Sovereign Risk Modeling

Capstone Project for Metis Data Science Bootcamp: Winter 2021 Cohort

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- BS in Computer Science, San Francisco State University, 2019
- Metis Data Science Bootcamp (2021 Winter Cohort: 1/4/21-3/26/21)
- Economics-related Final Project

Intro to Sovereign Risk

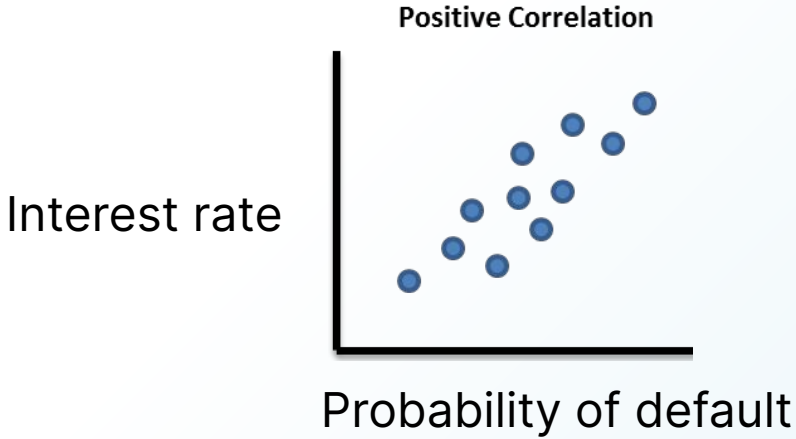
Governments of countries borrow money, mainly issuing bonds.

- The bonds are sold to investors.
- Associated with each bond there is an interest rate, which is paid periodically, with the principal paid after a certain number of years.

Advice to Bond Buyers

Some of these countries fail to pay back, and go into **Sovereign Default**

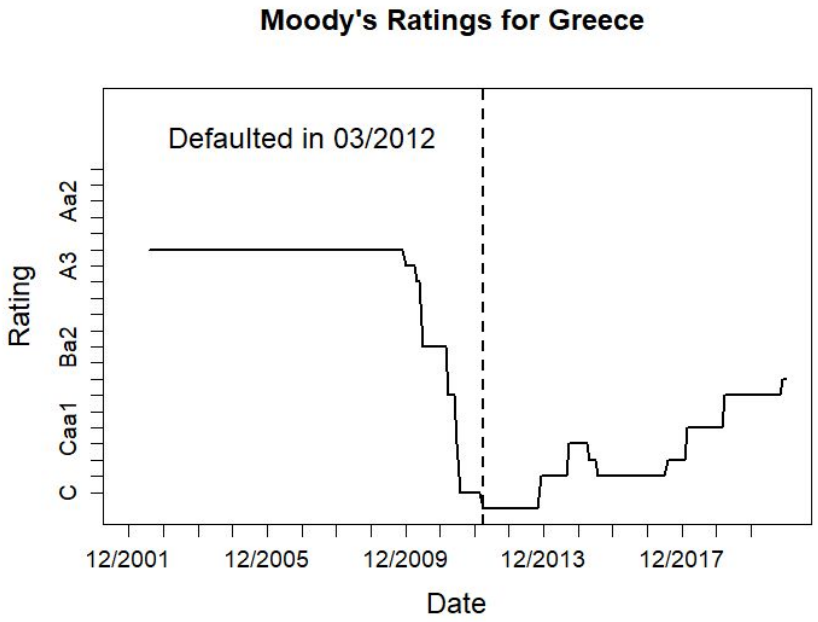
- The larger the probability of default, the the larger the interest rate is expected to be.



Case Study

Investor services have made poor predictions in the past, on multi-billion dollar bonds

- Investment grade, then junk



Why Make This Model?

Large corporations like such as Moody’s and S&P make similar predictions.

- However, there is a distinct lack of free, accessible models on Sovereign Default.
- None have free web apps hosted.

What Affects Sovereign Risk?

Variables that determine probability of default are macroeconomic quantities, such as GDP per capita, etc.

- Some defaults are not explained by macroeconomics, because some countries default for political reasons (e.g. Ecuador, 2008)

Purpose of Model

Target: Find the probability that a country will default on its debt in the next years.

Web app allows the user to change the model independent variable values or to use the IMF predictions to calculate the new probability of default.

Data Description

CSV files include:

- Economic data from IMF (1980-2020)
- IMF Projections for 2021-2025
- Data of all Sovereign Defaults and Restructurings* compiled by Professor Christoph Trebesch, Kiel University.

* Restructuring is counted the same as Default for our purposes

Model Information

- Algorithms: XGBoost in the web app (only want user to see best model)

- Metrics: Precision, Recall, AUC (unbalanced dataset, Accuracy is less important)

EDA

After preprocessing, features include: GDP per Capita, Unemployment, Export, Import, etc.

