PREDICT FOMC INTEREST RATE DECISION: DEC 17-18, 2024

December, 17 2024

Prepared by Hauwa

Executive Summary:

OBJECTIVE

The objective of this challenge is to build a multiclass classification model to predict the likely interest rate adjustment at the December 17-18, 2024 Federal Open Market Committee (FOMC) meeting. The model aims to forecast one of five possible rate changes: -0.50%, -0.25%, 0%, +0.25%, or +0.50%. This approach seeks to provide precise predictions that align with realistic policy options considered by the FOMC.

METHOD

The model utilizes historical economic data and market expectations to make predictions. Key economic indicators such as inflation, unemployment, GDP growth, and market expectations were selected as features. The Random Forest classifier was chosen due to its robustness in handling complex interactions between features. The dataset was split into training and testing sets, and hyperparameter tuning was performed to optimize the model.

KEY FINDINGS

Model Performance:

- Random Forest:
  - Accuracy: 75%
  - F1 Score: 0.4184
  - Most Likely Rate Change: 0%
  - Probability: High confidence in predicting 0% rate change (65.00%).
- Gradient Boosting:
  - Accuracy: 71%
  - F1 Score: 0.3958
  - Most Likely Rate Change: -0.25%
  - Probability: Very high confidence in predicting -0.25% rate change (84.05%).
- Support Vector Machine:
  - Accuracy: 58%
  - F1 Score: 0.4655
  - Most Likely Rate Change: 0%
  - Probability: High confidence in predicting 0% rate change (83.91%).

INTRODUCTION

The Federal Open Market Committee (FOMC) plays a vital role in shaping the U.S. economy by setting the federal funds rate, which influences borrowing costs for consumers, businesses, and governments. The FOMC meets eight times a year, roughly every six weeks, to review the state of the economy and decide whether to raise, lower, or keep interest rates unchanged. These decisions are crucial because they impact inflation, employment, economic growth, and financial markets.

The upcoming FOMC meeting on December 17-18, 2024, is particularly significant as it will help set the tone for the economic outlook going into the new year. The committee consists of 12 voting members—including the seven members of the Federal Reserve's Board of Governors and five regional Federal Reserve Bank presidents who serve on a rotating basis. Their decisions are based on key economic factors such as inflation levels, job growth, economic output, and market trends.

The outcome of these meetings can have widespread effects. For example, a rate hike can slow down inflation but also make borrowing more expensive, which may affect spending and investment. On the other hand, a rate cut can encourage borrowing and spending but may risk higher inflation. When the FOMC decides to hold rates steady, it often signals confidence in the current state of the economy. Because these decisions are so impactful, financial markets, businesses, and policymakers carefully follow every meeting.

This report aims to predict the outcome of the December 17-18, 2024, FOMC meeting by forecasting one of five possible interest rate changes: -0.50%, -0.25%, 0%, +0.25%, or +0.50%. Instead of just predicting whether rates will change or stay the same, this approach considers a wider range of possibilities, providing a clearer picture of what to expect.

Accurate predictions are important because they help businesses plan for changes in borrowing costs, guide investors in making informed decisions, and assist policymakers in understanding how the economy is likely to evolve. By examining past trends, key economic indicators, and market expectations, this report seeks to offer a better understanding of what might drive the FOMC's decision in December and why it matters for the broader economy.

3. DATA COLLECTION AND PREPARATION

DATA SOURCES

1. FRED Economic Indicators : Time series data including inflation (CPI), unemployment rates, GDP growth of period (1960 - 2024).
   - (https://fred.stlouisfed.org/docs/api/fred/)
2. Federal Open Market Committee (FOMC) Statements : Textual data from past FOMC statements (2000 - 2024)
   - (https://www.federalreserve.gov/monetarypolicy/fomccalendars.htm)
3. World Bank Economic Indicators : International economic indicators, such as GDP and employment data.
   - (https://data.worldbank.org)
4. OECD Economic Outlook: ata across member countries, including forecasts.
   - (https://data.oecd.org/)
5. Historical Interest Rate Data: Past patterns in federal funds rate changes.
   - (https://fred.stlouisfed.org/series/FEDFUNDS)
6. U.S. Inflation Data (CPI): Detailed inflation data for the U.S.
   (https://www.bls.gov/cpi/)
7. Employment and Labor Statistics: Data on U.S. labor market conditions.
   (https://www.bls.gov/data/)

DATA PREPROCESSING

- Handling Missing Values : Imputed missing values using using interpolation
- Conversion of low frequency data point to high frequency datapoint(Quartely gdp was converted to monthly gdp so as to correspond with other indicators which are monthly)
- Normalization: Standardized numerical features to ensure consistent data ranges..
- Time-Based Features*: Created lagged variables and rolling averages for modelling.

4. EXPLORATORY DATA ANALYSIS (EDA)

1. DESCRIPTIVE STATISTICS

Understanding The Summary Statistics Metrics:
Mean: The average value of the column.
Standard Deviation (std): Measures the amount of variation or dispersion from the mean.
25% (Q1): The first quartile, indicating that 25% of the data points are below this value.
50% (Median): The middle value of the data, indicating that 50% of the data points are below this value.
75% (Q3): The third quartile, indicating that 75% of the data points are below this value.
Min: The minimum value in the column.
Max: The maximum value in the column.

	Federal_Funds_Rate	Consumer_Price_Index	Unemployment_Rate	GDP_Growth_Rate	Consumer_Confidence	Personal_Consumption_Expenditures	Industrial_Production	Money_Supply	Real_GDP
count	779.000000	778.000000	779.000000	779.000000	778.000000	778.000000	778.000000	778.000000	779.000000
mean	4.799782	140.130616	5.889602	3.086264	85.672558	5861.989460	68.288276	5468.155141	11600.950596
std	3.645724	82.809946	1.697202	3.628610	12.686093	5269.943684	26.444885	5726.429207	5751.764311
min	0.050000	29.370000	3.400000	-28.100000	50.000000	323.600000	22.096000	298.200000	3470.278000
25%	1.940000	56.025000	4.700000	1.633333	76.108333	1116.850000	45.380700	1052.700000	6346.837000
50%	4.760000	139.900000	5.600000	3.066667	89.300000	4167.750000	63.144600	3399.250000	10347.429000
75%	6.525000	212.943750	7.000000	4.583333	95.050000	9917.425000	95.643725	7802.450000	16611.690000
max	19.100000	315.454000	14.800000	35.200000	112.000000	20099.500000	104.103800	21723.200000	23386.733000

FROM THE TABLE ABOVE
FED FUND RATE:
- Mean: 4.799782. This is the averagefed fund rate over the observed period.
- Std: 3.645724.
- 25% (Q1): 1.94. This means 25% of the fed fund rate values are below Q1.
- 50% (Median): 4.76. This is the median fed fund rate, indicating the middle value.
- 75% (Q3): 6.525. This means 75% of the fed fund rate values are below Q3.
- Min: 0.05 The lowest observed Real GDP.
- Max: 19.1. The highest observed Real GDP.

