Sovereign bond yield spreads and sustainability: An empirical analysis of OECD countries

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Abstract. We study whether and how a country's environmental, social, and governance (ESG) performance relates to its sovereign borrowing costs in international capital markets. We hypothesize that good ESG performance plays an economic role: It signals a country's commitment to sustainability and long-term orientation and is a buffer against negative shocks, leading to lower sovereign bond yield spreads. Using a sample of 20 OECD countries over the period 1996-2012, we show that countries with good ESG performance are associated with lower default risk and lower sovereign bond yield spreads. Moreover, we show that the social and governance dimensions have a significant negative association with sovereign bond yield spreads, whereas the environmental dimension does not.

Keywords: ESG performance; sovereign bonds; sustainability; yield spreads

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1. INTRODUCTION

We investigate the drivers of sovereign bond yield spreads and focus on the role of sustainable development with respect to macroeconomic and financial conditions. There are two different strands of literature explaining why sustainability and sovereign bond spreads are related. The first builds upon investor preferences and values, which documents that although the main motives for an investment decision are guided by returns and diversification, an increasing number of investors are interested in the environmental, social, and governance (hereafter ESG) performance of their portfolio (Bénabou and Tirole, 2010; Kitzmueller and Shimshack, 2012). The second is primarily interested in financial performance and considers if non-financial factors in the investment process can bring improved profitability as well as better risk management (e.g. Galema et al., 2008; Lins et al, 2017). Some financial firms assume that ESG factors improve asset management in fixed income markets (Calvert, 2015; Hoepner et al., 2016). Investors may use ESG performance as a signal for the risk of losses when they consider lending money. As such, governments with poor ESG performance are more risky. Then, investors would require a higher interest rate to fund their debt. The quality of institutions determines how a government manages its debt (Icaza, 2016). When analyzing the relationship between bonds and ESG, most studies focus on corporate bonds (Godfrey et al., 2009; Bauer and Hann, 2011; El Ghoul et al., 2011; Hoepner et al., 2016). Few studies (Drut, 2010; Berg et al., 2016) investigate the relationship between ESG performance and sovereigns. This partly results from the lack of reliable data on ESG criteria and the absence of a clear methodology to assess ESG performance at a country level.

The validity of ESG data is highly disputed (e.g., Chatterji et al., 2009; Scholtens, 2017). We address this data issue by constructing a performance index from 18 different ESG indicators from reliable non-commercial providers for 20 OECD countries. We introduce a novel methodology for aggregating these indicators into four indexes, namely an environmental quality index, a social development index, a governance quality index, and a composite index. We analyze how a country's ESG performance relates to sovereign risk by exploring the link between overall ESG performance and sovereign bond spreads, and we decompose the impact along individual ESG factors. In a sensitivity analysis, we compare the role of ESG in euro member states to that in other OECD countries. In addition, we investigate whether the Global Financial Crisis altered the nature and/or strength of the ESG performance–sovereign risk nexus.

Our results illustrate the complexity of the economic relationship between a country's ESG performance and its sovereign risk. We find that ESG performance significantly and negatively relates to sovereign bond yield spreads. Both macroeconomic and ESG factors are priced by sovereign bond markets, with good ESG practices associated with less default risk and thus lower bond spreads. This implies that it is relevant to account for ESG performance when designing strategic asset allocation across countries. When considering the differentiated impact of the various ESG dimensions on sovereign bond yield spreads, we find that governance has a stronger impact than social performance, and that environmental performance appears to have no significant impact. Further, we establish that the relationship between sovereign risk and a country's ESG performance is stronger in euro member states than in other OECD countries. Last, is a stronger influence from ESG performance in the wake of the Global Financial Crisis.

The remainder of this paper is structured as follows. Section 2 investigates the literature and develops our hypotheses. Section 3 describes the data and provides descriptive statistics. Section 4 details our methodology. Section 5 describes the empirical results. Finally, Section 6 sets forth our conclusions.

2. BACKGROUND

Determinants of sovereign bond yields and spreads have been extensively investigated (Attinasi et al., 2009; Barbosa and Costa, 2010; Afonso et al., 2012; Poghosyan, 2012; D'Agostino and Ehrmann, 2013). In general, the literature concludes that sovereign bond spreads depend on fundamental conditions of the economy, most prominently in relation to government finances (Ardagna et al., 2007; Attinasi et al., 2009; Baldacci and Kumar, 2010; Beirne and Fratzscher, 2012; Aizenman and Hutchinson, 2013; Ghosh et al., 2013). For example, when public deficits and debt increase, sovereign bond yields soar in recognition of the higher risk (such as monetization-driven depreciation and inflation) carried by investors holding these securities. However, the literature is inconclusive regarding the dominant drivers of sovereign yield spreads and it seems that especially sovereign debt risks are underestimated (Dufrénot et al., 2016). Since the Global Financial Crisis (GFC), the relationship between sovereign bond spreads and macroeconomic fundamentals seems to have broken down. De Grauwe and Ji (2013) observe that the drop in spreads does not relate to changes in debt-to-GDP ratios. Poghosyan (2012) notes that despite the piling up of public debt in the US in the aftermath of the GFC, US bond yields have been trending downward. In contrast, despite a relatively low initial level of public debt, sovereign borrowing costs in some euro countries such as Spain have persistently exceeded those of more heavily indebted countries such as the UK. Thus, part of the spread is unexplained, and spreads seem to be higher than justified on fundamentals only (Di Cesare et al., 2012).

These findings have prompted renewed interest in the drivers of sovereign bond spreads. An increasing number of papers have set out to explore the use of qualitative factors as potential determinants of sovereign bond spreads. These factors may capture the "soft" aspects of a country's ability to service its debt obligations. This especially relates to the willingness—as opposed to the ability—of a country to pay interest, the flexibility of an economy and its growth capacity, the transparency of information, as well as a country's fiscal credibility and commitment to responsible borrowing. In this respect, it is important to realize that sovereigns wish to maintain a solid reputation to ensure access to financial markets. A more long-term orientation of a country signals its commitment to maintaining a good reputation and is associated with a lower likelihood of defaulting on its debt obligations (Eaton and Gersovitz, 1981). Nelson (2013) and Papanikos (2014) argue that financial markets consider a variety of qualitative indicators (such as government reputation or political issues), not just debt levels, when evaluating the manageability of a country's debt. In this respect, sustainable exploitation of natural resources and building up social capital could also reflect a long-term orientation of a country. In case of default, this would not only affect a country's opportunities to borrow money, it would also reduce the value of its environmental and social resources. In addition, these resources might act as a buffer against negative shocks. Thus, there is a clear case for focusing on ESG performance in relation to sovereign yields (Sachs, 2015).

Few researchers investigate the relationship between ESG performance and sovereign bond spreads. Berg et al. (2016) argue that environmental and social information helps to assess the expected value and volatility of sovereign bond spreads in emerging markets. However, these authors arrive at mixed findings as to how this information affects spreads and ratings. Scholtens (2017) argues that financial institutions should also account for ecological dimensions. He points to both positive and negative spillovers between financial and environmental performance. Accounting for these factors would inform financial institutions and their stakeholders about their societal and economic roles in a more efficient and effective manner. Gervich (2011) thinks environmental indicators may be an "early warning" system that can help predict a nation's financial collapse before it is predicted by conventional economic indicators. Further, sovereign bond spreads are sensitive to governance factors (i.e., the quality of legal institutions), as is evident when investigating country risk and ratings (Erb et al., 1996; Haque et al., 1998; Ciocchini et al., 2003; Butler et al., 2009; Bundala, 2013). Therefore, we hypothesize that ESG performance of a country is of economic relevance too. That is, it signals a country's long-term orientation and is a buffer against shocks. Countries with good ESG performance may have lower default risk and, hence, lower costs of debt. Thus, our first hypothesis is that countries with high ESG scores have lower bond yield spreads, and we test:

H1: There is a negative relationship between a country's ESG performance and sovereign bond spreads.

