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Environmental performance and sovereign bond yields

Evidence from emerging markets

by

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Abstract

This thesis analyses if investors price a country's environmental (E) performance into sovereign bond yields. The sample consists of 17 emerging countries from 2011 to 2020. Environmental performance is measured by aggregating 12 metrics from World Bank's Environmental, Social & Governance database to a single index using principal component analysis. The panel data model combines the E index and the usual macro-financial metrics key to assessing sovereign risk. The results show that environmental aspects also determine the level of compensation. This means that in addition to keeping a country's financials in line, extra-financial performance is crucial as well. Moreover, the magnitude of the index is only behind the first lag of the yield and the currency premium and is higher than S&P's credit ratings' coefficient. The result remains robust after altering the composition of the E index, controlling for the exchange rate, and adding the Human Development Index.

Keywords: sovereign yields, environmental performance, principal component analysis

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1 Introduction

In 2015 the Sustainable Development Goals and the Paris Agreement were introduced to stress the importance of a more sustainable way of life. Environmental, Social, and Governance (ESG) scores have become the key basis for measuring sustainability, which means that entities are assessed on those three levels. A growing amount of data has created research that studies ESG factors' impact on different financial instruments. In this paper, sovereign debt yields are in focus. Better use of its natural resources, a higher education level among its people and lower corruption levels indicate lower sovereign risk (Ciocchini et al. (2003); Hill Clarvis et al. (2014); Margaretic and Pouget (2018)).

One drawback is that research covers mainly developed economies where ESG practices have become the norm and reporting is even compulsory. This is supported by Morgenstern et al. (2022), who showed that ESG metrics' have higher significance in Europe than in other regions. In addition, papers from Friede et al. (2015) and Gerard (2019) show that ESG has mainly been related to stock performance which shows a clear focus on company-level. While coverage of sovereign risk has increased in the last ten years, the focus is similarly on advanced economies (Capelle-Blancard et al. (2019); Crifo et al. (2017)) or a mix of countries (de Boyrie and Pavlova (2020); Hübel (2022); Semet et al. (2021)). Boehm (2022) and Margaretic and Pouget (2018) are the few who have shifted their focus solely to developing countries. A better understanding of the relationship between ESG and emerging markets would help make better investment decisions. Moreover, Danila (2022) proposed that these countries could be the main source of ESG-focused investment opportunities for investors looking to make an impact.

This paper investigates the relationship between countries' environmental (E) scores and government bond yields among emerging markets. While all three components in ESG are important, Hill Clarvis et al. (2014) stress the importance of the environmental factors solely in sovereign bonds. This is supported by research (de Boyrie and Pavlova (2020); Dudás and Naffa (2020); Pineau et al. (2022); Semet et al. (2021)). In contrast, in studies of emerging markets (Margaretic & Pouget, 2018) and OECD countries (Capelle-Blancard et al., 2019), the E pillar was not statistically significant. While the samples of those two papers covered periods until 2010 and 2012, this research will use more recent data to examine whether investors have changed their perspectives and have begun pricing environmental factors into sovereign bond yields. The main difference of this paper is that instead of using an available E score, an index of 12 environmental variables is composed using principal component analysis similar to Capelle-Blancard et al. (2019). The results indicate that environmental performance is important, and a better score lowers the bond yields. Robustness checks further support this.

The remainder of the paper is sectioned into five parts. The <u>second</u> chapter gives an overview of sustainability and previous research. Data and methods are described in chapter <u>three</u>. Part <u>four</u> outlines the results from the regressions and <u>lastly</u>, robustness checks are conducted. The <u>final</u> part gives the concluding remarks.

2 Background

2.1 Change towards sustainability

A transition to a more sustainable economy has gained momentum in the 21st century. The change also shifts the attention to investments that align with it. This is supported by the United Nations Principles for Sustainable Investing, which provide a framework for incorporating Environmental, Social, and Governance (ESG) factors into investment decisions to create a more sustainable global financial system whose objectives are aligned with those of society as a whole (UN, n.d).

Investing is always associated with different types of risks. Climate change brings about two new types of risks: transition and physical. The first can be tied to a specific event that could destroy assets, and the latter is caused by long-term climate changes that could disrupt, for example, supply chains. U.S. Environmental Protection Agency lists four categories of transition risks. These can prevail through some regulatory, technological, market or reputational changes that, in the end, could fail some business models and create stranded assets. Physical risk can be either acute or chronic. These are the risks that investors also need to account for in addition to the risks usually associated with investments (business, systemic, default risks).