Real GDP:
- Mean: 11,601. This is the average Real GDP over the observed period.
- Std: 5,752.
- 25% (Q1): 6,347. This means 25% of the Real GDP values are below 6,347.
- 50% (Median): 10,347. This is the median Real GDP, indicating the middle value.
- 75% (Q3): 16,612. This means 75% of the Real GDP values are below 16,612.
- Min: 3,470. The lowest observed Real GDP.
- Max: 23,287. The highest observed Real GDP.

4. EXPLORATORY DATA ANALYSIS (EDA)

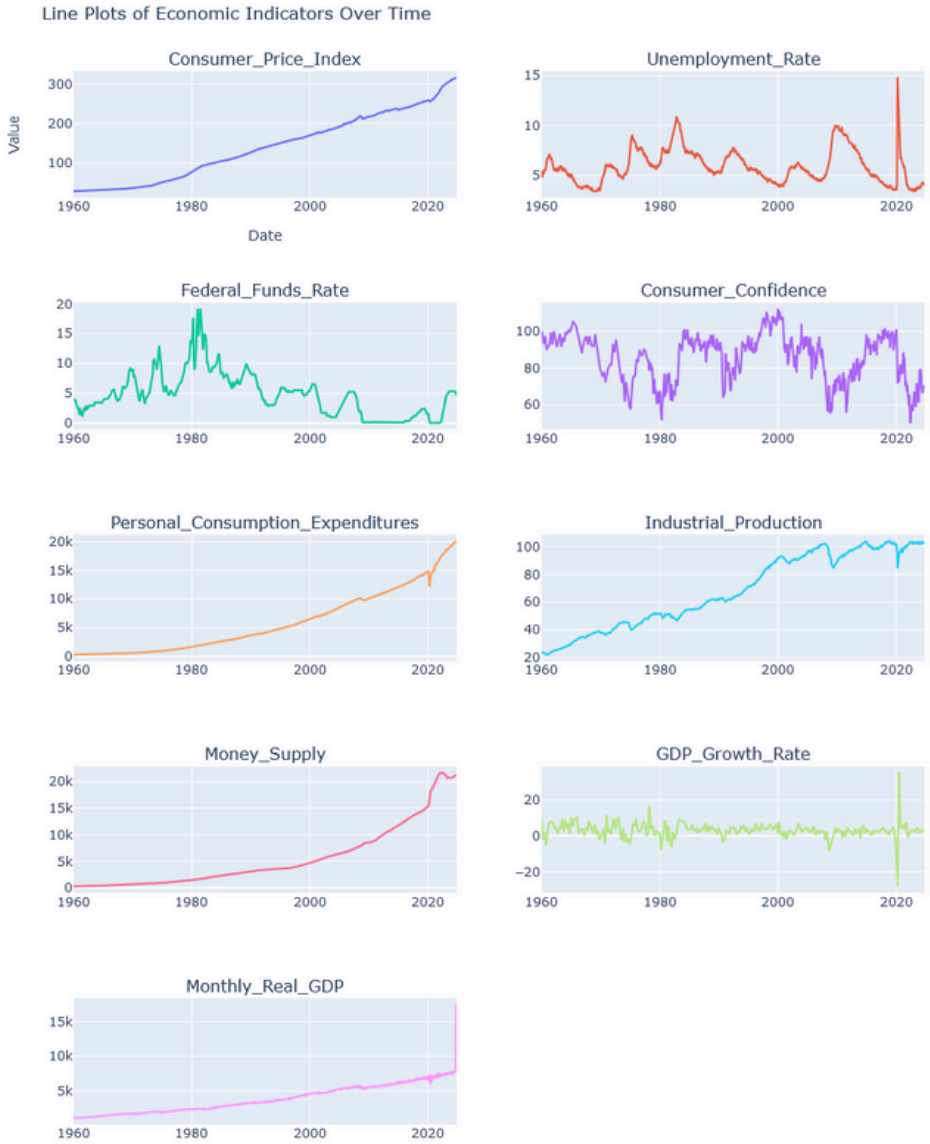
1.1 DESCRIPTIVE STATISTICS

	Date	All_Items	Food_and_Beverages	Housing	Apparel	Transportation	Medical_Care	Recreation	Energy
count	240	240.000000	240.000000	240.000000	240.000000	240.000000	240.000000	240.000000	240.000000
mean	2009-12-15 23:00:00	215.356433	118.129829	191.955417	216.109767	250.415683	311.968029	183.937963	180.556208
min	2000-01-01 00:00:00	169.300000	111.337000	109.900000	165.600000	190.600000	235.500000	144.300000	121.600000
25%	2004-12-24 06:00:00	191.700000	114.532250	148.250000	188.550000	221.600000	271.750000	163.256250	155.650000
50%	2009-12-16 12:00:00	217.378000	118.080500	195.177000	219.030000	249.040000	310.035000	188.654500	192.160000
75%	2014-12-08 18:00:00	237.058500	120.450000	235.709000	246.019500	274.188250	351.119500	204.880000	199.869500
max	2019-12-01 00:00:00	258.630000	131.600000	268.092000	260.483000	322.247000	387.533000	218.502000	214.373000
std	NaN	25.464855	4.496235	48.829714	29.410826	34.769759	45.176043	22.564783	25.493160

