Beyond Credit Ratings

The Role of (E)SG in Sovereign Debt Investments

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Abstract:

The study investigates the correlation between ESG performance and sovereign bond yield spreads using regression analysis. The results reveal a significant negative correlation between the Governance and Social indices and bond spreads, emphasising the importance of good governance practices and social stability in reducing the risk of sovereign debt default. However, the Environmental index does not exhibit a significant correlation, possibly due to a time-horizon mismatch and limited selection of environmental variables. Integrating ESG performance, particularly Governance and Social factors, alongside traditional credit ratings can provide investors with a comprehensive view of risk in sovereign debt investments. Monitoring ESG signals and excluding the worst ESG performers from portfolios may help reduce volatility while maintaining portfolio characteristics. The study acknowledges limitations, such as time horizon mismatch, omitted variable bias, and data quality, suggesting avenues for future research to address these limitations and enhance the robustness of the analysis.

Keywords:

ESG rating, Sovereign debt investments, Sovereign bond yields, Sustainability

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1 Introduction

1.1 Background

ESG (Environmental, Social, and Governance) investing is becoming increasingly popular among investors. ESG investments consider the environmental impact, social responsibility, and governance aspects of the investment. According to a report by PwC (2022), institutional investment in ESG-focused products is expected to rise by 84% to SEK 346.5 trillion between 2021 and 2026 with a CAGR of approximately 13%. Investments in ESG products are then expected to account for approximately 22% of total global assets under management.

To enable investors to account for ESG factors, regulators have enforced audited reporting demands on corporations. In Sweden, corporate sustainability reporting has been mandatory, from previously being voluntary, by the Annual Accounts Act since 2016 for larger companies Swedish Agency for Growth Policy Analysis (2018). The regulation is adopted from the EU Non-Financial Reporting Directive (NFRD) in 2014 European Parliament and Council (2014). The regulatory demand for non-financial reporting has increased, especially in Europe. For example, one recently adopted framework was the EU Taxonomy in 2020 European Commission (2021). The increasing awareness regarding non-financial reporting is also noticeable through articles such as "Accounting for Climate Change" by Kaplan and Ramanna (2021) in Harvard Business Review. The article extends critique against the catch-all non-financial corporate reporting and suggests further improving and extending the current framework with so-called E-liabilities.

Today it is not only regulators that have an extensive focus on ESG. All the major rating agencies today provide ESG ratings on firms, regions, and sectors Deloitte (2021). However, when comparing methodologies employed by different agencies, it becomes increasingly evident that the space is immature and that multiple different methodologies and data sources are used.

In addition to the increased focus on ESG by regulators and rating agencies for corporate information, investors are also paying more attention to the ESG credentials of fixed-income instruments. There exist many different types of fixed-income instruments, but one important type is government bonds through sovereign issuers which represent 50 % of the fixed-income market according to a report made by World Bank (2020).

This investor attention has led to the development of new themed financial products such as green bonds which according to International Finance Corporation (2016) was first issued in 2007 by the European Investment Bank dedicated to renewable energy and energy efficiency projects. Another example is social bonds

issued by Social Finance (2021) with the objective of reducing the reoffending rate among short-sentenced offenders leaving Peterborough prison.

While issuers of corporate financial instruments deal with natural regulatory pressure related to ESG reporting, the same is not true for the vastly larger market for instruments issued by sovereigns. The lack of regulation among sovereigns leads to a lack of accountability and transparency in reporting ESG data on their issued financial instruments. This in turn makes it difficult for sovereign debt investors to incorporate ESG factors into their investment thesis.

There have been multiple efforts to solve this problem by creating an ESG rating for government bonds by utilising UN-associated World Bank public database to create country-level ESG indices as a proxy for the issuers' ESG performance. Pineau, Le, and Estran (2022) investigated the importance of ESG factors in sovereign credit ratings, Crifo, Diaye, and Oueghlissi (2017) did similar investigations for sovereign borrowing costs and Gibson and Krueger (2019) for sovereign bond yield spreads. However, there are only a few rating agencies which provide these ratings to the market, one example being the Institutional Shareholder Services Group of Companies (ISS). Asset managers reports such as Morgan Stanley Investment Management (2021), Franklin Templeton (2022) and AllianceBernstein (2021) also tried to establish their own ratings using undisclosed methodologies. The hardship of incorporating ESG considerations in investment analysis for fixed-income investments is concerning when considering the United Nations Principles for Responsible Investment (UN PRI) which have been signed by 3,000 institutions, representing approximately SEK 1,000 trillion assets under management according to World Bank (2020). The signatory asset managers, who have a large portion of their portfolio in government bonds according to an institutional investment report by Allianz Global Investors (2017), need to improve their integration ESG data into their investment decision in order to rightfully claim that the UN PRI is honoured.

1.2 Research questions

In light of the above, it is interesting to further investigate how macro-level ESG data can be used in sovereign fixed-income debt instruments. To answer this, the following research question has been studied:

Is there a historic correlation between country-level ESG factors and government bond yield spreads for OECD countries?

1.3 Methodology

To answer the research questions a set of regressions were performed. The dependent variable was always the 10-year government bond yield spreads of the OECD countries (excluding Estonia, Mexico, and Turkey due to missing bond yield data) in 2015. The US bond yield was used as a reference point, to calculate the spread. As independent variables, we used Environmental, Social, and Government indices created from associated variables from the world bank public database. These variables are summarised in Table 1. A method called Principal Component Analysis (PCA) was used to create the indices from the raw ESG data. A set of control variables were also used in the regressions to check the robustness of the results. More details about the selection of variables and the creation of indices can be found in the methodology section.

1.4 Results

From the regression, we found that both the Social and Governance indices have significant negative correlations with the yield spreads. This means that for countries with strong Social and Governance performance, the yields tend to be lower and vice versa. However, the Environmental variable was not found to be significantly correlated with the yield spreads.

1.5 Interpretation

These results imply that ESG performance, particularly in the Social and Governance dimensions, can provide an alternative and multi-dimensional view of risk, complementing traditional credit ratings when considering sovereign debt investments. The potential long time horizon until the materialisation of ESG risk factors emphasises the importance of actively monitoring and evaluating early warning signals to anticipate potential impacts on the credit risk profile of sovereign issuers. Additionally, investors should be aware of the non-linear relationship between ESG performance and yield spreads. This non-linear relationship could make investors consider the exclusion of the worst ESG performers to reduce portfolio volatility without significantly altering its other characteristics.

2 Main Empirical Analysis

This section will serve as a detailed description and motivation of the methodology applied to answer the research questions. The methodology contains four main steps, 2.1 Delimitation, 2.2 Data gathering, 2.3 Creation of indices, and 2.4 Regression analysis.

2.1 Delimitations

2.1.1 10-year government bond

The chosen fixed-income instrument was 10-year government bonds. The 10-year government bond was chosen as they are widely used as a benchmark for pricing other financial assets and also has easily available data for many countries.

2.1.2 OECD countries

The analysis was delimited to OECD countries. This decision was mainly driven by the fact that OECD countries have frequent and available reporting of both ESG-variables and government bond-yield spreads. Moreover, in order for the correlation mentioned in the research question to appear, the studied countries need to have a functioning bond market. It's reasonably safe to assume that this is the case for the majority of OECD countries. Moreover, this delimitation is also motivated from an asset management perspective since investments into sovereign debt of OECD countries are more frequent in asset managers' portfolios than investments into non-OECD countries according to public trading platform TradingView (2023).

2.1.3 Single year case study

The analysis is a single year case study, rather than a time-series analysis due to the low quality of data on an aggregate level. 2015 was selected since it had the fewest data points missing for both bond yield data and ESG data.

2.2 Data gathering

2.2.1 ESG variables

The ESG performance data were retrieved from three different databases aggregated and hosted by World Bank. The set of variables was chosen based on the previous research by Crifo et al. (2017). Variables were collected from three different databases World Development Indicators (WDI), World Governance Indicators (WGI) and Environment Social and Governance (ESG). The full list of variables and references are found in Table 1.

The database consisted of thousands of variables, from these we collected 25 variables. Firstly, we collected six Environmental variables, such as air quality and forest area, where high performance in these variables may positively correlate to long-term commitment and willingness to pay off debt Eaton and Gersovitz (1981). Secondly, we collected seven Social variables, such as school enrolment

and life expectancy, which according to Lins, Servaes, and Tamayo (2017) is regarded as a long-term commitment and therefore may correlate with willingness to pay off debt. Lastly, we collected six governance variables, such as Rule of Law and Regulatory Quality which are shown to be positively associated with economic performance according to Kaufmann, Kraay, and Mastruzzi (2010) and Butler and Fauver Butler and Fauver.

