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WHAT DRIVES THE ISSUANCE OF GREEN BONDS – WHAT COUNTRY CHARACTERISTICS HAVE AN EFFECT ON THE ISSUANCE OF GREEN BONDS?

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### Abstract

We perform a two-step analysis to (i) understand what country characteristics influence the probability that green bonds have been issued in it, and (ii) evaluate what country characteristics affect the volume of green bonds issued in it. By running a logistic regression with 119 countries, we find evidence that the level of development, environmental preferences, transparency and quality of the financial markets, and absence of corruption have a positive effect on the probability of green bonds having been issued in a country. Furthermore, our results suggest that conditional on issuance, environmental preferences also have a positive effect on the volume issued in a country.

Keywords: Climate Finance, Environmental Preferences, Green Bonds, Green Finance

## 1. Introduction

The transition to a low-carbon, cleaner and more sustainable economy has already begun. While governments are increasingly taking policy actions and investing in those aspects, businesses are incorporating sustainability into their strategies, and the population is becoming more aware and progressively engaging with this cause.

Nevertheless, there are still many challenges associated with this transition, and they are related to the complexity of the interactions between human society's activities and the environment. Nature provides us with an extensive diversity of ecosystem services, such as the provision of food and clean water, and climate regulation. However, over the past centuries, the growth of the human population and the intensification of its activities has increased the pressure society imposes on the environment, thus threatening the provision of these services with a negative impact on the welfare of current and future populations (Heal, 2000).

Because environmental quality is a public good, the costs imposed by human activities on the environment are typically not fully internalised as markets for the related products and services do not work properly, implying that prices are distorted below its social value. This makes the transition towards a more sustainable economy all the more challenging, as society must come up with innovative ways of factoring in nature – in general – and ecosystem services – in particular – into the traditional economic and financial systems.

Green bonds are one solution which can help to promote this transition. They differ from regular bonds only regarding their proceeds, which are specifically used to finance green projects (*i.e.* projects that have positive environmental impacts). These bonds should usually be aligned with the four components of the Green Bond Principles (*e.g.* use of proceeds, process for project evaluation and selection, management of proceeds, and reporting). However, compliance is voluntary and external reviews although recommended are not mandatory (Green Bond

Principles, 2018). Moreover, there is still debate regarding the different shades of green – or the different levels of environmental quality a project can have (Cicero, 2015).

The first green bond was issued in 2007 by the European Investment Bank (EIB). Since then, this market has grown significantly and in 2017 issuance reached US\$ 155.5 billion worldwide (Climate Bonds Initiative, 2018). There is still a lot of potential for further growth as current estimates suggest that the needed annual investments in green infrastructures are projected to reach US\$ 5.7 trillion in 2020 (World Economic Forum, 2013). However, this market is not yet globally spread. In 2017, issuances were dominated by the US, China and France which accounted for 56% of the total (Climate Bonds Initiative, 2018).

Transitioning to a sustainable economy and mitigating climate change are global challenges. In 2015, the Paris Agreement was ratified by more than 180 countries committing to combat climate change and adapt to its effects (UN, 2018). Still, the efforts undertaken differ significantly among countries as does the climate risk each country faces.

Until now, green bonds – either government or corporate – have been issued in 44 countries (Bloomberg, 2018).<sup>1</sup> Even if there is some agreement regarding the challenges that developing countries face when trying to transition to a more sustainable economy and to fund climate mitigation and adaptation (World Bank, 2018), there are some puzzling aspects regarding how the green bonds' market is developing worldwide that make the analysis performed in this study relevant.

While green bond issuance has occurred in 26 out of 36 OECD countries, some small states with a not-so-strong economy are among the 44 in which green bonds have been issued – including Fiji, Mauritius and Costa Rica. Meanwhile, China – an emerging market with a poor

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<sup>1</sup> We here sum up issuances by Cayman, British Virgin Islands, Bermuda and England as issuances of the United Kingdom and we consider Taiwan and Hong Kong issuances within China's. Issuances by multilateral organisations, such as the European Investment Bank and the World Bank, which are not country-specific, were not included in the analysis.

track record on most environmental issues – has been the second largest issuer in 2017, behind only the USA.

In this study, we aim first at contributing to understanding what country-specific characteristics are driving the usage of this specific instrument – that is: why the issuance of green bonds has taken place in some countries and not in others – and, second, conditional on green bonds having been issued, to explain how country-specific characteristics may influence the volume issued.

Through our empirical analysis, we find evidence suggesting that a country's environmental preferences, the transparency and quality of its financial markets, its stage of development and its level of corruption have a significant effect on the likelihood of green bond having been issued in the country. Our results also point toward a lack of correlation between the climate risk faced by a country and the issuance of green bonds.

In other words, we find that green bonds are more likely to have been issued in countries which are more developed, have stronger environmental preferences, have more transparent and better-quality financial markets and have lower levels of corruption. Moreover, a country's level of exposure to climate risk does not seem to affect the likelihood of green bond issuance.

Finally, when analysing for countries in which green bonds have been issued, we find evidence that – among the characteristics evaluated – only a country's environmental preferences have a significant effect on the volume issued.

Through understanding which country characteristics may have driven the issuance of green bonds, the evidence found in this study can help policymakers and international organisations to better shape the mechanisms to incentivise the issuance of green bonds and thus fund climate mitigation and the transition to a more sustainable economy.

The remainder of this study is organised as follows. In section 2, a literature review on the topic of green bonds and investors' preferences is presented. Section 3 describes the framework of the analysis performed, section 4 the data used, and section 5 the empirical methodology applied. Then, section 6 presents the empirical results, and section 7 the limitations and possibilities for further research. Finally, section 8 offers conclusions.

