

Article

Does ESG Disclosure Affect Corporate-Bond Credit Spreads? Evidence from China

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Abstract: With the exponential development of an ecological and sustainable economy and society, the concept and practice of environmental, social, and governance (ESG) investments are being popularized in the capital market of China. ESG disclosure is an important supplement to financial disclosure and plays an increasingly significant role in asset pricing. In this paper, we selected corporate bond data in China's secondary bond market from 2015 to 2020, and introduced the Nelson–Siegel model to study the influence of ESG disclosure on corporate bond credit spreads in the secondary market. This model passed robustness tests when we used alternative data fitted by the modified Nelson–Siegel model. Results show that ESG disclosure significantly reduces credit spreads on corporate bonds in the secondary market. State ownership and industry play significant roles in moderating the impact of ESG disclosure on corporate bond credit spreads. Specifically, the ESG disclosure of non-state-owned companies and companies in non-high-pollution and -energy-consumption industries has a greater impact on reducing corporate bond credit spreads. Therefore, we urge regulatory departments to establish a sound ESG disclosure evaluation system, and the issue companies to improve the quality of their ESG disclosure, especially non-state-owned companies, and those in non-high-pollution and -energy-consumption industries. Corporate bond investors would benefit from integrating ESG information into their investment decision-making process.

Keywords: ESG disclosure; credit spreads; corporate bond



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1. Introduction

Since the first corporate bond in China was issued in 2007, China's corporate bond market has experienced rapid growth in recent years as part of the government's effort to reform the capital market. According to Wind Information Co. (Wind database), from the end of 2007 to the end of 2020, the number of corporate bonds issued in China increased from 5 to 8972; the issuing scale increased from RMB 5.2 billion to RMB 7680.3 billion, and the proportion of credit bonds increased from 0.44% to 17.92%. Corporate bonds are the second largest type of credit bonds after interbank negotiable deposit certificates. By the end of 2020, outstanding corporate bonds in China reached USD 5.6 trillion, just behind the United States, with USD 10.6 trillion, maintaining its position as the second largest corporate bond market in the world (according to SIFMA: Available online: <https://www.sifma.org/resources/research/us-corporate-bonds-statistics/> and the Asian Development Bank: Available online: <https://asianbondsonline.adb.org/economy/?economy=CN#data>, accessed on 9 May 2021).

Credit spread is an important indicator of the credit risk of firms. Previous studies mainly focused on monetary policy, economic environment, and microfactors such as credit rating and equity structure. With continuous research, increasing attention is being paid to the influence of corporate financial information on credit spreads. As a new investment

philosophy, environmental, social, and governance (ESG) evaluates firms by analyzing various sustainable development indicators that are different from financial information, aiming to bring the environment, social responsibility, and governance of a firm into the investment decision-making process, so as to achieve long-term and sustainable investment, avoiding the loss caused by the excessive pursuit of short-term financial objectives at the expense of non-financial indicators. ESG is the extension and enrichment of the concept of green and responsible investment, and it is an important standard for the international community to measure the level of the green and sustainable development of firms. By the end of 2020, more than 30 countries and regions in the world included ESG into information disclosure requirements in the capital market. The concept and practice of ESG investments were also rapidly developed in China.

There is no consensus on the relationship between ESG disclosure and corporate financing cost. Most studies support the idea that ESG disclosure can reduce the cost of financing and enhance corporate value. However, some studies concluded that ESG disclosure has nothing to do with or even has negative impact on corporate value. Therefore, we take the annual data of corporate bonds issued and circulated by listed companies in the Shanghai and Shenzhen Stock Exchanges from 2015 to 2020 as the initial sample to study the relationship between ESG disclosure and credit spreads of corporate bonds in the secondary market. Compared with previous studies on ESG disclosure and bond pricing, this paper focuses on corporate bonds in the secondary market. We used the Nelson–Siegel (NS) term structure model of interest rates to obtain the credit spreads of corporate bonds, and introduce interactive terms to study the moderating roles of state ownership and industry in the impact of ESG disclosure on the credit spreads of corporate bonds. We then test the robustness of the model by replacing the explained variable with the credit spreads calculated by the modified Nelson–Siegel model. Our study extends the literature on corporate bond credit spreads and provides more empirical support in the field of ESG disclosure. It has theoretical and practical significance in improving the pricing mechanism of corporate bonds in the secondary market, guiding the market to green and sustainable investing.

The remainder of the article is organized as follows. Section 2 reviews the literature background and develops the hypotheses. Section 3 explains the sample selection and model construction. Empirical results are reported in Section 4. Section 5 concludes this study.

2. Literature Review and Hypotheses

2.1. Literature Review

Credit spread is an important indicator of corporate credit risk faced by investors. After Merton pioneered the use of the structural model to explain the option value of bond default [1], macro factors became well studied, including monetary policy [2,3] and the economic environment [4], and micro factors, including credit rating [5] and equity structure [6]. More recently, attention has been paid to the influence of financial information on credit spreads. However, financial information is not a complete and objective evaluation of the company's operating condition. On the one hand, firms are motivated to hide their real business situation, which leads to information asymmetry between the debtor and creditor. On the other hand, firms can manipulate accounting information through earnings management or other methods [7–9].