The shift to sustainable investments has also yielded two opposing types of ESG investors, according to Chatzitheodorou et al. (2019). Investors exploit E and S for profit or are driven by social and value-based motivations. Morgenstern et al. (2022) note that ESG investments' popularity might stem from the reduction of transition and physical risks due to higher ESG compliance and showing altruistic motives, similar to the second type of investors Chatzitheodorou et al. (2019) proposed.

2.2 ESG in research

Sustainability's importance and data availability have opened a new research field that tries to see whether abnormal profits could be obtained when incorporating non-financial information like ESG (e.g., socially responsible investments vs conventional). Private rating agencies like MSCI, S&P, and Moody's have begun computing and publishing ESG scores. Higher scores indicate better compliance with the changing environment and protection against transition and physical risks. Although using those readily available and easy-to-grasp scores in analyses is convenient, they may also carry problems. Larcker et al. (2022) identify three of those. First, completeness focuses on missing data and uneven reporting of metrics. Secondly, standardization deals with values reported in different scales. Lastly, consistency might not be followed since the area is relatively new and modifications to improve calculations affect comparability. Halbritter and Dorfleitner (2015) tested the relationship between ESG and financial performance using three different ESG ratings. They concluded that those three ratings did not provide consistent aggregate or individual pillar-level results. This is also supported by Anand et al. (2023).

Research on ESG and financial performance is skewed towards corporations and stocks. Friede et al. (2015) analyzed more than 2000 empirical studies involving ESG and financial performance, where 36 of those covered corporate bonds. The authors reported that 64% of those found a positive link; the rest were neutral or presented mixed results. Gerard (2019) focused specifically on corporate fixed-income studies. He stated that this asset class is much more limited in number of research compared to stocks, as is illustrated by the previous example. Overall, the author concludes that the results are mixed. He proposes this could be the case because ESG might already be priced into markets. On the other hand, it could yield from the previously mentioned case that results can depend on the data provider's choice. Based on these findings, this thesis will shift focus to debt, specifically sovereign.

2.3 Sovereign risk

Sovereign debt is a government's debt used to finance the issuer's undertakings. Eaton and Gersovitz (1981) proposed that sovereign debt is repaid mostly because of reputation, which offers some security for future financing. Reinhart et al. (2003) added that history also matters since past defaults make future ones more likely. Dufrénot et al. (2016) note that only macro-financial metrics could underestimate financial stress. Moreover, according to Di Cesare et al. (2012) analysis, the sovereign bond yield spreads have reached levels far higher than what could be justified considering macroeconomic and fiscal fundamentals for numerous countries. These aspects could be arguments for including ESG in sovereign debt analysis.

On the one hand, if a country signals high sustainability, it shows commitment to long-term commitments, including debt repayment (Margaretic & Pouget, 2018). On the other hand, ESG could provide the additional explanatory power needed to assess government bonds fully. While all three aspects of ESG are important, Hill Clarvis et al. (2014) argue that the environmental pillar should have a much bigger focus in the sovereign bond analysis since, ultimately, all economic activity is dependent on the availability of ecosystem services. They propose that natural resource-related risks, their magnitude and the country's resilience provide a more accurate risk assessment.

Studies that link sovereign debt and ESG factors are relatively new, mainly from the last decade. Crifo et al. (2017) concluded that while higher ESG corresponded to lower bond spreads, credit ratings had a more substantial impact in absolute terms. This gives a notion that non-financial ratings are taken as compliments to financial ones. Capelle-Blancard et al. (2019) found that ESG impacted sovereign bond spreads and that governance had the most decisive impact out of the three factors. The social pillar was also significant, but environmental aspects were not priced into yield spreads. Tang (2017) and Hübel (2022) determined that ESG was also priced into sovereign credit default swap (CDS) spreads.

2.4 Extra-financial performance in emerging markets

The literature has had a higher focus on developed countries which is plausible since mandatory ESG reporting is becoming the norm. Moreover, better data availability and quality allow for better research. On the other hand, investments aim to profit, and emerging markets could offer more possibilities for abnormal returns because they seem more persistent, indicating inefficiency (Caporale et al., 2022). Moreover, researching emerging markets is necessary to base portfolio diversification decisions. Drut (2010) reports that while incorporating ESG metrics into sovereign bond investment decisions does decrease the number of diversification options, it does that at a meager cost. In addition, he demonstrates with a sample of 20 developed countries that improving a portfolio's E and S ratings do not cause a high diversification cost, but G does.

