

## **Final Weekly Report**

This report includes details from my final project presentation.

The FOMC, or Federal Open Market Committee, is the branch of the Federal Reserve System that oversees the nation's open market operations, which are the main tools used to regulate the supply of money that's readily available to the public and financial institutions.

The FOMC typically meets eight times a year, though it can meet more frequently if necessary. During these meetings, members discuss the outlook for the U.S. economy and monetary policy options. This includes making key decisions about interest rates and the growth of the U.S. money supply.

The chair of the Federal Reserve holds press conferences after these meetings to communicate the FOMC's decisions to the public.

This project aims first, to develop a sentiment index for the statements made by the chair of the Federal Reserve Board of Governors after the Federal Open Market Committee (FOMC) meetings; and second, to explore if such a sentiment index can be useful in predicting financial market conditions.

### **What are you going to do?**

This research project builds an index that measures the overall sentiments in one of the most important US economic policy institutions, namely the FOMC meeting statements by implementing a state-of-the art Large Language Model (LLM), namely FinBERT. This index is named the FOMC Sentiment Index (FOMC-SI). FOMC-SI will be used to investigate if the overall sentiment in the FOMC meeting statements can predict economic or market conditions.

### **How is it done today? Current Limitations?**

Currently, there are many studies that use sentiment analysis in various contexts. However, there is not any sentiment analysis designed on FOMC statements.

**What is your idea to do something better?**

This is the first sentiment index designed for the FOMC statements. Therefore, it will be the only index that can be used to assess the overall sentiment in these policy statements. Designing an FOMC sentiment index will allow users to (i) to assess the overall sentiment among the key monetary policy makers in the US over time; (ii) the index can be used to analyze link between the policy makers' sentiment and a number of economic and market variables via regressions.

**Who will benefit from your work? Why?**

Policy makers, central banks, market participants (investment companies, banks, hedge funds, etc.), and researchers in economics and finance...

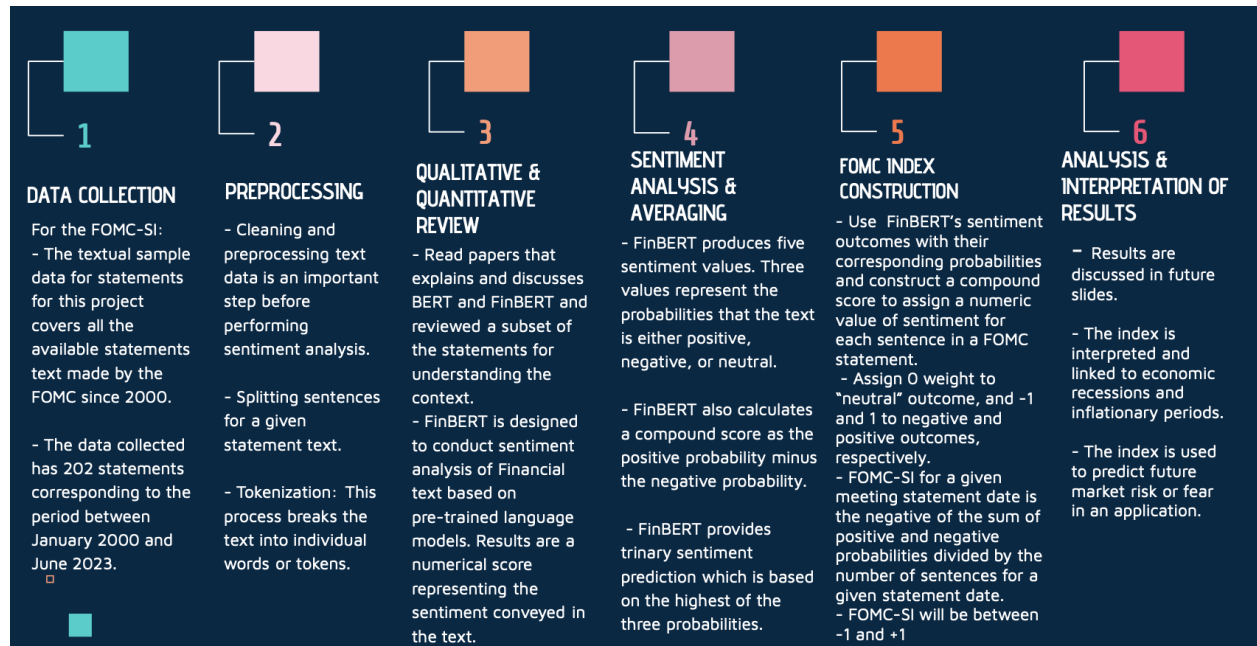
**What risks do you anticipate?**

Although FinBERT is trained on a large textual data on economics and finance, the training data may not truly reflect/capture the textual data in FOMC policy statements as these policy statements generally contain specific jargons and hence, the context may not be clearly understood by the model.