Existing studies show that, through information disclosure, companies reduce the information asymmetry between investors and rating agencies, and then reduce debt cost and credit spreads. Asymmetric information makes it difficult for investors to reasonably predict the value of the firm, causing deviated forecasts of the term structure of credit spreads [10], and increasing the financing cost of the firms as the compensation for higher default risk [11]. Information asymmetry also increases the volatility of corporate value, which leads investors to adopt more conservative estimates for the future value of the company [12]. On the contrary, timely and detailed information disclosure can lower the

expected risk of default from creditors and underwriters and reduce the actual interest of bonds issued by the firm [13]. Liao et al. investigated the effects of agency and information asymmetry issues embedded in the structural form credit models on bank credit risk evaluation [14]. The availability and readability of financial information have significant impacts on the ratings from rating agencies, thus affecting the debt cost of firms [15].

The quality of information disclosure is also crucial. With the improvement of the quality of information disclosure, the pressure on the financing cost of firms is relieved [16,17], mainly because the expectation of financial stability rises, which reduces the expectation of default risk [18]. Moreover, financial transparency has an even greater impact on the credit spreads of short-term bonds [17].

The concept of ESG investments originated from ethical and responsible investments [19]. When the public's awareness of environmental and resource issues dramatically increases, it is necessary to realize the green and sustainable development of the economy. In recent years, the research regarding the impact of ESG information disclosure on firm values and financing costs has experienced robust global escalation [20–25], but their results are different. Most studies support that ESG disclosure reduces financing cost and improves corporate value, while some studies believe that ESG disclosure is not or is even negatively related to company value. From the geographical perspective, the research on European and American markets confirms a positive impact of ESG disclosure, but those on emerging markets (such as the Southeast Asia market) are inconclusive. Firms effectively reduce information asymmetry by environmental information disclosure so as to obtain the attention and recognition of investors, and to promote their company value [26]. Branco and Rodrigues are the first researchers who found that the disclosure of social responsibility information helps strengthen corporate governance and improve the efficiency of using various resources [27]. Mohanty et al. point out that companies with high ESG rates are less exposed to systematic risk factors and subject to a lower expected cost of capital, and thus higher valuations in a DCF model framework (Mohanty, 2021 B [28]). Dhaliwal et al. believe that reducing the financing cost is the potential motivation for firms to disclose corporate social responsibility (CSR). Empirical results prove that because high-quality information disclosure reduces the prediction errors made by analysts, firms are more likely to obtain large-scale financing at a lower cost [29]. Jang et al. find that ESG scores reveal valuable information about the risk of firms. Additionally, this effect is particularly conspicuous for small firms with significant information asymmetry [30]. Mervelskemper and Streit study the effectiveness of a firm's strategy to report ESG activities and they conclude that ESG performance is more positively valued when firms publish an ESG report [31]. Friede et al. review more than 2000 papers on ESG and corporate value, and find that more than 90% of them show that ESG improves the company's financial situation and corporate value [32]. Similarly, Benlemlih et al. find that a positive variation in CSR ratings significantly reduces systematic risk and improves the firm value [33]. Azmi et al. study the influence of ESG disclosure on the corporate value using the GMM model. They find that the regular disclosure of ESG information can improve the efficiency of cash usage and reduce the cost of corporate equity [34].

On the contrary, some studies reach opposite conclusions. Limkriangkrai and Durand discover that firms with high composite ESG ratings tend to increase their leverage by using a lower cost of debt [35]. Fatemi et al. also conclude that because there are no strict disclosure requirements and unified standards, many firms publish ESG reports that are mostly empty words, and lack supporting statistical data. Even companies in poor operating conditions can whitewash themselves by issuing ESG reports [36]. Dutta and Nezlobin study the impact of information disclosure on equity cost and investor welfare through rigorous mathematical deductions in dynamic scenarios. They prove that when a firm's cash flow growth rate is above a certain threshold, information disclosure can reduce its equity cost, and vice versa [37]. Chen and Yang propose an overreaction hypothesis, stating that investors tend to exaggerate corporate ESG information, leading to ESG momentum effects in financial markets. Their empirical results prove that an ESG

momentum strategy leads to a substantial increase in market performance in the short run but a decrease in the long run [38].

In addition, some studies find that firms with high environmental risk or poor environmental reputation tend to publish ESG information [39], while some other scholars point out that there is no correlation between ESG performance and ESG information disclosure [40,41].

2.2. Hypotheses

Investors rely on publicly released information to evaluate listed companies. Firms with good operating conditions, strong sustainable development ability and high market valuations are more motivated to actively transmit true, effective, and positive signals to the market. Even though ESG information disclosure is not mandatorily imposed by regulators, it provides references for corporate bond investing as helpful as financial information. The credit spreads of corporate bonds are the risk compensation required by investors which is relative to risk-free returns. Non-systematic risks will be reflected in asset pricing in financial markets. Improving the quality of information disclosure can help companies reduce non-systematic risks and improve their financial situation, as well as reduce their frictions with environmentalists and government departments, and obtain more recognition from investors. Based on the above theoretical analysis, we put forward Hypothesis 1.

Hypothesis 1 (H1). *ESG disclosure can improve the valuation of corporate bonds in the secondary market and reduce corporate bond credit spreads, ceteris paribus.*

In our study, state-owned companies refer to the limited liability companies listed on the Shanghai and Shenzhen Stock Exchanges with more than 50% state-owned capital or those actually controlled by the state through articles of association or other agreements. Different from non-state-owned companies, state-owned companies undertake the policy task of guiding national economic operation. The default risk of state-owned companies is smaller than that of non-state-owned companies. We expect that the valuations of state-owned corporate bonds in the secondary market are higher and their credit spreads are lower. Non-state-owned companies rely more on information disclosure to transmit positive signals to the outsiders to improve their competitiveness in the capital market; therefore, their ESG information plays a more important role. We put forward the second hypothesis to test if state ownership has a moderating effect on ESG disclosure.