Some researchers have extended their work into emerging markets as well. Margaretic and Pouget (2018) examined 33 emerging economies' sovereign bond spreads and concluded that during 2001-2010 social and governance proved significant, but investors did not seem to think environmental factors were important. In a recent study, Boehm (2022) concluded that traditional and climate-related institutions affect sovereign creditworthiness in emerging markets. In addition, countries with lower institutional quality have been hurt substantially worse by temperature deviations from historical values. Pineau et al. (2022) showed that non-ESG factors and the environmental pillar were the critical variables for sovereign credit ratings in emerging and developing countries. Semet et al. (2021) concluded that the focus is on E when investors analyse sovereign risk after accounting for the income levels of different countries. The authors explain this because investors are more concerned with transition risks in developed countries, whereas emerging markets are more affected by physical risks. De Boyrie and Pavlova (2020) based their research on the framework developed by Hill Clarvis et al. (2014) and concluded that the first lag of the environmental score has a negative relationship with a country's CDS spread.

Although Boehm (2022), de Boyrie and Pavlova (2020), Pineau et al. (2022) and Semet et al. (2021) have found that environmental factors do play a role in sovereign credit assessment, results from both developed (Capelle-Blancard et al., 2019) and emerging countries (Margaretic & Pouget, 2018) raise a question whether investors have changed their perspectives on pricing the environmental performance of a country into its sovereign bond yields. This question is also supported by the argument for the E pillar from Hill Clarvis et al. (2014) and the low cost of diversifying based on the same pillar from Drut (2010).

3 Methodology

3.1 Dataset

The dataset covers 17 emerging countries from 2011 to 2020 using annual observations. The observed countries are Brazil, Chile, China, Colombia, the Czech Republic, India, Indonesia, the Republic of Korea, Malaysia, Mexico, Nigeria, Poland, Romania, South Africa, Thailand, Turkey and Ukraine. The countries were chosen from the most prominent emerging markets bond indices (Vanguard EM Government Bond ETF, JPMorgan GBI-EM index, iShares EM GB index fund) and the classification of emerging markets from Refinitiv. The limited sample and periods are due to data availability which among emerging markets is scarce. Data is collected from Bloomberg, World Bank, IMF and Refinitiv. The dependent variable is the 10-year government bond yield. Explanatory variables are composed of two parts: macro-financial and environmental factors.

3.1.1 Macro-financial variables

The first set consists of standard macro-financial metrics based on previous literature. These include both global and country-specific factors. The government's gross debt-to-GDP ratio indicates default risk because higher debt levels require more available funds to service it. Therefore, the expected relationship with yields is positive. GDP growth is essential since higher values indicate economic advancement, thus making debt repayments more probable. It is expected that higher growth will reduce yields. Inflation's impact can go either way. It can be good as it increases profits and tax revenue. On the other hand, high levels or high volatility signals instability and higher risk. The current account-to-GDP ratio indicates a country's competitive position and the ease at which a country can raise funds, according to Capelle-Blancard et al. (2019). The primary balance-to-GDP ratio shows how much a government spends on public services of the amount it collects as revenue to GDP. Trade openness is calculated by dividing the sum of imports and exports by GDP. Ferrucci (2003) argues that a lower ratio constrains the ability to generate a needed traded surplus to service the debt. Reserves-to-imports ratio assesses a country's liquidity position hence the access to credit. Those last four financial metrics are expected to impact sovereign bond yields negatively. Finally, credit ratings show creditworthiness and give insight into the probability of default. Credit ratings from S&P are converted into numerical values where default (SD) has the lowest value of 1, and the highest rating (AAA) corresponds to the value of 27. Table 1 shows the descriptive statistics of the macro-financial variables.

Table 1. Descriptive statistics of the dependent and explanatory variables.

	Mean	**Standard Deviation**	**Min**	**Max**	**Count**
10Y gov bond yield	5.097	3.100	0.414	16.092	169
GDP growth	2.817	3.630	-10.079	11.200	170
Debt/GDP	43.871	18.660	10.300	96.800	170
Inflation	4.650	5.003	-1.545	48.700	170
Current account balance/GDP	-0.823	3.653	-8.870	10.905	170
Primary balance/GDP	-1.108	2.101	-9.212	3.003	170
Trade/GDP	72.723	36.667	16.352	157.575	170
Reserves/Imports	65.432	35.375	10.763	183.018	170
S&P credit rating	18.076 (BBB)	3.518	8 (CCC-)	24 (AA)	170

All variables in Table 1 are presented in percentages except for S&P credit rating. There is one missing observation among the dependent variable. South Africa did not have data for 2018. The table illustrates the fact that the sample is diverse. While the average annual inflation over the whole sample is 4.65%, there are countries who have experienced disinflation and even annual price changes of nearly 50%. The same goes for credit ratings. On average, the score is in the investment grade level, but the lowest score (Ukraine in 2014) in the sample indicates a dependency on favourable settings to fulfil financial obligations, while the highest score (the Republic of Korea from 2016 to 2020) translates to very low probability to not meet its commitments according to S&P's scale (S&P, n.d).

