Does Adopting and Legalizing Cryptocurrencies Affect Sovereign Credit Ratings?

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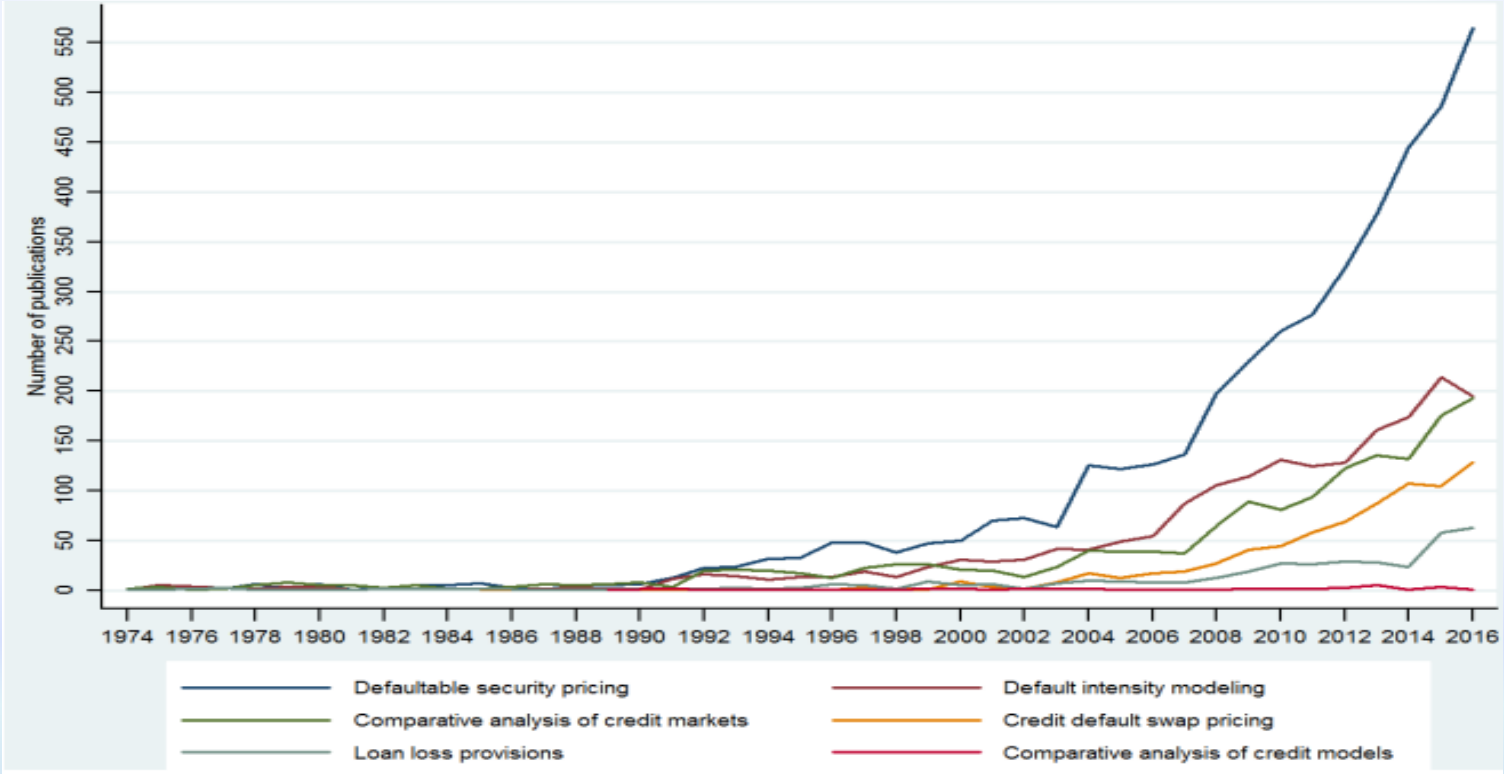
Sovereign Credit Rating and its Importance

- ✓ The sovereign credit rating is an assessment of the country's credit risk
- ✓ In the last five and a half decades there has been an exponential increase in the total number of credit risk studies (Zamore et al., 2018)



Source: Zamore et al., 2018

The Effects of the Sovereign Credit Rating

The sovereign credit rating affects the **domestic market yields**

(Faff et al., 2001; Gande and Parsley, 2005)

The sovereign credit rating affects **market yields in other countries** ("spillover" effect)

(Kaminsky and Schmukler, 2002; Abad, Alsakka and ap Gwilym, 2018)

The sovereign rating also affects **the flow of FDI**, where countries with a lower rating tend to invest in countries with a higher rating

(Cai, Kim and Wu, 2019)

In light of all these effects, it becomes important to examine the factors that influence the sovereign rating

Theoretical Framework

- ✓ There are several theories to explain the sovereign credit risk

- ✓ But, in recent years**, the institutional quality theory** is gaining momentum and proving how significant it is (Butler & Fauver, 2006; Ozturk, 2014; Huang, Lin & Yang, 2019)

Theoretical Framework

North (1990) defines institutions as:

"**humanly devised constraints that structure political, economic and social interaction**“

Formal institutions
(laws, regulations, and governance structures)

- Provide stability and predictability in economic transactions, reducing uncertainty and fostering growth

(North, 1990; Acemoglu, Johnson & Robinson, 2005)

Informal institutions
(social norms, traditions, culture, and beliefs)

- Complement the formal institutions by influencing economic behavior through cultural and social norms

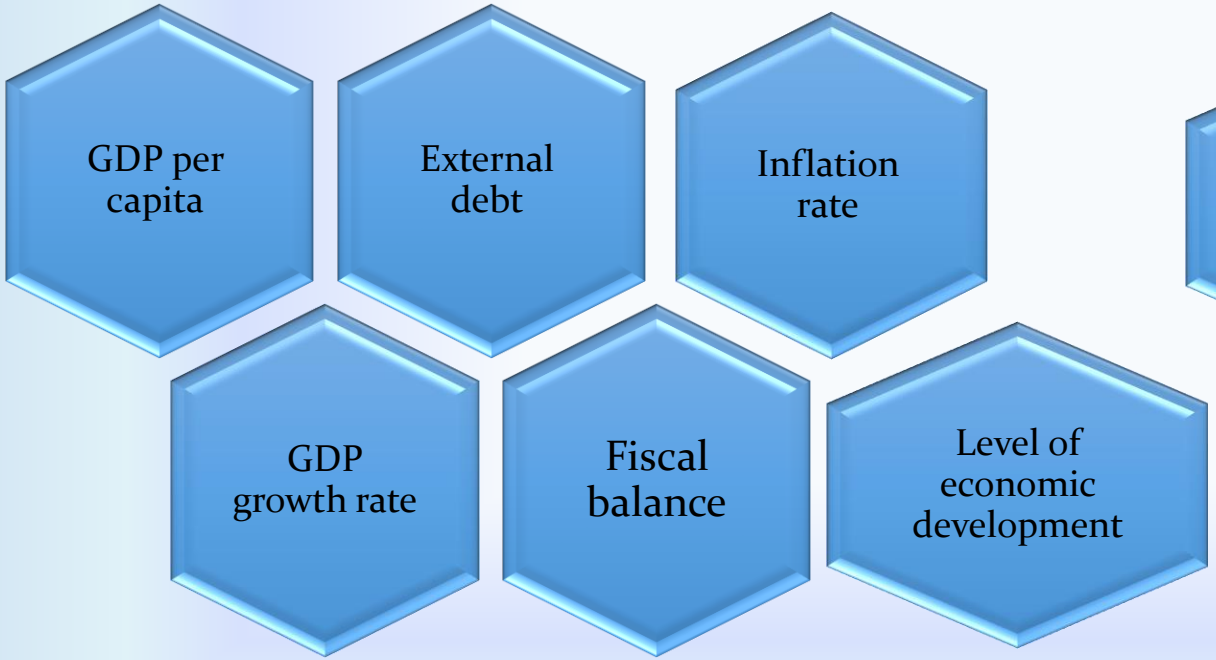
(Putnam, 1993; Williamson, 2000)

