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How Large is the Sovereign Greenium?

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How Large is the Sovereign Greenium?*

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Abstract

This paper assembles a comprehensive sovereign green bond database and estimates the sovereign *greenium*. The development of green bond markets has been one of the most important financial breakthroughs in the domain of sustainable finance during the last 15 years. A central benefit associated with green bonds has been that they exhibit a positive green premium (*greenium*), i.e., a lower yield relative to a similar conventional bond. Yet, issuances at the sovereign level have been relatively recent and not well documented in the literature. We find that green bonds are issued at a relatively small premium (4 basis points on average) in Advanced Economies. Yet, importantly, the *greenium* is growing over time and is considerably larger (11 basis points on average) for Emerging Market Economies.

JEL Classification F34, G15, H63, Q01, Q58.

Keywords Green bonds, Sustainable finance, Financial innovation, Sovereign debt, Greenium, Climate change.

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1 Introduction

Financial markets will play a catalytic role in financing the adaptation and mitigation to climate change. Maltais and Nykvist (2020) show that green bonds in the private sector have become the most prominent innovations in the field of sustainable finance in the last fifteen years.[1] The literature often cites the bond issued by the European Investment Bank in 2007 as the first green bond (Cortellini and Panetta, 2021, OECD, 2021). Since then, international organizations, municipalities, and private sectors have increased the issuance. Yet, the issuances at the sovereign level have been relatively recent and not well documented in the literature. Until 2015, although the annual total issuance of green bonds had reached $40 billion, no issuance by central governments was recorded. In 2016, building on the momentum of the Paris Agreement adopted in 2015, Poland became the first issuer of sovereign green bonds. The issuance of these instruments could provide an additional source of stable financing with more favorable market access conditions, mitigate the stress of climate risks on public finances and facilitate the transition to greener low-carbon economies.

A central benefit associated with green bonds has been labeled as the green premium (*greenium*).[2] When a green bond exhibits a lower yield compared to a similar conventional bond without the green label, the green bond is said to exhibit positive *greenium*. Theoretically, the *greenium* can take either positive or negative signs. On one hand, the issuance amount and liquidity are smaller than conventional bonds, which could lead to a negative *greenium*. On the other hand, environmental, social, and governance investors' demand for green bonds and more information on the use of proceeds can justify a positive *greenium*. Thus, whether sovereign green bonds are issued and traded at a positive *greenium* is an empirical question.

Given that the issuance of green bonds at the sovereign level is a recent phenomenon, the literature analyzing their pricing is scarce and, to our knowledge, there are no comprehensive empirical studies of the sovereign *greenium*. This paper fills this gap and estimates the sovereign *greenium*

[1] Green bonds refer to debt securities issued to raise capital earmarked for green projects (see ICMA, 2021).
[2] Doronzo et al. (2021) discuss costs and benefits of sovereign green bond issuance.

using a comprehensive sovereign green bond database. First, we focus on the twin bonds issued by Denmark and Germany with the explicit purpose of measuring the *greenium*. The twin-bond analysis reveals that the *greenium* has been on average positive but small (around 3 bps), and even negative for some periods. Second, we compile a dataset of conventional and green bonds for the rest of the countries that did not issue twin bonds, and use it to estimate the *greenium* through panel regression analysis. In line with the results from the twin bonds, we find that the average *greenium* is small and positive (around 4 bps). However, we find significant variation in the estimated *greenium* depending on the country's stage of development and the currency of the bond: the estimated *greenium* is larger in developing economies and in foreign currency-denominated bonds. Finally, our analysis suggests that the *greenium* has been increasing over time. These results are consistent with those in Baker et al. (2022), who analyze the pricing of U.S. corporate and municipal green bond markets.

The rest of the article proceeds as follows. Section 2 presents the *greenium* for twin bonds. Section 3 presents the regression analysis and *greenium* estimates. Section 4 concludes.

