r/Wallstreetbets: A Hitchhiker's Guide to the Moon or to the Ground?

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Purpose of the project

This project seeks to preliminarily explore the relationship between the sentiment espoused on the popular internet forum, Reddit's r/Wallstreetbets subreddit, and the stock market (as a proxy for the US economy) and compare it to that of the Federal Open Market Committee (FOMC) statements, one year from the start of the latest interest rate hike cycle in March 2022. Known for risky stock bets, edgy humor, and viral popularity during the COVID-19 Pandemic, we wanted to know whether the Redditors on r/Wallstreetbets have an accurate gauge of the macroeconomy – is it a Hitchhiker's Guide to the Moon or to the ground?

We expect to see a minimum or even negative correlation between Reddit sentiments and stock closing prices and a positive correlation between FOMC statements sentiments and stock closing prices.

Method and data processing

To answer the above question, we decided to conduct sentiment analysis and calculate compound sentiment scores (mean compound sentiment scores for Reddit posts) for each data entry and run regressions on stock indices S&P 500/Dow Jones/NASDAQ (proxy of the US economy).

We scraped FOMC statements from the Federal Reserve's official website (https://www.federalreserve.gov/newsevents/pressreleases.htm) and posts from the Reddit subreddit r/Wallstreetbets (https://www.reddit.com/r/wallstreetbets/) between March 1st, 2022 to March 31st, 2023. The start date was chosen since the FED started announcing a series of Federal Funds Rate hikes to ease the post-pandemic inflation not seen in decades.

In general, the scraping and cleaning were straightforward, with only streamlining *datetime* objects causing minor hurdles; the recent changes in Reddit's API policy didn't affect our scraping effort. The FOMC statements were scraped using the *selenium* package, while the Reddit posts were scraped using the *praw* package. Considering the amount of Reddit posts irrelevant to the macroeconomic focus of this project, we applied keywords ('inflation,' 'interest rate,' 'unemployment rate,' 'forecast,' 'recession') while scraping. The stock closing prices were scraped from Yahoo! finance using the y*finance* package. In the end, we obtained 9 FOMC statements and 539 Reddit posts, as well as 273 entries for stock closing prices. The raw data underwent a series of preprocessing steps to optimize its suitability for subsequent analysis. Stopwords were removed, and lemmatization applied to reduce words to their base forms. Subsequently, sentiment analysis was conducted on the preprocessed text utilizing the VADER sentiment analyzer. The compound score was then utilized to categorize the data into three sentiments: 'positive,' 'neutral,' or 'negative.' These sentiments serve as key metrics for generating various visualizations. In addition, a simple sentiment analysis model was constructed using a Support Vector Machine (SVM) classifier.

While the project initially requested the use of *Shiny*, we discovered that *Dash* offers a better dashboard creation experience. Currently, we leverage both *Shiny* (codes provided in *my_app*) and *Dash* (codes provided in *dash_app*) to craft dynamic dashboards showcasing our findings and interactive graphs.

With *Dash*, we extend our capabilities by creating additional sections, including the integration of raw data we've scraped and an interactive text predictions section for users to engage with. Moreover, we explore the deployment of our *Dash* application to Render, a unified cloud platform that streamlines the building and running of all our apps. Links are provided in a latter section.

Observations

The observations and data visualization outcomes are presented in the form of two dashboards[1]; the graphs are attached in the Appendix for ease of reference.

Line graphs

We plotted the compound sentiments and monthly mean compound sentiments for Reddit posts on top of the major stock indices. We also used OLS to estimate the correlation between the data set sentiments and the closing prices. All the models (FOMC/Reddit on S&P 500/Dow Jones/NASDAQ) are sadly not statistically significant, which is similar to what we expected to see for the Reddit posts. Interestingly, the R-squared from the FOMC-stock indices pairs is higher than that of Reddit-stock indices pairs. Regression results are saved as Charts 1-6 in the Appendix section.

Word cloud

The word cloud visually represents the most frequently occurring keywords in the statements and posts we extracted. Notably, the FOMC statement features a prevalence of formal policy vocabulary and technical jargon, including terms like monetary policy, federal fund rate, and (rate) target. In contrast, the Reddit posts' word cloud emphasizes topics such as inflation, recession, market, company, and price, which hold more individual-level significance due to their direct impact on personal circumstances.

Aggregate sentiment

Aggregately, the FOMC statements show a mean compound score of 0.0972, while Reddit posts have a score of -0.0432, showing the difference in sentiments among the two data sets.

