status with explosive upward trend.
  - Microsoft's remarkably strong and consistent growth.
  - Apple's substantial percentage gains.
  - Amazon and Google's significant overall growth with more volatile paths.

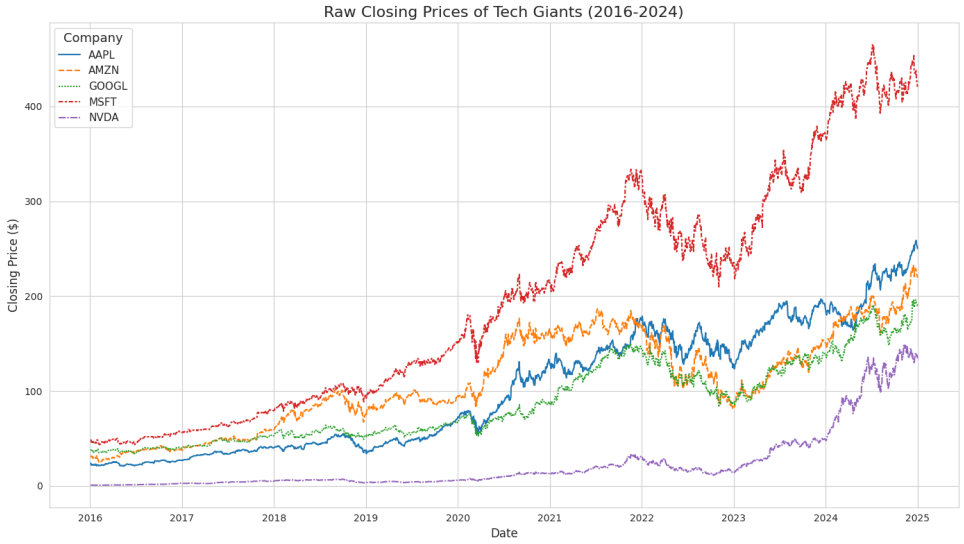


Figure 1: Raw Closing Prices of Tech Giants (2016-2024)

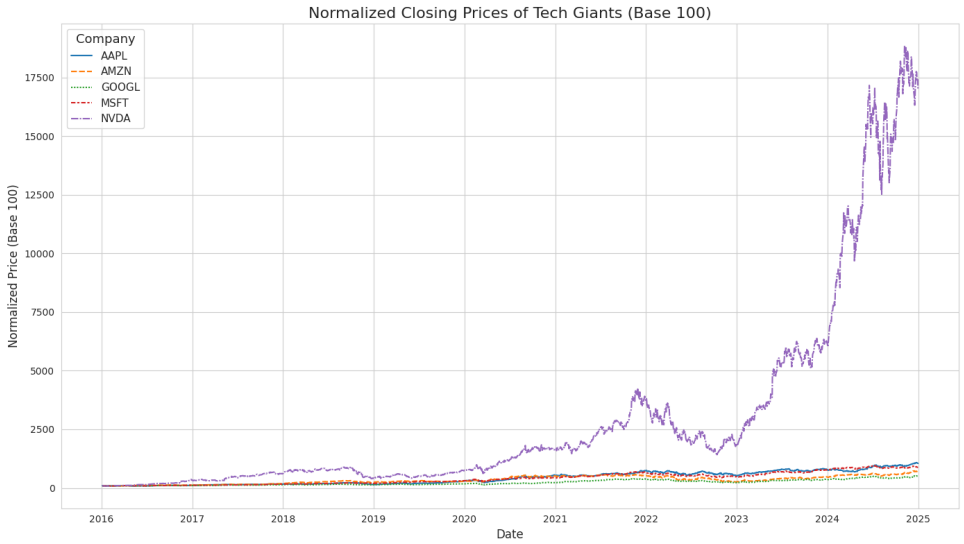


Figure 2: Normalized Closing Prices of Tech Giants (Base 100)

3 Unpacking Risk: Volatility and Returns

This section delves into the risk-reward profiles of the tech giants, measured by volatility and daily returns.

- Definition of volatility as the degree of price fluctuation and its relation to risk.
- Analysis of the distribution of daily returns for each company.
- Insights from a scatter plot comparing annualized volatility against mean annualized returns:
  - Nvidia: Highest volatility coupled with unparalleled returns.

  - Microsoft: Impressive balance of substantial returns and notably lower volatility.
  - Apple: Comparatively steady performer with solid returns and manageable risk.
  - Amazon and Google: Middle ground with decent returns but more pronounced daily swings.