2 Twin Bonds

Germany has issued twin bonds since 2020 to provide a benchmark of *greenium*. Twin bonds consist of a conventional bond and a green bond that share the same maturity date and coupon. The main difference is that the use of proceeds from the green bond is limited to green projects. They are, however, also different in that the green bond's issuance volume is smaller, and the issuance date is later. For example, in the twin bonds with maturity in 2030, the conventional bond was issued in August 2019 with a size of €30 billion, while the green bond was issued in May 2021 with a size of €6 billion. Through the issuance of twin bonds, Germany aims to establish the yields of green Federal securities as the reference for the Euro green finance market (German Finance Agency, 2022).

Table 1 presents the distribution of the sovereign *greenium* for all the twin bonds that have been issued so far. It shows that Germany's *greenium* is on average between 2 to 4 bps. As of October 2022, four German twin bonds are on the market with a maturity date in 2025, 2030, 2031, and 2050.

Figure 1: Twin bonds

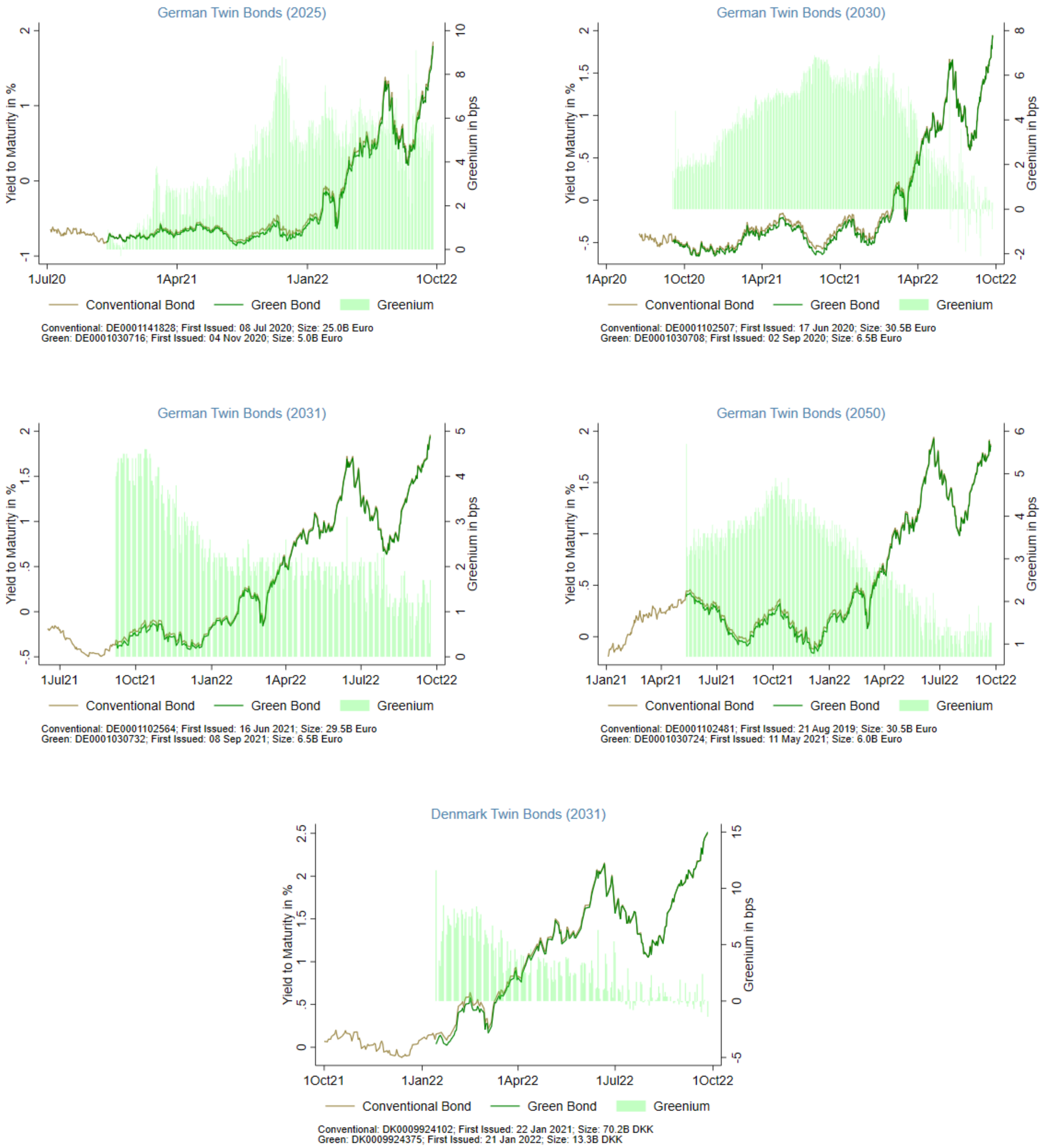


Table 1: Greenium (bps) of the 5 twin bonds.

Country	Maturity	mean	min	p25	p50	p75	max
Germany	2025	2.93	0.7	1.9	3.24	3.8	5.7
Germany	2030	2.34	0.3	1.8	2.1	2.7	4.6
Germany	2031	3.77	-2.1	2.0	4.3	5.4	6.9
Germany	2050	3.99	-0.3	2.5	4.3	5.6	9.1
Denmark	2031	2.92	-1.4	0.8	2.5	4.6	11.6

Coupons are zero for all bonds. Figure 1 shows that, although the *greenium* is mostly positive, it can turn negative when the yield dives, as can be seen in the twin bonds with maturity in 2030. Interestingly, the negative *greenium* does not happen in all maturities, although the time series of yield to maturity shares a similar pattern.

Following Germany's model, Denmark issued twin green bonds in January 2022.[3] Figure 1 shows that the first month recorded nearly 5 basis points of *greenium*, but it has been in a downward trend afterwards, and the sign sometimes turns negative in 2022Q3. Table 1 shows that the average sovereign *greenium* for the case of Denmark is 3 bps.

3 Panel Data Analysis

Since twin bonds are not available in other countries, *greenium* needs to be estimated with a different approach. In this exercise we estimate *greenium* using panel regression analysis, comparing the differences in the yield of green and conventional bonds. This section presents data sources, summary statistics of green versus conventional bonds, regression specification, and empirical results.