Determinants of Sovereign Credit Ratings

The earlier studies

Macroeconomic variables

The most frequent are:

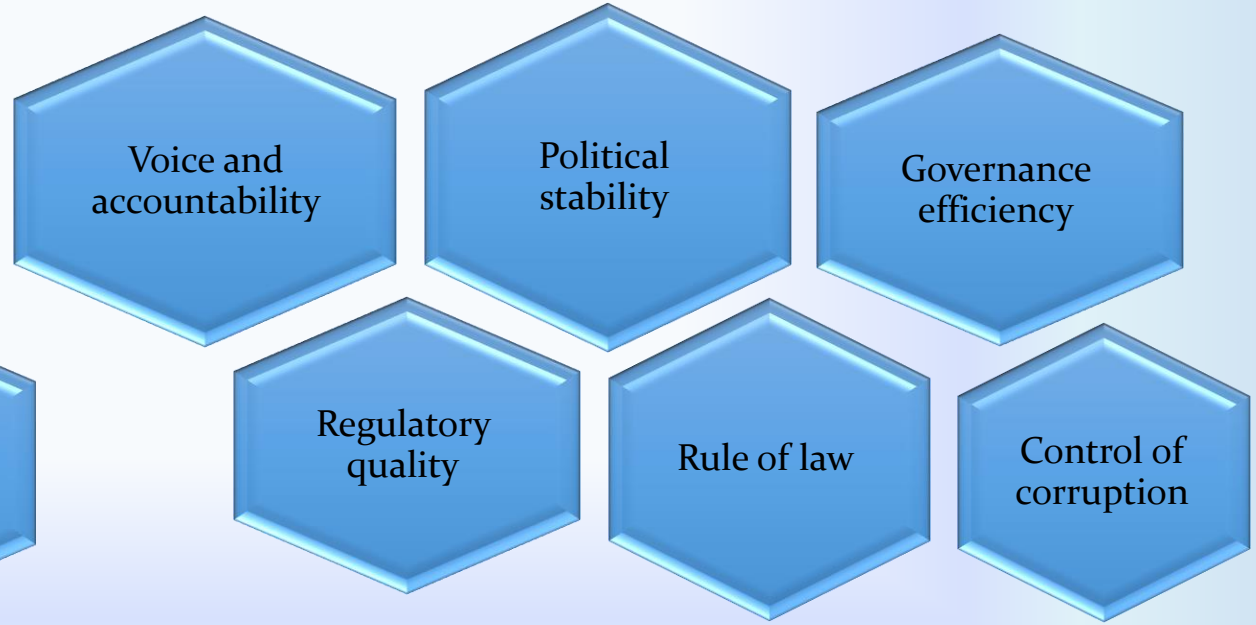


(Cantor and Packer, 1996; Afonso, 2003; Mellios and Paget-Blanc, 2006; Canuto, Dos Santos and de Sá Porto, 2012)

More recent studies

Governance variables

The most frequent are:



(Butler and Fauver, 2006; Ozturk, 2014; Huang, Lin and Yang, 2019)

Determinants of Sovereign Credit Ratings

But, in recent years another variable has been found…

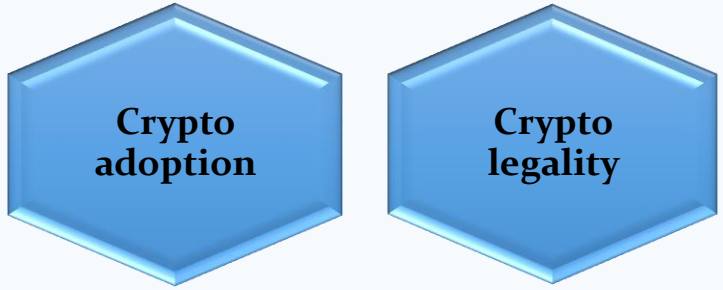
(Roychoudhury and Lawson, 2010; Calcagno and Benefield, 2013; Belasen, Hafer and Jategaonkar, 2015)

A body of research consistently demonstrates a **positive relationship** between economic freedom and sovereign credit ratings

This, when it was found that higher economic freedom is related to a better credit rating, while a decrease in economic freedom leads to higher credit costs and lower bond ratings

The Contribution of this Study

This study combines macroeconomic and governance variables with an examination of economic freedom, incorporating two new variables



Reasons for this choice:

- ✓ Recent studies showing a positive relationship between economic freedom and crypto adoption (Vincent and Evans, 2019; Ricci, 2020)
- ✓ Exponential growing of crypto research (García-Corral et al., 2022)
- ✓ Each of these variables offers different insights into institutional quality theory, with crypto legality reflecting formal institutions and crypto adoption reflecting informal institutions

The Ambivalence of Cryptocurrencies

Crypto adoption can have two **opposing effects** on sovereign risk

Advantages

- ✓ Lower transaction costs
- ✓ Increased security and privacy
- ✓ Potential for higher financial inclusion

(Ohnesorge, 2018; Rejeb, Rejeb and Keogh, 2021)

Disadvantages & Challenges

- × Technical complexity and security concerns
- × Sometimes used to circumvent international sanctions as well as engage in illegal activities
- × Cyber security threats further complicate their use in digital transformation

(Flori, 2019; Pandya et al., 2019; Baraković and Husić, 2022; Mahdavieh, 2022)

Crypto legality can also have **two opposing effects** on sovereign risk

- ✓ El Salvador, the first country to introduce crypto as a legal process in 2021, experienced a significant increase in domestic tourism and the return of the El Salvadoran diaspora
- ✓ In addition to these, it has earned $85 million as of March 11, 2024, with BTC prices hitting an all-time high above $72,000 on March 11