Chatterji et al. (2009) and Godfrey et al. (2009) argue that combining distinct features of sustainability to create "a single monolithic construct" dilutes the observable financial effects of unidimensional features. In particular, governance is frequently studied in connection with country risk (Erb et al., 1996; Haque et al., 1998; Ciocchini et al., 2003; Butler and Fauver, 2006; Afonso et al., 2007; Connolly, 2007). Therefore, we want to relate governance directly to sovereign bond spreads. We expect that if there is an impact, this shows up in the governance dimension of ESG. For equity markets, Edmans (2011) suggests a firm's social performance can be advantageous for its financial performance. However, thus far, social factors have not been studied in the context of bond markets. We feel they deserve attention as potential drivers of bond spreads, since they make up the stock of human and social capital in a country and, as such, contribute to potential productivity. This too would imply a negative relationship between social performance and bond spreads. As there is no prior research on this issue, any hypothesis can be only exploratory in nature. Regarding the environmental dimension, the risks that this factor poses to both firms and economic growth are well known, and the existing evidence supports the broader economic impact of climate change, pollution, loss of ecosystem services, large-scale environmental accidents, etc. (Grossman and Krueger, 1991; Heyes, 2000; Decker and Woher, 2012; De Haan et al., 2012). This too would result in a hypothesis that holds that there is a negative relationship between environmental performance and bond spreads. As to the scarce empirical literature on bond markets, UNEP (2011) is unable to establish a significant correlation between a country's ecological balance and its credit rating. Berg et al. (2016) find that environmental performance is sometimes positively associated with credit rating in emerging markets, but it shows a mixed relation with bond spreads. Although both social and environmental performance potentially influence economic performance, the relationship appears to be weak. This sets these factors apart from governance performance. Given the lack of theory and limited empirical evidence thus far, a hypothesis about how environmental performance relates to bond spreads will have an exploratory nature. Thus, we will test:

H2: The components of corporate social responsibility have a differential impact on sovereign bond yields.

3. DATA

3.1 Country ESG performance: ESG index

To construct the composite ESG index, we account for recommendations made in ESG analysis reports published by rating agencies and asset managers. These reports include VIGEO (2013), HSBC AM (2013), Natixis AM (2013), MSCI ESG Country Ratings (2013), and Neuberger Berman's emerging market debt team (2014) (see Table A.1.1 in the Appendix). Despite their wide use, there are concerns about the validity and reliability of these ratings (Chatterji et al., 2009). Most ESG ratings measure policy, and potentially merely symbolic activities, rather than actual reductions of environmental or social impacts and associated risks (Gonenc and Scholtens, 2017). In addition, while capturing a broad scope of potentially relevant issues, it is often ambiguous what actually gets measured. ESG ratings are not verified, validated, or replicable with the help of public information (Halbritter and Dorfleitner, 2015; Delmas et al., 2011). We aim to address some of these limitations and try to generate new insights as to whether, when, and which kind of ESG is value-relevant. To this extent, we do not rely on qualifications by ratings institutions, but select directly observable items. We feel this allows for a more coherent and transparent analysis.

To measure a country's environmental performance, we use World Development Indicators (WDI) proposed by the World Bank Group, which contain information on air quality, water and sanitation, forests, and renewable energy. Countries that perform well in this regard do their best to maintain and improve the environment. They show long-term commitment, which may positively relate to their willingness to pay off their debt (Eaton and Gersovitz, 1981). We also use the WDI dataset to obtain information on education, demography, health, employment, and gender equality. Here, countries performing well show commitment to their stock of human and social capital, which is regarded as long-term commitment as well (Lins et al., 2017). The data on democratic institutions and safety policy are from Kaufmann et al. (2005). Their dataset presents estimates of six dimensions of governance: voice and accountability, political stability and absence of violence, country effectiveness, regulatory quality, rule of law, and control of corruption. These dimensions positively associate with economic performance (Kaufmann et al., 2005; Butler and Fauver, 2006; Butler et al., 2009). Thus, in all, we have 18 items to assess ESG performance at the country level (six for each of the three dimensions; details are presented in Table A.1.2 of the Appendix). For the environmental and social items, we assume that better performance improves the quality of natural resources and the quality of social and human capital, respectively. For the six governance items, we assume that better performance in each reflects better quality of governance and institutions. The social and environmental variables especially relate to long-term commitment, whereas the governance variables are closer to the efficiency and effectiveness of economic processes. It might be that financial markets have more appreciation for the latter than the former because many market participants highly discount the future (Gollier, 2013; Zingales, 2015).

There is no generally accepted framework to relate the 18 items to sovereign yield spreads. Therefore, we construct an ESG index as a proxy and follow the method of Nicoletti et al. (2000), which relies on principal component analysis (PCA). PCA differs from other standard methods, such as a ranking-of-ranking approach that initially ranks countries according to each of the basic indicators, and then averages the individual ranking positions to produce a final country ranking. PCA differs from a subjective weighting scheme based on expert assessment of the importance of the data comprising the ESG analysis found in the literature to weigh composite indexes. In particular, it considers not only the first principal component to weight the index, but also the factor loadings of the consecutively extracted components. The advantage is that a larger proportion of the variance in the dataset is explained (Tabachnick and Fidell, 2007). Further, the estimates of the rotated factor loadings provide the key for aggregating the detailed indicators into factor-specific scores (see Tables A.1.3–A.1.5 in the Appendix). We construct summary indicators of the sub-domains by aggregating the detailed indicators using the weights estimated by means of factor analysis (see Table A.1.6 in the Appendix). The interpretation of these weights obtained by squaring and normalizing the factor loadings, is as follows: the squared factor loadings represent the proportion of the total unit variance of the indicator explained by the factor. We aggregate these summary indicators into a global index: the ESG index (ESGGI). Thus, the ESGGI results from factor analysis, in which each ESG component is weighted according to its contribution to the overall data variance. Hence, the ESGGI is an index that measures the sustainability performance of a particular country.

The sub-domain indicators used to build the ESGGI are the governance quality index (GOVI), the social development index (SODI), and the environmental quality index (ENVI). GOVI assesses regulatory effectiveness by including six sub-components: rule of law, political stability, voice of the people, corruption control, country effectiveness and regulatory quality. High scores signal a high degree of legal quality. SODI captures a country's effort in terms of human development and includes six sub-components: school enrollment secondary, life expectancy, health expenditure, ratio of female-to-male labor participation, gender parity index, and non-vulnerable employment. SODI is a measure of the degree of social welfare of a given country, with high scores signaling a high degree of social development. ENVI measures how well countries manage their natural resources and the degree to which they are concerned with their environment. ENVI includes six sub-components: air quality, wastewater treatment, sanitation, biodiversity, forest cover, and renewable energy. High scores signal strong environmental performance.

3.2 Sovereign bond yield spreads

Data on government bond yields are from Bloomberg. We calculate sovereign bond spreads as the difference between the interest rate the country pays on its external US dollar–denominated debt and the rate offered by the US Treasury on debt of comparable maturity (Hilscher and Nosbusch, 2010). Typically, we consider the yield on sovereign bonds of a particular country minus the yield on US sovereign bonds from the yield curve for a fixed maturity; both values relate to end-of-year. We treat the yield on the benchmark US bond as the risk-free rate or the numeraire over which the country's yield spread is computed. We use both 12-month and 10-year benchmark country bond yields from monthly data on secondary market bond yields.

3.3 Control variables

In line with the literature on the determinants of sovereign risk (Attinasi et al., 2009; Barbosa and Costa, 2010; Afonso et al., 2012; D'Agostino and Ehrmann, 2013), we include several macroeconomic covariates in our model (for a detailed description, see Tables A.2.1–A.2.3 in the Appendix). First is GDP growth rate, which is an indicator of the evolution of a country's wealth; relatively high values point to the debt burden becoming easier to bear in the future. Eichengreen and Mody (2000) and Cantor and Packer (1996) find that high country growth rates enhance the ability to repay debt, thus reducing spreads. Second is the inflation rate. According to Nickel et al., (2009) the impact of inflation on sovereign risk reflects two opposing effects. On the one hand, higher inflation rates increase the country tax base and reduce the real value of outstanding debt denominated in domestic currency. This should overall relax the country's financing constraints and result in a reduction of bond spreads on foreign currency borrowing. On the other hand, higher inflation rates, especially if in excess of certain thresholds, are associated with increased macroeconomic instability and would thus be harmful to a country's creditworthiness. The overall expected impact of inflation on yield spreads is thus ambiguous. To assess the fiscal condition of a country, we rely on two variables: total public debt and primary balance, both in relation to GDP. Countries with higher levels of debt and/or larger fiscal deficits would be considered less creditworthy and this would thus amplify default risk (Attinasi et al., 2009; Sgherri and Zoli, 2009; Gruber and Kamin, 2012). The expected impact of both variables on sovereign bond yield spreads is positive. An additional variable is the current account of the balance of payments, which will negatively affect country bond yields. This variable is an indicator of competitiveness and the ability to raise funds for debt servicing. Therefore, when it improves, sovereign spreads should decline and sovereign ratings rise. The expected impact of the current account balance is negative. An additional covariate is country openness, which plays an important role in explaining an economy's cost of borrowing, as the penalty for sovereign default is higher in terms of capital reversion in an open than in a closed economy. The higher this ratio, the greater the ability of the country to generate the required trade surpluses to refinance the present stock of debt, or to finance new debt. The expected sign of the coefficient is positive. The liquidity ratio measures access to credit in relation to national reserves. Here, we use the ratio of international reserves to GDP. The lower the ratio of international reserves to GDP, the greater the threat of a sudden liquidity crisis, and the lower the country rating (Edwards, 1983). The expected impact of this liquidity ratio is negative. Finally, the sovereign credit rating reflects a country's creditworthiness; relatively high values represent a lower probability of default. Afonso et al. (2012) find that sovereign credit ratings and outlook announcements have a statistically significant negative impact on spreads. The expected sign of this coefficient is negative.

