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# Sustainability and Credit Spreads in Japan

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# Sustainability and Credit Spreads in Japan*

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Abstract

Does the market value corporate environmental, social, and governance (ESG) performance in corporate bond credit spreads? We directly measure the relationship between corporate ESG performance and credit spread by constructing the firm-level corporate bond credit spread based on the `bottom-up' approach. We find that ESG performance has a significantly negative effect on credit spreads, but its impact varies across ESG pillars and the credit quality of the issuing firms. Our results also indicate that with greater recognition of the importance of ESG investing, increasing ESG performance has the stronger effect of decreasing credit spreads. Furthermore, our analysis suggests differential trends across the pillars and issuing firms' credit quality. More specifically, the environmental pillar has the largest impact on the credit spreads for low-rated firms, partly reflecting the global trend toward facilitating sustainable finance. Within the E, S, and G pillars, the resource use category, human rights category, and management category respectively show the most prominent lowering effects on credit spreads.

Keywords: Corporate bond spread, ESG investing, PRI, Sustainability
JEL classification: G12, M14, Q56



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# 1 Introduction

The rapid expansion of environmental, social, and governance (ESG) investing raises a question vis-à-vis if the asset prices reflect the firm's ESG performance. Early empirical research related to the relationship between corporate social responsibility (CSR) and financial performance shows mixed results. For example, Kitzmueller and Shimshack (2012) state that there is sparse evidence that environmental performance enhances financial performance. Conversely, recent studies on ESG investing provide extensive evidence to recognize the importance of ESG engagement and ESG-related risk in asset prices, returns, and portfolio choices. This factor is empirically analyzed mostly in the response of stock prices to the ESG-related risk. For example, Hong and Kacperczyk (2009) study the stock prices and returns of "sin" stocks (alcohol, tobacco, and gaming) and find that sin stocks receive less coverage from analysts and have higher returns than otherwise comparable stocks; Borgers et al. (2015) show the positive relation between mutual fund returns and sin stock exposure using the performance of US equity mutual funds between 2004 and 2012; Hong and Kostovetsky (2012) reveal a connection between political value/bias and social responsible investment (SRI) fund management that explicit SRI funds are more likely to be managed by Democratic managers; Gibson Brandon and Krüger (2018) measure the portfolio-level environmental and social characteristics of institutional investors and show that the environmental and social portfolio policies can reduce the portfolio risk; and a theoretical model in Colonnello et al. (2019) suggests an ethical preference-based model to study the sin-stock anomaly and discloses the non-pecuniary factors in the formation of investment decisions and asset prices. However, several research questions remain. The first is whether ESG performance is reflected in the pricing of bonds, which are less affected by growth options than stocks. Second, to what extent does each ESG issue affect corporate bond pricing through a firm's risk component? The third is whether the impact of ESG performance on asset pricing is constant across a firm's credit quality and over time.

An investigation of these questions necessitates the firm-level corporate bond credit spreads and ESG performance measures in which metrics for ESG issues are observable for the investor. Thus, we construct the firm-level corporate bond credit spreads and explore the impacts of a firm's ESG performance on corporate bond credit spreads. This allows us to directly measure the impacts of ESG performance in corporate spreads; moreover, this method makes our firm-level credit spread

data less contaminated by a small number of issuers with large outstanding corporate bonds than the individual bond issue level data.

Our first contribution is to directly measure the impacts of a firm's ESG performance in corporate spreads. The corporate bond credit spread is considered to represent the default risk of the corporate bond issuing firms; Longstaff et al. (2005) find that the majority of credit spreads is due to a default risk. In this study, we construct firm credit spreads which can be viewed as a representation of a default risk based on the "bottom-up" approach according to Gilchrist et al. (2009) and Gilchrist and Zakrajšek (2012). This allows us to directly quantify the impact of a firm's ESG performance on its credit spreads. The market evaluates the risk of firms that differ in the sustainability associated with their ESG activities. There are several recent empirical studies on firms' ESG performances and individual corporate bond pricing, e.g., Stellner et al. (2015) on Eurozone corporate bonds and Jang et al. (2020) on ESG scores and bond returns in Korea. Our direct assessment reveals that ESG performance affects the corporate credit spreads of firms, particularly in the lower credit rating categories. Bai et al. (2019) find that bondholders are more sensitive to downside risk compared to stockholders. Given that the engagement on ESG issues to possibly enhance sustainability reduces a firm's downside risk, which Hoepner et al. (2020) show evidence of using firms' stock return, our findings suggest that lowly rated issuing firms benefit from the engagement on ESG issues.

Our second contribution is to estimate the differential impacts of ESG pillars in the corporate credit spreads in the Japanese corporate bond market. As OECD (2020) documents the strong growth potential of Japan's sustainable investing (third largest center behind the EU and US), Japan's Government Pension Investment Fund (GPIF), the world's largest pension fund, has become a signatory to the United Nation's Principles for Responsible Investment (UN-PRI) since September 16, 2015, which made ESG issues the center of attention in the Japanese financial markets. Notwithstanding a comparatively modest assets under management of approximately USD 2 trillion according to OECD (2020), ESG issues have become a critical criteria for investment decisions in Japan. Meanwhile, ESG issues also provide investment opportunities for investors not only in Japan but also in other countries. This study offers possibilities for the better understanding of the individual risk element of corporate ESG strategies. Bouslah et al. (2013) suggest positive/negative impacts of the individual dimensions of social performance on firm risk using the US equity data. While our results show the lowering effects of ESG scores on corporate credit

spreads, the significance and the magnitude of reduction in corporate spreads depend on the credit quality of issuing firms. The results of additional analyses based on ESG category scores also show similar patterns. Our study contributes to the previous literature on the links between ESG engagements and corporate bond credit spreads by including the findings from the Japanese market.

Thereafter, we investigate whether the impacts of ESG scores on corporate credit spreads are constant over time. Our final contribution is to examine the heterogeneity in the impacts of ESG performance on corporate credit spreads across ESG categories and over time. This adds to the literature which assumes time-variant impacts of ESG engagements on asset prices, e.g., Nofsinger and Varma (2014) examine the ESG equity fund performance during market crisis periods. As it took a longer time in the Japanese than in the EU or US market before ESG investing sank in, the assumption relating to the constant impacts of ESG performance during our sample period seemed unreasonable. We consider the recent upward momentum of ESG investing in the empirical analysis and use the number of signatories to the UN-PRI as a proxy to recognize the importance of ESG investing globally. The findings indicate the heterogeneity in impact that reflects the accelerating climate risk recognition.[1] We observe large distinctions between ESG issues and find that the impact of the environmental (governance) issue is the largest (smallest) recently. This reduction in corporate spreads is more pronounced for lowly rated firms.

Our main findings that corporate ESG performance is a significant determinant of corporate bond credit spreads also add to the literature on the determinants of corporate bond credit spreads. Our method to construct the firm-level credit spread builds on Gilchrist and Zakrajšek (2012), who propose the "bottom-up" approach, and the results indicate that better ESG performance tends to lower credit spreads, even after controlling the issuing firm's financial health, credit rating, and three macroeconomic fundamental risk dimensions in Wu and Zhang (2008). Moreover, this result appears to be stronger for lowly rated firms. To check the robustness of our results, we consider the potential endogeneity concern. Specifically, we address endogeneity concerns that could be due,

[1] It has also been motivating research with respect to environmental innovation, such as Acemoglu et al. (2018) who develop a microeconomic model of the transition to clean technology and find that both carbon taxes and research subsidies encourage production and innovation in clean technologies. In ESG investing, the research on green assets is enhanced; Pastor et al. (2020) theoretically model ESG criteria and find that investors enjoy holding green assets that hedge climate risk, resulting in having low expected returns; Krueger et al. (2020) explore the climate risk perceptions among institutional investors and their survey's findings indicate that institutional investors believe that equity valuations do not fully reflect the risks from climate change and consider climate risks as important investment risks; while Baker et al. (2018) and Jiazhen Wang (2020) estimate the green bond issuance premium in the US and China, respectively.

for example, to the confounding factors that firms could achieve better ESG performance based on *ex ante* knowledge about risk surrounding. That could also affect the corporate default probability and hence corporate credit spreads. The instrumental variable (IV) results show that corporate ESG performance remains a significant factor of corporate bond credit spreads. This could be because the corporate bond credit spread in the secondary market is inherently forward-looking, see, e.g., Stock and Watson (2003), Gilchrist and Zakrajšek (2012), Faust et al. (2013), and Favara et al. (2016); in this sense, the reverse causality between credit spreads and ESG scores seems unlikely to be present, and we could reasonably overlook this issue.

The remainder of the paper is organized as follows: in Section 2, we describe the empirical strategy, construction of firm-level credit spread data and sample for our dataset, specifications to be estimated, and provide summary statistics. In Section 3, we present the main results and robustness check by employing the IV approach based on the two-stage least squares (2SLS). We investigate the impacts of ESG performance on corporate credit spreads across a firm's credit quality and over time in Section 4. The conclusions are presented in the final section.