2.2.2 Control variables

We also include several control variables in our analysis. The selection of variables was again inspired by Crifo et al. (2017) which chose variables considered as determinants of sovereign risk according to Afonso, Arghyrou, and Kontonikas (2009), Barbosa and Costa (2010) and EU institute European Stability Mechanism (2018).

Firstly, the GDP growth rate was chosen, which is an indicator of the evolution of a country's wealth; A high GDP growth indicates that the country will grow in economic strength and the debt burden will consequently become easier to bear in the future.

Secondly, the inflation rate was chosen as a control variable acting as a proxy for a country's monetary policy according to Attinasi, Checherita, and Nickel (2009), there are two opposing consequences of inflation on sovereign risk. One perspective is that higher inflation rates can broaden the tax base of a nation and reduce the real value of outstanding domestic currency-denominated debt. This can ease financial constraints and lower bond margins on borrowing in foreign currencies. Conversely, higher inflation rates are associated with increased macroeconomic instability and could negatively impact a country's creditworthiness if they exceed certain levels.

Thirdly, variables are selected to evaluate the fiscal condition of a country: total public debt and primary balance in relation to GDP. A higher level of debt and larger fiscal deficits suggest a higher risk of default according to Attinasi et al. (2009), Sgherri and Zoli (2010) and Gruber and Kamin (2005).

Fourthly, the current account of the balance of payments is used as a control variable. This variable is an indicator of the ability to raise funds for debt servicing and a high balance should imply a negative impact on spreads. The expected impact of the current account balance is negative. Lastly, the two last control variables were total reserves in months of import and trade as a percentage of GDP. Reserves should have a positive impact on debt repayment ability and higher trade activity should increase a country's ability to refinance its present stock of debt.

A summary of the ESG data selected ESG variables and control variables can be found in table 1.

Table 1: Summary of gathered data to be used in regression analysis

Type	Variables	Database	Identifier
Dependent variable	10 Years Government Bond Yield	OECD	n.a.
Control variable	GDP per capita growth (annual %)	WDI	NY.GDP.PCAP.KD.ZG
Control variable	Inflation, consumer prices (annual %)	WDI	FP.CPI.TOTL.ZG
Control variable	Net lending (+) / net borrowing (-) (% of GDP)	WDI	GC.NLD.TOTL.GD.ZS
Control variable	Current account balance (% of GDP)	WDI	BN.CAB.XOKA.GD.ZS
Control variable	Total reserves in months of imports	WDI	FI.RES.TOTL.MO
Control variable	Trade (% of GDP)	WDI	NE.TRD.GNFS.ZS
Environmental factor	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)	ESG	EN.ATM.PM25.MC.M3
Environmental factor	CO2 emissions (metric tons per capita)	ESG	EN.ATM.CO2E.PC
Environmental factor	Forest area (% of land area)	ESG	AG.LND.FRST.ZS
Environmental factor	Combustible renewables and waste (% of total energy)	WDI	EG.USE.CRNW.ZS
Environmental factor	Renewable electricity output (% of total electricity output)	ESG	EG.ELC.RNEW.ZS
Environmental factor	Renewable energy consumption (% of total final energy consumption)	ESG	EG.FEC.RNEW.ZS
Social factor	School enrollment, secondary (% gross)	ESG	SE.PRM.ENRR
Social factor	Life expectancy at birth, total (years)	ESG	SP.DYN.LE00.IN
Social factor	Domestic general government health expenditure (% of current health expenditure)	WDI	SH.XPD.GHED.CH.ZS
Social factor	Ratio of female to male labor force participation rate (%) (modeled ILO estimate)	WDI	SL.TLF.CACT.FM.ZS
Social factor	Mortality rate, under-5 (per 1,000 live births)	ESG	SH.DYN.MORT
Social factor	School enrollment, secondary (gross), gender parity index (GPI)	ESG	SE.PRM.ENRR
Social factor	Vulnerable employment, total (% of total employment) (modeled ILO estimate)	WDI	SL.EMP.VULN.ZS
Governance Factor	Control of Corruption: Estimate	WGI	CC.EST
Governance Factor	Rule of Law: Estimate	WGI	RL.EST
Governance Factor	Voice and Accountability: Estimate	WGI	VA.EST
Governance Factor	Government Effectiveness: Estimate	WGI	GE.EST
Governance Factor	Political Stability and Absence of Violence/Terrorism: Estimate	WGI	PV.EST
Governance Factor	Regulatory Quality: Estimate	WGI	RQ.EST

2.3 Index creation

By combining the data for each collected variable into indices, it is possible to answer the question of whether Environmental, Social, or Governance viewed as a concept is correlated to bond yield spreads, not just whether a specific variable is correlated to the yield spreads.

There exist a few ESG rating indices published by actors, such as Institutional Shareholder Services Group of Companies (ISS) (2021) and Crifo et al. (2017). Despite their use, these ratings' validity and dependability have been questioned Chatterji, Levine, and Toffel (2009). According to Gonenc and Scholtens (2017), the majority of ESG ratings reflect policy rather than real reductions of environmental or social consequences and associated risks. Additionally, even though the ratings cover a wide range of potentially important concerns, it is frequently unclear what is actually measured. Moreover, according to Halbritter and Dorfleitner (2015) the ESG ratings are not verified, validated, or replicable. With this in mind, we instead created our own indices using a technique called Principal Component Analysis (PCA) and publicly available data.

PCA is a statistical technique for reducing the dimension of a dataset. The popularity of PCA stems from its property of preserving the maximum amount of

information in the dataset. Formally, PCA is defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by some scalar projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate (called the second principal component), and so on. More about PCA can be reviewed in a machine learning textbook such as Bishop (2006). A mathematically rigorous explanation of PCA can be found in Appendix A.6.

By applying PCA to our dataset we can transform the data into E, S, and G indices. We can also create other indices, e.g. ESG indices by applying the same PCA transformation to the entire datasets, and not just groups of data.

2.4 Regression analysis

To draw conclusions about the correlation between ESG performance and government bond yield spreads a series of regression analyses were performed. The dependent variable was the yield spreads in every regression, while the independent variables were an index, e.g. E index, together with the control variables.

3 Interpretation of Empirical Results

3.1 Results

The results are summarised in table 2. The table presents the independent variables of each regression, the significance of the index variable, and the regression coefficient of the index variable. The coefficient represents the unit change in the yield spread for a unit change of the index variable. The complete regression outputs can be found in Appendix B.

Table 2: Summary of regression results. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Independent variables	**Regression coefficient**
E-index, control variables	$+0.019\%$
S-index, control variables	$-0.077\%^{**}$
G-index, control variables	$-0.951\%^{***}$
ESG-index, control variables	-0.030%
SG-index, control variables	$-0.168\%^{***}$

3.2 Mechanisms

The results of our study indicate that the Governance, Social and SG indices have significant negative correlations with the bond yield spreads, while the Environmental index and overall ESG index exhibit no significant correlation. The Governance and Social Index are also found to be highly correlated with each other. Moreover, when looking at the regression plots in Appendix D, we can see that the relationship between ESG scores seems to be non-linear for outliers.

In this section, possible underlying reasons for these results are discussed.

3.2.1 Governance index

We begin by discussing the Governance index. According to Delmas and Lim (2017), there are several possible reasons why governance factors, i.e. quality of legal institutions, have a negative correlation with bond yield spreads. One explanation is that good governance practices can increase political stability and lead to more efficient use of resources. Both these factors can, in turn, lead to higher economic growth rates according to a report by OECD (2015) which creates higher tax revenues for the government. This is important since total tax revenues account for more than 80% of total government revenue in about half of the countries in the world – and more than 50% in almost every country according to Our World in Data (2022). Tax revenues are thus an essential determiner of their ability to pay off debt.

According to Pech (2022), the mechanism at play may be that countries with good governance practices often have well-established rule of law and a robust legal framework that protects the rights of bondholders. This ensures that bondholders' interests are safeguarded and provides them with legal recourse in case of any disputes. The presence of a strong legal framework thus reduces perceived investment risks, thereby lowering bond yields.