Our sample comprises yearly observations regarding 20 countries from 1996 to 2014, resulting in 340 observations. The country sample consists of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Throughout our analysis, the US does not appear, as the yield on US bonds is the risk-free rate or numeraire by which we compute the country's yield spread. Lack of sustainability information constrains the inclusion of more countries and the examination of a longer period.

Table 1 gives the average ESG global index (ESGGI), as well as the average of the three sub-indexes for the 20 countries over the period 1996 to 2014. Further, it ranks these countries from the best performer (rank 1) to the worst. It shows that these countries have relatively high ratings for GOVI and SODI but obtain relatively poor ratings for ENVI. The variation in the ratings score is much larger for social and environmental than for governance. This reveals that even in this sample of high-income countries that are quite homogeneous from a wealth point of view, there are substantial differences regarding the three ESG dimensions. The Nordic countries, New Zealand and Canada are at the top, and Italy, Ireland, and Greece are in the bottom positions. To evaluate relationships involving ESG indexes, the Spearman's rank correlation of the aggregate index and its components is used; see Table 2. It shows the sub-indexes positively correlate: higher values of environmental quality are associated with better governance and/or more favorable social conditions. The correlations are far from perfect though; they range from 32% between ENVI and GOVI to 41% between SODI and GOVI; between SOCI and GOVI, this correlation is around 70%.

[INSERT TABLE 1 AND 2 ABOUT HERE]

4. MODEL AND METHOD

This section introduces the model and explains how we estimate it. Further, we discuss how we account for the robustness of our analysis.

4.1. Model specifications

In line with our hypotheses and building on the literature (Afonso et al., 2012; Beirne and Fratzscher, 2013), we model the link between ESG performance and sovereign risk using a standard panel model with country fixed effects.[2] In its most simple form, this approach relies on the following equation:

$$Y_{i,t} = \beta_0 + \beta_1 Y_{i,t-1} + \beta_2 ESG_{i,t-1} + \beta_3 \left(\frac{\Delta GDP}{GDP}\right)_{i,t} + \beta_4 \left(\frac{\Delta P}{P}\right)_{i,t} + \beta_5 \left(\frac{Debt}{GDP}\right)_{i,t} + \beta_6 \left(\frac{PB}{GDP}\right)_{i,t} + \beta_7 \left(\frac{CA}{GDP}\right)_{i,t} + \beta_8 \left(\frac{X+M}{GDP}\right)_{i,t} + \beta_9 \left(\frac{Reserves}{GDP}\right)_{i,t} + \beta_{10} S\&P_{i,t} \quad + \; \varepsilon_{i,t}. (1)$$

[2] We perform a Hausman test, which clearly indicates that a fixed effects model needs to be estimated instead of a random effects model. The results are available upon request.

where i = 1 to n (number of countries) and t = 1 to T (number of periods). Equation (1) models sovereign bond spreads. The spreads can be either 12-month bond spreads or 10-year bond spreads; they are regressed on a number of covariates incorporating country-specific fixed effects. We include lagged sovereign bond spreads to account for the persistence inherent to spreads (Hallerberg and Wolff, 2008; Gerlach et al., 2010; Afonso et al., 2012). The persistent nature of spreads implies that the exclusion of the lagged spread term from the model would generate an omitted variable bias. *ESG* denotes the ESG indicator (*ESGGI, ENVI, SODI* or *GOVI*) and is our variable of interest, $\left(\frac{\Delta GDP}{GDP}\right)$ denotes GDP growth, $\left(\frac{\Delta P}{P}\right)$ denotes inflation rate, $\left(\frac{Debt}{GDP}\right)$ denotes gross country debt-to-GDP ratio, $\left(\frac{PB}{GDP}\right)$ denotes country primary balance to GDP ratio, $\left(\frac{CA}{GDP}\right)$ denotes current account to GDP ratio, $\left(\frac{X+M}{GDP}\right)$ denotes trade openness ratio, $\left(\frac{Reserves}{Import}\right)$ denotes ratio of reserves to imports, and (S&P) denotes Standard and Poor's sovereign ratings, assigning a numerical variable of 1 to CCC, 2 to B- and so on, to AAA.

Next, we extend the analysis by accounting for the role of the individual ESG dimensions. This allows us to look into the potential differences in the financial impact of separate ESG dimensions on sovereign bond spreads. The motivation for doing so underlies our second hypothesis (see Section 2). More specifically, we estimate equation (1) and replace (ESGGI) with (GOVI), (SODI) and (ENVI), which are the governance quality index, social development index and environmental quality index, respectively. The ESG (*ESGGI*, *GOVI*, *SODI*, *ENVI*) indicators are lagged in all models. This is because the primary scope of this study is examination of the relationship between ESG and sovereign risk, where ESG indicators are variables that influence sovereign bond spreads. Further, lagging the ESG measures helps to reduce the alleged endogeneity problems and simultaneity bias that may arise due to contemporaneous bidirectional causality between ESG issues and sovereign risk. In addition, a common practice with rating agencies and international organizations is to assemble the various ESG data at the end of each year. Therefore, lagging the ESG indicators helps to ensure that the ESG index for each country is public knowledge at time t and is incorporated by financial market participants in terms of price formation.

We also investigate the sensitivity of the analysis for institutional and historical factors. Beirne and Fratzscher (2013) argue that sovereign risk is substantially underpriced during the pre-crisis period of 2000–2007, especially in more peripheral economies that use the euro (Greece, Ireland, Portugal, Spain and Italy). They argue that public debt levels, fiscal deficits and the current account of the balance of payments explain very little of the pricing of risk in euro area countries before the crisis, but have much more explanatory power for sovereign risk in other advanced economies. Beirne and Fratzscher (2013) argue that the small spreads and very high co-movements of sovereign yields within the euro area suggest that other factors may have been key determinants of sovereign debt (and risk) (Cesare et al., 2012; Hochstein, 2013; Fontana and Scheicher, 2016). Therefore, we will compare two different subsets of the sample: One relates to the institutional setting and compares euro countries with non-euro countries; the other relates to the historical setting and compares pre- and post-GFC effects.

Blundell–Wignall (2012) notes that the euro exposes its member states to asymmetric real shocks through external competitiveness and trade. With the inability to adjust the exchange rate, these pressures are forced into the labor market and may have led some euro members to try to alleviate pressures with fiscal slippage, contributing to underlying financial instability (Blundell–Wignall, 2012). The prevailing working assumption of financial markets, that a sovereign default within the currency union is almost impossible, explains why the price of sovereign risk in the eurozone is not determined by fundamentals alone (Di Cesare et al., 2012; Hochstein, 2013; Nelson, 2013; Papanikos, 2014). Thus, the interest rates of eurozone government bonds may insufficiently reflect the credit risk of individual countries. As a result, investors in euro member sovereign debt may be more sensitive to ESG performance compared to other advanced economies. Therefore, we investigate whether the effect of ESG performance on sovereign bond spreads is more pronounced in euro countries than in other OECD member states.

