SEPOL 416 Capstone Project: Decoding Market Reactions: Unveiling the Impact of FOMC Statements with NLP and Machine Learning Methods

Qingyang Tian
Supervisor:
Dr. Ruhan Circi &
Dr. Ruhan Ogut

Northwestern

Outline

I. Introduction

- The Federal Open Market Committee (FOMC) plays a crucial role in setting U.S. monetary policy.
- **Frequency:** 8 times per year
- Market participants closely analyze FOMC statements, which influence investor expectations and risk sentiment.
- These communications impact asset prices in **various financial markets.**

Dovish Tone	Hawkish Tone
• Lower interest rates and economic support • **Rate cuts or quantitative easing** • boost **stock prices**	• Inflation control and Economic tightening • **Rate hikes or reduced liquidity** • Leads to **market volatility**

I. Research Questions

- **Motivation for This Research**
  - Central Bank Communication is Critical
  - Financial Market Sensitivity
  - Bridging Economic Policy & Market Behavior
  - Advancements in NLP Tools

Research Question：
How do FOMC meeting statements relate stock prices indices and asset price trends?

II. Prior Research

NLP tools measure how qualitative economic descriptions in post-meeting statements impact bond prices (Taeyoung et al., 2021).

Fine-tuned FinBERT on FOMC minutes to enhance sentiment analysis of monetary policy communications (Ziwei et al., 2023).

Applied sentiment analysis (Loughran-McDonald, BERT, XLNet) to FOMC statements, predicting federal funds rate changes and S&P 500 correlations (Tomokuni et al., 2023).

My research：
Using various NLP tools to analyze the impact brought by the FOMC statements to the Specific industries of the Stock Market

II. Prior Research

My research: **Stock Market Indices from different industries**

Symbol	Index Name	Description
^SP500-60	S&P 500 Real Estate (Sector)	Tracks the **real estate sector** within the **S&P 500**, including REITs and property investment firms.
^SP500-50	S&P 500 Utilities (Sector)	Focuses on **utility companies** (electricity, water, gas) within the S&P 500.
^SP500-25	**S&P 500 Consumer Discretionary (Sector)**	**Represents consumer discretionary stocks (e.g., retail, entertainment, automotive) within the S&P 500.**

III. Data and identification strategy

Data Sources

- FOMC Meeting Statements (2004-2024) from the Federal Reserve Board
- Stock Market Data For Different Industries **(Real Estate, Utilities, Consumer Discretionary)** from Yahoo Finance

NLP Techniques Used

- **Text Preprocessing:** Tokenization, Lowercasing, Stemming/Lemmatization , Stopword Removal, etc
- **Text Analysis (TF-IDF):** Identifying Hawkish and Dovish Keywords from the FOMC Statements and then apply TF-IDF vectorization.
- **Sentiment Analysis (FinBert):** Measuring sentiment in FOMC Statements and divided into three groups (Hawkish, Neutral, Dovish Score tell them what is it

Workflow

Data Collection

- Collect 2004 to 2024 FOMC statements from the Federal Reserve Board
- Collect Stock Price Indexes from Different industries of S&P 500

Data Processing

- Data Import & Cleaning
- Select specific FOMC meeting date from Federal Reserve Board
- Calculate the Difference of index closing prices within a day, a week, and 4 weeks

NLP Analysis

- Extract Specific Keywords and Compute TF-IDF
- Extract Sentiments Using FinBERT
- Extract BERT-Based Features Using FinBERT and PCA analysis

Exploratory Data Analysis

- S&P 500 Index volatility over time
- Distribution of market difference after 1 day, 1 week & 4 week
- Correlation between FinBERT Sentiment & Market Difference