## 2. Literature Review

Green bonds are relatively new instruments, and although the market, as well as the interest in the subject, has been growing consistently over the last decade, the literature on green bonds is still in its early days.

Much of the growth in the green bond market is due to the growing interest that investors show for these assets – an increased demand. Investors are becoming more aware of the benefits created by green projects (Shishlov, 2016) and of the risk that climate change can impose on more traditional financial assets (OECD, 2015), thus anticipating more stringent climate policies in the future. According to Morgan Stanley (2016), 55% of investors state they are interested in sustainable investing.

On the supply side, governments and corporations have multiple reasons for issuing green bonds. Most of the climate adaptation and mitigation projects are expected to be implemented by cities (Banga, 2018), which means that local governments must obtain the funds to invest in them. Green bonds can serve as a compelling solution for this. Moreover, by creating an institutional framework for the issuance of green bonds and setting the example, governments can influence growth in this market.

Meanwhile, having a green image can enhance corporations' value (Hamilton, 2011) which makes it attractive for businesses to consider issuing green bonds as part of its corporate sustainability strategy. Green bonds issuance – like other pro-green and sustainable strategies

that companies can adopt (*e.g.* corporate social responsibility, carbon offsetting, climate mitigation, internal carbon pricing) – can also help companies hedge against compliance and climate risks in the future (Pinkse, 2007).

While the green bond market has been growing exponentially over the last few years, its size remains tiny when compared to the total fixed-income market (Franklin, 2016). Moreover, issuance has been uneven between different regions and markets, and in many developing countries it remains incipient (Banga, 2018). While US\$ 17 billion of the proceeds from green bonds were directed to cities in developed economies, only US\$ 2.2 billion were directed to cities in developing economies (Climate Bonds Initiative, 2016).

A significant share of the existing literature on green bonds focuses on specific financial aspects of green bonds. Zerbib (2018) uses green bonds as an instrument to identify the effect that the green label has on bond market prices. The author uses matching to compare green bonds with counterfactual conventional bonds and obtains results that point to a negative green bond premium of 2 base points (bps) – meaning that the yield of a green bond is lower than that of the counterfactual conventional bond. Similarly, Baker et al. (2018) analyse the USA bond market based on a sample of municipal bonds. Likewise, the authors find that green bonds are issued with lower yields when compared to regular bonds.

Ehlers and Packer (2017) and Hachenberg and Schiereck (2018) also find evidence of a negative green bond premium – 18 bps and 1 bp respectively – by using an approach similar to Zerbib (2017) but with a more specific focus – the primary market between 2014 and 2017 and the secondary market between 2015 and 2016, respectively. Moreover, Barclays (2015) and Bloomberg (2017) focus on the secondary market and similarly find evidence pointing towards a negative green bond premium.

Meanwhile, studies from the HSBC (2016), the Climate Bonds Initiative (2017), the OECD (2017), Petrova (2016) and Shishlov (2016) focus on comparing the difference in yield at issuance (primary market) between conventional and regular bonds and find no evidence of a significant discrepancy. Karpf and Mandel (2018) obtain evidence of a positive green bond premium – meaning that green bonds are issued with higher yields – when controlling for the number of transactions as a proxy for bond’s liquidity.

Karpf and Mandel (2017) compare the returns on green bonds to that of regular bonds and find evidence that returns on the latest are on average higher. Although they mention that this spread can be explained by characteristics that are issuer or bond specific, they conclude that green bonds are traded at lower prices than what could be expected. Ley (2017) performs a comparative analysis between 359 green bonds and 1291 regular bonds and the author’s results provide evidence of a better performance in terms of financial returns for the green bonds.

Gyura (2017) analyses the existing approaches for green bonds sustainability ratings and points out that there is room for improvements in those ratings, with increased competition between providers being key to enable this development.

Chiesa and Barua (2018) investigate which characteristics can affect the issue size of green bonds, and how do these differ across emerging and non-emerging markets. The sample consists of green bond issuing firms, and the author includes a series of bond-, issuer-, economic- and market-specific characteristics in the model. The study finds evidence that bonds issued in emerging markets are larger in volume than those issued in non-emerging markets.

While the existing literature on green bonds has been thoroughly scrutinised, the authors were not able to find studies proposing a broader analysis by comparing the issuance of green bonds between different countries and the drivers of this issuance. This study builds much on findings from Banga (2018) and aims at filling this gap in the literature.



Banga (2018) uses a qualitative approach to identify the drivers of the green bond market and the main barriers to the growth of this market, with a specific focus on developing countries. The author identifies the key obstacles to the development of the green bond market, namely: the high transaction costs, the minimum issuing size, and the lack of institutional arrangements. Throughout the study, the author frequently emphasises the difference in issuance between the different countries.

Based on this literature review, we may conclude that to date no study has addressed the issues discussed in this paper from an empirical perspective. The contribution of this study to the literature is twofold: (i) to identify what country characteristics are driving the issuance of green bonds, and (ii) conditional on the issuance of green bonds to understand what features drive the volume of green bonds issued.

### 3. Analytical Framework

We begin the analysis by evaluating the effect of specific characteristics on whether green bonds have or not been issued in a country. Based on an extensive literature review followed by a data-driven approach, we estimate a model which predicts how likely it is that green bonds have been issued in a country, given its specific characteristics. For the countries in which there has been green bond issuance, we also analyse the effect these characteristics can have on the volume of green bonds issued. In other words, given that a country has issued green bonds, what attributes have an effect on the volume issued.

