

Predicting Federal Funds Rate

NYU Machine Learning in Financial Engineering
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Federal Funds Rate

- Target interest rate range set by the Federal Open Market Committee (FOMC)
- Set eight times a year
- 12 FOMC members vote on the rate decision
- Influenced by economic indicators, such as the core inflation rate and the durable goods orders report, and job reports
- There was a series of 11 consecutive rate hikes, 4 of which were this year
- Last 2 decisions were to hold rates
- Current rate is at 5.25-5.5%



Importance

- It sets all other rates such as loans rates, credit card rates, and mortgages
- Impacts the stock market
 - “Don’t fight the Fed”
 - Buy stocks during rate cuts
 - Sell stocks during rate hikes
- Housing markets
 - 30y mortgage at 7% vs 5% early in the year, peak at 8%
 - Discourages buying houses



Interest rate hike dumps Dow

Many financial markets took a pounding after the nation's central bank pushed up interest rates for the first time in five years. Wall Street's best-known barometer which has been flirting with the unprecedented 4,000 level, tumbled. The announcement was made "to avoid any misunderstanding of the banks charge each for overnight loans, by nearly a quarter percentage point to 3.25 percent. It was the But it was the way the announcement unfolded that unraveled them. The Fed's Open Market Committee made the decision to a closed meeting that

Mortgage refinance demand jumps 14% as rates fall to lowest point since August

PUBLISHED WED, DEC 6 2023 7:00 AM EST | UPDATED 6 HOURS AGO

Problem



Using economic indicators, predict if the FOMC will raise, hold, cut rates in the next meeting to help make better financial decisions

Dataset

Original data, from St. Louis Fed website, was till 1954, FOMC statements till 1994 to Sept 2023, total 357 records used

Target: Features:

- 1 - decrease (33%)
 - 0 - hold (18%)
 - 1 - increase (49%)
- **PCE** - Personal Consumption Expenditures - a measure of the prices that Americans pay for goods and services Excluding Food/Energy
 - **Consumer_Sentiment** - Consumer Opinion Surveys: Confidence Indicator
 - **Supply_NewHouse** - months' supply is the ratio of new houses for sale to new houses sold
 - **CPI** - Consumer Price Index for All Urban Consumers
 - **ISM PMI** - purchasing managers' index (PMI), is a monthly indicator of U.S. economic activity based on a survey of purchasing managers at more than 300 manufacturing firms
 - **Housing_starts** - New Privately-Owned Housing units in Thousands
 - **Unemp_rates** - Unemployment Rate, Percent, Monthly, Seasonally Adjusted
 - **SPX** - monthly average S&P 500 index value
 - **10y_try** - monthly average 10 year US Treasury Yield
 - **sentiment_score_LM** - shows the sentiment score generated by counting sentimental words in Loughran and McDonald word list
 - **Sentiment** - Positive / Negative / Neutral)

Feature Engineering

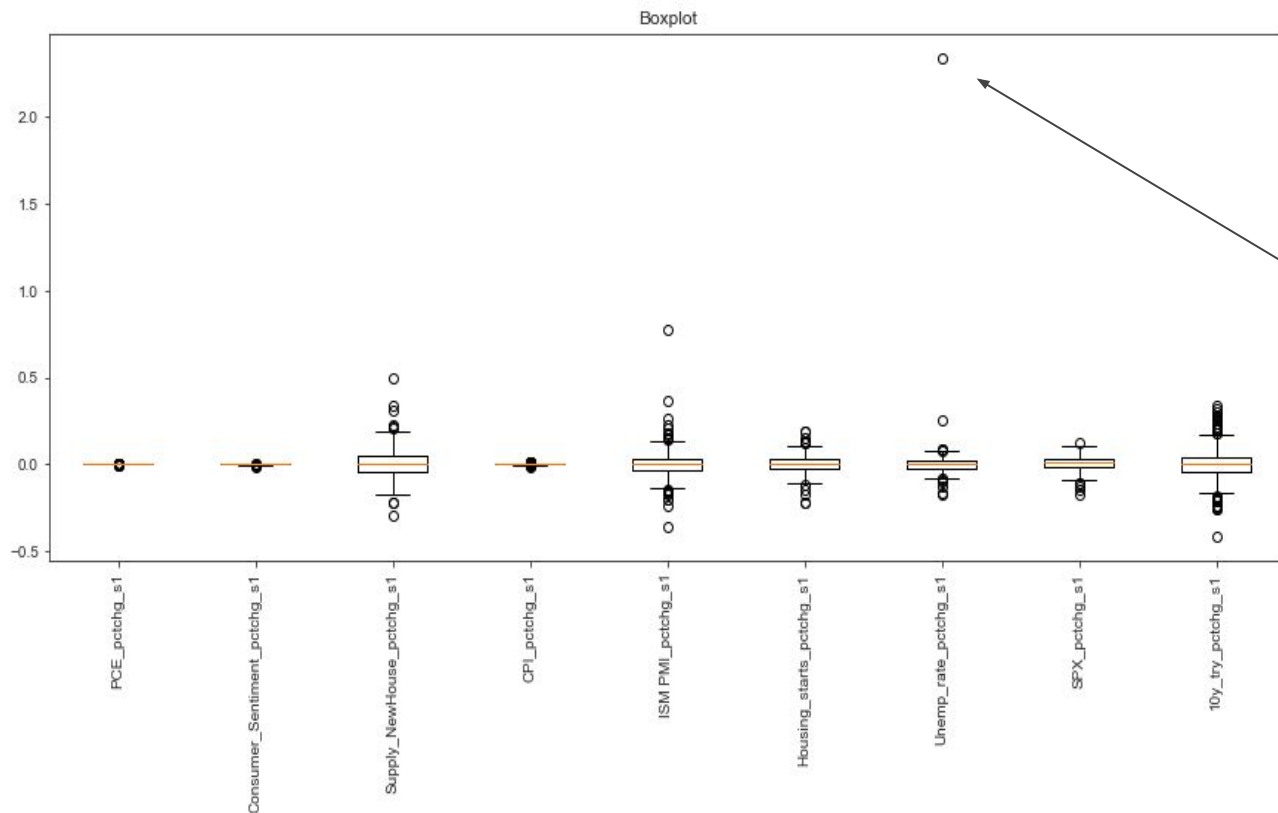
- Calculated percent changes
- Created Shifts to get prior months