Additionally, countries with good governance practices often enjoy positive investor sentiment due to their reputation for responsible governance, transparent disclosure and respect for the rule of law. Positive sentiment attracts a broader investor base, including international investors seeking safe and stable investments to a report by UNCTAD (2022). The increased demand for government bonds lowers their yields.

3.2.2 Social index

We continue by discussing the Social index. There are several possible reasons why Social variables have a negative correlation with bond yield spreads. One possible

explanation is that countries with strong performance in social variables, such as low-income inequality, access to education, healthcare, and social safety nets, tend to have greater social stability. Social stability reduces the risk of social unrest, protests, or political instability, which are factors that can negatively impact a country's economy and financial markets. Lower risk of social instability leads to lower bond yield spreads as investors perceive lower risk in holding government bonds.

Moreover, countries that prioritise social variables often invest in human capital development such as education and skills training. A well-educated and skilled workforce contributes to economic productivity and competitiveness, leading to higher economic growth according to Berger and Fisher (2013). Using the same argument as previously, this should lead to a higher ability to repay debt and thus lower yields.

Although Social variables serve as indicators for sovereign debt risk, many argue that it is the public governance that drives sovereign issuer's progress toward social development Krebbers (2020). This is also reflected in Appendix B.6 where it is shown that the S and G index has a strong correlation. It could thus be argued that many of the underlying mechanisms explaining the correlations between the S and G-indices with the yield spreads are the same.

3.2.3 Environmental index

The only variable which did not exhibit a significant correlation with the yield spreads was the environmental index. This is in line with the results of similar studies made by asset managers Morgan Stanley Investment Management (2021) and Allianz Global Investors (2017). One potential reason for this might be a time-horizon mismatch. The consequences of environmental issues often take a long time to appear and the time until impact may extend beyond the 10-year period of the bonds studied in this paper. Bond yields are typically more influenced by short-to-medium-term economic factors and government policies rather than long-term considerations according to Diebold and Li (2003). This mismatch in time horizons would then diminish the correlation between environmental variables and bond yields. Similar findings were made in Berg, Margaretic, and Pouget (2016) which suggest that environmental (and social factors), in contrast to governance, affect sovereign bond spreads with a lag as the impact of measures to improve these factors tends to materialise over time.

Another reason for the lack of correlation might be that a large share of the set of variables we chose to include in our E-index does not reflect a risk for investors. For example, it is not clear how the percentage of forest area of a country influences

the country's ability to repay its sovereign debt. It might be the case that if we had included other environmental variables in our E-index, we would have observed a significant correlation. Nonetheless, this still does not rebut the observation that environmental variables might be less correlated to bond yield spreads than social and governance variables.

The lack of significance for the Environmental index, likely also explains why the composite ESG index is not significantly correlated with yield spreads. The addition of the environmental data to the composite index removes the correlation that would have been present if only the governance and social index would have been included.

3.2.4 Non-linearity of results

Although a linear regression has been performed in the study, the relationship between ESG performance and yield spreads seems to be of non-linear nature for outliers. When looking at the visualised regressions in appendix D, we see that the market seems to penalise countries with the lowest ESG scores more than would be expected when looking at the linear trend line.

One reason for this non-linear behaviour could be that market sentiment plays a crucial role in determining bond yields. Countries with low ESG scores may face negative market sentiment due to concerns about their environmental impact, social stability, or governance practices. Research shows that corporate bonds appear underpriced (with high yields) during pessimistic periods and overpriced (with low yields) during optimism periods Nayak (2010), the same may be true for sovereign bonds in the context of ESG performance. If that is the case, negative sentiment can lead to a disproportionate increase in bond yields as investors perceive higher risk and are more hesitant to invest in those countries, creating a non-linear relationship.

3.3 Interpretations

There are different ways to interpret the results of this study in the context of fixed-income investments. Some industry reports, such as Morgan Stanley Investment Management (2021) and Allianz Global Investors (2017) argue that traditional credit ratings do not adequately reflect a country's ESG performance. However, our results indicate that there is a significant correlation between ESG performance and bond yield. This illustrates that ESG performance, especially Social and Governance performance, can be used as an alternative and multi-dimensional view of risk that investors can use to complement the information currently contained in traditional credit ratings. Important to also note is that using an overall ESG

index as a risk measure might not be useful due to the lack of correlation with yields caused by the inclusion of environmental variables.

Moreover, as discussed earlier, studies such as Berger and Fisher (2013) indicate that ESG risk factors gain significance over time (especially Environmental and Social factors), suggesting their long-term nature. This has implications for portfolio management, particularly concerning sovereign ESG risk factors. These factors may appear insignificant during a holding period. Still, they can suddenly become activated due to a combination of adverse circumstances, leading to a substantial alteration in the credit risk profile of a sovereign issuer. Therefore, it is crucial to anticipate ESG risks by actively monitoring and evaluating early warning signals to mitigate their potential impact.

Finally, observing the non-linear relationship between ESG performance and yield spreads is important for investors' asset allocations. Investors should be aware that countries which are part of the group of worst ESG performers may be subject to extreme pricing adjustments in terms of bond yields. To reduce the volatility of the portfolio, investors may therefore consider excluding the worst ESG performers completely, especially since according to Allianz Global Investors (2017) excluding the worst ESG-performing countries does not alter the main characteristics of a portfolio.

3.4 Limitations of the study and future research

One limitation arises from the time horizon mismatch between the ESG variables and the bond yield data used in the analysis. As previously discussed, ESG factors typically have longer-term impacts that may take time to materialise and affect bond yields. However, the thesis utilises 10-year bond data, which might not fully capture the long-term effects of ESG performance. Considering a longer maturity, such as 30-year bond yields, would have been beneficial to capture a more comprehensive understanding of the relationship between ESG and bond yields.

Another limitation stems from the thesis's reliance on data solely from 2015. Restricting the analysis to a single year may not provide a complete picture of the relationship between ESG performance and sovereign bond yields. ESG factors and their importance in financial markets have evolved over time, and analysing a broader time range would have allowed for a more comprehensive examination of the correlation.

One potential limitation of the regression analysis is omitted variable bias, which can be further studied in Stock and Watson (2007). Omitted variables bias refers to relevant factors that are not included in the regression model but can impact

both the independent variable (ESG performance) and the dependent variable (bond yield spreads). For example, factors such as macroeconomic indicators, fiscal policies, political stability, or specific country characteristics may influence both ESG performance and bond yields. Although we have incorporated some control variables, we may have not included all the important variables and omitted variable bias may therefore still be present. The omission of these variables can lead to biased estimates and an incomplete understanding of the true relationship between ESG and bond yields.

Lastly, the quality of ESG data is another limitation of the study. ESG data vary in coverage, consistency, and comparability across countries and time periods. Variations in measurement methodologies, disclosure practices, or reporting standards could introduce inconsistencies and affect the accuracy of the findings. These data limitations can impact the robustness of the results and conclusions drawn in the thesis.

4 Conclusion

In conclusion, this thesis provides insights into the correlation between ESG performance and sovereign bond yield spreads. The findings indicate a significant negative correlation between the Governance and Social indices and bond spreads, highlighting the importance of good governance practices and social stability in reducing the risk of sovereign debt default which in turn leads to lower sovereign bond yields. However, the Environmental index did not show a significant correlation with bond yields, potentially due to a time-horizon mismatch and the limited selection of environmental variables.

Regarding the practical implications of the thesis, integrating ESG performance, particularly Governance and Social factors, alongside traditional credit ratings can provide investors with a more comprehensive view of risk in sovereign debt investments. The findings underscore the importance of actively monitoring and evaluating ESG signals related to ESG risks which in some cases can materialise slowly over time. Furthermore, the study concludes that investors should consider excluding the worst ESG performers from their portfolios to lower volatility while keeping other characteristics of their portfolios.

The study has a number of limitations. Future research could for example explore longer-term bond data, such as 30-year yields, to capture the full impact of ESG factors. Additionally, addressing the potential issue of omitted variable bias and enhancing the robustness of the analysis would strengthen the conclusions.

References

Afonso, A., Arghyrou, M., & Kontonikas, A. (2009). *The determinants of sovereign bond yield spreads in the emu* (Tech. Rep.). SSRN.

AllianceBernstein. (2021). *Missing pieces: A better approach to sovereign esg analysis.* https://www.alliancebernstein.com/americas/en/institutions/insights/investment-insights/missing-pieces-a-better-approach-to-sovereign-esg-analysis.html.