Machine Learning

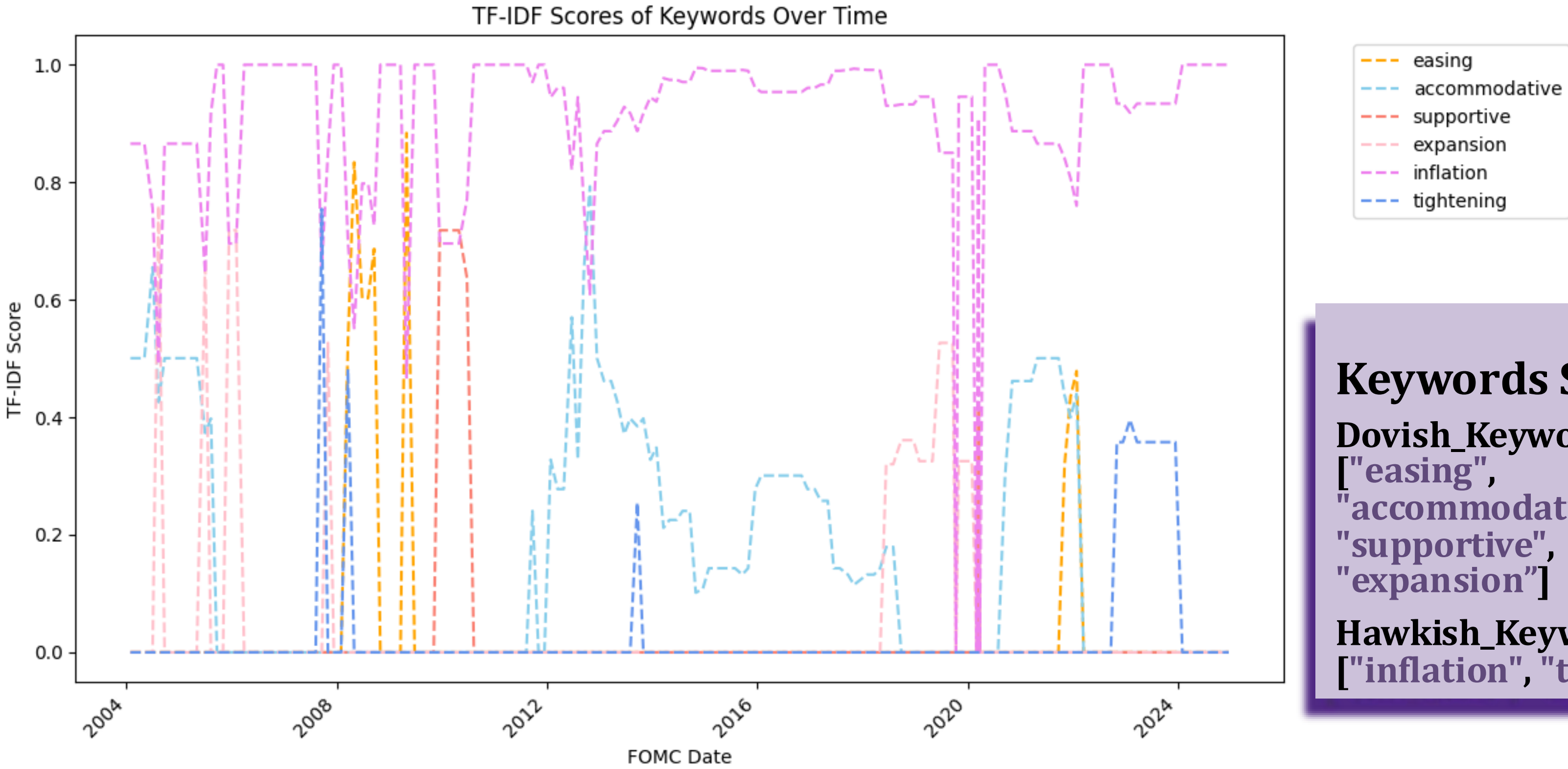
- Time series Train-Test Split (80,20), predict the differences for the last 20% of the dataset
- Model training with Logistic regression, Random Forest

Model Evaluation

- Hyperparameter Tuning & Cross Validation
- Confusion Matrix & Accuracy, Recall, Precision, F1 Scores

IV. Descriptive Analysis:

NLP ---- TF-IDF



Keywords Selection:

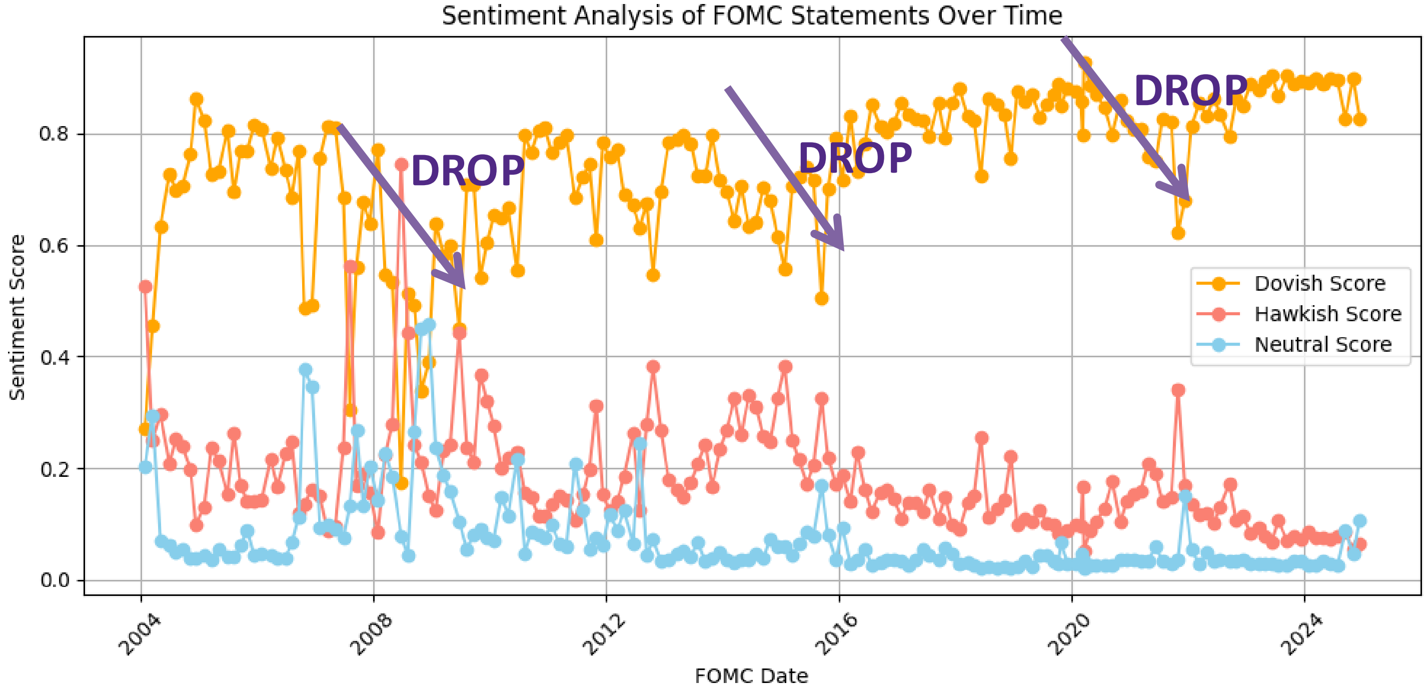
Dovish_Keywords = ["easing", "accommodative", "supportive", "expansion"]

Hawkish_Keywords = ["inflation", "tightening"]

"Inflation" consistently has high relevance, peaking in recent years, but experienced a sudden drop in 2020 year.
"Easing" & "Accommodative" were prominent before 2008 & 2020, likely during economic stimulus periods.
"Tightening" gained relevance post-2008 and again post-2020, indicating policy shifts toward tightening.
"Expansion" & "Supportive" had temporary spikes, aligning with economic stimulus phases.

IV. Descriptive Analysis:

NLP ---- Sentiment Analysis



Dovish sentiment (high values)	• dominates, suggesting a preference for **lower interest rates and economic support**.
Hawkish sentiment (fluctuating)	• spikes during **2008-2010 and 2016-2018**, aligning with **tightening cycles and rate hikes**.
Neutral sentiment (consistently low)	• remains minor, indicating statements generally lean **toward a stance rather than neutrality**.