observation_date	Unemp_rate	Unemp_rate_s1	Unemp_rate_s2	Unemp_rate_s3	Unemp_rate_pctchg	Unemp_rate_pctchg_s1	Unemp_rate_pctchg_s2	Unemp_rate_pctchg_s3	SPX_pctchg_s3
1/1/1994	6.6	6.5	6.6	6.8	1.5%	-1.5%	-2.9%	1.5%	1.9%
2/1/1994	6.6	6.6	6.5	6.6	0.0%	1.5%	-1.5%	-2.9%	-1.3%
3/1/1994	6.5	6.6	6.6	6.5	-1.5%	0.0%	1.5%	-1.5%	1.0%
4/1/1994	6.4	6.5	6.6	6.6	-1.5%	-1.5%	0.0%	1.5%	3.3%
5/1/1994	6.1	6.4	6.5	6.6	-4.7%	-1.5%	-1.5%	0.0%	-3.0%
6/1/1994	6.1	6.1	6.4	6.5	0.0%	-4.7%	-1.5%	-1.5%	-4.6%
7/1/1994	6.1	6.1	6.1	6.4	0.0%	0.0%	-4.7%	-1.5%	1.2%
8/1/1994	6	6.1	6.1	6.1	-1.6%	0.0%	0.0%	-4.7%	1.2%
9/1/1994	5.9	6	6.1	6.1	-1.7%	-1.6%	0.0%	0.0%	-2.7%
10/1/1994	5.8	5.9	6	6.1	-1.7%	-1.7%	-1.6%	0.0%	3.1%
11/1/1994	5.6	5.8	5.9	6	-3.4%	-1.7%	-1.7%	-1.6%	3.8%
12/1/1994	5.5	5.6	5.8	5.9	-1.8%	-3.4%	-1.7%	-1.7%	-2.7%

