

# Predicting Corporate Bond Ratings

Chadwick Balloo, Flatiron School

# Scope and Purpose

- Moody's rates corporate bonds on a scale of Aaa to C (1-21) based on credit issue and borrower quality
- Using the issuer's financial data and relevant statistics, can we predict a bond's credit rating?
- Given current ratings, how can we use predicted ratings to profit?

# The Data

- Bond Data - Markets.BusinessInsider.com - 6,130 corporate bonds
- Stock Data - iShares by BlackRock - ishares.com - 439 stocks from the Russell 1000
- Financial Data - Yahoo Finance - financial ratios and statistics

# The Process

## Data Cleaning and EDA

### **Technologies:**

- pandas
- numpy
- seaborn
- yellowbrick
- sklearn

## Modeling

### **Models:**

- ordinal log reg
- random forest
- knn
- kmeans

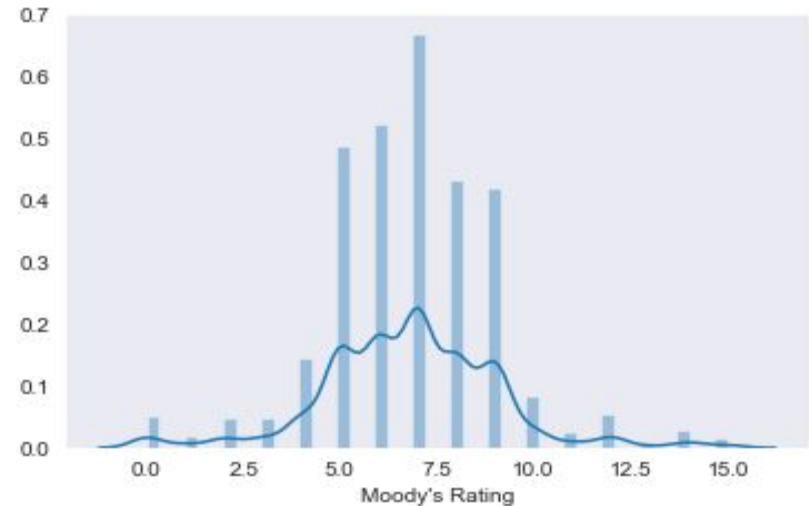
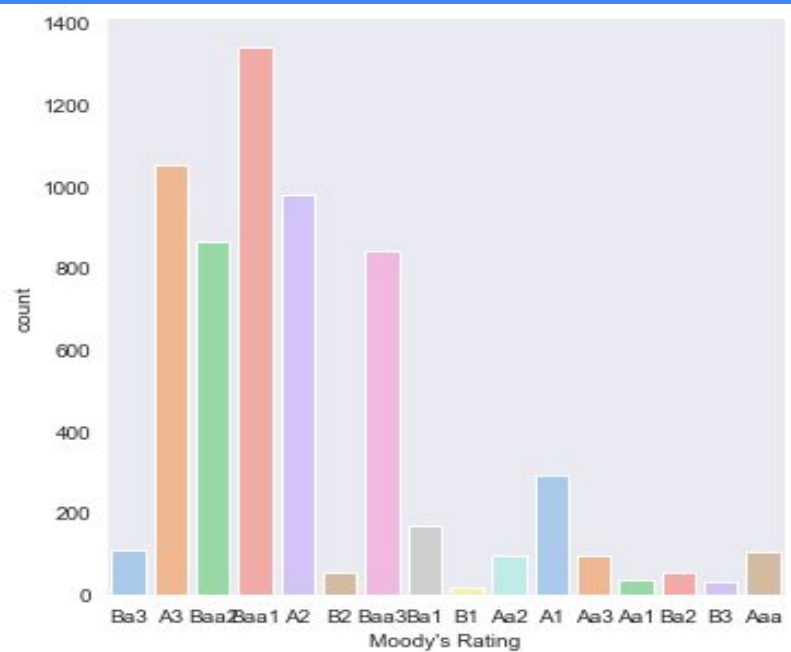
## Refining and Evaluation

