

REPORT ON ADVANCED INFORMATION VISUALIZATION FOR STOCK MARKET ANALYSIS

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Abstract

This report introduces an interactive visualization dashboard designed for analyzing NYSE-listed stocks. Leveraging data from the `yfinance` API, the dashboard explores price trends, volatility, and key performance metrics for top stocks. By combining static and dynamic visualizations built using Python, Visualisation libraries like Matplotlib, Plotly, Dash and Streamlit, the tool simplifies complex stock market data, making insights accessible to a broader audience.

Introduction

The stock market is complex, and analyzing trends often requires technical expertise. This project aims to simplify stock analysis by leveraging advanced visualizations. We address key questions such as:

- How do stock prices evolve over time?
- What is the relationship between volatility and performance metrics?
- How can data-driven insights guide investment decisions?
- What are the key trends, price movements, and volatility of the selected stock over the chosen time period, and how can these insights guide investment decisions?
- How has the closing price of the selected stock evolved over the past year?
- What is the trade-off between risk (volatility) and return for selected stocks?
- How do selected stocks compare across key financial metrics such as P/E Ratio, Volatility, Market Cap, and YTD Performance?
- How do stocks evolve over time in terms of valuation (P/E Ratio) and risk (Volatility)?

Our tool targets users unfamiliar with financial terminology, providing clear and actionable visual insights.

Background

The stock market comprises numerous parameters that help evaluate a stock's performance, trends, and risk profiles. Our interactive dashboard is designed to simplify this complex data for users, enabling clear and insightful analysis. The following metrics are central to our stock market analysis:

Key Financial Metrics

- **Closing Price:** The price of the stock at the end of a trading session, reflecting the day's market sentiment.
- **Open Price:** The starting price at which the stock begins trading during the day.
- **High and Low Prices:** The maximum and minimum prices recorded for the stock during a specific time period.
- **Trading Volume:** The number of shares traded during the period. Higher volumes indicate higher investor activity.
- **52-Week Change (%):** The percentage change in the stock price over the past year, showing growth or decline.
- **Price-to-Earnings (P/E) Ratio:** A valuation measure comparing the stock's price to its earnings. Lower P/E ratios may indicate undervaluation.

- **Market Capitalization (Market Cap):** Total value of outstanding shares, indicating company size and stability.
- **Dividend Yield (%):** The annual dividends expressed as a percentage of the current stock price, appealing to income-focused investors.
- **Debt-to-Equity Ratio:** Measures the financial leverage of a company. A higher ratio signals greater reliance on debt.
- **Sector and Industry Classification:** Stocks are grouped into sectors such as Energy, Industrials, Financial Services, Consumer Cyclical, and Communication Services for comparative analysis.
- **Volatility Analysis:** Measures price fluctuations over time, crucial for assessing risk-return trade-offs.

Technical Implementation

Data Collection and Preprocessing

Data for the dashboard was collected using the `yfinance` API, focusing on the top NYSE-listed stocks based on market capitalization. The raw data included various metrics such as open price, closing price, trading volume, market cap, and volatility. The collected data underwent the following preprocessing steps:

- **Data Cleaning:** Using the Pandas library, missing values were handled, and unnecessary columns were removed to optimize the dataset.
- **Data Formatting:** Timestamps were converted into human-readable dates, and numerical fields (e.g., prices, volumes) were standardized for consistency.
- **Dynamic DataFrames:** Cleaned datasets were dynamically displayed using Streamlit's interactive features. Users can filter the dataset based on specific time periods, sectors, and stock symbols.