4.1 EXPLORATORY DATA ANALYSIS (EDA)

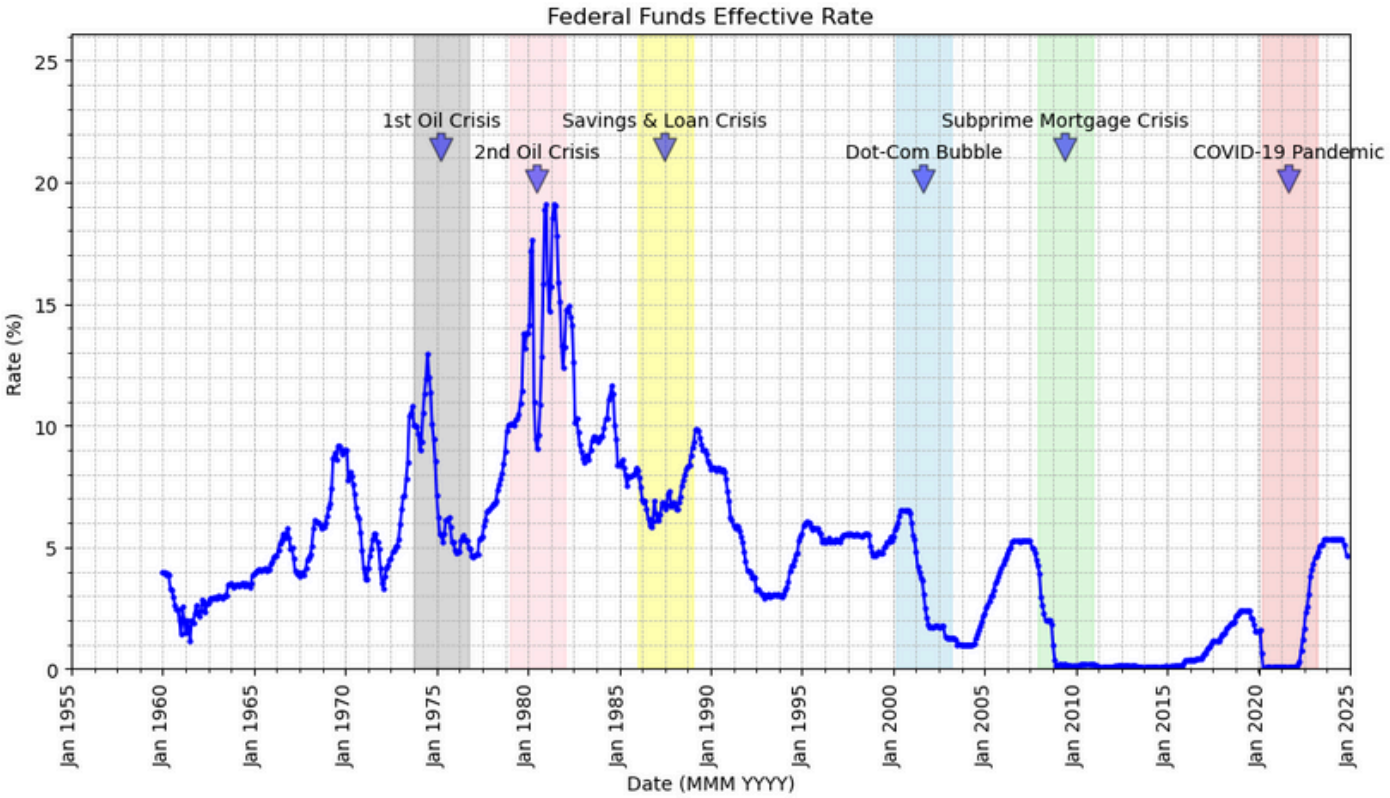
Inflation Rate: The histogram shows a concentration of values around a central range, indicating that most of the time, inflation rates fall within a specific band. There are fewer instances of extremely high or low inflation.
Unemployment Rate: The distribution is skewed towards lower unemployment rates, with a long tail extending towards higher rates, reflecting periods of economic distress.
Federal Funds Rate: The histogram shows a wide range of values, indicating that the Federal Funds Rate has varied significantly over time, reflecting different monetary policy stances.
Consumer Confidence: The distribution is relatively narrow, suggesting that consumer confidence tends to stay within a certain range, with fewer extreme values.
Personal Consumption Expenditures: The histogram shows a concentration of values in a specific range, indicating stable consumer spending patterns with fewer extreme values.
Industrial Production: The distribution is broad, reflecting varying levels of industrial activity over time.
Money Supply: The histogram shows a wide range of values, indicating significant growth in the money supply over time.
GDP Growth Rate: The histtogram shows a symmetrical distribution . The distribution is centered around a specific range, with a few instances of very high or very low growth rates, indicating periods of rapid economic change.
Monthly Real GDP: The histogram shows a concentration of values in a specific range, reflecting steady economic growth with fewer extreme values.

4.2 EXPLORATORY DATA ANALYSIS (EDA)



The line plots of the economic indicators over time reveal several key trends:
Inflation Rate: The plot shows periods of both high and low inflation, indicating varying economic conditions over time.
Unemployment Rate: The unemployment rate exhibits cyclical patterns, with noticeable peaks during economic downturns.
Federal Funds Rate: The Federal Funds Rate shows significant fluctuations, reflecting changes in monetary policy.
Consumer Confidence: Consumer confidence generally trends upwards but shows dips during economic recessions.
Personal Consumption Expenditures: This indicator shows a steady increase over time, reflecting growing consumer spending.
Industrial Production: Industrial production exhibits cyclical patterns, with periods of growth and contraction.
Money Supply: The money supply shows a general upward trend, indicating an increase in the amount of money in circulation.
GDP Growth Rate: The GDP growth rate shows significant variability, highlighting periods of economic expansion and contraction.
Monthly Real GDP: Monthly Real GDP shows a general upward trend, indicating overall economic growth over time.

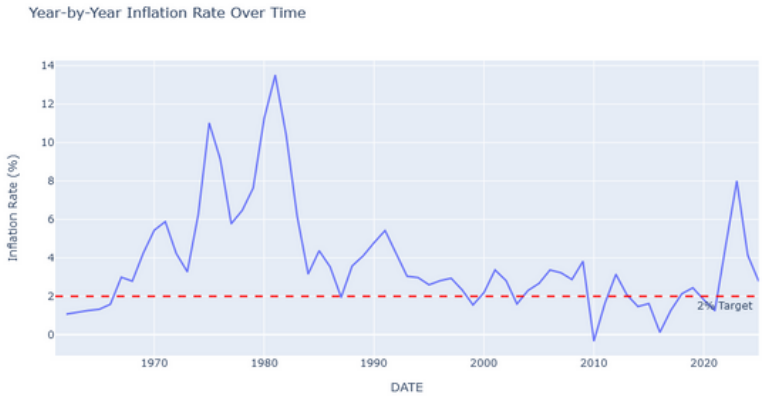
4.3 EXPLORATORY DATA ANALYSIS (EDA)