**Out of pocket costs? Complete within 11 weeks?**

This project is feasible within the given time-frame. I decided to do sentiment analysis instead of topic modeling in order to finish within 11 weeks and also decided not to re-train the model.

**Technical Approach Visual**



## More on Architecture

### 1) Function that Implements FinBERT

```
# Function to perform sentiment analysis on text data
def predict_sentiment(text_data):
    # Tokenize the input text data
    tokens = tokenizer(text_data, padding=True, truncation=True, return_tensors='pt')

    # Pass the tokenized data through the finBERT model to get predicted sentiment scores
    with torch.no_grad():
        outputs = model(**tokens)
        logits = outputs.logits

    # Get predicted sentiment labels (positive, neutral, negative) from logits
    _, predicted_labels = torch.max(logits, dim=-1)
    # Convert the logits to probabilities
    probs = torch.nn.functional.softmax(outputs.logits, dim=-1)
    # Convert probabilities tensor to numpy array
    probs_np = probs.detach().numpy()

    # Map numerical labels back to sentiment categories
    sentiment_mapping = {'negative': 1, 'neutral': 2, 'positive': 3}
    predicted_sentiments = [sentiment_mapping[label.item()] for label in predicted_labels]
    predicted_sentiments_pd = pd.DataFrame({'text': text_data, 'Predicted Sentiment': predicted_sentiments})
    # Create a new DataFrame with dates and probabilities
    df_probs = pd.DataFrame({
        'negative_prob': probs_np[:, 1],
        'neutral_prob': probs_np[:, 2],
        'positive_prob': probs_np[:, 3]
    })
    # Print the probabilities
    # Print the results
    predicted_sentiments_pr = pd.concat([predicted_sentiments_pd, df_probs], axis=1)
    # Print the predicted sentiments
    return predicted_sentiments_pr
```

### 2) Function that Calculates the Index

```
if __name__ == "__main__":
    fomc_si = []
    for value in text_data:
        text_i = value
        #print(text_i)
        predicted_sentiments = predict_sentiment(text_i)
        predicted_sentiments['fomc_idx_num'] =
np.where(predicted_sentiments['Predicted Sentiment'] == 'neutral', 0,
-1 * predicted_sentiments['negative_prob'] +
1 * predicted_sentiments['positive_prob'])
        fomc_si.append(-predicted_sentiments['fomc_idx_num'].mean())
```

### 3) FinBERT Outputs

	Text	Predicted Sentiment	negative_prob	neutral_prob	positive_prob	fomc_idx_num
0	Financial market conditions have deteriorated...	neutral	0.011720	0.965730	0.022550	0.000000
1	In these circumstances, although recent data s...	negative	0.698202	0.080262	0.021536	-0.876665
2	The Committee is monitoring the situation and ...	positive	0.208174	0.070815	0.721011	0.512837

### 4) FOMC Sentiment Index

Date	Statement	Statement_sentence	FOMC Sentiment Index
0	2000-02-02 The Federal Open Market Committee voted today ...	[The Federal Open Market Committee voted today...	-0.070471
1	2000-03-21 The Federal Open Market Committee voted today ...	[The Federal Open Market Committee voted today...	-0.328228
2	2000-05-16 The Federal Open Market Committee voted today ...	[The Federal Open Market Committee voted today...	-0.189806
3	2000-06-28 The Federal Open Market Committee at its meeti...	[The Federal Open Market Committee at its meeti...	0.261819
4	2000-08-22 The Federal Open Market Committee at its meeti...	[The Federal Open Market Committee at its meeti...	0.157842
...	...	...	...
197	2023-02-01 Recent indicators point to modest growth in sp...	[Recent indicators point to modest growth in s...	-0.204597
198	2023-03-22 Recent indicators point to modest growth in sp...	[Recent indicators point to modest growth in s...	-0.215664
199	2023-05-03 Economic activity expanded at a modest pace in...	[Economic activity expanded at a modest pace L...	-0.331972
200	2023-06-14 Recent indicators suggest that economic activ...	[Recent indicators suggest that economic activ...	-0.338476
201	2023-07-26 Recent indicators suggest that economic activ...	[Recent indicators suggest that economic activ...	-0.303405