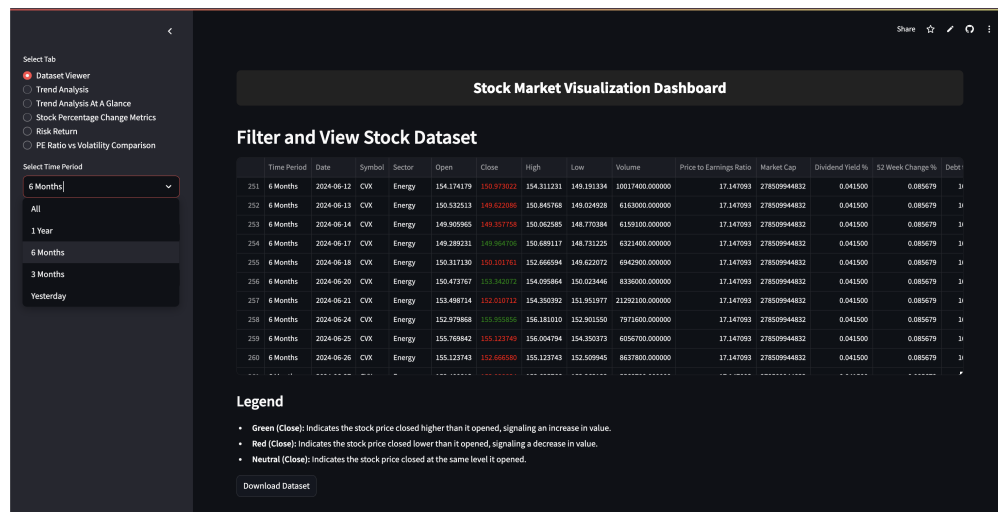


Figure 1: Time Period Filter in Dataset Viewer

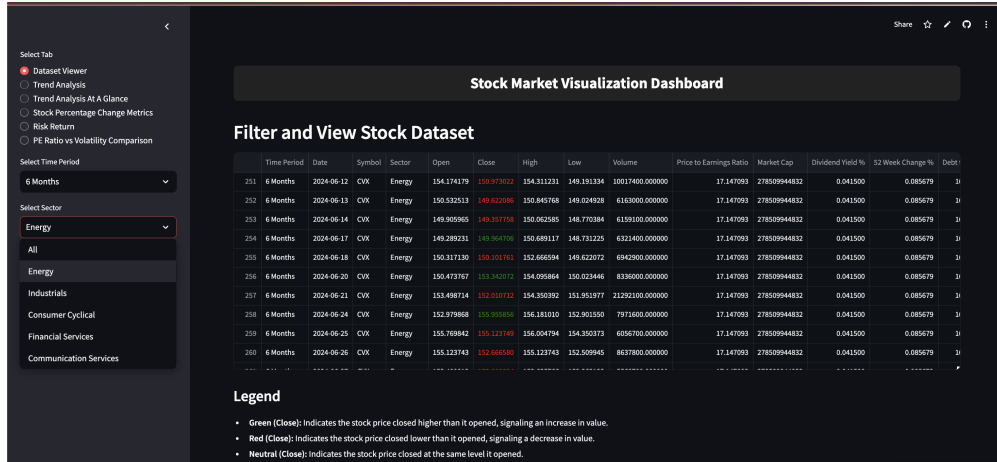


Figure 2: Sector Filter in Dataset Viewer

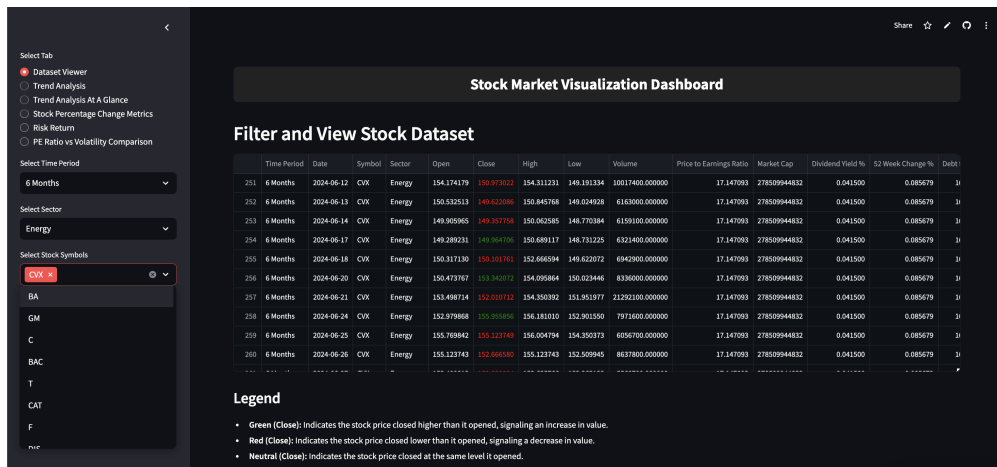


Figure 3: Stock Symbol Filter in Dataset Viewer

Trend Analysis

The **Trend Analysis** section leverages Streamlit, Plotly, and Seaborn libraries to create interactive visualizations that analyze stock price movements and trends over selected time periods.

Key Features:

- **Candlestick Charts:** Visualize daily stock movements with Open, High, Low, and Close (OHLC) values, providing a comprehensive overview of stock trends.
- **Moving Averages:** A configurable moving average (e.g., 5 to 50 days) smooths out short-term price fluctuations to highlight long-term trends.
- **Dynamic Filters:**
 - **Time Period Filter:** Users can choose predefined ranges such as 1 Year, 6 Months, and 3 Months to explore trends.
 - **Stock Symbol Filter:** Enables filtering specific stock tickers for focused analysis.
- **Range Slider:** Allows users to dynamically adjust the moving average duration for a more flexible and interactive experience.



Figure 4: Candlestick Chart with Trend Line and Moving Average for CVX

Insights Gained:

- The **highest price** recorded during the selected period was \$164.68, while the **lowest value** was \$133.85.
- The **moving average line** smooths short-term fluctuations and highlights broader price trends, assisting in identifying key bullish and bearish phases.
- Interactive filters, including the **symbol selector** and **time range**, allow users to customize the visualization for tailored stock analysis.
- The **range slider** provides additional flexibility by enabling users to explore moving averages over configurable durations (e.g., 5–50 days).

Supporting Explanation: Candlestick charts provide four critical data points (Open, High, Low, Close) for each stock over a specified period. The moving average line adds clarity by smoothing short-term noise, making long-term trends easier to observe. Figure above illustrate these components.

Trend Analysis at a Glance