Specifically, our two research questions are:

**RQ1.** What country-specific characteristics have an effect on the probability that green bonds have been issued in a country?

**RQ2.** Considering that green bonds have been issued in a country, what country-specific characteristics may explain the volume of green bonds that have been issued in it?

Thus, we are testing whether a selection of characteristics has an effect on the likelihood of green bond issuance in the different countries and if they can also influence the volume issued. For the purpose of this study, we do not differentiate between corporate and government green bonds. Moreover, due to the nature of our database, we also make no distinction regarding when the green bonds were issued. Because green bonds are a relatively recent instrument and because bonds, in general, are long-term assets, a yearly comparison or a panel analysis at this point would not be much informative.

To answer both **RQ1** and **RQ2**, we run econometric models in which the issuance of green bonds and the volume of green bonds issued are the dependent variables, respectively. The independent variables used in the regressions are country characteristics that provide information regarding its environmental preferences, its financial markets, its stage of development, its level of corruption, and its exposure to climate risk.

The variables used to test these effects are detailed in section 4.2.3. Explanatory Variables. All variables used in this study are country specific.

## 4. Data

### 4.1. Sample Description.

To answer **RQ1**, we include a broad sample of 119 countries for which we were able to obtain sufficient data to run the regression - which represents 61% of the world's existing countries in 2018 (Worldometer, 2018). From these 119 countries, 40 have had green bonds issuance (34%) while 79 haven't. To answer **RQ2**, we consider only these 40 countries in which green bonds have been issued. The countries included in both analyses are listed in the Annexes.

In this study, we have included issuances from Taiwan and Hong Kong into China's and issuances from Cayman, Bermuda and the British Virgin Islands into the UK's. While green bond data was available separately for these regions, this was not the case for most of the

independent variables considered, which is why we chose to aggregate. Furthermore, Mauritius, Luxembourg, Fiji and the United Arab Emirates are the only countries in which there has been green bond issuance which were not included in the sample due to the lack of data.

## 4.2. Variable Description

Table 1 summarises the variables employed in the models.

*Table 1 - Description of the Variables*

Variable	Description	Source
<b>Dependent</b>		
<i>GBDummy</i>	1 if green bonds have been issued in the country, 0 if not	Bloomberg Terminal 2018
<i>GBRatio</i>	The volume of green bonds that have been issued in a country (in US\$, from 2010 to 2018) divided by the country's GDP (in US\$)	Bloomberg Terminal 2018
<b>Control</b>		
<i>GDP</i>	The country's gross domestic product (in US\$)	World Bank 2015
<i>ANS</i>	The country's adjusted net savings divided by the country's gross national income (in %)	World Bank 2015
<b>Explanatory</b>		
<i>EPIYale</i>	The country's Environmental Performance Index (in scale: 0 to 100)	Yale 2018
<i>BasicWelfare</i>	The extent to which basic welfare – social security, health and education – has been achieved in the country (in scale: 0 to 1)	IDEA 2015
<i>CreditInfo</i>	The country's 2015 depth of credit information index (in scale: 0 to 8)	World Bank 2015
<i>AbsenceOfCorruption</i>	The extent to which the executive and public administration in a country does not abuse office for personal gain (in scale: 0 to 1)	IDEA 2015
<i>ClimateRisk</i>	The extent to which a country has been affected by the impacts of weather-related events (in score)	GermanWatch 2016

### 4.2.1. Dependent Variables

To answer **RQ1**, we build a model in which the dependent variable is a binary variable which takes the value of 1 for countries in which green bonds (corporate, government or both, as well as both active and mature bonds) have been issued or 0 for countries in which no green bond was issued. This variable is named *GBDummy*. To generate this variable, we use data extracted

from the Bloomberg Terminal for all bonds issued between 2010 and November 2018 with the green bond use of proceeds filter. We use the country of issuance information available in the bond database to attribute values 1 or 0 for each country in the sample.

Also using the same Bloomberg database, we created the *GBVolume* variable. This variable consists of a sum of the volume of all green bonds issued in each country between 2010 and November 2018 in US\$. Although the first green bond was issued in 2007, the issuer was the EIB which is a supranational institution. The first country-specific green bond was issued only in 2010. For the purpose of this study, all green bonds listed in the Bloomberg database as supranational (SNAT) were not included, as they are not country specific.

Finally, to answer **RQ2**, we created the *GBRatio* variable by dividing the *GBVolume* variable by the country gross domestic product (*GDP*) in 2015, using World Bank data, as follows.

$$GBRatio = \frac{GBVolume}{GDP} \quad (1)$$

We used this approach to adjust the green bond volume to the size of each country's economy and thus to eliminate a potential bias.

We chose to use the sum of the volume of green bonds instead of using data available from the latest year or running a panel analysis because issuance has been uneven across different years for most countries. This is to be expected because (i) this is an instrument still in its early years, and (ii) bonds are long-term debt securities, with maturities often longer than ten years, which can make a yearly assessment inadequate.

We decided to use the ratio instead of the volume to eliminate the effects of a country's economy size of our dependent variable. Also, we chose not to use the total volume of bonds (regular plus green) for this adjustment because we want to capture the effect of financial markets characteristics in the model. For this purpose, the use of the total volume of bonds would create

an endogeneity issue, as the model could be capturing the independent variables' effect on the full bond market and not specifically the green bond market.

Finally, we chose to use data from 2015 because the World Bank database contains many missing values for more recent years for either *GDP* or the other variables which were also extracted from this database.