Histogram of compound scores

These histograms show the compound sentiment scores for the two data sets. We can see that the sentiments expressed within the FOMC statement are less extreme than those in Reddit posts.

Time series analysis

These graphs show the compound scores for both data sets. We can see that the FOMC statements show the lowest compound sentiment scores between August 2022 and January 2023, while Reddit dipped lowest in May 2022 and then went on a generally upward trend.

Top 20 Bigrams

These graphs show the top bigrams by frequency in both data sets. Similar to the word cloud results, we can see that the FOMC statements contain more official and technical jargon, while the Reddit posts hold more words relevant to individuals' daily lives.

[1]On render and *Dash* package https://final-project-redditpower.onrender.com/

Conclusions

Like our initial expectation, Reddit posts' correlations with stock closing prices aren't significant or large. On the other hand, despite line graphs seemingly showing co-movement between sentiments expressed in FOMC statements and stock closing prices, the relationship seems to be not robust statistically. These could be explained by some of the limitations we describe below.

Limitations of this project

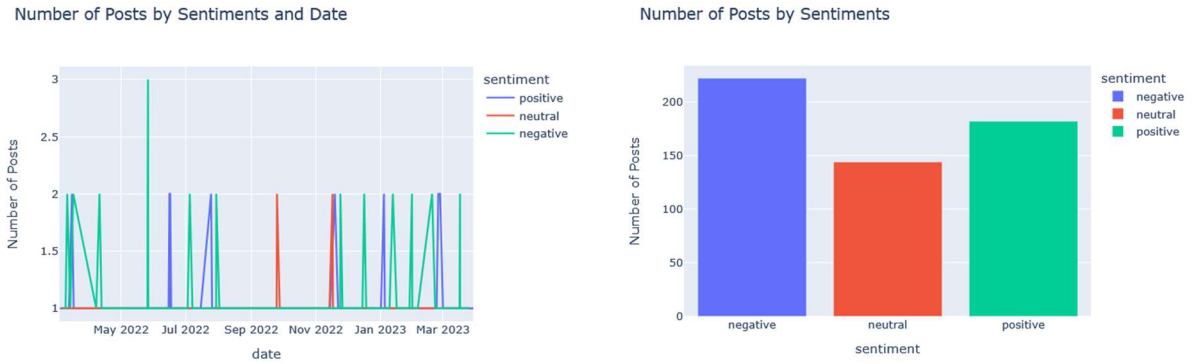
Despite the interesting results we observed, several limitations could be improved upon.

- Data size: since we only considered the official FOMC statements under the *monetary policy* category on FED's website, only 9 observations were available for analysis. Further explorations could consider exploring the other released meeting minutes, yet these are usually published in PDFs, thus complicated text processing is required.
- Asynchronous effect: this preliminary project only takes account of synchronous correlation. Future projects with similar aims should consider the asynchronous effects of independent variables.
- Sentiment Analysis and Text Predictions model: Despite our efforts to build the model, the model's accuracy is reported to be around 70%, indicating room for improvement. Our model did not achieve high accuracy as we relied on a sentiment analyzer for sentiment classification initially. A common practice to improve accuracy involves manually labeling sentiment and utilizing *scikit-learn* to build a model.
- Deployment of *Dash* App: There are limitations to our current setup. Since we're using the free version of *Render*, the website we deployed will shut down during periods of inactivity. Reloading the app takes approximately three minutes.