# 2 Empirical Strategy

We investigate the relationship between a company's ESG performance and its credit spread in Japan. In response to the society's increasing demand for pro-social behavior, firms voluntarily provide relevant information to stakeholders. However, this type of information published by the firm may not be credible in nature, see Tirole (2017). Hence, we use the sustainability metrics at the firm-level provided by the ESG ratings provider and observable to the investor. Notwithstanding the shortcomings already reported by Boffo and Patalano (2020) regarding the strong variation of ESG ratings among providers owing to the different frameworks, measures, and data use, the growing use of ESG scores as a benchmark for ESG investing indicates that they provide useful reference points.

To address the research question relating to whether a firm's pro-social behavior decreases the perception of its risk as measured by corporate bond credit spreads, we construct the individual issuer's credit spreads in the following subsection. Thereafter, we discuss the empirical specification controls for the firm's financial and macroeconomic factors.

## 2.1 Data and Sample

We use a comprehensive dataset of individual corporate bond prices obtained from the Japan Standard Bond Price database, which includes such information as the interest rates, coupon rates, redemption dates, and issue dates of public and private offerings of domestic bonds, foreign bonds, and Eurobonds. This data source provides the most extensive coverage of secondary market prices of corporate bonds publicly issued in the Japanese market. To construct the individual firm's credit spreads, we limit our sample to only straight corporate bonds that are publicly issued in Japan by Japanese corporations. We exclude subordinated corporate bonds and Fiscal Investment and Loan Program agency bonds that are guaranteed by the central government. To ensure that we measure the borrowing costs of firms at the same point in their capital structures, we limit the sample to only senior issues with fixed coupon schedules, following prior studies. The original yield data have a daily frequency, and we use the last observed yield data in December to construct a dataset of year-end compound yields for individual corporate bond issues to match the ESG annual data.[2]

We use these data and those on the government bond zero curve to calculate the credit spread. The government bond yield data are obtained from Thomson Reuters Eikon, which collects market data on Japanese government bonds from Tradeweb and calculates the zero curve. Thomson Reuters Eikon offers government bond zero curve data with different maturities, ranging from one month to forty years. If the government bond zero curve is missing for a particular corporate bond maturity, it is filled via cubic spline interpolation.

We employ the "bottom-up" approach proposed by Gilchrist et al. (2009) and Gilchrist and Zakrajšek (2012) to construct the firm-level credit spread index. With individual corporate and government bond data, credit spreads are calculated as differences between corporate and government bond yields of the same maturity. Thus, we calculate credit spreads using corporate and government bond yields with exactly the same maturity. Thereafter, for the estimation, we obtain the year-end credit spreads of outstanding corporate bonds traded in the secondary market between 2007 and 2018. Our estimation sample of credit spreads is limited to corporate bonds with fixed coupon schedules and bullet bonds with no embedded options.

Specifically, the credit spread for corporate bond $k$ with maturity $m$ issued by firm $i$ at time $t$

[2]Because of this treatment, if a firm does not have any observed yield data in December, the firm is dropped from our dataset.

is given by:

$$S_{imt}[k] = y_{imt}[k] - y^f_{mt}[k],$$

and $y_{imt}[k]$ is the yield of corporate bond $k$ with maturity $m$ at year $t$, while $y^f_{mt}[k]$ is the corresponding government bond yield of the thereafter same maturity at time $t$.

Given these credit spreads, we calculate the individual firm's credit spreads for bonds from the same firm as:

$$cs_{it} = \frac{1}{N_{it}} \sum_k S_{it}[k],$$

where $N_{it}$ is the number of observations in year $t$ of corporate bonds issued by firm $i$. That is, an individual firm $i$'s credit spread in a given year is the arithmetic average of the firm's year-end credit spreads for its outstanding bonds.

We eliminate extreme observations including bond and month observations with credit spreads greater than 2,000 basis points following previous studies, such as that of Gilchrist and Zakrajšek (2012). As a lower bound, we eliminate observations with credit spreads below zero basis points to avoid including negative credit spreads which are economically nonsensical.

For the company's corporate responsibility commitments, we use four ESG scores provided by the Refinitiv (Thomson Reuters)—one of the largest ESG information providers—including MSCI, Sustainalytics, Bloomberg, and RobecoSAM (Boffo and Patalano (2020)) and have been employed in academic research, for example Stellner et al. (2015). They provide more than 450 different metrics, and among them, we use scores related to 10 main important categories: emission, innovation, resource use, CSR strategy, management, shareholders, community, human rights, product responsibility, and workforce.[3] Of the 10 main categories, emission, innovation, and resource use are bunched into environmental score, while CSR strategy, management, and shareholders (community, human rights, product responsibility, and workforce) are rolled up into governance (social) score. We collect these ESG scores of Japanese listed firms from Datastream: ESG score and its three pillar scores, i.e., environmental, social, and governance scores.

According to the Refinitiv (Thomson Reuters) ESG scoring methodology, which produces a score between 0 and 100, the ESG score measures a company's ESG performance based on verifiable reported data in the public domain. Hence, we use this ESG score as a variable for the

[3]The details of the data process, global coverage, scores structure, and calculation methodology are explained in "Environmental, Social and Governance (ESG) scores from Refinitive April 2020."

company's ESG performance. We also use three pillar scores, environmental, social, and governance scores, as variables for the company's performance in each important area. While we use four ESG scores in our estimation, Table 1 shows that these scores are highly correlated among themselves. That is, firms that receive a high score in one of the four variables tend to also receive high scores in the other variables. Hence, we do not use all four variables in the estimation simultaneously, but use each variable by itself.

[Table 1 around here]

We match the credit spread data and ESG scores with the firm's dataset, which includes credit rating and financial indicators, to control the firm's financial health and credit quality. Following previous studies, e.g., Stellner et al. (2015), financial indicators include firm's total revenue, earnings before interest and taxes (EBIT) margin (EBIT/total revenue), debt/capital, capital expenditure (CapEx)/total revenue, return on invested capital (ROIC), and equity volatility. Furthermore, the issuer's credit rating information is used to control the credit quality of the issuer. The firm's information is also taken from the Thomson Reuters database and is as of immediately prior to the year-end credit spread point.

Finally, we incorporate three macroeconomic factors that Wu and Zhang (2008) identify three fundamental risk dimensions underlying an economy: inflation, real output growth, and financial market volatility. The growth rate (year-on-year) of the consumer price index (CPI) is used as an inflation factor. These data are obtained from the Statistics Bureau of Japan. As a real output growth variable, we use the real gross domestic product (GDP) growth (year-on-year) published by the Cabinet Office, Government of Japan. Lastly, we include the percent change in Nikkei Volatility Index (year-on-year) as a measure of the financial market volatility to capture the compound effect of business risk throughout the economy and financial leverage following Wu and Zhang (2008). This factor is considered to affect the pricing of corporate bond, as in Merton (1974).

The final sample is the unbalanced panel data that consist of 245 firms. The sample period is from 2007 to 2018.

## 2.2 Empirical Specification

Do well-performed ESG activities help hedge against ESG risks and lower a company's default risk? To address this question, we examine whether and how a company's ESG performances

influence its credit spread, i.e., the cost of fundraising, after controlling for other characteristics of the credit spread determinants. To capture this effect, we estimate the following model:

$$Credit\ spread_{it} = \alpha_t + \alpha_i + \delta ESG\ score_{it} + \gamma Controls_{it} + \beta Macro_t + \epsilon_{it} \tag{1}$$

where the dependent variable throughout our analysis is the year-end credit spread in basis points of a company $i$ at time $t$. The explanatory variable of interest is the company's ESG performance measured in terms of the (i) ESG, (ii) environmental, (iii) social, and (iv) governance scores of company $i$ at time $t$. Depending on the specification, we use one of the four ESG scores at a time due to their high correlation.

We include control variables, specific to company $i$, commonly used in the literature on credit spread determinants. These are credit rating and financial indicators: issuer's credit rating, logarithm of total revenue, EBIT margin (EBIT/total revenue), debt/capital, CapEx/total revenue, ROIC, and equity volatility. We also include a set of three macroeconomic variables at time $t$ to capture the macroeconomic fluctuations that affect the movement of the credit spreads: the (year-on-year) growth rates of CPI and GDP, as well as the Nikkei Volatility Index. These are time series variables that are not specific to the company. Moreover, the model specification contains firm- and time-fixed effects.

The coefficient of interest is $\delta$. The ESG scores take values between 0 and 100, meaning that the higher the better. While we use four different ESG scores as the explanatory variable, it holds in all four scores that the higher the better. If we find that $\delta$ is statistically significant and negative, then the ESG performance of a company is an important driver of credit spreads as well as beneficial to lower the company's financing cost. We do not necessarily assume that each ESG factor, "E," "S," or "G" has a homogeneous impact on credit spreads. Their impacts or relevance to the economy may change over time during the sample period. We will consider the heterogeneity in impacts following the main results.