(Bastardo, 2023; Young, 2024)

- × On the other hand, some countries like Honduras and Nigeria have recently outlawed crypto, this is mainly due to concerns of money laundering and illegal activities

("Honduras watchdog bans institutions from trading crypto", 2024; Olawoyin, 2024)

Literature Review

Classification of Variables & Hypotheses

Table 1. Classification of variables & hypotheses

Variable name	Institution	Hypotheses Direction (+\-)
Inflation rate	Formal	(-)
GDP growth rate	Formal	+
Gini coefficient	Formal and informal	(-)
GDP per capita PPP	Formal	+
Human Development Index	Formal	+
Debt to export ratio	Formal	(-)
Budget balance	Formal	+
Economic freedom	Formal	+
Political stability	Informal	+
Rule of law	Formal and informal	+
Crypto adoption	Informal	+
Crypto legality	Formal	+
GDP PPP	Formal	+

Note: Direction + its meaning, positive hypothesis. That is, we expect a positive relationship between the variable and the sovereign rating. Respectively, direction (-) meaning, negative hypothesis. That is, we expect a negative relationship between the variable and the sovereign rating.

Source: Of the authors.

Crypto Adoption & Crypto Legality

Crypto adoption

- ✓ Informal institutions, which include social norms, culture and trust influence the adoption of new technologies (Lee, Trimi and Kim, 2013; Cristofaro et al., 2022; Jalan et al., 2023)
- ✓ Cultural dimensions like individualism affect adoption rates. For example, the USA's individualism fosters tech adoption, while South Korea's collectivism hinders it (Lee, Trimi & Kim, 2013)
- ✓ Higher social trust boosts crypto adoption, while long-term orientation hinders it (Jalan et al., 2023)

These cultural differences lead to varying degrees of crypto adoption globally

Crypto Adoption & Crypto Legality

Crypto legality

- ✓ Refers to formal institutions, which include laws, governance structures and formal regulations established by governments and financial authorities
- ✓ All of these play a significant role in determining the legal status of cryptocurrencies

The legal status of crypto varies around the world, with some countries recognizing them as digital assets while others prohibit their use. This lack of uniformity highlights the need for clear legal frameworks (Zatti, 2019)

Our Hypotheses

- ✓ Despite the much ambivalence shown about crypto adoption and legality, We anticipate a positive relationship between crypto adoption and legality and the sovereign rating

- ✓ This expectation is rooted in their connection to economic freedom and institutional quality

Therefore:

H1 - There is a **positive relationship** between crypto adoption and rating levels

H2 - There is a **positive relationship** between crypto legality and rating levels

Methodology and Data

Variables Description

- ✓ We collected data on **137 countries**, of which 52 are developed countries and 85 are developing (United Nations Statistics Division, 2022)
- ✓ **The dependent variable**: The long-term foreign currency rating classifications of S&P and Moody's, in January 2024

Why these two agencies?

I. These two agencies together make up about 80 per cent of the credit rating market (European Securities and Markets Authority, 2023)

II. Several researchers in the field used the credit ratings of these two agencies (Cantor and Packer, 1996; Afonso, 2003; Borio and Packer, 2004)

* Table A.1 in the appendix shows the rating levels and a summary description, given by Moody's. Table A.2 in the appendix shows the rating classifications for each country, according to each of the two agencies

Variables Description – Con.

Table 2. Description of variables

Variable name	Nickname	Unit of measurement	Data Source
GDP PPP	GDPPPP	millions of international dollars	The World bank, 2022
Inflation Rate	INF	Annual %	International Monetary Fund, 2023
GDP Growth Rate	GDPGR	Annual %	International Monetary Fund, 2023
GDP Per Capita PPP	GDPPCPPP	International dollars per capita	International Monetary Fund, 2023
Gini Coefficient	GINICOEFF	Index	Wisevoter, 2023
Human Development Index	HDI	Index	Human development index, 2021
Debt To Export Ratio	DEBTX	Ratio	The World bank, 2022
Government Budget Balance	BUDGET	Ratio	International Monetary Fund, 2023
Crypto Adoption	CRYPTOADOP	Index	Chainalysis, 2023
Crypto Legality	CRYPTOLEGAL	Category	atlanticcouncil, 2023 CoinGecko
Economic Freedom	ECONOMYFREE	Index	Heritage - index of economic freedom, 2023
Voiceand Accountability	VOICEACCOUNT	Index	WorldWide Goverence indicators (WGI), 2022
Political Stability	POLITICALSTAB	Index	WorldWide Goverence indicators (WGI), 2022
Goverence Effectiveness	GOVERENCEEFFEC	Index	WorldWide Goverence indicators (WGI), 2022
Regulatory Quality	REGULQUAL	Index	WorldWide Goverence indicators (WGI), 2022
Control of Corruption	CONTROLCORRUP	Index	WorldWide Goverence indicators (WGI), 2022
Rule of Law	RULELAW	Index	WorldWide Goverence indicators (WGI), 2022
Sovereign credit rating, Foreign currency, Long Term (Moody's)	RATING	Ordinary	Moody's website, 2024
Sovereign credit rating, Foreign currency, Long Term (S&P)		Ordinary	Country Economy Website, 2024 S&P Website, 2024

Note: Before the regression analysis, crypto legality converted from a categorical variable to a three-level scale: illegal (1), neutral (2), and legal (3).

Linear Transformation for the Dependent Variable

- ✓ In this sample, we included countries spanning the credit rating spectrum, from the highest AAA rating (Aaa) to C rating
- ✓ The conversion from letters to numerical ratings using a linear transformation follows Cantor and Packer (1996), Afonso (2003) and Kotěšovcová, Mihola and Budinský (2019)

Table 3. Linear transformation of the rating levels

	Rating Levels										
S&P	C	CC	CCC-	CCC	CCC+	B-	B	B+	BB-	BB	
Moody's	C	Ca	Caa3	Caa2	Caa1	B3	B2	B1	Ba3	Ba2	
RATING	1	2	3	4	5	6	7	8	9	10	
	Rating Levels										
S&P	BB+	BBB-	BBB	BBB+	A-	A	A+	AA-	AA	AA+	AAA
Moody's	Ba1	Baa3	Baa2	Baa1	A3	A2	A1	Aa3	Aa2	Aa1	Aaa
RATING	11	12	13	14	15	16	17	18	19	20	21