202 rows x 4 columns

## Research and Innovation

This project is novel in a number of fronts:

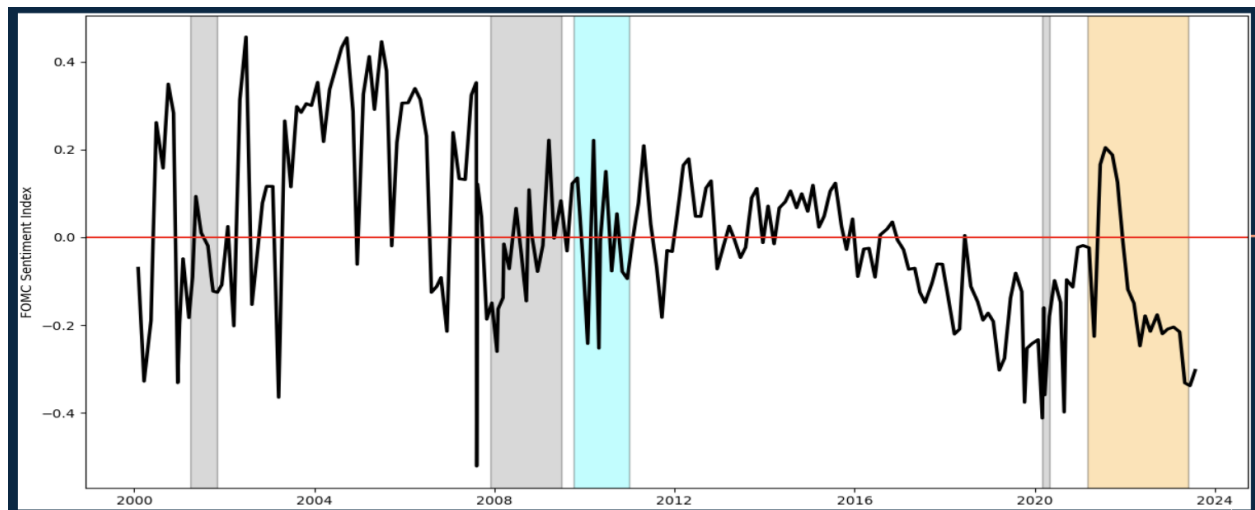
- This is the first project that designs a sentiment index for one of the major policy statements in the US.
- It implements FinBERT that is based on BERT, a LLM on textual data that is very specific in nature and drafted to reflect policy decisions and associated analysis of economic and financial conditions with specific jargons and language.
- It is a precursor to potentially a much larger project as it can lead to the development of Federal Reserve Board's and similar policy institutions development of their own LLMs.
- Provides an index that can be used as a tool for assessing the overall sentiment of FOMC members and provides a comprehensive view of sentiment trends over time. This can allow for potentially revealing patterns related to economic conditions and policy decisions.
- The Index can be used to build predictive models that can link it to economic and market conditions and variables.

## FOMC-SI Summary Statistics

- By construction, the index is between  $[-1, 1]$
- A sentiment index of -1 means an extremely positive sentiment.
- A sentiment index close to +1 means a very negative sentiment.
- A sentiment index close to 0 means a neutral sentiment.
- The index range is between -0.52 and +0.46.
- Average for the entire history of statements is -0.002 which is close to a "neutral" sentiment!

```
count    202.000000
mean     -0.002321
std       0.195040
min      -0.521710
25%      -0.139679
50%      -0.020917
75%       0.116388
max       0.456938
Name: FOMC Sentiment Index, dtype: float64
```