Ebner (2009) examines sovereign government bond spreads in crisis and non-crisis periods and argues that there is a significant difference in government bond spread determinants during such periods. He finds that during a crisis period, macroeconomic factors become less significant explanatory variables, while other factors like political uncertainty, market instability, and global factors play a more important role in explaining spreads. Dailami et al. (2008) propose a framework in which the probability of default is a nonlinear function of the risk-free rate (US Treasuries), implying that the US interest rate alone is not sufficient to explain the spread.

Interactions with the severity of debt dynamics, global liquidity conditions, appetite for risk, and shock indicators are also important and one has to differentiate between crisis and non-crisis periods. Bernoth et al. (2004) and Bernoth and Erdogan (2012) observe that the general pricing of risk has increased over time in the EMU. Therefore, we seek to examine the extent to which the determinants of spreads may have changed between the pre- and post-crisis periods.

4.2. Econometric strategy

A major concern is that the lagged dependent variable on the right-hand side of the model might be serially correlated and hence correlated with the error term, which makes the LSDV (least squares dummy variable) and OLS (ordinary least squares) estimators biased and inconsistent (Baltagi and Chang, 1994). More specifically, the OLS coefficient for the lagged dependent variable is biased upwards, while the LSDV estimator is biased downwards (Nickell, 1981). Therefore, a consistent estimate should lie between the two estimators (LSDV and OLS). To this end, Kiviet (1995) derives an approximation for the bias of the LSDV estimator when the errors are serially uncorrelated and the regressors are exogenous, and proposes an estimator that results from subtracting a consistent estimate of this bias from the LSDV estimator. Using Monte Carlo simulations, Judson and Owen (1999) show that with balanced dynamic panels characterized by $N < 20$ and $T < 50$ as is the case here, the Kiviet corrected LSDV (LSDVC) estimator of the coefficient on the lagged dependent variable behaves better than the Anderson–Hsiao and the Arellano–Bond estimators.[3] The idea behind LSDVC is to derive an accurate approximation of the LSDV bias and then remove it from the LSDV estimator. Kiviet (1995) obtains LSDVC by purging LSDV of bias approximations containing terms of at most order $N^{-1} T^{-1}$. Kiviet (1999) provides a further refinement with approximations of at most order $N^{-1}T^{-2}$. Bun and Kiviet (2003) obtain formulas that are as accurate as Kiviet's (1999) but easier to implement and argue that LSDVC is a suitable tool of inference in dynamic panel models with a small number of cross-sectional units. Bruno (2005) computes the bias correction for unbalanced dynamic panels, making it possible to have missing values in the dataset. However, unlike previous estimators that

[3] With unbalanced panels, by the time T reaches 30, Judson and Owen find the LSDV estimator without bias correction is superior to the Arellano-Bond estimators. Bruno (2005) develops the LSDVC estimator for an unbalanced panel.

allow effective estimation in the presence of endogenous regressors (GMM estimator, System GMM estimator), the LSDVC estimators assume weak exogeneity (Kiviet, 1999).

Of course, all estimators have advantages and disadvantages given the size of our panel and our study object. However, to eliminate inefficient estimators, we first perform the OLS and LSDV (fixed effect) regression. The estimation results display bounds on the coefficient of the lagged dependent variables. Then, we estimate model (1) with the estimators of Anderson and Hsiao (1982) in difference and in level, the GMM estimators of Arellano–Bond (1991) and Bundell and Bond (1998) and the LSDVC estimator of Bruno (2005). Further, we use auto-correlation tests, over-identification tests, as well as tests of endogeneity for each explanatory variable.[4] Of the five candidate estimators, only one provides the coefficient on the lagged dependent variable in the bounds of its OLS and FE counterparts, namely the LSDVC estimator of Bruno (2005).[5] The endogeneity tests confirm the efficiency of this estimator, as all explanatory variables are exogenous, except for the lagged dependent variable.

4.3. Robustness

Next to these estimations, we perform a number of robustness checks. First, we assess the extent to which the coefficients change if we exclude the sovereign ratings as a potential input factor from our statistical analysis. Altman and Saunders (2001) argue that the ability of ratings to predict default is poor and, hence, their usefulness for the calculation of risk weights is limited. Their arguments suggest that rating agencies provide little if any new information to the market, but rather reflect information already incorporated in market prices. Yet, according to Hochstein (2013), adding sovereign ratings may improve the explanatory power of sovereign spread models.

Second, we remove Greece because we suspect this country may be an outlier because of its fiscal problems and the special treatment it received from international monetary and fiscal authorities (see Di Cesare et al., 2012; Georgoutsos and Migiakis, 2013; Papanikos, 2014).

[4] These results are available upon request.
[5] Bloom et al. (2007), Potrafke (2010), Celasum and Harms (2010), de Rassenfosse and van Pottelsberghe de la Potterie (2012) are notable examples of applications of LSDVC to panels with a small number of countries.

Third, we back-test our models by generating in-sample predictions for bond spreads, which are compared with the actual bond spreads. As such, we follow the suggestion by Berg and Pattillo (1998), Kumar et al. (2003) and Comelli (2012). In this regard, we proceed as follows. The time dimension of our panel consists of T observations. We re-estimate the model using the data in a subsample comprising $t < T$ observations (the estimation sample) to generate bond spread forecasts in the remainder ($T - t$) of the whole sample (the forecasting sample). We re-estimate bond spreads for the periods 1996–2006, 1996–2007 and 1996–2008 (the estimation samples) to forecast bond spreads in the periods 2007–2014, 2008–2014 and 2009–2014, respectively (the forecasting samples). The purpose of this exercise is to investigate whether the model can accurately predict bond spreads in periods that are not included in the estimation sample. We use different estimation samples because we want to determine whether the in-sample forecasting ability of the model changes with the beginning of the GFC. We use linear prediction (LP) methods to generate in-sample predictions for bond spreads. We re-estimate the model in the estimation sample and obtain the coefficient estimates.[6] Then, in the forecasting sample, we multiply the explanatory variables by the estimated coefficients to generate bond spread forecasts for all sample countries. To assess the model's ability to generate informative in-sample bond spread predictions, we proceed as follows. In each year of the forecasting sample, we assign a value of 1 if actual and predicted bond spreads change in the same direction (e.g., they both increase or decrease). Otherwise, if actual and predicted spreads change in the opposite direction, we assign a value of zero. We then calculate the probability that the LP forecasting method correctly predicts the direction of yearly changes in actual bond spreads.

5. RESULTS

5.1 Main results

We first estimate equation (1) (basic and extended with individual ESG dimensions) for the full sample period and report the results from the LSDVC estimations in Table 3.

[6] We calculate LP from the fitted model. The model can be thought of as estimating a set of parameters $b1, b2, ..., bk$, and the LP *is* $y_{pj}=b_1x_{1j}+b_2x_{2j}+...+b_kx_{kj}$ where $j=t+1, t+2, ..T$. The values y_{pj} are the out-of-sample predictions; x_{1j}, $x_{2j}...x_{kj}$ are the values of the explanatory variables in the forecasting period and are not used to fit the model (hence to obtain $b1, b2, \ldots, bk$).

[INSERT TABLE 3 ABOUT HERE]

The results show that the yield spreads appear to be highly persistent. We also obtain statistically significant coefficients with the expected signs throughout for the competitiveness and fundraising ability indicators (i.e., current account of balance of payments) and financial ratings (S&P rating). The estimated ESG coefficients are negative and statistically significant at the 1% level, except for ENVI, suggesting that high country ESG scores reduce the spreads. To be specific, the ESGGI coefficient is 0.153. Specifically, in terms of magnitude, this means that an increase of 10 percent in ESGGI reduces 10-year sovereign spreads by approximately 16%. Therefore, we conclude that the results support our hypothesis that there is a negative association between ESG and sovereign yield spreads (H1).

These results show that there is value added by incorporating ESG into sovereign risk analysis. In addition to the conventional factors (fundraising ability and credit risk), there is a discernible financial effect of sustainability-related information on sovereign spreads. The literature argues that there are three types of potential determinants that may affect spreads (Attinasi et al., 2009; Afonso et al., 2012): credit risk (i.e., a country's creditworthiness as reflected by its fiscal and macroeconomic position), liquidity risk (i.e., the size and depth of a government's bond market), and international risk aversion (i.e., investor sentiment toward this class of assets for each country). We show that ESG matters for the evolution of government bond spreads too, as there is a significant association between ESG and sovereign spreads. As such, we conclude that ESG is material when it comes to sovereign bond yield spreads.