Hypothesis 2 (H2). *Compared with state-owned companies, the ESG disclosure of non-state-owned companies reduces the credit spreads of corporate bonds by a greater extent.*

According to Industrial Classification for National Economic Activities (2019), we classify the industries of (1) power, heat, gas and water production and supply, (2) construction, and (3) mining as high-pollution and -energy-consumption industries, and the other 17 industries as non-high-pollution and -energy-consumption industries. Then, we study how the impact of ESG disclosure on corporate bond credit spreads is affected by these two categories of industries. Compared with other industries, external investors have a more negative impression of high-pollution and -energy-consumption industries and may pay more attention to their ESG disclosure. It is expected that for these companies, the ESG information is more crucial in investors' decision making, and improving the quality of ESG disclosure is more conducive to corporate image, increasing intangible assets, and firm valuation, and reducing corporate bond credit spreads. This leads to the third hypothesis.

Hypothesis 3 (H3). *Compared with other firms, the ESG disclosure of high-pollution and -energy-consumption firms reduces the credit spread of corporate bonds by a greater extent.*

3. Sample Selection and Model Setup

3.1. Sample Selection

Based on the annual data of corporate bonds issued and circulated by listed firms on the Shanghai and Shenzhen Stock Exchanges from 2015 to 2020, we constructed the sample as follows: (1) eliminate floating-rate corporate bonds; (2) remove bonds with missing data; (3) remove bonds with negative credit spreads; (4) eliminate bonds issued by securities companies. Our final sample contains 2103 corporate bonds. To minimize the impact of extreme entries, we winsorized those in the 5% tail. Same with Deng [20] and Broadstock [42], the ESG disclosure data in this paper came from the third-party rating agency SynTao Green Finance (for more information on SynTao's ESG rating system please visit website: http://syntaogf.com/Menu_EN.asp?ID=34, last accessed on 27 June 2021), a leading consultancy specialized in providing ESG data and green finance advisory in China. It divides firms into ten gradations according to a certain rating framework consisting of three levels of indicators. There are three indicators at Level 1: environmental (E), social (S) and corporate governance (G). Then, at Level 2, the three indicators are further subdivided into 13 issues. At the last level, there are more than 200 core and sector indicators which can be labeled with either ESG management or ESG risk exposure. According to the collected ESG information, the ESG indexes are multiplied by weights to obtain the ESG rating scores. The other data are extracted from Wind.

3.2. Calculating Corporate Bond Credit Spreads

We first used the NS model [43] to fit the yield curve of treasury bonds, and obtained the yield of treasury bonds with any remaining maturity as the risk-free yield.

According to the NS model, the relationship between the spot interest rate $r(t)$ and the remaining maturity t is as follows:

$$r(t) = \beta_0 + \beta_1 \left(\frac{1 - e^{-t/\tau}}{t/\tau} \right) + \beta_2 \left(\frac{1 - e^{-t/\tau}}{t/\tau} - e^{-t/\tau} \right) \quad (1)$$

$$r(0) = f(0) = \beta_0 + \beta_1 \quad (2)$$

$$r(\infty) = f(\infty) = \beta_0 \quad (3)$$

where t is the remaining maturity of treasury bonds. The four parameters, τ , β_0 , β_1 , and β_2 , are solved by an optimization equation. τ is the parameter to be estimated with a positive sign, corresponding to the extreme point of forward interest rate function, and controlling the decay rate of β_0 , β_1 and β_2 .

The bond price is the discount value of future cash flow, and C_t^i is the cash flow of the treasury bond i in period t , so the current theoretical price of treasury bond i traded in the market is:

$$P_i' = \sum_0^T C_t^i e^{-r(t)t} \quad (4)$$

where the corresponding real price of national debt is P_i . The optimization equation is as follows:

$$\min \sum_{i=1}^n (P_i - P_i')^2 \quad (5)$$

The parameters of the NS model can be obtained by importing data. Then, we calculated the yields of treasury bonds with different residual maturities as risk-free maturity yields.

3.3. Model Construction

Considering that the credit spreads of corporate bonds are affected by the macro-economic environment, bond characteristics and micro elements at the same time, we

referred to Gong et al. and Fang et al. to build a fixed-effect multiple-regression model covering all three elements [44,45]:

$$\begin{aligned} Spread_{i,t} = \alpha & + \beta_1 ESG_{i,t} + \beta_2 Maturity_{i,t} + \beta_3 Rating_{i,t} + \beta_4 ROA_{i,t} \\ & + \beta_5 Multiplier_{i,t} + \beta_6 EPS_{i,t} + \beta_7 Cash_{i,t} + \beta_8 Growth_{i,t} \\ & + \beta_9 Litigation_{i,t} + \beta_{10} CPI_{i,t} + \beta_{11} GDP_{i,t} + \beta_{12} M2_{i,t} \\ & + \eta_{Bond} + \eta_{Year} + \varepsilon_{i,t} \end{aligned} \quad (6)$$

The meanings of variables are shown in Table 1. The effects of bond and year are fixed. ε is the random error term.

Table 1. Description of variables.