- Examination of the 30-day rolling annualized volatility to understand dynamic shifts in risk levels over time.

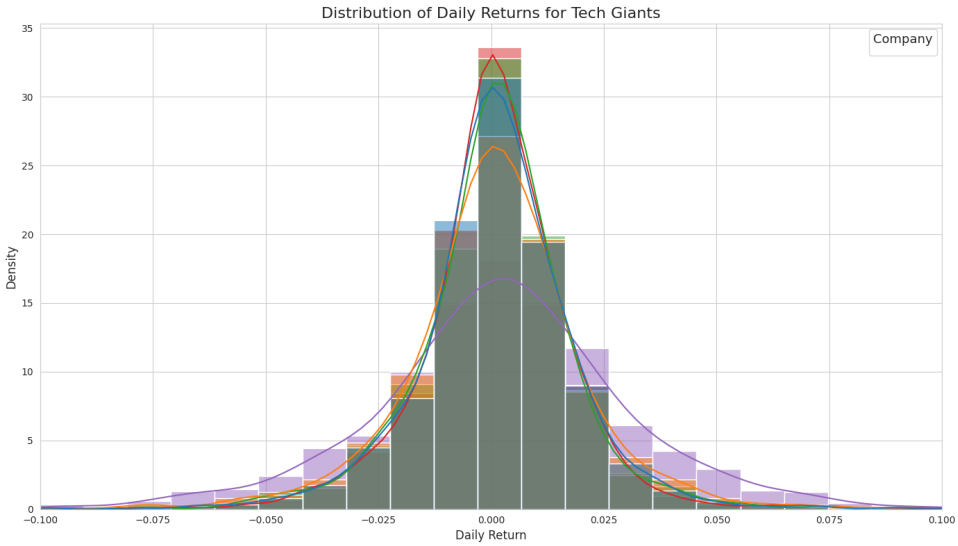


Figure 3: Distribution of Daily Returns for Tech Giants

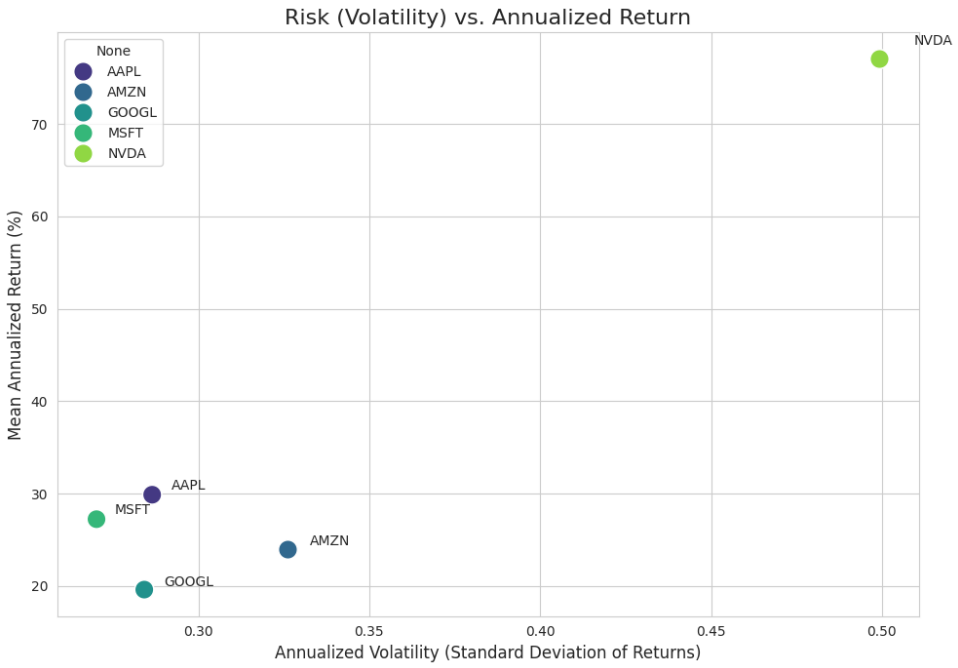


Figure 4: Risk (Volatility) vs. Annualized Return

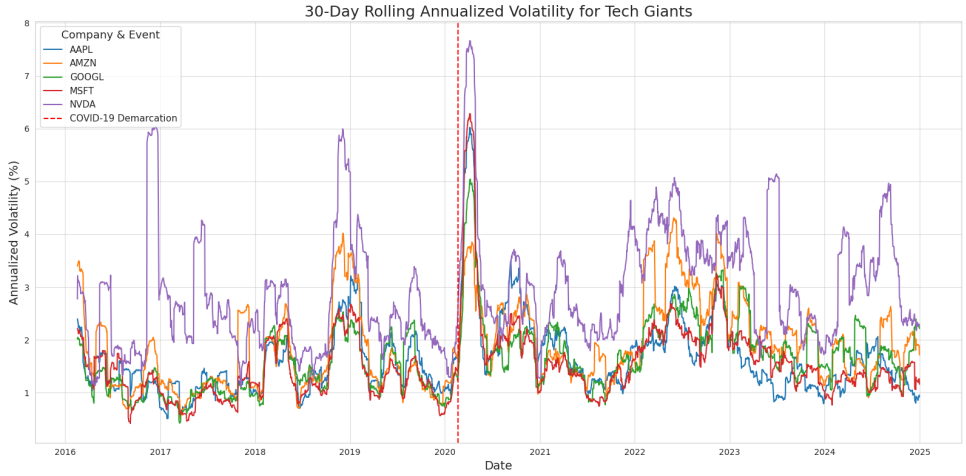


Figure 5: 30-Day Rolling Annualized Volatility for Tech Giants

4 Investor's Lens: Hypothetical Investment Returns

This section quantifies the tangible wealth generation potential through a compelling hypothetical investment scenario.

- Scenario: A $1000 investment allocated to each tech giant at the start of the post-COVID period (February 19, 2020), held until the end of 2024.
- Results powerfully underscoring wealth generation potential:
  - Nvidia: Extraordinary performance, turning $1000 into over $17,000 (1614% return).
  - Apple, Google, and Microsoft: Substantial gains (135% to 219%).
  - Amazon: Solid 102% return.