Allianz Global Investors. (2017). *Esg in sovereign bonds.* https://es.allianzgi.com/-/media/allianzgi/eu/makler-spain-new/documents/sri-seminar/esg-in-sovereign-bonds.pdf?la=es-es&hash=D7A110F8C127976F2198F863C94C2CA9.

Attinasi, M.-G., Checherita, C., & Nickel, C. (2009). *What explains the surge in euro area sovereign spreads during the financial crisis of 2007-09?* (Tech. Rep.). European Central Bank.

Barbosa, L., & Costa, S. (2010). *Determinants of sovereign bond yield spreads in the euro area in the context of the economic and financial crisis* (Tech. Rep.). Banco de Portugal.

Berg, F., Margaretic, P., & Pouget, S. (2016). *Sovereign bond spreads and extra-financial information: an empirical analysis of emerging markets* (Working Paper). Banco Central de Chile.

Berger, N., & Fisher, P. (2013). *A well-educated workforce is key to state prosperity* (Tech. Rep.). Washington, DC: Economic Policy Institute. Retrieved from https://www.epi.org/publication/states-education-productivity-growth-foundations/

Bishop, C. M. (2006). *Pattern recognition and machine learning.* Springer.

Butler, A. W., & Fauver, L. (2006). Institutional environment and sovereign credit ratings. *Financial Management*, *35*(3), 53–79.

Chatterji, A. K., Levine, D. I., & Toffel, M. W. (2009). How well do social ratings actually measure corporate social responsibility? *Journal of Economics & Management Strategy*, *18*(1), 125–169.

Crifo, P., Diaye, M.-A., & Oueghlissi, R. (2017). The effect of countries' esg ratings on their sovereign borrowing costs. *The Quarterly Review of Economics and Finance*, *66*, 13-20. doi: 10.1016/j.qref.2017.04.011

Delmas, M. A., & Lim, J. (2017). Corporate environmental performance and lobbying. *Academy of Management Discoveries*, *3*(3), 302–321.

Deloitte. (2021). *Comparing rating agencies and esg methodologies.* https://www2.deloitte.com/content/dam/Deloitte/ce/Documents/about-deloitte/ce_table_ratings_esg_eng.pdf.

Diebold, F. X., & Li, C. (2003). *Forecasting the term structure of government bond yields* (Working Paper No. 10048). National Bureau of Economic Research. Retrieved from https://www.nber.org/papers/w10048

Eaton, J., & Gersovitz, M. (1981). Debt with potential repudiation: Theoretical and empirical analysis. *The Review of Economic Studies*, *48*(2), 289–309.

European Commission. (2021). *Eu taxonomy for sustainable activities.* https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en.

European Parliament and Council. (2014, 10 22). *Directive 2014/95/eu of the european parliament and of the council.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0095.

European Stability Mechanism. (2018). *The pricing of g7 sovereign bond spreads - the times, they are a-changin* (Tech. Rep.). European Stability Mechanism.

Franklin Templeton. (2022). *Update on our esg scores.* https://franklintempletonprod.widen.net/content/esfsbbqhv6/pdf/update-on-our-esg-scores-1022-u.pdf.

Gibson, R., & Krueger, P. (2019). Esg and financial performance: Aggregated evidence from more than 2000 empirical studies. *Journal of Corporate Finance*, *50*, 44-58. doi: 10.1016/j.jcorpfin.2018.10.014

Gonenc, H., & Scholtens, B. (2017). Environmental and financial performance of fossil fuel firms: A closer inspection of their interaction. *Ecological Economics*, *132*, 307–328.

Gruber, J. W., & Kamin, S. B. (2005). *Fiscal positions and government bond yields in oecd countries* (Tech. Rep.). Board of Governors of the Federal Reserve System (US).

Halbritter, G., & Dorfleitner, G. (2015). The wages of social responsibility — where are they? a critical review of esg investing. *Review of Financial Economics*, *26*(1), 25–35.

Institutional Shareholder Services Group of Companies (ISS). (2021). *Country rating.* https://www.issgovernance.com/esg/ratings/country-rating/.

International Finance Corporation. (2016, 12). *Mobilizing private climate finance—green bonds and beyond.* https://www.ifc.org/wps/wcm/connect/2996f197-a75b-422a-9e2f-cdc022d8ea96/EMCompass+Note+25+Green+Bonds+FINAL+12-5.pdf?MOD=AJPERES&CVID=lzgXSmr.

Kaplan, R. S., & Ramanna, K. (2021, 11). *Accounting for climate change.* https://hbr.org/2021/11/accounting-for-climate-change.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). *The worldwide governance indicators: Methodology and analytical issues* (Tech. Rep.). World Bank Policy Research Working Paper No. 5430.

Krebbers, A. (2020). *There's no successful e or s without a functioning g in esg.* https://www.natwest.com/corporates/insights/sustainability/theres-no-successful-e-or-s-without-a-functioning-g-in-esg.html. (Accessed on May, 2023)

Lins, K. V., Servaes, H., & Tamayo, A. (2017). Social capital, trust, and firm performance: The value of corporate social responsibility during the financial crisis. *The Journal of Finance*, *72*(4), 1785-1824. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/jofi.12505 doi: https://doi.org/10.1111/jofi.12505

Morgan Stanley Investment Management. (2021). *Esg in sovereign fixed income investing.* https://www.morganstanley.com/im/publication/insights/articles/article_esginsovereignfixedincomeinvesting_us.pdf.

Nayak, S. (2010). Investor sentiment and corporate bond yield spreads. *Review of Behavioral Finance*, *2*, 59–80.

OECD. (2015). *G20/oecd principles of corporate governance* (Tech. Rep.). Paris: OECD Publishing. Retrieved from https://www.oecd-ilibrary.org/docserver/9789264236882-en.pdf?expires=1684070256&id=id&accname=ocid196107&checksum=E6D9CA019C311D93BEBF9E1BDD32F6C8

Our World in Data. (2022). *Taxation.* https://ourworldindata.org/taxation.

Pech, L. (2022). The rule of law as a well-established and well-defined principle of eu law. *Hague Journal on the Rule of Law*, *14*, 107–138.

Pineau, E., Le, P., & Estran, R. (2022). Importance of esg factors in sovereign credit ratings. *Finance Research Letters*, *49*, 102966. doi: 10.1016/j.frl.2022.102966

PwC. (2022, 10 10). *Esg-focused institutional investment seen soaring 84% to us$33.9 trillion in 2026, making up 21.5% of assets under management: Pwc report.* https://www.pwc.com/gx/en/news-room/press-releases/2022/awm-revolution-2022-report.html.

Sgherri, S., & Zoli, E. (2010). *Euro area sovereign risk during the crisis.* International Monetary Fund.

Social Finance. (2021). *Reducing reoffending in peterborough.* https://www.socialfinance.org.uk/projects/reducing-reoffending-in-peterborough.

Stock, J. H., & Watson, M. W. (2007). *Introductory econometrics.* Cambridge University Press.

Swedish Agency for Growth Policy Analysis. (2018, 12 14). *From voluntary to mandatory sustainability reporting.* https://www.tillvaxtanalys.se/in-english/publications/pm/pm/2018-12-14-from-voluntary-to-mandatory-sustainability-reporting.html.

TradingView. (2023). *Major 10-year bond prices.* https://www.tradingview.com/markets/bonds/prices-major/. (Accessed: May 2023)

UNCTAD. (2022). *World investment report 2022: International tax reforms and sustainable investment* (Tech. Rep.). Geneva: United Nations Conference

on Trade and Development. Retrieved from https://unctad.org/system/files/official-document/iteteb20033_en.pdf

World Bank. (2020). *World bank: Environmental, social and governance (esg) data: A guide for investors.* https://thedocs.worldbank.org/en/doc/375981604591250621-0340022020/original/WorldBankESGGuide2020FINAL.11.5.2020.pdf.