3.1.2 Environmental variables

The second part consists of 12 environmental factors that compose an environmental score for each country for each time period. While there are 32 environmental factors in the World Banks ESG dataset, the final set of variables depended on data availability for the selected countries and periods. In addition, all metrics have the same directionality (a lower number indicates better performance).

Table 2 shows a complete list of used variables, and the descriptive statistics of those variables are in Table 6 in the Appendix. The chosen metrics cover vast areas in the field, like natural resources, water, emissions, forest and temperature.

Table 2. Variables that were used to construct the environmental performance index

	Variables used for the environmental index
E1	Adjusted savings: natural resources depletion (% of GNI)
E2	Annual freshwater withdrawals. total (% of internal resources)
E3	CO2 emissions (metric tons per capita)
E4	Cooling Degree Days
E5	Energy intensity level of primary energy (MJ/$2017 PPP GDP)
E6	Heating Degree Days
E7	Land Surface Temperature
E8	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
E9	Methane emissions (metric tons of CO2 equivalent per capita)
E10	Nitrous oxide emissions (metric tons of CO2 equivalent per capita)
E11	Population density (people per sq. km of land area)
E12	Tree Cover Loss (hectares)

3.2 Principal component analysis

Those 12 variables will be related to each other with principal component analysis (PCA), which allows to retain most of the variance while reducing the dimensionality. This paper relies on the methodology applied by Capelle-Blancard et al. (2019), with the difference of applying it to emerging markets instead of OECD countries and to a newer period. Nicoletti et al. (2000) and Pineau et al. (2022) have also used this method. Nicoletti et al. (2000) highlight the steps needed to get meaningful results from PCA: testing the data, extracting the factors, factor rotation and weights construction.

The data used in PCA is usually standardized before running the analysis since variance depends on the scale. For example, the nitrous oxide emissions average value over the whole sample is 0.4, while for tree cover loss, it is 402 841. After standardization, the data has to be tested for suitability. The Kaiser-Meyer-Olkin (KMO) test is used to assess sampling adequacy. Kaiser and Rice (1974) state that test values below 0.6 are insufficient, so there are better methods to continue with than PCA. The test yielded a value of 0.66 for this dataset. Another test is Bartlett's test of sphericity which measures the correlations in the dataset and tests whether the correlations between the variables are 0. This is important since the variables have to have common characteristics that eventually present themselves in the index. In this case, the homogeneity of variances is rejected with a p-value of 0.0. Those two test results allow to continue with PCA. However, it is important to note the relatively low value of the KMO test.

The components are formed by selecting linear combinations of the variables which maximize the variance. The first component always explains the highest amount, and all the following contribute less and less. The number of principal components in the final index is decided from the eigenvalues representing the variance explained compared to the original dataset. Kaiser

(1960) proposed the eigenvalue rule, which states that components with an eigenvalue greater than one should be included. The first four components had an eigenvalue greater than unity.

Next, the rotation of factors changes the loadings of those 12 individual metrics to improve interpretability. This analysis uses varimax rotation, as did Nicoletti et al. (2000) and Capelle-Blancard et al. (2019). The loadings are changed so that the number of indicators with salient loadings (over 0.4) on the same factor is minimized. This means that each variable is associated with at most one factor. After the rotation, the final composition of the components is defined by selecting the variables with the highest loadings. While variable E6 did not have a salient loading, it is still included, as done by Capelle-Blancard et al. (2019). The division of the variables between different components can be seen in Table 9 in the Appendix. The final loadings are obtained using normalized squared loadings, shown in Table 10 in the Appendix.

In order to combine those four individual components into a single index, their contributions to explaining the overall variation are calculated. These are shown in Table 11 in the Appendix. After that, contribution-weighted components are added together. Table 3. Ranking of the countries based on their final E score obtained from PCA shows the average E score from 2010 to 2019 (the regression uses the first lag of the index) and ranks the countries on that basis.

Table 3. Ranking of the countries based on their final E score obtained from PCA

Country	Average score	Rank
Chile	-0.668	1
Romania	-0.595	2
Ukraine	-0.372	3
Poland	-0.367	4
Czech Republic	-0.345	5
Turkey	-0.339	6
China	-0.103	7
Colombia	-0.003	8
Mexico	0.141	9
Nigeria	0.146	10
Indonesia	0.177	11
Korea	0.192	12
Malaysia	0.192	13
Thailand	0.326	14
South Africa	0.460	15
Brazil	0.574	16
India	0.586	17

This shows that in the current sample, on average, Chile is the best-performing country concerning environmental factors, while India is the worst. It is important to note that contrary to previous literature, a positive relationship between the dependent variable and the E score is expected since a lower score indicates better performance and lower risk, which should also lower the yields.