IV. Feature Extraction & Prediction Analysis

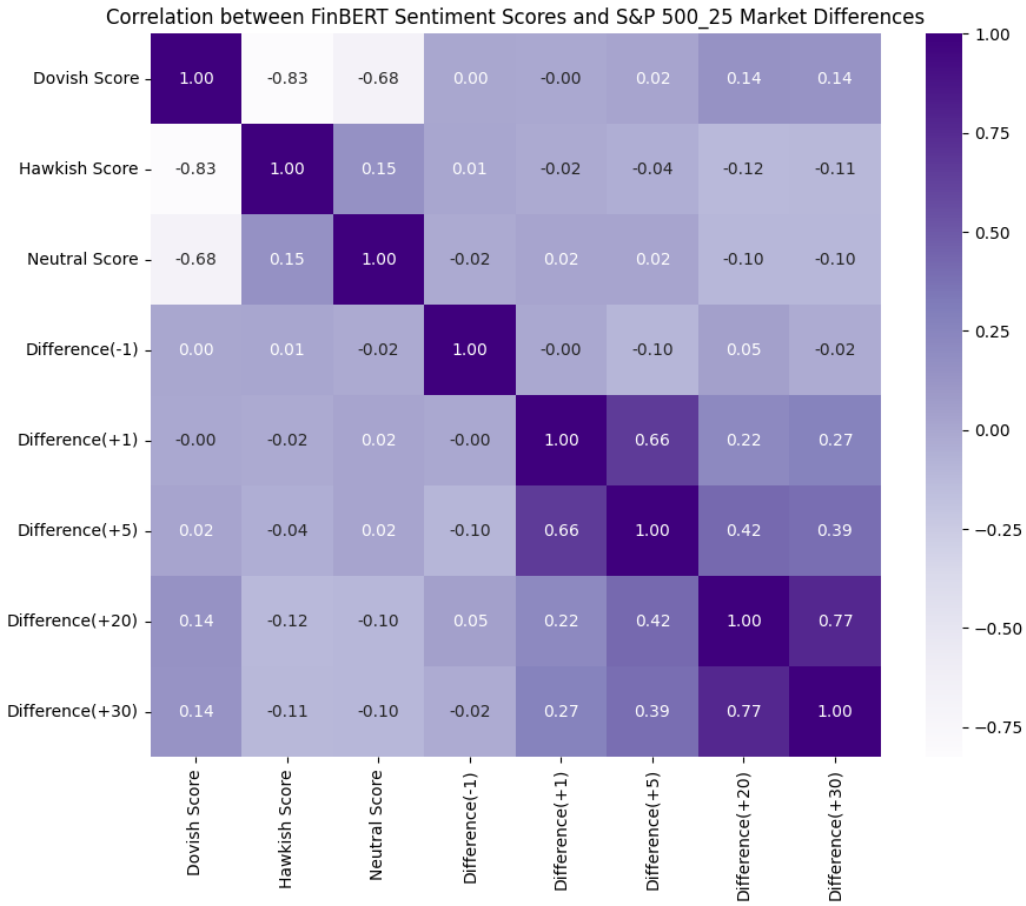
NLP Analysis ---- Extract BERT-Based Features Using FinBERT and PCA analysis

- **FinBERT Embeddings (768 Dimensions)**
  - FinBERT is a **finance-specific BERT model** used for **NLP in financial texts**.
  - It converts text into **768-dimensional embeddings** for numerical analysis.