Variables	Indicators	Index Attribute
Spread	Corporate bond credit spreads	
ESG	ESG disclosure	–
Maturity	Remaining maturity of bond	+
Rating	Debt rating	–
ROA	Return on assets	–
Multiplier	Equity Multiplier	+ / –
EPS	Earnings per share	–
Cash	Cash ratio	–
Growth	Net profit growth rate	–
Litigation	Time(s) of being prosecuted	+
CPI	Consumer Price Index	–
GDP	GDP growth rate	–
M2	Broad money supply	–

4. Results and Discussions

4.1. Descriptive Statistics

Table 2 shows the descriptive statistics of the variables. The mean value of credit spreads of corporate bonds is 2.50, meaning that the yield to maturity of corporate bonds is 2.50% higher than that of treasury bonds with the same maturity fitted by the NS model. The mean value of ESG is 2.99, and the standard deviation is 0.71, which mean that the ESG disclosure ratings of most corporate bonds range from the C+ to B level. The average residual maturity of corporate bonds is 2.68 years, and the standard deviation is 1.84, which indicate that the residual maturities of most corporate bonds circulating in the secondary market are from 0.84 to 4.52 years, that is, most of the corporate bonds in circulation are middle- and short-term bonds. The mean value of corporate bond credit ratings is 10.37, the overall standard deviation is 1.2, the inter-group standard deviation is 1.13, and the intra-group standard deviation is 0.45, indicating that the corporate bond credit ratings are mostly above grade AA, and the credit ratings of the same bond change little over years. This is in line with the overrating of corporate bonds in China.

Table 3 lists the descriptive statistical results of ESG disclosure by year, industry, and state ownership, respectively. The ESG disclosure rating scores increased year by year (except 2015), which is closely related to the improvement of the information disclosure system requested by China's regulatory authorities. It indicates that the concepts of environment protection, responsible investment, and corporate governance are increasingly recognized by investors in China. Moreover, the ESG disclosure scores of state-owned companies are higher than those of non-state-owned companies, and high-pollution and -energy-consumption companies score higher than the others.

Table 2. Descriptive statistics.

Variable	No. of Observations	Mean	Std. Dev.	Min	Max
Spread	2103	2.50	2.99	0.02	9.02
ESG	2103	2.99	0.71	1.00	6.00
Maturity	2103	2.68	1.84	0.00	12.40
Rating	2103	10.37	1.20	1.00	11.00
ROA	2103	1.92	1.95	−5.04	5.26
Multiplier	2103	4.33	2.45	0.00	10.06
EPS	2103	0.40	0.44	−0.40	1.50
Cash	2103	0.30	0.39	−1.15	1.81
Growth	2103	−0.03	1.73	−10.24	10.99
Litigation	2103	1.30	5.63	0.00	100.00
CPI	2103	2.38	0.45	1.40	2.90
GDP	2103	5.10	1.97	2.30	7.00
M2	2103	9.37	1.33	8.10	13.30

Table 3. Descriptive statistics by groups.

Group	Segment	No. of Observations	Mean	Std. Dev.	Min	Max
Industry	Non-high-pollution and -high-energy-consumption industries	1501	2.94	0.71	1	6
	High-pollution and -high-energy-consumption industries	602	3.11	0.71	2	6
Property	non-SOC	1575	2.99	0.73	1	6
	SOC	528	3.53	0.66	2	5
Year	2015	111	2.94	0.70	1	5
	2016	112	2.82	0.65	2	4
	2017	170	2.85	0.80	2	4
	2018	415	2.87	0.69	2	6
	2019	611	2.96	0.73	2	6
	2020	684	3.16	0.67	2	6
Full Sample	—	2103	2.99	0.71	1	6

4.2. Regressions

4.2.1. Full Sample Regression and the Moderating Effect of State Ownership

We adopted fixed-effect panel-data regressions based on the Hausman test results, which rejected pooled OLS and random-effect regressions. We firstly set the credit spreads of corporate bonds as the explained variable, the ESG disclosure as the explanatory variable and others as control variables. Secondly, considering the moderating effect of state ownership (SOC), a multiple regression model with $(ESG \times SOC)$ was constructed. Finally, regressions were carried out separately by groups of SOC and non-SOC. Their results are shown in Table 4.

$$\begin{aligned}
 Spreads_{i,t} = \alpha & + \beta_1 ESG_{i,t} + \beta_2 ESG_{i,t} \times SOC_{i,t} + \beta_3 Maturity_{i,t} + \beta_4 Rating_{i,t} \\
 & + \beta_5 ROA_{i,t} + \beta_6 Multiplier_{i,t} + \beta_7 EPS_{i,t} + \beta_8 Cash_{i,t} \\
 & + \beta_9 Growth_{i,t} + \beta_{10} Litigation_{i,t} + \beta_{11} CPI_{i,t} + \beta_{12} GDP_{i,t} \\
 & + \beta_{13} M2_{i,t} + \eta_{Bond} + \eta_{Year} + \varepsilon_{i,t}
 \end{aligned} \quad (7)$$

Overall, the goodness of fit of the model is more than 50%, both in the full sample and grouped regressions, indicating that we obtained an ideal fitting effect.

The results in Column 1 show a negative correlation between ESG disclosure and credit spreads of corporate bonds at the 1% significance level under the full sample regression. When the ESG disclosure rating increases one unit, the corporate bond credit spread decreases 0.35% on average. This supports Hypothesis 1 that bonds issued by companies with ESG disclosure are valued higher than the others in the secondary market. The results of the full sample regression with interaction terms reported in Column 2 are similar to

those of the full sample regression. The correlation between ESG disclosure and corporate bond credit spreads is significantly negative at the 1% level. The interaction coefficient is 0.108 and significant at the 5% level, meaning that the identity as a state-owned company will lead to a smaller decline in corporate bond credit spread. Next, corporate bonds are divided into the state-owned-company group (SOC = 1) and non-state-owned-company group (SOC = 0). The ESG disclosure coefficients of the two groups are significantly negative, which indicates that the improvement of the ESG disclosure rating can reduce the credit spreads for both state-owned and non-state-owned companies. The ESG disclosure coefficient of state-owned companies is -0.235 , and that of non-state-owned companies is -0.346 , as listed in Columns 3 and 4, respectively, which indicate that the impact of ESG disclosure on reducing credit spreads is stronger in non-state-owned companies. This result is consistent with Hypothesis 2.