In specification (1), we assume that the ESG performance has a constant impact over time. This implies that the recent expansion of ESG investing is ignored in estimating the impacts. We extend the basic model to explore whether the impact of ESG scores on corporate credit spreads reflects the global trend toward facilitating ESG investment. Consequently, we modify (1) as follows:

$$Credit\ spread_{it} = \alpha_t + \alpha_i + \delta_1 ESG\ score_{it} + \delta_2 PRI_t ESG\ score_{it} + \gamma Controls_{it} + \beta Macro_t + \epsilon_{it}. \tag{2}$$

In addition to the inclusion of $ESG\ score_{it}$, we add an interaction term, $PRI_t ESG\ score_{it}$ to capture a global trend of sustainable finance. The interaction variable for a global trend interacts with $PRI$, the number of signatories to the UN-PRI published by the PRI. While this annual measure allows for the emanation of a differential effect from a global trend toward expanding sustainable finance, the interaction term allows for a differential effect on each ESG score on which the investor places emphasis during our sample period.[4]

## 2.3 Summary Statistics

The summary statistics for firm-specific variables to be used in the analysis are reported in Table 2, which decomposes the variables into between and within outputs. Our dataset is the unbalanced panel data from 2007 to 2018. The overall and within outputs are calculated over 2,353 firm-years of data. The rows labeled "overall" show the summary statistics calculated for the entire dataset; the "between" is calculated over 245 firms (firm-level means). The average number of years a firm is observed in our data is approximately 10. The rows labeled "within" provide the information within each firm. The within output refers to the deviation from each firm's average, thus some of these deviations are naturally negative.[5]

[Table 2 around here]

As explained in Subsection 2.1, we eliminate extreme observations such that bond and month observations with credit spreads greater than 2,000 basis points or below zero basis points to avoid including negative credit spreads. We see that the average credit spreads for each firm vary between 15.2 and 1040.4. The figures within this range show that some firms significantly deviate from their average. The firm credit spread indicators have sufficient variation and reflect fluctuation over time because our sample period includes the global financial crisis period.

Note that the mean ESG score is 47.8. Similarly the mean environmental and governance scores are 51.5 and 52.1, respectively. These scores take values between 0 and 100, thus our sample mean suggests that our dataset is not biased toward high- or low-performance firm groups. The mean

[4]Note that the coefficients of variation of PRI and ESG are 0.48 and 0.45, respectively, indicating that neither variables are dominant factor of the interaction. We conduct a robustness check using an alternative proxy, e.g., a dummy for the period after GPIF becomes a signatory to the UN-PRI, and confirm that the results are qualitatively similar. The results are not reported to conserve space.

[5]The definition of "within" here is $x_{it} - \bar{x}_i + \bar{\bar{x}}$. The global mean $\bar{\bar{x}}$ is added back in so that the results are comparable.

social score is 40.3, which is slightly lower than that of the other scores. The "between" minimum and maximum values indicate that the firm-level means for social score is not biased toward the low-performance groups.

In addition to the financial indicators in Table 2, the credit rating information is used in the estimation. The rating categories in the estimation sample range from AAA (approximately 1%) to CCC (approximately 0.2%). The average rating of the sample firms is the A rating category (approximately 59%).

# 3 Results

## 3.1 Main results

In this subsection, we report our benchmark results based on Equation (1). One of our main contributions of this study is to examine whether and how a company's ESG performances influence its credit spreads, i.e., the cost of fundraising, after controlling for other characteristics of the credit spread determinants. Another contribution of our study is to separately investigate the impacts of ESG issues on corporate spreads for the Japanese corporate bond market.

To measure the impacts of firm's ESG performance on corporate spreads, we estimate Equation (1) via the panel fixed effects ordinary least squares (OLS) using the clustered standard errors by firms. We present the results for four sets of regressions. Each set uses a different sustainability measurement variable: ESG, environmental, social, or governance score. The estimation results are reported in Table 3. As evident in column (1) of Table 3, the coefficient of the ESG score, which is our main interest, is significantly negative, with an estimate of $-0.65$. This indicates that if the firm's ESG score increases by 1 point, the credit spread of the firm tends to decrease by 0.65 basis points. This means that the ESG score could affect credit spread by 65 basis points at the maximum, as the ESG scores take values between 0 and 100. Given the extremely low interest rate environments in Japan over the last two decades or thereabouts, this can be considered as a relatively significant impact.

[Table 3 around here]

Many control variables are significant with most of them showing expected relationships. For example, the credit rating dummies indicate that credit spreads approximately increase monotonically as the credit rating worsens. The only exception is the relation between AAA and AA

ratings, where the results indicate that both ratings essentially have the same credit spreads on average. This is because Japanese corporate bonds with AA ratings are considered to have almost no default risk with no significant difference from those with AAA ratings. Additionally, the results suggest that credit spreads tend to be larger as bond ratings deteriorate. The logarithm of total revenue is significantly positive, which is highly contrary to the results of Stellner et al. (2015), showing an interesting difference between Japanese and European corporate bond markets. One possible reason for the difference is that in Japan, firms with larger revenues tend to issue more corporate bonds, thereby paying more premium. Another significant firm variable is the ROIC with a negative sign, which is consistent with Stellner et al. (2015), reflecting lower default risk. All macroeconomic control variables are significant with expected signs. Specifically, GDP growth rates have negative signs, suggesting that good economic conditions generally lower credit spreads. Similarly, inflation tends to decrease credit spreads, as higher inflation is associated with better economic condition for our sample period in Japan. Finally, stock price volatility changes have positive signs because higher uncertainty in the stock market generally reduces risk appetite in financial markets.

To investigate the impact of ESG pillars on corporate spreads separately, we re-estimate Equation (1) using the score of each pillar rather than the ESG score.[6] The estimation results are summarized in the last three columns of Table 3, showing a clear difference between the environmental pillar and the two other pillars. While the environmental score shows no significant impact on credit spreads, the social and governance scores have significantly negative effects on credit spreads. In other words, firms with higher social and governance scores can enjoy lower credit spreads, but firms cannot benefit from the higher environmental score. Against the backdrop of the global trend for tackling climate change, the insignificant impact of the environmental score on credit spreads seems counterintuitive. Notably, Japanese companies own more environment-related technologies than those in other countries; Haščič and Migotto (2015) shows that Japan has the highest ratio of the world's high-value inventions among foremost inventor countries globally in environment-related technologies between 2009 and 2011. Judging from the fact that Japan is at least one of the top performers in environmental-related technologies in Haščič and Migotto (2015), Japanese companies are considered sensitive to environmental issues. It is ambiguous

[6]The high correlation among these scores can cause the multicollinearity problem; thus, we conduct estimations separately throughout this study.

whether the estimated impact of the environmental score incorporates the recent social preference to aggressively tackle the environmental issue. We will investigate this aspect in the next section.

## 3.2 Instruments and 2SLS

We employ an IV approach based on the 2SLS to consider the potential endogeneity problem. In addition to the potential endogeneity concerns that ensue from non-experimental analysis, the confounding factor may influence corporate ESG performance and credit spreads. For instance, the firm with an *ex ante* understanding of risk surrounding could achieve better ESG performance, which may also affect the firm's default probability and hence a corporate credit spread. We assume that variables on the right-hand side in Equation (1) are only exogenous and predetermined, including the ESG variable. In this subsection, we address the endogeneity problem as a robustness test.

For the excluded instruments which must be correlated with the endogenous regressor, our first instrument is the downside risk calculated based on Bai et al. (2019). Their proxy for downside risk is the 5% value at risk estimated from the lower tail of the empirical return distribution of corporate bonds, i.e., the second lowest monthly corporate bond return observation over the past 36 months. Following their method, we calculate monthly return and downside risk proxy by expanding the sample period for our corporate spread dataset, whereafter the value at year-end is used as a proxy for downside risk. As bondholders are sensitive to downside risk, corporate engagement in ESG issues can help to hedge ESG-related risk and reduce a firm's downside risk. Hoepner et al. (2020) show evidence, using stock price data, that the engagement on ESG issues reduces firms' downside risk.

The other instruments we use are according to each ESG issue. A set of excluded instruments are: issuing firm's downside risk, return on equity (ROE), and deviation of the annual mean temperature in Japan for ESG scores; issuing firm's downside risk, yearly difference in emission score, and the logarithm of working capital for environmental scores; issuing firm's downside risk, ROE, and the logarithm of the number of suicides in Japan for social scores; and issuing firm's downside risk, ROE, and the logarithms of the number of Japanese nationals and female employees in Japan for governance scores. Data on deviation of the annual mean temperature, the number of suicides, Japanese nationals, and female employees are obtained from the Japan Meteorological Agency; National Police Agency; Ministry of Health, Labour and Welfare; and Ministry of Internal Affairs

and Communications.