Table 3 also allows us to examine the nature of the effects of ESG on spreads by separately examining the ESG components (right-hand column). We verify the interest-reducing effects of country sustainability and it appears they are associated with governance and social factors. However, there is no relationship between environmental factors and sovereign bond spreads. The negative and significant coefficients of SODI and GOVI suggest that good social and governance performance may be associated with lower sovereign bond spreads. The economic magnitude of a change in the country governance score on sovereign spreads is larger than the impact of an equal change in the social score: a 10 percent unit increase in the governance dimension decreases 10-year sovereign bond spreads by approximately 7.4% compared to 4.9% for the same increase in the social dimension. These findings support our second hypothesis regarding the three dimensions having a heterogeneous impact on sovereign bond yield spreads. It shows that governance concerns are the most relevant ESG issue for sovereign risk analysis, social concerns are in second place, and environmental indicators do not appear to play a role here. The latter finding contrasts with some of the findings of Berg et al. (2016), who study emerging markets.

5.2 Sensitivity and robustness analysis

We conduct several sensitivity analyses along institutional and historical lines. First, we split the sample into countries that use the euro as their currency and those that do not. Table 4 depicts the influence of overall country ESG scores on 10-year sovereign spreads by distinguishing between euro area and non-euro area countries. This table shows that the interest-reducing effect of country ESG performance on 10-year spreads holds in both areas. Further, the coefficient of ESGGI, estimated at 0.122 in non-euro countries and at 0.212 in euro countries, suggests that the relationship between country ESG performance and sovereign bond spreads is stronger in the eurozone. Hence, sustainability seems to have a stronger impact on spreads in euro area countries. However, the differential between the two is only marginally significant.

[INSERT TABLE 4 ABOUT HERE]

Next, we split the sample into two sub-periods, namely the period preceding the GFC (1996–2006) and the crisis period (2007–2014). The results produced by these analyses are in Table 5 and provide a very clear picture. We establish that in the wake of the GFC, ESG performance is a significant factor regarding sovereign bond spreads. This confirms the assumption that during crisis periods, ESG sustainability indicators help inform investors about country risk.

[INSERT TABLE 5 ABOUT HERE]

We also conduct robustness checks to investigate the sensitivity of our results to modeling choices. We exclude Standard and Poor's ratings from our control variables and remove Greece from the sample. Further, we back-test our model by generating in-sample predictions that are then compared with the actual bond spreads. Table 6 shows that all coefficients of ESGGI have the same sign and significance when Greece and the S&P rating are excluded. The coefficients are larger when we exclude the S&P credit ratings indicator from the explanatory variables, which suggests sovereign credit ratings capture some of the effects measured by ESGGI.

[INSERT TABLE 6 ABOUT HERE]

Finally, for each country, we consider the probability that the LP method correctly predicts the direction of the yearly change in actual bond spreads.[7] We consider LP to perform well in predicting the direction of the yearly change in bond spreads if, for a given country, the probability is above 0.7 in every forecasting period. By contrast, the model performs poorly if, for a given country, the probability is below 0.6 in any forecast period. Thus, it seems that the 10-year model appears to succeed in predicting movements in bond spreads for all countries for which the probability is above 0.6. Further, on average, the probability that the LP method correctly predicts the direction of the yearly change in actual bond spreads is lower in the period 2008–2014.

Thus, we establish that institutional environment and especially history can play a role as to the sensitivity of sovereign bond yield spreads in relation to ESG performance. Further, we conclude that the results from the estimations of our model are robust to changes in the model and to adjustments in sample composition.

6. CONCLUSION

Especially since the European sovereign debt crisis, many policymakers and investors have sought a better understanding of sovereign risk and its impact on investment returns. As part of this trend toward broader risk analysis, some observers argue that sustainability should be integrated in analysis and policy. They argue sustainability has a significant impact on a country's

[7] Results available upon request.

creditworthiness and, therefore, it is a potential risk factor, along with traditional sovereign risk factors like public debt, inflation, and GDP growth. The reasons for this specific relationship are that good sustainability signals a country's long-term commitment and might act as a buffer against shocks. More sustainable countries are less risky and face lower financing costs.

We assess the value added of including sustainability in conventional sovereign risk analysis. To this extent, we construct a sustainability index that relies on several indicators relating to various subdimensions, namely governance and social and environmental factors. We include sustainability (and, separately, the subdimensions) as a covariate in our model, which attempts to explain sovereign bond spreads and relies on dynamic panel regressions with data from 20 developed countries for the period 1996–2014. This allows us to illustrate the complexity and variability of the economic impact of the ESG performance on sovereign risk.

We find that there is a strong negative relationship between overall ESG performance and sovereign bond spreads. Hence, sovereign bond markets price country ESG factors. It appears that above-average ESG performance is associated with less default risk and, thus, with lower sovereign bond spreads. This result is in line with evidence from private bond markets (see Hoepner et al., 2016) and seems highly relevant when designing strategic international asset allocations. Second, the financial impact of governance factors is more pronounced compared to that of social and environmental factors. Third, the relationship between ESG factors and sovereign spreads in euro area countries is somewhat stronger than in other developed countries. Fourth, the relationship between ESG performance and sovereign spreads is stronger in the wake of the GFC than in the pre-crisis period. Robustness checks regarding model specification, sampling, and estimation method support these results. Our in-depth assessment of the relationship between country risk, as indicated by sovereign bond spreads, and ESG is interesting and relevant from several perspectives. From the academic perspective, we provide a more complete and thorough understanding of the relationship between country risk and sustainability performance because we show sustainability significantly influences country ratings. For policy makers and investors, our results show the importance of considering sustainability criteria at the macro-level when assessing or managing risk.

There are limitations of our analysis due to data availability. This relates to the validity and reliability of variables that proxy for ESG factors, as well as to their coverage, which is limited to a select number of countries. However, we expect that with the propagation of the UN's Sustainable Development Goals and their growing use worldwide by policy makers, business and society, this will improve over the next decade. The process by which we assess country sustainability characteristics leads to the creation of a single rating and corresponding score for each dimension (i.e., environment, social, governance). Although this is highly useful from a practical point of view, some suggest that ESG issues (or sustainability) should always be disaggregated into those related to positive and those related to negative social/environmental performance, as these are conceptually and practically different and thus so are their financial outcomes (Chatterji et al., 2009). It would also be worthwhile to include more countries, especially developing countries, in the analysis as well as to estimate the model over a much longer time span. Finally, alternative methodologies can be considered. First, although bond market event studies are not straightforward (Bessembinder et al., 2009; Ederington et al., 2015), one might conduct an event study, similar, for instance, to Capelle–Blancard and Laguna (2010) to assess the impact of ESG news on yield spreads. Second, it would be interesting to use a difference-in-difference framework, if there is access to an appropriate quasi-experiment. These methods may prove relevant, and we leave this for future research.

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Sovereign bond yield spreads and sustainability: An empirical analysis of OECD countries

HIGHLIGHTS

- We study how sustainability affects sovereign bond spreads.
- We find that countries with good sustainability performance tend to have less default risk and lower bond spreads.
- In particular, governance and social factors appear to have an impact, but environmental factors do not.