#### 4.2.2. Control Variables

Each country's 2015 gross domestic product (*GDP*) in US\$ was included to control for the size of its economy. Moreover, the countries' 2015 adjusted net savings as a percentage of gross national income (*ANS*) were included in the model as this measure is deemed to be the leading economic indicator of weak sustainability (Heal, 2012). The adjusted net savings measure is calculated by adding education expenditure to the net national savings and then subtracting energy, mineral and net forest depletion, as well as damages from carbon dioxide and particulate emissions. The source for both *GDP* and *ANS* data is The World Bank.

#### 4.2.3. Explanatory Variables

In our analysis, we included five explanatory variables for which we are assessing the effect on green bond issuance. The variables are indicators of a country's environmental preferences, financial markets condition, development stage, corruption level, and exposure to climate risk.

To assess a country's environmental preferences, we used the Environmental Performance Index (*EPIYale*) calculated by the University of Yale in collaboration with the World Economic Forum. The index allows a quantitative assessment of how environmental performance differs between various countries at a given point in time. Moreover, the index is updated biannually, which allows for an observation of the development of countries' environmental performance over time. The first version of the index was published in 2006, and the more recent update available is the 2018 publication – which was the one used in this study.

The index is calculated on a scale from 0 to 100, with 0 being the worst and 100 the best. It is calculated through a weighted average of twenty-four indicators across ten categories (air quality, water quality, heavy metals, biodiversity & habitat, forests, fisheries, climate & energy, air pollution, water resources and agriculture).

In this study, we are considering *EPIYale* as a proxy for a country's environmental preferences – the assumption is that a country's environmental performance and its environmental preferences are strongly correlated. Hence, by estimating the coefficient for *EPIYale* in the model, we are trying to capture if a country's environmental preferences have an effect on the issuance of green bonds.

To assess the condition of a country's financial markets, we used 2015 data on the Depth of Credit Information Index (*CreditInfo*) published by The World Bank. The index is calculated in a scale from 0 to 8, with 0 being the lowest and 8 the highest and it measures the availability and quality of credit information available.

In this study, we are considering *CreditInfo* as a proxy for the transparency and quality of the financial markets in a country. Thus, by estimating the coefficient for *CreditInfo* in the model, we are trying to perceive if the transparency and quality of a country's financial markets influence the issuance of green bonds.

To assess the stage of development and life conditions of a country, we used 2015 data on the Basic Welfare indicator (*BasicWelfare*) published by IDEA – The International Institute for Democracy and Electoral Assistance. The gauge is calculated in a scale from 0 to 1, with 0 being the lowest and 1 the highest and it measures the extent to which basic welfare – social security, health and education – has been achieved in the country.

In this study, we use *BasicWelfare* as a proxy for the level of development in a country. Thus, by estimating the coefficient for *BasicWelfare* in the model, we are trying to perceive if a country's stage of development influences the issuance of green bonds.

To assess a country's level of corruption, we used 2015 data on the Absence of Corruption indicator (*AbsenceOfCorruption*) published by IDEA – The International Institute for Democracy and Electoral Assistance. The indicator is calculated in a scale from 0 to 1, with 0 being the lowest (lowest absence of corruption, meaning more corruption) and 1 the highest (highest absence of corruption, which means less corruption) and it measures the extent to which the executive and public administration in a country does not abuse office for personal gain.

By estimating the coefficient for *AbsenceOfCorruption* in the model, we are trying to perceive if a country's level of corruption influences the issuance of green bonds.

Finally, to assess the level of risk to the effects of climate change faced by each country, we used the 2016 Global Climate Risk Index (*ClimateRisk*), published by the GermanWatch. The index provides a quantitative gauge that measures to what extent countries and regions have been affected by the impacts of weather-related events (*e.g.* storms, floods, heat waves).

By estimating the coefficient for *ClimateRisk* in the model, we are trying to perceive if a country's level of exposure to climate risk influences the issuance of green bonds.

#### 4.3. Descriptive Statistics

Tables 2 and 3 summarise the descriptive statistics for the employed variables. Table 2 includes all of the 119 countries included in the first-step regression (**RQ1**) and Table 3 includes only the 40 countries included in the second-step regression (**RQ2**), for which *GBDummy* is equal to 1. Annexes I, II and III list the countries in which green bonds have been issued, the countries

included in the first-step regression and the countries included in the second-step regression, respectively.

*Table 2- Descriptive Statistics for the First-Step Regression*

Variable	Value		Frequency	Percentage	
GBDummy	1 (issuance)		40	34%	
	0 (no issuance)		79	66%	
Variable	Mean	Median	Standard Deviation	Minimum	Maximum
EPIYale	57.54	58.46	13.90	27.43	87.42
CreditInfo	5.75	7.00	2.64	0.00	8.00
AbsenceOfCorruption	0.47	0.44	0.22	0.09	1.00
BasicWelfare	0.56	0.59	0.21	0.14	0.94
ClimateRisk	69.82	64.83	30.00	2.33	109.50
ANS	7.11	7.48	13.51	- 39.56	38.39
GDP (billions)	600.80	80.55	2,018.76	1.05	18,120.71
N = 119 observations					

*Table 3 - Descriptive Statistics for the Second-Step Regression*

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
GBRatio	0.0082	0.0042	0.0097	0.0001	0.0446
EPIYale	68.32	70.26	11.95	30.57	87.42
CreditInfo	7.08	7.00	0.89	5.00	8.00
AbsenceOfCorruption	0.65	0.66	0.21	0.11	1.00
BasicWelfare	0.74	0.79	0.17	0.27	0.94
ClimateRisk	66.38	62.59	25.22	18.33	109.50
ANS	11.20	10.24	7.49	-7.50	34.14
GDP (billions)	1,581.98	479.21	3,280.74	22.57	18,120.71
N = 40 observations					

From comparing the values in Tables 2 and 3, we can observe that the mean values of *EPIYale*, *CreditInfo*, *BasicWelfare*, *AbsenceOfCorruption*, *GDP* and *ANS* are higher when considering only the countries in which there has been green bond issuance.