Table 4 reports the estimation results of Equation (1) from the IV approach based on 2SLS. The 2SLS results are restricted to those on the second stage to save space.[7] Our main results remain robust even when we assume the endogeneity of corporate ESG engagement. In the estimation with the IV approach, we should be careful of serious problems which arise when the correlations between the excluded instruments and endogenous regressors are zero or weak. The underidentification test (Kleibergen-Paap statistics) in Table 4 confirms that our estimation model is not underidentified. We conduct additional tests to establish whether the correlations between the excluded instruments and endogenous regressors are nonzero but weak, as this weak-instruments problem could be a serious issue. Therefore, we also report the Kleibergen-Paap Wald *rk F* statistic based on cluster-robust standard errors in Table 4.

[Table 4 around here]

Finally, we report the $p$-value of Hansen J statistics for the overidentification test, which is consistent in the presence of heteroskedasticity. Our instrument suitability is not rejected by this overidentification test. Note that the test for exogeneity of the environmental score as an ESG measure in column (2) of Table 4 fails to reject the null hypothesis that the environmental score is exogenous. The environmental score coefficient in our main results in Table 3 is not significant, and it remains insignificant in Table 4. Hence, our main results remain qualitatively same.

The ESG pillar scores in columns (1) - (4) of Table 4 bear negative coefficients. Each of them is statistically significant in all specifications, except for column (2), which is also insignificant in Table 3. Overall, the corresponding effect is higher, and the IV results are stronger in terms of the magnitude of the estimated effects relative to the OLS results, but the statistical significance is similar.

We address the possible endogeneity issue in this subsection to check the robustness of our main results. With regard to the reverse causality between credit spread and ESG performance, we are less concerned about this issue because corporate bond credit spreads in the secondary market are inherently forward-looking, see, e.g., Stock and Watson (2003), Gilchrist and Zakrajšek (2012), Faust et al. (2013), and Favara et al. (2016). It seems unlikely that the past corporate ESG activities are determined by corporate credit spread, a forward-looking variable. Therefore, it is not unreasonable to assume no reverse causality.

[7] The first stage results are available upon request.

# 4 Credit quality and global trends of responsible investment

The previous section provides clear evidence of a negative relationship between ESG scores and credit spreads. That is, the firm that attains a better ESG performance can enjoy a lower financing cost. Additional analysis indicates that the social and governance scores play a more important role in this negative relationship than the environmental score. One of the key assumptions for the analyses so far is that the effects of ESG scores are homogeneous across firms regardless of their credit ratings and time. However, it could be possible that higher ESG scores can provide stronger signals for corporate bonds in lower credit rating categories. Moreover, the role of ESG scores can be more important, as ESG investing develops in more recent years. Therefore, in this section, we will relax these homogeneity assumptions across credit quality and time to determine whether our results are robust for these assumptions and provide more precise insights if some heterogeneity exists.

## 4.1 Credit quality levels

One possible reason why higher ESG scores lower credit spreads is that the former is closely related to the firm's sustainability. If this is the case, it is reasonable that there is a negative relationship between ESG scores and the credit risk of firms. Consequently, high ESG scores could reduce firms' credit spreads. However, this also suggests that firms with little credit risk should not be considerably affected by ESG scores. In other words, only firms whose credit risk is non-negligible can comparatively benefit from high ESG scores. We will consider this possibility more carefully in this subsection.

To examine the possible differences in the effects of ESG scores on credit spreads between low and high credit risk firms, we divide the sample based on the credit rating information. In Japan, firms with A rating or above are considered to have little default risk in general. Notably, firms with AAA or AA rating have rarely failed for over 20 years in Japan, and the default risk of A rating is generally considered to be less than 1%. However, the default risk of firms with BBB rating or below is typically regarded as non-negligible, although the defaults of BBB-rated firms are still rather seldomly observed in Japan, except in 2009 when two defaults of BBB-rated firms have been reported, according to the Moody's rating. Therefore, it is fair to say that there is little credit risk for the firms with A rating or above in Japan, but there exists some credit risk for firms

with BBB rating or below. Given this observation, we split the sample into two groups depending on whether the firm's rating is above A or below BBB, whereafter we re-estimate model (1) using each subsample.

Table 5 presents the estimation results for each subsample, and we can find noticeable differences between the two subsamples. Specifically, for the above A-rated firm group, although the ESG score shows a significantly negative impact on credit spread, each pillar's score is insignificant. Moreover, the magnitude of the significant impact of the ESG score is estimated as $-0.17$ bps, which is less than one-third of that of the previous section. Similar tendencies can be observed in macroeconomic variables, meaning that the effects of the macroeconomic variables are significant but generally weaker for this group. These observations are consistent with our prediction that credit risk–lowering variables have smaller effects on credit spreads for small credit risk firms.

[Table 5 around here]

Nonetheless, for the below BBB-rated firm group, the ESG scores have a significantly negative impact on credit spreads with a much larger magnitude than that of the previous section and the above A-rated firm group. For this group, if the ESG score increases by one point, the credit spread tends to be lower by 3.25 bps, which is more than 20 times the impact compared to the above A-rated firm group. Furthermore, for the below BBB-rated firm group, the social and governance pillar scores show significantly negative effects on credit spreads with estimates of $-2.59$ and $-2.63$, respectively. This result is consistent with that of the previous section in terms of significance but also demonstrates an interesting difference in the magnitude. The magnitudes of the impacts of the macroeconomic variables also indicate the same tendencies. These results are reasonable, as those variables that can be a signal for the lower credit risk should have larger impacts on credit spreads for higher credit risk firms.

The results suggesting the negative relationship between ESG performance and credit spreads in this subsample analysis are consistent with those in the previous section. When comparing the effects of the overall ESG score, the magnitude for the lowly rated firms, estimated as $-3.25$ bps, which is approximately five times that presented in Table 3, implies that the effect of ESG performance to reduce credit spreads is considerably higher for firms with higher credit risk.

## 4.2 Effects of PRI Signatory growth

Over the last decade, ESG investing has been attracting considerable attention. As a natural consequence, the level of ESG investment has grown significantly over the past 10 years. This suggests that investors have begun to pay more attention to the ESG performance of firms when they make investment decisions. One possible implication of this fact is that ESG scores might play a more important role in financial markets with the development of ESG investments. If this is the case, ESG scores should have larger impacts on credit spreads more recently. We will examine whether this is the case in this subsection.

The goal of the analysis in this subsection is to examine whether the impact of ESG scores on credit spreads has been stronger with the development of ESG investments. Thus, we modify the benchmark regression model (1) to capture the possible time-varying effects of ESG scores, thereby reflecting the development of ESG investments. Specifically, our new regression model is given by Equation (2) by adding an interaction term between the ESG score and a measure of the development of ESG investments evaluated by the number of UN-PRI signatories.In this specification, the effects of the ESG score will change with the number of PRI signatories. More specifically, the impact can be calculated as: $\delta_1 + \delta_2 PRI_t$.

Table 6 reports the estimation results of Equation 2 based on the full sample. An important result of this table is that, with this specification, the coefficient of the ESG measure is not significant any more regardless of the ESG measures. Conversely, the coefficient of the interaction term is highly significant for all ESG measures, including the environmental score. This is highly contrasting to the results of the previous section, where we could not find any significant evidence of a negative relationship between the environmental score and credit spreads. More importantly, this result indicates that the effects of ESG scores on credit spreads have been increasing with the development of ESG investments, as measured by the number of UN-PRI signatories. For example, if the number of UN-PRI signatories increases by 1, the negative impact of the ESG score on credit spreads increases by 0.0002. Given that the number of PRI signatories has exceeded 3000 in 2020, the total effects could be substantial. To elucidate this point clearly, we plot the evolution of the impact of ESG scores on credit spreads based on the estimation results of Table 6 in Panel (a) of Figure 1. Apparently, the impacts of the ESG scores increase rather linearly with the development of ESG investments. As of 2020, the negative impacts range from $0.24$ to $0.50$, depending on the ESG measures.

[Table 6 around here]

[Figure 1 around here]

To accommodate the possible difference in the effects of ESG scores between the credit ratings, we also estimate Equation (2) using the subsamples, namely the above A- and below BBB-rated firm groups. The estimation results are shown in Table 7. Evidently, although none of the coefficients of the ESG measure is significant, that of the interaction term is highly significant for all cases. These results are consistent with those of the previous subsection, but they also show a clear tendency that the magnitude of coefficient of the interaction term is strikingly larger for the below BBB-rated firm groups. This result is similar to the finding of the previous sections, but the current result means that the increasing rates in the impacts of ESG scores for the below BBB-rated firm group are considerably higher than those for the above A-rated firm group. To see this graphically, Panels (b) and (c) of Figure 1 plot the evolution of the impact of ESG scores on credit spreads based on the estimation results of Table 7. The graphs suggest that the negative impact of ESG scores increases rather linearly with the development of ESG investments for both groups, but the increasing rates for the below BBB-rated group are much larger. Therefore, as of 2020, the negative impacts range from $0.17$ to $0.23$ for the above A-rated group, but the corresponding range is from 2.0 to 4.3 for the below BBB-rated group.