3.1 Data sources

Green bond data and local-currency-denominated conventional bond data are from Eikon. Conventional Eurobond data are from the IMF Sovereign Spread Monitor.

[3] To support the liquidity in the green bond, investors can switch the 10-year green twin bond to the corresponding and more liquid conventional bond one-to-one, but not vice versa.

3.2 Summary statistics

The sample includes 23 green bonds issued by 15 countries. Note that although there are 56 sovereign green bonds in the raw sample, only 23 green bonds are included in the estimation as we require the country to have issued a conventional bond denominated in the same currency as of the green bond. That is, if a country has issued a USD-denominated green bond but does not have an outstanding USD-denominated conventional bond, the green bond is dropped from the sample. Out of the 23 green bonds, the minimum maturity is 5 years, the maximum is 32 years, and 19 bonds have a maturity longer than 10 years. The conventional bond counterparts for each country in the sample are selected to cover the relevant years. The minimum maturity for conventional bonds is set as the minimum of the green bond minus 7 years, and the maximum maturity is set as the maximum of the green bond plus 7 years.

The final sample comprises 189 conventional bonds and 23 green bonds issued by 15 countries. 17 green bonds are denominated in euros by 11 countries, three green bonds are denominated in US dollars (issued by Chile and Egypt), and two green bonds issued by the UK and one by Sweden are denominated in their local currencies.

Annex Table 3 shows the summary statistics of issuance size, yield-to-maturity, spread, and maturity of the green and conventional bonds in the sample, separately for advanced economies (AEs) and emerging market and developing economies (EMDEs). Annex Table 4 shows the statistics for euro-denominated bonds. Below we document some of the most salient features we observe in our sample:

- $Issuance\ size$. Sovereign green bond issuance is still relatively small, about 2 percent of the total sovereign bond issuance in Eikon (2018-2020 average), including both sovereign green and conventional bonds. Nonetheless, the share is growing significantly from 2.6 percent in 2018 to 3.2 percent in 2021. The share of green bond issuance and the growth are larger in the EMDEs than in AEs.