The Trend Analysis at a Glance section provides an overview of stock price performance using dynamic visualizations. This section focuses on presenting concise insights through interactive tables and line charts.

Key Features:

- **Stock Table Overview:** Displays key metrics, including the Open, Close, High, and Low prices for selected stocks over a custom time period (1 year, 6 months, or 3 months).
- **Percentage Change:** Highlights percentage growth or decline in stock price over the period, with conditional formatting for visual emphasis.
- **Interactive Line Chart:** A dynamically updated line chart visualizes closing price trends for the selected stock.
- **Playback Controls:** Users can animate the trend over time using play/pause functionality for better trend exploration.

Visualization Details: Figure 5 presents a table showing stock metrics such as 52-week change percentages and analyst decisions for selected stocks, allowing users to quickly identify significant trends.

Insights Gained:

- The stock **BA** experienced a significant decline, with a percentage change of -33.86% .
- The highest closing price during the period was \$264.27, while the lowest closing price was \$138.14.



Figure 5: Stock Table Overview with Key Insights and animated line chart for Stock BA Closing Price Trends

- The animated line chart effectively illustrates the downward trend, helping users observe price volatility and identify fluctuations over time.

Supporting Explanation: The combination of interactive tables and animated line charts provides a comprehensive understanding of stock performance. The table summarizes key metrics such as price movements, percentage changes, and analyst recommendations, offering quick and actionable insights. Meanwhile, the line chart offers a detailed visualization of stock price trends over the selected time period, enabling users to assess volatility and make informed, data-driven decisions.

Stock Percentage Change Metrics

The Stock Percentage Change Metrics section enables users to analyze stock performance over multiple time frames, including 1 Year, 6 Months, and 3 Months. The visualizations use grouped bar charts, animated bar chart races, and supporting descriptive insights to illustrate comparative percentage changes effectively.