[Table 7 around here]

In sum, the results in these subsections are clear cut. The negative impacts of ESG scores on credit spreads have been increasing with the development of ESG investments. This result is independent of the ESG measures and bond credit rating groups. However, our results also demonstrate that the increasing rates of the negative impacts for the below BBB-rated firm group are much larger than those for the above A-rated firm group.

## 4.3 Effectiveness of ESG categories

Thus far, we have estimated our specification using ESG pillar scores. However, each pillar covers the broad ESG categories impacting corporations.[8] In this subsection, we further investigate the impacts of each ESG category that formulates the three ESG pillars to examine which ESG

[8] In fact, the ESG category score is a relative sum of the category weights which vary per industry for the environmental and social categories and remain the same across industries for governance.

categories drive the lowering effect on credit spreads. The underlying categories are as follows: resource use, emission, and innovation, for environment; workforce, human rights, community, and product responsibility, for social; and management, shareholders, CSR strategy, for governance.

We employ the approach in the last subsection to consider the time-varying ESG effect and estimate Equation (2) using the ESG category score for an ESG score. Figure 2 presents the annual effects of the underlying ESG categories that formulate the three ESG pillars by issuer's credit quality. The annual effect is calculated as in the last subsection to vary with the number of PRI signatories. Panels (a)–(c) are for the highly rated issuer, i.e., above A-rated firm group, while those of (d)–(f) are for the lowly rated issuer sample, i.e., below BBB-rated firm group. The estimates of the coefficient for "ESG category score $\times$ the number of PRI signatory" are mostly statistically significant, but even at a 10% significance level, a few are not; the human rights category for highly rated issuers and CSR strategy category for lowly rated issuers.

It is evident from Figure 2 that the magnitude of the reduction of credit spread by the increase in ESG scores has become larger recently for all ESG categories. This is consistent with the pattern presented in the last subsection. Moreover, Panels (d)–(f) show the larger magnitude of the reduction in credit spreads than Panels (a)–(c). For instance, the estimated reduction in credit spreads by an increase in the emission category score in 2018 is -0.116 for the highly rated issuer, while it is -2.089 for the lowly rated issuer. Thus, the reduction in credit spreads depends on the issuer's credit quality for all ESG categories, where the larger reduction is observed for below the BBB-rated firm group.

[Figure 2 around here]

An important finding is that the results for highly rated issuers show a similar pattern in Panels (a)–(c), where the annual lowering effect of credit spread is more or less uniform across categories; however, for lowly rated issuers, it varies substantially across categories within each ESG pillar, as can be seen in Panels (d)–(f). When we investigate each category's credit spread lowering effect, a similar pattern emerges. In Panel (d), i.e., the environment pillar, the resource use category's lowering effects of credit spreads exceed that of innovation. Especially in the social pillar, the human rights category's credit spread lowering effect is noticeable, exceeding that of all other categories. Likewise, in the governance pillar, the management category shows a larger impact on credit spreads than that of the CSR strategy category.

Overall, the analysis of the ESG category indicates the heterogeneous pattern of the negative effects of its scores on credit spreads across the issuer's credit quality. For the above A-rated firm group, the emission, workforce, and CSR strategy categories are the most influential in lowering the credit spreads in the E, S, and G pillars, respectively. Conversely, for the below BBB-rated firm group, the influential categories change in each pillar over time. The resource use, human right, and management categories are distinctly emerging in each ESG pillar, respectively.

# 5 Conclusions

This study presents evidence suggesting that ESG performance can be an important determinant of corporate bond credit spreads, an association that has not yet been well investigated in the literature. The sustainable finance product market is rapidly growing amid the coronavirus disease (COVID-19) pandemic, and new types of debt instruments have emerged: green, social, sustainability, and transition bonds. However, it is unclear how the market values corporate ESG performance and firms' credit risk.

An important feature of this study is the use of the firm-level credit spread constructed from individual bond-level data by employing the bottom-up approach, which allows us to directly measure the link between corporate ESG performance and corporate bond credit spreads. The results in this study indicate that the higher corporate ESG performance significantly decreases corporate bond credit spreads, especially for lowly rated firms. These results have potential implications for firms in connection to new issues of sustainable finance products in the bond market: lowly rated firms can highlight their risk management and/or resilience to hedge ESG risks by attaining better ESG performance and may benefit from the lower fundraising costs. Meanwhile, for investors who are concerned about the fiduciary responsibilities of the board of a corporation or the trustees of a pension fund, under this prolonged, very low interest environment, lowly rated corporate bonds with relatively higher spreads appear attractive.

We also find heterogeneity in impacts among ESG pillars over time, particularly for the environmental issue, and it is more pronounced for lowly rated firms. This finding is important toward understanding the trend and characteristics of ESG investing. We acknowledge the role of governance that is the core of corporate management; however, the market evaluates less governance issue, contrariwise, while the environmental issue arises from the recent global challenges against

climate change. Regarding the time-varying magnitude of impact, the increasing rates of the negative impacts are considerably larger for lowly rated firms than those for highly rated firms. The results of the ESG category score analysis show similar patterns across ESG categories.

The findings of this study provide broad insights not only for asset pricing but also for macroeconomic policy. In September 2020, the European Central Bank stated that they would support sustainable finance and confront the climate change menace by accepting green bonds as collateral with payouts linked to sustainability targets and included them in its asset purchase schemes. This fast-growing green finance is irreversible, and COVID-19 is driving ESG investing with a social as well as a green agenda. This study documents heterogeneity in the impacts of ESG performance on asset prices. Moreover, the impacts are shown to have become greater recently, and this trend is expected to grow. Therefore, our results relating to which of the ESG categories plays a key role in the market can be attributed to different needs from the policymakers as well as market participants.