- Merging adds Sovereign Default and Restructuring data to anchor IMF dataset (1980-2020).

- EDA: Number of defaults/year

  (20th century > 21st century)

EDA: Null values

The macroeconomic data starts in 1980. The model uses the **median value** of the **geographic region** to fill out the **missing data**.

Geographic regions (based on World Bank classification) are:

Americas	Asia
Europe	Africa
Scandinavia	Latin America

Correlations between Features and Probability of Default (PD)

Positive (+)

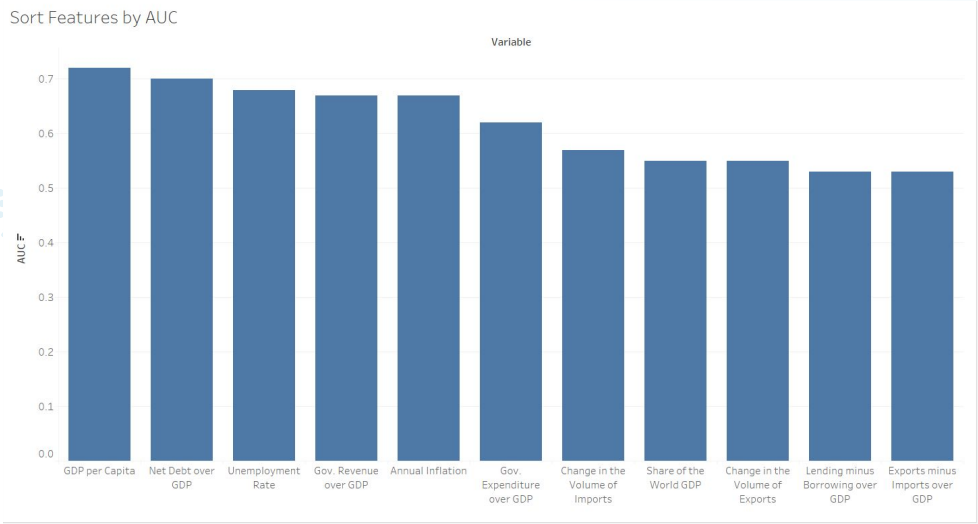
- Debt over GDP
- Annual Inflation
- Unemployment Rate

Negative (-)

- GDP per Capita
- Change in Imports
- Change in Export
- Gov Revenue/GDP
- Gov Expenditure/ GDP
- Gov Lending minus Borrowing
- Exports minus Imports
- Share of the World GDP

Findings: Biggest Predictor

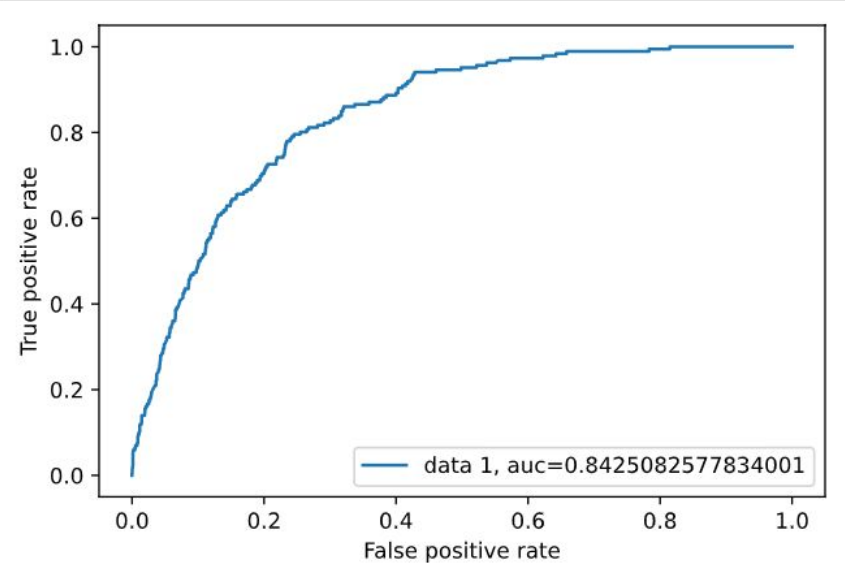
- Richer countries (higher GDP per capita) are less likely to default. It is important to keep debt low.
- Importance of each variables by AUC (Predictive power)



Results

XGBoost

- AUC = 0.84
- Precision = 0.43
- Recall = 0.12



Error Types

False Positive **(+)**

- Model falsely predicts sovereign default where there is none.

False Negative **(-)**

- Model falsely predicts no sovereign default where there is default.