- Demonstration of the profound impact of compounding returns and outsized financial rewards in high-growth companies.

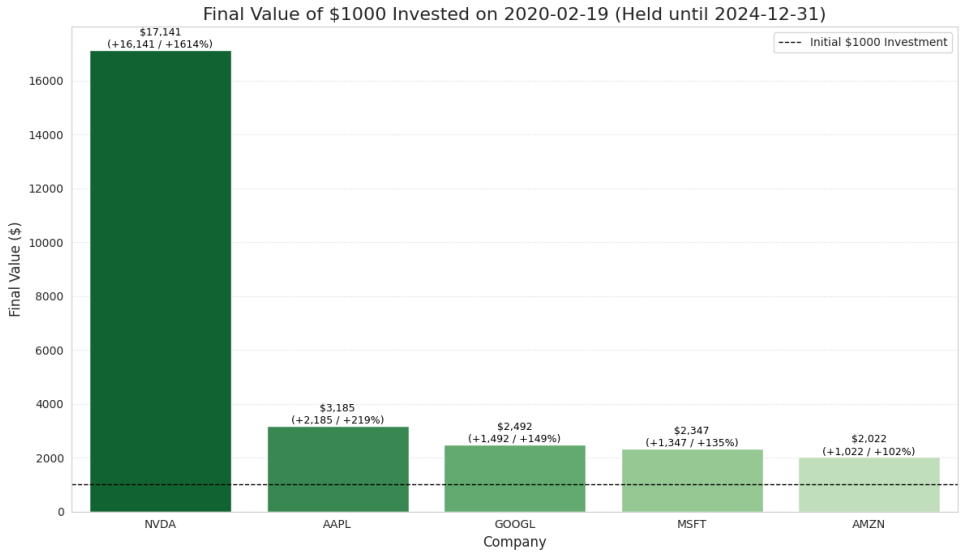


Figure 6: Final Value of $1000 Invested on 2020-02-19 (Held until 2024-12-31)

5 Market Interplay: Volume & Correlations

This section examines trading volume and inter-stock correlations, vital for understanding broader market context and portfolio diversification.

- Trading volume as a pulse check on investor interest and market activity.
- Observation of a general upward trend in daily trading volume for most tech giants, reflecting growing market participation.
- Nvidia's exceptionally high trading volumes during its rapid growth phase, signaling intense investor activity.
- Spikes in volume often coinciding with major news events or earnings reports.
- Examination of correlation between daily returns of tech titans:
  - High degree of positive correlation (generally 0.5 to 0.7 or higher).
  - Implications for portfolio diversification: limited protection against sector-wide downturns by holding only these tech giants.