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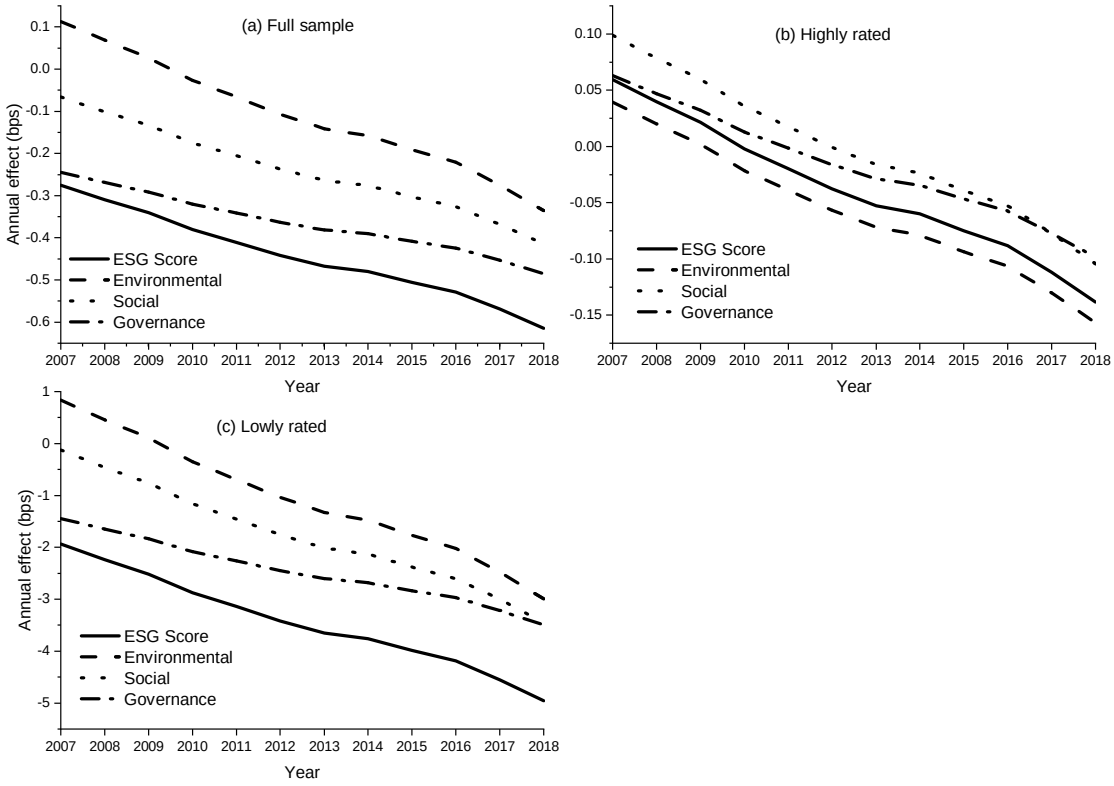
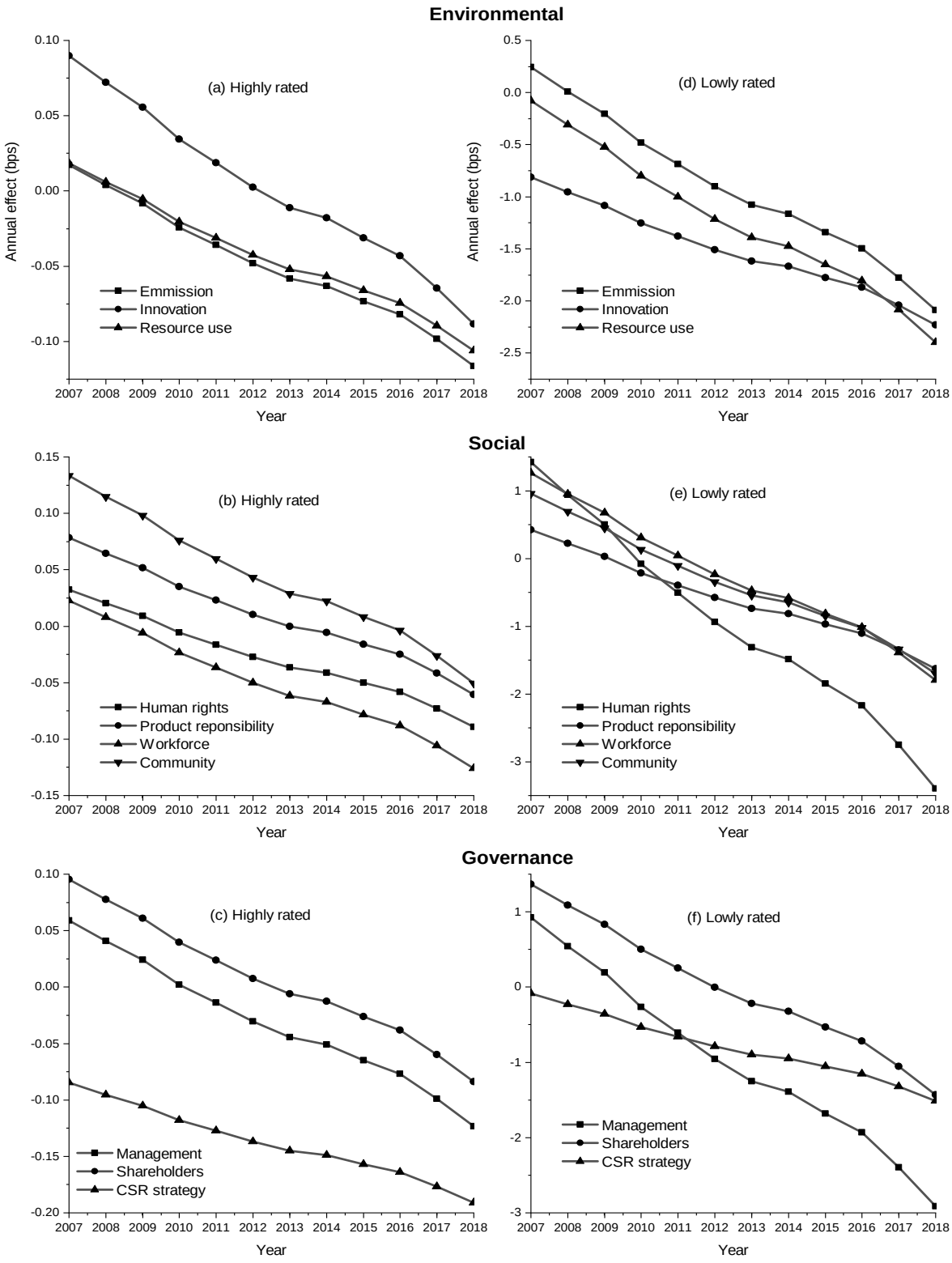
Figure 1: Time-varying annual effects of each ESG score by rating grade




*Notes*: Figures illustrate the time-varying annual effect of each ESG score on credit spreads induced by the development of ESG investments measured by the number of UN-PRI signatories using the full sample (a), highly rated issuer sample, i.e., above A-rated categories (b), and lowly rated issuer sample, i.e., below BBB-rated categories (c). The annual effects of each ESG score are drawn as solid lines; while the dashed, dotted, and chain lines represent the environmental, social, and governance scores, respectively.

Figure 2: Time-varying annual effects by rating grade and underlying ESG categories




*Notes*: Figures show plots of the time-varying annual effects of the underlying ESG categories that formulate the three ESG pillars: environmental, social, and corporate governance. The sample of Panels (a)–(c) is the above A-rated firm group, and that of Panels (d)–(f) is the below BBB-rated firm group.

Table 1: Correlations of ESG score variables

| | ESG Score | Environmental | Social | Governance |
|---|---|---|---|---|
| ESG Score | 1 | | | |
| Environmental | 0.723*** | 1 | | |
| Social | 0.890*** | 0.508*** | 1 | |
| Governance | 0.844*** | 0.392*** | 0.662*** | 1 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$Notes$: The table presents the correlations of the company's ESG performance: *ESG score*, *Environmental*, *Social*, and *Governance* scores.

Table 2: Descriptive statistics

| | | Mean | Std. Dev. | Min | Max | N/n/$\bar{T}$ |
|---|---|---|---|---|---|---|
| Credit spread (bp) | overall | 46.1 | 91.7 | 7.1 | 1864.1 | 2353 |
| | between | | 75.8 | 15.2 | 1040.4 | 245 |
| | within | | 65.5 | -793.3 | 1083.8 | 10 |
| ESG score | overall | 47.8 | 20.0 | 2.2 | 89.9 | 2353 |
| | between | | 18.9 | 3.8 | 82.6 | 245 |
| | within | | 7.7 | 0.5 | 87.2 | 10 |
| Environmental score | overall | 51.5 | 23.7 | 2.1 | 98.4 | 2353 |
| | between | | 21.1 | 6.7 | 95.7 | 245 |
| | within | | 11.8 | -5.6 | 90.4 | 10 |
| Governance score | overall | 52.1 | 27.2 | 0 | 97.4 | 2353 |
| | between | | 25.6 | 0 | 92.9 | 245 |
| | within | | 10.7 | -26.2 | 115.1 | 10 |
| Social score | overall | 40.3 | 22.4 | 0.26 | 93.9 | 2353 |
| | between | | 20.5 | 2.0 | 85.6 | 245 |
| | within | | 10.2 | -6.0 | 86.4 | 10 |
| Revenues (JPYbn) | overall | 1713.5 | 2525.5 | 15 | 29000 | 2353 |
| | between | | 2359.8 | 32.1 | 24000 | 245 |
| | within | | 493.5 | -3286.5 | 6713.5 | 10 |
| EBIT margin | overall | 0.08 | 0.09 | -1.0 | 0.65 | 2353 |
| | between | | 0.08 | -0.03 | 0.61 | 245 |
| | within | | 0.06 | -0.89 | 0.57 | 10 |
| Debt/Capital | overall | 0.55 | 0.42 | 0 | 12.0 | 2353 |
| | between | | 0.34 | .002 | 2.31 | 245 |
| | within | | 0.26 | -1.39 | 10.2 | 10 |
| Capex/Revenue | overall | 0.07 | 0.08 | 0 | 1 | 2353 |
| | between | | 0.07 | 0.001 | 0.67 | 245 |
| | within | | 0.03 | -0.18 | 0.56 | 10 |
| ROIC | overall | 4.2 | 4.5 | -34.7 | 25.8 | 2353 |
| | between | | 2.9 | -7.1 | 19.1 | 245 |
| | within | | 3.7 | -27.4 | 21.9 | 10 |
| Equity volatility | overall | 26.4 | 6.9 | 10.8 | 55.0 | 2353 |
| | between | | 6.3 | 13.4 | 49.5 | 245 |
| | within | | 3.1 | 11.7 | 41.6 | 10 |

*Notes*: The table presents the summary statistics for the unbalanced panel data from 2007 to 2018. N, n, and $\bar{T}$ refer to the observations with firm-year data, the number of firms, and the average number of years per issuing firm, respectively.

