



Bank of America Reputational Risk AI Model

University of Chicago

MS in Financial Mathematics Project Lab (Autumn 2023)

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Objectives

- Scrape the web for news articles related to Bank of America (BofA)
- Manually label article sentiment (positive, neutral, or negative)
- Develop and train a primary (Roberta LSTM) and challenger (Chat-GPT) model
- Use both models to predict daily sentiment scores towards BofA
- Regress historical sentiment scores on lagged CDS spread and stock price data

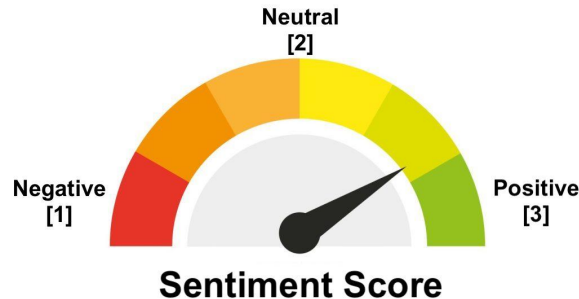
Web Scraper

- Application Programming Interface (API's): Gnews and Newspaper3k
- Database: 2008-01-01 to 2023-12-31 (16,465 articles)
 - Salience: Number of times key words like “Bank of America, BofA, BAML, Merrill” mentioned in article
 - Validity: Complete Article

	date	link	media	title	corpora	salience	validity
1							
2	2008-01-01 08:00:00	https://news.google.com/rss/articles/CBMiW2h	Boston Herald	As Change Agent, Yvonne	If you haven't heard of Yvonne	4	TRUE
3	2008-01-01 08:00:00	https://news.google.com/rss/articles/CBMiNm	China.org	The Soong Ching Ling I kn	Home / Top News Tools: Save	1	TRUE
4	2008-01-02 08:00:00	https://news.google.com/rss/articles/CBMiKmh	Towleroad	Connecticut Man Shot to	Police have charged Marcos M	1	TRUE
5	2008-01-03 08:00:00	https://news.google.com/rss/articles/CBMiLWh	SFist	Window Plummets from	Kearny Street (at California) w	2	TRUE
6	2008-01-03 08:00:00	https://news.google.com/rss/articles/CBMiU2h	CBS News	U.S. Stocks Higher After Ec	NEW YORK (MarketWatch) -- U	1	TRUE
7	2008-01-06 08:00:00	https://news.google.com/rss/articles/CBMiS2h	Seeking Alpha	Earnings Power vs. Invest	When we invest in stocks base	3	TRUE
8	2008-01-11 08:00:00	https://news.google.com/rss/articles/CBMiGh	CNBC	WaMu Has Discussed Mer	No deal is imminent but the t	2	TRUE
9	2008-01-11 08:00:00	https://news.google.com/rss/articles/CBMiVGh	The New York Times	A Toilet That Uses 14 Gall	Some City Room readers were	1	TRUE
10	2008-01-15 08:00:00	https://news.google.com/rss/articles/CBMiLmh	WIRED	NSA Must Examine All Inte	The nation's top spy, Michael	1	TRUE

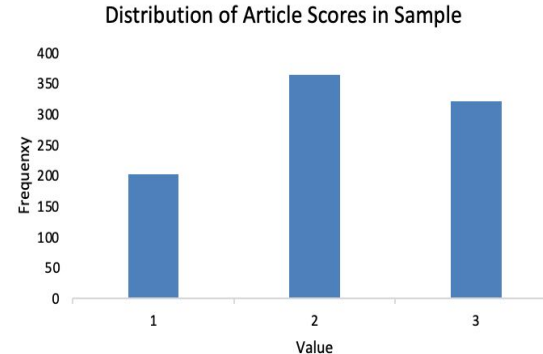
Data Collection

- 1 - Negative Sentiment (202 Articles)
- 2 - Neutral Sentiment (365 Articles)
- 3 - Positive Sentiment (322 Articles)