Feature Engineering - Sentiment features

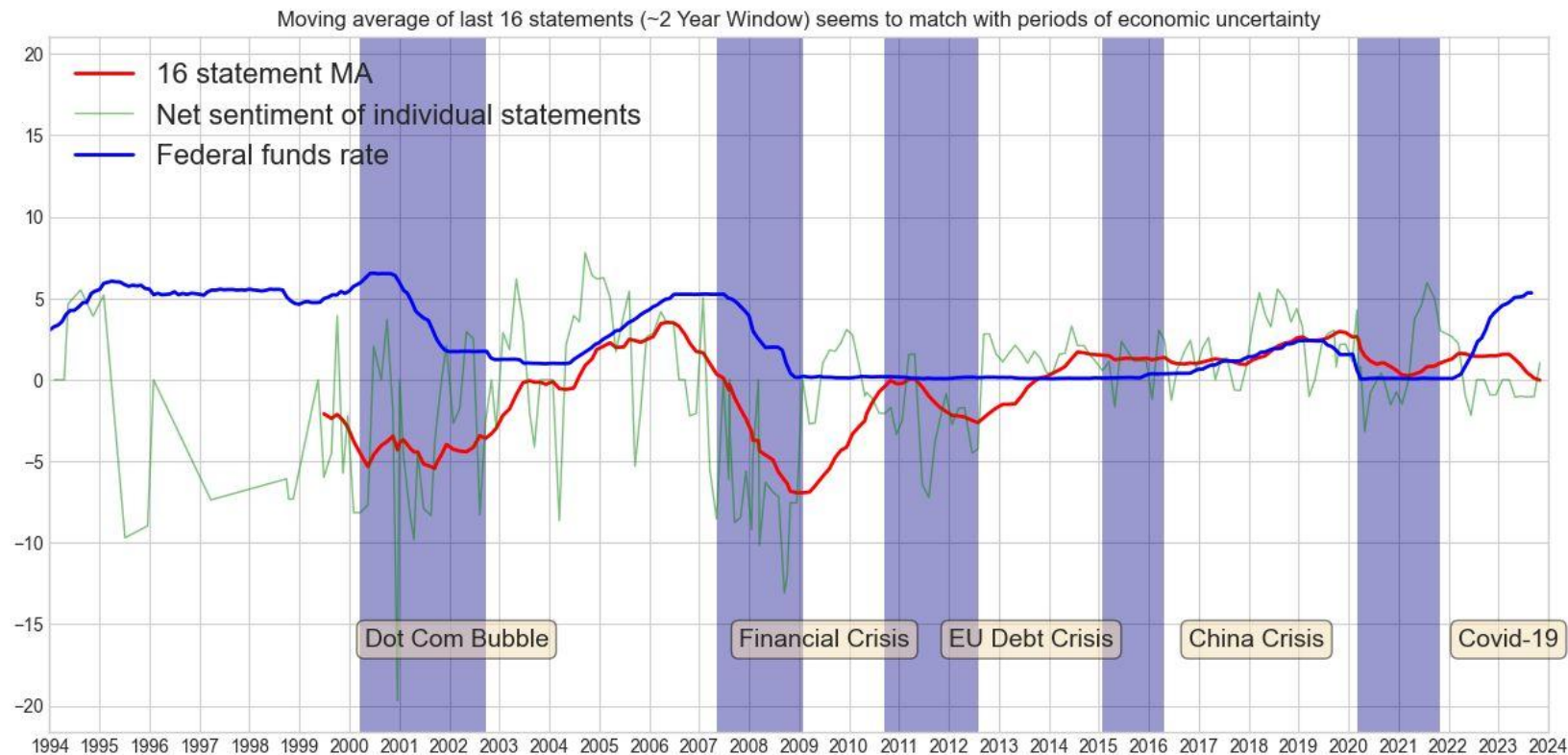
- Scrapes FOMC statements that are released the same day when the rate is decided
- The sentiment (Positive / Negative / Neutral) generated by a pre-trained BERT model on financial news (from hugging face)
- Sentiment_score_LM: shows the sentiment score generated by counting sentimental words in Loughran and McDonald word list
 - $(\text{number of positive words} - \text{number of negative words}) / \text{total word count of statement}$

Exploratory Data Analysis



- Unemployment Rate percent change from 1 month
- 250% increase from 4% to 15% unemployment rate on May 5/1/2020
- Removed point

Exploratory Data Analysis



Feature Selection - PCA and Lasso

- 20 out of 84 features are selected for modeling
- Promising features (considering Lasso results):
 - 'ISM PMI'
 - 'PCE_pctchg'
 - 'ISM PMI_pctchg_s1'
 - 'Unemp_rate'
 - 'Unemp_rate_s3'
 - 'Unemp_rate_pctchg_s3'
 - '10y_try_s1'
 - '10y_try_pctchg_s1'
 - '10y_try_pctchg_s2'
 - 'Housing_starts_pctchg'
 - 'Housing_starts_s3'
 - 'Consumer_Sentiment_pctchg'
 - 'Consumer_Sentiment_pctchg_s1'
 - 'CPI_pctchg'
 - 'SPX_pctchg'
 - 'sentiment_score_LM_s1'
 - 'Sentiment_s1'
 - 'Sentiment_s2'
 - 'Sentiment_s3'
 - 'sentiment_score_LM_s3'

Data Processing: Obstacles

Missing Data

Sentiment missing

Eight rate decisions per year caused missing sentiments for some months. Forward filling is used.

Imbalance Data

Oversampling

Target 'hold' is significantly less than 'increase' or 'decrease'. SMOTE is used to oversample minority class on train set in the baseline model. But we decided not to use SMOTE as it is not appropriate for time series