Table 3: Credit spreads and sustainability measures: Panel OLS results

| | (1) ESG score | (2) Environmental score | (3) Social score | (4) Governance score |
|---|---|---|---|---|
| Sustainability measurement | -0.65** | -0.11 | -0.39** | -0.45** |
| | (0.279) | (0.124) | (0.172) | (0.189) |
| AAA rating | -1063.88*** | -1063.89*** | -1062.93*** | -1069.27*** |
| | (101.768) | (101.868) | (102.112) | (102.600) |
| AA rating | -1065.40*** | -1063.53*** | -1063.68*** | -1070.40*** |
| | (101.266) | (101.124) | (101.320) | (102.088) |
| A rating | -1050.07*** | -1048.13*** | -1048.08*** | -1054.76*** |
| | (100.624) | (100.458) | (100.666) | (101.370) |
| BBB rating | -1010.59*** | -1007.96*** | -1008.39*** | -1016.31*** |
| | (96.742) | (96.498) | (96.838) | (97.358) |
| BB rating | -660.39*** | -664.31*** | -660.46*** | -668.76*** |
| | (128.155) | (126.618) | (129.647) | (126.833) |
| B rating | -553.36*** | -557.09*** | -551.21*** | -560.73*** |
| | (123.684) | (124.189) | (125.117) | (123.812) |
| ln(Revenue) | 49.32* | 45.64* | 47.76* | 49.79* |
| | (26.067) | (25.698) | (25.919) | (26.038) |
| EBIT margin | -71.81 | -73.62 | -71.50 | -74.88 |
| | (96.934) | (96.879) | (97.302) | (97.303) |
| Debt/Capital | -1.36 | -0.57 | -1.25 | -1.11 |
| | (10.160) | (10.678) | (10.267) | (10.243) |
| Capex/Revenue | 113.49 | 111.94 | 108.74 | 113.62 |
| | (69.231) | (68.432) | (69.607) | (71.174) |
| ROIC | -2.54* | -2.53* | -2.50* | -2.56* |
| | (1.388) | (1.400) | (1.382) | (1.392) |
| Price volatility | 0.33 | 0.39 | 0.27 | 0.35 |
| | (0.823) | (0.819) | (0.837) | (0.812) |
| $\Delta$ GDP | -3.62*** | -3.74*** | -3.70*** | -3.58*** |
| | (0.573) | (0.568) | (0.571) | (0.576) |
| $\Delta$ CPI | -7.08*** | -7.35*** | -7.14*** | -7.02*** |
| | (2.502) | (2.530) | (2.512) | (2.487) |
| $\Delta$ NVIX | 0.28*** | 0.30*** | 0.29*** | 0.28*** |
| | (0.029) | (0.031) | (0.030) | (0.028) |
| Firm Fixed Effects | YES | YES | YES | YES |
| Year Fixed Effects | YES | YES | YES | YES |
| Observations | 2353 | 2353 | 2353 | 2353 |
| Adjusted $R^2$ | 0.60 | 0.60 | 0.60 | 0.60 |

*Notes*: The table presents the estimation results of Equation (1) based on sustainability measurements (1) ESG, (2) Environmental, (3) Governance, and (4) Social scores of issuing firms, their financial indicators, and macroeconomic controls. Baseline rating category is below CCC. Standard errors (SE) clustered at the firm level in parenthesis. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 4: Credit spreads and sustainability measures: 2SLS results

| | (1) ESG score | (2) Environmental score | (3) Social score | (4) Governance score |
|---|---|---|---|---|
| Sustainability | -15.12*** | -1.27 | -2.44*** | -3.63** |
| measurement | (3.571) | (2.125) | (0.932) | (1.430) |
| AAA rating | -600.71*** | -394.03*** | -530.57*** | -534.22*** |
| | (159.600) | (90.769) | (144.974) | (141.545) |
| AA rating | -642.05*** | -392.71*** | -535.91*** | -545.43*** |
| | (153.953) | (89.962) | (144.947) | (141.389) |
| A rating | -629.41*** | -378.79*** | -521.26*** | -527.16*** |
| | (155.298) | (88.788) | (146.580) | (142.877) |
| BBB rating | -601.39*** | -319.12*** | -479.87*** | -495.06*** |
| | (157.399) | (92.879) | (146.785) | (143.329) |
| ln(Revenue) | 103.18** | 24.79 | 47.53* | 71.28** |
| | (45.257) | (16.192) | (25.081) | (29.321) |
| EBIT margin | 19.93 | 105.92 | -2.53 | -20.48 |
| | (88.792) | (108.898) | (66.416) | (71.086) |
| Debt/Capital | -17.00 | 28.27 | -2.78 | -5.13 |
| | (10.615) | (31.547) | (8.320) | (8.119) |
| Capex/Revenue | 183.01 | 45.29 | 96.19 | 140.46 |
| | (112.992) | (75.734) | (75.351) | (93.681) |
| ROIC | -3.20* | -3.52* | -3.08** | -3.46** |
| | (1.820) | (1.904) | (1.467) | (1.566) |
| Price volatility | -1.67 | -0.11 | -0.29 | 0.13 |
| | (1.830) | (1.306) | (1.116) | (1.013) |
| $\Delta$ GDP | -2.33 | -3.06*** | -4.19*** | -3.10*** |
| | (1.408) | (0.644) | (0.705) | (0.931) |
| $\Delta$ CPI | -0.02 | -5.70*** | -6.19** | -4.72 |
| | (4.273) | (1.649) | (2.903) | (2.999) |
| $\Delta$ NVIX | -0.01 | 0.28*** | 0.25*** | 0.18*** |
| | (0.109) | (0.042) | (0.037) | (0.057) |
| Firm Fixed Effects | YES | YES | YES | YES |
| Year Fixed Effects | YES | YES | YES | YES |
| Observations | 1983 | 1565 | 1983 | 1983 |
| Kleib.-Paap underid. test | 11.7 | 8.68 | 52.44 | 64.20 |
| p-val | 0.01 | 0.03 | 0.00 | 0.00 |
| Kleibergen-Paap F-stats | 19.94 | 3.24 | 38.96 | 45.22 |
| Hansen J (prob) | 0.41 | 0.06 | 0.17 | 0.07 |

*Notes*: The table presents the estimation results of Equation (1) based on 2SLS. Baseline rating category is below the BB-rated categories. SE clustered at the firm level in parenthesis. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 5: By credit rating levels

| | High (above A rating) | | | | Low (below BBB rating) | | | |
|---|---|---|---|---|---|---|---|---|
| | ESG score | Environmental score | Social score | Governance score | ESG score | Environmental score | Social score | Governance score |
| Sustainability measurement | -0.17* | -0.06 | -0.09 | -0.07 | -3.25** | -0.57 | -2.59** | -2.63** |
| | (0.086) | (0.052) | (0.057) | (0.062) | (1.324) | (0.634) | (1.126) | (1.159) |
| AAA rating | -5.07 | -5.49 | -5.36 | -5.37 | | | | |
| | (4.775) | (4.643) | (5.372) | (5.112) | | | | |
| AA rating | -8.97*** | -8.91*** | -9.02*** | -9.00*** | | | | |
| | (2.715) | (2.682) | (2.691) | (2.687) | | | | |
| BBB rating | | | | | -294.09*** | -274.49*** | -274.14*** | -296.35*** |
| | | | | | (30.764) | (29.664) | (28.810) | (32.558) |
| ln(Revenue) | 4.13 | 3.04 | 3.68 | 3.70 | 175.02 | 183.34* | 166.90 | 194.18* |
| | (6.593) | (6.573) | (6.645) | (6.801) | (106.024) | (105.532) | (107.306) | (105.807) |
| EBIT margin | 38.21 | 37.85 | 38.18 | 37.44 | -391.05 | -358.42 | -393.01 | -385.53 |
| | (67.001) | (66.813) | (67.042) | (67.154) | (411.465) | (416.650) | (404.242) | (415.197) |
| Debt/Capital | 21.02** | 22.04** | 21.28** | 21.61** | -12.59 | -12.98 | -12.57 | -11.10 |
| | (10.319) | (10.108) | (10.459) | (10.243) | (11.266) | (11.665) | (10.413) | (10.966) |
| Capex/Revenue | 92.46 | 92.23 | 90.97 | 91.78 | 514.74** | 600.16** | 555.89** | 510.46* |
| | (60.610) | (60.386) | (60.832) | (60.723) | (242.274) | (248.722) | (261.581) | (256.804) |
| ROIC | -0.71* | -0.70 | -0.70* | -0.71* | -5.15 | -6.04 | -5.02 | -5.32 |
| | (0.425) | (0.424) | (0.424) | (0.423) | (5.065) | (5.331) | (4.734) | (5.149) |
| Price volatility | 0.51** | 0.51** | 0.49** | 0.51** | -6.50 | -5.73 | -7.48 | -6.64 |
| | (0.224) | (0.224) | (0.225) | (0.224) | (4.407) | (4.408) | (4.672) | (4.347) |
| Δ GDP | -2.82*** | -2.84*** | -2.83*** | -2.82*** | -9.46*** | -9.80*** | -9.73*** | -8.90*** |
| | (0.352) | (0.350) | (0.352) | (0.357) | (3.083) | (3.153) | (3.061) | (3.129) |
| Δ CPI | -2.95*** | -3.01*** | -2.98*** | -2.97*** | -31.74** | -30.54** | -30.38** | -30.11** |
| | (0.364) | (0.365) | (0.357) | (0.359) | (12.280) | (12.451) | (12.482) | (12.190) |
| Δ NVIX | 0.19*** | 0.20*** | 0.19*** | 0.19*** | 0.77*** | 0.78*** | 0.74*** | 0.71*** |
| | (0.015) | (0.015) | (0.015) | (0.015) | (0.168) | (0.191) | (0.179) | (0.175) |
| Firm Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Year Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Observations | 2041 | 2041 | 2041 | 2041 | 312 | 312 | 312 | 312 |
| Adjusted $R^2$ | 0.55 | 0.55 | 0.55 | 0.55 | 0.68 | 0.68 | 0.68 | 0.68 |