3.3 Panel regression

A panel regression is used after obtaining the environmental performance score for each period and country. A panel data model uses either fixed or random effects. Previous papers have used fixed effects models, assuming that some features are constant over time, entity, or both. This approach tackles the omitted variables bias, which can distort the estimations. Crifo et al. (2017), de Boyrie and Pavlova (2020), Boehm (2022) and Hübel (2022) controlled for both time and entity effects while Capelle-Blancard et al. (2019) did so only for time.

Equation 1. Formula for the panel data model

$$
\begin{aligned}
Yield_{i.t} = \beta_0 + \beta_1 E_{i.t-1} + \beta_2 Currency\ dummy_i + \beta_3 \frac{Debt}{GDP}_{i.t} + \beta_4 GDP\ growth_{i.t} \\
+ \beta_5 Inflation_{i.t} + \beta_6 \frac{CA}{GDP}_{i.t} + \beta_7 \frac{X+M}{GDP}_{i.t} + \beta_8 \frac{Reserves}{M}_{i.t} \\
+ \beta_9 Credit\ Rating_{i.t} + \beta_{10} \frac{PB}{GDP}_{i.t} + \beta_{11} Yield_{i.t-1} + \varepsilon_{i.t}
\end{aligned}
$$

Equation 1 shows the model set up for the regressions. CA denotes current account, X and M refer to exports and imports, respectively, and PB stands for primary balance. The subscript i refers to the country, and t to the period. The currency dummy does not have a time subscript since the currency is the same throughout the period.

The suitability of fixed effects will be tested with the Hausman test. In addition to the previously mentioned variables, a dummy variable for currency and the first lag of the dependent variable is added. The currency dummy is needed to account for the differences in currency in the dataset. Due to data availability, some yields are based on the country's local currency and some in US dollars. The first lag of the yields is vital due to the momentum effect, which refers to the persistence in financial data where increases are followed by increases and vice versa.

4 Analysis

4.1 Results

Table 4 shows the results from the regressions. First, a pooled OLS model is estimated. A pooled model does not consider the structure of panel data, and it is considered a good starting point and is usually taken as a reference. Wooldridge (2018) provides one approach to choosing a model for panel data. If a different sample for each period is selected, then pooled OLS should be used. On the other hand, when the same sample is observed over the periods, then fixed or random effect models will be more suitable. Based on this, different fixed effects and random effects models are fitted. Before continuing with panel data models, the pooled OLS showed problems with heteroskedasticity and autocorrelation, which cause inefficient estimators. Therefore, heteroskedasticity and autocorrelation consistent (HAC) estimators are applied to the following models.

From Capelle-Blancard et al. (2019), a model with time-fixed effects is tested first. Time effects are such characteristics that do not change across entities but do over time. Meaning in each period, their effect on different countries is the same. The results suggest that the time-fixed effects model is also suitable for emerging countries. The model explains nearly 90% of the overall variance in the dependent variable. The E index is statistically significant on a 5% level and has a positive sign, as expected.

The coefficient for environmental performance implies that an improvement (decrease) of one unit in the score lowers the sovereign bond yield by 43 basis points. Only the first lag of the yield and the dummy variable for the currency has a higher magnitude, suggesting that environmental performance substantially impacts yields. Contrary to the findings of Crifo et al. (2017), the current results show that the extra-financial measure has a more notable influence in absolute terms than traditional credit rating (43 bp vs 17 bp). This might be because of the reasoning Semet et al. (2021) provided, where emerging markets are more affected by physical risks than developed countries, and therefore, environmental factors have a significant impact.

In addition, the currency dummy is significant and indicates that investors demand a premium when investing in local currency. On the other hand, three explanatory variables (GDP growth, debt level and the current account balance/GDP) do not show statistical significance. Moreover, higher debt levels to GDP imply lower yields which does not follow economic logic. The latter is also the case in Crifo et al. (2017) results. The current account-to-GDP ratio also has an opposing relationship to what was expected.

The results show that multiple metrics are necessary when assessing emerging markets' government bond yields. In addition, the extra-financial environmental performance variable proved significant in the model, indicating that investors have begun incorporating this kind of extra-financial information when pricing sovereign bonds. The importance of environmental performance aligns with de Boyrie and Pavlova (2020), Boehm (2022) and Semet et al. (2021), but not with Capelle-Blancard et al. (2019) and Margaretic and Pouget (2018). In addition, it is interesting to point out that for OECD countries, only a handful of variables account for the majority of the variance found in the sovereign risk measure (Capelle-Blancard et al. (2019); Crifo et al. (2017)) whereas, for the emerging countries, the majority of chosen variables show significance.