Table 4. Regressions with and without the interaction effect of state ownership.

Variables	Full Sample	Full Sample, State Ownership	SOC	Non-SOC
	Spread	Spread	Spread	Spread
	(1)	(2)	(3)	(4)
ESG	-0.350^{***} (-4.79)	-0.381^{***} (-4.75)	-0.235^{**} (-1.99)	-0.346^{***} (-3.88)
ESG * SOC		0.108^{**} (1.97)		
Maturity	0.078^{**} (2.49)	0.076^{**} (2.42)	0.108^{***} (2.68)	0.053^{*} (1.71)
Rating	-0.314^{***} (-5.57)	-0.308^{***} (-5.48)	-0.322^{***} (-7.33)	-0.454^{***} (-9.25)
ROA	-0.368^{***} (-9.66)	-0.370^{***} (-9.68)	-0.524^{***} (-6.65)	-0.342^{***} (-8.04)
Multiplier	0.292^{***} (9.56)	0.286^{***} (9.24)	0.401^{***} (6.41)	0.267^{***} (7.83)
EPS	-1.743^{***} (-9.55)	-1.742^{***} (-9.56)	-0.718^{**} (-2.04)	-1.857^{***} (-9.03)
Cash	-1.239^{***} (-9.78)	-1.247^{***} (-9.87)	-2.388^{***} (-8.40)	-0.985^{***} (-7.05)
Growth	-0.172^{***} (-5.49)	-0.169^{***} (-5.38)	-0.082 (-1.47)	-0.191^{***} (-5.65)
Litigation	0.317^{***} (4.61)	0.321^{***} (4.72)	0.297^{***} (3.84)	0.415^{***} (4.11)
CPI	-0.115 (-1.05)	-0.185^{*} (-1.75)	-0.132 (-0.59)	-0.412^{***} (-3.39)
GDP	-0.024 (-0.31)	-0.046^{*} (-1.68)	-0.097^{*} (-1.73)	-0.025 (-0.78)
M2	-0.127^{***} (-4.04)	-0.127^{***} (-4.03)	-0.144^{***} (-2.81)	-0.075^{*} (-1.92)
Constant	9.039^{***} (11.38)	9.044^{***} (11.43)	13.518^{***} (4.28)	7.654^{***} (8.81)
Fixed Effect	Yes	Yes	Yes	Yes
Observations	2103	2103	602	1501
R-square	0.502	0.670	0.584	0.528

T-statistics are in brackets. *, **, and *** indicate that the correlation is significant at 10%, 5%, and 1% levels, respectively. Standard errors are adjusted at the level of corporate bonds. R-square is the goodness of fit within the group.

4.2.2. Moderating Effect of Industry

In this part, by constructing the following fixed-effect multiple-regression model with the interaction between ESG information disclosure and industry ($ESG \times Industry$), we

study the moderating effect of industry on the relationship between ESG disclosure and corporate bond credit spreads:

$$\begin{aligned} Spreads_{i,t} = \alpha & + \beta_1 ESG_{i,t} + \beta_2 ESG_{i,t} \times Industry_{i,t} + \beta_3 Maturity_{i,t} + \beta_4 Rating_{i,t} \\ & + \beta_5 ROA_{i,t} + \beta_6 Multiplier_{i,t} + \beta_7 EPS_{i,t} + \beta_8 Cash_{i,t} \\ & + \beta_9 Growth_{i,t} + \beta_{10} Litigation_{i,t} + \beta_{11} CPI_{i,t} + \beta_{12} GDP_{i,t} \\ & + \beta_{13} M2_{i,t} + \eta_{Bond} + \eta_{Year} + \varepsilon_{i,t} \end{aligned} \quad (8)$$

Furthermore, the sample is grouped by high-pollution and -energy-consumption industries (industry = 1) and non-high-pollution and -energy-consumption industries (industry = 0). Regression results are shown in Table 5.

Table 5. Regressions with and without the interaction effect of industry.

Variables	Full Sample	Full Sample, Industry	High-Pollution and -Energy-Consumption	Non-High
	Spread	Spread	Spread	Spread
	(1)	(2)	(3)	(4)
ESG	−0.350 *** (−4.79)	−0.333 *** (−4.41)	−0.235 *** (−2.86)	−0.396 *** (−3.88)
ESG * Industry		0.141 * (1.72)		
Maturity	0.078 ** (2.49)	0.081 ** (2.57)	0.108 *** (2.68)	0.053 (1.11)
Rating	−0.314 *** (−5.57)	−0.306 *** (−5.41)	−0.322 *** (−7.33)	−0.454 *** (−9.25)
ROA	−0.368 *** (−9.66)	−0.368 *** (−9.66)	−0.524 *** (−6.65)	−0.342 *** (−8.04)
Multiplier	0.292 *** (9.56)	0.291 *** (9.51)	0.401 *** (6.41)	0.267 *** (7.83)
EPS	−1.743 *** (−9.55)	−1.751 *** (−9.57)	−0.718 ** (−2.04)	−1.857 *** (−9.03)
Cash	−1.239 *** (−9.78)	−1.253 *** (−9.83)	−2.388 *** (−8.40)	−0.985 *** (−7.05)
Growth	−0.172 *** (−5.49)	−0.170 *** (−5.39)	−0.082 (−1.47)	−0.191 *** (−5.65)
Litigation	0.317 *** (4.61)	0.186 * (1.73)	0.328 *** (2.86)	0.423 *** (3.72)
CPI	−0.115 (−1.05)	−0.188 * (−1.77)	−0.132 (−0.59)	−0.412 *** (−3.39)
GDP	−0.024 (−0.31)	−0.043 (−1.58)	−0.097 * (−1.73)	−0.025 (−0.78)
M2	−0.127 *** (−4.04)	−0.126 *** (−3.99)	−0.144 *** (−2.81)	−0.075 * (−1.92)
Constant	9.039 *** (11.38)	8.926 *** (11.06)	13.518 *** (4.28)	7.654 *** (8.81)
Fixed Effect	Yes	Yes	Yes	Yes
Observations	2103	2103	602	1501
R-square	0.502	0.502	0.504	0.528