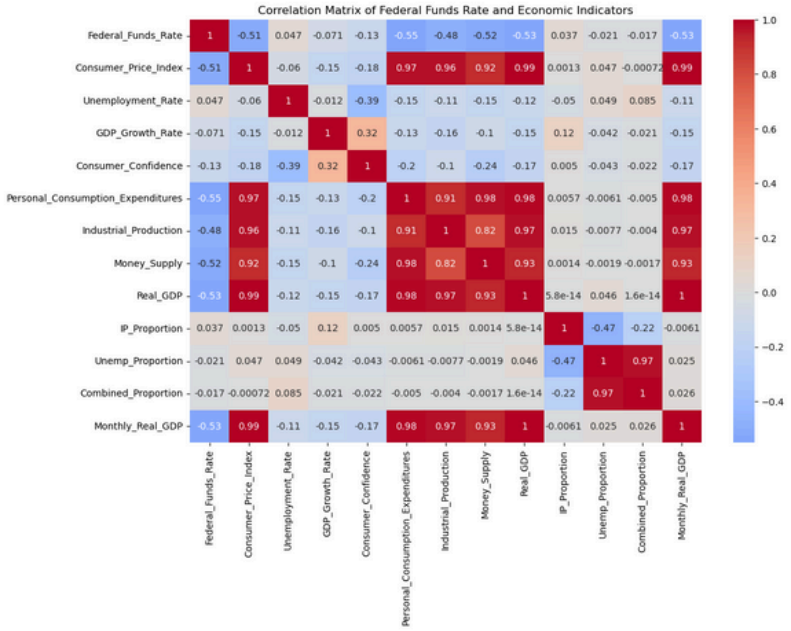
The plot of the Federal Funds Effective Rate over time, with key financial events highlighted, provides a clear visual representation of how significant economic events have influenced monetary policy. Notable periods such as the COVID-19 Pandemic, Subprime Mortgage Crisis, Dot-Com Bubble, and the 1st and 2nd Oil Crises are marked, showing corresponding fluctuations in the Federal Funds Rate. This visualization underscores the Federal Reserve's responses to major financial disruptions, illustrating the impact of these events on interest rate decisions.

Here are some insights from the chart:
COVID-19 Pandemic (2020):
The Federal Funds Rate dropped significantly in response to the economic impact of the COVID-19 pandemic, reaching near-zero levels to stimulate the economy.
Subprime Mortgage Crisis (2007-2009):
During the Subprime Mortgage Crisis, the Federal Funds Rate was reduced drastically to counteract the financial turmoil and recession, reaching near-zero levels by the end of 2008.
Dot-Com Bubble (2000-2002):
The Federal Funds Rate was lowered in response to the burst of the Dot-Com Bubble, with a notable decrease starting in 2001 to mitigate the economic slowdown.
Savings & Loan Crisis (1986-1995):
The Federal Funds Rate saw fluctuations during the Savings & Loan Crisis, with periods of both increases and decreases as the Federal Reserve navigated through the financial instability.
2nd Oil Crisis (1979-1980):
The Federal Funds Rate was significantly increased during the 2nd Oil Crisis to combat high inflation, reaching some of the highest levels in the chart.
1st Oil Crisis (1973-1974):
Similar to the 2nd Oil Crisis, the Federal Funds Rate was raised to address inflationary pressures caused by the 1st Oil Crisis.

4.4 EXPLORATORY DATA ANALYSIS (EDA)



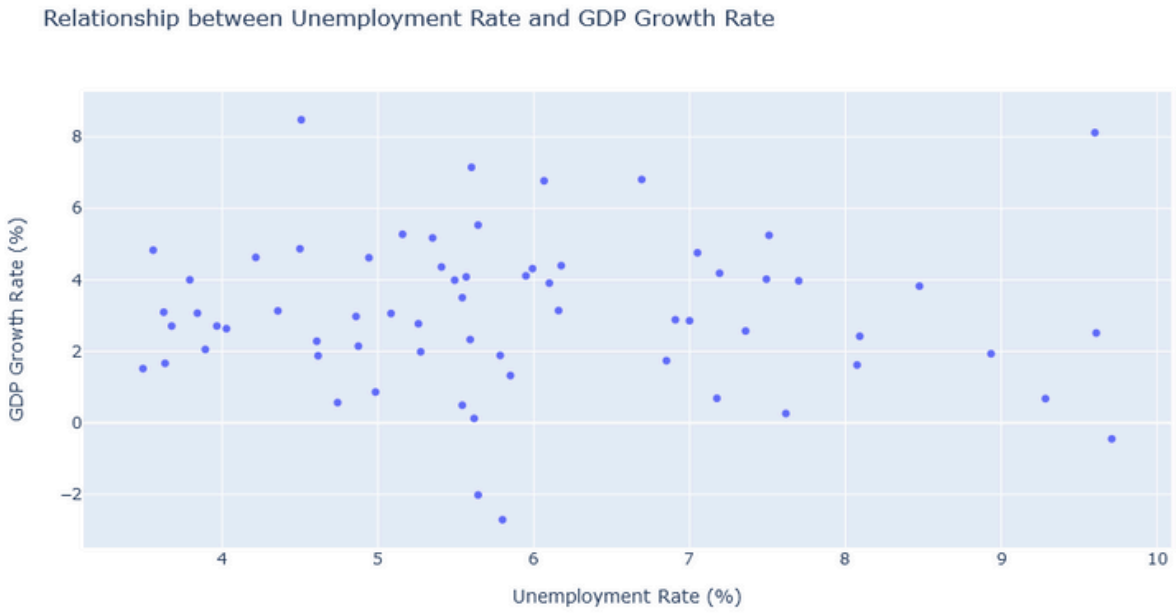
The year-by-year inflation rate, derived from the Consumer Price Index (CPI), exhibits notable fluctuations from 1960 onwards. High inflation periods, particularly in the 1970s and early 1980s, align with historical economic events such as oil shocks and policy changes. Conversely, periods of low inflation or deflation, especially in the late 2000s and early 2010s, reflect economic downturns and recovery phases. The 2% reference line underscores the deviations from this common central bank target, highlighting the challenges in maintaining stable inflation over the decades.

