

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.

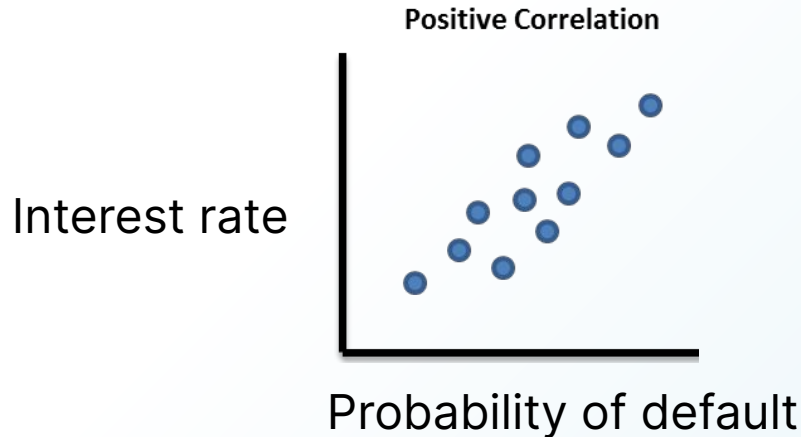
- The bonds are sold to investors.
- Associated with each bond there is an interest rate, which is paid periodically, with the principal paid after a certain number of years.



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.



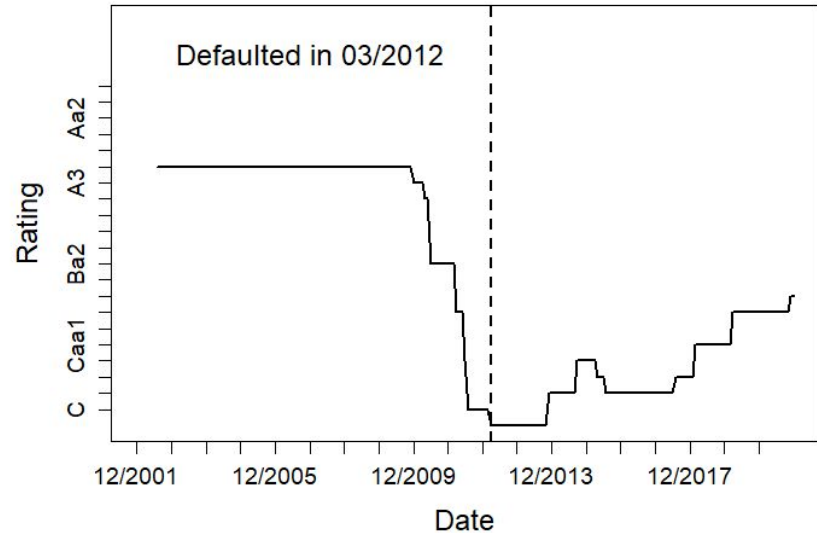
Case Study

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

- Investment grade, then junk



Moody's Ratings for Greece



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.

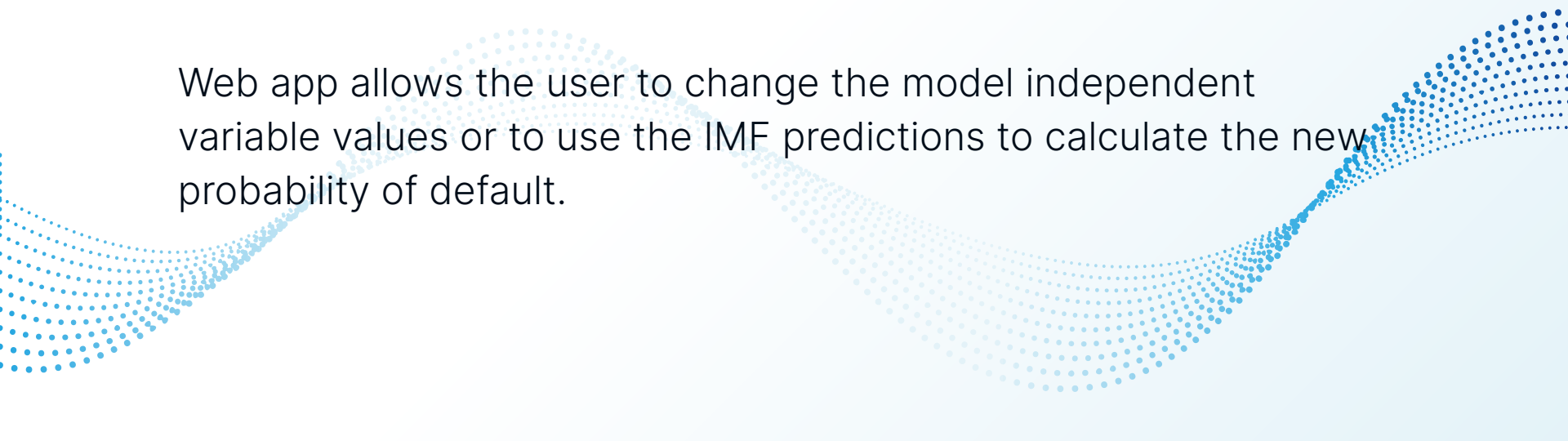
- Some defaults are not explained by macroeconomics, because some countries default for political reasons (e.g. Ecuador, 2008)



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.

A decorative graphic consisting of multiple overlapping, wavy lines of blue dots. The dots are arranged in a way that creates a sense of motion and depth, flowing from the bottom left towards the top right, framing the text on the slide.

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)



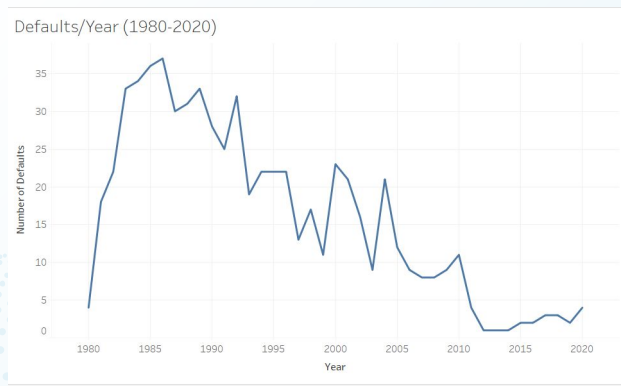
XGBoost

- 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)

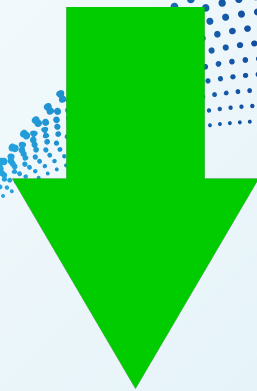
Positive (+)

- Debt over GDP
- Annual Inflation
- Unemployment Rate



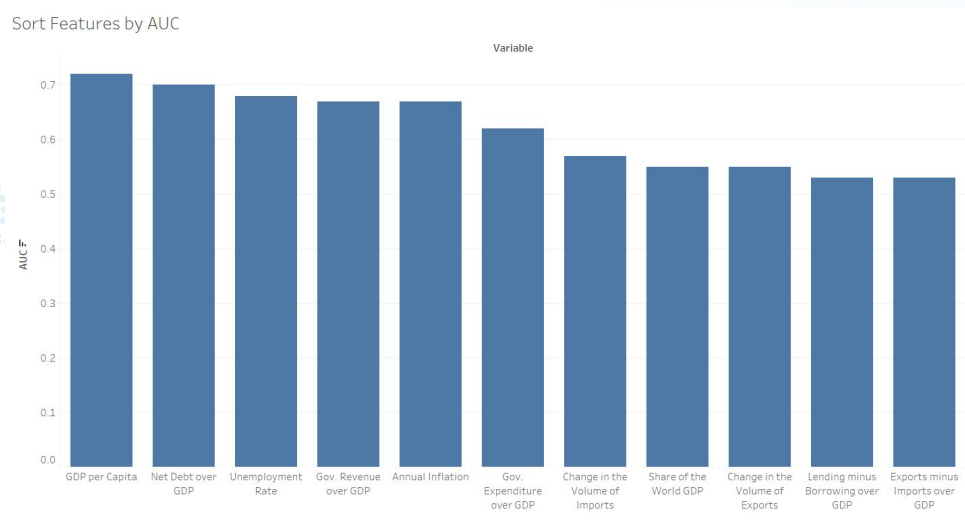
Negative (-)

- 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

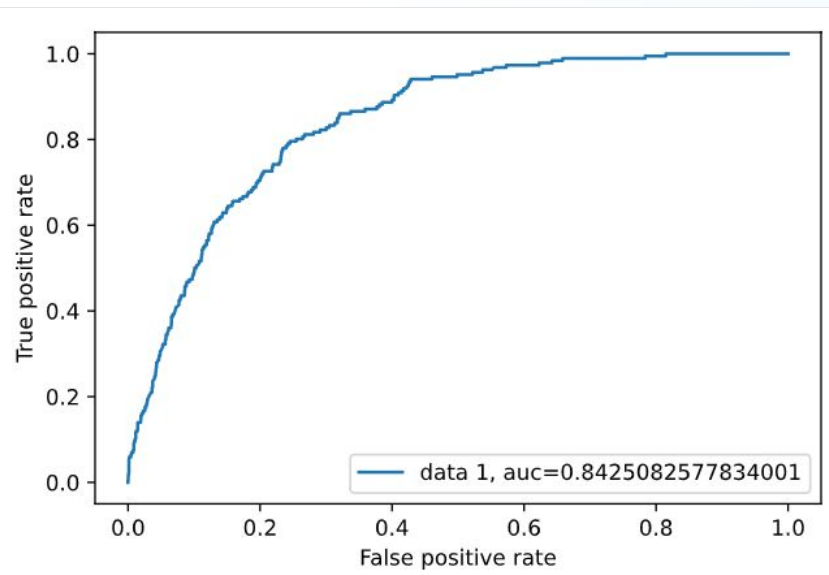
- Richer countries (higher GDP per capita) are less likely to default. It is important to keep debt low.
- Importance of each variables by AUC (Predictive power)



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

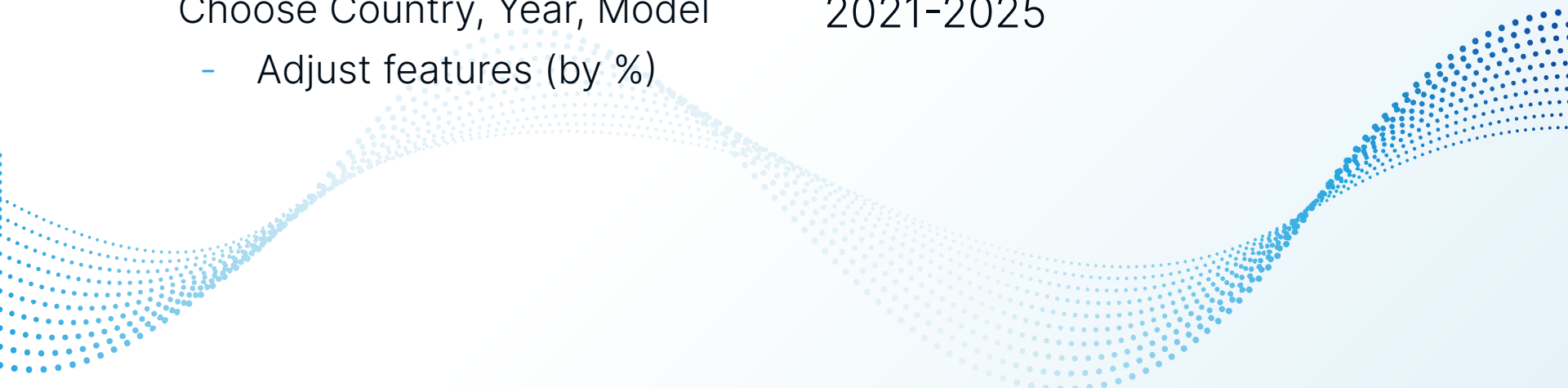
Made w/ Streamlit

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

The screenshot shows a web application running on localhost:8501. The interface is divided into two main sections. On the left is a sidebar with input controls for various economic indicators, all currently set to 0.00. These include Log10 GDP per capita change, Annual inflation, Change in volume of imports, Change in volume of exports, Unemployment rate, and Gov revenue per GDP. A 'Select Country' dropdown is set to 'Argentina'. On the right is the main content area, which displays the title 'Probability of Default of the Selected Country in 2021 Using Input Quantities'. Below this title is a table showing the default probability for Argentina in 2021 as 8.8887. Further down, the section 'Predictions Using the Forecasts from the IMF for the Selected Year' is shown, with the year set to 2021. This section contains a table listing the top 10 countries most likely to default, ranked by their predicted default probability.