T-statistics are in brackets. *, **, and *** indicate that the correlation is significant at 10%, 5%, and 1% levels, respectively. Standard errors are adjusted at the level of corporate bonds. R-square is the goodness of fit within the group.

The results in Table 5 are similar to those of the full sample regression. As shown in Column 2, the regression coefficient of interaction term is positive at the significance level of 5%, which means that the impact of ESG disclosure on corporate bond credit spreads will decrease less when a firm belongs to high-pollution and -energy-consumption industries. Furthermore, the group regression results based on industry in Columns 3 and 4 show that the ESG information disclosure coefficients of the two groups are negative at the significance level of 1%, which indicates that ESG disclosure can help firms reduce their credit spreads

no matter which industry it belongs to. In Column 3, the ESG coefficient of high-pollution and -energy-consumption industry is -0.235 , indicating that the improvement of ESG disclosure level by one unit can reduce the credit spread in the secondary market by 0.235% , which is significantly less than that of the non-high-pollution and -energy-consumption industry group (0.396%) in Column 4.

These results are contrary to Hypothesis 3. The possible explanation is that the government imposes higher requirements on environmental and social responsibility information disclosure for firms in high-pollution and -energy-consumption industries. In order to comply with the requirements, firms must publish environmental and social responsibility reports involuntarily. Some firms tend to exaggerate to meet the regulatory requirements, which reduces the quality and credibility of the disclosure. Under this circumstance, ESG disclosure contributes less to reducing credit spreads.

4.3. Endogeneity

The information disclosure of a company is often affected by the average level of information disclosure of other companies in the same industry. In order to alleviate endogeneity, we use instrumental variables to modify the model. Corporate bonds are categorized by industry according to the latest Industrial Classification for National Economic Activities (2019). The mean values of the ESG disclosure of companies in the same industry in the same year are taken as instrumental variables to run two-stage-least-squares (2SLS) regressions, and the data with less than eight corporate bonds in the same industry are deleted, leaving 1632 bonds for the analysis.

In the first stage, we set the mean of ESG disclosure (ESG_AVG) as the instrumental variable and the ESG disclosure (ESG) as the dependent variable, to obtain the exogenous part of ESG fitting value ESG*.

$$ESG^*_{i,t} = \alpha + \beta_1 ESG_AVG_{i,t} + \beta_2 Maturity_{i,t} + \beta_3 Rating_{i,t} + \beta_4 ROA_{i,t} + \beta_5 Multiplier_{i,t} + \beta_6 EPS_{i,t} + \beta_7 Cash_{i,t} + \beta_8 Growth_{i,t} + \beta_9 Litigation_{i,t} + \beta_{10} CPI_{i,t} + \beta_{11} GDP_{i,t} + \beta_{12} M2_{i,t} + \eta_{Bond} + \eta_{Year} + \varepsilon_{i,t} \quad (9)$$

In the second stage, we regressed corporate bond credit spreads (Spread) to the fitted value (ESG*), to revise the endogenous explanatory variable.

$$Spreads_{i,t} = \alpha + \beta_1 ESG^*_{i,t} + \beta_2 Maturity_{i,t} + \beta_3 Rating_{i,t} + \beta_4 ROA_{i,t} + \beta_5 Multiplier_{i,t} + \beta_6 EPS_{i,t} + \beta_7 Cash_{i,t} + \beta_8 Growth_{i,t} + \beta_9 Litigation_{i,t} + \beta_{10} CPI_{i,t} + \beta_{11} GDP_{i,t} + \beta_{12} M2_{i,t} + \eta_{Bond} + \eta_{Year} + \varepsilon_{i,t} \quad (10)$$

The 2SLS regression results of ESG disclosure and corporate bond credit spreads are shown in Table 6.

Regression results of the first stage are shown in Column 1. When we regressed the average ESG disclosure (ESG_AVG) of each industry as the instrumental variable to ESG disclosure (ESG) and kept other control variables consistent with the original regression model, its coefficient was 0.827 , which is significant at the 1% level. Regression results of the second stage are shown in Column 2. When we regressed Spread to ESG*, the coefficient of ESG was still significantly negative at the level of 1% . Moreover, the results for most variables are not different from those of the original regression model, in terms of coefficient sign, significance level and fitting effect. Therefore, the 2SLS regression results support the hypothesis that ESG disclosure reduces credit spreads of corporate bonds, and there is no significant endogenous problem found in the original model.

Table 6. 2SLS regressions testing endogeneity.

