Factor Analysis and Visualization of U.S. Stock Market Data

Team 028 - CSE6242 - Spring 2025

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Motivation & Introduction

What is the problem:

The U.S. Federal Reserve's monetary policies significantly impact stock markets, yet specific effects across different sectors remain ambiguous and difficult to quantify. Investors and financial analysts often find it challenging to predict sector-specific responses to key monetary policies such as interest rate adjustments and shifts in economic conditions. These detailed insights are critical because they enable better risk management, informed strategic decision-making, and improved exploitation of market opportunities. The primary aim of this project is to demystify these complex relationships by developing practical, user-friendly visualization tools that clearly illustrate sector-specific market dynamics in response to monetary policies.

Why is it important and why should we care:

Understanding the sector-specific impacts of the Federal Reserve's monetary policies is important because it enables investors and analysts to better manage risk, make informed investment decisions, and safeguard their portfolios against market volatility. Given today's interconnected global economy, accurately predicting how different sectors respond to economic changes not only maximizes investment returns but also enhances overall financial security and economic stability.

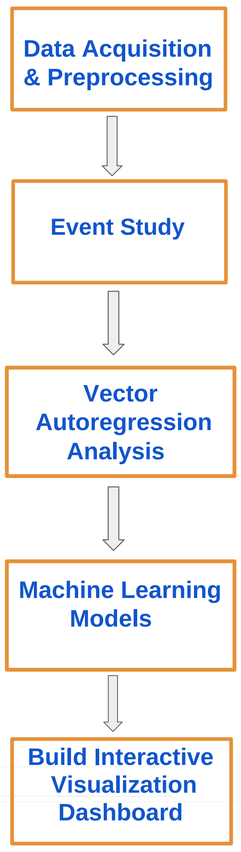
Data

Our comprehensive dataset was meticulously curated from credible and publicly accessible sources:

- **Stock Market Data: Historical stock prices of all S&P 500 constituents and Select Sector SPDR ETFs, covering the 11 major Global Industry Classification Standard (GICS) sectors (source: Kaggle).**
- **Federal Reserve Data: Detailed macroeconomic indicators, including the Federal Funds Rate, 10-Year Treasury Constant Maturity Rate, GDP Growth Rate, and Unemployment Rate, directly sourced from official Federal Reserve databases.**
- **FOMC Meeting Data: Records of Federal Open Market Committee decisions, including actual interest rate adjustments and unexpected surprise elements (source: Federal Reserve).**

These datasets span diverse economic scenarios, offering a robust foundation for analyzing and forecasting sector-specific market responses.

Approach



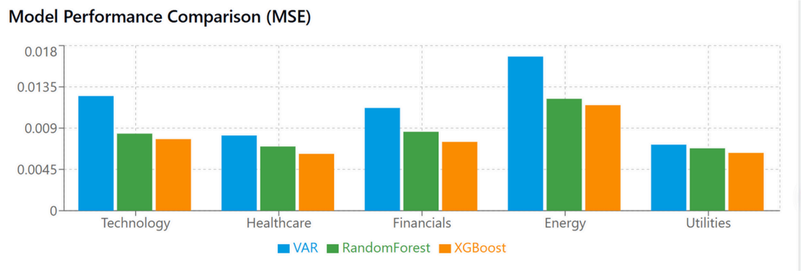


Figure 1. model performance comparison

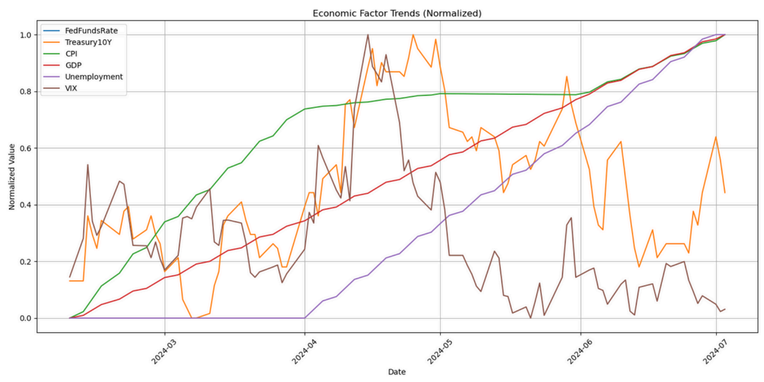


Figure 2. Random Forest model, Economic_Factor_Trends(Normalized)

Our project leverages a multi-faceted analytical framework composed of:

- **Event Study Analysis: A rigorous methodology focusing on immediate market reactions around FOMC announcements. By calculating cumulative abnormal returns (CAR), we quantified the distinct short-term impact of monetary policy changes on sector performance.**
- **Time Series Analysis (VAR): The Vector Autoregression model allowed us to capture complex, interdependent relationships between economic indicators and sector returns over extended periods, effectively demonstrating how sectors dynamically adjust to economic shocks.**
- **Machine Learning Models: Utilizing advanced machine learning algorithms such as Gradient Boosted Trees (XGBoost) and Random Forest classifiers, we developed predictive models capable of identifying key factors driving sector returns and forecasting future performance.**

These methodologies collectively provide comprehensive insights: event studies reveal immediate effects, VAR analysis uncovers dynamic and prolonged interactions, and machine learning models offer powerful predictive capabilities. A major innovation of our approach is the integration of these analytical methods with an interactive visualization dashboard, designed for intuitive and practical exploration by investors.

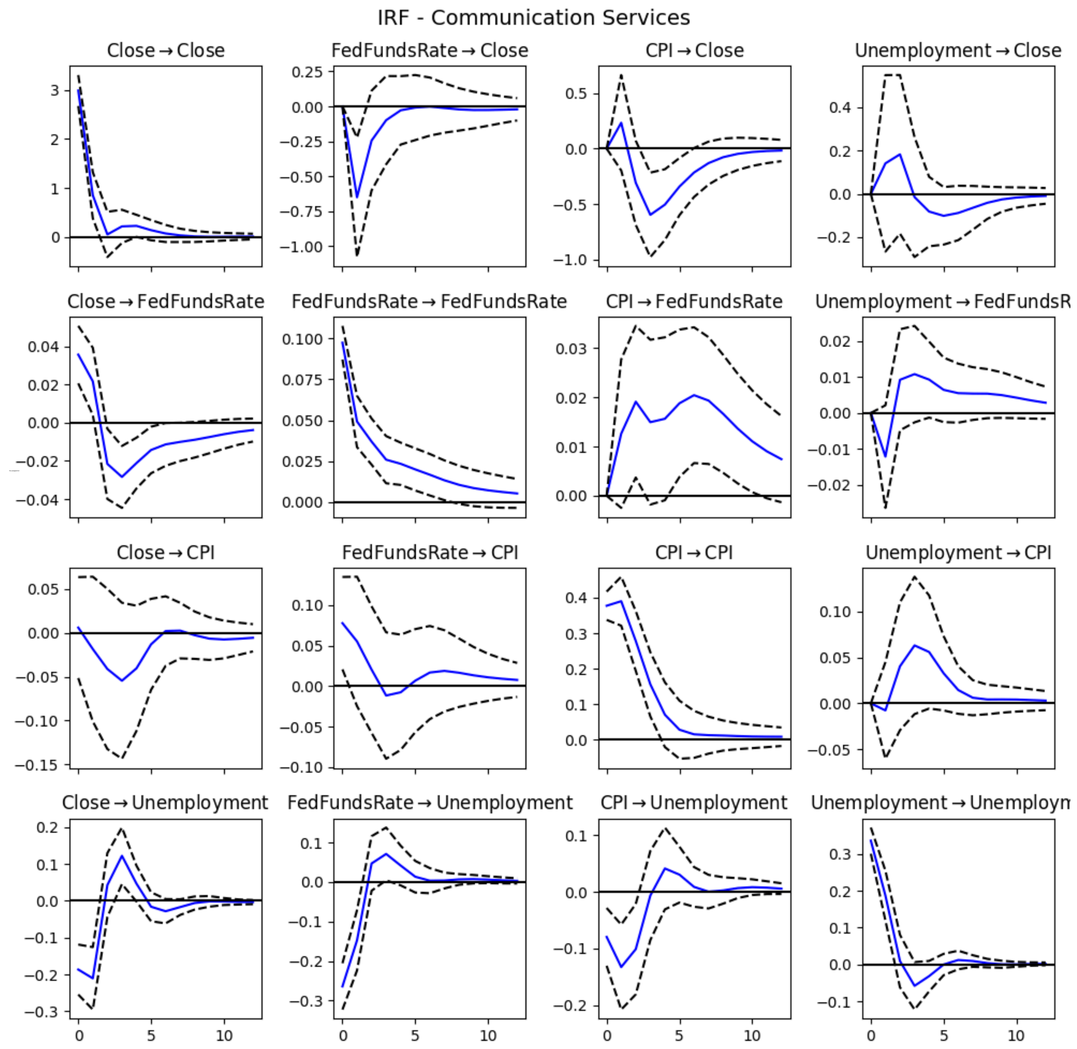


Figure 3: the VAR Model for Communication Services Sector

Experiments and Results

How did you evaluate your approaches?