Select Country

Argentina

Log10 GDP per capita change (%)

0.00

Annual inflation (%)

0.00

Change in volume of imports (%)

0.00

Change in volume of exports (%)

0.00

Unemployment rate (%)

0.00

Gov revenue per GDP (%)

0.00

Probability of Default of the Selected Country in 2021 Using Input Quantities

	Country_Name	Country_code	Year	Default_Probability
0	Argentina	ARG	2021	8.8887

Predictions Using the Forecasts from the IMF for the Selected Year

Countries most likely to default

year = 2021

	Country_Name	Country_code	Year	log_gdp_per_capita	annual_inflation	cha
0	Namibia	NAM	2021	3.7052	3.7210	
1	Jamaica	JAM	2021	3.7654	3.9100	
2	Burkina Faso	BFA	2021	2.8891	-3.2330	
3	Yemen Rep.	YEM	2021	2.8531	10	
4	Zimbabwe	ZWE	2021	3.0985	255.2920	
5	Kenya	KEN	2021	3.3020	5.2040	
6	Sudan	SDN	2021	2.8875	50.9940	
7	Venezuela RB	VEN	2021	3.3616	19,906.0200	
8	Senegal	SEN	2021	3.1601	1.0200	
9	Macedonia FYR	MKD	2021	3.7860	0.7660	
10	Gambia The	GMB	2021	2.8889	7.1160	

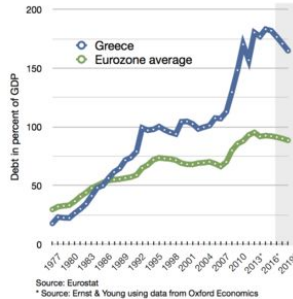
Model Advantages

- 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

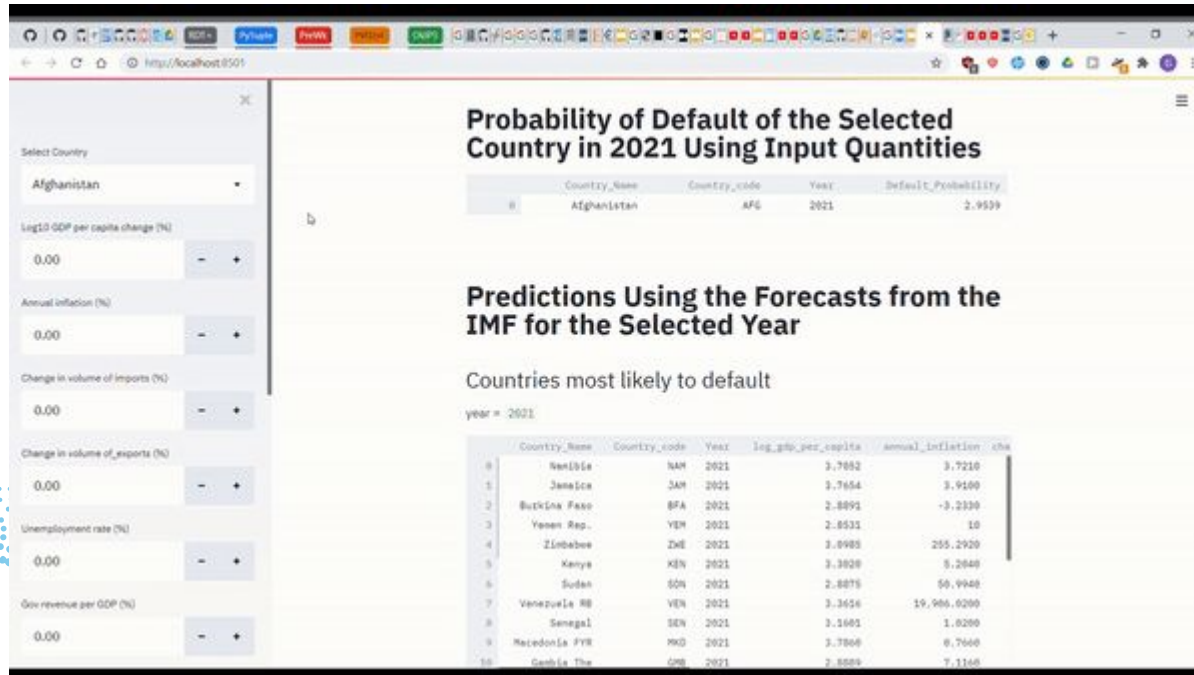


Thank You for Watching

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Appendix: Gif of Demo

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



Appendix