Variables	Stage1	Stage2
	ESG	Spread
	(1)	(2)
ESG_AVG	0.827 *** (18.97)	
ESG		−0.274 *** (−4.61)
Maturity	−0.130 *** (−9.07)	0.122 *** (8.71)
Rating	−0.234 *** (−10.41)	−0.316 *** (−9.08)
ROA	1.444 ** (2.08)	−2.046 *** (−5.43)
Multiplier	−0.018 (−0.23)	0.111 *** (6.14)
EPS	0.458 *** (6.31)	−0.218 *** (−6.56)
Cash	0.147 (1.32)	−0.062 (−0.714)
Growth	0.172 *** (5.49)	−0.132 *** (−3.14)
Litigation	0.317 *** (4.61)	0.421 *** (5.13)
CPI	0.018 (0.15)	−0.145 (−1.02)
GDP	−0.044 (−1.61)	−0.046 (−0.68)
M2	−1.320 *** (−12.04)	−0.131 *** (−4.12)
Constant	4.018 *** (11.43)	6.124 *** (17.16)
Fixed Effect	Yes	Yes
Observations	1632	1632
R-square	0.612	0.573

T-statistics are in brackets. **, and *** indicate that the correlation is significant at the 10%, 5%, and 1% levels, respectively. Standard errors are adjusted at the level of corporate bonds. R-square is the goodness of fit within the group.

4.4. Robustness Tests

We use the modified NS model (hereafter the NSM model) [46] to re-fit the treasury yield curve, and the yields to the maturity of corporate bonds are matched with the newly fitted treasury interest rates, so as to obtain the alternative data of corporate bond credit spreads.

Based on the classical NS model, the NSM model is obtained by extending the exponential polynomial method. The functional relationship between the spot interest rate $r(t)$ and the remaining maturity term t is:

$$r(t) = \beta_0 + (\beta_1 + \beta_2 + 2\beta_3 + 6\beta_4)\left(\frac{1 - e^{-t/\tau}}{t/\tau}\right) - \left[(\beta_2 + 2\beta_3 + 6\beta_4) + (\beta_3 + 3\beta_4)\frac{t}{\tau} + \beta_4\left(\frac{t}{\tau}\right)^2 \right] e^{-t/\tau} \quad (11)$$

$$r(0) = f(0) = \beta_0 + \beta_1 \quad (12)$$

$$r(\infty) = f(\infty) = \beta_0 \quad (13)$$

Based on the NS model, the risk-free return rates of treasury bonds and then new credit spreads are calculated. Results in Table 7 show that in full-sample and sub-sample regressions grouped by state ownership and industry, ESG coefficients remain highly significant and negative when we import new credit spreads data. The regression results

are consistent with the original results, indicating that the original empirical analysis passed the robustness tests.

Table 7. Robustness test results.

Variables	Full Sample1	Full Sample2	Sub-Sample1 (State-Owned)	Sub-Sample2 (Non-State-Owned)	Full Sample3	Sub-Sample3 (High Pollution and High Energy Consumption)	Sub-Sample4 (Non-High Pollution and High Energy Consumption)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ESG	−0.293 *** (−4.63)	−0.292 *** (−4.62)	−0.224 * (−1.71)	−0.320 *** (−4.08)	−0.257 *** (−3.98)	−0.288 *** (−2.70)	−0.355 *** (−3.36)
ESG * SOE		0.102 ** (2.03)					
ESG * Industry					0.087 *** (2.81)		
Maturity	0.326 *** (12.29)	0.323 *** (12.15)	0.342 *** (4.89)	0.335 *** (11.49)	0.332 *** (12.70)	0.296 *** (7.80)	0.332 *** (8.97)
Rating	−0.183 *** (−4.52)	−0.176 *** (−4.35)	−0.191 (−1.20)	−0.205 *** (−4.61)	−0.166 *** (−4.13)	−0.446 * (−1.91)	−0.152 *** (−3.59)
ROA	−0.411 *** (−12.52)	−0.413 *** (−12.51)	−0.478 *** (−6.95)	−0.369 *** (−9.53)	−0.412 *** (−12.52)	−0.561 *** (−8.54)	−0.381 *** (−10.36)
Multiplier	0.252 *** (9.98)	0.245 *** (9.55)	0.144 ** (2.04)	0.283 *** (10.27)	0.248 *** (9.81)	0.327 *** (6.50)	0.228 *** (7.95)
EPS	−1.844 *** (−11.71)	−1.844 *** (−11.73)	−1.564 *** (−4.19)	−1.936 *** (−11.09)	−1.866 *** (−11.84)	−1.164 *** (−3.99)	−1.918 *** (−10.74)
Cash	−1.248 *** (−10.50)	−1.258 *** (−10.64)	−1.586 *** (−6.01)	−1.085 *** (−8.21)	−1.283 *** (−10.76)	−2.362 *** (−8.80)	−1.038 *** (−7.87)
Growth	−0.210 *** (−7.62)	−0.206 *** (−7.50)	−0.185 *** (−4.02)	−0.228 *** (−6.15)	−0.205 *** (−7.41)	−0.124 ** (−2.47)	−0.221 *** (−7.48)
Litigation	0.008 (0.70)	0.008 (0.73)	0.060 ** (2.02)	0.004 (0.35)	0.009 (0.77)	0.039 (1.31)	0.010 (0.83)
CPI	−0.169 * (−1.71)	−0.168 * (−1.70)	−0.385 (−1.57)	−0.063 (−0.59)	−0.162 * (−1.66)	−0.382 ** (−2.00)	0.015 (0.13)
GDP	−0.081 *** (−3.36)	−0.082 *** (−3.45)	−0.077 (−1.57)	−0.082 *** (−2.97)	−0.078 *** (−3.26)	−0.058 (−1.28)	−0.089 *** (−3.13)
M2	−0.202 *** (−6.49)	−0.202 *** (−6.49)	−0.186 ** (−2.11)	−0.197 *** (−6.13)	−0.199 *** (−6.38)	−0.197 *** (−3.57)	−0.166 *** (−4.48)
Constant	9.003 *** (13.50)	9.001 *** (13.53)	9.939 *** (4.98)	8.598 *** (11.65)	8.736 *** (13.01)	11.792 *** (4.40)	7.986 *** (10.75)
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2103	2103	528	1575	2103	602	1501
R-Square	0.617	0.638	0.627	0.639	0.640	0.670	0.657