Source: Authors' own calculation

Descriptive Statistics and Correlation Matrix

Table 4. Descriptive statistics

Variable	Obs.	Mean	Std. Dev	Min.	Max.	25%	50%	75%
GDPPPP	130	1,190,927.000	3,683,192.000	1,789.198	30,337,137.000	63,258.040	205,778.500	759,593.600
INF	129	9.225	25.547	0.900-	250.000	3.000	4.500	6.200
GDPGR	131	2.791	2.140	2.700-	8.100	1.300	2.500	4.350
GDPPCPPP	132	33,765.580	28,986.060	1,509.618	143,303.600	11,286.030	24,496.280	51,496.120
GINICOEFF	124	37.549	8.218	23.200	63.000	31.650	35.700	42.300
HDI	133	0.769	0.134	0.428	0.962	0.691	0.790	0.876
DEBTX	68	8.293	6.454	0.491	37.794	3.725	6.676	11.416
BUDGET	130	2.829-	3.939	19.083-	15.143	4.896-	3.341-	1.358 -
POLITICALSTAB	135	0.031	0.839	2.479-	1.644	0.481-	0.102	0.684
VOICEACCOUNT	134	0.108	0.943	1.673-	1.775	0.652-	0.117	0.948
ECONOMYFREE	129	61.949	9.637	25.758	83.933	54.983	61.783	68.858
CRYPTOLEGAL	137	2.674	0.654	1.000	3.000	3.000	3.000	3.000
CONTROLCORRUP	135	0.130	1.000	1.651-	2.403	0.632-	0.103-	0.762
CRYPTOADOP	128	0.050	0.123	0.000	1.000	0.005	0.014	0.046
REGULQUAL	135	0.237	0.914	2.046-	2.214	0.461-	0.140	0.975
GOVERENCEEFFEC	135	0.226	0.897	1.746-	2.145	0.411-	0.065	0.994
RULELAW	135	0.150	0.935	2.197-	1.958	0.535-	0.041-	0.818
RATING – SP	122	12.479	5.376	2.000	21.000	8.000	12.000	17.000
RATING - MOODYS	137	11.131	5.926	1.000	21.000	6.000	11.000	16.000

Source: Authors' own calculation

Table 5. Correlation matrix

Variables	GDPPPP	INF	GDPGR	GDPPCPPP	GINICOEFF	HDI	DEBTX	BUDGET	POLITICALSTAB	VOICEACCOUNT	ECONOMYFREE	CRYPTOLEGAL	CONTROLCORRUP	CRYPTOADOP	REGULQUAL	GOVERENCEEFFEC	RULELAW	RATING - SP	RATING - MOODYS
GDPPPP	1																		
INF	0.02-	1																	
GDPGR	0.022	0.054-	1																
GDPPCPPP	0.107	0.135-	**424.-	1															
GINICOEFF	0.003	0.067	0.174	**322.-	1														
HDI	0.125	0.085-	**495.-	**813.	**436.-	1													
DEBTX	0.135-	**329.	**326.-	0.191-	0.009-	0.214-	1												
BUDGET	*207.-	0.119-	0.157-	**395.	0.001	**259.	0.07-	1											
POLITICALSTAB	0.061-	*216.-	*211.-	**593.	0.124-	**615.	0.178-	**344.	1										
VOICEACCOUNT	0.038-	*178.-	**408.-	**511.	*214.-	**610.	0.008	0.035	**646.	1									
ECONOMYFREE	0.04-	**429.-	**410.-	**728.	**346.-	**702.	0.23-	**306.	**664.	**714.	1								
CRYPTOLEGAL	0.079-	0.014-	**231.-	**253.	0.077-	**313.	0.075	0.076	**278.	**381.	**389.	1							
CONTROLCORRUP	0.086	**231.-	**389.-	**776.	**310.-	**746.	0.083-	**245.	**741.	**753.	**822.	**346.	1						
CRYPTOADOP	**445.	0.058	0.123	0.131-	0.022-	0.136-	0.082-	**267.-	**243.-	0.108-	0.139-	0.086	0.125-	1					
REGULQUAL	0.071	**321.-	**403.-	**797.	**295.-	**792.	0.216-	**249.	**704.	**744.	**916.	**419.	**916.	0.124-	1				
GOVERENCEEFFEC	0.149	**273.-	**347.-	**817.	**348.-	**793.	0.059-	**260.	**731.	**694.	**850.	**371.	**931.	0.049-	**942.	1			
RULELAW	0.111	**287.-	**389.-	**794.	**328.-	**776.	0.108-	**246.	**761.	**764.	**840.	**351.	**947.	0.083-	**948.	**950.	1		
RATING - SP	*196.	**264.-	**462.-	**795.	**371.-	**773.	**485.-	**299.	**649.	**615.	**797.	**287.	**823.	0.069-	**884.	**875.	**870.	1	
RATING - MOODYS	**235.	**294.-	**380.-	**776.	**276.-	**732.	**343.-	**323.	**599.	**602.	**818.	**309.	**796.	0.022-	**884.	**865.	**841.	**983.	1

Source: Authors' own calculation

Data Processing Process & Selection of the Variables

- ✓ We used DataRobot, an automated machine-learning method
- ✓ We followed a number of new studies in different fields, which used DataRobot and we performed the same methodology as them (Alon et al., 2022; Seeber et al., 2022)
- ✓ Figure 1 describes the feature engineering process we performed in DataRobot, before selecting the best model

Figure 1. Feature Engineering Process

Source: DataRobot

Data Processing Process & Selection of the Variables

- ✓ We ran all 17 independent variables, But we found that some of the independent variables are redundant
- ✓ Therefore, we removed 4 variables that were found to be redundant
- ✓ The general model to estimate presented in **equation (1)**, which describes the final 13 variables selected. These appear in ascending order, according to their degree of impact on Moody's rating, which will be reported in the results section:

$$\text{RATING}_i = \alpha 0 + \alpha 1\text{ECONOMYFREE}_i + \alpha 2\text{RULELAW}_i + \alpha 3\text{GDPPPP}_I + \alpha 4\text{GDPPCPPP}_i + \alpha 5\text{HDI}_i + \alpha 6\text{INF}_i + \alpha 7\text{BUDGET}_I + \alpha 8DEBTX_i + \alpha 9GINICOEFF_i + \alpha 10PLOTICALSTAB_i + \alpha 11CRYPTOADOP_I + \alpha 12CRYPTOLEGAL_i + \alpha 13GDPGR_i \quad (1)$$

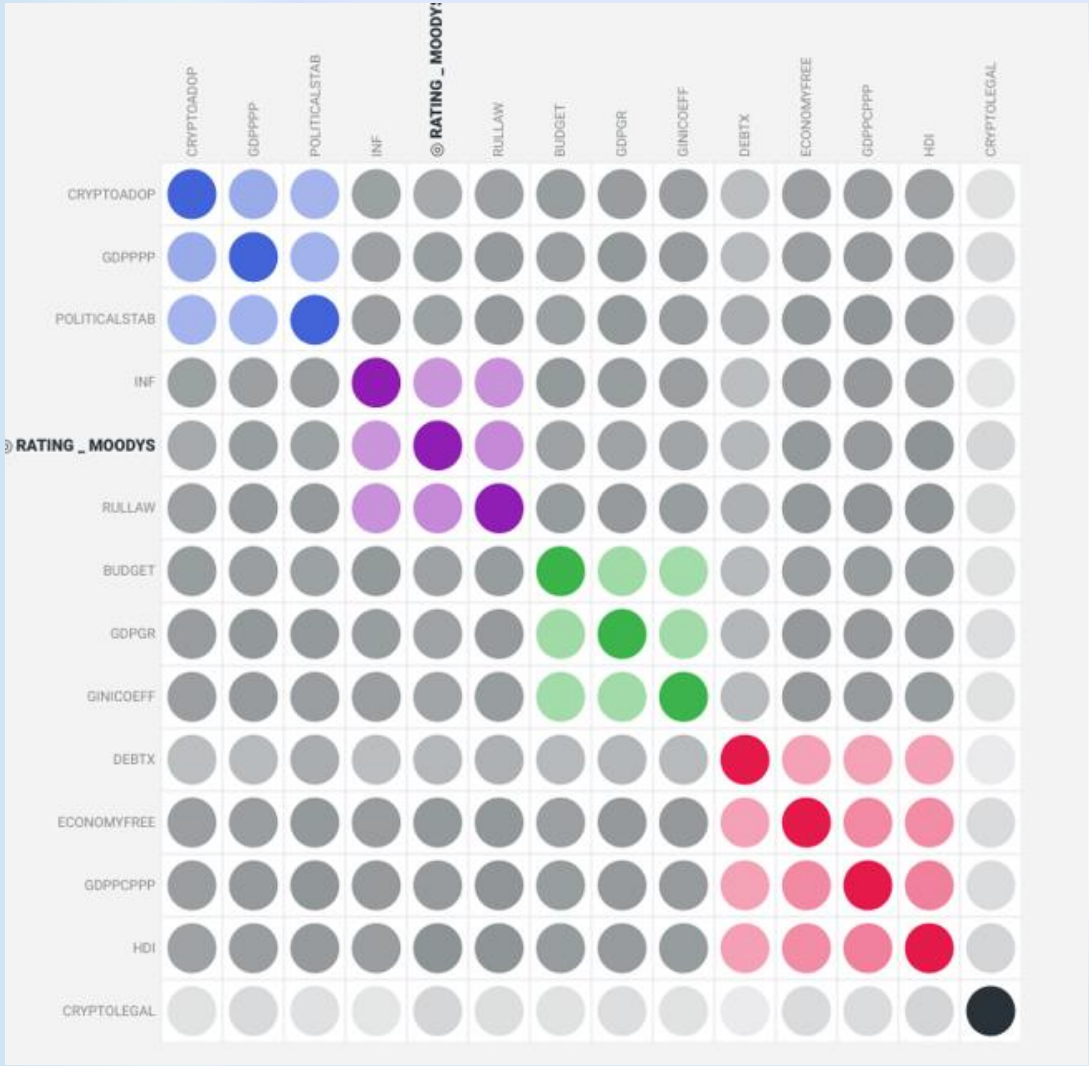
The Selected Model

- ✓ After selecting the final 13 variables, we selected the best model
- ✓ Most researchers in the field used OLS regression (Cantor and Packer, 1996; Afonso, 2003; Canuto, Dos Santos and de Sá Porto, 2012)
- ✓ However, OLS needs to meet several assumptions, which were not met in our data set
- ✓ Therefore, we looked for alternative models, while running 9 different models in Data Robot

- ✓ Finally, **ridge regression** did produce the best results, so we chose it as the selected model
- ✓ Many agree that ridge regression effectively **handles multicollinearity**, **improving the stability and accuracy** of the model (Zhang and Ibrahim, 2005; Gorgees and Ali, 2017)

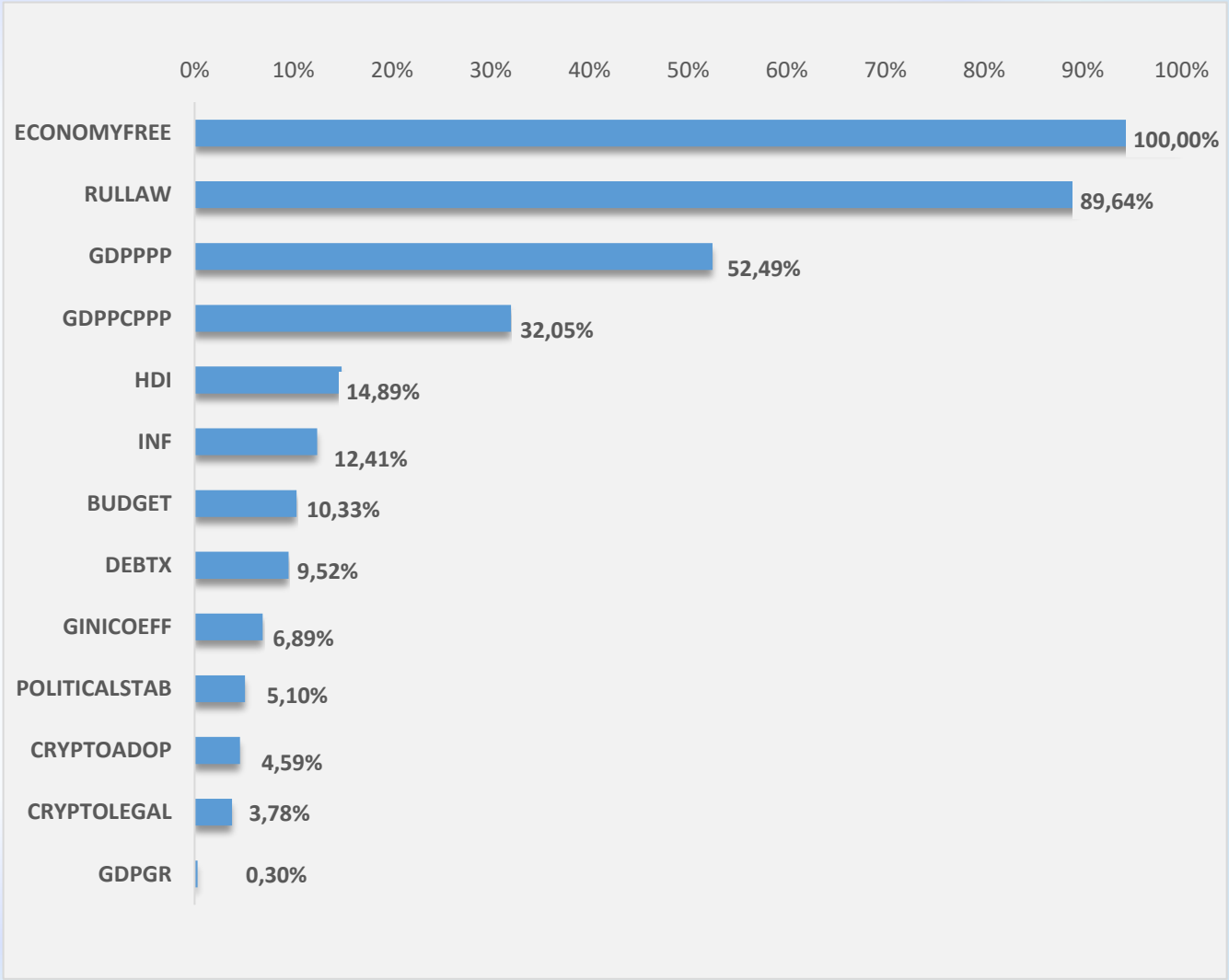
Results

Figure 2. Feature association matrix



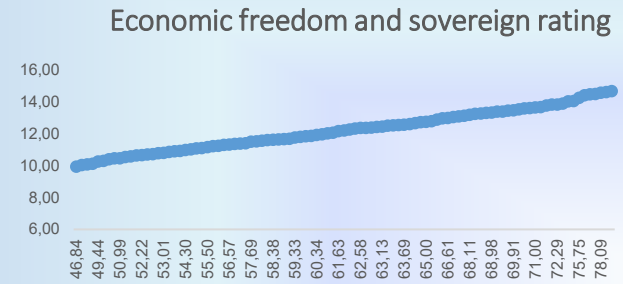
Source: DataRobot

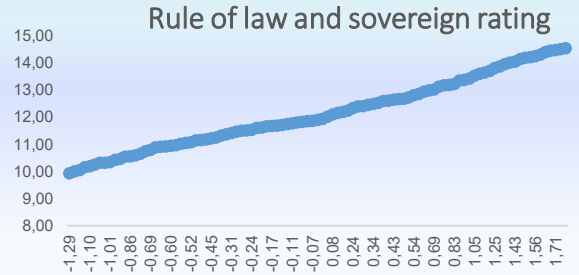
Figure 3. Features impact

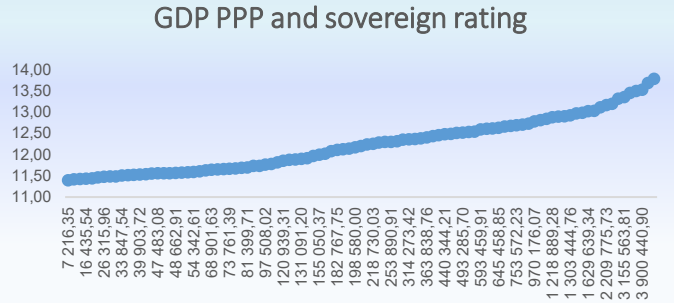


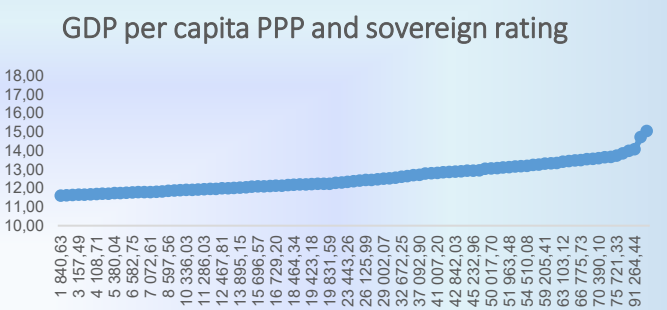
Source: DataRobot

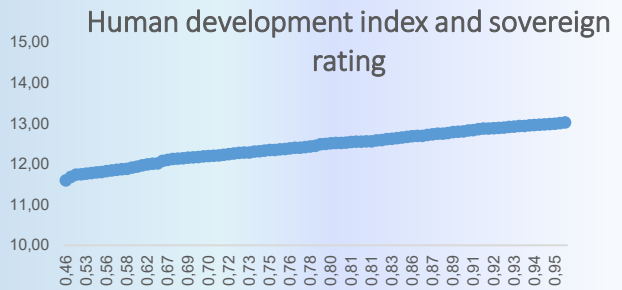
Figure 4. Partial dependence (feature effects)