### **Methods:**

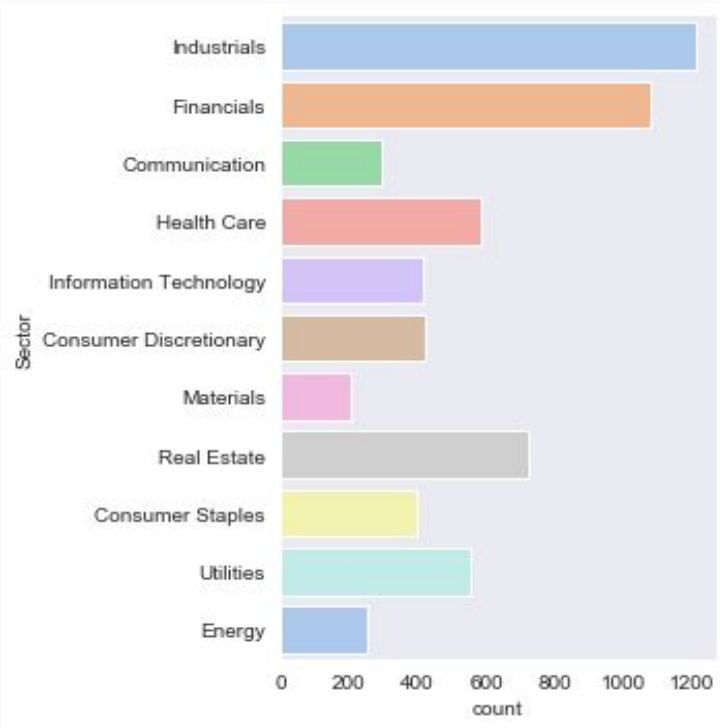
- distance maps
- feature importance
- class balance

# Exploring the Data

- Breakdown by rating
- Baa1, A2, A3, Baa2, Baa3,
  - “High ability or acceptable ability to repay short term debt”
  - Indicates shift toward higher debt levels and riskier debt

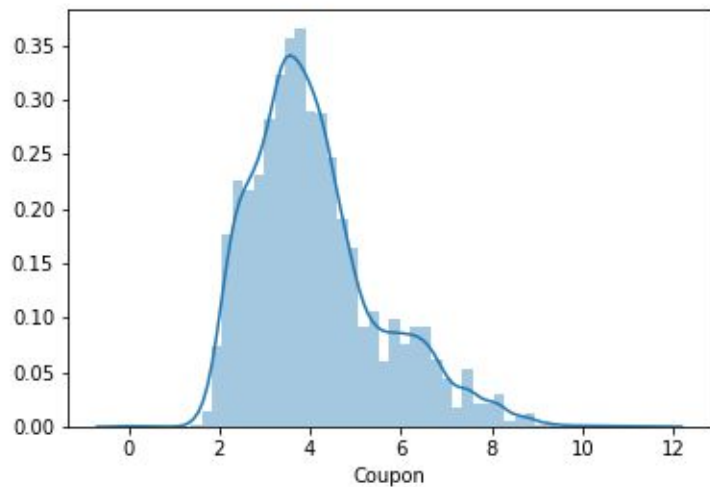


# Sector Breakdown



- Industrials, Financials, Real Estate, HC, Utilities
- Typical of how these sectors conduct business

# Coupon and Yield



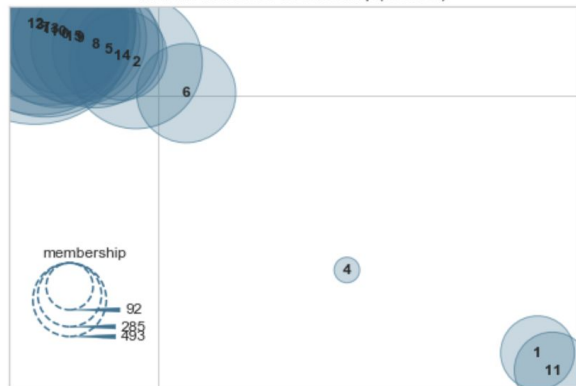
Skewed to the right, higher coupons for riskier debt

## Moody's Rating

|      | Coupon   | Yield    |
|------|----------|----------|
| A1   | 3.472656 | 2.438255 |
| A2   | 3.356087 | 2.469162 |
| A3   | 3.928774 | 2.635681 |
| Aa1  | 3.066303 | 2.310270 |
| Aa2  | 3.579974 | 2.385795 |
| Aa3  | 4.013421 | 2.621684 |
| Aaa  | 3.511478 | 2.346516 |
| B1   | 6.356944 | 3.900589 |
| B2   | 6.495536 | 5.457689 |
| B3   | 6.687500 | 7.535608 |
| Ba1  | 4.983394 | 3.770574 |
| Ba2  | 5.463113 | 3.719412 |
| Ba3  | 5.622248 | 4.311754 |
| Baa1 | 4.303829 | 2.817916 |
| Baa2 | 4.492211 | 3.085166 |
| Baa3 | 4.226217 | 3.060150 |