As a confirmation, a random effects model is estimated to conduct the Hausman test to narrow down further the possible models to fit. The null hypothesis indicates that a random effects model is preferred over fixed effects one. The test's p-value was $1.4*10^{-18}$, which implies that the null hypothesis is rejected and a model with fixed effects should be used. This is in line with the results from Capelle-Blancard et al. (2019), Hübel (2022) and Margaretic and Pouget (2018).

Finally, other specifications test whether the overall model can be improved. Options are to control for both time and entity effects as did Crifo et al. (2017), de Boyrie and Pavlova (2020), Boehm (2022) and Hübel (2022) or only entity fixed effects which has not come across previous literature. Both specifications performed equally poorly for the current data, with an R^2 of 0.35 and 0.32, respectively. The models did not show the momentum effect and produced mixed signs for coefficients (varying across models and being against economic logic). Taking into account both time and entity fixed effects approach performed well for Crifo et al. (2017) and Hübel (2022), but the difference might come from samples and the difference in the dependent variable (23 OECD countries and yield spreads; 60 mixed countries and CDS spreads). These results justify the choice of the time-fixed effects model as the final one.

Table 4. Results from the regressions.

Model	Pooled OLS	Random	Fixed time
Intercept	**5.9461*** **	**5.9670*** **	**5.7531*** **
	(1.1941)	(1.0415)	(1.7997)
Yield $_{t-1}$	**0.5222*** **	**0.5210*** **	**0.5524*** **
	(0.0614)	(0.0763)	(0.1165)
E	0.4720	0.4721*	**0.4263** **
	(0.3303)	(0.2477)	(0.1899)
GDP growth	0.0247	0.0249	-0.0306
	(0.0309)	(0.0204)	(0.0397)
Debt/GDP	-0.0002	-0.0002	-0.0011
	(0.0076)	(0.0028)	(0.0024)
Inflation	**0.1088*** **	**0.1088*** **	**0.0941*** **
	(0.0264)	(0.0207)	(0.0177)
CA balance/GDP	-0.0169	-0.0170	0.0032
	(0.0352)	(0.0342)	(0.0291)
Primary balance/GDP	0.0009	0.0010	-0.0889*
	(0.0548)	(0.0664)	(0.0479)
Trade/GDP	**-0.0155*** **	**-0.0155*** **	**-0.0153*** **
	(0.0043)	(0.0029)	(0.0043)
Reserves/Imports	**-0.0096** **	**-0.0096*** **	**-0.0089** **
	(0.0039)	(0.0019)	(0.0036)
S&P credit rating	**-0.1851*** **	**-0.1859*** **	**-0.1719*** **
	(0.0475)	(0.0362)	(0.0544)
Currency dummy	**1.4160*** **	**1.4191*** **	**1.2839*** **
	(0.2846)	(0.3557)	(0.4530)
Nr of observations	166	166	166
Covariance Estimator	Unadjusted	Driscoll-Kraay	Driscoll-Kraay
R-squared	0.8572	0.8567	0.8872
P-value (F-stat)	0	0	0
Effects			Time

Standard errors are reported in the parentheses. Statistical significance is marked with *, **, *** which represent significance on a 1%, 5% and 10% level.

4.2 Robustness

In order to validate those obtained results, robustness checks are needed. The first robustness check uses an E index composed of principal components that do not consider that one variable. Here, three variations are conducted, and the results are presented in Table 5. As mentioned in the PCA methodology section, one of the 12 variables did not have a salient loading but was included. This approach does not change the initial results where investors also favour better handling of environmental aspects and lower the demanded yield.

Hübel (2022) included currency returns when examining CDS spreads. Therefore, the second regression includes each country's local currency's spot exchange rate to the US dollar. Accounting for the exchange rate could be necessary since the global trade currency is usually the US dollar. Thus, the rate is significant in determining a country's purchasing power and affecting its capabilities to trade. This addition is statistically significant, but the impact of the change in the exchange rate on government bond yields is almost non-existent. The E index is still statistically significant.

The third variation includes the Human Development Index (HDI) by the United Nations. This index was used by Margaretic and Pouget (2018) when assessing the social (S) pillar's impact on sovereign bond spreads in emerging markets. Here, incorporating social aspects of a country yields statistically significant results, and a higher performance lowers the dependent variable. On the other hand, the E index's coefficient has increased by 50% while remaining significant, although at a 10% level. The higher coefficient is consistent with the results from Semet et al. (2021), who report that E dominates S. The loss of significance might confirm the results from Capelle-Blancard et al. (2019) and Margaretic and Pouget (2018) hat on the pillar level, E loses its importance when more extra-financial aspects are taken into account as well. The impact of the S pillar is consistent with the results from Margaretic and Pouget (2018) that the relationship is negative.