False Negatives are more concerning, as investors stand to lose more money from holding bonds of a country that defaults than failing to invest in a country that doesn't default

Confusion Matrix Results

- The model predicts well the countries that do not default, which is important for interest rate evaluations.
- It missed a greater number of countries that defaults.
- Precision = 0.43 Recall = 0.12

Errors are reasonably large as macroeconomics does not explain all defaults.

	Predicted No Default	**Predicted Yes Default**
Actual No Default	**2265**	**29**
Actual Yes Default	**164**	**22**

Web App

Made w/ Streamlit

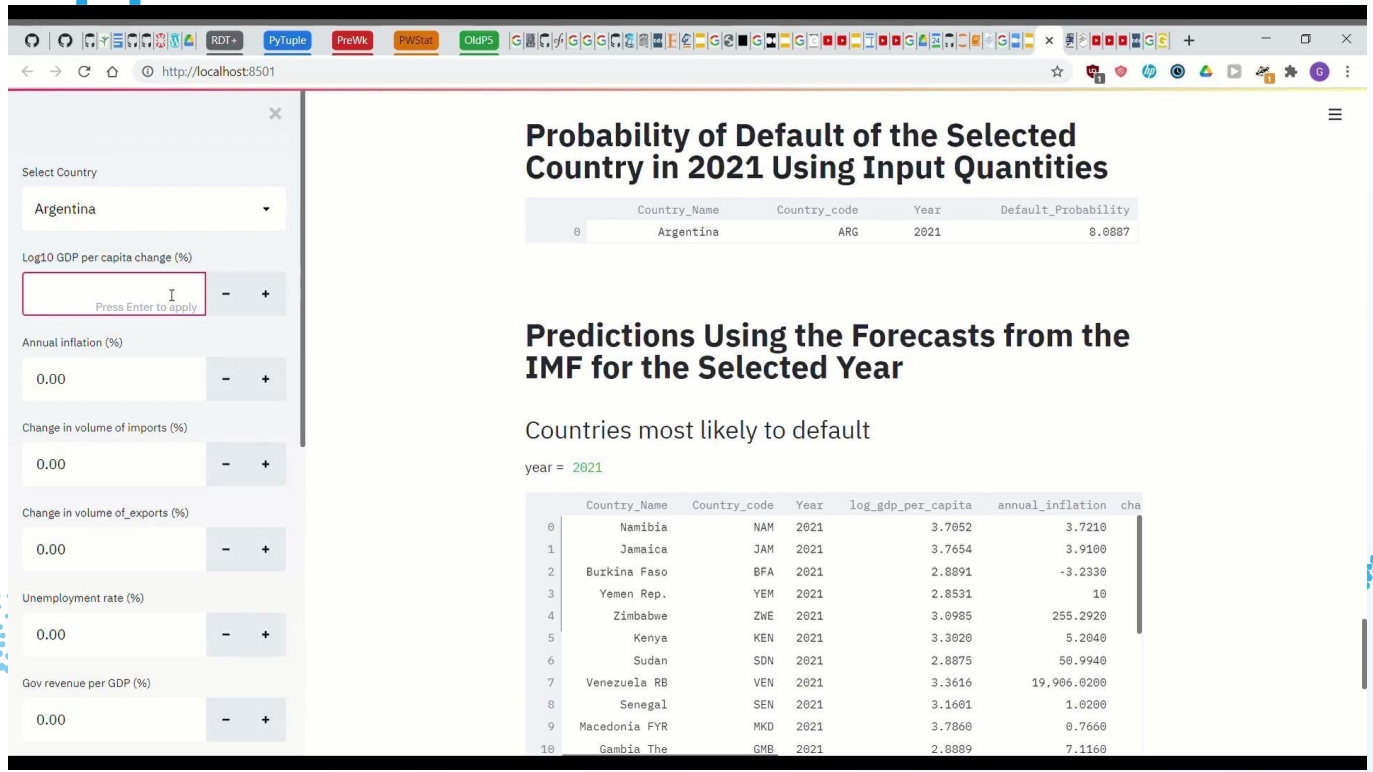
Host on Heroku

Choose Country, Year, Model

- Adjust features (by %)

User can change % values based on model or use IMF predictions for years 2021-2025

App Demonstration

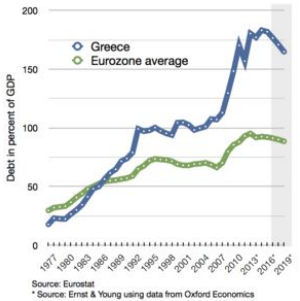


Model Advantages

- Web app
- It is open source, contrary to Moody’s and S&P models.
- Warn investors of the risk of default when investing in Sovereign bonds.