# KMeans Clustering

KMeans Intercluster Distance Map (via MDS)



| Predicted | Moody's Rating | Ticker | Name                     |
|-----------|----------------|--------|--------------------------|
| A3        | Aaa            | JNJ    | JOHNSON & JOHNSON        |
| Ba3       | A3             | UTHR   | UNITED THERAPEUTICS CORP |
| Baa1      | Baa2           | KMI    | KINDER MORGAN INC        |
| Ba1       | A3             | MS     | MORGAN STANLEY           |
| B3        | A2             | LLY    | ELI LILLY                |

| Predicted | Moody's Rating | Ticker | Name                         |
|-----------|----------------|--------|------------------------------|
| Ba3       | Baa3           | DISCK  | DISCOVERY INC SERIES C       |
| Aa1       | Aaa            | MSFT   | MICROSOFT CORP               |
| B1        | Baa2           | NOC    | NORTHROP GRUMMAN CORP        |
| B1        | Baa1           | WM     | WASTE MANAGEMENT INC         |
| Aa3       | A3             | UAL    | UNITED AIRLINES HOLDINGS INC |

| Moody's Rating | Predicted | Ticker | Name                              | Coupon | Yield    |
|----------------|-----------|--------|-----------------------------------|--------|----------|
| A3             | Ba3       | AMH    | AMERICAN HOMES RENT REIT CLASS A  | 2.0995 | 1.910000 |
| A3             | Aa3       | UAL    | UNITED AIRLINES HOLDINGS INC      | 4.7000 | 2.498236 |
| A3             | Ba1       | UPS    | UNITED PARCEL SERVICE INC CLASS B | 4.7000 | 2.498236 |
| A3             | Ba1       | MS     | MORGAN STANLEY                    | 4.4310 | 2.920000 |
| A3             | Ba1       | CAT    | CATERPILLAR INC                   | 2.5500 | 1.870000 |
| A3             | Ba3       | AAL    | AMERICAN AIRLINES GROUP INC       | 4.2000 | 2.290000 |
| A3             | Baa2      | C      | CITIGROUP INC                     | 4.0440 | 2.640000 |
| A3             | Aa3       | UAL    | UNITED AIRLINES HOLDINGS INC      | 3.8750 | 2.498236 |
| A3             | Aaa       | GILD   | GILEAD SCIENCES INC               | 2.5000 | 2.090000 |
| A3             | Baa1      | AIG    | AMERICAN INTERNATIONAL GROUP INC  | 3.0000 | 2.260000 |



# Ordinal Log Reg


- Performed poorly, likely due to number of classes
- MAE:
  - 1.75
  - 2.4 baseline

# KNN

- Performed poorly for large dataset
  - Mean CV Score: .46
- Performed well for smaller dataset (~1800)
  - Mean CV Score: .83

KNeighborsClassifier Classification Report

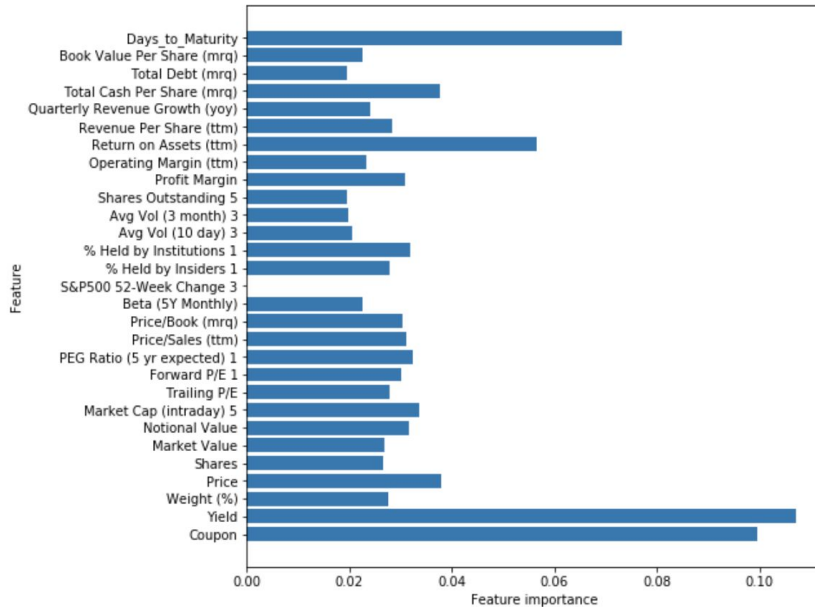
|      |           |        |       |         |
|------|-----------|--------|-------|---------|
| B1   | 0.615     | 0.505  | 0.554 | 218     |
| Aa1  | 0.729     | 0.611  | 0.665 | 211     |
| B3   | 0.647     | 0.576  | 0.609 | 356     |
| Ba2  | 0.300     | 0.429  | 0.353 | 21      |
| Aaa  | 0.500     | 0.700  | 0.583 | 10      |
| Aa2  | 0.762     | 0.842  | 0.800 | 38      |
| Aa3  | 0.500     | 0.111  | 0.182 | 9       |
| A1   | 0.250     | 0.077  | 0.118 | 13      |
| B2   | 0.200     | 0.250  | 0.222 | 4       |
| Baa1 | 0.958     | 1.000  | 0.979 | 23      |
| A3   | 0.560     | 0.438  | 0.491 | 32      |
| Baa3 | 0.727     | 0.640  | 0.681 | 25      |
| Ba1  | 1.000     | 1.000  | 1.000 | 7       |
| Baa2 | 0.489     | 0.611  | 0.543 | 244     |
| Ba3  | 0.498     | 0.595  | 0.542 | 252     |
| A2   | 0.671     | 0.757  | 0.711 | 70      |
|      | precision | recall | f1    | support |