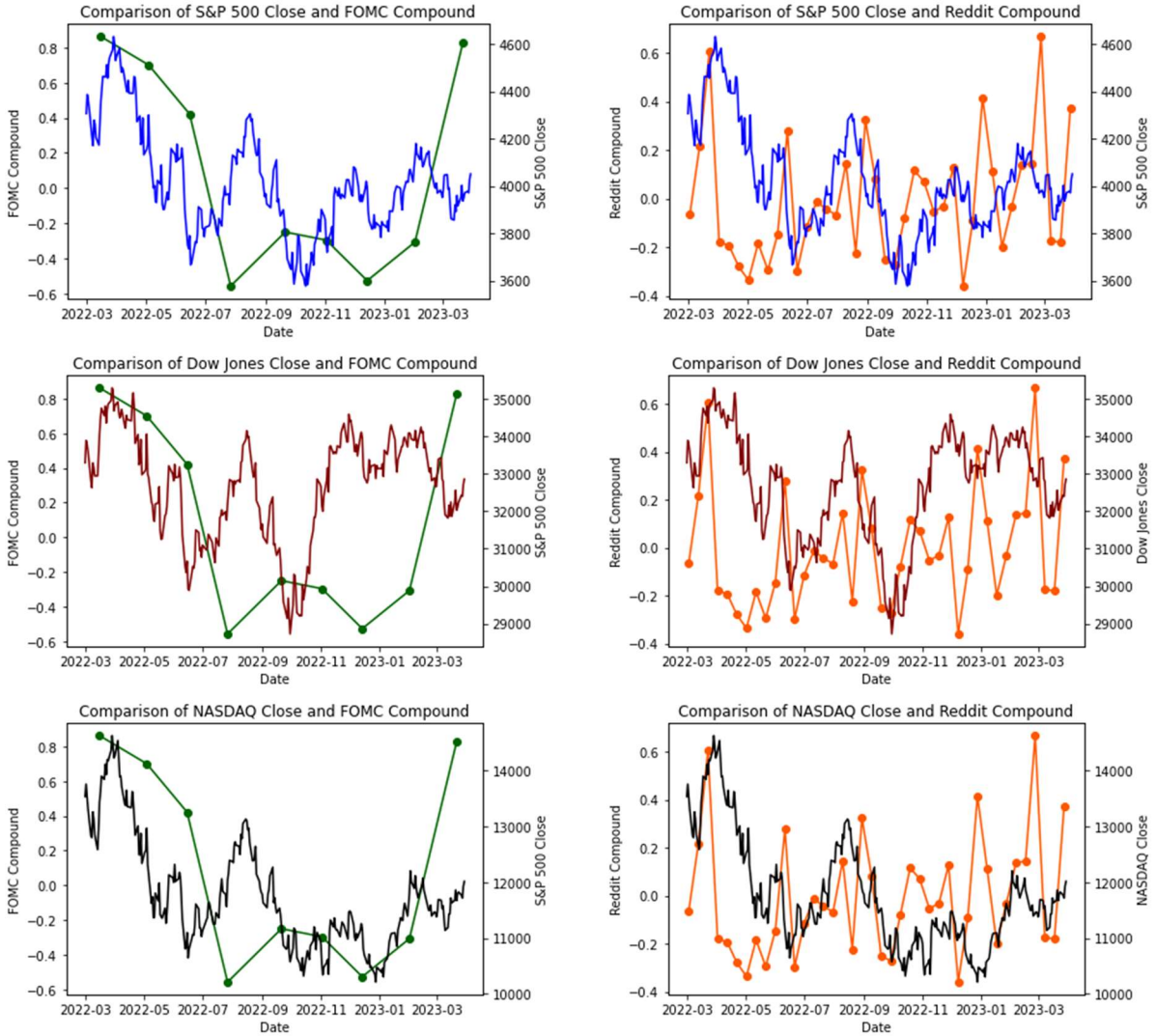
Links to our Dashboard:

1. Live Dashboard: https://final-project-redditpower.onrender.com/
2. Recording Videos:
   a. Shiny:https://drive.google.com/file/d/1H9iUpVwLCTOEYxZ-SGpQJ1TVlxa9LTjX/view?usp=sharing
   b. Dash:https://drive.google.com/file/d/1RjovGxy0-zOWs280Hx2cMX5ojr8djWo-/view?usp=sharing

Appendix

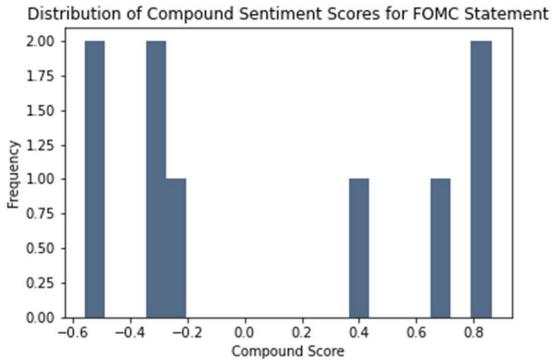


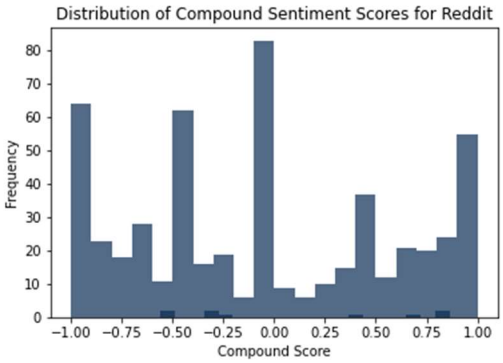
Graph 1. Basic Classifications of Sentiments