Table 1: ESGGI, GOVI, SODI and ENVI: scores and rank

ESG Score	ESGGI		GOVI		SODI		ENVI	
	Score	rank	Score	Rank	Score	Rank	Score	Rank
Norway	87.95	1	96.31	6	82.53	1	76.57	1
New Zealand	82.95	2	97.20	3	76.40	6	60.36	2
Sweden	82.13	3	96.89	4	81.95	2	54.66	5
Finland	79.95	4	98.58	1	79.32	4	45.12	8
Canada	79.71	5	94.46	8	76.30	7	55.09	4
Austria	79.61	6	94.01	9	72.45	13	60.36	2
Switzerland	78.20	7	96.45	5	71.56	15	52.02	6
Denmark	77.55	8	97.78	2	80.65	3	37.63	11
Netherland	74.31	9	96.31	6	75.67	9	43.43	9
Australia	71.78	10	93.61	10	76.44	5	27.74	19
Japan	71.27	11	84.41	16	71.61	14	46.59	7
UK	71.17	12	91.57	11	74.50	10	30.97	18
Germany	71.00	13	91.50	12	73.42	12	33.61	14
France	70.50	14	86.69	14	76.29	8	34.66	13
Belgium	70.04	15	88.90	13	73.71	11	32.06	16
Spain	67.66	17	82.41	18	69.03	17	39.48	10
Portugal	67.26	16	85.28	15	66.72	18	35.31	12
Italy	61.65	18	71.90	19	62.75	19	31.09	17
Ireland	60.91	19	82.64	17	70.64	16	32.84	15
Greece	58.19	20	70.93	20	61.15	20	30.06	20
Mean	73.63		90.38		73.63		42.96	
St.dev	7.18		8.13		6.11		13.06	

(a) We rank countries, respectively, from the highest performing with regard to governance, social policy and environmental quality to the lowest performing. The scores are averaged over the period 1996–2012. ESGGI is the overall country sustainability index score and obtained by means of factor analysis, in which each component of the ESG framework is weighted according to its contribution to the overall variance in the data (see Table A.1.6 in the Appendix). The sub-domain indicators used to build ESGGI are governance quality index (GOVI), social development index (SODI) and environmental quality index (ENVI) (see Table A.1.2). GOVI assesses regulatory effectiveness by including six sub-components: rule of law, political stability, voice of the people, corruption control, country effectiveness and regulatory quality. High scores signal a high degree of legal quality. SODI captures a country's effort in terms of human development and includes six sub-components: school enrollment secondary, life expectancy, health expenditure, ratio of female-to-male labor participation, gender parity index, and non-vulnerable employment. SODI is a measure of the degree of social welfare of a given country, with high scores signaling a high degree of social development. ENVI measures how well countries manage their natural resources and the degree to which they are concerned with their environment. ENVI includes six sub-components: air quality, wastewater treatment, sanitation, biodiversity, forest cover, and renewable energy. High scores signal strong environmental performance.

Table 2: Spearman's rank correlation of the ESG scores

	ESGGI	GOVI	SODI	ENVI
ESGGI	1.00			
GOVI	0.85***	1.00		
SOCI	0.81***	0.70***	1.00	
ENVI	0.75***	0.32***	0.41***	1.00

* significant at 10%, ** significant at 5%, *** significant at 1%.

This table shows the Spearman rank correlations of the overall country sustainability index ESGGI and the three sub-domain indicators GOVI for the governance quality index, SODI for the social development index, and ENVI for the environmental quality index. For contents of the indexes see Table A.1.2. For construction of the ESGGI see Table A.1.6.

Table 3: Sovereign bond spreads: effect of global and individual dimensions of ESG performance

	Sovereign bond spread (***Yi,t***) 10YR	
	Basic	**Extended**
Y(lagged)	0.560***	0.558***
	(0.049)	(0.049)
ESGGI(lagged)	–0.153***	
	(0.072)	
GOVI (lagged)		–0.074***
		(0.033)
SODI(lagged)		–0.049***
		(0.024)
ENVI(lagged)		–0.030
		(0.040)
ΔGDP/GDP	0.040	0.052
	(0.037)	(0.038)
ΔP/P	–0.062	–0.056
	(0.063)	(0.063)
Debt/GDP	0.005	0.007*
	(0.004)	(0.004)
PB/GDP	0.029	0.033
	(0.026)	(0.025)
CA/GDP	–0.046*	–0.054***
	(0.023)	(0.025)
(X+M)/GDP	–0.011	–0.010
	(0.009)	(0.009)
Reserves/import	–0.570	–0.666
	(0.460)	(0.471)
S&P	–0.336***	–0.382***
	(0.056)	(0.065)
Time effects	Yes	Yes
Observations	360	360
R–squared	0.70	0.43

Notes: Bootstrap standard errors based on 500 replications are reported in parentheses under the coefficient value: * significant at 10%, ** significant at 5%, *** significant at 1%.
This table shows the LSDVC estimation results for equation (1) for the complete sample period. The column basic relates to the model which includes the overall country sustainability index ESGGI and the column extended relates to the model which includes the three sub-domain indexes, namely the governance index (GOVI), the social development index (SODI), and the environmental quality index (ENVI). ΔGDP/GDP is GDP growth, ΔP/P is inflation, Debt/GDP is the debt ratio, PB/GDP is the primary net lending/borrowing plus net interest payable/paid over GDP, CA/CDP is the current account, (X+M)/GDP is for trade openness, Reserves/import is the liquidity ratio, and S&P is the sovereign credit risk rating from S&P (see Table A.2.1 in the Appendix).

Table 4: Sovereign bond spreads: euro-area and non-euro area economies

	Sovereign bond spread ($Y_{i,t}$) 10YR	
	EURO	**NON-EURO**
Y(lagged)	0.552***	0.877***
	(0.071)	(0.067)
ESGGI(lagged)	–0.212*	–0.122***
	(0.124)	(0.037)
ΔGDP/GDP	0.053	0.021
	(0.051)	(0.031)
ΔP/P	–0.169*	0.037
	(0.100)	(0.036)
Debt/GDP	0.001	–0.000
	(0.007)	(0.003)
PB/GDP	0.004	0.030
	(0.042)	(0.016)
CA/GDP	–0.069*	–0.020
	(0.042)	(0.014)
(X+M)/GDP	–0.011	0.006
	(0.019)	(0.005)
Reserves/import	–0.508	–0.264
	(0.180)	(0.210)
S&P	–0.334***	–0.011
	(0.084)	(0.062)
Time effects	Yes	Yes
Observations	198	162
R–squared	0.72	0.92

Notes: Bootstrap standard errors based on 500 replications are reported in parentheses under the coefficient value: * significant at 10%, ** significant at 5%, *** significant at 1%.
This table shows the LSDVC estimation results for equation (1) for the complete sample period. The column EURO relates to the sample where we include OECD countries which use the Euro as their currency (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain) and the column extended relates to the sample which has the other OECD countries (Australia, Austria, Canada, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom). The US is used as the numeraire. ESGGI is for the overall country sustainability index, ΔGDP/GDP is GDP growth, ΔP/P is inflation, Debt/GDP is the debt ratio, PB/GDP is the primary net lending/borrowing plus net interest payable/paid over GDP, CA/CDP is the current account, (X+M)/GDP is for trade openness, Reserves/import is the liquidity ratio, and S&P is the sovereign credit risk rating from S&P (see Table A.2.1 in the Appendix).

Table 5: Sovereign bond spreads: coefficient estimates, accounting for GFC

	Sovereign bond spread (*Yi,t*) (10-year)	
	1996–2006	**2007–2014**
Y(lagged)	0.624***	0.521***
	(0.039)	(0.099)
ESGGI(lagged)	–0.037	–0.516***
	(0.026)	(0.277)
ΔGDP/GDP	0.035*	–0.038
	(0.019)	(0.095)
ΔP/P	0.022	–0.323*
	(0.024)	(0.168)
Debt/GDP	0.005*	–0.015
	(0.003)	(0.015)
PB/GDP	–0.004	0.023
	(0.013)	(0.068)
CA/GDP	–0.006	–0.030
	(0.010)	(0.077)
(X+M)/GDP	–0.004	–0.056*
	(0.004)	(0.031)
Reserves/import	0.074	–0.100
	(0.211)	(1.486)
S&P	–0.048	–0.420***
	(0.046)	(0.122)
Time effects	Yes	Yes
Observations	200	160
R–squared	0.70	0.60

Notes: Bootstrap standard errors based on 500 replications are reported in parentheses under the coefficient value: * significant at 10%, ** significant at 5%, *** significant at 1%.
This table shows the LSDVC estimation results for equation (1) for the two periods: the pre-crisis period (1996-2006) and the Global Financial Crisis and its aftermath (2007-2014). ESGGI is for the overall country sustainability index, ΔGDP/GDP is GDP growth, ΔP/P is inflation, Debt/GDP is the debt ratio, PB/GDP is the primary net lending/borrowing plus net interest payable/paid over GDP, CA/CDP is the current account, (X+M)/GDP is for trade openness, Reserves/import is the liquidity ratio, and S&P is the sovereign credit risk rating from S&P (see Table A.2.1 in the Appendix).