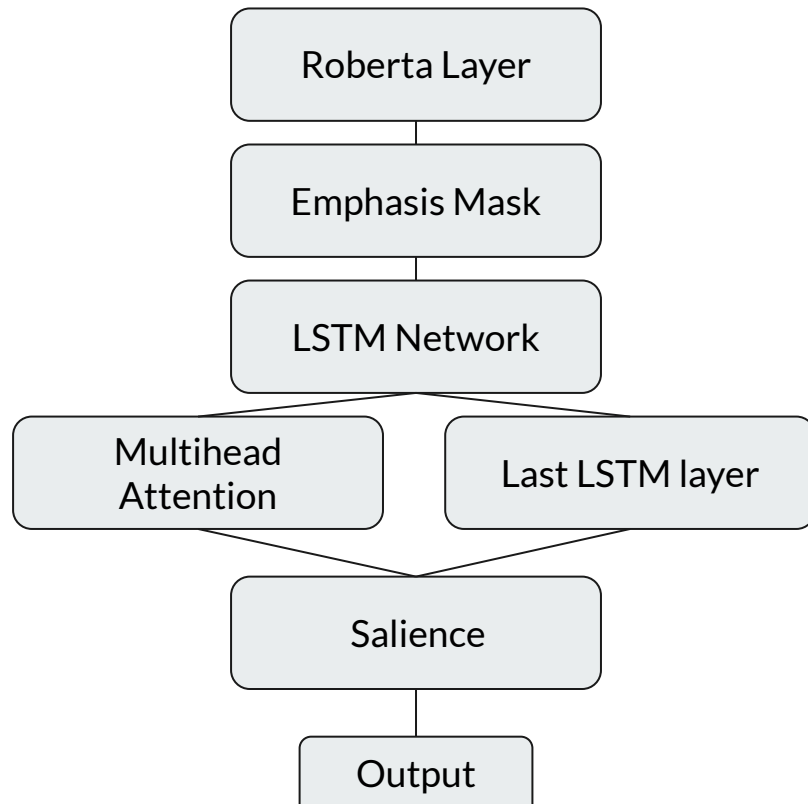
Total Sample Size - 889 Articles

- Labelled articles were split into training and testing sets (80/20)



Primary Model

- Modern Pre-trained Transformer
 - Preprocessed using native BERT tokenizer
 - Modified Transformer with special 'BofA' tokens
 - Outputs preliminary logits
- Emphasis Mask
 - Outputs are checked for special tokens
 - Tokens are emphasized by hyperparameter scaling
- LSTM Network
 - Used for sequential analysis
- Multihead Attention Layer
 - Applies an attention filter on the sequence itself - better contextual inference
- Average out the sequential output with attention layer and appended Saliency





Experimental Model

- Comparing Experimental Longformer with Primary Roberta Model:
 - slightly less predictive power
 - significantly higher computing time

Conclusion:

Larger word processing limit 512 vs 1000 does not seem to increase the model's predictive power with the current sample size.

Challenger Model

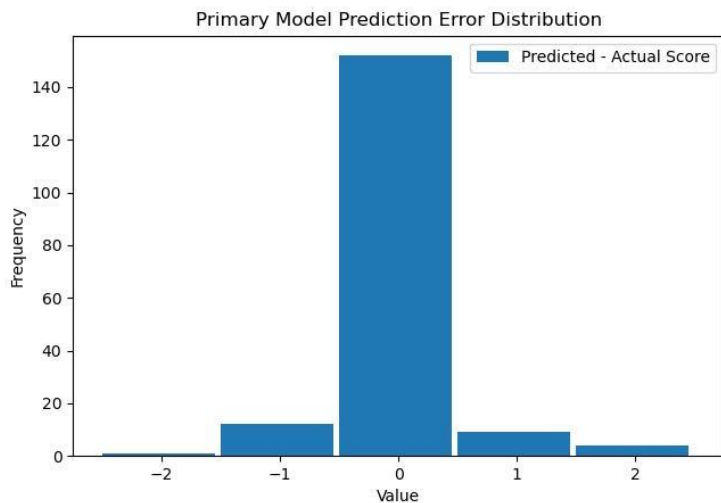
Model: gpt-3.5-turbo-1106 (*additional: text-davinci-002, gpt-4*)

Prompt: Pretend you are a news analyst and you want to rate a news article's sentiment towards Bank of America, or any of its subsidiaries like Merrill Lynch and BofA securities on a scale from 1-3 (1 = negative, 2 = neutral, 3 = positive). Again, rate the sentiment towards BofA within the context of the article and remember only 3 rating choices are allowed (1-3). And give me only the rating number with no additional comments. What would you score for the article below: {article}?