Overall, the results are robust to the chosen specifications. Incorporating other non-financial metrics in the regression might change the environmental factor's importance, as demonstrated by including the HDI. In addition, the relatively small sample by entity and time and the low value from the KMO test might make the model and the E index more sensitive to additional specifications.

Table 5. Results from robustness checks.

Added variables	**E (11 variables)**	**FX rate to USD**	**HDI**
Intercept	**6.2842*****	**6.8641*****	**10.587*****
	(-1.6954)	(-1.6338)	(-2.2735)
CA balance/GDP	-0.0041	0.0046	-0.0356
	(-0.0311)	(-0.0309)	(-0.0322)
E (12 variables)		**0.9290*****	0.6452*
		(-0.3351)	(-0.3631)
E (11 variables)	**0.8871****		
	(-0.3471)		
GDP growth	-0.0188	-0.0116	-0.0557
	(-0.0415)	(-0.042)	(-0.0346)
Primary balance/GDP	**-0.0950****	-0.0952*	-0.0541*
	(-0.0442)	(-0.0492)	(-0.0289)
Reserves/Imports	**-0.0092*****	**-0.0100*****	**-0.0108*****
	(-0.0032)	(-0.0031)	(-0.0033)
Trade/GDP	**-0.0161*****	**-0.0179*****	**-0.0113*****
	(-0.0039)	(-0.0042)	(-0.0032)
S&P credit rating	**-0.1873*****	**-0.1965*****	**-0.1398*****
	(-0.0491)	(-0.0446)	(-0.0441)
Currency dummy	**1.2433*****	**1.1836*****	**1.2072*****
	(-0.4062)	(-0.3877)	(-0.3601)
Debt/GDP	**-0.0059****	**-0.0074*****	-0.0027
	(-0.0025)	(-0.0024)	(-0.0035)
Inflation	**0.0970*****	**0.0947*****	**0.0938*****
	(-0.0189)	(-0.0162)	(-0.026)
$Yield_{t-1}$	**0.5526*****	**0.5400*****	**0.4581*****
	(-0.1028)	(-0.097)	(-0.1179)
FX rate to USD		**$-5.211*10^{-05}$*****	
		($-6.477*10^{-06}$)	
HDI			**-6.3660*****
			(-1.2872)
Nr of observations	166	166	166
Covariance Estimator	Driscoll-Kraay	Driscoll-Kraay	Driscoll-Kraay
R-squared	0.8904	0.8906	0.8926
P-value (F-stat)	0	0	0
Effects	Time	Time	Time

Standard errors are reported in the parentheses. Statistical significance is marked with *, **, *** which represent significance on a 1%, 5% and 10% level.

5 Conclusion

The Sustainable Development Goals, the Paris Agreement and Principles for Sustainable Investing are all frameworks which help guide the global economy to a more sustainable one. The introduction of Environmental, Social & Governance (ESG) metrics and scores have enabled the comparison of compliance to the transition. Moreover, seeking an abnormal profit by integrating extra-financial metrics has gained momentum. While the data availability has skewed research towards developed countries, corporations and stocks, papers focusing on sovereign instruments have also emerged.

Since governance has been studied broadly in corporate finance before ESG surfaced and the argument for the importance of the E pillar by Hill Clarvis et al. (2014), this paper focused solely on the environmental aspect as have de Boyrie and Pavlova (2020) and Boehm (2022). Since ESG scores from different data providers might change results (Halbritter & Dorfleitner, 2015), 12 individual environmental metrics from World Bank were collected and aggregated into a single index with principal component analysis. The difference from previous papers is that the chosen variables all show better performance when their value is lower. Thus, the expected relationship with yields is positive. Data from 17 emerging market countries over the period of 2011 to 2020 showed that environmental factors are being priced into sovereign bond yields, and a better (lower in this paper) score lowers the compensation required by investors. The long-term thinking aligns with investors' interests, which lowers the expected rate of return. In addition, it makes economic sense since a better handling of natural resources should signal long-term thinking and reduce the threat of exploitation for a short-term profit. The result was robust when considering the local currency's spot rate to the US dollar, the social pillar and modifying the composition of the E index.

In conclusion, the paper focused on a very relevant topic, sustainability, and contributed to the limited research on sovereign bonds and emerging markets. While the results show that investors price environmental performance into yields, it was seen that the inclusion of the S indicator changed the results of the E index. In addition, there is no official method to aggregate those individual E metrics into an index. Thus, a more comprehensive sample and different methods would be needed to validate those results. Overall, the outcome of this study indicates that environmental aspects are important on a sovereign level and provide insights into emerging markets' sovereign bond yield composition.