Overfitting

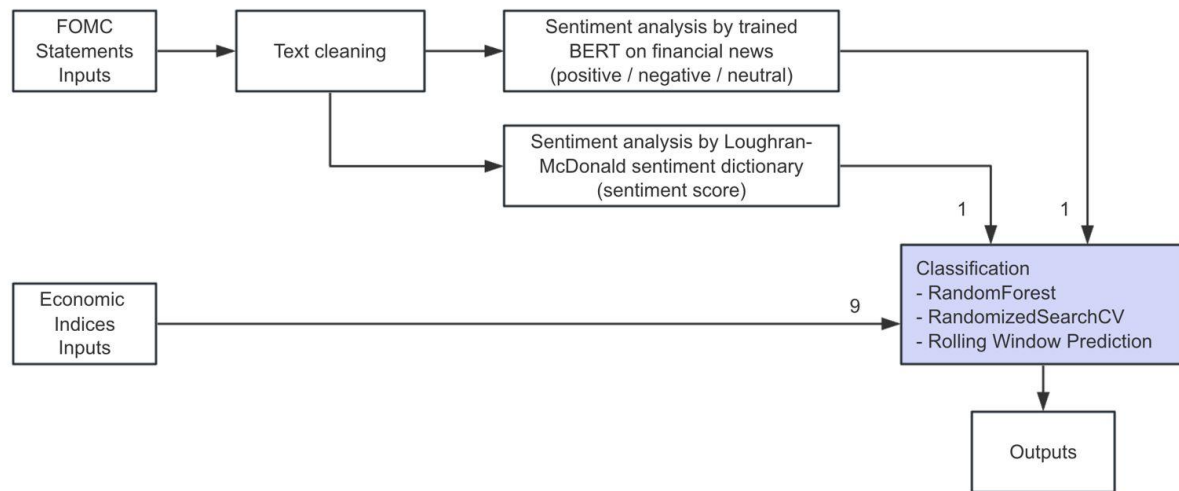
Increase conversion

Splitting by time caused training set accuracy was higher than test set
We used rolling window as training

Building Model

Model

- We used Random Forest
- Split the data by time (Baseline model) and rolling windows
- Initial Train set -
 - 1994 to 2017 (78%)
- Test set - rolling
- Hyperparameter Tuning
- 5 split cross validation



Evaluation Metrics

Recall is important in this project because we always want to be right

- Greater cost incurred if model predicts wrong
- Example: Model predicts rates will decrease, leading portfolio managers to buy but in reality Fed hike rates causing a bear market

	Baseline	Rolling Window
	Test	Test
Accuracy	43%	61%
F1 score	41%	59%
Precision	40%	59%
Recall	43%	61%

Confusion matrix

Baseline

		Predicted Category		
Actual Category	-1	33.33	6.66	60
	0	17.64	5.88	76.47
	1	26.66	13.33	60
		-1	0	1

Rolling window

		Predicted Category		
Actual Category	-1	33.33	13.33	53.33
	0	23.52	29.41	47.05
	1	11.11	6.66	82.22
		-1	0	1

Target:

-1 - decrease
0 - hold
1 - increase

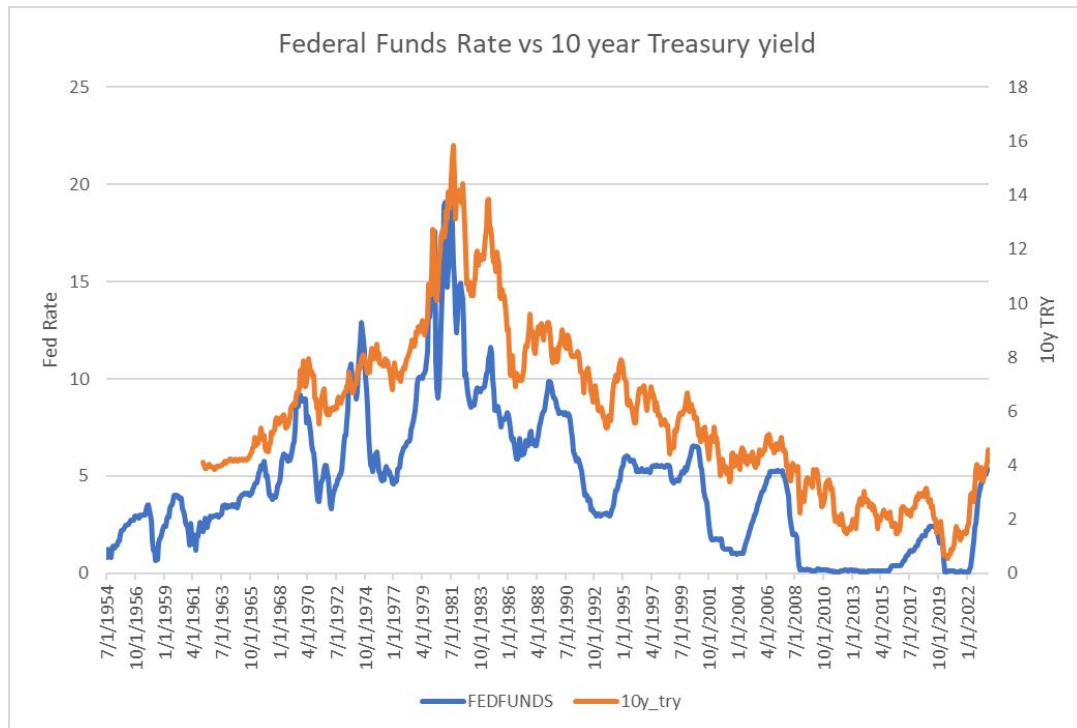
Recall by Quarters

	Recall
Qtr1	61%
Qtr2	60%
Qtr3	66%
Qtr4	56%

Target				Grand Total
Quarters	decrease	hold	increase	
Qtr1	34.44%	11.11%	54.44%	100.00%
Qtr2	25.56%	17.78%	56.67%	100.00%
Qtr3	33.33%	16.67%	50.00%	100.00%
Qtr4	40.23%	26.44%	33.33%	100.00%
Grand Total	33.33%	17.93%	48.74%	100.00%

Best features

Rolling Model	
10y_TRY_s1	0.101
ISM_PMI	0.089
sentiment_score_LM_s3	0.079
Housing_starts_s3	0.078
PCE_pctchg	0.063
Unemp_rate_pctchg_s3	0.054
Housing_starts_pctchg	0.052
Unemp_rate	0.048
Consumer_Sentiment_pctchg_s1	0.046



Future Steps

- Scrape more textual data
 - FOMC minutes
 - News reports
 - Conferences
- Include more economic features like GDP, durable goods report





Let's check out the app!