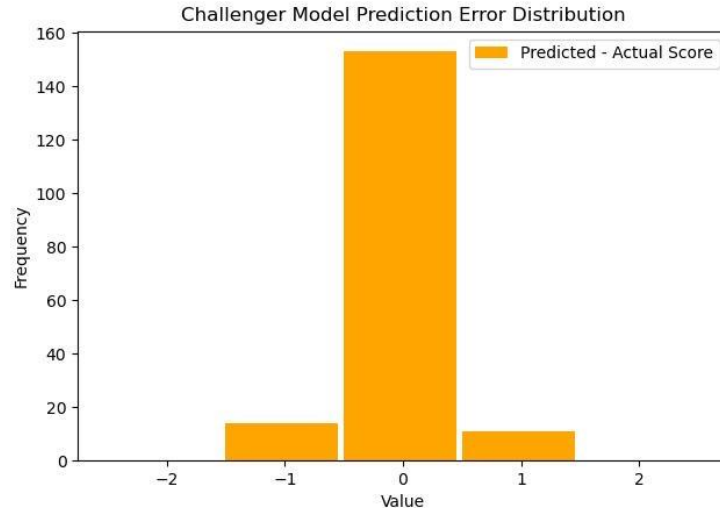
Fine-tuning: Additional training for increased specificity



Model Performance Comparison



Accuracy Score: **85.39%**
Mean Absolute Error: **0.17**



Accuracy Score: **85.96%**
Mean Absolute Error: **0.14**



Scoring Methodology

- **Initial Score (S):** The initial score assigned to an article on a scale from 1 to 3.
- **Completeness Factor (C):** If the article is complete, $C = 0$; if incomplete, $C = 0.25$ (*An incomplete article is given 75% weightage as compared to a complete article*).
- **Credibility Factor (Cr):** If the article is from a credible source, $Cr = 0$; if from a non-credible source, $Cr = 0.40$ (*A non-credible article is given 60% weightage as compared to a credible article*).
- **Neutral Score (N):** The neutral score, which is 2 in this scale.

The Final Score (F) for each article can be calculated as follows:

$$F = S + C \times (N - S) + Cr \times (N - S)$$



Aggregated Scoring Methodology

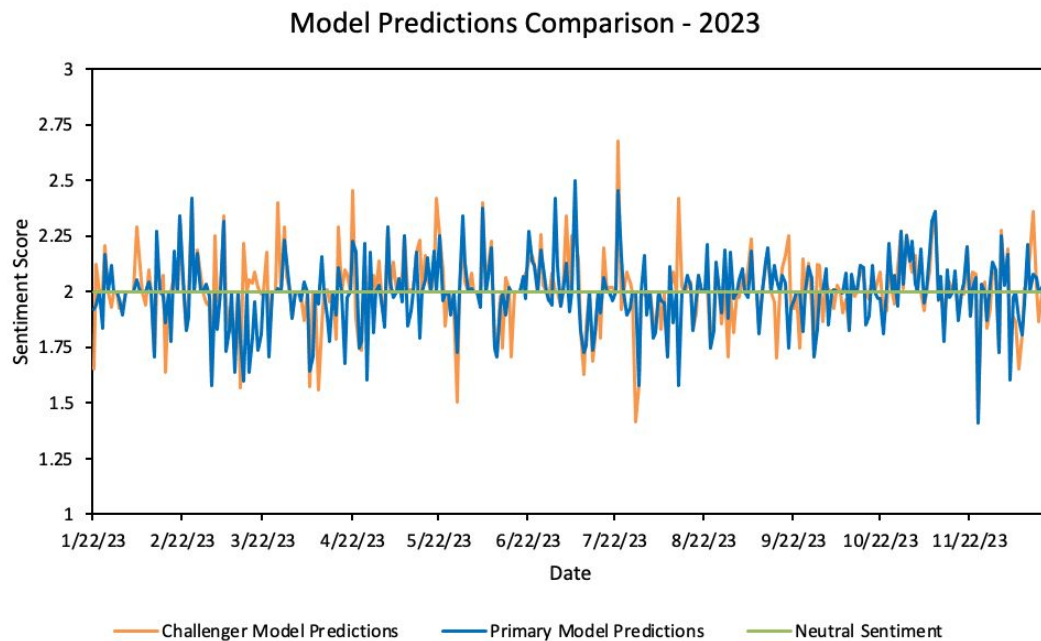
- **Aggregated Score (A):** The average score assigned to all articles on a given day.
- **Neutral Score (N):** The neutral score, which is 2 in this scale.
- **Article Count (C):** Number of unique articles scraped on a given day.
- **Penalty (P):** Assigned such that days with a lower article count are biased towards a neutral score due to lower confidence as a result of smaller sample size.