Key Features:

- **Percentage Change Grouped Bar Charts:**
 - Shows comparative percentage changes for stocks over predefined time periods: 1 Year, 6 Months, and 3 Months.
 - Enables quick identification of stocks with positive or negative growth.
- **Animated Bar Chart Race:**
 - Displays the percentage change dynamically over a 10-year period.
 - Offers an intuitive way to compare stock performance trends over time.
- **Interactive Insights:**
 - Highlights key observations and explains deceptive visualizations, emphasizing the importance of percentage change over absolute stock prices.

Insights Gained:



Figure 6: Grouped Bar Chart: Percentage Changes Over Time Periods

- Stocks such as CVX and GM show marginal positive growth across shorter durations (3 and 6 months), while BA displayed a consistent decline across all time periods.
- The grouped bar chart highlights the relative percentage changes effectively, normalizing stock performance for meaningful comparisons.
- Animated bar chart races provide a dynamic perspective on long-term trends, showcasing growth patterns across a decade.

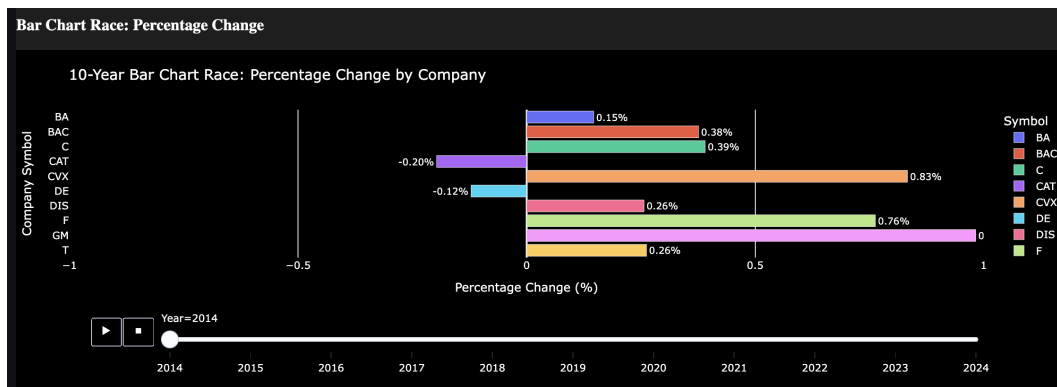


Figure 7: Bar Chart Race: Percentage Change Across 10 Years

Supporting Explanation: As demonstrated in Figures 6 and 7, percentage change metrics normalize stock performance by focusing on relative growth or decline rather than absolute stock prices.

- This method eliminates distortions caused by stock splits or differing price ranges, enabling an accurate comparison of company performance.
- The deceptive visualization explanation (Figure 8) emphasizes that absolute prices can mislead viewers into assuming higher prices indicate better performance.

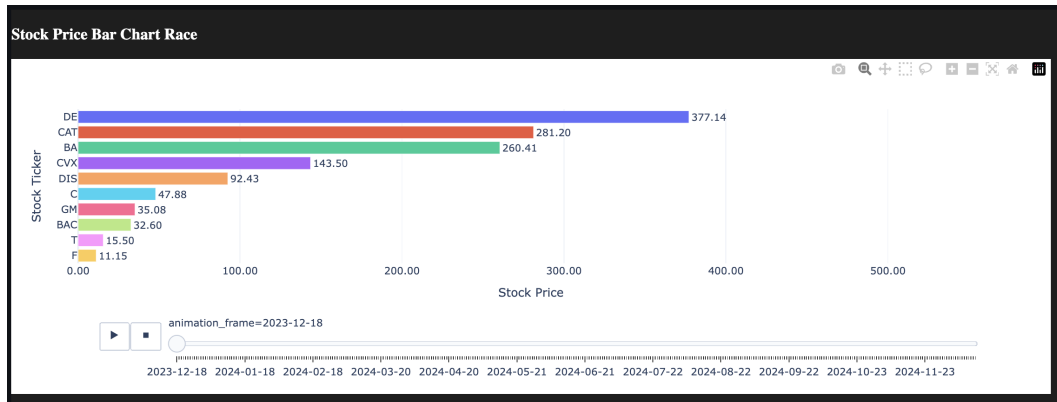


Figure 8: Insights on Deceptive Visualizations for Stock Comparisons

Visualization Libraries and Frameworks

The **Trend Analysis** module integrates the following libraries and tools:

- **Python Libraries:**
 - Pandas for data manipulation and preprocessing.
 - Plotly for creating interactive candlestick charts and line visualizations.
 - Seaborn for statistical data visualization.
- **Frameworks:** Streamlit for building the interactive dashboard interface.

Risk-Return Analysis

The **Risk-Return** section employs an interactive Bubble Matrix Visualization to evaluate the trade-off between risk (volatility) and returns for selected stocks. This helps users identify opportunities aligned with their financial goals.

Technical Implementation Tools and Libraries:

- Python Libraries: Pandas (data manipulation), Plotly (Bubble charts).
- Framework: Streamlit for dashboard interactivity.

Visualization Design:

- A bubble matrix visualizes the relationship between stock volatility (risk) on the x-axis and annual returns on the y-axis.
- Bubble size represents the magnitude of the stock's volume or market significance.
- A dynamic color scale reflects the annual returns: Yellow for high returns, Purple for negative returns.

Key Features:

- **Risk-Return Trade-Off:** Users can identify stocks with high returns and low volatility, ensuring informed decision-making.
- **Interactive Stock Selection:** Users can filter specific stocks of interest (e.g., CVX, GM, BA, etc.).
- **Visual Balance:** The matrix highlights stocks with the best return-to-risk balance through bubble size, positioning, and color.

Insights Gained:

- The stock **C** demonstrated the highest annual return of 49.32%, with moderate volatility.

- **CVX** had the lowest risk (Volatility: 0.19), making it a stable investment option.
- The stock **T** achieved the best return-to-risk balance with a Return-to-Risk Ratio of 232.77.
- **BA** exhibited high volatility (0.34) with negative returns, signaling significant risk.

Supporting Visualization:



Figure 9: Risk-Return Bubble Matrix Visualization for Selected Stocks

P/E Ratio vs Volatility Comparison

The P/E Ratio vs Volatility Comparison section provides two advanced visualizations to analyze how selected stocks compare in terms of valuation (P/E ratio) and risk (volatility):

Parallel Coordinates Chart The Parallel Coordinates Chart allows users to compare multiple metrics, including P/E Ratio, Annualized Volatility, Market Cap, and YTD Performance for selected stocks. It provides a comprehensive multi-dimensional view for stock analysis.

Key Features:

- **Parallel Axes Representation:** Visualizes multiple metrics simultaneously for selected stocks.
- **Color Encoding:** Highlights YTD performance using a color gradient to identify the best and worst-performing stocks.
- **Stock Comparison:** Allows a detailed analysis of trends across financial metrics for various companies.

Insights Gained:

- Stocks like GM showed the highest YTD Performance 55.72%, making it a top-performing stock.