## FOMC Sentiment Index Over Time



### KEY:

**FOMC Index: Positive -> Negative Sentiment;  
Negative -> Positive Sentiment**

### US Recessions

European Debt Crisis

Post Covid Inflationary Period

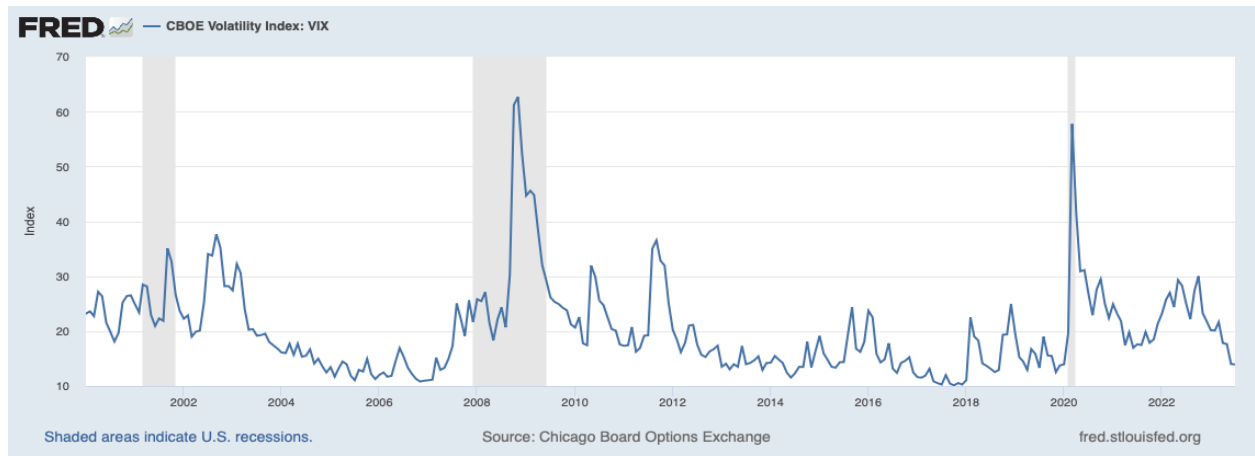
- (1) Gray Area 1: April to November 2001 Recession... Pre-recession the sentiment is more positive. During the recession, there is almost neutral very small negative sentiment. After the 2002 crisis until 2007, there is swinging but tends to stay above zero, meaning the FOMC statements tend to be negative. Why? Potentially the risks are accumulating in good times. This is because people are taking more mortgages etc. So statements are more cautious.

- (2) Gray Area 2: Global Financial Crisis starts in 2007 and ends around 2009. The sentiment index increases as the recession unfolds and hence becomes more negative. Tends to remain around zero after the GFC partly because the European Debt Crisis unfolds around 2010 and 2011.
- (3) European Debt Crisis: After the European debt crisis the sentiment stays above zero which is similar to pre 2007 so economists are cautious about the overall economy.
- (4) Covid (2020): Prior to covid there is improvement.
- (5) Post Covid Period: The sentiment turns negative because the policy makers possibly think that government spending has increased, and interest rates declined to zero, inflation became a problem as well.

Only recently did the index come down, potentially indicating that the policy makers are more optimistic about the soft landing.

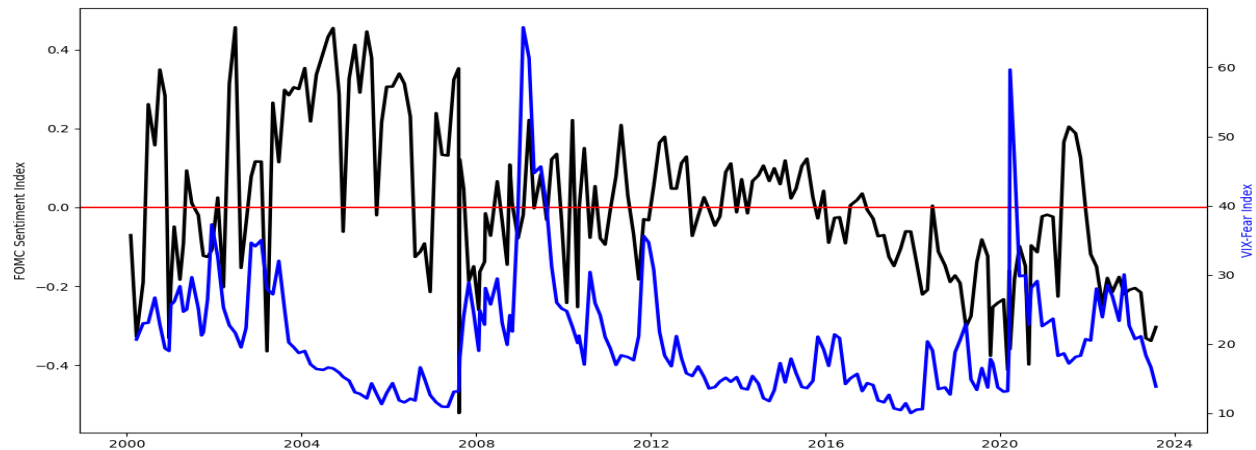
#### **Application: Can FOMC-SI Predict VIX?**