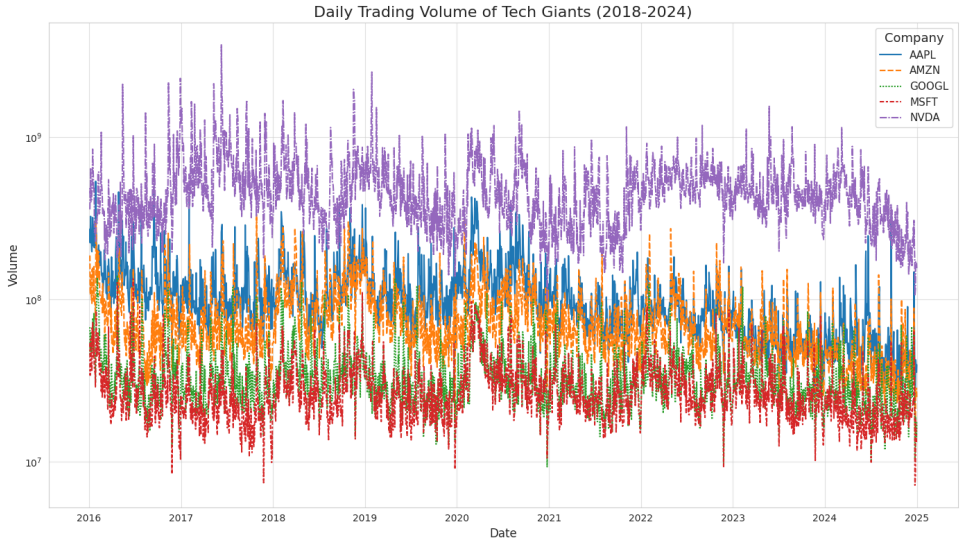


Figure 7: Daily Trading Volume of Tech Giants (2016-2024)

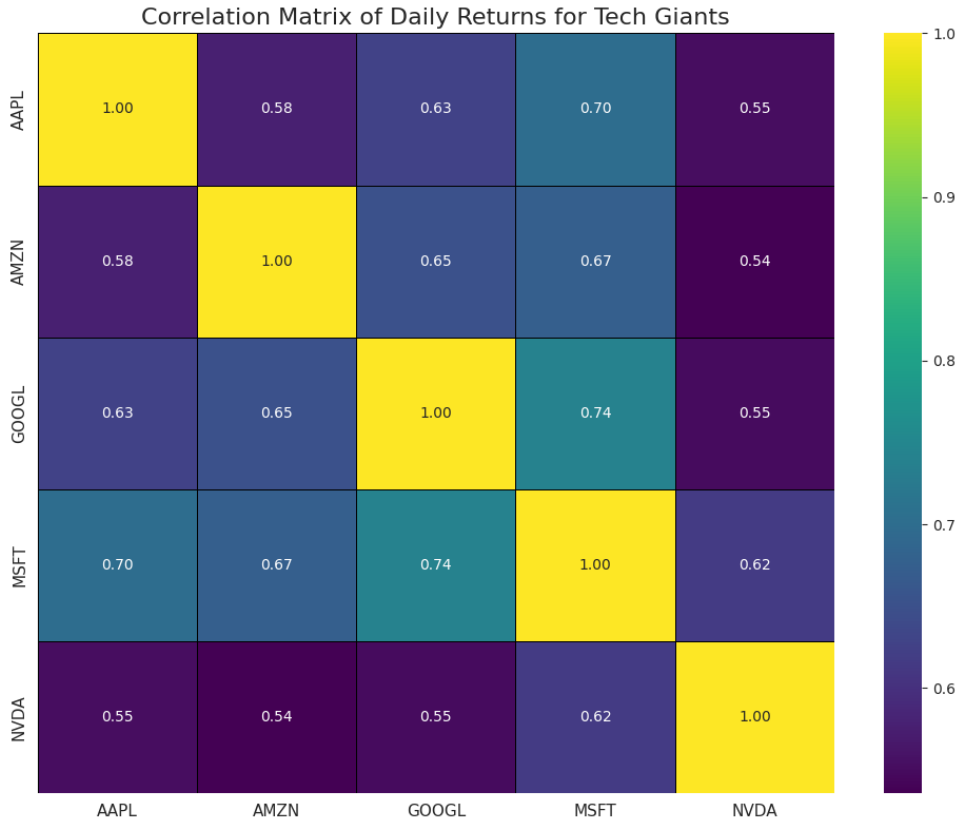


Figure 8: Correlation Matrix of Daily Returns for Tech Giants

6 The Pandemic's Mark: COVID-19 Impact Analysis

This section meticulously quantifies the unprecedented impact of the COVID-19 pandemic on stock volatility and growth.