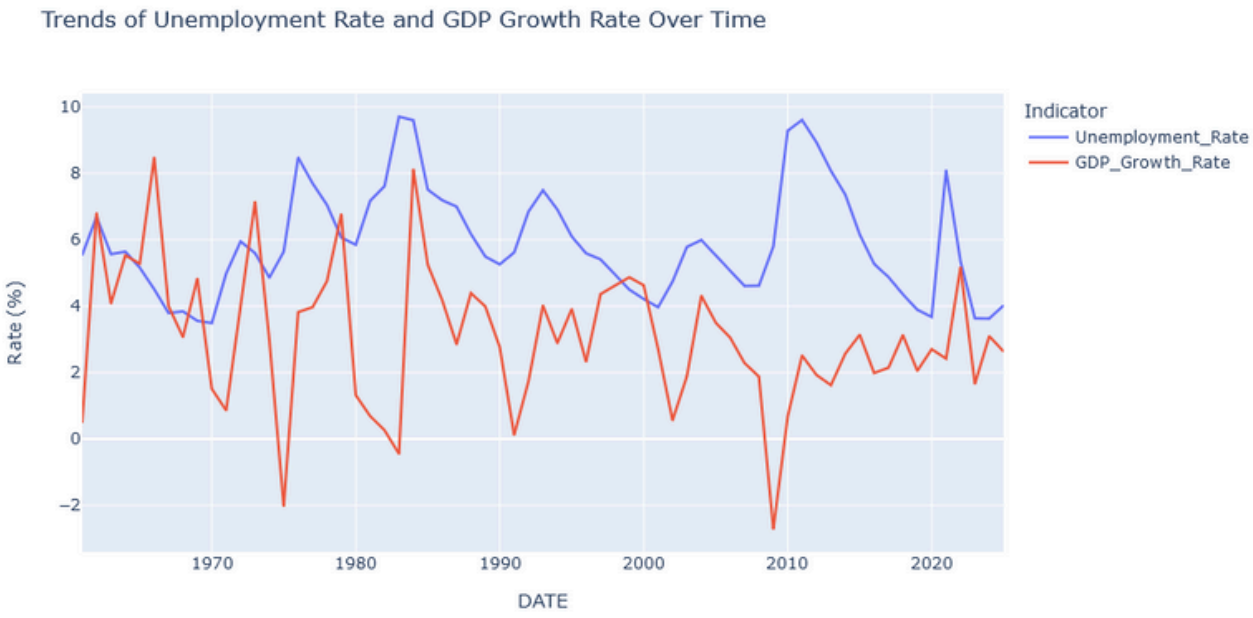


Federal_Funds_Rate	1.000000
Consumer_Price_Index	-0.505271
Unemployment_Rate	0.047137
GDP_Growth_Rate	-0.071430
Consumer_Confidence	-0.132219
Personal_Consumption_Expenditures	-0.550851
Industrial_Production	-0.480112
Money_Supply	-0.517452
Real_GDP	-0.531331
IP_Proportion	0.037334
Unemp_Proportion	-0.021137
Combined_Proportion	-0.017343
Monthly_Real_GDP	-0.532754

The correlation matrix reveals that the Federal Funds Rate has moderate negative correlations with several key economic indicators, including the Inflation Rate, Personal Consumption Expenditures, Industrial Production, Money Supply, and Monthly Real GDP. These negative correlations suggest that higher interest rates are generally associated with lower values in these indicators. The correlations with Consumer Confidence, GDP Growth Rate, and Unemployment Rate are weaker, indicating that other factors also influence these metrics. Overall, the Federal Funds Rate appears to have a significant impact on key economic metrics, aligning with traditional economic theorie

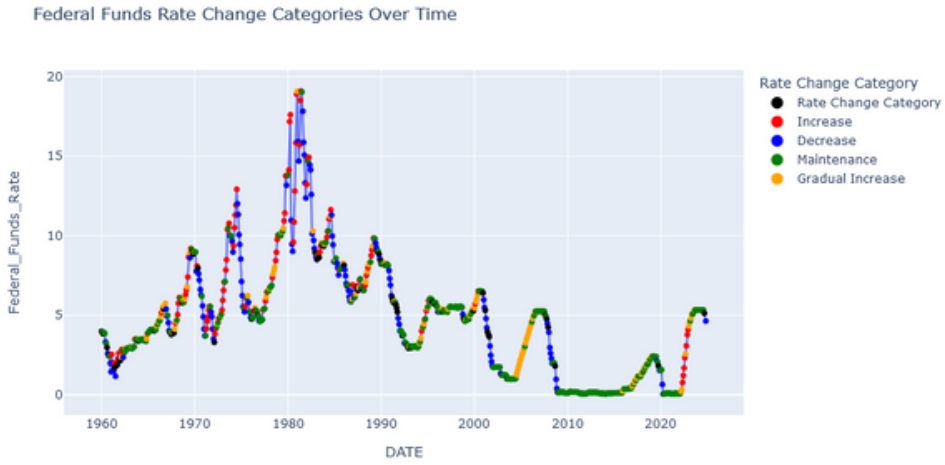
4.5 EXPLORATORY DATA ANALYSIS (EDA)

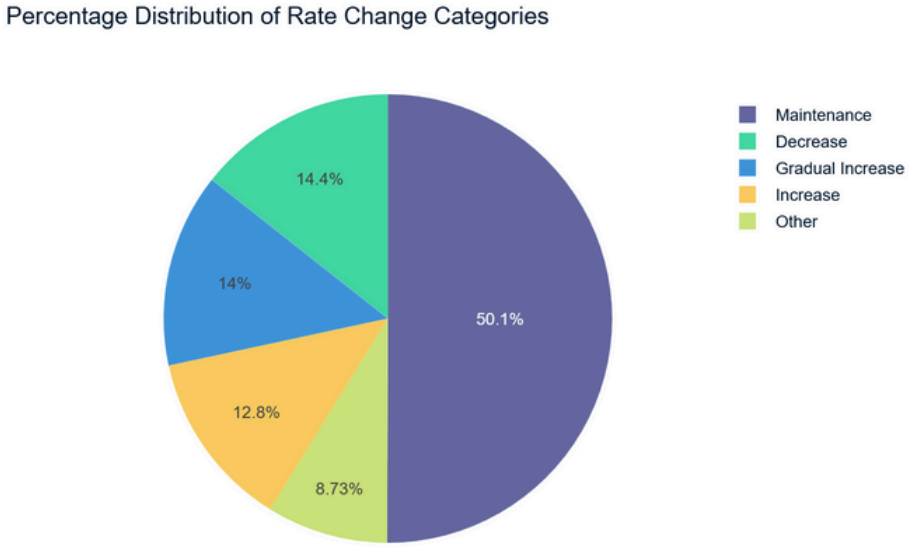




The scatter plot reveals a generally inverse relationship between the unemployment rate and GDP growth rate, indicating that higher unemployment rates often correspond with lower GDP growth rates. The line plot shows the trends of both indicators over time, highlighting periods of economic downturns, such as the early 1980s and the late 2000s, where high unemployment rates coincide with negative or low GDP growth rates. These visualizations underscore the cyclical nature of the economy and the interplay between labor market conditions and overall economic performance.