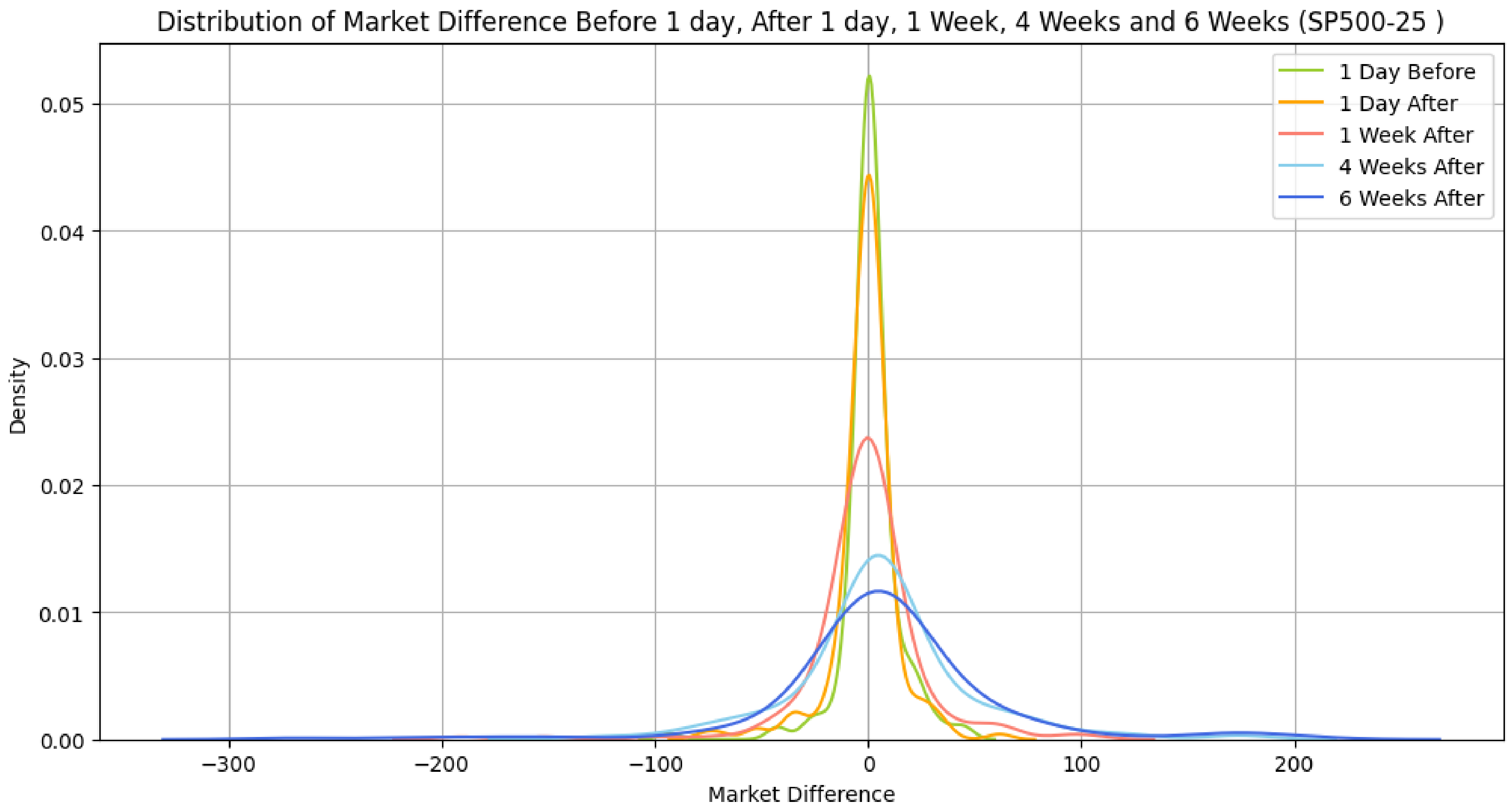
- Dimensionality Reduction Using Principal Component Analysis
  - PCA **reduces feature dimensions** while keeping 90% variance.
  - Helps in **improving computation efficiency** and **avoiding overfitting**.

- Reduced 768 variables to 30

IV. Descriptive Analysis



IV. Descriptive Analysis



V. Predictive Analysis

- **Number of input variables:** 39
  - 6 Keywords Selection
  - 3 Sentimental Scores
  - 30 BERT Based Features
- **Output variable (for this presentation)** S&P 500-25 Difference (+1)

Input Variables

- Keywords TF-IDF values
- Sentiment Scores
- BERT-based Features by using PCA Analysis

Output Variables

- S&P 500-25 Difference (+1)

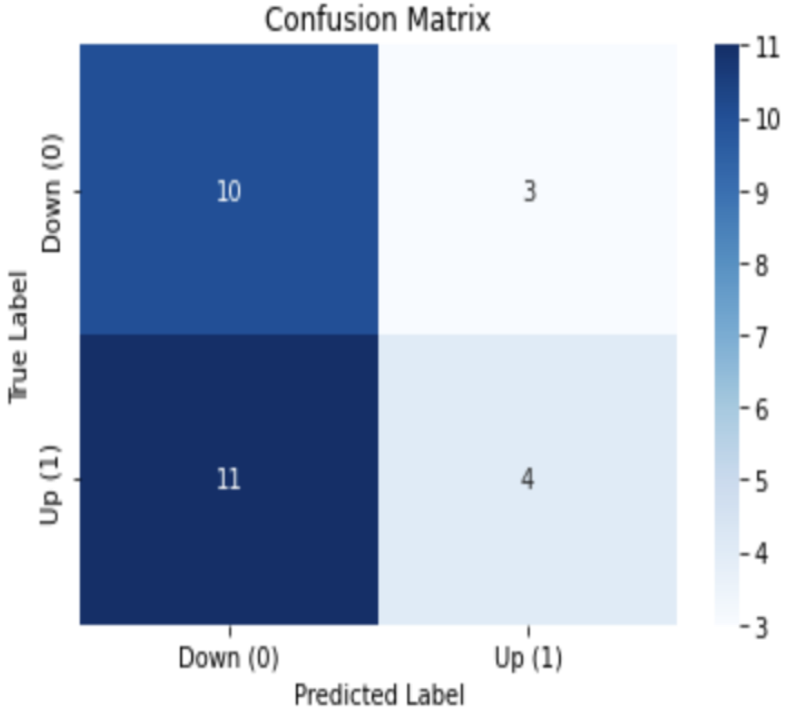
VI. Prediction Results & Model Evaluation