World Bank. (2023). *Databank.* https://databank.worldbank.org/. (Accessed: March, 2023)

Appendices

A Indices

A.1 E index

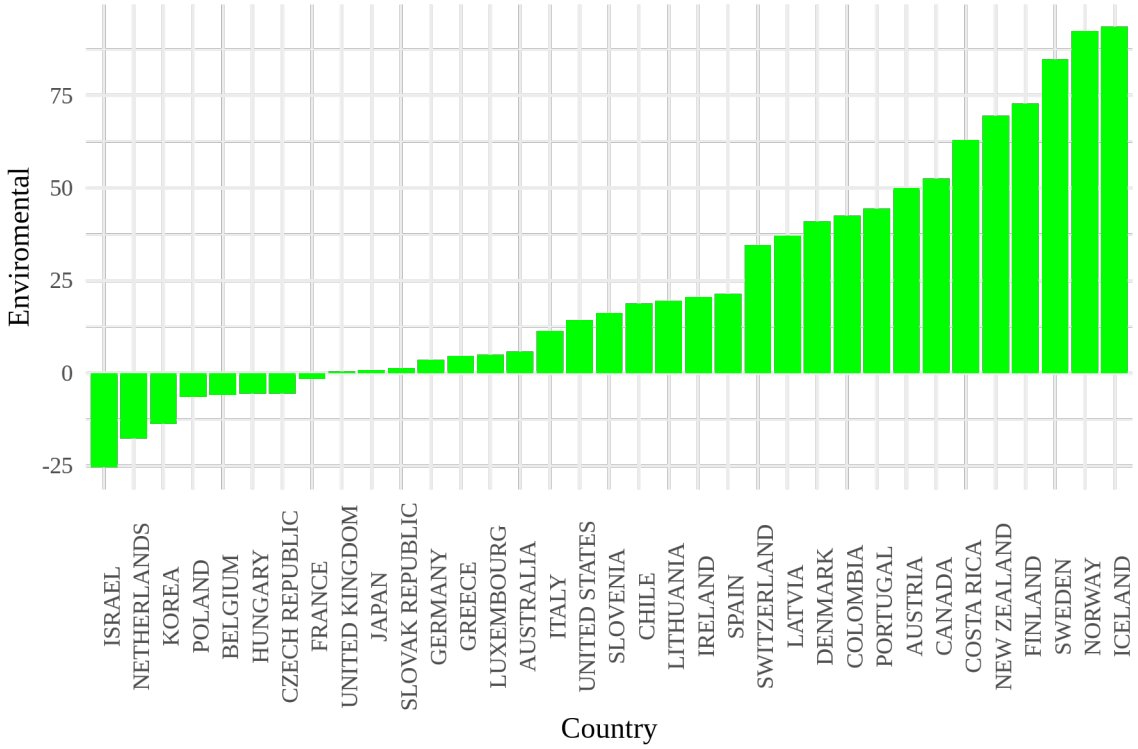


Figure 1: Visualisation of the Environmental index

A.2 S index

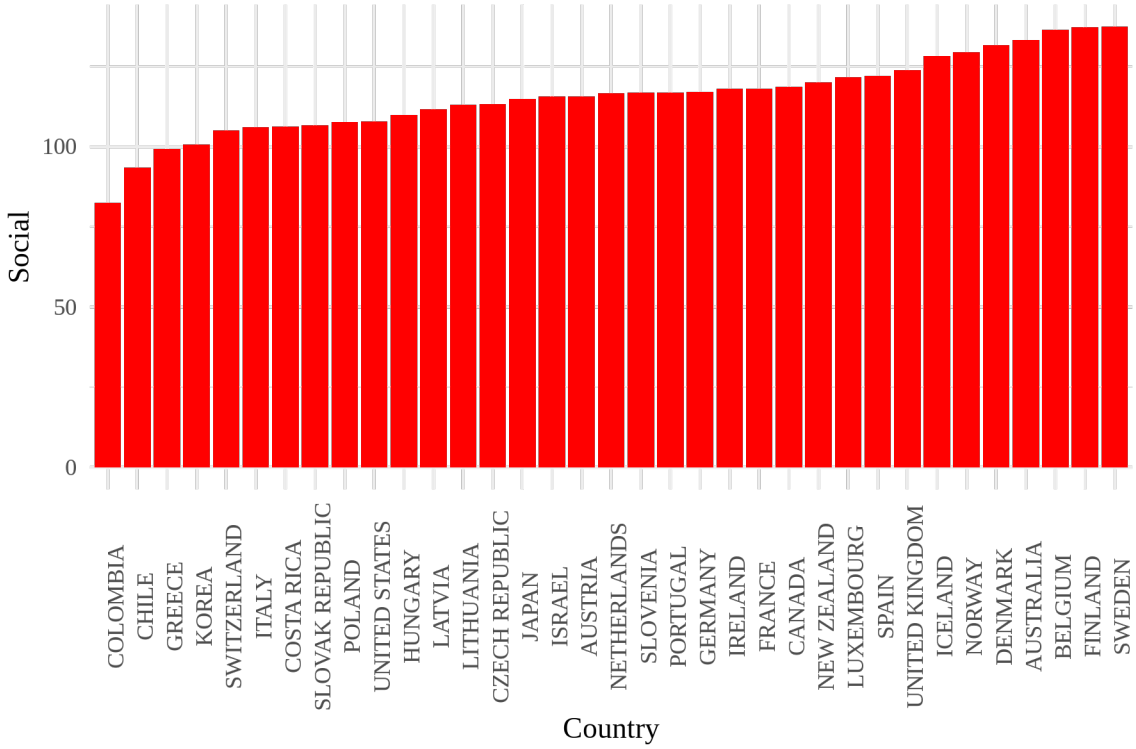


Figure 2: Visualisation of the Social index

A.3 G index

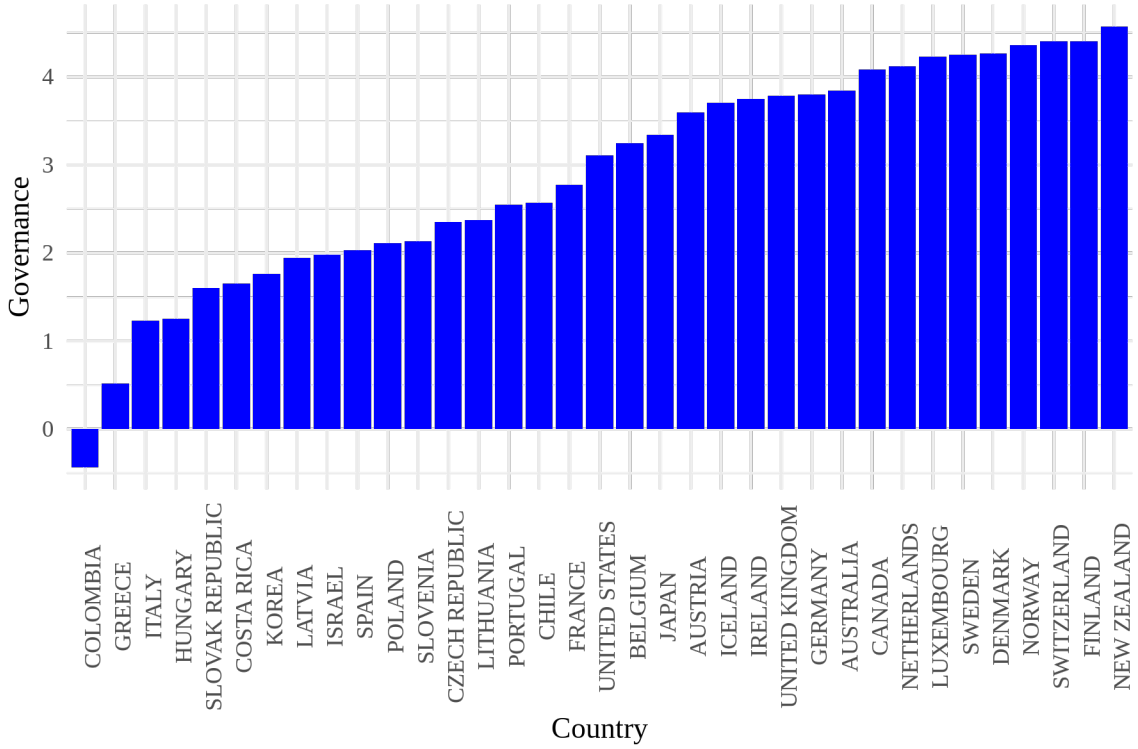


Figure 3: Visualisation of the Governance index

A.4 SG index

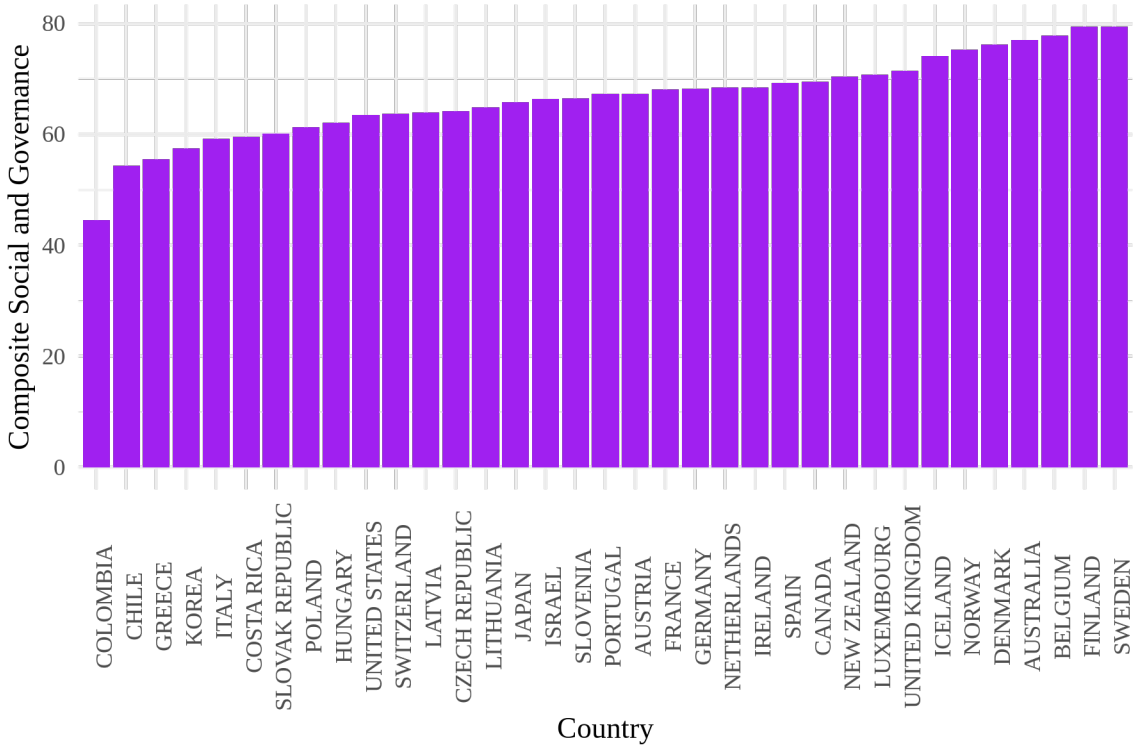


Figure 4: Visualisation of the SG index

A.5 ESG index

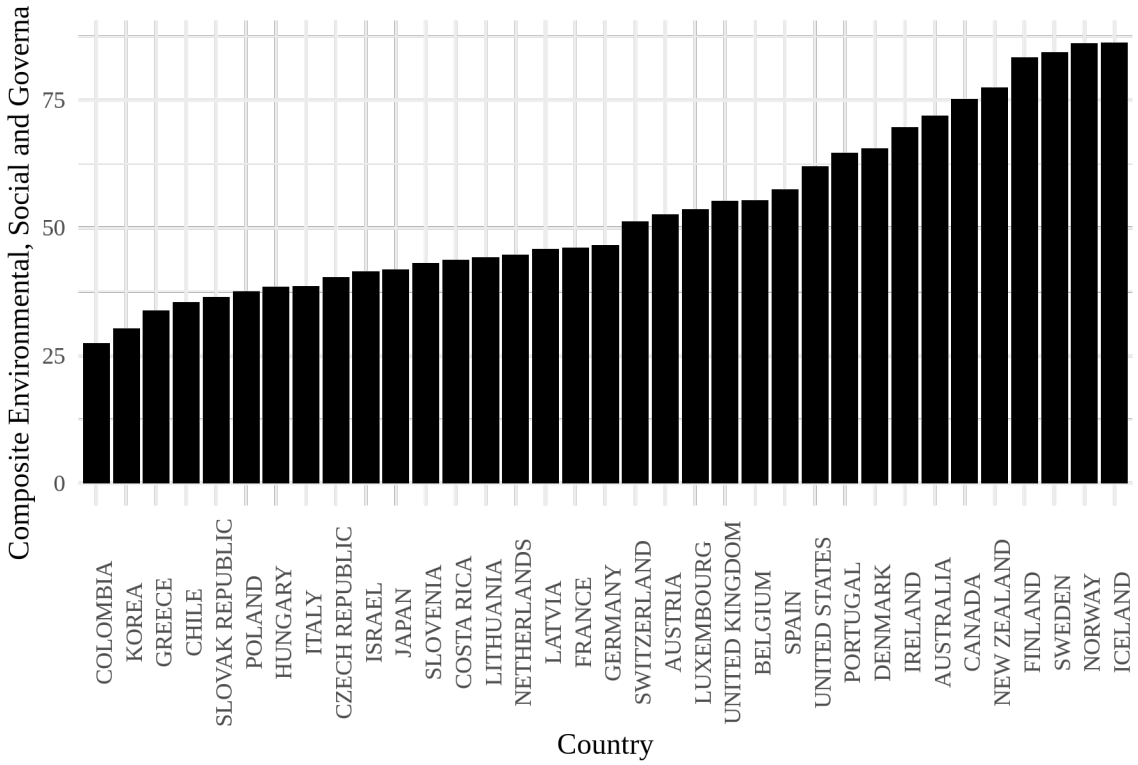


Figure 5: Visualisation of the ESG index

A.6 PCA - mathematical motivation

Let $\mathbf{y} \in \mathbb{R}^d$ describe an observed point. We then have that the expected variance of this observed point is $V(\mathbf{y}) = E_{\mathbf{y}}[(\mathbf{y} - E[\mathbf{y}])^T(\mathbf{y} - E[\mathbf{y}])]$. Let $\mathbf{W} \in \mathbb{R}^{d \times k}$ be the linear transformation from d to k dimensions with orthonormal columns. The variance of a observed transformed point $\mathbf{x} = \mathbf{W}^T\mathbf{y}$ is then

$$V(\mathbf{x}) = E_{\mathbf{y}}[(\mathbf{W}^T(\mathbf{y} - E[\mathbf{y}])^T\mathbf{W}^T(\mathbf{y} - E[\mathbf{y}])] = E_{\mathbf{y}}[(\mathbf{y} - E[\mathbf{y}])^T\mathbf{W}\mathbf{W}^T(\mathbf{y} - E[\mathbf{y}])].$$

The key property of PCA is that the PCA transformation maximizes this variance. We use the sample mean to express the variance further according to