- Establishment of **February 20, 2020**, as the critical demarcation date, dividing the dataset into "Pre-COVID" and "Post-COVID" periods.

6.1 Investigating Shift in Stock Volatility

- Primary inquiry: Whether volatility (risk) was significantly affected following the COVID-19 pandemic.
- Hypothesis formulation:
  - H0: $\sigma^2_{\text{pre}} = \sigma^2_{\text{post}}$ (No significant change in variance/volatility)
  - H1: $\sigma^2_{\text{pre}} \neq \sigma^2_{\text{post}}$ (Significant change in variance/volatility)
- Employment of Levene's Test, a robust statistical tool, to assess the variance change.
- Presentation of Levene's test findings:

Table 1: Levene's Test Findings for Stock Volatility (Pre- vs. Post-COVID)

Company	**Std Dev Pre-COVID (Annualized)**	**Std Dev Post-COVID (Annualized)**	**Levene Statistic**	**P-value**	**Conclusion**
AAPL	0.2441	0.3181	38.5449	0.0000	Reject H0 (Significant Change)
AMZN	0.2785	0.3618	59.0576	0.0000	Reject H0 (Significant Change)
GOOGL	0.2225	0.3276	86.3460	0.0000	Reject H0 (Significant Change)
MSFT	0.2195	0.3067	56.2356	0.0000	Reject H0 (Significant Change)
NVDA	0.4437	0.5422	51.8879	0.0000	Reject H0 (Significant Change)

- Interpretation of results: Statistically significant change in volatility for most/all tech giants in the post-COVID era, reflecting heightened uncertainty.

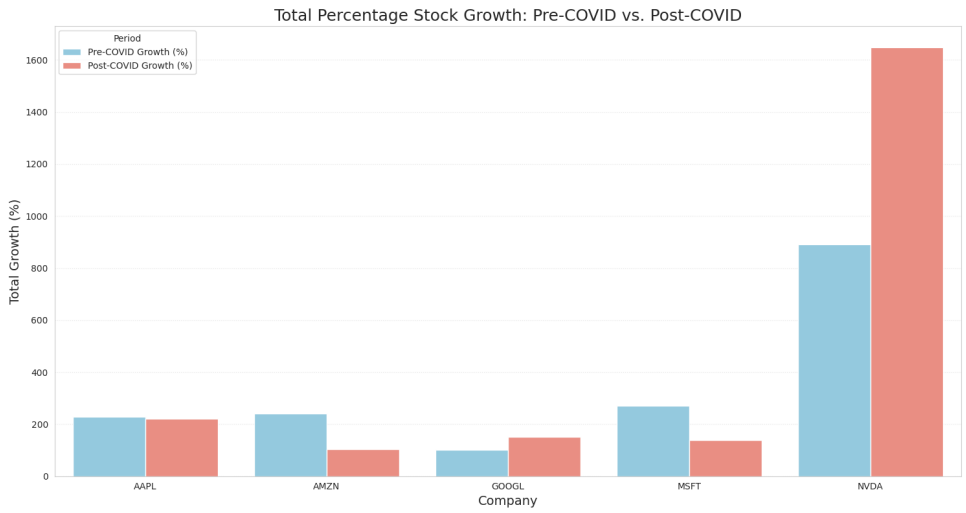


Figure 9: Total Percentage Stock Growth: Pre-COVID vs. Post-COVID

6.2 A Comprehensive Exploratory Analysis of the Data

- Comparison of total percentage growth in pre- and post-COVID periods, revealing substantially higher growth in the post-COVID era for nearly every company.
- Discussion on how the pandemic acted as a catalyst for growth across many tech sector segments.
- Focused visualization on Nvidia's accelerated growth, demonstrating the dramatic steepening of its post-pandemic growth curve.