- $Maturity$. The average maturity is longer for green bonds: 17 years for green bonds and 12.2 years for conventional bonds (Annex Table 5). This pattern is consistent with the idea that green bonds can help countries extend the maturity profiles of their debt. The long maturity is in line with the long-term payoff profile of green investments. The longer maturity of green bond debt is more pronounced in EMDEs, with a difference of almost 6 years.

- $Yield$. The summary statistics already indicate the presence of greenium: the average yield of green bonds is 13.2 basis point lower than conventional bonds in AEs and 181.4 basis points lower in EMDEs. The regression analysis will test the significance of this *greenium*.

3.3 Regression Specification

The baseline panel regression specification is as follows:

$$y_{ijt} = \beta\, \mathbb{I}.Green_{ijt} + \gamma_1 Tenor_{ijt} + \gamma_2 Spread_{ijt} + \alpha_j + \alpha_t + \epsilon_{ijt}, \tag{1}$$

where the dependent variable is Z-Spread of bond i of country j at time t, $\mathbb{I}.Green$ is a dummy variable for a green bond. Z-Spread is defined as the number of additional basis points to the Treasury yield curve so that the net present value of the bond equals the market price of the bond. Compared to yield to maturity, the Z-Spread uses the entire yield curve in valuation and thus provides a more realistic valuation of the bond.

The baseline control variables include the remaining maturity $Tenor_{ijt}$ to control for term premium, bid-ask spread $Spread_{ijt}$ to control for liquidity, country fixed effects α_j to control for time invariant country characteristics, and time fixed effects α_t to control for common time-varying movement in yields. We are interested in the estimate of β as it measures the significance of the *greenium*: the difference in the yield suggested by Z-spread of green versus conventional bonds controlling for maturity and liquidity differences.

Table 2: Greenium Estimation

Dependent = Z Spread	(1) All	(2) EUR/USD	(3) AEs	(4) EMDEs
Green	-4.06***	-3.66***	-2.74***	-11.55***
	(0.74)	(0.78)	(0.18)	(1.41)
Remaining Tenor (months)	0.24***	0.24***	0.12***	0.36***
	(0.00)	(0.00)	(0.00)	(0.01)
Bid-Ask Spread (BPS)	0.75***	0.68***	0.56***	-0.27*
	(0.11)	(0.11)	(0.04)	(0.15)
Country FE	Y	Y	Y	Y
Week FE	Y	Y	Y	Y
Currency FE	Y	Y	Y	Y
R^2	0.85	0.85	0.89	0.87
Bond-Day	70,839	65,349	40,880	29,959
Bonds	118	100	71	47
Green Bonds	23	20	15	8
Countries	15	13	10	5