## 5. Methodology

The methodology used in this study consists of a two-step econometric analysis.



In the first-step, to answer **RQ1**, we estimate the following model:

$$GBDumy = \beta_0 + \beta_1 EPIYale + \beta_2 BasicWelfare + \beta_3 CreditInfo + \beta_4 AbsenceofCorruption + \beta_5 ClimateRisk + \beta_6 GDP + \beta_7 ANS \quad (2)$$

Because *GBDumy* is a dichotomous variable, we run a binary logistic regression to estimate this model.<sup>2</sup> The coefficients on the explanatory variables ( $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ ,  $\beta_4$  and  $\beta_5$ ) measure the effects we are trying to estimate.

In the second-step, to answer **RQ2**, we estimate the following model:

$$GBRatio = \beta_0 + \beta_1 EPIYale + \beta_2 BasicWelfare + \beta_3 CreditInfo + \beta_4 AbsenceofCorruption + \beta_5 ClimateRisk + \beta_6 GDP + \beta_7 ANS \quad (3)$$

Because *GBRatio* is a continuous variable, we run an ordinary least squares (OLS) regression to estimate this model. The coefficients on the explanatory variables ( $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ ,  $\beta_4$  and  $\beta_5$ ) measure the effects we are trying to estimate.

We ran a univariate analysis through a series of Spearman correlation tests to investigate the correlation between the variables. The results are presented in Annex V.

## 6. Empirical Results

### 6.1. Main Findings

#### 6.1.1. First-Step Analysis

Table 4 summarises the results of the binary logistic regression performed in the first-step analysis to evaluate the effect of the explanatory variables in the dependent variable – *GBDumy*. The coefficients should be interpreted in terms of odds ratio. Thus, a coefficient greater than 1 for an explanatory variable means that its effect on the outcome variable is

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<sup>2</sup> Because we could here use either probit or logit, we tested both regressions and obtained very similar results. We chose to use logistic because it allows for an easier interpretation of coefficients in terms of odds ratios.

positive – the higher the value of the explanatory variable, the greater the probability of green bonds having been issued in the country.

Table 4 - Summarized results of the binary logistic regression (first-step)

	Model 1a	Model 2a	Model 3a
<b>Control</b>			
<i>GDP</i>	1.00*** (0.000)	1.00*** (0.006)	1.00*** (0.001)
<i>ANS</i>	1.03 (0.250)	1.00 (0.925)	0.98 (0.658)
<b>Explanatory</b>			
<i>EPIYale</i>		1.09* (0.071)	1.10* (0.096)
<i>BasicWelfare</i>		166.57* (0.090)	0.13 (0.604)
<i>CreditInfo</i>		2.16** (0.035)	2.62** (0.033)
<i>AbsenceOfCorruption</i>			2716.72*** (0.009)
<i>ClimateRisk</i>			1.01 (0.743)
LR	53.99***	85.05***	93.68***
Pseudo R <sup>2</sup>	0.36	0.56	0.62
			N = 119

Odds ratio reported

\* significant at 10%  
 \*\* significant at 5%  
 \*\*\* significant at 1%

Model 1a includes only the control variables – *GDP* and *ANS*. Model 2a includes three explanatory variables: *EPIYale* for environmental preferences, *BasicWelfare* for development, and *CreditInfo* for transparency and quality of the financial system. Model 3a further includes *AbsenceOfCorruption* and *ClimateRisk*.

The Pseudo R<sup>2</sup> increases consistently when we add more variables to the models and has a value of 0.36 for Model 1a, 0.56 for Model 2a, and 0.62 for Model 3a. The last result indicates that 62% of the variation in the outcome variable – issuance/no issuance of green bonds – can be explained by the proposed model.

In all of the models we ran, the odds ratio for *GDP* is statistically significant and has a value of 1.00, meaning that an increase in *GDP* has no effect in the probability of green bonds having been issued in a country.

In Model 2a, *EPIYale*, *BasicWelfare*<sup>3</sup> and *CreditInfo* have odds ratios that are statistically significant and greater than 1 – suggesting that stronger environmental preferences, higher stage of development and increased quality and transparency in the financial markets increase the probability of green bonds having been issued in a country.

In Model 3a, *EPIYale* and *CreditInfo* remain significant. Furthermore, *AbsenceOfCorruption*<sup>3</sup> has an odds ratio that is significant and higher than 1 – suggesting that lower levels of corruption increase the likelihood of green bond issuance in a country. In this model, *BasicWelfare* becomes not significant. However, this does not necessarily weaken the hypothesis that the stage of development has a significant effect on green bond issuance because *AbsenceOfCorruption* is a variable that is also strongly associated with the level of development.

Finally, the odds ratio coefficient on *ClimateRisk* is not significant, suggesting that there is not an association between the risk of climate change faced by a country and whether or not green bonds have been issued in the country.

### 6.1.2. Second-Step Analysis

Table 5 summarises the results of the OLS regression performed in the second-step analysis to evaluate the effect of the explanatory variables in the dependent variable (*GBRatio*).