$$P = (1 + 20 \times C) / (30 \times C)$$

The Final Score (F) for each day is calculated by multiplying the aggregated score for each day with the penalty and then recentering to neutral, as shown below:

$$F = A \times P + N \times (1 - P)$$

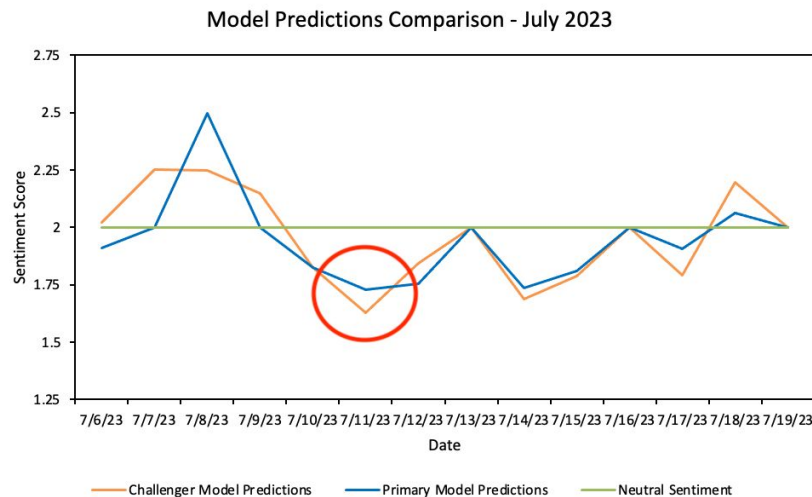
Historical Backtesting



Negative Example

July 11th, 2023

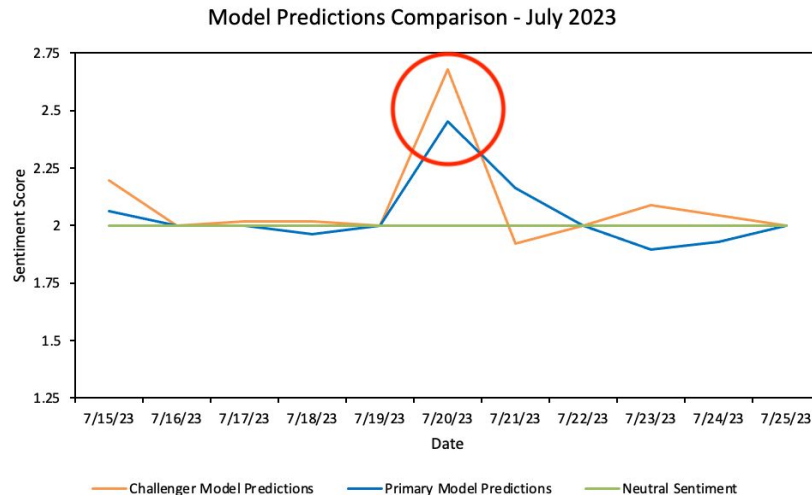
- Bank of America Faces Regulatory Action from CFPB for Unlawful Violations
- **CBS News:** “Bank of America ordered to pay millions for bogus fees”
- **NPR:** “Bank of America ordered to reimburse millions for 'junk fees'”
- **Investment News:** “Merrill Lynch smacked with \$12 million penalty for reporting violations”
- **CNBC:** “Bank of America fined \$150 million for consumer abuses including fake accounts”