Table 6: Sovereign bond spreads: robustness checks

	Sovereign bond spread ($Y_{i,t}$) 10-year		
	Basic	**Excluding Greece**	**Excluding S&P**
Y(lagged)	0.560***	0.584***	0.786***
	(0.049)	(0.053)	(0.048)
ESGGI(lagged)	–0.153***	–0.113***	–0.207***
	(0.072)	(0.041)	(0.075)
ΔGDP/GDP	0.040	0.001	0.065*
	(0.037)	(0.022)	(0.038)
ΔP/P	–0.062	–0.017	–0.012*
	(0.063)	(0.037)	(0.067)
Debt/GDP	0.005	–0.006***	0.002
	(0.004)	(0.003)	(0.004)
PB/GDP	0.029	0.028***	0.040
	(0.026)	(0.014)	(0.028)
CA/GDP	–0.046*	–0.011	–0.029
	(0.023)	(0.015)	(0.025)
(X+M)/GDP	–0.011	–0.001	–0.001
	(0.009)	(0.006)	(0.010)
Reserves/import	–0.570	–0.280	–0.760***
	(0.460)	(0.278)	(0.503)
S&P	–0.336***	–0.161***	
	(0.056)	(0.035)	
Time effects	Yes	Yes	Yes
Observations	360	324	360
R–squared	0.70	0.75	0.67

Notes: Bootstrap standard errors based on 500 replications are reported in parentheses under the coefficient value: * significant at 10%, ** significant at 5%, *** significant at 1%.
This table shows the LSDVC estimation results for equation (1) for the base model (basic) and for two robustness checks. In column Excluding Greece, we exclude Greece from the sample. In column Excluding S&P we exclude the variable S&P sovereign credit risk rating from the estimations. ESGGI is for the overall country sustainability index, ΔGDP/GDP is GDP growth, ΔP/P is inflation, Debt/GDP is the debt ratio, PB/GDP is the primary net lending/borrowing plus net interest payable/paid over GDP, CA/CDP is the current account, (X+M)/GDP is for trade openness, Reserves/import is the liquidity ratio, and S&P is the sovereign credit risk rating from S&P (see Table A.2.1 in the Appendix).

APPENDIX

A.1: Principal component analysis

Principal component analysis (PCA) is a multivariate statistical technique that, when applied to a dataset, reveals which variables in the set form coherent subsets that are relatively independent of one another. Variables that are highly correlated are combined into components. The components are expected to reveal the underlying processes that created the correlation among the variables (Tabachnick and Fidell, 2007). PCA aims to extract the maximum variance from a dataset with each component (Tabachnick and Fidell, 2007) as the first principal component is the linear combination of observed variables that maximally separate subjects by maximizing the variance of their components scores. The second component is computed from the residual correlations; it is the linear combination of observed variables that extracts maximum variability. This variability is uncorrelated to the first component. The subsequent components also extract maximum variability from the residual correlations and are independent from all other components (Tabachnick and Fidell, 2007). The extracted components represent most of the variance of the original dataset and can be used in further analysis. In mathematical terms, PCA can be explained as follows: From a set of variables $X1$, $X2$ to Xn, the principal components $PC1$ to PCm are extracted:

$$PC1 = a11X1 + a12X2 + \ldots a1nXn \ldots PCm$$
$$= am1X1 + am2X2 + \cdots amnXn$$

where amn represents the weight for the m^{th} principal component and the n^{th} variable. The weights of each principal component are given by the eigenvectors of the correlation matrix or the co-variance matrix. The variance () for each principal component is given by the eigenvalue of the corresponding eigenvector.

The PCA conducted in this paper involves several steps:

1. For the factor analysis to yield meaningful results, the variables in the dataset have to be related to each other: if the correlations between variables are small, it is unlikely that they share common factors. This paper relies on the Kaiser–Meyer–Olkin (KMO) measure to test the correlation of the basic indicators. The KMO statistic is a ratio of the sum of squared correlations to the sum of

squared correlations plus the sum of squared partial correlations (Tabachnick and Fidell, 2007). The KMO statistic should be at least 0.6 in order to proceed with factor analysis (Kaiser and Rice, 1974).

2. The second step involves factor extraction, i.e., identification of the number of factors necessary to represent the data and the method for calculating them. Each factor is defined as a set of coefficients (so-called loadings), each measuring the correlation between the individual indicators and the latent factor. PCA is used to extract the factors. In PCA, linear combinations of the basic indicators are formed as follows: the first principal component is the combination that accounts for the largest amount of variability in the sample. The second principal component accounts for the next largest amount of variance and is uncorrelated with the first. Successive components explain smaller and smaller portions of the sample variance and are all uncorrelated with each other.

3. The third step involves the rotation of factors. Rotation is a standard step in factor analysis. It provides a criterion for eliminating the indeterminacy implicit in factor analysis results. The rotation changes the factor loadings and consequently the interpretation of the factors, but the different factor analytical solutions are mathematically equivalent in that they explain the same portion of the sample variance. Factor rotation is obtained using the varimax method, which attempts to minimize the number of variables that have high loadings (so-called salient loadings) on the same factor. This is a transformation of factorial axes that makes it possible to approximate a "simple structure" of the factors, in which each indicator is "loaded" exclusively on one of the retained factors. This enhances the interpretability of these factors.

4. The final step involves construction of the weights used to construct the summary indicators. The approach followed in this paper is to weight each detailed indicator according to the proportion of its variance explained by the factor it is associated with (i.e., the normalized squared loading), while each factor is weighted according to its contribution to the portion of the explained variance in the dataset (i.e., the normalized sum of squared loadings).

Table A.1.1: ESG analysis dimensions

Dimensions of ESG included in reports		VIGEO	HBC AM	Natixis AM	MSCI ESG	Neuberger Berman
Environmental	Air quality	X	X	X	X	
	Water and sanitation	X	X	X	X	
	Forests	X	X	X	X	X
	Renewable energy	X				
Social	Human capital	X		X		X
	Demography		X	X		
	Health	X	X	X	X	
	Gender equality	X				
	Employment	X	X	X		
Governance	Democratic	X	X		X	
	Safety policy	X				X

Table A.1.2: Items used to assess ESG performance

Dimension	Measuring items	Code	*Source*
Environmental			
Air quality	Control air pollution	Air	WDI
Water and sanitation	Waste water treatment	Waste	WDI
Forests	Forest area (% of land area)	Forest	WDI
Renewable energy	Combustible renewable energy (% of total energy)	Combust	WDI
	Renewable electricity output (% of total electricity)	Electricity	WDI
	Renewable energy consumption (% of total energy)	Energy	WDI
Social			
Human capital	School enrollment secondary (% gross)	Enroll	WDI
Demography	Life expectancy	Life	WDI
Health	Health expenditure, public (% of total health expenditure)	Health	WDI
Gender equality	Ratio of female-to-male labor force participation rate (%)	Femaletomale	WDI
	Gender parity index	GPI	WDI
Employment	Non-vulnerable employment (% of total employment)	Nonvulnerable	WDI
Governance			
Democratic institution	Control of corruption	Corruption	WGI
	Rule of law	Rule	WGI
	Voice and accountability	Voice	WGI
Safety policy	Country effectiveness	Effectiveness	WGI
	Political stability	Stability	WGI
	Regulatory quality	Regulatory	WGI

Table A.1.3: Descriptive statistics of ESG dataset

Variable	Mean	St. dev.	Min	Max
Air	74.22	19.43	10.26	98.53
Waste	72.35	20.79	4.00	100.00
Forest	33.63	18.27	0.23	73.70
Combust	70.19	25.86	3.14	100.00
Electricity	27.76	27.59	0.04	99.99
Energy	16.71	15.59	0.61	77.36
Enroll	105.02	15.64	59.40	164.81
Health	71.59	11.84	36.62	92.81
Life	79.94	11.36	37.42	99.41
Nonvulnerable	86.49	9.01	42.82	97.21
Femaletomale	74.89	11.40	30.55	94.06
GPI	1.00	0.04	0.80	1.15
Corruption	83.61	15.23	23.90	100.00
Rule	84.60	15.01	24.88	100.48
Voice	84.92	13.79	23.56	100.96
Effectiveness	86.04	11.21	45.85	100.49
Stability	72.56	22.59	7.11	100.00
Regulatory	86.33	10.31	54.90	101.47

Notes: The Kaiser–Meyer–Olkin (KMO) test for sampling adequacy, overall MSA. The KMO statistic is a ratio of the sum of squared correlations to the sum of squared correlations plus the sum of squared partial correlations. The KMO statistic should be at least 0.6 to proceed with factor analysis.