Recommendations Correlated with Avoiding Sovereign Default

- **Keeping debt low as % of GDP** (unlike Greece)
- **Increasing trade** (both imports and exports)
- **Keeping balanced budget**



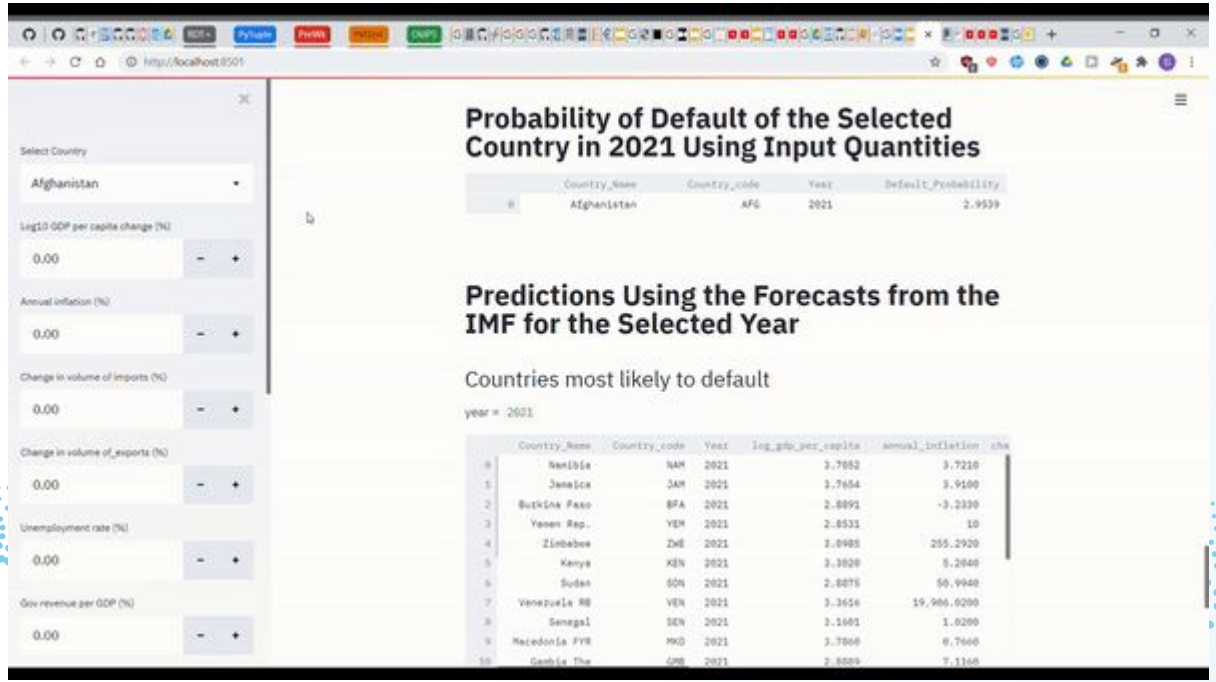
Future Potential

- More frequent data (monthly > quarterly > annual)
- Accurate/complete 20th century data
- Try to use paid data, such as country reserves and political risk measures

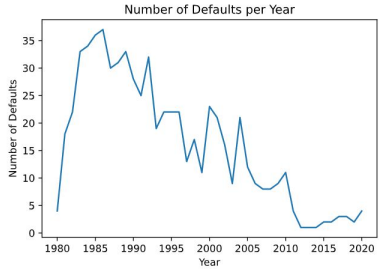
Thank You for Watching

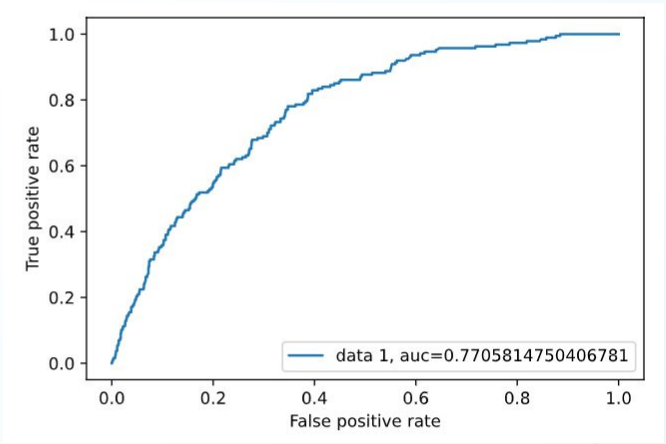
Appendix: Gif of Demo

- Showed video in presentation as I know how to pause & start it



Appendix


Number of Defaults per Year
Number of Defaults
Year
0
5
10
15
20
25
30
35
1980
1985
1990
1995
2000
2005
2010
2015
2020


True positive rate
False positive rate
0.0
0.2
0.4
0.6
0.8
1.0
data 1, auc=0.7705814750406781