$$\begin{aligned} V(\mathbf{x}) &= \frac{1}{n}\sum_{i=1}^{n}((\mathbf{y_i} - E[\mathbf{y_i}])^T\mathbf{W}\mathbf{W}^T(\mathbf{y_i} - E[\mathbf{y_i}])) \\ &= \frac{1}{n}Tr((\mathbf{Y} - E[\mathbf{Y}])^T\mathbf{W}\mathbf{W}^T(\mathbf{Y} - E[\mathbf{Y}])) = \frac{1}{n}Tr(\mathbf{Z}^T\mathbf{W}\mathbf{W}^T\mathbf{Z}) \end{aligned}$$

where we have set $\mathbf{Z} = \mathbf{Y} - E[\mathbf{Y}]$ (this is the centered data matrix). $E[\mathbf{Y}]$ is in practice approximated as $E[\mathbf{Y}] \approx \frac{1}{n}\mathbf{Y}\mathbf{1}_n\mathbf{1}_n^T$. Now consider the SVD $\mathbf{Z} = \mathbf{U}\mathbf{\Sigma}\mathbf{V}^T$. We then have that

$$\begin{aligned} V(\mathbf{x}) &= \frac{1}{n}Tr((\mathbf{U}\mathbf{\Sigma}\mathbf{V}^T)^T\mathbf{W}\mathbf{W}^T\mathbf{U}\mathbf{\Sigma}\mathbf{V}^T) \\ &= \frac{1}{n}Tr(\mathbf{V}\mathbf{\Sigma}\mathbf{U}^T\mathbf{W}\mathbf{W}^T\mathbf{U}\mathbf{\Sigma}\mathbf{V}^T). \end{aligned}$$

We want to maximize this expressions. We observe that the above expression reaches its maximum when the k columns of $\mathbf{W}$ are co-linear with the columns of $\mathbf{U}$ that are associated with the $\mathbf{k}$ largest singular values in $\mathbf{\Sigma}$, i.e. $\mathbf{W} = \mathbf{U}_k$. Let our data set be described by $\mathbf{Y} \in \mathbb{R}^{d \times n}$. The linear transform of our data $\mathbf{Y}$ is then achieved through $\mathbf{X} = \mathbf{W}^T\mathbf{Y} = \mathbf{U}_k^T\mathbf{Y}$. $\mathbf{X} \in \mathbb{R}^{k \times n}$ is our new transformed data with lower dimensionality ($k < d$).