Train/test split:
Time Series Split is used to ensure that training always occurs on past data while testing is done on future data

Logistic Regression (Linear Model)

Evaluation Metrics	Score
Accuracy	0.5
Precision	0.5272
Recall	0.5
F1 Score	0.4679

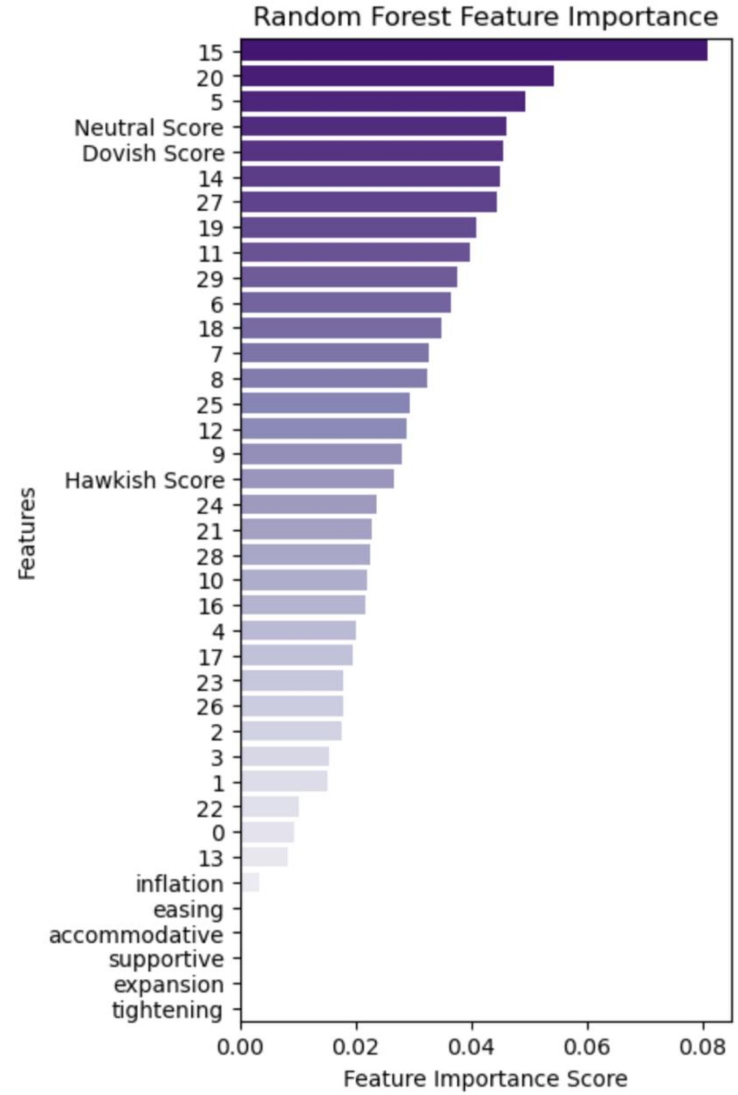
Potential Reasons for the low Score:
The non-linear nature of the data and market movements may not be linearly separable



VI. Models Evaluation

Random Forest:

Evaluation Metrics	Score
Accuracy	0.9642
Precision	0.9668
Recall	0.9643
F1 Score	0.9643



Feature Importance Insights:

- **FinBERT embedding capture the context well**
- **Neutral and Dovish Scores** are the most influential factors in predicting market movements.
- **Policy-related keywords** (inflation, easing, tightening, etc.) have minimal impact, indicating that market responses are driven more by sentiment than explicit policy language.

VI. Conclusion & Policy Insights

Conclusion

- BERT model, NLP features and flexible ML method show promise to predict the market movement.

Policy Insights

- **Improve Fed communication strategies** to reduce uncertainty.
- **Anticipate industry-specific market movements** for proactive policy-making.

VI. Limitation & Next Steps

Limited effects for the selected keywords due to the rare appearance

- Use other NLP techniques

Small datasets, which may lead to **overfitting**

- Increase dataset size

Analyze **broader financial markets** to refine Fed policy strategies.

References

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Q & A

Thanks for watching~