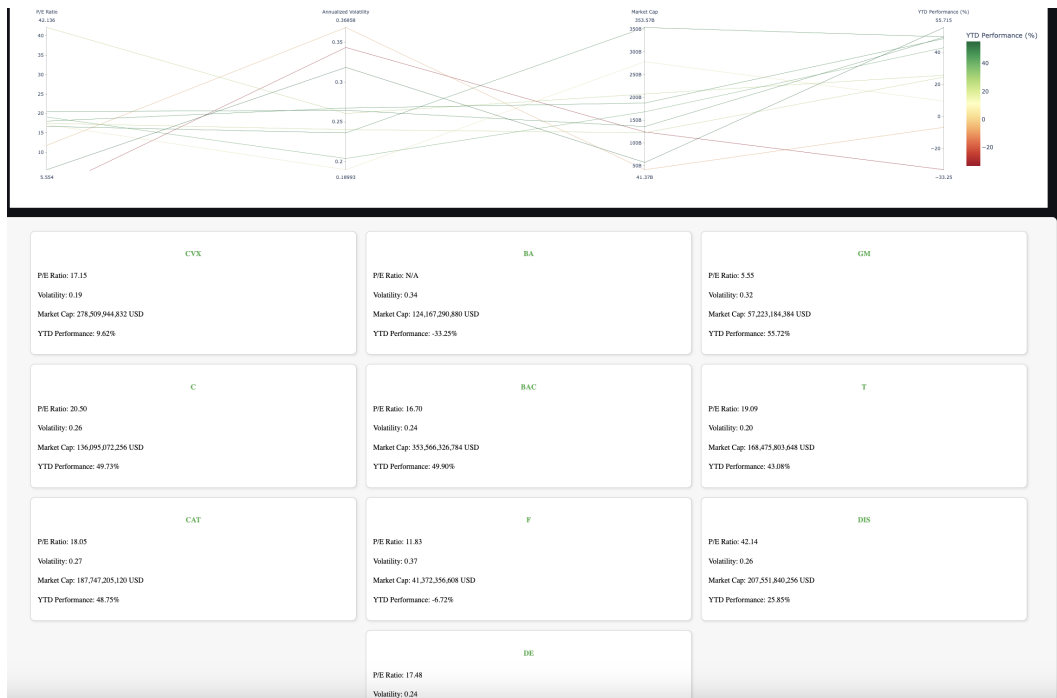


Figure 10: Parallel Coordinates Chart for Stock Comparison

- BAC had the largest Market Cap (\$353,566,326,784), indicating its strong market presence.
- C displayed the lowest volatility (0.01), representing minimal risk in price fluctuations.
- Multi-dimensional analysis helped identify stocks balancing risk, return, and valuation effectively.

Animated Bubble Chart The Animated Bubble Chart dynamically visualizes the relationship between the P/E Ratio, Volatility, and YTD Performance of selected stocks over time. Each bubble represents a stock, with its position on the axes showing its valuation and risk, size reflecting market cap, and color denoting performance.

Key Features:

- **Dynamic Bubbles:** Visualizes stocks as bubbles with attributes such as size (Market Cap) and color (YTD Performance).
- **Animation Over Time:** Enables users to observe how stocks evolve in terms of risk and valuation across different dates.
- **Interactive Tooltips:** Displays stock-specific metrics such as P/E ratio, volatility, and market cap upon hovering.

Insights Gained:

- GM achieved the highest YTD performance 55.72%, showcasing its strong annual growth.
- BAC retained the largest market capitalization, reinforcing its dominance among selected stocks.
- C maintained the lowest volatility across the analyzed period, indicating stability.
- The animation revealed shifts in stock behavior over time, helping investors identify trends and balanced opportunities.

Supporting Explanation The Parallel Coordinates Chart and the Animated Bubble Chart complement each other by providing static and dynamic perspectives on stock metrics:

- Parallel Coordinates help analyze multiple financial metrics for all stocks simultaneously.