Appendix

Federal Funds Rate

What?

- target interest rate range set by the Federal Open Market Committee (FOMC)
- Current rate is at 5.25-5.5%

When?

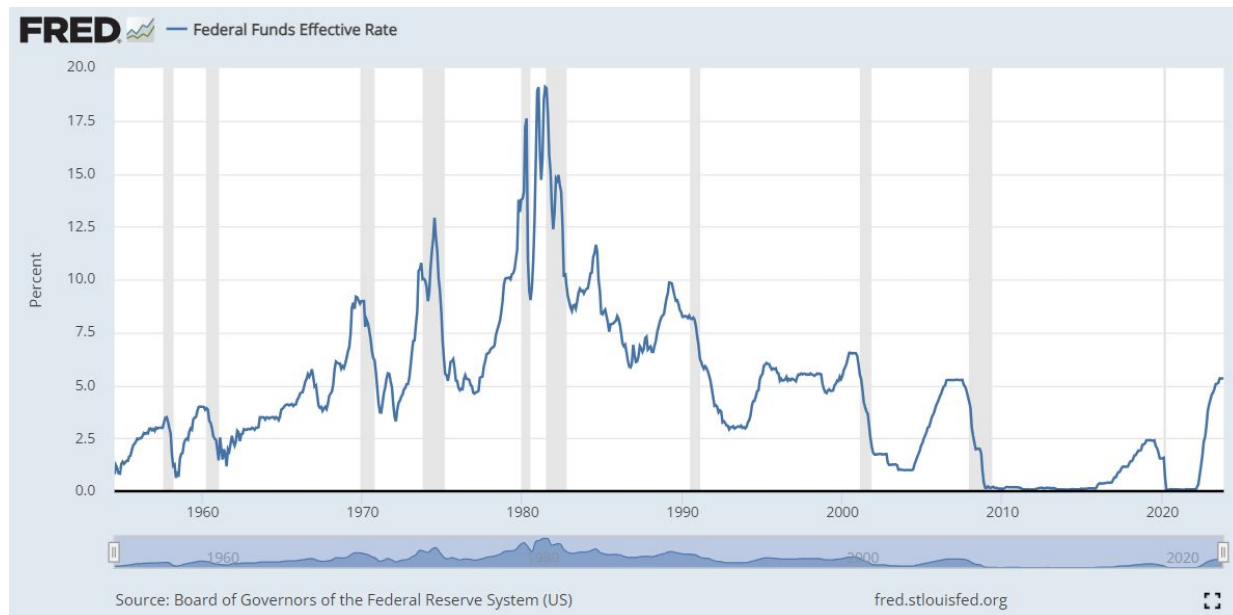
- The Federal Open Market Committee (FOMC) meets eight times a year to determine the federal funds target rate.

Why?