Positive Example

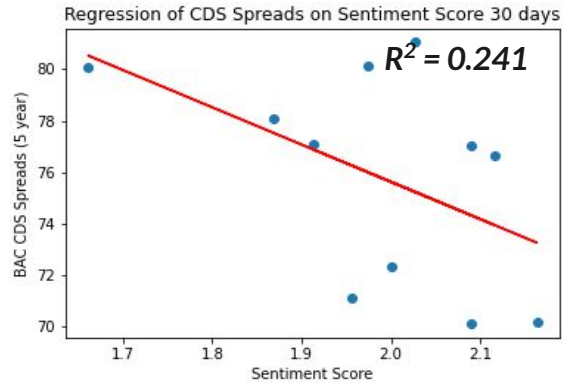
July 23rd, 2023

- Bank of America Announced an Increase in Stock Dividend
- **Yahoo Finance:** “Bank of America (NYSE:BAC) Has Announced That It Will Be Increasing Its Dividend To \$0.24”
- **The Motley Fool:** “If You Invested \$10,000 in Bank of America in 2010, This Is How Much You Would Have Today”
- **Market Watch:** “Bank of America Corp. stock outperforms competitors on strong trading day”

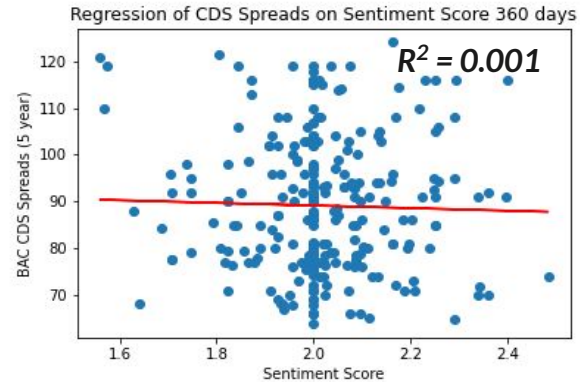
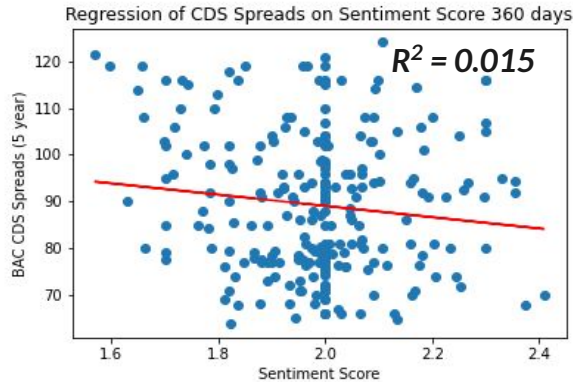
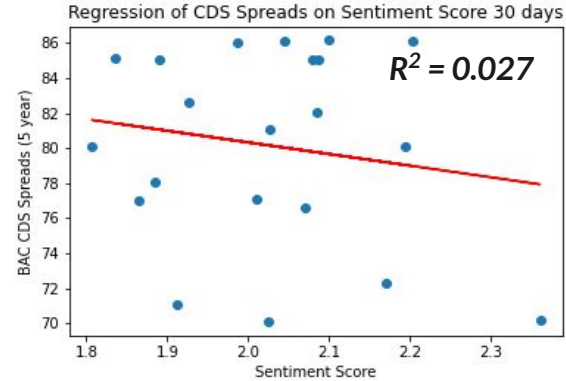