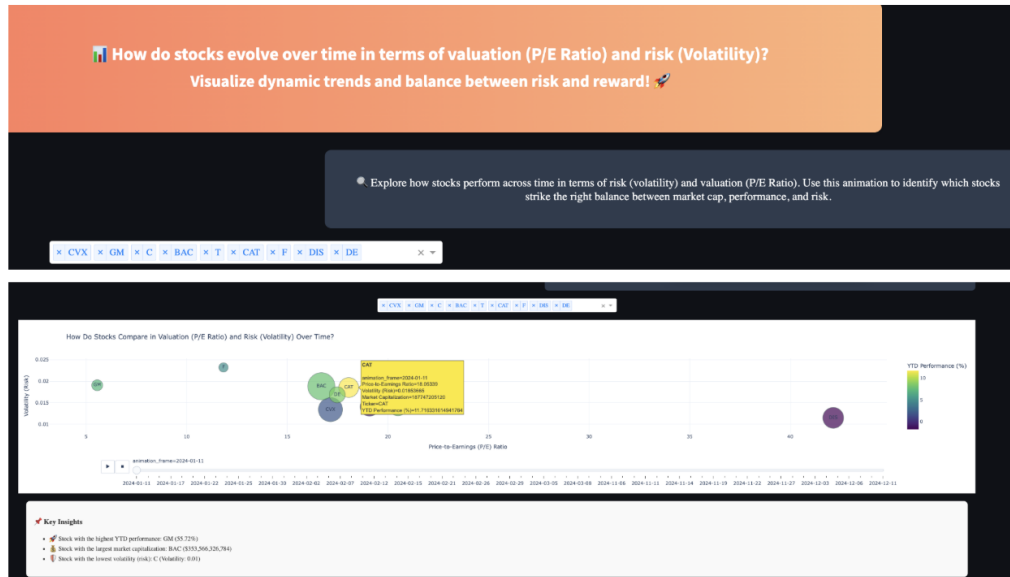


Figure 11: Animated Bubble Chart: P/E Ratio vs Volatility Over Time

- Animated Bubble Charts offer a dynamic view, allowing users to observe stock trends over time.

Together, these visualizations enable investors to make informed decisions by identifying high-performing stocks, minimizing risk, and balancing valuation metrics.

User Journey: From Beginner to Insightful Analysis

Imagine a user, Alex, who knows nothing about the stock market. Curious about investments but overwhelmed by technical jargon, Alex visits the Stock Market Visualization Dashboard. Here's how the journey unfolds:

Step 1: Exploring the Dashboard Upon landing on the dashboard, Alex notices the clean layout and clear labels. The interactive interface encourages exploration without prior knowledge of stocks. A simple welcome message or guide helps Alex understand what the dashboard offers.

Step 2: Understanding Basic Metrics Alex starts with the “Trend Analysis” section, where the dashboard displays an interactive **Candlestick Chart** (Figure 4). The chart visually represents stock price movements over time, breaking it down into four key metrics: Open, High, Low, and Close prices. By hovering over data points, Alex learns how stock prices change daily.

Step 3: Using the Slider to Explore Moving Averages Intrigued, Alex notices a **range slider** below the chart. By adjusting the slider, Alex explores the concept of **Moving Averages** for different durations (5–50 days). This feature helps Alex understand long-term trends versus short-term fluctuations.

Step 4: Filtering Stocks by Symbols and Sectors Next, Alex uses the **Stock Symbol Filter** and **Sector Filter** to focus on specific companies or sectors, such as Energy or Financial Services. This allows Alex to see how individual stocks behave compared to the broader market.

Step 5: Observing Risk-Return Trade-Offs In the **Risk-Return Analysis** section, Alex discovers the **Bubble Chart** (Figure 9). The interactive chart visually balances risk (volatility) on the x-axis and returns on the y-axis, with bubble size representing market significance. Alex identifies which stocks have high returns with minimal risk, learning to analyze investments effectively.

Step 6: Dynamic Comparison of Stock Metrics Alex then explores the **P/E Ratio vs Volatility** section. Using the **Animated Bubble Chart** and **Parallel Coordinates Chart**, Alex compares key financial metrics like Market Cap,

P/E Ratio, and Volatility across multiple companies. The animations help Alex observe how these values evolve over time.

Step 7: Insights and Decision-Making By the end of the journey, Alex feels empowered. The dashboard breaks complex financial data into visually engaging, easy-to-understand charts. From understanding basic metrics to exploring risk-return trade-offs, Alex now has the confidence to analyze stocks and make data-driven decisions.

Outcome: The dashboard successfully guided a beginner like Alex to transform from a stock market novice into someone capable of understanding and interpreting financial data effectively.