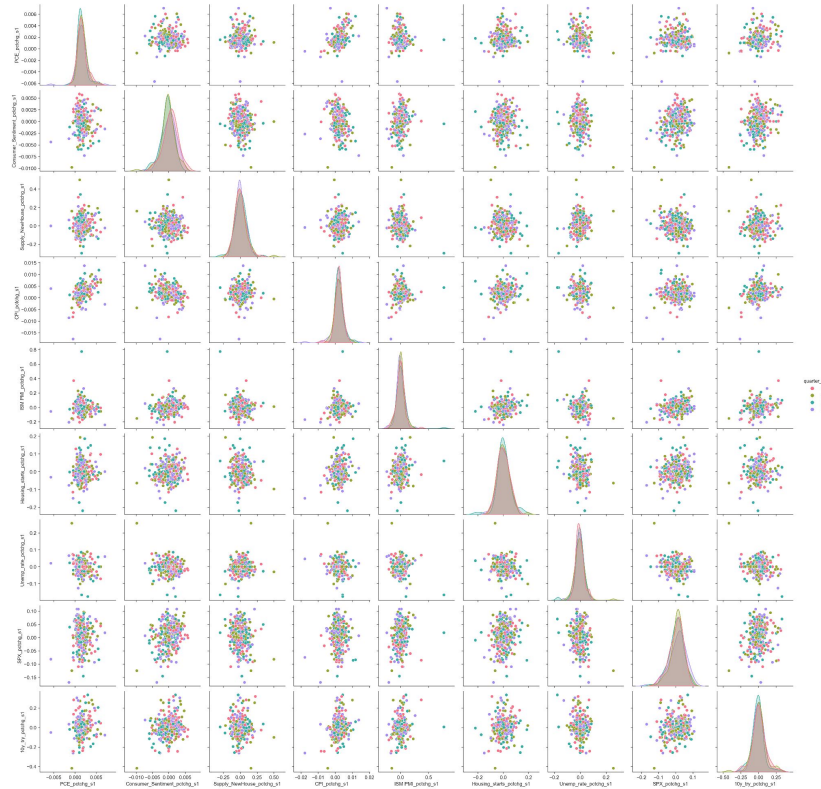
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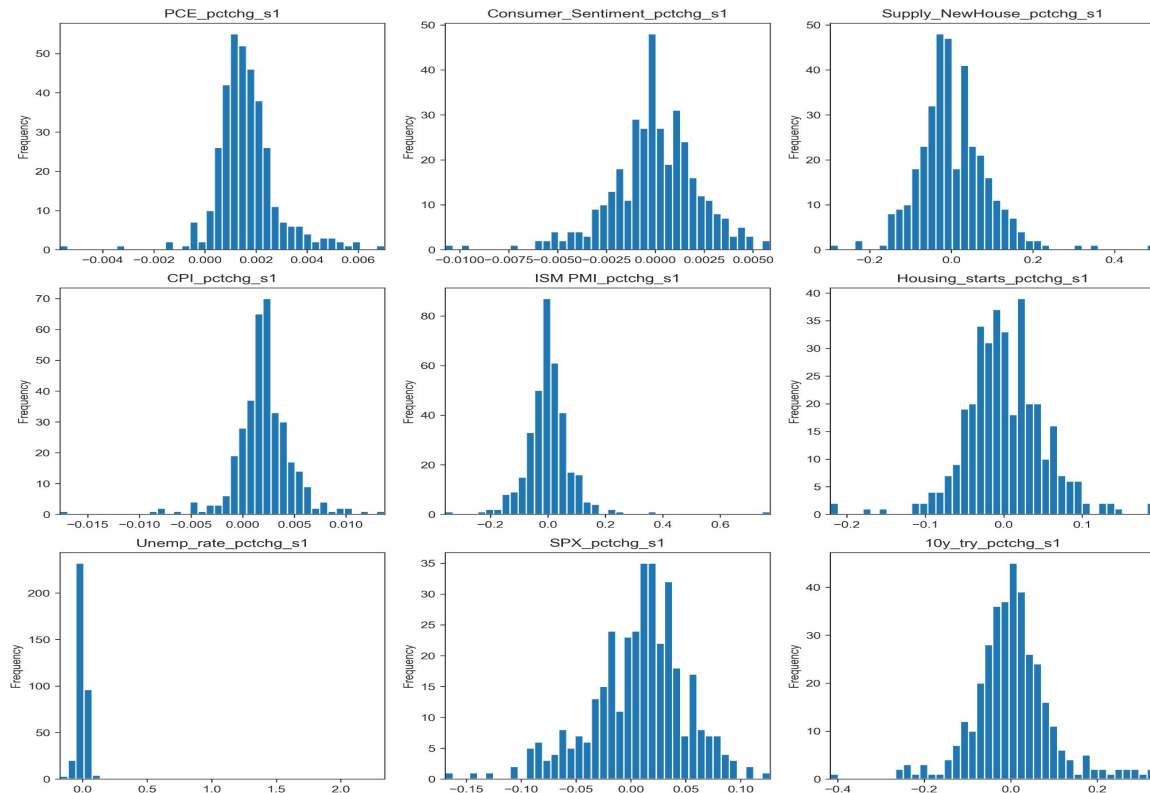


Exploratory Data Analysis



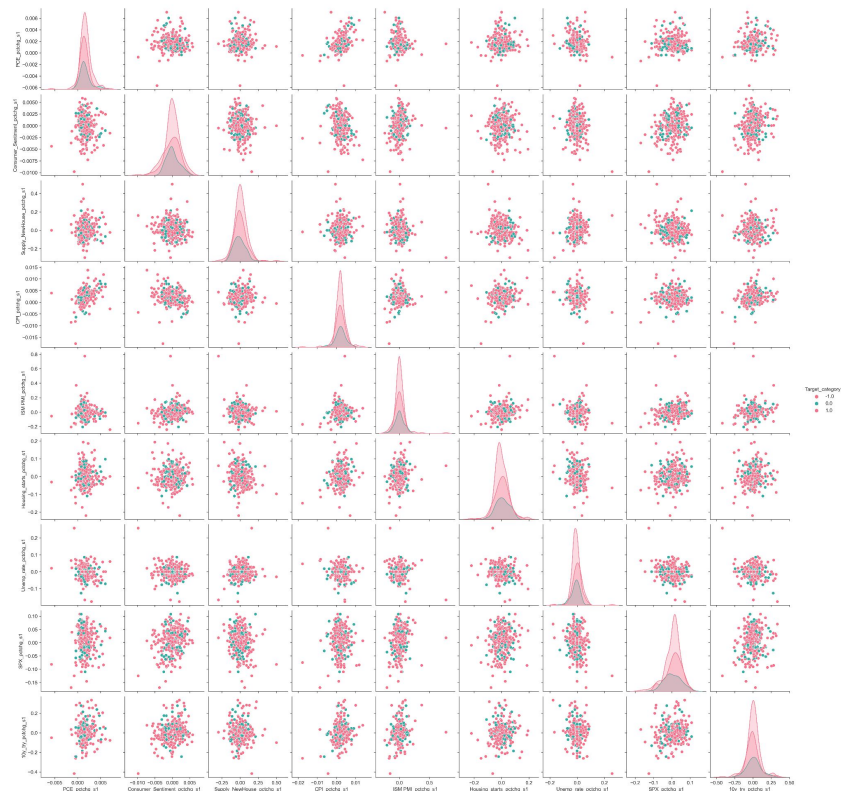
- Pair plot after removing the extreme value of Unemp_rate_pchng_s1
- Data points classified by quarter of the year
- Approximately normally distributed