Table A.1.4: Total variance explained by the eigenvalue of the extracted components

Component	Eigenvalue	Difference	Proportion	Cumulative
1	8.39	5.71	0.47	0.47
2	2.69	1.36	0.15	0.62
3	1.33	0.33	0.08	0.70

Notes: The eigenvalue (variance) for each principal component indicates the percentage of variation explained in the total dataset. Using the Kaiser's criterion or the eigenvalue rule, components with an eigenvalue of 1.0 or more are extracted. According to these criteria, the indicators are correlated with three main factors, which account for 70 per cent of total variance.

Table A.1.5: Principal component analysis (PCA) results

Variables	Component1	Component2	Component3
Air	–0.01	0.45	**0.71**
Waste	–0.67	–0.25	**0.24**
Forest	0.15	0.31	**0.35**
Combustion	0.17	–0.21	**0.70**
Electricity	0.14	0.02	**0.93**
Energy	0.00	0.23	**0.90**
Enroll	0.49	**0.48**	–0.03
Life	0.38	**0.80**	0.24
Health	0.25	**0.47**	0.09
Femaletomale	0.39	**0.81**	0.23
GPI	0.17	**0.59**	–0.05
Nonvulnerable	0.51	**0.67**	0.07
Corruption	**0.90**	0.24	0.17
Rule	**0.91**	0.26	0.18
Voice	**0.83**	0.40	0.19
Effectiveness	**0.90**	0.27	0.17
Stability	**0.60**	0.30	0.33
Regulatory	**0.86**	0.28	0.10
Total variance explained by factors (%)	46.69	14.93	7.86
Eigenvalue	8.38	2.69	1.33

[(a)] = Based on rotated component matrix.
[(b)] = 0.71 is the factor loading on the air quality variable on the third component.

Three principal components extract most of the variance from the original dataset. Control corruption (0.90), rule of law (0.91), voice (0.83), effectiveness (0.90), political stability (0.60) and security and regulatory quality (0.86) have the highest factor loading on the first component. This component is labeled "governance quality index" (GOVI). This GOVI dimension explains most of the variance from the dataset: 46.69%. In the second component, enrollsec (0.48) health (0.47), life (0.80), non-vulnerable (0.67), female-to-male labor participation (0.81) and gpisecprim (0.59) loaded the highest on the component (this component is labeled "social development index" – SODI). This SODI dimension explains 14.93% of the total variance. Finally, air quality (0.71), water (0.24), forest (0.35), combust (0.70), electricity (0.90) and energy (0.93) are the variables with the highest factor loading on the third component (labeled "environmental quality index" – ENVI). This component is related to the environmental indicators. It explains 7.86% of total variance.

Table A.1.6: Construction of the ESG index[a]

Variables	**Component1**	**Component2**	**Component3**
Air	0.00	0.00	**0.17**[b]
Waste	0.00	0.00	**0.02**
Forest	0.00	0.00	**0.04**
Combust	0.00	0.00	**0.17**
Electricity	0.00	0.00	**0.30**
Energy	0.00	0.00	**0.30**
Enroll	0.00	**0.09**	0.00
Life	0.00	**0.08**	0.00
Health	0.00	**0.25**	0.00
Femaletomale	0.00	**0.18**	0.00
GPI	0.00	**0.27**	0.00
Nonvulnerable	0.00	**0.13**	0.00
Corruption	**0.19**	0.00	0.00
Rule	**0.20**	0.00	0.00
Voice	**0.16**	0.00	0.00
Effectiveness	**0.19**	0.00	0.00
Stability	**0.08**	0.00	0.00
Regulatory	**0.18**	0.00	0.00
Total variance explained by factors (%)	0.45[c]	0.30	0.25
Eigenvalue	5.65	3.52	3.27
Total variance explained by factors (%)	46.69	14.93	7.86

(a)=Based on rotated component matrix
(b)=Normalized squared factor loadings
(c)=Weighting of the intermediate composite index expressed as total percentage of explained variance of each component

The approach followed in this paper is to weight each detailed indicator according to the proportion of its variance that is explained by the factor it is associated with (i.e., normalized squared loading), while each factor is weighted according to its contribution to the proportion of the explained variance in the dataset (i.e., normalized sum of squared loading). More precisely, at first, we identify the intermediate composite indexes (which refer to the extracted components). Then, each intermediate composite index is loaded by using the variables with the highest factor on corresponding component. The weighting of each of the variables is derived by squaring the factor loading of the variables. The squared factor loading represents the proportion of the total unit variance of the indicator, which is explained by the component. Specifically, the first component, which represents the first composite index: “governance quality index” (GOVI) is computed as follows: GOVI = 0.19*corruption +0.20*rule + 0.16*voice + 0.19*effectiveness+ 0.08*stability+ 0.18*regulatory. Once the three intermediate composite indexes are constructed, they are aggregated by allocating a weight to each of them equal to the proportion of the explained variance in the dataset. For example, the weighting of the first intermediate composite index is 0.45 (45%), calculated as follows: 5.65/(5.65 + 3.52 + 3.27). In the same manner, the weights of each intermediate composite index in the total composite index are calculated. Note that the weighting of each consecutive intermediate composite index contributed less to explaining the variance in the dataset, decreasing from 46.69% to 7.86%. The ESG global index is then obtained as follows: ESGGI = 0.45*GOVI+ 0.30*SODI + 0.25*ENVI.

Table A.2.1: Description of variables

Variable Name	Code	Description	Source
Dependent variable			
10-year sovereign Spread	Spread (10YR)	Spreads are yield on sovereign bonds of the considered country minus yield on US sovereign bonds	Bloomberg
Independent variable			
GDP growth	ΔGDP/GDP	Annual percentages of constant price GDP changes	IMF
Inflation	ΔP/P	Annual percentages of average consumer price changes	
Fiscal condition	Debt/GDP	All liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future	IMF
	PB/GDP	Primary net lending/borrowing plus net interest payable/paid	IMF
Current account	CA/GDP	All transactions other than those in financial and capital items	IMF
Liquidity ratio	Reserves/Import	Total reserves comprise holdings of monetary gold special drawing rights, and holdings of foreign exchange under the control of monetary authorities	WB
Trade openness	(X + M)/GDP	The sum of exports and imports of goods and services measured as a share of gross domestic product	WB
S&P sovereign ratings	S&P	Numerical variable assigning 1 to BB, 2 to BB+ and so on through 13 to AAA	Reuters
ESG	ESGindex	Our variable of interest (ESGGI, ENVI, SODI, GOVI)	

Table A.2.2: Descriptive statistics

Variables	N	Mean	St. Dev	Min	Max
Spread (10YR)	380	0.204	2.06	–4.30	21.59
ESGGI	380	73.63	7.18	56.28	89.23
ΔGDP/GDP	380	1.98	2.54	–9.13	10.83
ΔP/P	380	1.83	1.26	–2.53	6.95
Debt/GDP	380	68.79	40.00	9.675	242.11
PB/GDP	380	0.40	4.22	–29.81	15.88
CA/GDP	380	0.95	5.62	–15.18	16.23
(X+M)/GDP	380	77.25	35.59	18.34	209.65
Reserves/import	380	0.26	0.86	0.04	1.67
S&P	380	12.67	2.33	1	14

Table A.2.3: Pearson correlation matrix of independent variables: sovereign bond spreads

		1	2	3	4	5	6	7	8	9	10
1.	**Y (10YR)**	1									
2.	**ESGGI**	0.02	1								
3.	**ΔGDP/GDP**	–0.20***	–0.03	1							
4.	**ΔP/P**	–0.05	0.13***	0.20***	1						
5.	**Debt/GDP**	0.06	0.06	–0.33***	–0.17***	1					
6.	**PB/GDP**	–0.09	–0.25***	–0.05	0.34***	–0.02	1				
7.	**CA/GDP**	–0.32**	–0.20***	0.44***	0.15***	–0.32***	0.30***	1			
8.	**(X+M)/GDP**	–0.16	0.43***	–0.15***	0.07	0.29***	–0.02	–0.17***	1		
9.	**Reserves/import**	–0.11**	0.19	0.11**	–0.09	–0.41***	0.08	0.13**	–0.32***	1	
10.	**S&P**	–0.28***	0.46***	0.02	0.33***	–0.01	–0.36***	–0.07	0.25***	–0.04	1

* significant at 10%, ** significant at 5%, *** significant at 1%

Figure 1. Heterogeneity across countries and over time