Model 1b includes only the control variables (*GDP* and *ANS*). Model 2b includes three explanatory variables: *EPIYale* for environmental preferences, *BasicWelfare* for development,

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<sup>3</sup> The coefficients on *BasicWelfare* and *AbsenceOfCorruption* are high because the variables are expressed on a scale of 0 to 1.

and *CreditInfo* for transparency and quality of the financial system. Model 3b further includes *AbsenceOfCorruption* and *ClimateRisk*.

The Adjusted R<sup>2</sup> increases consistently when we add more variables to the models and has a value of 0.08 for Model 1b, 0.25 for Model 2b, and 0.26 for Model 3b, meaning that 26% of the variation in the outcome variable – adjusted volume of green bonds issued – can be explained by the proposed model.

*Table 5 - Summarized results of the OLS regression (second-step)*

	Model 1b	Model 2b	Model 3b
<b>Control</b>			
<i>GDP</i>	0.00000 (0.460)	0.00000 (0.633)	0.00000 (0.245)
<i>ANS</i>	0.00045** (0.029)	0.00045** (0.018)	0.00049** (0.013)
<b>Explanatory</b>			
<i>EPIYale</i>		0.00020 (0.153)	0.00029* (0.067)
<i>BasicWelfare</i>		0.01058 (0.306)	- 0.00709 (0.688)
<i>CreditInfo</i>		- 0.00168 (0.354)	- 0.00162 (0.374)
<i>AbsenceOfCorruption</i>			0.01457 (0.280)
<i>ClimateRisk</i>			- 0.00009 (0.200)
<b>Adjusted R<sup>2</sup></b>	<b>0.08</b>	<b>0.25</b>	<b>0.26</b>
			<b>N = 40</b>

Average marginal effects reported

\* significant at 10%  
 \*\* significant at 5%  
 \*\*\* significant at 1%

The coefficients in Table 5 are expressed in terms of average marginal effects, meaning that for a unit increase in the explanatory variable, the volume of green bonds issued in the country increases on average by the factor expressed by the coefficient, *ceteris paribus*.

In all of the models we ran, the marginal effect for *ANS* is statistically significant and has a positive value, meaning that a country with higher *ANS* has issued a greater adjusted volume of green bonds, on average *ceteris paribus*.

In Model 2b, all coefficients are statistically insignificant. However, in Model 3b, *EPIYale* has a positive and significant coefficient – suggesting that countries with stronger environmental preferences have issued on average a larger adjusted volume of green bonds, *ceteris paribus*.

## 6.2. Discussion

The results from our analyses provide evidence supporting the following statements:

- Green bonds issuance is more likely to have occurred in countries which are more developed and have less corruption.
- Green bonds issuance is more likely to have occurred in countries in which environmental preferences are stronger.
- Green bonds issuance is more likely to have occurred in countries in which the financial markets are more transparent and higher-quality.
- The climate risk a country faces does not affect the probability of green bonds having been issued in it.
- A country's environmental preferences have on average a positive marginal effect on the volume of green bonds issued, *ceteris paribus*.

From the results of the first-step regression, it seems that indeed our proposed model can answer **RQ1** and explain – even if to a limited extent – what characteristics seem to have an effect on the probability that green bonds have been issued in a country. However, the low Adjusted  $R^2$  for the second-step regression indicates that the model is less effective in answering **RQ2** and predicting the country characteristics that drive the volume of green bonds issued.

Regarding the effect of environmental preferences and the quality of financial markets on the green bonds' market, the authors were not able to find relevant literature. Still, it seems reasonable that countries with stronger environmental preferences and better financial markets are those in which green bond issuance is taking place. Further research that builds on these results is surely pertinent.

With regards to development, the main argument used by Banga (2018) is that developing countries have not yet been able to explore the green bonds market to the same extent that developed countries have.

Indeed, there is a relative agreement in the literature regarding developing countries' increased risk of suffering from the effects of climate change and their low capacity of funding climate mitigation and adaption (World Bank, 2018; Jacob et al., 2015). This challenge is much due to environmental sustainability competing with social and economic development in terms of funding, institutional framework and policies trade-off (Dercon, 2014; Barbier, 2016).

This study finds empirical evidence – specifically related to the green bonds market – that is consistent with this challenge faced by developing countries.

## 7. Limitations and Future Research

The results of this study should be considered in the context of its many limitations. Because the authors were not able to find similar studies to build on, this analysis consists of an original yet preliminary approach to try understanding the difference in green bond issuance between the different countries.

The analysis undertaken considers only green bond issuance and thus does not compare bond trading in the secondary market. Furthermore, we do not differentiate bonds regarding their issuer (government or corporate), rating, yield to maturity, callability, premium, issue size,

issue date or whether or not they went through second- or third-party verification of the green status.

Specifically, results of **RQ2** should be interpreted in the context of a selection bias – only countries in which there has been green bond issuance were included in the sample. Moreover, the sample considered is very limited, with only 40 individuals. These two issues – selection bias and small sample size – weaken the validity of the results. However, at present, these issues cannot be solved, as the sample size reflects the reality of green bond issuance. In a couple of years, once the green bond market matures and more countries become part of it, it might be interesting to repeat this assessment and hence obtain more robust results.

We limited our analysis to a set of characteristics we deemed to be relevant and for which we were able to find enough data. However, the model can be expanded, and some variables can be replaced. We did not aim to be exhaustive or absolute in our analysis but rather to propose an original approach to understanding the difference in green bond issuance between countries.