CDS Spread Data

Primary Model



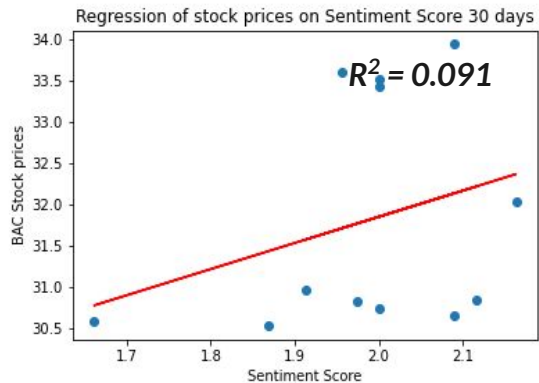
Challenger Model



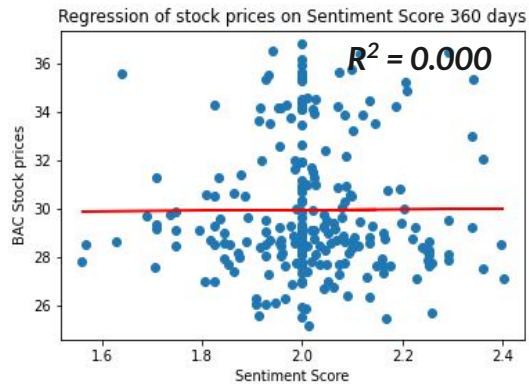
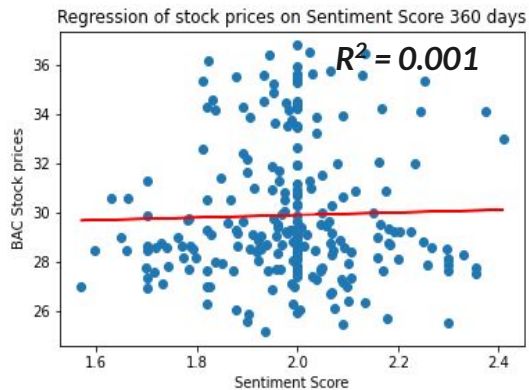
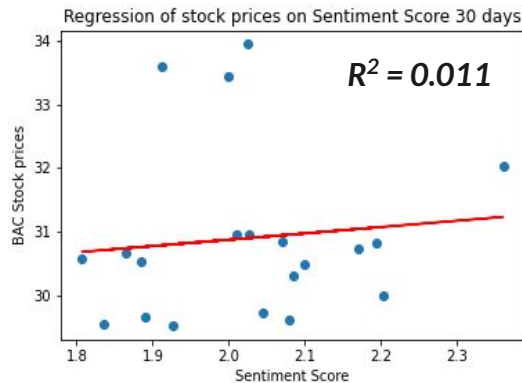
Stock Price Data



Primary Model



Challenger Model





Future Directions

- Track and compare sentiment scores for competitor banks
- Utilize additional news sources like social media
- Implement a bi-model approach - one model for classifying types of articles and another model for classifying sentiment



Managing Risk in Financial Institutions using AI (*Part 2*)

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Positive Impacts

- Enhanced fraud detection
- Streamlined regulatory compliance
- Improved credit risk modeling
- AI-driven analytics and anomaly detection

Challenges & Risks

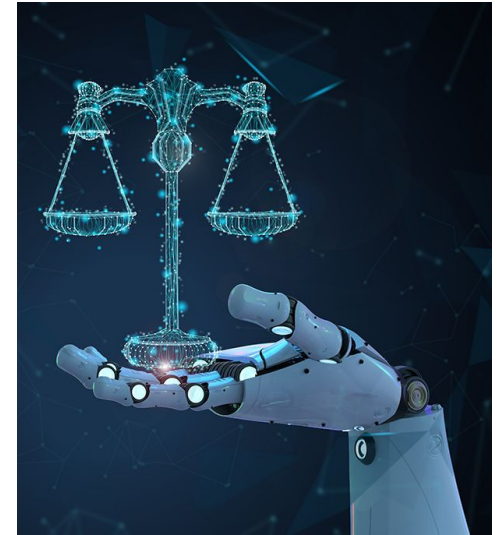
- Data privacy and security concerns
- Embedded bias within AI algorithms
- Explainability of AI Decisions
- Financial stability risks
- Cybersecurity threats



Regulatory Landscape of AI in Banking

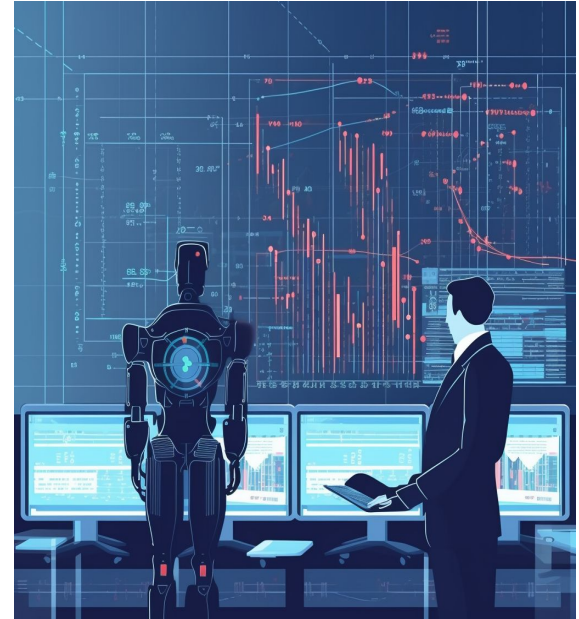
Regulations place emphasis on the transparency and ethical use of AI within financial services.