*Notes*: The table shows OLS estimations of Equation (1) by issuer's credit rating levels. The first four columns present results using the firm-level credit spreads for highly rated issuers, while the last four columns for lowly rated issuers. SE clustered at the firm level in parenthesis. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 6: Effects of signatory to the United Nation's Principles for Responsible Investment

| | (1) ESG score | (2) Environmental score | (3) Social score | (4) Governance score |
|---|---|---|---|---|
| Sustainability | -0.24 | 0.16 | -0.03 | -0.22 |
| measurement | (0.356) | (0.151) | (0.227) | (0.230) |
| Sustainability | -0.0002** | -0.0003*** | -0.0002** | -0.0001** |
| measurement× PRI | (0.00009) | (0.00008) | (0.00009) | (0.00006) |
| AAA rating | -1083.30*** | -1090.26*** | -1080.93*** | -1082.22*** |
| | (104.392) | (104.909) | (105.396) | (104.311) |
| AA rating | -1080.42*** | -1086.23*** | -1077.53*** | -1079.67*** |
| | (103.021) | (103.400) | (103.523) | (103.146) |
| A rating | -1061.02*** | -1065.76*** | -1058.86*** | -1060.71*** |
| | (101.908) | (102.172) | (102.346) | (102.032) |
| BBB rating | -1021.00*** | -1025.99*** | -1018.31*** | -1021.60*** |
| | (98.297) | (98.510) | (98.605) | (98.133) |
| BB rating | -663.26*** | -669.26*** | -662.65*** | -667.12*** |
| | (129.009) | (128.269) | (130.155) | (128.222) |
| B rating | -550.62*** | -555.45*** | -549.50*** | -554.20*** |
| | (122.173) | (121.804) | (123.395) | (122.918) |
| ln(Revenue) | 55.25** | 54.76** | 53.49* | 54.88** |
| | (27.437) | (27.211) | (27.437) | (27.103) |
| EBIT margin | -70.38 | -66.80 | -71.93 | -74.38 |
| | (97.298) | (97.649) | (97.436) | (97.309) |
| Debt/Capital | -3.19 | -3.49 | -2.78 | -2.65 |
| | (9.109) | (9.007) | (9.381) | (9.384) |
| Capex/Revenue | 109.91 | 103.76 | 109.13 | 110.83 |
| | (67.874) | (64.229) | (69.008) | (70.020) |
| ROIC | -2.51* | -2.55* | -2.47* | -2.52* |
| | (1.367) | (1.378) | (1.362) | (1.370) |
| Price volatility | 0.15 | 0.09 | 0.13 | 0.24 |
| | (0.861) | (0.862) | (0.873) | (0.847) |
| $\Delta$ GDP | -3.23*** | -3.14*** | -3.33*** | -3.27*** |
| | (0.602) | (0.596) | (0.604) | (0.601) |
| $\Delta$ CPI | -5.99*** | -5.51** | -6.27*** | -6.18*** |
| | (2.290) | (2.233) | (2.318) | (2.368) |
| $\Delta$ NVIX | 0.26*** | 0.25*** | 0.27*** | 0.27*** |
| | (0.029) | (0.028) | (0.029) | (0.029) |
| Firm Fixed Effects | YES | YES | YES | YES |
| Year Fixed Effects | YES | YES | YES | YES |
| Observations | 2353 | 2353 | 2353 | 2353 |
| Adjusted $R^2$ | 0.60 | 0.60 | 0.60 | 0.60 |

*Notes*: The table presents the estimation results of Equation (2) based on sustainability measurements (1) ESG, (2) Environmental, (3) Governance, and (4) Social scores of issuing firms, the interaction between sustainability measurement and the number of signatories to the UN-PRI, their financial indicators, and macroeconomic controls. Baseline rating category is the below CCC-rated categories. SE clustered at the firm level in parenthesis. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 7: By credit rating levels

| | High (above A rating) | | | | Low (below BBB rating) | | | |
|---|---|---|---|---|---|---|---|---|
| | ESG score | Environmental score | Social score | Governance score | ESG score | Environmental score | Social score | Governance score |
| Sustainability | 0.08 | 0.06 | 0.12 | 0.08 | -1.62 | 1.24 | 0.22 | -1.23 |
| measurement | (0.139) | (0.062) | (0.111) | (0.086) | (1.111) | (0.853) | (1.144) | (1.139) |
| Sustainability | -0.0001*** | -0.0001*** | -0.0001*** | -0.0001*** | -0.0017*** | -0.0022*** | -0.0019** | -0.0012** |
| measurement× PRI | (0.00004) | (0.00003) | (0.00004) | (0.00003) | (0.0005) | (0.0007) | (0.0008) | (0.0006) |
| AAA rating | -10.05 | -9.34 | -9.55 | -10.06 | | | | |
| | (7.792) | (6.826) | (7.892) | (7.623) | | | | |
| AA rating | -11.27*** | -11.07*** | -10.74*** | -11.19*** | | | | |
| | (3.034) | (3.035) | (2.941) | (2.996) | | | | |
| BBB rating | | | | | -337.00*** | -342.76*** | -326.44*** | -327.30*** |
| | | | | | (37.143) | (39.586) | (40.412) | (35.487) |
| ln(Revenue) | 8.00 | 7.43 | 7.33 | 7.78 | 166.63 | 174.22* | 167.90 | 180.48 |
| | (6.985) | (6.702) | (7.070) | (7.150) | (104.551) | (99.510) | (105.966) | (107.993) |
| EBIT margin | 37.62 | 39.40 | 36.56 | 36.85 | -412.16 | -358.01 | -399.38 | -403.29 |
| | (67.523) | (67.515) | (67.319) | (67.484) | (409.422) | (413.652) | (407.794) | (409.293) |
| Debt/Capital | 16.47* | 16.08* | 17.67* | 17.30* | -13.09 | -15.54 | -14.91* | -12.02 |
| | (9.573) | (9.600) | (9.802) | (9.529) | (8.469) | (9.427) | (8.679) | (9.105) |
| Capex/Revenue | 92.89 | 91.84 | 93.70 | 92.19 | 367.85 | 351.66 | 415.96* | 401.58 |
| | (59.974) | (58.689) | (60.682) | (60.204) | (239.283) | (219.088) | (231.973) | (258.528) |
| ROIC | -0.70 | -0.73* | -0.68 | -0.70 | -3.83 | -4.91 | -4.42 | -4.52 |
| | (0.428) | (0.428) | (0.426) | (0.426) | (4.295) | (4.660) | (4.282) | (4.588) |
| Price volatility | 0.39* | 0.38* | 0.39* | 0.43* | -8.79* | -9.34* | -8.94* | -8.24* |
| | (0.219) | (0.227) | (0.217) | (0.221) | (4.626) | (4.894) | (4.972) | (4.731) |
| Δ GDP | -2.59*** | -2.60*** | -2.63*** | -2.61*** | -7.84** | -7.27** | -8.41** | -7.84** |
| | (0.330) | (0.333) | (0.329) | (0.338) | (3.132) | (3.224) | (3.133) | (3.178) |
| Δ CPI | -2.40*** | -2.30*** | -2.56*** | -2.49*** | -24.46* | -19.90 | -23.26* | -23.89* |
| | (0.376) | (0.390) | (0.363) | (0.390) | (12.767) | (11.983) | (12.753) | (13.449) |
| Δ NVIX | 0.18*** | 0.18*** | 0.19*** | 0.18*** | 0.57*** | 0.47** | 0.60*** | 0.56*** |
| | (0.013) | (0.013) | (0.014) | (0.013) | (0.181) | (0.206) | (0.189) | (0.202) |
| Firm Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Year Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Observations | 2041 | 2041 | 2041 | 2041 | 312 | 312 | 312 | 312 |
| Adjusted $R^2$ | 0.56 | 0.55 | 0.56 | 0.56 | 0.68 | 0.68 | 0.68 | 0.69 |

*Notes*: The table shows the estimation results of Equation (2) based on sustainability measurements (1) ESG, (2) Environmental, (3) Governance, and (4) Social scores of issuing firms, the interaction between sustainability measurement and the number of signatories to the UN-PRI, their financial indicators, and macroeconomic controls by issuer's credit rating levels. The first four columns present results using firm-level credit spreads for highly rated issuers, while the last four columns show the results for lowly rated issuers. SE clustered at the firm level in parenthesis. *** significant at 1%, ** significant at 5%, * significant at 10%.