Another variable that could have been used as a proxy for a country's environmental preferences is the Climate Laws, Institutions and Measures Index, published by the European Bank for Reconstruction and Development in 2011. However, this data is available only for 95 countries and only for the year 2008 – which is why we chose to use *EPIYale*.

The World Bank presents a broad variety of information regarding the financial markets in different countries, and it would be interesting to investigate the effect of other variables on the issuance of green bonds. Specifically, we tried to include in our model the risk premium on lending, the lending interest rate and the interest rate spread. However, it was not possible to obtain valid results because the data was available only for a small group of countries.

A country's stage of development can also be measured by using a series of alternative variables, and it can be interesting to further explore how the different aspects of development affect the green bonds' market.

We also tried including more control variables, such as the country's bond market size and its GDP per capita. This led to worse econometric results (Pseudo R-squared, Log-Likelihood) and thus these variables were dropped.

Finally, further research can build upon the findings of this study, such as:

- An analysis from a demand-side perspective. Instead of comparing the issuance between the different countries, it would be interesting to examine which countries have invested more in buying green bonds. Because many bonds are issued in the international market and not directed to domestic buyers, this analysis could lead to different yet complementary results.
- A similar analysis which differentiates corporate and government bonds and evaluates if the results are significantly different from those presented in this study.
- An evaluation of the effects of green bond issuance in the countries' characteristics. As aforementioned, these instruments are new, and it is still early to evaluate the impact they are creating. However, in the future, it might be interesting to run a panel analysis and investigate if, in countries in which green bond issuance has been strong, environmental performance has improved, or climate risk has decreased.

## 8. Conclusions

While the green bond market has grown significantly in the last few years, issuance remains uneven between the different countries. In this paper, we found empirical evidence suggesting that the likelihood of green bonds having been issued is on average higher in countries which are more developed, have stronger environmental preferences, have more transparent and



better-quality financial markets and have less corruption. Our analysis fails to find a correlation between the likelihood of green bond issuance in a country and its exposure to the risk of climate change. Furthermore, conditional on green bonds having been issued in a country, we found evidence suggesting a positive correlation between the country's environmental preferences and the volume of green bonds issued in the country.

Finally, as previously acknowledged, our study has several limitations and should be considered as a preliminary empirical approach towards understanding what characteristics drive the green bonds' market in different countries. While there is room for more thorough investigation, much of it depends on the availability of new data – which makes this study an on-going research.

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## ANNEX I – List of countries in which green bonds have been issued until 2018

(Source: Bloomberg Terminal)

Argentina	Luxembourg
Australia	Malaysia
Austria	Mauritius
Belgium	Mexico
Brazil	Netherlands
Canada	New Zealand
Chile	Nigeria
China <sup>4</sup>	Norway
Colombia	Peru
Costa Rica	Poland
Denmark	Singapore
Estonia	Slovenia
Fiji	South Africa
Finland	South Korea
France	Spain
Germany	Sweden
Greece	Switzerland
India	United Arab Emirates
Indonesia	United Kingdom <sup>5</sup>
Ireland	USA
Italy	
Japan	
Latvia	
Lithuania	

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<sup>4</sup> Includes Taiwan and Hong Kong, which are listed separately in the Bloomberg Terminal.

<sup>5</sup> Includes Britain, Cayman Islands, British Virgin Islands, and Bermuda, which are listed separately in the Bloomberg Terminal.

## ANNEX II – List of countries included in the first-step regression

Albania	Ethiopia	Moldova	Sri Lanka
Algeria	Finland	Mongolia	Sudan
Angola	France	Morocco	Swaziland
Argentina	Georgia	Mozambique	Sweden
Armenia	Germany	Myanmar	Switzerland
Australia	Ghana	Namibia	Tanzania
Austria	Greece	Nepal	Thailand
Azerbaijan	Guatemala	Netherlands	Timor-Leste
Bangladesh	Guinea-Bissau	New Zealand	Togo
Belarus	Haiti	Nicaragua	Trinidad and Tobago
Belgium	Honduras	Niger	Tunisia
Benin	Hungary	Nigeria	Turkey
Botswana	India	Norway	Uganda
Brazil	Indonesia	Oman	Ukraine
Bulgaria	Iraq	Pakistan	United Kingdom
Burkina Faso	Ireland	Panama	Uruguay
Burundi	Israel	Paraguay	USA
Cambodia	Italy	Peru	Viet Nam
Cameroon	Jamaica	Philippines	Zambia
Canada	Japan	Poland	Zimbabwe
Chile	Kazakhstan	Portugal	
China	Kenya	Qatar	
Colombia	Kuwait	Romania	
Costa Rica	Latvia	Russia	
Croatia	Lebanon	Rwanda	
Cyprus	Lesotho	Saudi Arabia	
Dem. Rep. Congo	Liberia	Sierra Leone	
Denmark	Lithuania	Singapore	
Dominican Republic	Madagascar	Slovakia	
Ecuador	Malawi	Slovenia	
Egypt	Malaysia	South Africa	
El Salvador	Mauritania	South Korea	
Estonia	Mexico	Spain	

ANNEX III – List of countries included in the second-step regression

Argentina	Japan
Australia	Latvia
Austria	Lithuania
Belgium	Malaysia
Brazil	Mexico
Canada	Netherlands
Chile	New Zealand
China	Nigeria
Colombia	Norway
Costa Rica	Peru
Denmark	Poland
Estonia	Singapore
Finland	Slovenia
France	South Africa
Germany	South Korea
Greece	Spain
India	Sweden
Indonesia	Switzerland
Ireland	United Kingdom
Italy	USA

## ANNEX IV – Robustness Checks

To test the robustness of our findings, we add four extra variables to both our empirical models and check whether our results remain consistent.