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

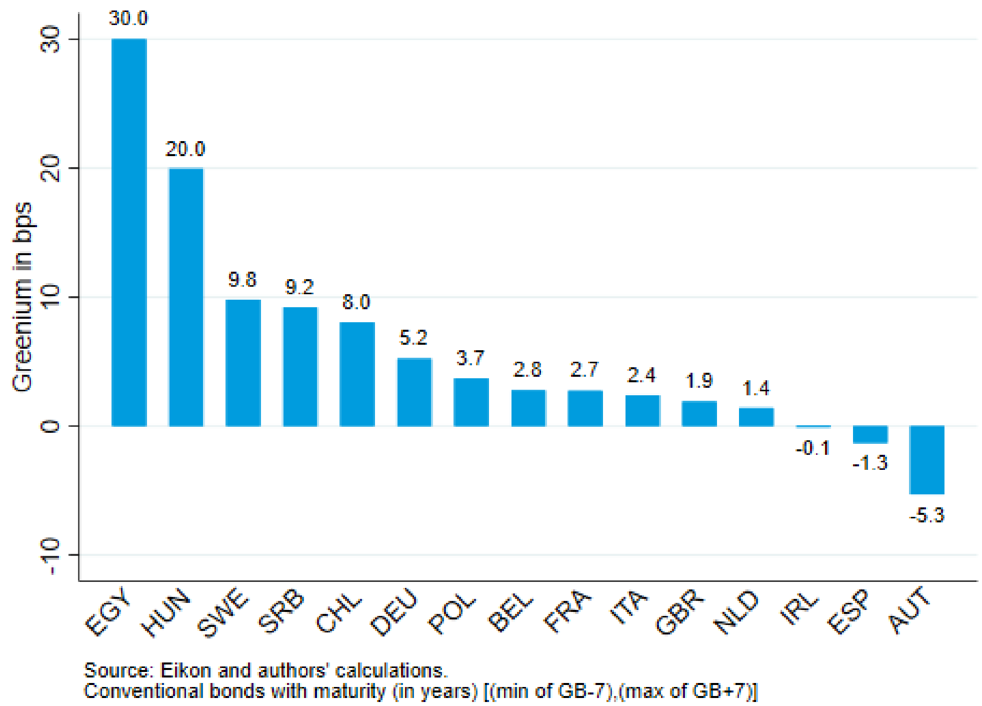
3.4 *Greenium* estimate

The estimated average greenium is 4.06 basis points as shown in Column (1) of Table 2. Columns (3) and (4) show that the average *greenium* in EMDEs is larger at 11.55 bps compared to 2.74 bps in AEs. To ensure that the estimated *greenium* is not coming from currency risk premia, column (2) shows the estimate when the sample is comprised of euro- and USD- denominated bonds. The result is robust: the estimated *greenium* amounts to 3.66 basis points.

By country estimate. In addition to the panel regression, we also estimate the *greenium* in each country using the same specification as in 1 but without country fixed effects. As shown in Figure 2, Egypt has a particularly high *greenium* of 30 bps, followed by Hungary with a 20 bps *greenium*. Overall, the estimated *greenium* is positive in 12 out of 15 countries in the sample.

Synthetic estimation method. As an alternative method, we estimate the yield of a counterfactual conventional bond that has the same characteristics as a greenbond. First, a regression of

Figure 2: Greenium Estimation by Country.



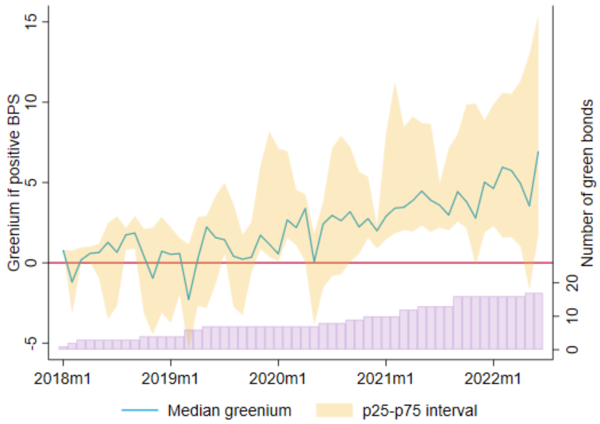
Z-Spread on tenor, bid-ask spread and weekly fixed effects using conventional bonds is run for each country. Then, the Z-Spread of a counterfactual conventional bond is predicted using the relevant information from the green bond and the coefficients obtained from the regressions.

As shown in Figure 3, this approach allows us to track the *greenium* estimates over time. For Euro-denominated green bonds, which are by far the largest currency of issuance, the median estimated *greenium* increases over time despite of a larger dispersion that might be due to more bonds being issued. We also find that USD-denominated bonds show an upward trend in its *greenium*.