B Regression results

B.1 Yield Spread vs Environmental Index with Control

Table 3: Regression Results

	Dependent variable:
	Yield Spread
Environmental Index	0.019
	(0.016)
GDP per capita growth (annual pct.)	0.012
	(0.114)
Inflation, consumer prices (annual pct.)	−0.356
	(0.370)
Net lending (+) / net borrowing (-) (pct. of GDP)	0.254
	(0.262)
Current account balance (pct. of GDP)	−0.152
	(0.138)
Total reserves in months of imports	0.068
	(0.127)
Trade (pct. of GDP)	−0.003
	(0.009)
Constant	−0.592
	(1.492)
Observations	35
R^2	0.281
Adjusted R^2	0.095
Residual Std. Error	2.382 (df = 27)
F Statistic	1.511 (df = 7; 27)
Note:	*p<0.1; **p<0.05; ***p<0.01

B.2 Yield Spread vs Social Index with Control

Table 4: Regression Results

	Dependent variable:
	Yield Spread
Social Index	-0.077^{**}
	(0.037)
GDP per capita growth (annual pct.)	0.020
	(0.108)
Inflation, consumer prices (annual pct.)	-0.223
	(0.360)
Net lending (+) / net borrowing (-) (pct. of GDP)	0.004
	(0.222)
Current account balance (pct. of GDP)	-0.107
	(0.135)
Total reserves in months of imports	-0.050
	(0.129)
Trade (pct. of GDP)	-0.009
	(0.008)
Constant	10.145^{**}
	(4.795)
Observations	35
R^2	0.347
Adjusted R^2	0.178
Residual Std. Error	2.271 (df = 27)
F Statistic	2.050^{*} (df = 7; 27)
Note:	*p<0.1; **p<0.05; ***p<0.01

B.3 Yield Spread vs Governance Index with Control

Table 5: Regression Results

	Dependent variable:
	Yield Spread
Governance Index	-0.951^{***}
	(0.333)
GDP per capita growth (annual pct.)	0.019
	(0.102)
Inflation, consumer prices (annual pct.)	-0.305
	(0.333)
Net lending (+) / net borrowing (-) (pct. of GDP)	-0.075
	(0.214)
Current account balance (pct. of GDP)	-0.098
	(0.126)
Total reserves in months of imports	-0.005
	(0.115)
Trade (pct. of GDP)	-0.008
	(0.007)
Constant	3.770^{**}
	(1.566)
Observations	35
R^2	0.419
Adjusted R^2	0.268
Residual Std. Error	2.143 (df = 27)
F Statistic	2.777^{**} (df = 7; 27)
Note:	*p<0.1; **p<0.05; ***p<0.01

B.4 Yield Spread vs Social and Governance Composite Index with Control

Table 6: Regression Results

	Dependent variable:
	Yield Spread
Social and Governance Composite Index	-0.143^{**}
	(0.060)
GDP per capita growth (annual pct.)	0.015
	(0.106)
Inflation, consumer prices (annual pct.)	-0.192
	(0.353)
Net lending (+) / net borrowing (-) (pct. of GDP)	-0.023
	(0.218)
Current account balance (pct. of GDP)	-0.094
	(0.132)
Total reserves in months of imports	-0.057
	(0.125)
Trade (pct. of GDP)	-0.009
	(0.008)
Constant	10.876^{**}
	(4.485)
Observations	35
R^2	0.375
Adjusted R^2	0.213
Residual Std. Error	2.221 (df = 27)
F Statistic	2.317^{*} (df = 7; 27)
Note:	*p<0.1; **p<0.05; ***p<0.01

B.5 Yield Spread vs Environmental, Social and Governance Composite Index with Control

Table 7: Regression Results

	Dependent variable:
	Yield Spread
Environmental, Social and Governance Composite Index	−0.029
	(0.029)
GDP per capita growth (annual pct.)	0.056
	(0.116)
Inflation, consumer prices (annual pct.)	−0.337
	(0.375)
Net lending (+) / net borrowing (-) (pct. of GDP)	−0.012
	(0.255)
Current account balance (pct. of GDP)	−0.161
	(0.139)
Total reserves in months of imports	0.003
	(0.135)
Trade (pct. of GDP)	−0.010
	(0.009)
Constant	2.632
	(2.463)
Observations	35
R^2	0.270
Adjusted R^2	0.081
Residual Std. Error	2.401 (df = 27)
F Statistic	1.426 (df = 7; 27)
Note:	*p<0.1; **p<0.05; ***p<0.01

B.6 Governance Index vs Social Index

Table 8: Regression Results

	Dependent variable:
	Governance Index
Social Index	0.074^{***}
	(0.012)
Constant	-5.683^{***}
	(1.435)
Observations	35
R^2	0.522
Adjusted R^2	0.508
Residual Std. Error	0.883 (df = 33)
F Statistic	36.087^{***} (df = 1; 33)
Note:	*p<0.1; **p<0.05; ***p<0.01

C Descriptive Statistics

Table 9: Descriptive statistics

Type	Statistic	N	Mean	St. Dev.	Min	Max
Yields	10 Years Government Bond Yield	35	2.3	2.5	−0.1	10.1
Dependent variable	Yield Spread (vs U.S.)	35	0.2	2.5	−2.2	7.9
Control variable	GDP per capita growth (annual %)	35	2.5	3.9	−0.1	23.2
Control variable	Inflation, consumer prices (annual %)	35	0.5	1.3	−1.7	5.0
Control variable	Net lending (+) / net borrowing (-) (% of GDP)	35	−1.6	2.3	−6.2	6.3
Control variable	Current account balance (% of GDP)	35	1.4	4.2	−6.4	8.9
Control variable	Total reserves in months of imports	35	3.6	3.9	0.02	16.8
Control variable	Trade (% of GDP)	35	100.6	63.4	27.8	351.1
Environmental factor	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)	35	68.1	40.0	0.0	100.0
Environmental factor	CO2 emissions (metric tons per capita)	35	7.4	3.7	1.5	16.0
Environmental factor	Forest area (% of land area)	35	35.6	18.5	0.5	73.7
Environmental factor	Combustible renewables and waste (% of total energy)	35	6.3	5.2	0.04	24.1
Environmental factor	Renewable electricity output (% of total electricity output)	35	40.0	28.0	1.9	100.0
Environmental factor	Renewable energy consumption (% of total final energy consumption)	35	22.7	16.7	2.7	77.3
Social factor	School enrollment, secondary (% gross)	35	113.5	17.3	91.0	163.9
Social factor	Life expectancy at birth, total (years)	35	80.5	2.5	74.3	83.8
Social factor	Domestic general government health expenditure (% of current health expenditure)	35	70.4	11.7	31.8	85.5
Social factor	Ratio of female to male labor force participation rate (%) (modeled ILO estimate)	35	80.5	6.7	65.8	90.3
Social factor	Mortality rate, under-5 (per 1,000 live births)	35	4.6	2.4	2.5	15.6
Social factor	School enrollment, secondary (gross), gender parity index (GPI)	35	1.0	0.1	0.9	1.1
Social factor	Vulnerable employment, total (% of total employment) (modeled ILO estimate)	35	12.5	8.0	4.1	46.9
Governance Factor	Control of Corruption: Estimate	35	1.2	0.8	−0.3	2.3
Governance Factor	Rule of Law: Estimate	35	1.3	0.6	−0.2	2.1
Governance Factor	Voice and Accountability: Estimate	35	1.2	0.4	0.004	1.7
Governance Factor	Government Effectiveness: Estimate	35	1.3	0.5	−0.1	2.0
Governance Factor	Political Stability and Absence of Violence/Terrorism: Estimate	35	0.7	0.6	−1.1	1.5
Governance Factor	Regulatory Quality: Estimate	35	1.3	0.4	0.4	1.9

