

Textual Analysis and Financial Statements

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Introduction

Corporate credit ratings represent professional estimations of the default risk carried by company debt. These ratings represent critical information for investors - not just institutional investors and financially sophisticated bondholders, but also stockholders, who may be wiped out completely in the event of bankruptcy. Analyzing ways to predict ratings can offer substantial value to a variety of stakeholders. Predictive models may be useful for investors without access to data, companies or potential lenders that seek information about influential factors,¹ and by any parties seeking interpolated ratings for companies that do not have them.

In this project, we seek to fully leverage the text of earnings calls, along with traditional financial measures and variables, to improve predictions of corporate credit ratings for any given company and quarter and better understand the importance of various influences.² Features capturing call readability, transparency, and engagement join pre-trained language model representations of sentiment (Araci, 2019) and traditional tabular variables as inputs to a variety of supervised machine learning techniques for classification from logistic regression to tree-based methods. We also make use of advances in the study of graph neural networks to model linkages between firms implied by mentions in calls. (Das et al., 2023)

To the best of our knowledge, the closest prior work to ours is Donovan et al. (2021), which leverages the textual content of earnings calls and financial statements to predict credit events such as bankruptcies, interest spread changes, and rating downgrades. Unigram and bigram word frequencies were used with the supervised machine learning techniques of Support Vector Regression, Latent Dirichlet Allocation, and Random Forests. The coefficient on a constructed textual measure of credit risk was found to be significant up the 1% level. In contrast to this approach, we focus on predicting the credit ratings themselves, and integrate more recent techniques such as neural language models and a wider variety of algorithms for classification.

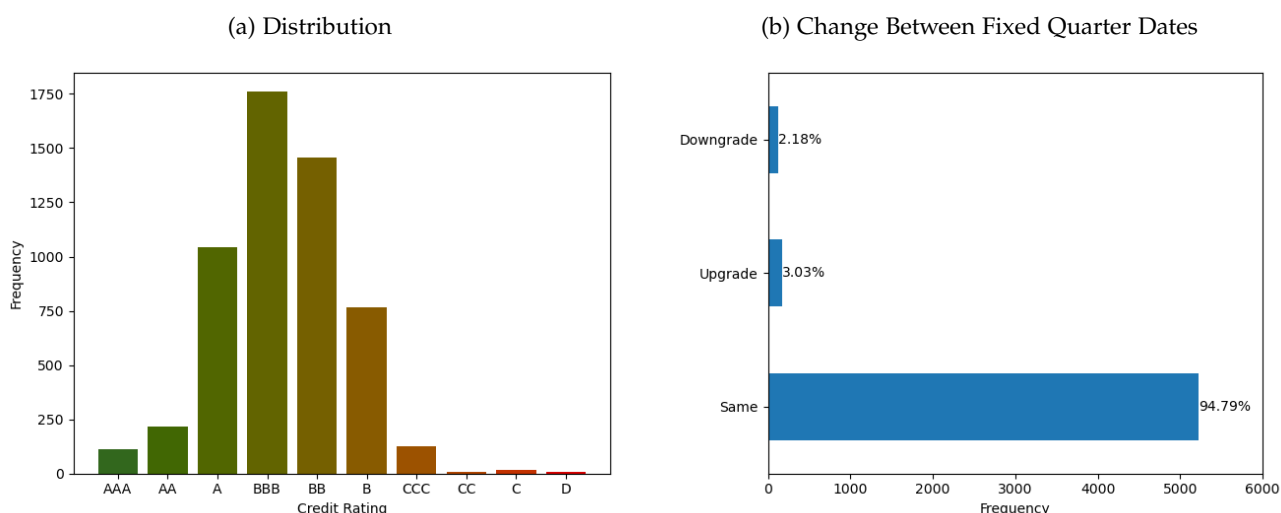
Data and Exploratory Data Analysis

We combine a wide variety of data sources to support our predictions of credit ratings - merging rating data with company earnings calls, financial statement variables, and industry sector. In our combined dataset, each observation represents a fixed quarter date (1/1, 4/1, 7/1, 10/1) for a company, with the company's most recent

¹There is evidence suggesting financial factors and projections have a causal impact on ratings and are not manipulated by companies in response to forecasted rating changes (He, 2018).

²Though much literature has focused on financial statements and reports and credit ratings (as just one example, see Makwana et al. (2022)), our paper takes a relatively underexplored approach, instead incorporating earnings call transcripts. We believe calls offer a richer picture of a firm's financial prospects because they include two-way conversation between company management and financial analysts in form of a Q and A section. This section incorporates the broader beliefs and concerns of the financial community into our predictions. Additionally, in contrast to financial statements, which must be (noisily) parsed to identify sections relevant to management analysis, earnings calls provide more directly valuable and readily available information.

Figure 1: Credit Ratings



credit rating, earnings call and associated financial statement variables, and sector attached. An example of many of the variables for a company by fixed quarter date can be found in Appendix Section A.5.

Our scope of interest is publicly traded companies from 2010-2016 (a limitation due to the availability of credit rating data) - the distribution of call year and quarters can be found in Appendix Figure A.1. To ensure comparability, we drop items missing any predictor variable, as well as some companies with only a few (3 or less) quarters. We identified one bankruptcy in our data - Peabody Energy on April 13, 2016 - and on further investigation, removed some quarters with incorrect ratings. In all, we have 5,509 quarters for 429 unique companies.

Credit Ratings

We make use of long-term credit rating issuances from S and P Rating Services, provided from a combination of two credit rating datasets downloaded in CSV and Excel format from Kaggle (Gewerc, 2020; Makwana, Bhatt and Delwadia, 2022). Each issuance can be a change in rating (upgrade, downgrade) or reaffirmation - they occur at ad-hoc intervals. We reshape these rating issuances to a dataset of ratings for each company on each fixed quarter date by creating a rating end date variable that is the date of the next issuance or end of data, and joining a list of the fixed quarter dates on the condition that the fixed quarter date is between the issuance date and the end date.

POTENTIALLY MOVE ALL DATA CLEANING STEPS TO APPENDIX.

Figure 1 shows the distribution of rating grades used in our final dataset. Finer grades (AA+, CCC-, etc.) are sometimes assigned by agencies, but these grades were converted by dropping the +/- for this project. Ratings of BBB and above are considered investment grade - these bonds carry empirical one-year default rates of 0 to 1%. Ratings below that are classified as junk, with default rates from 1 to 30, 40, or even 50% for some years (S and P Global Ratings, 2024). Most company-quarters have ratings around the BBB threshold, with very few cases on the extreme ends of the spectrum. Ratings also tend to be constant over time. Relative to the previous fixed quarter date, 94.79% of ratings remain the same. Rating on the previous fixed quarter date can thus be an extremely strong predictor.

Figure 2: Altman Z-Score



Earnings Calls

Our earnings call data comes from the Financial Modelling Prep API (Financial Modeling Prep, 2024), a trusted source widely used in industry. We remove all calls that happened more than 250 days prior and after the first day of the year and quarter they are supposed to discuss the results from, as well as calls for companies that provide them on an annual, rather than quarterly basis. Including both prepared remarks and analyst Q and A sessions, the overall average call length in our final data stands at 8,759.68 words.

Financial Statements

Our financial statement variables are also retrieved using the Financial Modelling Prep API. We make use of items from company balance sheets, cash flow statements, and income statements, as well as company market capitalization. We also calculated and included a wide variety of ratios, levels, and changes in variables. (for a list, see variables marked as 'Financial Statements' in Table A.1)

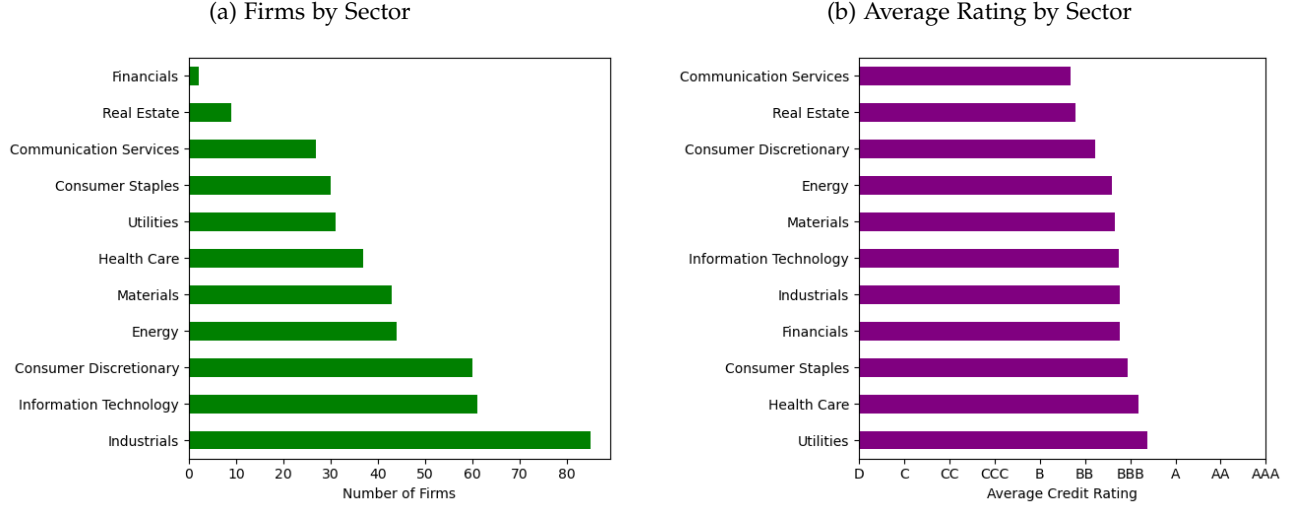
To prepare the data, we limit our observations to items reported in USD, check for and correct values off by a factor of 1,000 as a result of parsing,³ and check some accounting identities in Das et al. (2023),⁴ setting failing variables to missing. We also discard observations where statement filing dates do not agree between the three types of statements, where the filing date falls outside of the fixed quarter matched on via earnings call date, and where the filing date is more than 45 days after the earnings call date.

In some of our models, we make use of Altman's Z-score, a traditional measure of bankruptcy risk that accounts for company earnings, equity, and assets and liabilities (Altman, 1968) (for details on the construction of the score, see Appendix section A.3). Figure 2 shows the distribution of Z-scores in our dataset. Traditionally, values above 3.0 have been considered safe, while those below 1.8 are considered to have a high chance of bankruptcy. The average scores for each rating in our data seem to align well with this interpretation, with high scores being associated with higher ratings in a linear manner. Aside from a few quirks on the ends of the rating spectrum (where not many companies and ratings are available), Z-Score is likely to be highly useful as a predictor.

³If the last few digits are 000.00 and the item is above or below the 2.5% and 97.5% quantile, we divide by 1,000.

⁴We check total liabilities are greater than current liabilities, total assets are greater than total current assets, and net sales (revenue) is greater than EBIT. We originally also checked that total assets were greater than or equal to total equity + retained earnings + total liabilities, but this proved to be too restrictive.

Figure 3: Sector



Sector

The GCIS industry classification standard divides companies into 11 major industry sectors (S and P and MSCI, 2024).⁵ It is widely used in the financial community, and was developed in part by S and P, the same company responsible for our credit ratings. We obtained classifications from Kaggle in CSV format (Kozlov, 2022) and supplemented them with manual lookup. Figure 3 shows the sectoral imbalance present in our data, with a large share of firms in consumer, industrial, and technology sectors. However, when we quantize ratings and compute average values by sector, we do not see large differences, suggesting our results still may provide some generalizability. Though it is not yet clear that sector provides enough useful variation in rating to be a useful predictor, we still include it in our models, particularly as it may improve models including interactions (such as tree-based methods).

NLP Features

Our NLP features capture the transparency of discussion, level of engagement, and overall sentiment of calls.

- Numeric Transparency - Ratio of numbers to words in the word-tokenized call
- Readability - We construct the Gunning-Fog grade-level readability score (Gunning, 1952) as

$$0.4 \times \left(\frac{\text{Words}}{\text{Sentences}} + 100 \times \frac{3 + \text{Syllable Words}}{\text{Words}} \right)$$

- Word Count
- Number of Questions - Count of question marks - Normalized by call length/word count
- Tone - Following Price et al. (2012), we use the Harvard dictionary to count words falling in various categories (Positive, Negative, Active, Passive, etc.). Then we construct tone using the first principal component of the

⁵There are finer groupings as well, but this data was not easily obtainable for our project.

matrix with each call as a row and each column as one of the following:

Positive	Active	Strong	Overstated
Negative	Passive	Weak	Understated

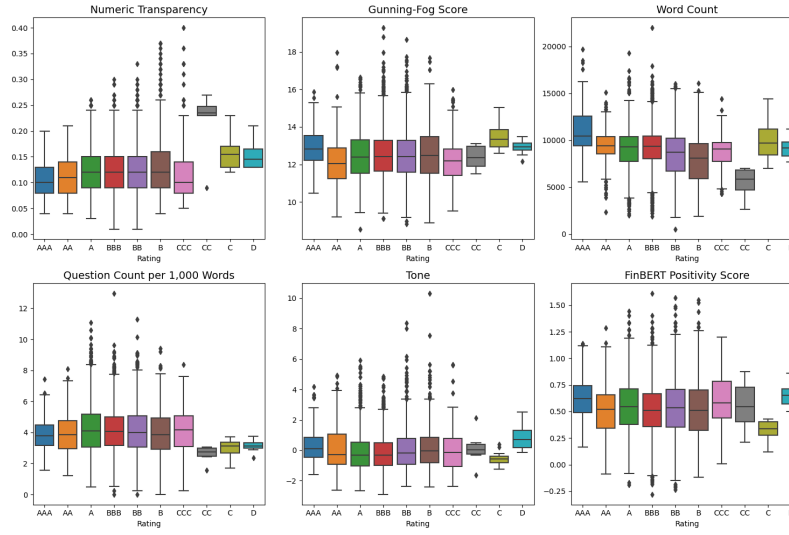
- FinBERT Positivity Score - ⁶

Examples for readability and tone can be found in Appendix Section A.4.

We removed observations with outliers for these features, produced, for example, as a result of zeroes or low values in denominators.

The distribution of each NLP feature by rating is shown in Figure 4 below. Lower quality companies seem to provide more numbers with less commentary and also have less readable calls (higher Gunning-Fog grade level). It appears to be the case that higher quality companies tend to have longer calls. Though somewhat noisy, our FinBERT positivity score does seem to correlate with higher ratings.

Figure 4: Distribution of NLP Features by Rating



Network of Firms

In addition to our standard NLP features, which already capture a rich representation of calls, we also created a network graph representing the connections between firms based on mentions within calls. We deployed transformer-based Named-Entity Recognition (NER) (spaCy, 2024) to identify company names in the text, then matched these names to standardized versions. An interactive visualization of our entire network of firms (aggregating mentions up from the call level - where we also have a network) can be found at <https://sites.google.com/view/isaac-liu/company-mentions-network>, and a 50% sample of nodes (faster load time) can be found at <https://sites.google.com/view/isaac-liu/co-mentions-50-node-sample>.

⁶We originally considered directly incorporating FinBERT embeddings into our models, or creating an end-to-end classifier making use of a BERT model. Our calls, however, are too long for readily available transformer embeddings or models to efficiently and effectively represent.

Modelling

Our overall model architecture is of the form

$$\text{Predicted Credit Rating} = f(\text{Altman-Z, Financial Variables, Sector, Previous Rating, NLP Features})$$

Logistic Regression

Table 1 shows prediction statistics for our initial set of classifiers - simple and interpretable logistic regression models aiming to predict ratings. For these models, we do not include the rating on the previous fixed quarter date (for those results, see Appendix Section A.8). For predicting changes in rating, see Appendix Section A.9.

Table 1: Logistic Regression Model Comparison

Model/Baseline	Accuracy	Share ≤ 1 Rating From Actual
Altman's Z	0.1923	0.4633
Financial Variables and Sector	0.6225	0.9186
Financial Variables, Sector, and NLP Features	0.6333	0.9267
Most Common Class Baseline	0.3247	

Altman's Z-Score alone performs poorly - worse than simply assuming each rating belonged to the most common class. Substantial improvement can be attained by adding financial variables (for a list, see items marked as Variable Type XXX in Table A.1) as well as sector, and a slight further improvement by adding our NLP features - though this second improvement is not statistically significant. These models including financial variables very frequently bring the predicted rating 1 rating or less away from the actual.

NOTE MCNEMAR?

The left side of Table 2 shows that our most complex model generally performs well across all classes, with only a few problems when predicting minority classes.

The right side of Table 2 shows the 15 most important individual features as determined by the average drop in test accuracy when the feature is permuted 1,000 times. Financial features appear to be the most important, with some contributions from our NLP features considering tone and word count.

RANK NLP FEATURES?

Table 2: Classification Report and Permutation Importance - Most Complex Logistic Regression Model

Rating	Precision	Recall	F1-Score	Support	Permuted Feature	Mean Accuracy Drop	Standard Deviation
A	0.5874	0.6298	0.6079	208	Ratio E	0.070625	0.009156
AA	0.6316	0.6923	0.6606	52	Passive Tone	0.056786	0.007741
AAA	0.8261	0.7917	0.8085	24	Sector: Utilities	0.043208	0.005661
B	0.5864	0.7273	0.6493	154	Interest Expense	0.043019	0.007802
BB	0.6275	0.5458	0.5838	284	Ratio D	0.041765	0.007607
BBB	0.6909	0.6281	0.6580	363	Ratio C	0.040578	0.008042
C	1.0000	1.0000	1.0000	4	Depreciation and Amortization (Income Statement)	0.038593	0.007163
CC	0.3333	1.0000	0.5000	2	Net Receivables	0.036435	0.007130
CCC	0.5556	0.7692	0.6452	26	Word Count	0.035743	0.007747
D	1.0000	1.0000	1.0000	1	Long-Term Debt	0.035463	0.007198
					Market Capitalization	0.031103	0.006867
					Goodwill and Intangible Assets	0.030084	0.007430
					Gross Profit	0.027059	0.006837
					Total Debt	0.026485	0.007413
					Net Debt	0.025156	0.007661

We are also able to inspect the coefficients of our logistic regression model to see if their direction aligns with our intuition concerning the impact of individual features.

XGBoost

In Table 3, we used the popular gradient boosting algorithm XGBoost to predict ratings, finding significant success. With the ability to model complex interactions between variables, we are able to attain substantially higher accuracy when including financial variables, and NLP features provide a statistically significant additional benefit. At around 90% accuracy, our best model attains a level of performance slightly exceeding that in Das et al. (2023), with the substantially harder prediction task of predicting from among 10 different ratings (rather than a binary investment grade versus junk classification), and without the affordances of a graph neural network or more complex ensembling. Our model is near perfect in placing ratings within a very close neighborhood of their actual values.

Table 3: XGBoost Model Comparison

Model/Baseline	Accuracy	Share ≤ 1 Rating From Actual
Altman’s Z	0.3855	0.7657
Financial Variables and Sector	0.7630	0.9597
Financial Variables, Sector, and NLP Features	0.9034	0.9857
Most Common Class Baseline	0.3247	

Table 4 demonstrates that this strong performance by our most complex model is consistent across all classes. Financial features appear to be the most important individual variables, though NLP features do also perform well in aggregate. Relative to prior work, our addition of far more financial factors, in combination with complex and transformer-based NLP features, in our large dataset, appears to greatly improve performance.

Table 4: Classification Report and Permutation Importance - Most Complex XGBoost Model

Rating	Precision	Recall	F1-Score	Support	Permuted Feature	Mean Accuracy Drop	Standard Deviation
A	0.8447	0.8894	0.8665	208	Retained Earnings	0.043819	0.005761
AA	0.8824	0.5769	0.6977	52	Market Capitalization	0.035169	0.005735
AAA	0.9048	0.7917	0.8444	24	Dividends Paid	0.021455	0.004481
B	0.9272	0.9091	0.9180	154	Debt Ratio	0.009987	0.003413
BB	0.9357	0.9225	0.9291	284	Common Stock	0.009693	0.002248
BBB	0.9129	0.9532	0.9326	363	Ratio E	0.009535	0.003463
C	1.0000	1.0000	1.0000	4	Other Total Stockholders’ Equity	0.009288	0.003028
CC	1.0000	0.5000	0.6667	2	Total Current Liabilities	0.006888	0.002785
CCC	0.7857	0.8462	0.8148	26	Inventory (Balance Sheet)	0.006802	0.002994
D	1.0000	1.0000	1.0000	1	Total Current Assets	0.006684	0.003243
					Selling General and Administrative Expenses	0.006031	0.002395
					Interest Expense	0.005973	0.002740
					Net Property Plant Equipment	0.005729	0.001915
					Ratio C	0.005677	0.002476
					Total Non-Current Assets	0.005589	0.003420

Graph Neural Network

We make use of the network of company mentions within earnings calls to train an end-to-end graph neural network for classification. Graph Neural Networks construct powerful representations of nodes/entities in a network of relationships by using message passing to aggregate features from neighboring nodes. In this work, we use a GraphSAGE (Hamilton, Ying and Leskovec, 2018) Graph Convolutional Network (GCN) implemented via the Deep Graph Library. (Deep Graph Library, 2024)

A GraphSage GCN is trained across a number of timesteps (here indexed by r) which progressively mix information from the embeddings of more and more distant neighbors. Creating these embeddings for a given timestep is a two-step process.

First, in the AGG step, the embeddings of the node’s direct neighbors are aggregated. Using what is referred to as pool or pooling aggregation, for node h , with neighborhood $N(i)$, at timestep r ,

$$h_{N(i)}^{(r)} = \max[(\sigma(W_{pool}h_j^{(r-1)} + b), \forall j \in N(i)]$$

meaning the neighboring embeddings from the previous timestep are fed through a fully connected neural network (weights W_{pool} , bias b , ReLU activation σ), and then the elementwise maximum across the new neighbor representations is taken as the aggregated vector.

Next, during the update (or COMBINE) step, we concatenate the representation of our node of interest from the previous timestep with this aggregated vector, then apply another set of weights and activation to get a fully updated node representation.

$$h_i^{(r)} = \sigma(W^{(r)} * \text{CONCAT}[h_i^{(r-1)}, h_{N(i)}^{(r)}])$$

Note that in our implementation the update step has no activation σ .

The operations for each timestep ultimately represent a layer of the neural network - a SAGEConv layer, of which we have 3. For our classification task, the last of these produces output of size 9 (number of classes) for each node, while we use vectors of size 32 for intermediate h values. The entire process is trained end-to-end with cross entropy loss. We perform weight decay at rate 5e-4 and train for 100 epochs at a learning rate of 0.01.

To initialize our network, we form an unweighted and undirected edge connection between nodes of firm by fixed quarters when a mention occurs in either call.

Because of the general sparsity of mentions, the size of this network and the size of our training and test datasets for this model is substantially limited.

GRAPH NN EDA

TRANSDUCTIVE VERSUS INDUCTIVE

CONTRAST with Das et al Das et al. (2023) and note usage of mentions and not cosine similarities

Conclusion

Overall, we have seen that we are able to predict credit ratings with a high degree of accuracy, but at the moment our results are largely driven by inclusion of the previous rating as a predictor. Our current NLP and textual features are unable to contribute much to improve our predictions.

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A Appendix

A.1 Summary Statistics for Numeric Variables

Table A.1 shows summary statistics for all numeric variables in our dataset. Important numeric and categorical variables are explained in the main text. We also have numerous date variables, which we may use in future predictions.

Table A.1: Numeric Summary Statistics

Variable Name	Mean	Minimum	Median	Maximum	Standard Deviation	Variable Type
Difference in Cash Per Share from prior fixed quarter	-0.01	-69.19	0.00	69.02	4.54	Additional Change Ratios
Difference in Cash Ratio from prior fixed quarter	0.05	-53.11	0.00	53.11	3.98	Additional Change Ratios
Difference in Debt Ratio (Alternative) from prior fixed quarter	0.00	-0.76	0.00	0.78	0.05	Additional Change Ratios
Difference in Debt Ratio from prior fixed quarter	0.00	-0.82	0.00	0.83	0.05	Additional Change Ratios
Difference in Debt to Equity Ratio from prior fixed quarter	-1.90	-1,915.81	0.00	1,892.37	113.71	Additional Change Ratios
Difference in EBIT to Revenue from prior fixed quarter	-0.00	-0.66	0.00	0.59	0.09	Additional Change Ratios
Difference in Enterprise Value Multiplier from prior fixed quarter	0.25	-1,036.95	0.00	1,036.95	121.22	Additional Change Ratios
Difference in Equity Multiplier from prior fixed quarter	-1.33	-1,292.75	0.00	1,292.75	80.06	Additional Change Ratios
Difference in Free Cash Flow Per Share from prior fixed quarter	0.01	-10.68	0.01	10.68	1.83	Additional Change Ratios
Difference in Free Cash Flow to Operating Cash Flow from prior fixed quarter	0.01	-13.40	0.00	13.40	2.40	Additional Change Ratios
Difference in Operating Cash Flow Per Share from prior fixed quarter	0.01	-12.80	0.02	12.80	1.79	Additional Change Ratios
Difference in Operating Cash Flow to Sales from prior fixed quarter	0.00	-0.79	0.01	0.79	0.14	Additional Change Ratios
Difference in Quick Ratio from prior fixed quarter	-0.00	-5.30	0.00	5.16	0.51	Additional Change Ratios
Difference in Return on Assets from prior fixed quarter	-0.00	-0.10	0.00	0.10	0.01	Additional Change Ratios
Difference in Return on Capital Employed from prior fixed quarter	-0.00	-0.14	0.00	0.13	0.02	Additional Change Ratios
Difference in Return on Equity from prior fixed quarter	-0.00	-2.11	0.00	2.11	0.23	Additional Change Ratios
Difference in Current Ratio from prior fixed quarter	-0.00	-6.87	0.00	6.97	0.61	Additional Change Ratios
Cash Per Share	4.57	0.00	2.13	69.91	9.64	Additional Ratios
Cash Ratio	1.21	0.00	0.28	53.17	6.23	Additional Ratios
Current Ratio	1.93	0.35	1.58	7.93	1.33	Additional Ratios
Debt Ratio	0.35	0.00	0.32	0.94	0.19	Additional Ratios
Debt Ratio (Alternative Definition)	0.65	0.28	0.64	1.22	0.17	Additional Ratios
Debt to Equity Ratio	-34.63	-1,890.41	1.70	25.40	256.02	Additional Ratios
EBIT to Revenue	0.12	-0.26	0.11	0.47	0.12	Additional Ratios
Enterprise Value Multiplier	59.08	-309.75	40.67	727.20	125.93	Additional Ratios
Equity Multiplier	-22.79	-1,270.10	2.71	22.64	175.08	Additional Ratios
Free Cash Flow Per Share	0.57	-2.98	0.39	7.70	1.52	Additional Ratios
Free Cash Flow to Operating Cash Flow	0.72	-2.42	0.66	10.98	1.86	Additional Ratios
Operating Cash Flow Per Share	1.48	-0.98	1.04	11.82	1.92	Additional Ratios
Operating Cash Flow to Sales	0.16	-0.15	0.14	0.64	0.15	Additional Ratios
Quick Ratio	1.36	0.00	1.15	6.12	0.98	Additional Ratios
Return on Assets	0.01	-0.03	0.01	0.06	0.02	Additional Ratios
Return on Capital Employed	0.03	-0.03	0.02	0.11	0.03	Additional Ratios
Return on Equity	0.01	-1.32	0.03	0.78	0.25	Additional Ratios
Altman's Z Score	1.88	-0.91	1.61	7.56	1.28	Altman's Z Score
Difference in Altman's Z from prior fixed quarter	-0.01	-4.84	0.01	4.41	0.39	Change Ratios
Difference in EBITDA Ratio from prior fixed quarter	-0.00	-3.09	0.00	5.20	0.16	Change Ratios
Difference in Gross Profit Ratio from prior fixed quarter	-0.00	-3.16	0.00	5.23	0.15	Change Ratios
Difference in Income Before Tax Ratio from prior fixed quarter	-0.00	-6.69	0.00	6.43	0.33	Change Ratios
Difference in Net Income Ratio from prior fixed quarter	-0.00	-7.13	0.00	5.45	0.28	Change Ratios
Difference in Operating Income Ratio from prior fixed quarter	-0.00	-7.36	0.00	5.20	0.27	Change Ratios
Difference in Ratio A from prior fixed quarter	-0.00	-0.10	0.00	0.10	0.01	Change Ratios
Difference in Ratio B from prior fixed quarter	-0.00	-0.56	0.00	0.57	0.04	Change Ratios
Difference in Ratio C from prior fixed quarter	-0.01	-7.77	0.01	7.15	0.57	Change Ratios
Difference in Ratio D from prior fixed quarter	-0.00	-0.57	0.00	0.60	0.05	Change Ratios
Difference in Ratio E from prior fixed quarter	0.00	-0.80	0.00	0.98	0.07	Change Ratios
Accounts Payable (Balance Sheet)	957,290,323.93	-237,651,171.00	356,700,000.00	11,433,000,000.00	1,551,108,353.02	Financial Statements
Accounts Payable (Cash Flow Statement)	5,154,565.15	-321,769,000.00	0.00	1,789,652,000.00	82,110,968.91	Financial Statements
Accounts Receivables	-11,478,236.25	-544,000,000.00	0.00	325,000,000.00	91,535,961.30	Financial Statements
Accumulated Other Comprehensive Income (Loss)	-404,483,300.22	-5,290,000,000.00	-77,514,000.00	431,595,000.00	874,353,108.41	Financial Statements
Capital Expenditure	-192,514,484.47	-1,867,000,000.00	-60,129,000.00	412,700.00	310,057,440.27	Financial Statements
Capital Lease Obligations	24,642,498.79	0.00	0.00	9,056,234,000.00	228,328,885.18	Financial Statements
Cash and Cash Equivalents	862,135,865.07	0.00	333,000,000.00	9,223,000,000.00	1,366,595,243.17	Financial Statements
Cash and Short Term Investments	1,060,086,810.64	0.00	363,008,000.00	15,601,000,000.00	1,890,682,420.93	Financial Statements
Cash at Beginning of Period	867,410,489.82	-2,556,000.00	334,000,000.00	9,610,000,000.00	1,388,834,800.13	Financial Statements
Cash at End of Period	871,017,693.39	-154,400.00	335,469,000.00	9,743,000,000.00	1,394,641,397.30	Financial Statements
Change in Working Capital	-17,557,103.20	-870,000,000.00	-2,384,000.00	753,000,000.00	183,788,257.05	Financial Statements
Common Stock	329,277,684.36	-539,800.00	3,800,000.00	9,817,134,000.00	925,626,949.20	Financial Statements
Common Stock Issued	44,672,509.36	-3,572,000.00	43,000.00	1,111,490,728.00	124,027,450.20	Financial Statements
Common Stock Repurchased	-78,527,033.90	-2,086,545,366.00	-773,000.00	545,656,614.52	188,219,352.34	Financial Statements
Cost and Expenses	2,317,513,877.07	-2,495,000.00	1,121,064,000.00	22,769,000,000.00	3,357,899,606.58	Financial Statements
Cost of Revenue	1,624,233,369.18	-3,094,000.00	787,700,000.00	18,303,000,000.00	2,405,765,370.43	Financial Statements
Debt Repayment	-247,880,234.24	-3,001,000,000.00	-33,400,000.00	200.00	471,724,050.37	Financial Statements
Deferred Income Tax	6,154,669.54	-253,000,000.00	64,000.00	1,850,454,000.00	58,927,713.28	Financial Statements
Deferred Revenue	310,000,739.66	-116,912,000.00	50,066,000.00	4,918,100,000.00	642,489,899.31	Financial Statements
Depreciation and Amortization (Cash Flow Statement)	141,811,048.14	-675,312.00	53,551,000.00	1,529,000,000.00	210,315,836.18	Financial Statements
Depreciation and Amortization (Income Statement)	140,571,212.83	-1,550,000.00	54,507,000.00	1,371,000,000.00	203,167,331.44	Financial Statements
Diluted EPS	0.51	-156.36	0.51	49.73	3.31	Financial Statements
Dividends Paid	-91,357,096.76	-1,233,000,000.00	-21,054,000.00	0.00	182,429,714.55	Financial Statements
EBITDA	444,995,396.82	-66,200,000.00	193,000,000.00	4,410,000,000.00	644,706,471.62	Financial Statements

Continued on next page

Table A.1: Numeric Summary Statistics

Variable Name	Mean	Minimum	Median	Maximum	Standard Deviation	Variable Type
EBITDA Ratio	0.20	-5.77	0.17	2.16	0.22	Financial Statements
EPS	0.52	-156.36	0.52	53.75	3.33	Financial Statements
Effect of Foreign Exchange Changes on Cash	-1,697,085.83	-65,000,000.00	0.00	52,000,000.00	11,200,007.88	Financial Statements
Free Cash Flow	156,892,657.81	-541,000,000.00	51,691,000.00	2,683,000,000.00	389,666,937.19	Financial Statements
General and Administrative Expenses	153,933,016.99	-2,738,500.00	33,768,000.00	2,007,000,000.00	303,900,948.38	Financial Statements
Goodwill	2,009,260,205.06	-202,702,100.00	636,039,000.00	23,389,000,000.00	3,554,057,246.39	Financial Statements
Goodwill and Intangible Assets	3,102,882,804.88	-1,618,944,000.00	970,000,000.00	37,123,000,000.00	5,639,038,312.52	Financial Statements
Gross Profit	861,821,178.07	-7,195,000.00	378,500,000.00	9,223,000,000.00	1,365,410,717.45	Financial Statements
Gross Profit Ratio	0.37	-5.65	0.34	2.32	0.26	Financial Statements
Income Before Tax	255,351,974.53	-353,153,000.00	91,900,000.00	2,951,000,000.00	434,623,029.43	Financial Statements
Income Before Tax Ratio	0.07	-9.38	0.09	2.68	0.35	Financial Statements
Income Tax Expense	69,444,774.33	-119,131,000.00	22,100,000.00	736,000,000.00	121,681,731.43	Financial Statements
Intangible Assets	835,940,509.51	-421,000.00	170,197,000.00	14,110,100,000.00	1,785,542,119.17	Financial Statements
Interest Expense	46,568,508.69	-16,400,000.00	23,000,000.00	386,000,000.00	61,712,161.15	Financial Statements
Interest Income	2,372,725.23	-62,900.00	0.00	69,000,000.00	6,859,086.75	Financial Statements
Inventory (Balance Sheet)	933,043,177.40	-19,626,000.00	403,789,000.00	8,328,000,000.00	1,398,934,358.21	Financial Statements
Inventory (Cash Flow Statement)	-10,302,495.14	-420,000,000.00	0.00	289,000,000.00	70,374,129.32	Financial Statements
Investments in Property, Plants, and Equipment	-193,897,744.95	-1,921,864,000.00	-60,373,000.00	412,700.00	313,436,441.14	Financial Statements
Long-Term Debt	4,159,473,460.27	-651,718.00	1,822,139,000.00	31,359,000,000.00	5,574,538,232.32	Financial Statements
Long-Term Investments	494,196,440.41	-490,677,000.00	12,449,000.00	10,981,000,000.00	1,359,571,399.50	Financial Statements
Minority Interest	90,043,651.07	-20,252,654.04	1,600,000.00	2,316,406,000.00	268,200,905.93	Financial Statements
Net Acquisitions	-32,878,764.18	-805,960,000.00	0.00	249,000,000.00	116,107,004.20	Financial Statements
Net Cash Provided by Operating Activities	352,446,106.81	-179,404,000.00	143,626,000.00	3,870,000,000.00	545,602,564.63	Financial Statements
Net Cash Used for Investing Activities	-252,575,304.44	-2,840,033,000.00	-71,100,000.00	325,900,000.00	443,647,871.52	Financial Statements
Net Cash Used or Provided by Financing Activities	-114,570,062.00	-2,444,000,000.00	-29,157,000.00	1,094,000,000.00	399,330,481.52	Financial Statements
Net Change in Cash	3,933,018.18	-1,161,000,000.00	573,000.00	1,401,000,000.00	269,005,283.68	Financial Statements
Net Debt	3,597,141,664.59	-1,044,500,000.00	1,508,594,000.00	30,761,000,000.00	5,338,457,121.62	Financial Statements
Net Income (Cash Flow Statement)	189,122,176.12	-327,000,000.00	66,190,000.00	2,402,000,000.00	336,635,167.35	Financial Statements
Net Income (Income Statement)	185,944,828.27	-329,864,000.00	66,389,000.00	2,340,000,000.00	330,952,161.49	Financial Statements
Net Income Ratio	0.05	-8.88	0.07	2.72	0.29	Financial Statements
Net Property Plant Equipment	4,931,687,321.78	0.00	1,389,600,000.00	44,441,000,000.00	7,885,938,319.99	Financial Statements
Net Receivables	1,276,905,848.63	-4,199,600.00	570,338,000.00	12,116,000,000.00	1,776,578,353.43	Financial Statements
Non-Current Deferred Revenue	248,840,448.23	-500,933,000.00	0.00	5,778,000,000.00	723,186,467.01	Financial Statements
Non-Current Deferred Tax Liabilities	702,874,797.74	-3,818,507.00	135,597,000.00	8,306,000,000.00	1,400,029,509.57	Financial Statements
Operating Cash Flow	352,446,106.81	-179,404,000.00	143,626,000.00	3,870,000,000.00	545,602,564.63	Financial Statements
Operating Expenses	538,189,512.49	-13,530,000.00	221,700,000.00	6,252,000,000.00	918,426,909.60	Financial Statements
Operating Income	302,231,079.76	-208,377,000.00	122,000,000.00	3,294,000,000.00	475,077,278.15	Financial Statements
Operating Income Ratio	0.11	-9.71	0.12	2.86	0.31	Financial Statements
Other Assets	5,662.39	-19,834,700.00	0.00	8,948,000.00	421,776.93	Financial Statements
Other Current Assets	370,526,390.88	-98,000.00	119,600,000.00	4,968,950,000.00	664,643,317.21	Financial Statements
Other Current Liabilities	955,075,890.93	-48,317,000.00	322,800,000.00	12,137,000,000.00	1,782,231,297.37	Financial Statements
Other Expenses	50,749,806.82	-64,000,000.00	585,000.00	16,189,674,590.00	342,110,629.66	Financial Statements
Other Financing Activities	217,421,866.42	-975,168,999.00	8,000,000.00	3,297,501,000.00	515,334,960.45	Financial Statements
Other Investing Activities	4,573,739.09	-448,000,000.00	106,000.00	3,060,433,659.00	96,736,267.62	Financial Statements
Other Liabilities	95,902.58	-3,063,000.00	0.00	51,076,000.00	1,967,227.53	Financial Statements
Other Non-Cash Items	15,325,139.75	-1,848,719,007.00	1,621,000.00	703,000,000.00	109,294,805.79	Financial Statements
Other Non-Current Assets	506,778,121.04	-75,012,534,818.00	158,696,000.00	8,037,000,000.00	1,778,143,597.09	Financial Statements
Other Non-Current Liabilities	975,892,048.39	-286,041,895.00	327,700,000.00	11,890,564,000.00	1,686,827,873.95	Financial Statements
Other Total Stockholders' Equity	1,135,331,510.72	-12,393,000,000.00	427,000,000.00	34,030,400,000.00	3,586,435,863.55	Financial Statements
Other Working Capital	21,414,823.22	-1,788,851,160.00	0.00	40,341,689,407.00	786,599,061.35	Financial Statements
Preferred Stock	9,475,146.22	0.00	0.00	401,500,000.00	42,785,110.93	Financial Statements
Purchases of Investments	-104,151,034.82	-11,997,654,000.00	0.00	81,823,000.00	346,711,949.30	Financial Statements
Research and Development Expenses	28,169,938.85	-214,000.00	0.00	893,000,000.00	94,071,513.75	Financial Statements
Retained Earnings	3,628,393,969.72	-4,839,000,000.00	1,293,100,000.00	37,899,000,000.00	6,424,744,717.89	Financial Statements
Revenue	2,728,749,857.76	-4,273,000.00	1,297,700,000.00	25,420,000,000.00	3,959,362,594.26	Financial Statements
Sales and Maturities of Investments	99,796,411.86	-9,409,000.00	0.00	8,936,406,000.00	311,292,561.88	Financial Statements
Selling General and Administrative Expenses	296,899,615.00	-5,054,000.00	119,600,000.00	3,343,000,000.00	486,131,457.73	Financial Statements
Selling and Marketing Expenses	25,431,647.83	-3,003,000.00	0.00	876,761,000.00	97,367,023.08	Financial Statements
Short Term Investments	182,988,242.55	-515,000.00	0.00	6,178,000,000.00	599,747,024.65	Financial Statements
Short-Term Debt	465,870,869.02	-655,561.00	83,800,000.00	5,363,000,000.00	885,210,679.51	Financial Statements
Stock-Based Compensation	14,496,292.55	-36,000,000.00	5,106,000.00	254,000,000.00	29,968,462.79	Financial Statements
Tax Assets	378,132,518.58	-2,310,712,000.00	48,963,000.00	6,535,000,000.00	909,237,680.35	Financial Statements
Tax Payable	60,670,669.07	-87,400.00	2,810,000.00	1,187,000,000.00	150,628,980.40	Financial Statements
Total Assets	15,592,495,985.55	123,279.00	7,048,475,000.00	131,119,000,000.00	21,911,032,910.64	Financial Statements
Total Current Assets	3,937,085,272.11	29,954.00	1,933,750,000.00	41,276,000,000.00	5,729,273,613.69	Financial Statements
Total Current Liabilities	2,811,976,684.34	24,083.00	1,138,200,000.00	29,919,000,000.00	4,247,045,840.39	Financial Statements
Total Debt	4,593,265,532.66	0.00	2,019,244,000.00	37,124,000,000.00	6,254,194,800.16	Financial Statements
Total Equity	4,968,502,543.29	-501,467,000.00	2,095,000,000.00	49,975,000,000.00	7,272,421,518.55	Financial Statements
Total Investments	729,199,594.64	-334,673,000.00	43,275,000.00	19,331,000,000.00	1,944,649,108.26	Financial Statements
Total Liabilities	9,817,545,124.72	79,283.00	4,308,693,000.00	87,293,000,000.00	13,527,062,565.42	Financial Statements
Total Liabilities and Stockholders' Equity	15,556,696,866.65	123,279.00	7,043,426,000.00	131,119,000,000.00	21,905,884,302.05	Financial Statements
Total Liabilities and Total Equity	15,556,696,866.65	123,279.00	7,043,426,000.00	131,119,000,000.00	21,905,884,302.05	Financial Statements
Total Non-Current Assets	11,011,964,229.49	49,861.00	4,119,200,000.00	104,263,000,000.00	15,994,777,583.25	Financial Statements
Total Non-Current Liabilities	6,639,451,321.63	53,696.00	2,809,300,000.00	54,300,000,000.00	9,424,654,097.47	Financial Statements
Total Other Income Expenses Net	-13,134,652.92	-503,976,000.00	-920,000.00	286,000,000.00	72,414,124.07	Financial Statements
Total Stockholders' Equity	4,933,321,107.00	-526,491,000.00	2,088,608,000.00	49,269,000,000.00	7,194,176,771.15	Financial Statements
Weighted Average Shares Outstanding	352,790,171.17	0.00	146,000,000.00	13,751,391,147.00	720,460,888.99	Financial Statements
Weighted Average Shares Outstanding (Diluted)	316,630,108.94	0.00	145,951,913.00	13,986,214,405.00	547,337,219.46	Financial Statements
Market Capitalization	18,996,749,034.57	106,422.00	6,409,459,125.00	726,320,349,360.00	44,246,873,159.19	Market Capitalization
Days Since Call	58.39	0.00	61.00	91.00	13.05	Metadata
FinBERT Positivity Score	0.53	-0.28	0.52	1.61	0.25	NLP Feature
First Principal Component of Tone	-0.03	-2.91	-0.22	10.33	1.28	NLP Feature
Gunning-Fog Score	12.50	8.55	12.41	19.29	1.31	NLP Feature
Number of Questions	36.50	0.00	35.00	107.00	16.38	NLP Feature
Number of Questions Divided By Call Word Count	0.00	0.00	0.00	0.01	0.00	NLP Feature

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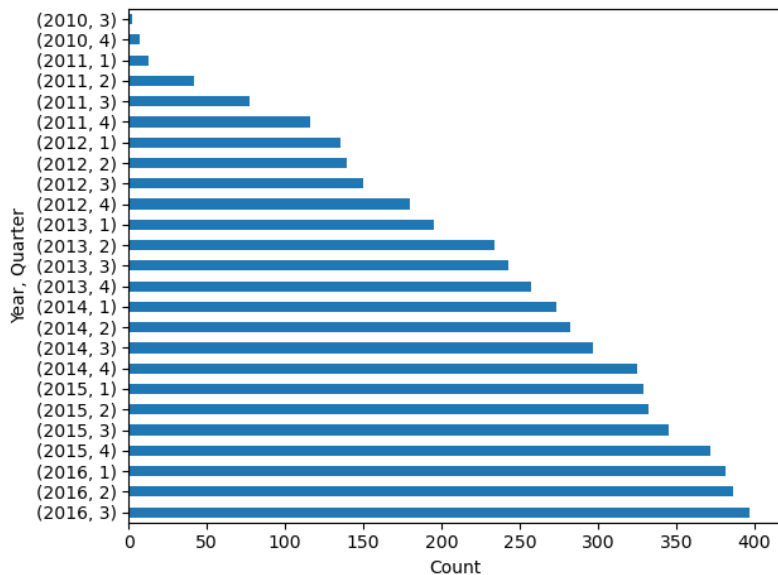
Table A.1: Numeric Summary Statistics

Variable Name	Mean	Minimum	Median	Maximum	Standard Deviation	Variable Type
Numeric Transparency	0.12	0.01	0.12	0.40	0.05	NLP Feature
Word Count	8,834.15	525.00	9,083.00	22,006.00	2,471.87	NLP Feature
Change Since Last Fixed Quarter Date	0.01	-2.00	0.00	2.00	0.26	Predicted - Change

A.2 Observations by Quarter and Year

Figure A.1 demonstrates that the data is temporally unbalanced, with many companies entering the dataset in later years, after they first receive an observable credit rating.

Figure A.1: Observations by Quarter and Year



A.3 Altman's Z-Score

As in Das et al. (2023), the components of the Z-score are as follows:

- A: EBIT / Total Assets
- B: Net Sales / Total Assets
- C: Market Capitalization / Total Liabilities
- D: Working Capital / Total Assets
- E: Retained Earnings / Total Assets

We Winsorize extreme values of Ratio A, B, D, and E by setting the top and bottom 2.5% of values to the 97.5 and 2.5 percentile, respectively. Due to the presence of additional outliers and the sourcing of market capitalization from a different dataset than the rest of the variables, Ratio C is instead Winsorized over the top and bottom 5% of values.

The ratios are combined via the following equation:

$$\text{Z-Score} = 3.3A + 0.99B + 0.6C + 1.2D + 1.4E$$

A.4 Examples of NLP Features

A.4.1 Readability: Gunning-Fog Index

Gale Klappa: We are looking here. Yes.

Ted Hayden – Point State Capital: Okay. And the equity ratio is like 53? It's a sliding scale I guess, right?

Gale Klappa: Pat, we had 52.2%, 53% up in utilities?

Patrick Keyes: 53.5 is the high end. We were underneath that.

Frederick Kuester: Midpoint is 51.

Gale Klappa: Yeah, our allowed range is 51% to 53.5%. As Pat said we were just under the 53.5%."

Gunning-Fog: 8.5

"We've reduced our group stores value by more than \$50 million and that's in spite of the significant growth that our operations have being through in that period, and I think the other thing that's key is the fact that our managers on our mines have risen to the challenge and certainly both the owned skills as far as our desire to see that all our operations manage their business as a commercially on - and with sound commercial decisions, as well as technically, and also treat our operations as if they were the owned and that's something that we believe we have invested quite significantly over the last couple of years and we are confident that we will continue to be able to streamline decisions and optimize their efficiency and running our businesses because we do it with top executives on start."

Gunning-Fog: 19.3

A.4.2 Tone (Principal Component)

"We had one disappointment with the second well in terms of the zone not really being present in terms of what we were looking for."

Tone: -2.9

"We see a great runway still ahead given the fragmented global landscape in concert, management, and ticketing."

Tone: 10.3

A.5 Example of One Observation in Final Data

Figure A.2 shows some variables for Apple Inc. for the fixed quarter date of October 1, 2014. Apple had a strong rating of AA at this time. This was supported, in part, by a relatively high Altman Z-Score. Sentiment and tone were generally positive, numeric transparency indicates there was a relatively high share of words to numbers (boldly indicating more commentary), and word count was around average.

Figure A.2: Apple Inc., October 1, 2014

(a) Metadata, Rating, and NLP Features

ticker	AAPL
fixed_quarter_date	2014-10-01
earnings_call_date	2014-07-22
Rating	AA
rating_date	2014-05-27
pos_score_finbert	0.765917
num_transparency	0.1
gf_score	12.781526
word_count	7587.0
num_questions	29.0
Positiv	298.0
Negativ	54.0
Strong	641.0
Weak	42.0
Active	495.0
Passive	186.0
Ovrst	364.0
Undrst	131.0
PN	5.518519
SW	15.261905
AP	2.66129
OU	2.778626
tone	3.188264

(b) Financial Data

Altman_Z	4.324703
filingDate	2014-07-23
currentRatio	1.470598
quickRatio	0.000609
cashRatio	0.280857
...	

A.6 Logistic Regression - Most Complex Model - Additional Details

A.7 XGBoost - Most Complex Model - Additional Details

A.8 Including Previous Rating

A.9 Predicting Changes in Rating

As shown in Figure 1, 94.79% of ratings remain the same of ratings remain the same from one fixed quarter date to the next (95.35% in our test dataset). This poses a serious challenge for classification, which is easily dominated by the majority class. We implemented SMOTE (Synthetic Minority Over-sampling Technique) (Chawla et al., 2002) to oversample the minority classes in the training data and balance the dataset.

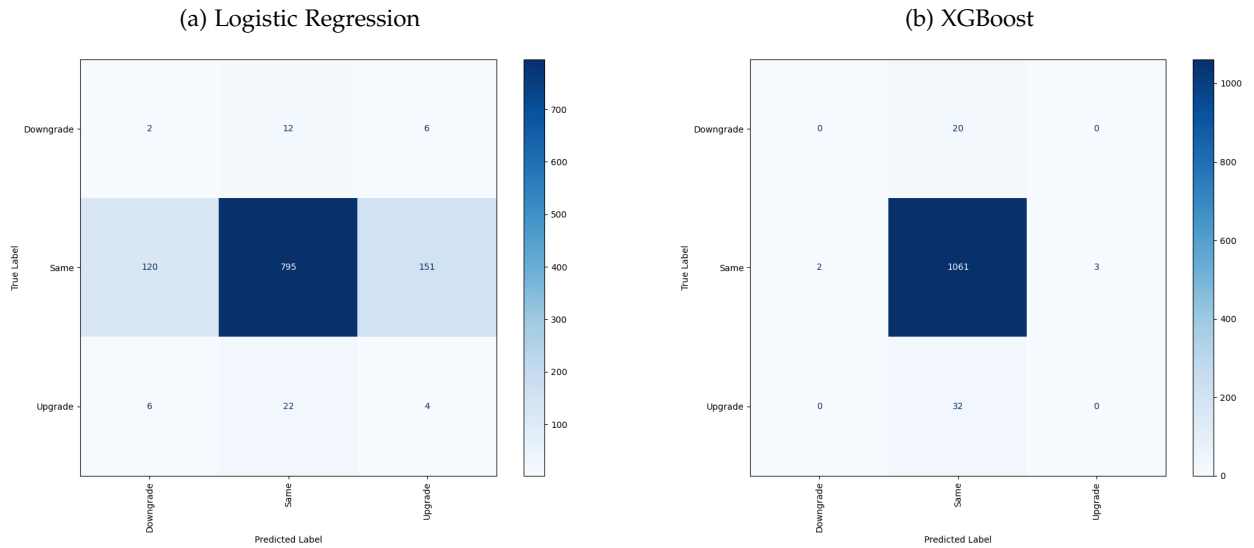
Table A.2 shows that SMOTE decreases the accuracy of our models relative to simply predicting the majority class, but increases the recall of the minority classes slightly in some cases (Figure A.3). We were not able to find a specification that greatly improved our predictions of minority classes. Improvements in accuracy when adding NLP features are small and insignificant.

Table A.2: Rating Changes Model Comparison

Model/Baseline	Accuracy	Model/Baseline	Accuracy
Altman's Z	0.5742	Altman's Z	0.8488
Financial Variables and Sector	0.7004	Financial Variables and Sector	0.9454
Financial Variables, Sector, and NLP Features	0.7165	Financial Variables, Sector, and NLP Features	0.9490
Most Common Class Baseline	0.9535	Most Common Class Baseline	0.9535

Logistic Regression
XGBoost

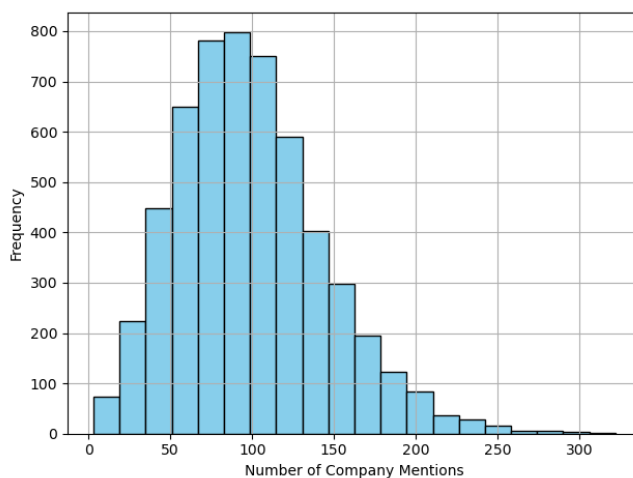
Figure A.3: Most Complex Model - Rating Changes Confusion Matrices



A.10 Company Mentions

On average, each earnings call has 98.63 company mentions. Figure A.4 shows the distribution. Note that many of these mentions are self-references, and do not provide linkages between firms.

Figure A.4: Company Mentions



POSSIBLY ADD NON SELF MENTION STATS???