- This application explores if the FOMC-SI can be useful in predicting economic and financial conditions.
- To this end, the index is used to assess if it can predict future values of VIX.
- The VIX Index, often referred to as the "fear gauge," is a measure of expected price fluctuations in the S&P 500 Index options over the next 30 days.
- The Chicago Board Options Exchange (CBOE) introduced the VIX Index in 1993, and it has since become one of the most recognized measures of market volatility.
- The VIX also reflects how much risk is accumulated in the markets and used often by market participants and economic policy makers to get a sense of overall market sentiment and risk.
- The VIX index generally increases during recessions and bad economic periods as can be seen in the figure.



### Application Results: FOMC Sentiment Index - VIX-Fear Index

- Collected daily VIX index from Bloomberg and calculated average VIX in between the FOMC statement dates for this analysis.
- The figure displays FOMC-SI together with the average VIX for the FOMC statement periods.
- Inspection of the plots reveals:
  - FOMC-SI is generally high (sentiment in FOMC statements are more negative) during periods when VIX is low.
  - This seemingly counterintuitive observation in fact may not be that counterintuitive.
  - Because, during episodes of low VIX, the markets are calm and risks tend to accumulate gradually and hence, FOMC members having considerable information about the markets and economic conditions are more cautious and possibly has more negative sentiments reflected in the statements.



Eg. During Covid, there is a spike in VIX. However, the index is low (positive sentiment). This is normal because policy makers know what to do in the sense that they will lower interest and increase the money supply to finance the government spending to combat with Covid. However, for post covid, the sentiment index starts to increase which reflects the potential FOMC members concern about the impact of policies made during the covid era and the inflation is becoming a resilient problem. There are many discussions about how much to increase the interest rates. Also VIX is low post Covid because the Covid induced economic crisis was around two months.

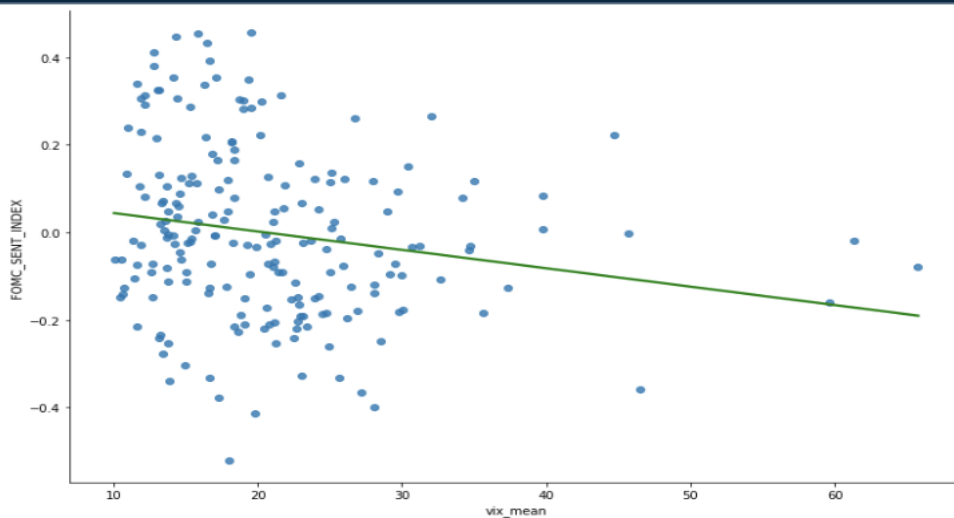
### Regression Analysis with FOMC-SI

- Run two regressions.
- (1) First model regresses VIX on statement date  $t$  on a constant and FOMC-SI on the previous statement date (i.e., at date  $t-1$ ).
- Results are reported in the Table.
- This model indicates a statistically significant coefficient for FOMC-SI (-8.531) with a p-value of 0.021 less than 0.05.
- This shows that the FOMC-SI is statistically significant and negative and hence, statistically predicts the future average value of VIX!
- As the displayed scatter plot with the fitted regression line shows, higher average VIX tends to associate with lower FOMC-SI (i.e., positive sentiment in the statements).