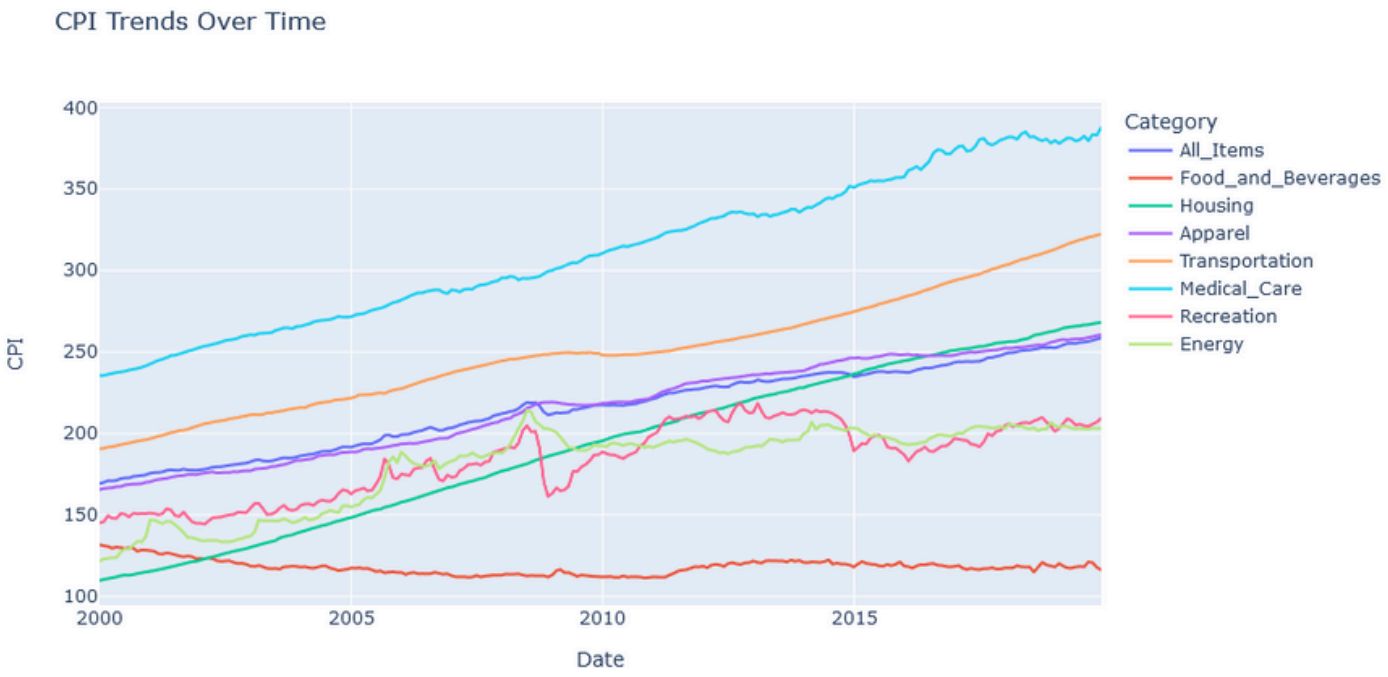
4.5 EXPLORATORY DATA ANALYSIS (EDA)





The analysis of the Federal Funds Rate changes revealed that the most common category is 'Maintenance', followed by 'Increase' and 'Decrease'. The bar chart over time highlights periods with frequent rate changes, The percentage distribution pie chart shows that 'Maintenance' accounts for the largest proportion of rate changes, indicating that the Federal Reserve often opts to keep rates steady. These visualizations offer a comprehensive view of the Federal Funds Rate changes and their frequency over time.

4.6 EXPLORATORY DATA ANALYSIS (EDA)



TThe exploratory data analysis (EDA) reveals that the Consumer Price Index (CPI) for all categories has generally increased over time from 2000 to 2024. Medical Care shows the highest CPI values, indicating significant cost increases in this category. All Items, Food and Beverages, and Housing also exhibit upward trends, reflecting overall inflation. Recreation has the lowest CPI values but still shows a gradual increase. These trends highlight the rising cost of living across various sectors over the years.

Histograms show right-skewed distributions for most categories, with Medical Care exhibiting the most pronounced spread. Overall, the analysis underscores the interconnected nature of CPI categories and the variability in pricing trends, with Medical Care showing the most significant fluctuations.

4.7 EXPLORATORY DATA ANALYSIS (EDA)

WORD CLOUD AND COUNT OF A SELECTED STATEMENT

	word	count
28	committee	22
23	inflation	16
89	monetary	9
39	goals	8
20	rate	8
90	policy	8
52	range	8
33	percent	8
37	risks	6
63	appropriate	6

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5. MACHINE LEARNING MODEL

Feature Engineering: Explanation of features created and why they were chosen.

1. Lag Features
   - Purpose: To capture the temporal dependencies and trends in the data.
   - Features Created:
     - Consumer_Price_Index (CPI) Lag: Previous values of the Consumer Price Index.
     - Unemployment_Rate Lag: Previous values of the Unemployment Rate.
2. Rolling Window Features
   - Purpose: To smooth out short-term fluctuations and highlight longer-term trends.
   - Features Created:
     - CPI_rolling_3m: 3-month rolling average of the Consumer Price Index.
     - Unemployment_rolling_3m: 3-month rolling average of the Unemployment Rate.
3. Rate of Change Features
   - Purpose: To capture the rate at which economic indicators are changing, which can be predictive of future trends.
   - Features Created:
     - CPI_rate_change: Percentage change in the Consumer Price Index.
     - Unemployment_rate_change: Percentage change in the Unemployment Rate.
4. Interaction Features
   - Purpose: To capture the combined effect of multiple features, which might be more predictive than individual features alone.
   - Features Created:
     - CPI_Unemployment_interaction: Product of the Consumer Price Index and the Unemployment Rate.
5. Trend Indicators
   - Purpose: To capture the direction of change in key economic indicators.
   - Features Created:
     - Funds_rate_trend: Sign of the difference in the Federal Funds Rate, indicating whether it is increasing or decreasing.
6. Target Variable
   - Purpose: To create a target variable for classification tasks.
   - Features Created:
     - rate_change: Difference in the Federal Funds Rate.
     - rate_change_class: Binned version of rate_change into categories for classification.

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5. 1 MACHINE LEARNING MODEL: MODEL SELECTION

```
Random Forest Results:
Mean Cross-validation F1 Score: 0.4184
Classification Report:
              precision    recall  f1-score   support

           0       0.71      0.45      0.56        11
           1       0.57      0.31      0.40        13
           2       0.81      0.91      0.86       112
           3       0.22      0.17      0.19        12
           4       0.57      0.50      0.53         8

    accuracy                           0.75       156
   macro avg       0.58      0.47      0.51       156
weighted avg       0.73      0.75      0.73       156


Gradient Boosting Results:
Mean Cross-validation F1 Score: 0.3958
Classification Report:
              precision    recall  f1-score   support

           0       0.50      0.45      0.48        11
           1       0.25      0.08      0.12        13
           2       0.80      0.89      0.84       112
           3       0.20      0.17      0.18        12
           4       0.43      0.38      0.40         8

    accuracy                           0.71       156
   macro avg       0.44      0.39      0.40       156
weighted avg       0.67      0.71      0.68       156


Support Vector Machine Results:
Mean Cross-validation F1 Score: 0.4655
Classification Report:
              precision    recall  f1-score   support

           0       0.50      0.55      0.52        11
           1       0.30      0.77      0.43        13
           2       0.92      0.54      0.69       112
           3       0.24      0.58      0.34        12
           4       0.38      0.75      0.50         8

    accuracy                           0.58       156
   macro avg       0.47      0.64      0.50       156
weighted avg       0.75      0.58      0.62       156
```

Random Forest:

- Mean Cross-Validation F1 Score: 0.4184
- Performance:
  - Achieved an overall accuracy of 75%.
  - High precision (0.81) and recall (0.91) for class 2 (112 samples), indicating that it is very good at identifying this class.
  - Mixed results for other classes, with lower precision and recall.