Table 6 presents the variables included.

*Table 6 - Description of the Variables*

Variable	Description	Source
<i>Pop</i>	The country's 2015 population	World Bank 2015
<i>UrbanPop</i>	Country's percentage of urban population in 2015 (in %)	World Bank 2015
<i>FDI</i>	Net inflows of foreign direct investment into a country (in current US\$)	World Bank 2015
<i>GovCons</i>	Government's 2015 final consumption as a percentage of GDP (in %)	World Bank 2015

With the added variables, the expanded version of our first-step model becomes as follows:

$$\begin{aligned}
 GB\text{Dummy} = & \beta_0 + \beta_1 EPIYale + \beta_2 BasicWelfare + \beta_3 CreditInfo + \\
 & \beta_4 AbsenceofCorruption + \beta_5 ClimateRisk + \beta_6 GDP + \beta_7 ANS + \\
 & \beta_8 Pop + \beta_9 UrbanPop + \beta_{10} FDI + \beta_{11} GovCons
 \end{aligned} \tag{4}$$

With the added variables, the expanded version of our second-step model becomes as follows:

$$\begin{aligned}
 GB\text{Ratio} = & \beta_0 + \beta_1 EPIYale + \beta_2 BasicWelfare + \beta_3 CreditInfo + \\
 & \beta_4 AbsenceofCorruption + \beta_5 ClimateRisk + \beta_6 GDP + \beta_7 ANS + \\
 & \beta_8 Pop + \beta_9 UrbanPop + \beta_{10} FDI + \beta_{11} GovCons
 \end{aligned} \tag{5}$$

Again, we run a binary logistic regression for the first-step model and an OLS regression for the second-step model. Tables 7 and 8 present our results.



Table 7- Summarized results of the binary logistic regression (first-step)

Model 4a	
<b>Control</b>	
<i>GDP</i>	1.00 (0.221)
<i>ANS</i>	0.95 (0.244)
<i>Pop</i>	1.00 (0.263)
<i>UrbanPop</i>	1.04 (0.210)
<i>FDI</i>	1.00 (0.465)
<i>GovCons</i>	0.95 (0.578)
<b>Explanatory</b>	
<i>EPIYale</i>	1.13* (0.085)
<i>BasicWelfare</i>	0.02 (0.408)
<i>CreditInfo</i>	2.56** (0.050)
<i>AbsenceOfCorruption</i>	15067.15*** (0.006)
<i>ClimateRisk</i>	1.01 (0.639)
Pseudo R <sup>2</sup>	0.65
N = 118 <sup>6</sup>	
Odds ratio reported	* significant at 10% ** significant at 5% *** significant at 1%

Based on the results presented in Table 7, the effects of *EPIYale*, *CreditInfo* and *AbsenceOfCorruption* on *GBDummy* remain positive and significant, indicating that our results are indeed robust.

<sup>6</sup> When including the additional variable to perform the robustness check, we lose an observation (Trinidad and Tobago) due to lack of data and are left with 118 countries instead of 119.

Likewise, results presented in Table 8 show that our second-step model is also robust and suggest that conditional on issuance, the effect of environmental preferences on the volume issued is positive and significant.

Table 8 - Summarized results of the OLS regression (second-step)

Model 4b	
<b>Control</b>	
<i>GDP</i>	0.00093 (0.427)
<i>ANS</i>	$4.14 \times 10^{-8}$ (0.233)
<i>Pop</i>	40.84907*** (0.009)
<i>UrbanPop</i>	$- 8.78 \times 10^{-7}$ (0.669)
<i>FDI</i>	0.05768 (0.168)
<i>GovCons</i>	$1.30 \times 10^{-9}$ ** (0.046)
<b>Explanatory</b>	
<i>EPIYale</i>	$7.70 \times 10^{-8}$ * (0.023)
<i>BasicWelfare</i>	$- 1.05 \times 10^{-8}$ (0.701)
<i>CreditInfo</i>	$9.10 \times 10^{-8}$ (0.744)
<i>AbsenceOfCorruption</i>	$- 1.85 \times 10^{-10}$ (0.379)
<i>ClimateRisk</i>	$- 9.24 \times 10^{-7}$ (0.410)
Adjusted R <sup>2</sup>	0.61
N = 40	
Average marginal effects reported	* significant at 10% ** significant at 5% *** significant at 1%

## ANNEX V – Multicollinearity Matrix

	Univariate Analysis – Spearman Correlations								
	1	2	3	4	5	6	7	8	9
1. <i>GBDummy</i>	1.000***								
2. <i>GBRatio</i>	0.973***	1.000***							
3. <i>GDP</i>	0.653***	0.633***	1.000***						
4. <i>ANS</i>	0.192**	0.237***	0.312***	1.000***					
5. <i>EPIYale</i>	0.556***	0.589***	0.532***	0.250***	1.000***				
6. <i>BasicWelfare</i>	0.595***	0.622***	0.545***	0.344***	0.792***	1.000***			
7. <i>CreditInfo</i>	0.347**	0.314***	0.366***	0.221**	0.338***	0.269***	1.000***		
8. <i>AbsenceOfCorruption</i>	0.568***	0.595***	0.352***	0.276***	0.592***	0.769***	0.175*	1.000***	
9. <i>ClimateRisk</i>	-0.075	-0.056	-0.251	-0.108	0.195**	0.097	-0.146	-0.004	1.000***

\* significant at 10%

\*\* significant at 5%

\*\*\* significant at 1%