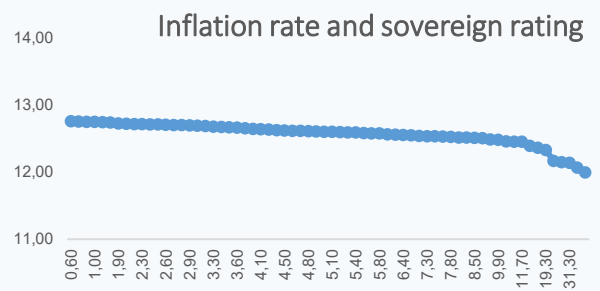


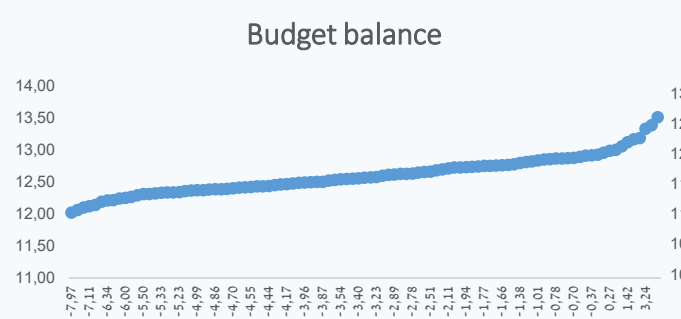


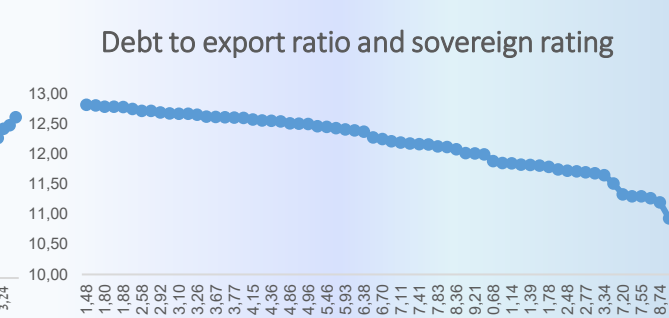


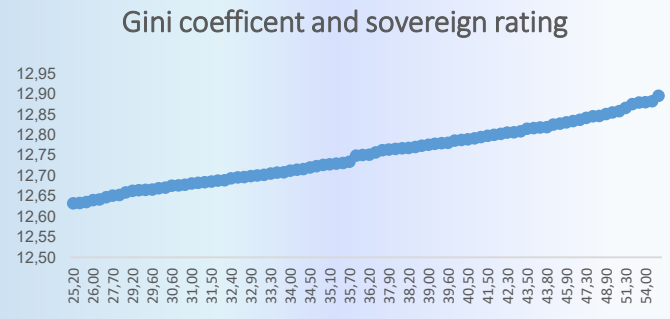


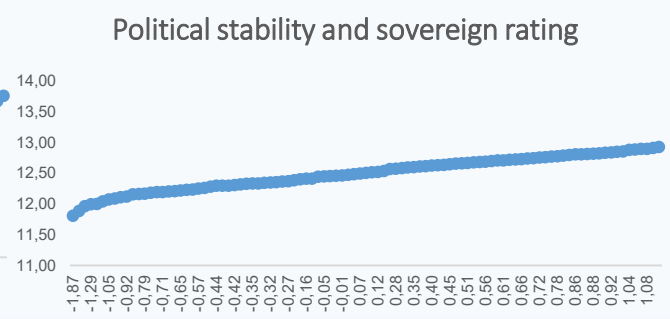


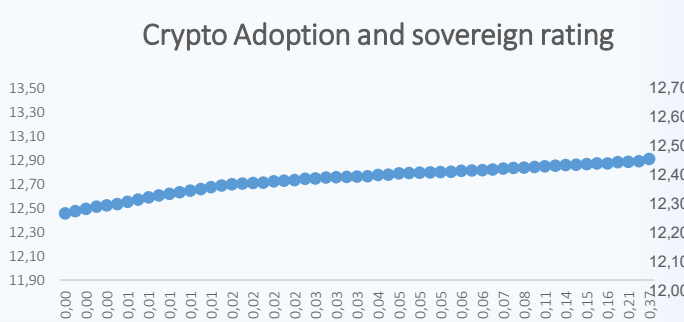


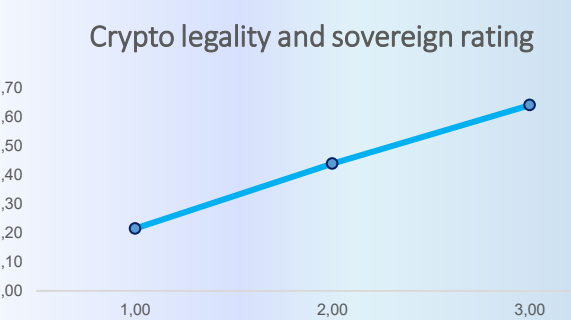


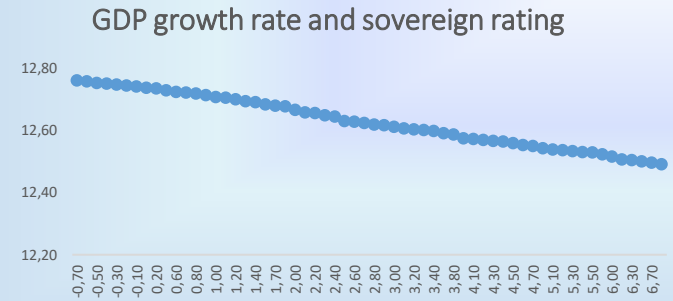






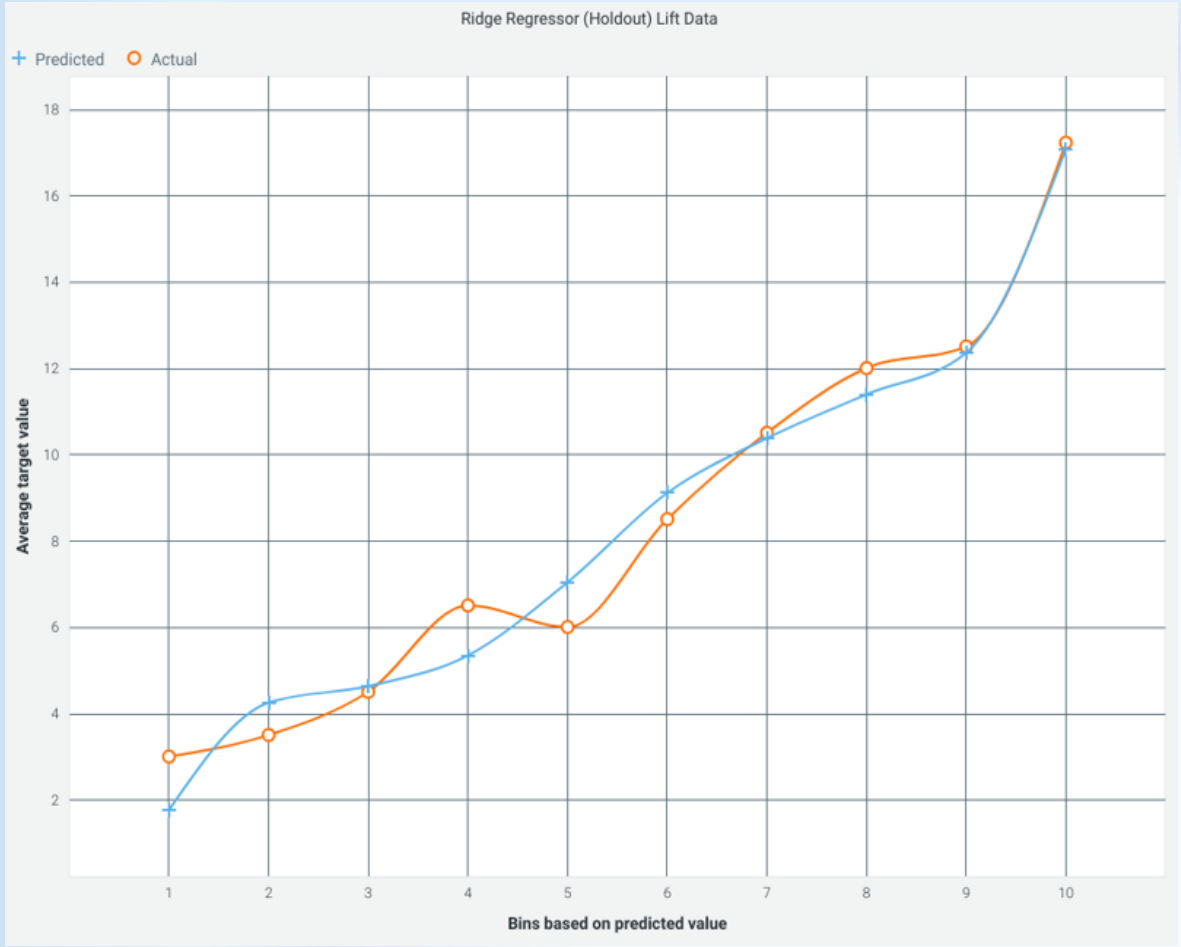






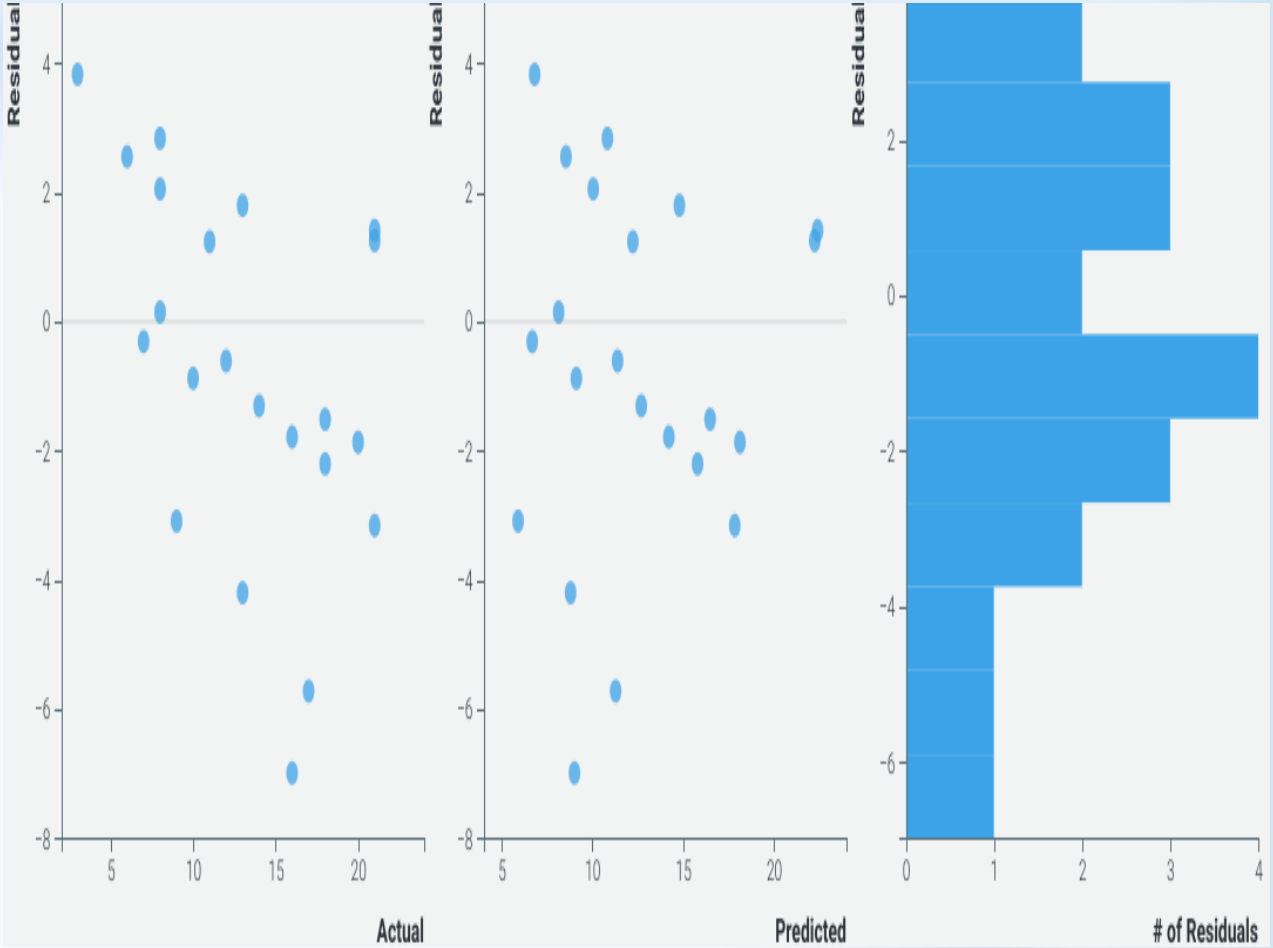
Source: DataRobot

Figure 5. Lift chart



Source: DataRobot

Figure 6. Residual distribution



Source: DataRobot

Robustness

✓ In this study, we used two types of robustness:

Robustness type	How
Target variable	As mentioned, because Moody's contained more observations than S&P and also because the correlation between the two is very high at 0.98, we decided to use Moody's and S&P as a robustness and showed similar results
Methodology (regression model)	We ran two types of regression, ridge and OLS

*Table A.3 in the appendix shows the results of the OLS regression, which presented less reliable and good results mainly because of its very high multicollinearity

This finding **further strengthens our choice of the ridge regression**, which as mentioned, one of its most prominent advantages is handling multicollinearity and overfitting through the regularization it performs, which OLS regression does not perform

Discussions

The Main Contributions of this Study

Despite the extensive literature on the determinants of sovereign credit rating, there is a significant lack both theoretically and methodologically

Therefore, the **main contributions** of this study are:

I. Investigation of two crypto variables that have not yet been studied

II. Comprehensive research that includes a theoretical framework

III. Using machine-learning techniques such as DataRobot and ridge regression, improved the robustness of the model by reducing problems such as multicollinearity and overfitting

The Main Findings and their Meanings

Crypto adoption:

Positive relationship with the rating levels

- Despite the ambivalence about cryptocurrencies, Countries that more adopt cryptocurrencies tend to have higher credit ratings
- This variable depends on **informal institutions** such as social trust, culture, social norms