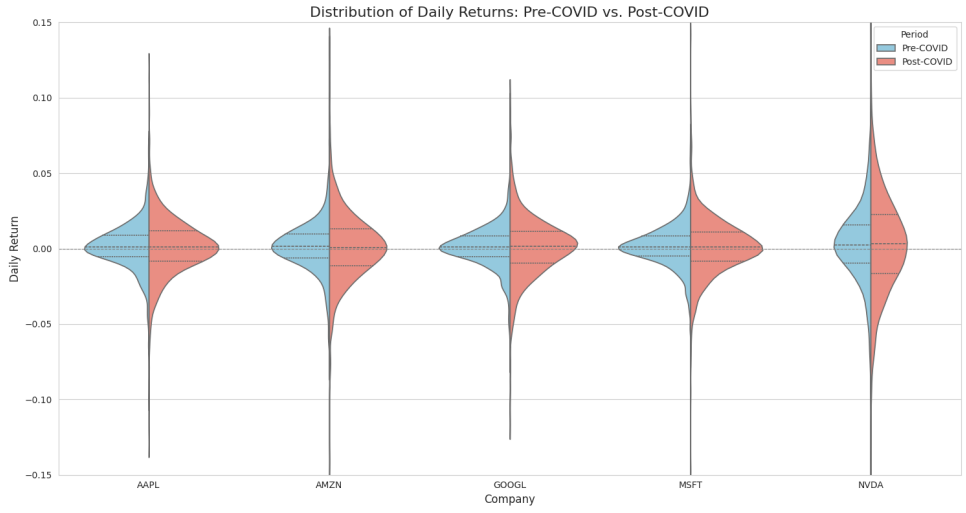


Figure 10: Distribution of Daily Returns: Pre-COVID vs. Post-COVID (Violin Plot)

6.3 Examining Intra-day Trading Dynamics

- Analysis of subtle shifts in intra-day trading dynamics, specifically the proportion of "up" days (closing price higher than opening price).

- Hypothesis formulation:
  - H0: $p_{\text{post}} = p_{\text{pre}}$ (No significant change in proportion of up days)
  - H1: $p_{\text{post}} \neq p_{\text{pre}}$ (Significant change in proportion of up days)
- Employment of z-test, a robust statistical tool, to assess the proportion change.
- Presentation of z-test findings:

Table 2: Z-test Findings for Intra-day "Up" Day Proportions (Pre- vs. Post-COVID)

Company	**Up_Pre (Close > Open)**	**Up_Post (Close > Open)**	**Z_Statistic**	**P_Value**	**Conclusion**
AAPL	0.508434	0.496899	0.408777	0.682704	Fail to Reject H0 (No Significant Change)
AMZN	0.508434	0.492248	0.573628	0.566220	Fail to Reject H0 (No Significant Change)
GOOGL	0.438554	0.506202	-2.397888	0.016490	Reject H0 (Significant Change)
MSFT	0.484337	0.509302	-0.884763	0.376285	Fail to Reject H0 (No Significant Change)
NVDA	0.513253	0.522481	-0.327289	0.743449	Fail to Reject H0 (No Significant Change)

- Interpretation of results: Google showed a statistically significant shift, while others did not.