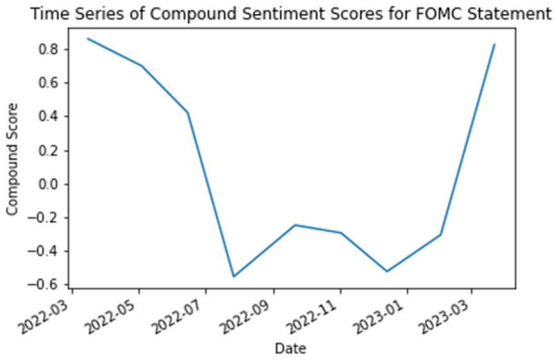
Graph 2. Line graphs showcasing the compound sentiment from FOMC statements and Reddit imposed on major stock indices

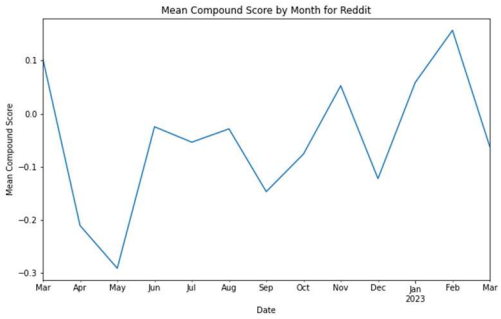
Graph 3. Word clouds



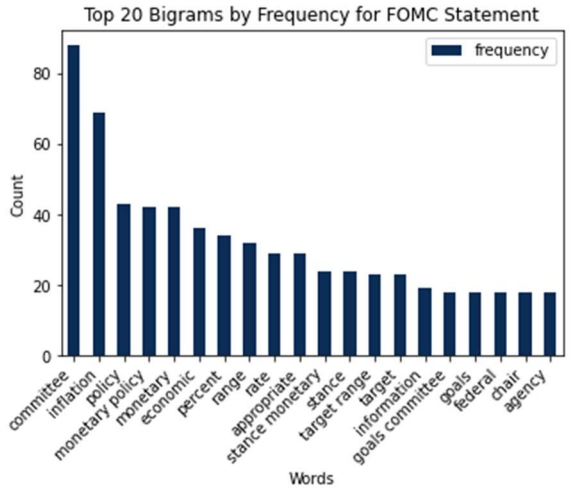


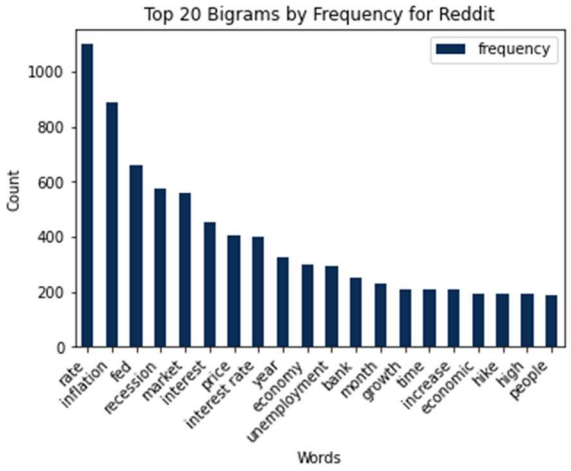
Graph 4. Distribution of compound sentiment scores





Graph 5. Times series of compound sentiment scores





Graph 6. TOP20 Bigrams by Frequency

OLS Regression Results

Dep. Variable:	Close	R-squared:	0.334
Model:	OLS	Adj. R-squared:	0.239
Method:	Least Squares	F-statistic:	3.514
Date:	Wed, 06 Dec 2023	Prob (F-statistic):	0.103
Time:	16:35:08	Log-Likelihood:	-71.945
No. Observations:	9	AIC:	147.9
Df Residuals:	7	BIC:	148.3
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.168e+04	274.988	42.485	0.000	1.1e+04	1.23e+04
compound	903.5193	481.967	1.875	0.103	-236.152	2043.191

Omnibus:	2.737	Durbin-Watson:	2.147
Prob(Omnibus):	0.255	Jarque-Bera (JB):	0.894
Skew:	-0.050	Prob(JB):	0.639
Kurtosis:	1.459	Cond. No.	1.80

Chart 1. Regression summary table for FOMC-NASDAQ

OLS Regression Results

Dep. Variable:	Close	R-squared:	0.012
Model:	OLS	Adj. R-squared:	-0.130
Method:	Least Squares	F-statistic:	0.08209
Date:	Wed, 06 Dec 2023	Prob (F-statistic):	0.783
Time:	16:35:08	Log-Likelihood:	-78.162
No. Observations:	9	AIC:	160.3
Df Residuals:	7	BIC:	160.7
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	3.257e+04	548.676	59.369	0.000	3.13e+04	3.39e+04
compound	275.5247	961.658	0.287	0.783	-1998.435	2549.484

Omnibus:	1.568	Durbin-Watson:	1.723
Prob(Omnibus):	0.457	Jarque-Bera (JB):	0.838
Skew:	-0.358	Prob(JB):	0.658
Kurtosis:	1.687	Cond. No.	1.80

Chart 2. Regression summary table for FOMC-Dow Jones

OLS Regression Results

Dep. Variable:	Close	R-squared:	0.184
Model:	OLS	Adj. R-squared:	0.068
Method:	Least Squares	F-statistic:	1.582
Date:	Wed, 06 Dec 2023	Prob (F-statistic):	0.249
Time:	16:35:08	Log-Likelihood:	-59.809
No. Observations:	9	AIC:	123.6
Df Residuals:	7	BIC:	124.0
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	3992.7814	71.401	55.921	0.000	3823.945	4161.618
compound	157.3907	125.144	1.258	0.249	-138.527	453.308

Omnibus:	4.829	Durbin-Watson:	2.119
Prob(Omnibus):	0.089	Jarque-Bera (JB):	1.150
Skew:	-0.163	Prob(JB):	0.563
Kurtosis:	1.279	Cond. No.	1.80

Chart 3. Regression summary table for FOMC-S&P500

OLS Regression Results

Dep. Variable:	Close	R-squared:	0.019
Model:	OLS	Adj. R-squared:	-0.019
Method:	Least Squares	F-statistic:	0.4972
Date:	Wed, 06 Dec 2023	Prob (F-statistic):	0.487
Time:	16:35:08	Log-Likelihood:	-229.93
No. Observations:	28	AIC:	463.9
Df Residuals:	26	BIC:	466.5
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.176e+04	175.531	66.974	0.000	1.14e+04	1.21e+04
compound	515.9913	731.801	0.705	0.487	-988.247	2020.229

Omnibus:	1.919	Durbin-Watson:	0.439
Prob(Omnibus):	0.383	Jarque-Bera (JB):	1.469
Skew:	0.553	Prob(JB):	0.480
Kurtosis:	2.813	Cond. No.	4.19

Chart 4. Regression summary table for Reddit-NASDAQ

OLS Regression Results

Dep. Variable:	Close	R-squared:	0.038
Model:	OLS	Adj. R-squared:	0.001
Method:	Least Squares	F-statistic:	1.032
Date:	Wed, 06 Dec 2023	Prob (F-statistic):	0.319
Time:	16:35:08	Log-Likelihood:	-240.61
No. Observations:	28	AIC:	485.2
Df Residuals:	26	BIC:	487.9
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	3.269e+04	257.010	127.187	0.000	3.22e+04	3.32e+04
compound	1088.3420	1071.491	1.016	0.319	-1114.140	3290.824

Omnibus:	2.635	Durbin-Watson:	0.737
Prob(Omnibus):	0.268	Jarque-Bera (JB):	2.326
Skew:	-0.638	Prob(JB):	0.313
Kurtosis:	2.395	Cond. No.	4.19

Chart 5. Regression summary table for Reddit-Dow Jones

OLS Regression Results

Dep. Variable:	Close	R-squared:	0.025
Model:	OLS	Adj. R-squared:	-0.013
Method:	Least Squares	F-statistic:	0.6664
Date:	Wed, 06 Dec 2023	Prob (F-statistic):	0.422
Time:	16:35:08	Log-Likelihood:	-187.50
No. Observations:	28	AIC:	379.0
Df Residuals:	26	BIC:	381.7
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	4015.2295	38.568	104.108	0.000	3935.952	4094.507
compound	131.2621	160.792	0.816	0.422	-199.250	461.775

Omnibus:	0.748	Durbin-Watson:	0.609
Prob(Omnibus):	0.688	Jarque-Bera (JB):	0.719
Skew:	0.344	Prob(JB):	0.698
Kurtosis:	2.621	Cond. No.	4.19

Chart 6. Regression summary table for Reddit-S&P500