- Therefore, cultural differences between the different countries cause changes in their adoption rates

Crypto legality:

Positive relationship with the rating levels

- Although several countries have recently banned the use of cryptocurrencies, it appears that countries that legalize cryptocurrencies tend to have higher credit ratings
- This variable depends on **formal institutions** such as laws, governance structures and formal regulations established by governments
- Therefore, policy makers who have not yet done so should reconsider

Therefore, **hypothesis H1 and H2 are supported**

Crypto adoption & crypto legality:

Similar degree of impact (4.59% and 3.7%, respectively)

- Emphasize the importance of both **formal and informal institutions** in shaping economic outcomes (Casson, Della Giusta and Kambhampati, 2010; Leković, 2011)

The Main Findings and their Meanings

Economic freedom

Although crypto adoption and legality were found to have a positive relationship on the sovereign rating, they are not the major variables, compared to others

Economic freedom has the highest impact (100%)

Its four categories - rule of law, size of government, regulatory efficiency, and open markets - are a roadmap for countries seeking to boost their sovereign credit ratings

Therefore, we recommend that policymakers consider both the formal & informal aspects involved in sovereign credit ratings

Formally: They should reduce regulations and restrictions, and encourage greater freedom of trade and investment

Informally: They should encourage an entrepreneurial culture, risk-taking and promote social trust

These improvements **in both formal and informal institutions** should help **reduce uncertainty about the country** and **improve its sovereign credit rating**

Suggestions for Future Studies

- ✓ While our study offers new and intriguing insights, additional avenues of research can improve its scope
- ✓ Future studies may adopt a panel data approach to see broader results and provide a more comprehensive understanding
- ✓ In addition, conducting research towards the middle or end of the year may ensure greater availability of data for the previous year

Questions ?