Gradient Boosting:

- Mean Cross-Validation F1 Score: 0.3958
- Performance:
  - Achieved an overall accuracy of 71%.
  - High precision (0.80) and recall (0.89) for class 2 (112 samples), similar to Random Forest.
  - Lower performance for other classes, with significantly lower precision and recall for class 1.

Support Vector Machine (SVM):

- Mean Cross-Validation F1 Score: 0.4655
- Performance:
  - Achieved an overall accuracy of 58%.
  - High precision (0.92) for class 2 but lower recall (0.54), suggesting it's good at predicting class 2 when it does, but it misses many instances.
  - Overall mixed performance, with some classes like 1 having high recall (0.77) but lower precision (0.30).

5. MACHINE LEARNING MODEL

Rationale for Model Selection:

1. Accuracy:
   - The Random Forest model had the highest overall accuracy (75%), indicating it correctly predicted the most instances compared to the other models.
2. . F1 Score:
   - The Support Vector Machine had the highest Mean Cross-Validation F1 Score (0.4655). The F1 score considers both precision and recall, making it a good metric for evaluating models in imbalanced datasets.
3. Class Performance:
   - For class 2, which appears to be the largest class with 112 samples, both Random Forest and Gradient Boosting performed well. However, Random Forest slightly edges out with better recall for this class.
   - The SVM model showed variable performance, with high precision in some classes but lower overall consistency.
4. Model Robustness:
   - Random Forests are less prone to overfitting due to their ensemble nature, making them a robust choice for diverse datasets.
   - Gradient Boosting is powerful but can overfit without careful tuning.
5. Overall Consistency:
   - Considering both accuracy and the balanced performance across classes, Random Forest emerges as a strong candidate. It offers a good trade-off between precision, recall, and robustness across the different classes.

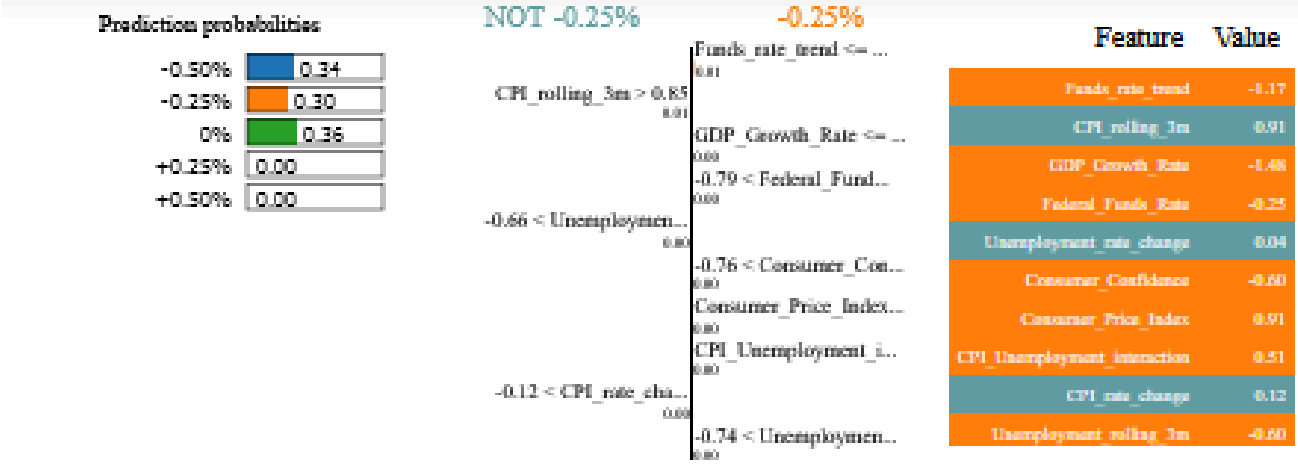
Conclusion:
Given the results, the Random Forest model is likely the best choice due to its balanced and consistent performance, high accuracy, and robustness across various classes.

Model	Predicted_Class	Probability_-0.50%	Probability_-0.25%	Probability_0%	Probability_+0.25%	Probability_+0.50%
Random forest	0%	0.0100	0.3400	0.6500	0.0000	0.0000
Gradient Boosting	-0.25%	0.0219	0.8405	0.1348	0.0019	0.0010
Support Vector Machine	0%	0.0301	0.1099	0.8391	0.0108	0.0101

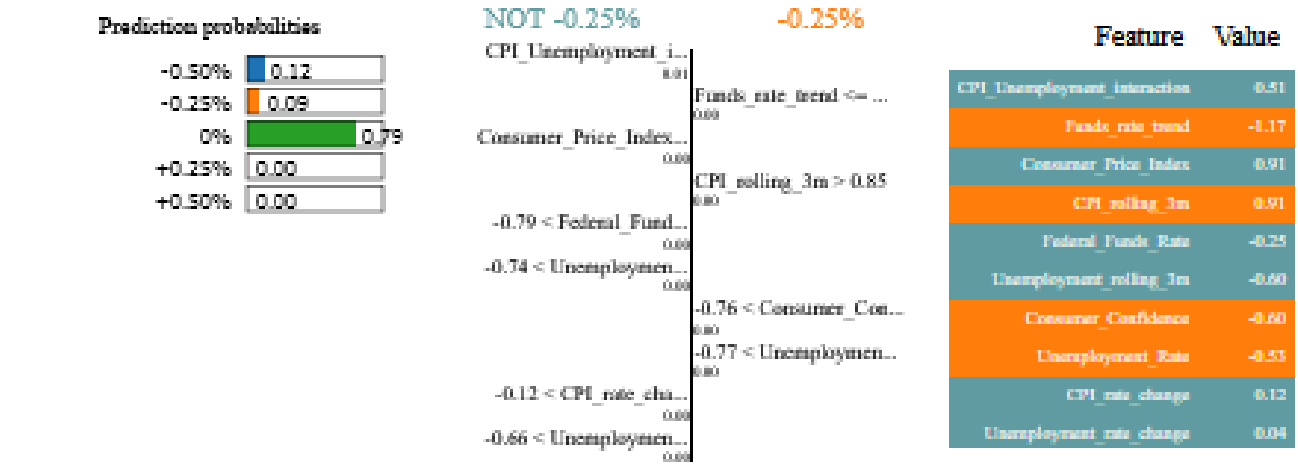
Prediction result:
Random forest: Most Likely Rate Change: 0%, with a high probability for 0% (65.00%).
Gradient boosting : Most Likely Rate Change: -0.25%, with a very high probability for -0.25% (84.05%).
Suport vector machine: Most Likely Rate Change: 0%, with a high probability for 0% (83.91%)