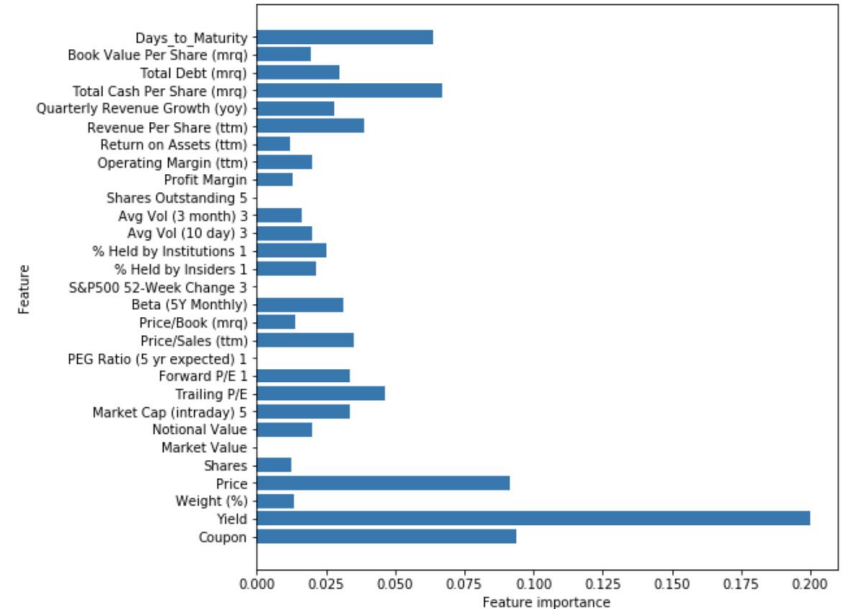
# Random Forest

- Accuracy Score: .74
  - Baseline: .42
- Also worked better on smaller data set

Forest



Tree



# Credit Analysis

Select a ticker:

|    | Predicted Rating | Moody's Rating | Ticker | Name                      | Coupon |
|----|------------------|----------------|--------|---------------------------|--------|
| 34 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 6.2500 |
| 35 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 3.8500 |
| 36 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 4.4000 |
| 37 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 2.9460 |
| 38 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 8.9500 |
| 39 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 7.7500 |
| 40 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 6.4000 |
| 41 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 5.0500 |
| 42 | Aa2              | Baa1           | VZ     | VERIZON COMMUNICATIONS... | 4.9500 |
| 43 | A3               | Aa2            | GOOGL  | ALPHABET INC CLASS A      | 3.6250 |
| 44 | A3               | Aa2            | GOOGL  | ALPHABET INC CLASS A      | 3.3750 |

# Implementation and Use

- Investors
  - Buying and selling opportunities
- Lenders
  - Monitoring borrowers and safety of loans
- Issuers
  - Financial health and reputation monitoring
  - Saving opportunity

# Conclusion and Improvements/Future Work

- Better data
  - aka paid data
  - More data
  - More features
- More models
  - Better parameters
- More accurate data
  - Too many Nans
  - Timely data - trending data