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Appendix A

Table 6. The descriptive statistics of the E components (not standardized)

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
Mean	2.220	18.627	5.018	2 585.625	4.829	3 098.662	23.978	29.314	0.986	0.403	141.256	402 840.888
Standard Deviation	2.143	13.785	3.110	2 086.373	1.842	2 960.155	7.085	23.108	0.409	0.154	133.838	800 832.060
Min	0.001	0.737	0.554	74	2.140	0	10.938	1.423	0.439	0.187	22.869	7 659
Max	9.271	45.022	12.225	6 182.060	10.260	8 648.070	34.437	85.222	2.136	0.881	530.377	5 378 844

Table 7. Correlation matrix of the used variables

	Yield	Yield t-1	E (12 variables)	E (11 variables)	GDP growth	Debt/ GDP	Inflation	CA balance/ GDP	Trade/ GDP
Yield	1								
Yield t-1	0.895***	1							
E (12 variables)	0.21***	0.183**	1						
E (11 variables)	0.211***	0.184**	1	1					
GDP growth	-0.03	-0.062	-0.016	-0.013	1				
Debt/GDP	0.337***	0.358***	0.558***	0.56***	-0.249***	1			
Inflation	0.587***	0.543***	0.005	0.007	-0.201***	0.277***	1		
CA balance/GDP	-0.253***	-0.271***	0.252***	0.254***	-0.068	0.231***	-0.126*	1	
Trade/GDP	-0.436***	-0.433***	-0.264***	-0.266***	-0.045	-0.196**	-0.242***	0.396***	1
Reserves/Imports	-0.203**	-0.197**	0.308***	0.31***	0.028	0.348***	-0.162**	0.233***	-0.352***
S&P	-0.722***	-0.712***	-0.144*	-0.145*	0.207***	-0.269***	-0.587***	0.351***	0.34***
PB/GDP	-0.127*	-0.16**	-0.025	-0.026	0.364***	-0.225***	0.061	0.075	0.251***
HDI	-0.751***	-0.727***	-0.496***	-0.499***	-0.119	-0.331***	-0.386***	0.109*	0.564***
FX rate to USD	-0.082	-0.071	0.106	0.11	0.095	-0.181**	-0.033	-0.107	-0.259***

Statistical significance is marked with *, **, *** which represent significance on a 1%, 5% and 10% level.

Table 8. Tabel 7 continued

	Reserves/ Imports	S&P	Primary balance/ GDP	HDI	FX rate to USD
Yield					
Yield t-1					
E (12 variables)					
E (11 variables)					
GDP growth					
Debt/GDP					
Inflation					
CA balance/GDP					
Trade/GDP					
Reserves/Imports	1				
S&P	0.25***	1			
PB/GDP	-0.214***	0.1	1		
HDI	-0.103	0.553***	0.193***	1	
FX rate to USD	-0.009	-0.073	0.019	-0.162**	1

Statistical significance is marked with *, **, *** which represent significance on a 1%, 5% and 10% level.

Appendix B

Table 9. PCA results based on rotation of factors.

	Principal Component 1	Principal Component 2	Principal Component 3	Principal Component 4
E1	**0.495***	-0.590	-0.125	0.141
E2	-0.082	**0.823**	-0.273	0.348
E3	-0.571	0.252	-0.015	**0.537**
E4	**0.930**	-0.047	0.068	-0.173
E5	-0.052	0.149	-0.103	**0.461**
E6	-0.941	0.067	-0.170	**0.079**
E7	**0.951**	-0.010	0.051	-0.017
E8	-0.111	**0.865**	-0.237	0.347
E9	0.278	-0.338	**0.855**	0.136
E10	-0.307	-0.339	**0.829**	-0.217
E11	0.097	**0.698**	-0.385	0.094
E12	0.246	-0.045	**0.667**	-0.243

*Loadings in bold represent salient loadings and the allocation of the variable to the specific component.

Table 10. Normalized squared factor loadings

	Principal Component 1	Principal Component 2	Principal Component 3	Principal Component 4
E1	0.122			
E2		0.354		
E3				0.569
E4	0.430			
E5				0.419
E6				0.012
E7	0.449			
E8		0.391		
E9			0.392	
E10			0.369	
E11		0.255		
E12			0.238	

Table 11. Each components weight in the final index

	Principal Component 1	Principal Component 2	Principal Component 3	Principal Component 4
Weight	37.89%	28.05%	23.95%	10.11%