D Visualised regressions

D.1 Environmental index

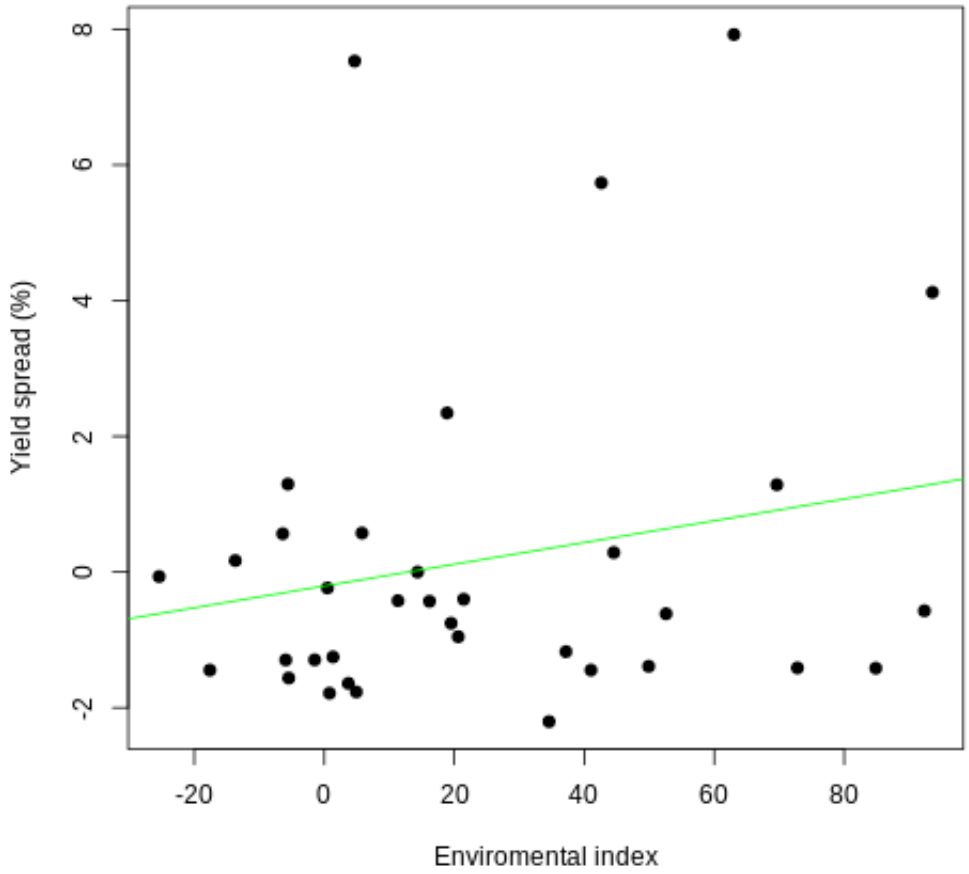


Figure 6: Visualisation of yield spreads regressed on the Environmental index

D.2 Social index

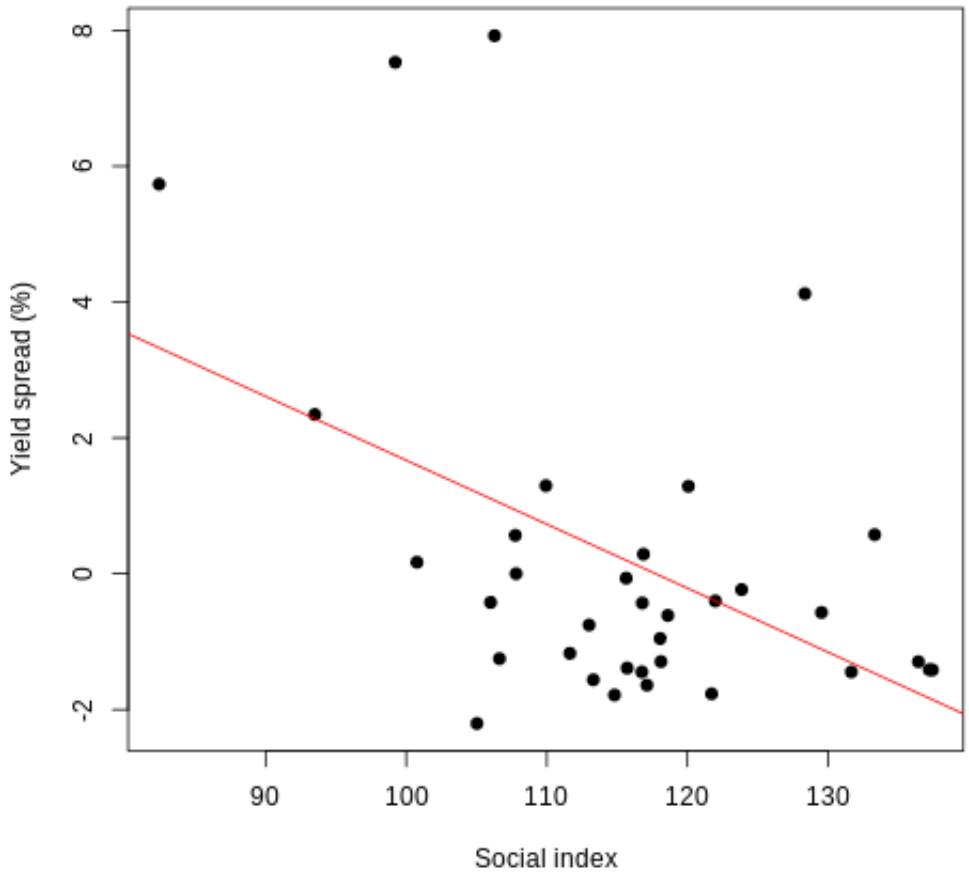


Figure 7: Visualisation of yield spreads regressed on the Social index

D.3 Governance index

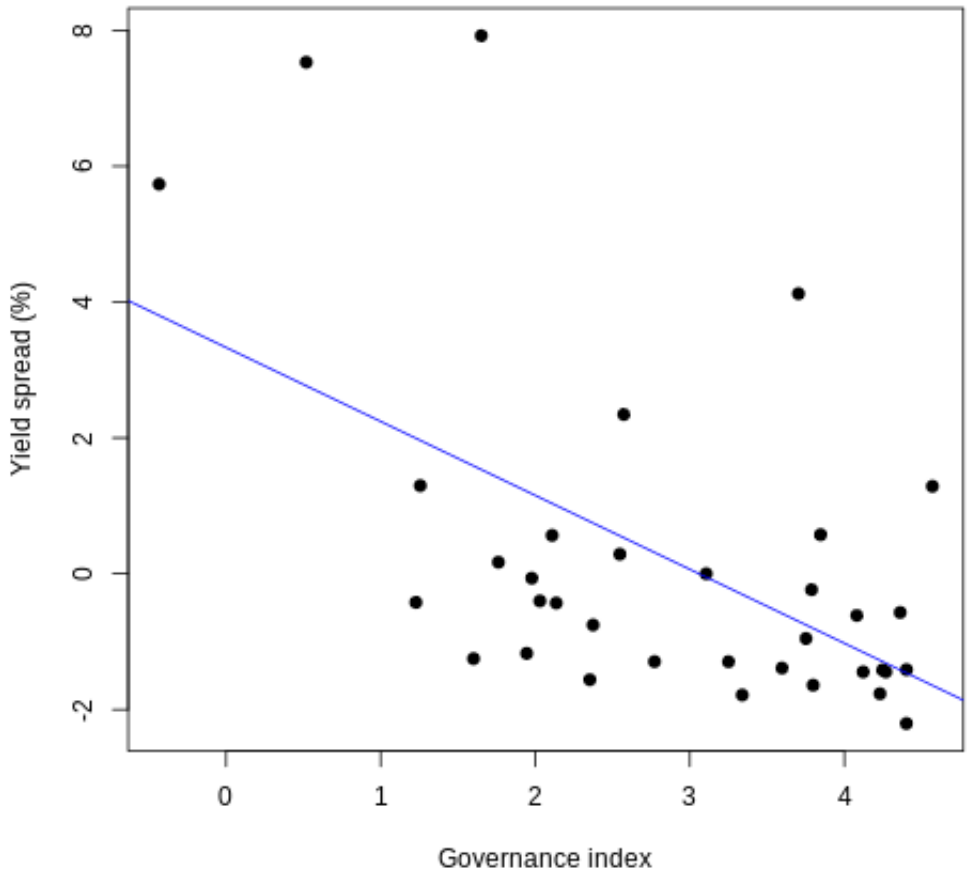


Figure 8: Visualisation of yield spreads regressed on the Governance index