Exploratory Data Analysis



Normally distributed
data points

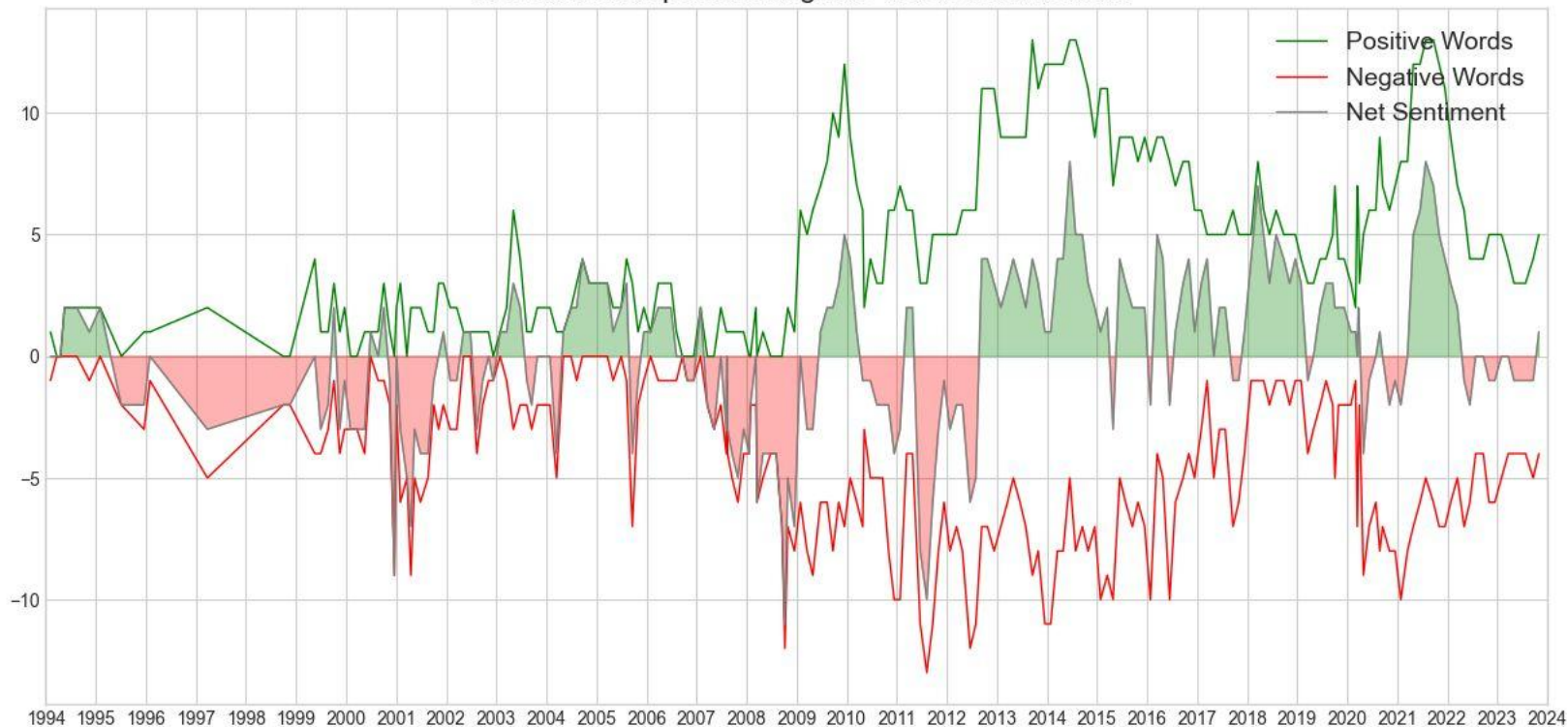
Exploratory Data Analysis



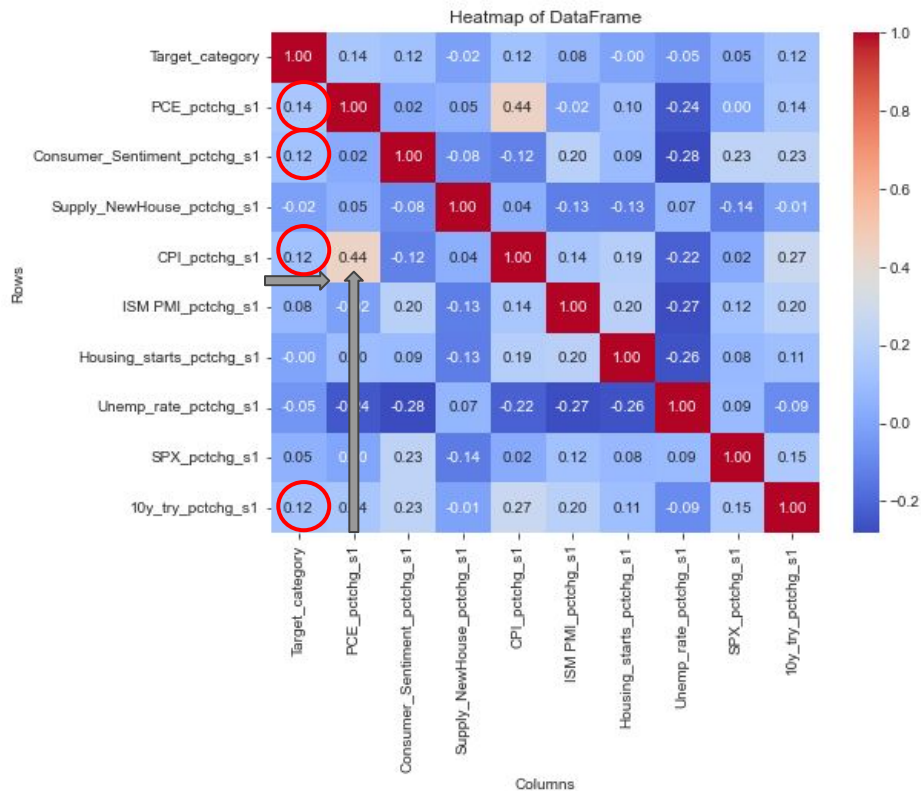
- Pair plot after removing the extreme value of Unemp_rate_pctchg_s1
- Data points classified by quarter of the year
- Approximately normally distributed
- 'Increase' 48.7%, 'decrease' 33.3%, hold '18%'
- Imbalanced categories

Net Sentiment

The number of positive/negative words in statement



Exploratory Data Analysis

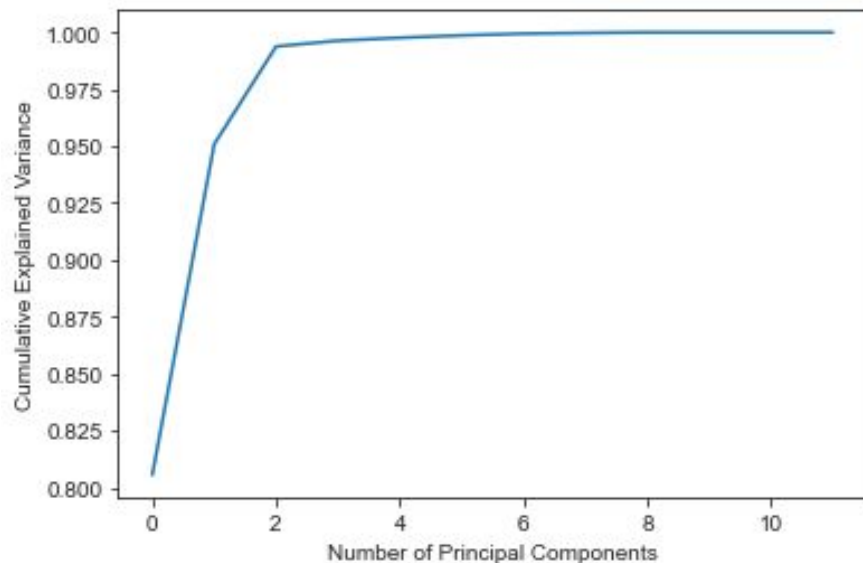


PCE_pctchg_s1 is positively correlated with CPI_pctchg_s1 at 0.44

Target_category positively correlated to

- PCE_pctchg_s1,
- Consumer_Sentiment_pctchg_s1,
- CPI_pctchg_s1,
- 10y_try_pctchg_s1

Feature Selection - PCA



Top features for PC1:

'sentiment_score_LM_s1' = 0.81
'Sentiment_s1' = 0.15
'sentiment_score_LM_pctchg_s1' = 0.04
'Unemp_rate_pctchg_s1' = 0.0025
'10y_try_pctchg_s1' = 0.0013
'Housing_starts_pctchg_s1' = 0.001
'Supply_NewHouse_pctchg_s1',
'SPX_pctchg_s1',
'ISM PMI_pctchg_s1',
'CPI_pctchg_s1',
'Consumer_Sentiment_pctchg_s1',
'PCE_pctchg_s1'