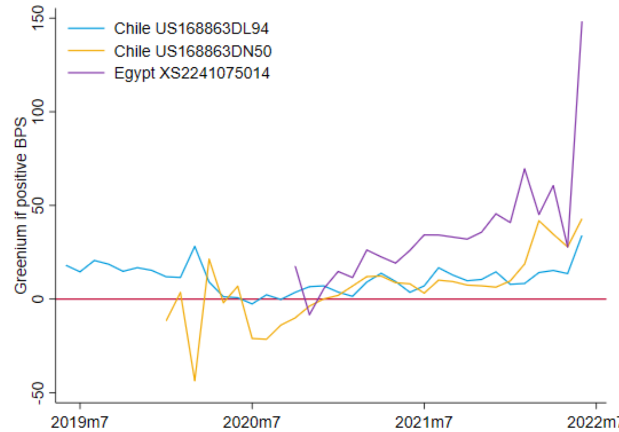
4 Conclusions

The growing popularity of green bonds may allow governments to issue bonds with longer maturities (given the longer horizon of green projects) and at a lower borrowing cost relative to conventional bonds: the *greenium*. However, the issuances at the sovereign level have been relatively recent and not well documented in the literature. This paper is the first empirical study to estimate the sovereign

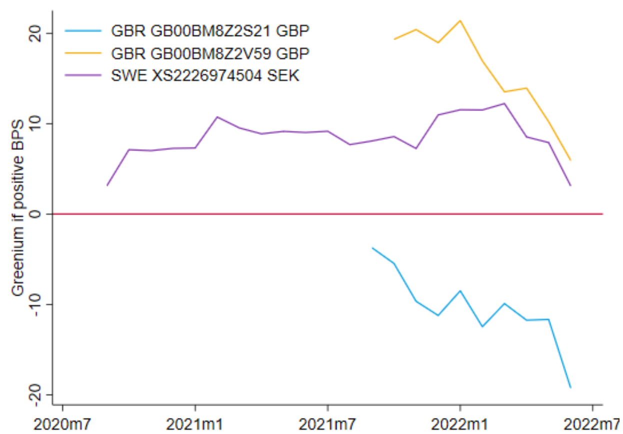
Figure 3: Synthetic Greenium Estimation.



(a) EUR Bonds



(b) USD Bonds



(c) Local Currency Bonds

greenium using both the twin bonds issued by Denmark and Germany, and panel regression analysis. While the estimated *greenium* in this paper is not large, it has been increasing over time alongside the level of sovereign green bond issuances. Whether the administrative costs associated with green bond issuance exceed the benefit is a country-specific question, but strengthening peer learning and climate information architecture could help reduce the costs and increase the benefits over time (Ferreira et al., 2021, Gao and Schmittmann, 2022). It remains an open question whether the purpose of the project associated with the green bond is a key determinant of the *greenium*, and whether green bonds have resulted in the climate outcomes they intended to achieve.

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A Appendix

Table 3: Summary Statistics by AE and Green.

	Green	Yield	Z Spread	Maturity
AE	0	64.39	-3.96	14.19
AE	1	51.18	-4.95	17.06
EMDEs	0	290.30	203.29	9.17
EMDEs	1	171.88	110.81	16.22

Table 4: Only Euro-denominated Bonds.

	Green	Yield	Z Spread	Maturity
AE	0	55.56	0.87	14.94
AE	1	47.64	-2.31	17.32
EMDEs	0	90.84	59.68	8.80
EMDEs	1	83.15	61.92	15.10

Table 5: Bond Maturity by Country (min-7,max+7)

	Green	N	Maturity	Min	p25	p50	p75	Max
AEs	N	136	12.3	1.0	4.0	8.0	17.5	50.0
AEs	Y	15	18.2	5.0	10.0	21.0	24.0	32.0
EMDEs	N	53	12.0	2.0	5.3	7.9	14.6	39.4
EMDEs	Y	8	14.9	5.0	8.0	11.0	22.5	31.0
All	N	189	12.2	1.0	5.0	8.0	15.0	50.0
All	Y	23	17.0	5.0	10.0	15.0	24.0	32.0
Total		212	12.7	1.0	5.0	9.0	20.0	50.0