- The European Union AI Act (2021)
- The White House AI Bill of Rights (2022)
- The Schatz-Kennedy AI Labeling Act (2023)
- US Consumer Financial Protection Bureau (CFPB)



Future of AI in Financial Institutions

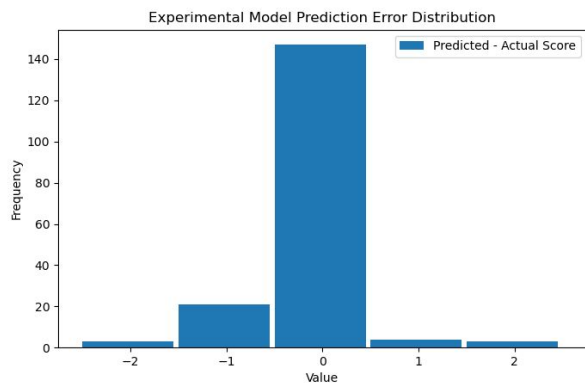
- Multiplying innovation velocity
- Supercharging the future of work
- Upholding high standards for testing and validation
- Revolutionizing client interactions and increasing efficiency in advisory practices
- Growth of value in global wealth management and scale of global economy attributed to GenAI





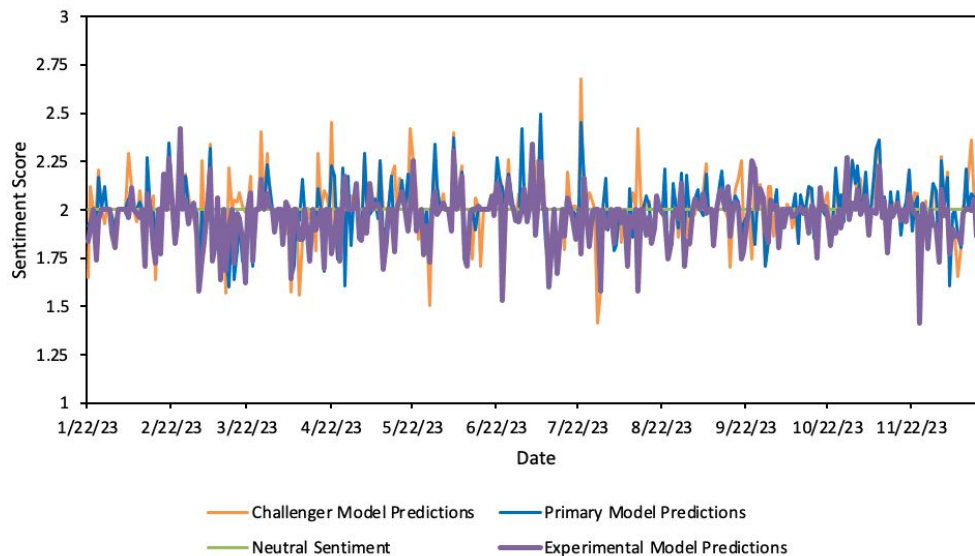
Questions

Appendix - A



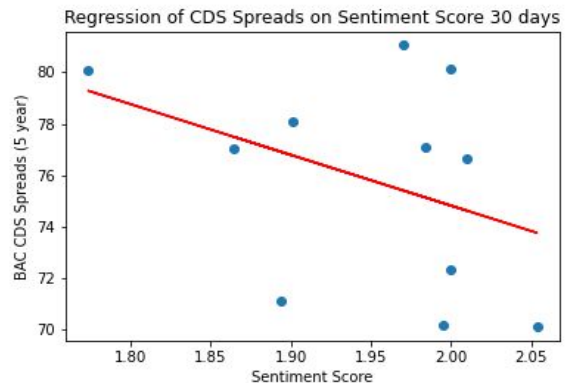
Accuracy Score: **82.58%**
Mean Absolute Error: **0.21**

Model Predictions Comparison - 2023



Appendix - B

CDS Spread Data



Stock Price Data