Discussion

Throughout this project, we explored the stock market dynamics by leveraging advanced visualization techniques such as candlestick charts, parallel coordinates, animated bar charts, and bubble charts. These tools enabled us to analyze trends, compare performance, and observe risk-return trade-offs across selected stocks.

Key Learnings:

- **Hands-on Implementation:** We deepened our understanding of data visualization libraries like Plotly, Seaborn, and Streamlit to create interactive dashboards.
- **Financial Analysis:** The project enhanced our ability to interpret key financial metrics such as P/E Ratios, Volatility, Market Cap, and YTD Performance.
- **Deceptive vs Earnest Visualizations:** By designing both informative and deceptive visualizations, we learned how visual encoding can influence perceptions and highlight the importance of transparency in data representation.

Challenges Encountered and Shortcomings:

- **Data Cleaning and Integration:** Ensuring consistency across different stocks and aligning attributes such as dates, prices, and metrics was time-consuming and required multiple iterations.
- **Performance Optimization:** The dashboard struggled with latency when handling large datasets or rendering complex visualizations. Further optimization using data caching or pagination can improve responsiveness.
- **Interactivity Trade-offs:** While Streamlit provided interactivity, the framework has limitations in handling highly customized or real-time visual updates compared to alternatives like D3.js.
- **Real-time Data Absence:** The lack of integration with real-time APIs limited our dashboard to historical analysis only. Incorporating live market tracking would provide more value to users.
- **Limited Predictive Analysis:** Although visualizations provide actionable insights, the dashboard does not incorporate predictive analytics for future trends or volatility forecasts due to time constraints.
- **User Guidance:** While the user journey section helps beginners, additional tooltips or a guided walkthrough within the dashboard interface could further improve usability.

This project tested our ability to combine technical skills with creative storytelling, ensuring that the visualizations were not only informative but also engaging for the target audience.

Conclusion

In conclusion, the Stock Market Visualization Dashboard provided a comprehensive platform to analyze and compare stock performance across multiple dimensions. Key takeaways included identifying trends using candlestick charts, evaluating percentage changes with grouped bar charts, analyzing risk-return trade-offs via bubble charts, and observing multi-dimensional relationships with parallel coordinates.

If given more time, we would:

- **Incorporate Predictive Analytics:** Use machine learning models to forecast stock trends and volatility.

- Enhance User Interactivity: Add more advanced filtering options, such as sector-specific analysis or customizable metrics.
- Expand Data Sources: Integrate real-time data APIs to enable live market tracking.

This project highlighted the importance of visual storytelling in simplifying complex financial data, empowering users to make data-driven investment decisions.

Works Cited

The following references were used to create this project:

- Plotly Documentation [2]
- Streamlit Documentation [4]
- yFinance Library for Stock Data [5]
- Seaborn Visualization Library [3]
- Investopedia - Financial Metrics and Analysis [1]

Team Contributions

The success of this project was the result of a truly collaborative effort between both team members. Every aspect, from initial brainstorming sessions to the final implementation, involved collective discussions and inputs. Both members contributed equally to the ideation and development of the visualizations, ensuring that each attribute and visualization design reflected shared insights. Decisions on key features, such as the candlestick charts, risk-return bubble matrix, and animated visualizations, were made through joint analysis and refinement. Every detail, including data pre-processing, technical challenges, and design aesthetics, was reviewed and executed with mutual agreement. This collaborative approach not only enhanced the quality of the project but also ensured that diverse perspectives shaped the final outcome.

References

- [1] *Investopedia - Financial Metrics and Analysis*. <https://www.investopedia.com/>. Accessed: 2024-12-17.
- [2] *Plotly Documentation*. <https://plotly.com/>. Accessed: 2024-12-17.
- [3] *Seaborn Visualization Library*. <https://seaborn.pydata.org/>. Accessed: 2024-12-17.
- [4] *Streamlit Documentation*. <https://docs.streamlit.io/>. Accessed: 2024-12-17.
- [5] *yFinance Library for Stock Data*. <https://pypi.org/project/yfinance/>. Accessed: 2024-12-17.