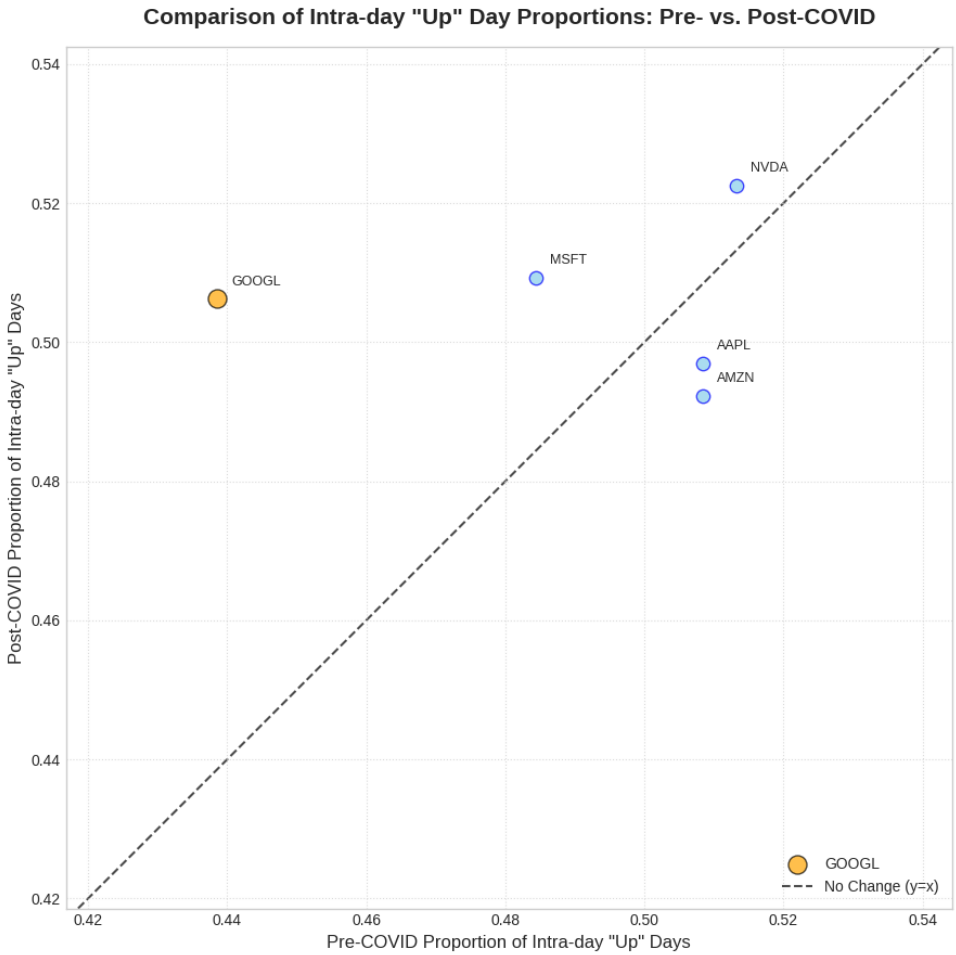


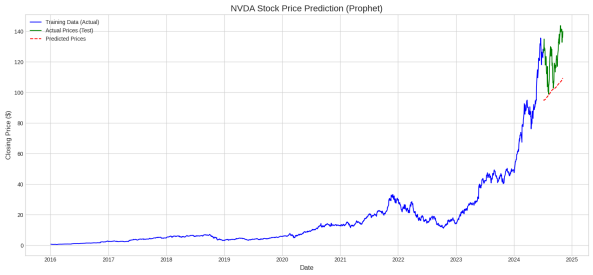
Figure 11: Comparison of Intra-day "Up" Day Proportions: Pre- vs. Post-COVID

7 Glimpsing the Future: Stock Trajectory Prediction

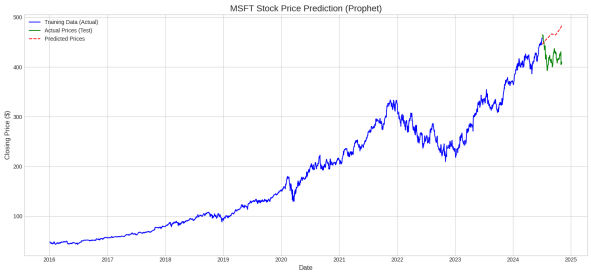
This section discusses the inherent challenges of stock forecasting and the application of Facebook's Prophet library to attempt informed projections.

- Acknowledgment of financial markets' complexity and unpredictability.
- Methodology:
  - Leveraging Facebook's Prophet library for time series forecasting.
  - Data preparation: splitting historical prices into a training set and a test set (most recent six months).
  - Model training for each of the five tech stocks.
- Findings:
  - Models generally captured overall long-term trends and broader movements.
  - Struggles to perfectly forecast sharp, sudden price changes or precise daily fluctuations.

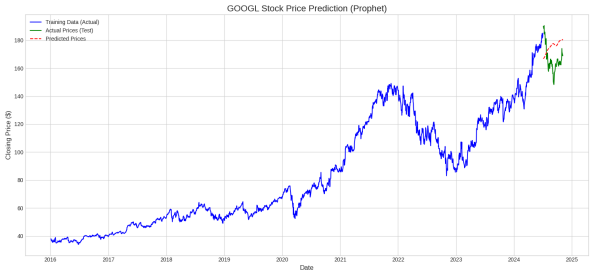
- Quantitative evaluation using metrics: Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE).
- Discussion on the degradation of accuracy as the prediction horizon extends.