$$VIX_t = \alpha + \beta FOMC - SI_{t-1} + error_t$$

OLS Regression Results						
Dep. Variable:	vix_mean	R-squared:	0.036			
Model:	OLS	Adj. R-squared:	0.031			
Method:	Least Squares	F-statistic:	5.401			
Date:	Sat, 05 Aug 2023	Prob (F-statistic):	0.0211			
Time:	15:31:00	Log-Likelihood:	-717.20			
No. Observations:	201	AIC:	1438.			
Df Residuals:	199	BIC:	1445.			
Df Model:	1					
Covariance Type:	HAC					
	coef	std err	t	P> t	[0.025	0.975]
Intercept	20.7215	1.495	13.860	0.000	17.773	23.670
FOMC_SI.shift(1)	-8.5314	3.671	-2.324	0.021	-15.770	-1.293
Omnibus:	107.125	Durbin-Watson:	0.433			
Prob(Omnibus):	0.000	Jarque-Bera (JB):	528.598			
Skew:	2.094	Prob(JB):	1.65e-115			
Kurtosis:	9.752	Cond. No.	5.16			



### Regression Analysis with FOMC-SI continued...

- (2) The second model augments the first regression by also including the lagged VIX to control for the inertia high VIX periods usually followed by a period of high VIX or low VIX periods usually followed by a period of low VIX as can be observed from the figure on slide 11.
- Like the first model, this second model also indicates a statistically significant coefficient for FOMC-SI (-3.800) with a p-value of 0.002 and hence, the statistical significance of FOMC-SI in predicting the future average value of VIX!
- Results for this model suggest that even after controlling for the persistence in VIX, FOMC-SI is statistically significantly negative and predicts next statement period's average VIX.

- Results from both models are promising and show that additional work with different economic and financial market variables such as unemployment rate, GDP growth, or inflation may be useful.

$$VIX_t = \alpha + \beta FOMC - SI_{t-1} + \delta VIX_{t-1} + error_t$$

OLS Regression Results

Dep. Variable:	vix_mean	R-squared:	0.650
Model:	OLS	Adj. R-squared:	0.646
Method:	Least Squares	F-statistic:	105.6
Date:	Sat, 05 Aug 2023	Prob (F-statistic):	6.77e-32
Time:	15:35:45	Log-Likelihood:	-612.91
No. Observations:	200	AIC:	1232.
Df Residuals:	197	BIC:	1242.
Df Model:	2		
Covariance Type:	HAC		

	coef	std err	t	P> t	[0.025	0.975]
Intercept	4.2898	1.166	3.680	0.000	1.991	6.588
vix_mean.shift(1)	0.7917	0.057	13.984	0.000	0.680	0.903
FOMC_SI.shift(1)	-3.7990	1.198	-3.172	0.002	-6.161	-1.437

Omnibus:	185.739	Durbin-Watson:	1.778
Prob(Omnibus):	0.000	Jarque-Bera (JB):	3958.497
Skew:	3.508	Prob(JB):	0.00
Kurtosis:	23.635	Cond. No.	117.

## Conclusion

Developed a sentiment index to gauge the overall sentiment in one of the major policy statements in the US.

- Developed a jupyter notebook that can be used to implement FinBERT in a given text data and implemented it to calculate FOMC-SI for each FOMC meeting date.
- FOMC-SI is calculated with all the publicly available FOMC statements and hence, historical evolution of the sentiment can be analyzed.
- Applied FOMC-SI to an important market fear gauge, namely VIX and showed that the FOMC-SI can predict future value of VIX!

Also this project accomplished its midterm results.

## **Future Work**

Create a sentiment analysis model trained on more relevant financial text.

- Training a domain-specific sentiment analysis model using financial data can potentially lead to more accurate and contextually relevant sentiment predictions for financial documents like FOMC speeches, economic reports, company earnings calls, news articles, and social media posts related to the financial market.
- This will allow for a more accurate and contextually meaningful sentiment analysis tool for financial applications.
- Suggest a project that develops Federal Reserve's own LLM training as the text data in policy institutions can be different from the text data BERT and FinBERT as well as other LLMs are trained on.