T-statistics are in brackets. *, **, and *** indicate that the correlation is significant at the 10%, 5%, and 1% levels, respectively. Standard errors are adjusted at the level of corporate bonds. R-square is the goodness of fit within the group.

4.5. Discussions

The descriptive statistics show that we have a sample of mostly middle- and short-term corporate bonds, with credit ratings above AA and ESG disclosure ratings at C+ to B levels. The ESG disclosure ratings of state-owned companies and high-pollution and -energy-consumption companies are higher than their oppositions. For all sample companies, the ratings increase over the sample years, indicating the rising recognition of ESG investments in China. The regression results of the full sample show that ESG disclosure is negatively correlated with corporate bond credit spreads. At the significance level of 1%, the ESG disclosure coefficient is −0.35, indicating that each unit increase in ESG disclosure level reduces corporate bond credit spread by 0.35%.

Moreover, the state ownership can adjust the impact of ESG disclosure on corporate bond credit spreads. The interaction coefficient of ESG disclosure and state ownership is significantly positive, indicating that the credit spreads of corporate bonds issued by state-owned companies decrease less with higher ESG disclosure ratings. By grouping regressions into state-owned and non-state-owned company groups, we find that for the non-state-owned company group, ESG information disclosure reduces corporate bond credit spreads by a greater extent.

Finally, being categorized in a high-pollution and -energy-consumption industry can adjust the impact of ESG information disclosure on the bond credit spreads of a company. The interaction coefficient between ESG disclosure and industry is significantly positive, indicating that ESG disclosure impacts corporate bond credit spreads less if a firm belongs to high-pollution and -energy-consumption industries. By grouping regressions, we find that when compared with high-pollution and -energy-consumption companies, the ESG disclosure of non-high-pollution and -energy-consumption companies reduces corporate bond credit spreads by a greater extent.

5. Conclusions and Implications

With rising awareness of the significance of ESG investments in China, we contribute to the empirical studies on the impact of ESG disclosure on corporate bond credit spreads. Although the majority of existing research supports an optimistic view that ESG disclosure reduces corporate bond credit spreads and thus benefits corporate value, there is no consensus yet. In accordance with the mainstream theories, we propose three hypotheses to test: (1) ESG disclosure can improve the valuation of corporate bonds in the secondary market and reduce corporate bond credit spreads; (2) compared with state-owned companies, the ESG disclosure of non-state-owned companies reduces credit spreads of corporate bonds by a greater extent; (3) compared with other firms, the ESG disclosure of high-pollution and -energy-consumption firms reduces the credit spreads of corporate bonds by a greater extent.

Based on the data of 2103 listed firms on the Shanghai and Shenzhen Stock Exchanges from 2015 to 2020, and adopting fixed-effect panel regressions, we find that ESG disclosure can significantly reduce corporate bond credit spreads in the secondary market of China, which is consistent with Hypothesis 1. Considering the moderating effects of state ownership and industry, regressions are re-run with interaction terms as well as in grouped samples. It turns out that for non-state-owned companies and non-high-pollution and -energy-consumption companies, ESG information disclosure reduces corporate bond credit spreads by a greater extent than for their oppositions. Therefore, Hypothesis 2 is supported, and Hypothesis 3 is rejected.

Our study confirms the mainstream theory that ESG disclosure may increase corporate value by reducing their bond credit spreads, and this impact is greater for non-state-owned companies. A more significant finding is that when industry is regarded as an interaction effect in the model, the results are opposite to what we propose. This indicates that theories should be carefully tested due to the characteristics of Chinese companies and the secondary market. Therefore, further research is needed to explore the interaction effect of industry in this area.

The findings of our study help the Chinese regulatory authorities and financial institutions to deeply understand the impact of ESG disclosure on market entities, and provide reference for the formulation of relevant policies, so as to improve the secondary market bond pricing mechanism and the green and sustainable development of the capital market in China. At the same time, this paper provides useful advice for firms to improve their operation and for investors to make better investment decisions. First, China's capital market should establish a sound ESG disclosure evaluation system. ESG information reflects important information different from operating, financial, and cash flow information of the firm. The regular issuing of ESG reports is conducive to reducing the information asymmetry between creditors and issuers, and improving the pricing mechanism of corpo-

rate bonds. Second, corporate bond issuers, especially non-state-owned companies and those in non-high-pollution and -energy-consumption industries, should increase ESG investments and actively disclose ESG information to the market. Improving the quality of ESG disclosure will also help them gain more recognition from investors, enhance the competitiveness of corporate bonds in the secondary market, reduce corporate financing costs and achieve long-term sustainable development. Third, corporate bond investors should integrate ESG information into investment decisions to obtain more accurate corporate bond pricing information. All these efforts will help guide the capital market to achieve long-term healthy development.

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