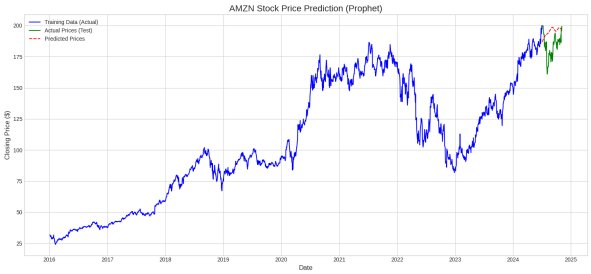
(a) NVDA Stock Price Prediction (Prophet)



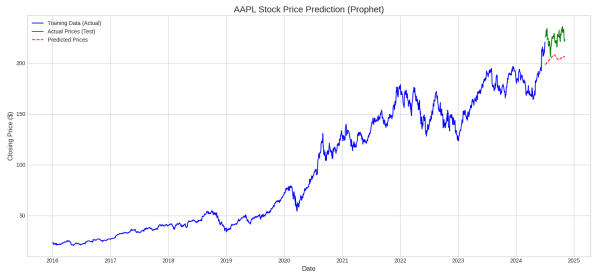
(b) MSFT Stock Price Prediction (Prophet)



(c) GOOGL Stock Price Prediction (Prophet)



(d) AMZN Stock Price Prediction (Prophet)



(e) AAPL Stock Price Prediction (Prophet)

Figure 12: Stock Price Predictions using Prophet for Tech Giants

8 Conclusion: A Legacy Forged in Data

This section provides a concise summary of the key findings and overall insights derived from the comprehensive analysis of the tech giants' stock performance.

- Recap of Nvidia's explosive ascent and its role post-COVID digital acceleration.
- Summary of Microsoft's remarkable blend of robust growth and relative stability.
- Discussion on the COVID-19 pandemic as a powerful catalyst:
  - Profoundly reshaped risk profiles, leading to statistically significant shifts in stock volatility.

  - Accelerated growth trajectories for many tech giants despite initial market shock.
  - Maintained high correlation, reflecting shared susceptibilities to broader market forces.

- Overall assessment of stock trajectory prediction: valuable for understanding general trends and underlying momentum, despite precision remaining an elusive goal.

- Emphasizing the narratives of innovation, market adaptation, and the interplay between technological advancement and global events.

9 Limitations & Future Work

This section critically discusses the constraints of the current study and outlines promising avenues for future research, aiming to enhance the depth and breadth of the analysis.

9.1 Limitations:

- **Binary Period Definition:** The reliance on a single, sharp demarcation date for "Pre-COVID" and "Post-COVID" might oversimplify the gradual unfolding of the pandemic's economic and market impacts.

- **Causation vs. Correlation:** While statistically significant changes are observed, the analysis primarily establishes correlation, not definitive causation, as other macroeconomic or geopolitical factors could also have contributed.

- **Normality Assumptions in Testing:** Extreme non-normality in daily returns (common in financial data) could potentially affect the power or Type I error rate of the statistical tests, despite Levene's test being robust.

- **Model Simplification (Prophet):** Prophet models, while powerful, simplify complex stock market dynamics and do not inherently account for non-linear relationships, sudden market shocks (unless explicitly modeled as events), or intricate inter-stock dependencies without additional regressors.

- **Data Granularity:** Using only daily returns captures day-to-day volatility but does not delve into intraday dynamics or longer-term structural shifts that might require lower-frequency data or more granular intra-day analysis.

9.2 Future Work:

- **Formal Event Study Analysis:** Conducting a rigorous event study to quantify the abnormal returns and volatility around specific, well-defined pandemic-related events (e.g., major vaccine announcements, specific lockdown/reopening news, significant earnings reports during the pandemic).

- **External Regressors in Forecasting:** Enhancing prediction models by incorporating external factors (e.g., key economic indicators like GDP growth, inflation, interest rates; sentiment analysis from news or social media; company-specific fundamental data) as external regressors to potentially improve predictive accuracy.

- **Comparison to Market Benchmarks:** Extending the analysis by comparing the volatility and growth shifts of these tech giants against broader market indices (e.g., S&P 500, Nasdaq Composite) to discern whether their observed changes were unique or broadly reflective of overall market behavior.
- **Deep Learning for Forecasting:** Exploring the application of deep learning models, such as Long Short-Term Memory (LSTM) networks, which are designed to capture complex temporal dependencies in time series data, though this would significantly increase model complexity and computational requirements.
- **Sector-Specific Analysis:** Broadening the study to include more companies within the tech sector (and perhaps other sectors) to gain a more comprehensive understanding of industry-wide impacts and potential leadership changes.