Our experimental evaluations delivered insightful and actionable results:

- **Event Study Findings: Sector responses to monetary policy announcements varied significantly, confirming our hypothesis of differential sector impacts. For instance, Financials were highly reactive and experienced significant declines following rate hikes, whereas Utilities showed remarkable stability, highlighting investor preference for defensive sectors during policy uncertainties.**
- **VAR Analysis Outcomes: Revealed sector-specific sensitivities to macroeconomic shocks. Notably, sectors such as Financials, Real Estate, and Technology demonstrated heightened sensitivity to interest rate increases, while Utilities and Health Care sectors maintained stability. Additionally, inflation spikes boosted Energy sector returns but negatively impacted consumer-oriented sectors, showcasing the asymmetric impacts of economic shocks.**
- **Machine Learning Results: Our predictive models achieved notable accuracy, particularly in forecasting sector returns. Gradient Boosted Trees consistently outperformed traditional methods, reaching accuracy rates up to 79% for Utilities, Real Estate, and Financial sectors. Feature importance analysis identified CPI and VIX as the most influential indicators, underscoring their role in predicting sector dynamics.**

In summary, our integrated approach effectively identified nuanced sector reactions to monetary policies and macroeconomic conditions, significantly enhancing predictive accuracy and strategic insights beyond conventional static analysis methods.

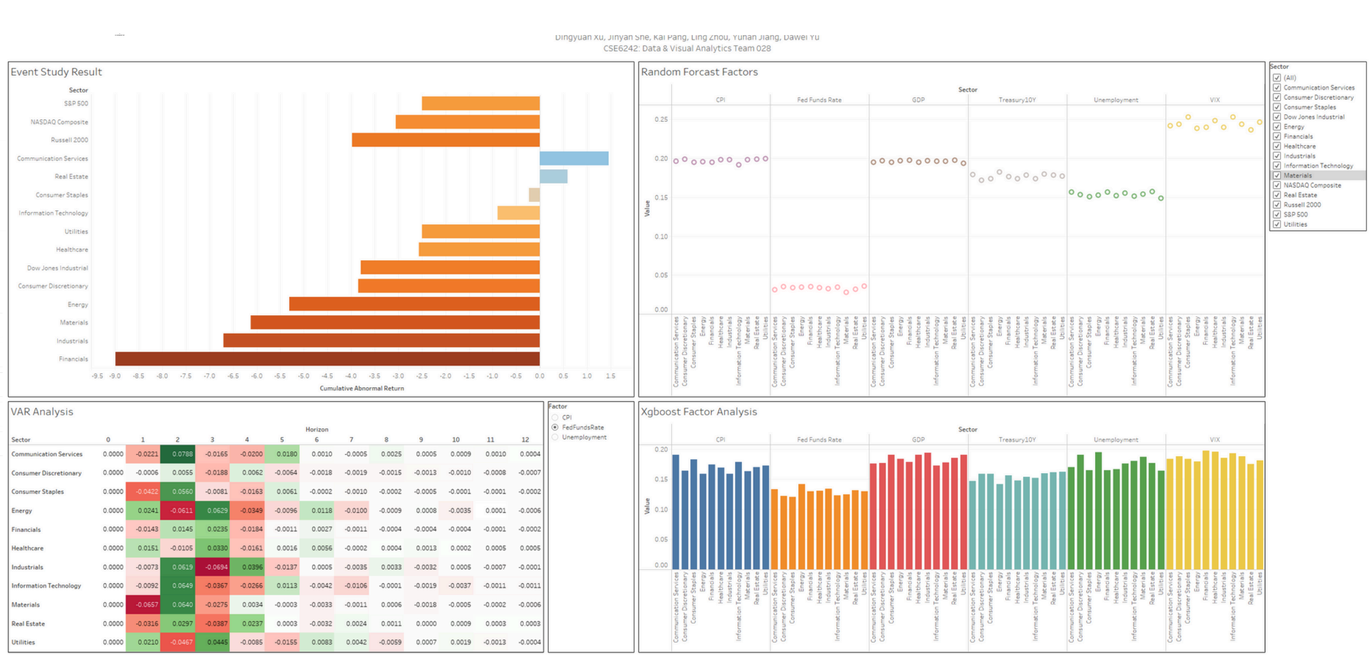


Figure 4. Screenshot of Tableau Visualition