5. 2 MACHINE LEARNING MODEL

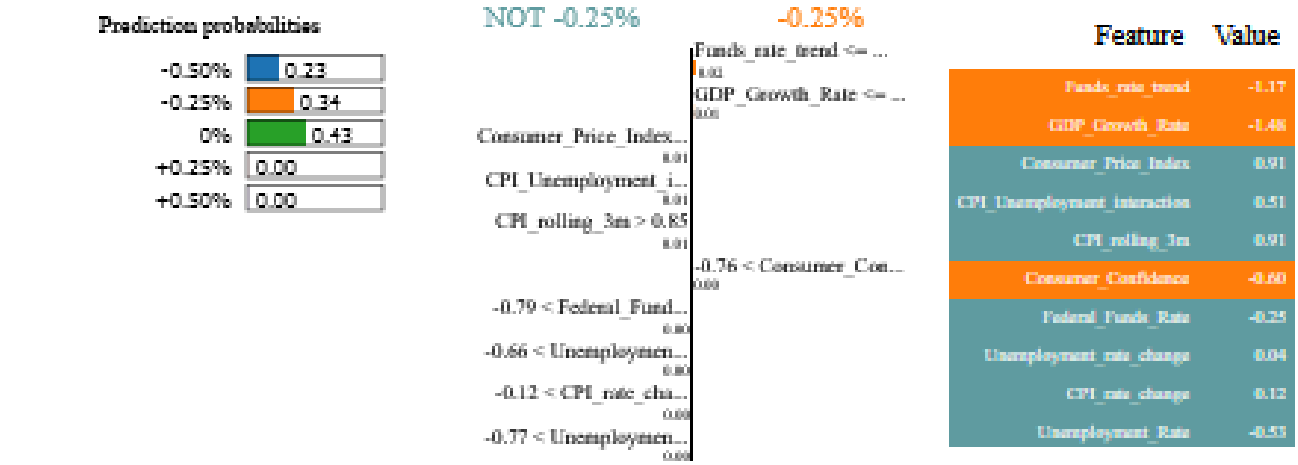
Interpretability: Use of interpretability techniques (LIME) to explain the model's predictions.



LIME Explanation for Gradient Boosting:



LIME Explanation for Support Vector Machine:



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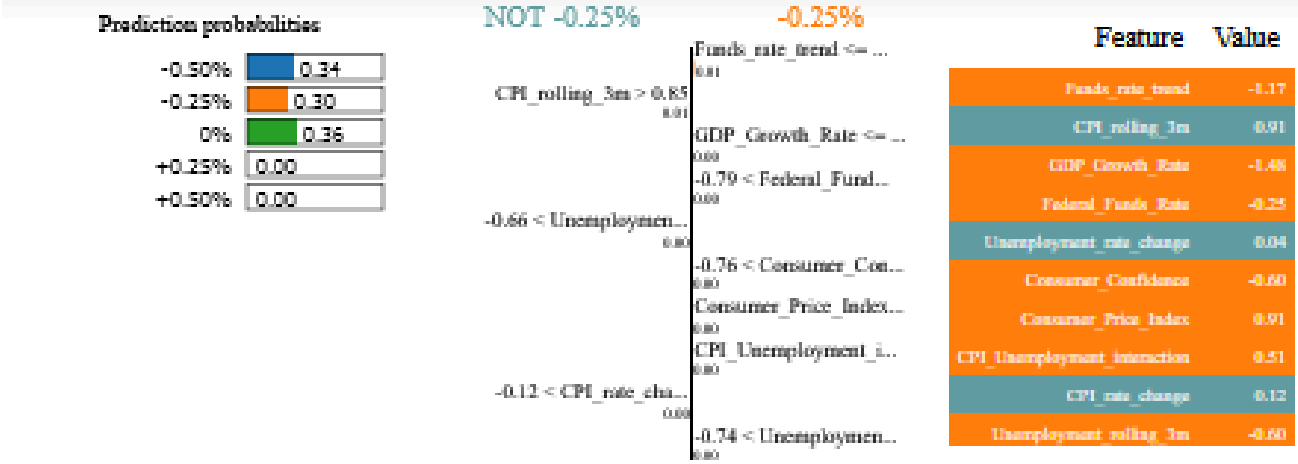
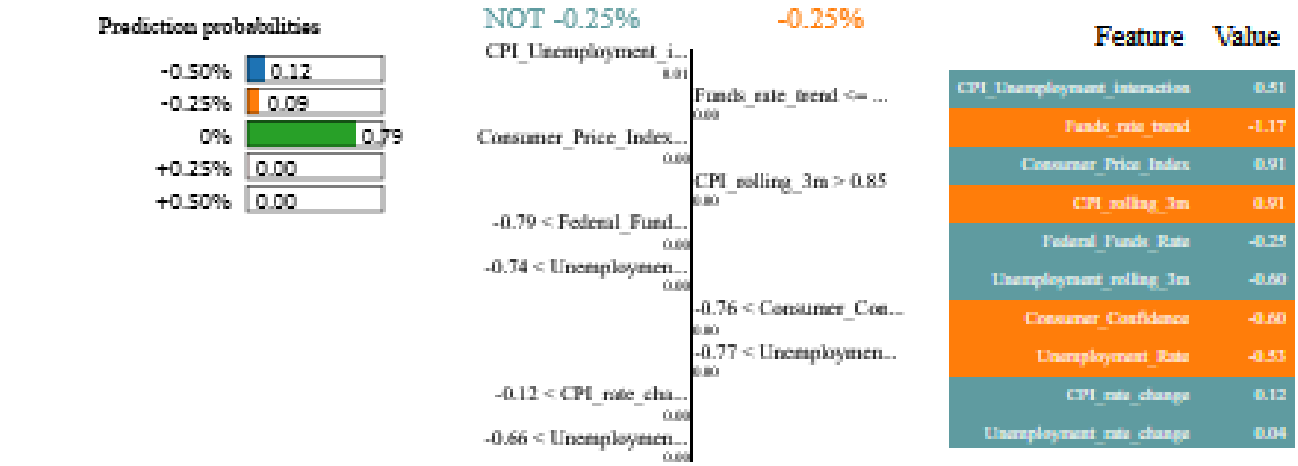


LIME Explanation for Gradient Boosting:



LIME Explanation for Support Vector Machine: