Oeconomia
Copernicana

Volume 15 Issue 2 June 2024

p-ISSN 2083-1277, e-ISSN 2353-1827

www.oeconomia.pl

ORIGINAL ARTICLE

Citation: Zhang, H., Miao, L., Mu, G., & Wu, K.-S. (2024). Concave and convex effects of ESG performance on corporate sustainable development: Evidence from China. *Oeconomia Copernicana, 15*(2), 595–636. https://doi.org/10.24136/oc.2972

Contact to corresponding author: Kun-Shan Wu, kunshan@mail.tku.edu.tw

Article history: Received: 22.02.2024; Accepted: 9.06.2024; Published online: 30.06.2024

XueHui Zhang
Inner Mongolia University of Technology, China
orcid.org/0000-0002-6705-691X

Le Miao
Inner Mongolia University of Technology, China
orcid.org/0009-0008-0460-8159

Guoying Mu
Inner Mongolia University of Technology, China
orcid.org/0009-0005-4988-8164

Kun-Shan Wu
Tamkang University, Taiwan
orcid.org/0000-0001-9550-8840

Concave and convex effects of ESG performance on corporate sustainable development: Evidence from China

JEL Classification: *G28; G32; G3*

Keywords: *ESG; corporate sustainable development; quantile regression; double-edged effect*

Abstract

Research background: Corporate sustainable development (CSD) is essential to a company's success and survival. Environmental, social, and governance (ESG) are regarded as major factors in measuring the impact of CSD. Companies that perform well in terms of ESG can maintain a competitive advantage and achieve sustainable development. Poor management of ESG performance and involvement in controversial activity can harm a company's credibility and reputation in the market, as well as negatively impact sustainable development.
Purpose of the article: Drawing on the stakeholder and signaling theories, this paper investigates the curvilinear nexus between ESG performance and CSD.
Methods: Empirical studies were conducted on a sample of 697 Chinese listed manufacturing firms that disclosed ESG information from 2010 to 2020, with a total of 5699 firm-year observations. Quantile regression analysis and the U-test were used to examine the curvilinear ESG-CSD relationship. This technique was supplemented by conducting instrumental variables tests and propensity score matching to address concerns relating to the potential existence of endogeneity problems.
Findings & value added: The results of the quantile regression estimation confirm the concave-convex (inverted U-shaped and U-shaped) ESG-CSD relationship via the U-test. The relationships between the environmental and social components and CSD follow an inverted U-shaped or half-inverted U-shaped pattern, while the relationship between the governance component and CSD exhibits a concave-convex pattern. A concave ESG-CSD nexus is evident in environmentally sensitive industries, whereas a half concave-convex ESG-CSD nexus is confirmed in non-environmentally sensitive industries. This study improves scholars' understanding of ESG performance and provides a comprehensive perspective on the double-edged effects (positive and negative consequences) of ESG practices. The instrumentalization of ESG practices for management to seek personal gain has a negative impact on CSD, while ESG practices that add value for stakeholders have a positive impact. These findings provide empirical evidence for Chinese publicly listed manufacturing firms to effectively conduct ESG practices.

Introduction

Corporate sustainable development (CSD) is an essential strategic tool for firms seeking to ensure their long-term growth, survival, and development in the context of increasingly competitive business markets (L´opez & Monfort, 2017; Sanoran, 2023). The terms 'sustainable growth' and 'sustainable development' are often used interchangeably (Naseer Naseer & Bagh, 2024). Sustainable growth rate (SGR) is a financial indicator that measures the maximum growth rate a company could achieve without increasing its leverage level (Higgins, 1977), and is used to assess the future potential for sustainable development of the company (Wang *et al.*, 2022). In the context of today's fast-changing political, economic, governance, and competitive environment, companies are struggling to achieve CSD (or SGR) (Mamilla, 2019).

Sustainable development is a current international trend, with many countries placing emphasis on enterprises to disclose environmental, social, and governance (ESG) performance (Chen & Xie, 2022). Due to an intensifying worldwide focus on ESG factors, corporate ability for sustainable growth has emerged as a critical aspect of financial decision-making (Liao *et al*., 2022). The fundamental concept of ESG is for enterprises to take into account the welfare of the environment, society, and pertinent stakeholders in their commercial operations and investment strategies to achieve sustainable growth and economic goals (Hao & He, 2022; Luo *et al*., 2023). Companies with greater ESG performance[1] can maintain a competitive advantage and achieve CSD (Wang & Jin, 2023). Conversely, poor ESG performance and the potential involvement in controversial incidents or activities may not only harm the company's credibility and reputation in the market, but also exert an adverse impact on financial performance and CSD (Oprean-Stan *et al*., 2020). ESG performance is one of the key ways to enhance CSD, with the interdependence between economic, social, and environmental components being fundamental (Lazar & Chithra, 2022).

The relationship between ESG performance (proxied by Bloomberg's ESG score) and CSD is still not clear, which presents a challenge when formulating management policies (de la Fuente *et al*., 2022). Despite extant literature investigating the ESG-CSD nexus, there remains a substantial gap in understanding the multifaceted effect of ESG performance on CSD. For example, the stakeholder theory proposes goodwill or moral capital among stakeholders is increased with greater investment into ESG practices (El Ghoul *et al*., 2011), leading to greater financial performance and CSD (Jonwall *et al*., 2023). The results of other studies also show a positive ESG-CSD relationship (Oprean-Stan *et al*., 2022; Wang & Jin, 2023). However, in accordance with the signaling theory proposed by Spence (1973), ESG performance may hinder sustainable growth due to the possibility of incurring specific expenses, giving rise to the perception of greenwashing, which is misleading disclosure of environmental information, and amplifying operating costs (Wang *et al*., 2022), thereby resulting in an adverse correlation with CSD (Christensen *et al*., 2022; Deng *et al*., 2023). Such contentious re-

[1] ESG performance is a measure of how well a company is adhering to these criteria, which is usually proxied by ESG scores. ESG scores measure how well a company operates in areas other than its financial success (Ammar Zahid *et al*., 2023).

sults indicate a potential non-linear correlation between ESG performance and CSD, and both a positive and negative association.

In addition, lower ESG performance is found to have a positive impact on CSD, while higher ESG performance results in lower CSD in some companies. As postulated by Li *et al*. (2022), the shift from positive to negative CSD results could be attributed to the alignment of ESG strategies, for example, ESG activities that address stakeholders' demands can enhance CSD, while management's self-interested ESG activities can be detrimental to CSD.

The rapid development of industrialization and urbanization has resulted in China's continued high demand for energy, with carbon dioxide emissions accounting for 29% of global emissions, exceeding those of the USA and Europe combined (Cao *et al*., 2021). In the light of China's dual carbon (carbon peaking and carbon neutrality) goals and the prioritization of sustainable development, the ESG concept has garnered significant interest in the Chinese market (Chai *et al*., 2023). As ESG development in China is still in the preliminary stages, investors and companies may lack clarity regarding the specific implications of ESG practices on CSD (Wu *et al*., 2021; Zhao *et al*., 2022).

Corporate fulfillment of ESG responsibilities is an important tool for achieving sustainable social development (Litvinenko *et al*., 2022). Manufacturing is a pivotal component of the real economy, as it addresses not only economic implications, but also environmental and social impacts arising from its operations (Luo *et al*., 2023). Thus, it is imperative to incentivize manufacturing firms to invest proactively in ESG by examining the impact of ESG performance on the CSD of manufacturing firms in China.

This research's primary objective is to fill current knowledge gaps by empirically investigating the nonlinear impact of ESG performance and its individual components (environmental, social, and governance) on CSD in Chinese listed manufacturing firms. The Bloomberg ESG score is used to measure ESG performance, whereas corporate SGR and market-based metrics are used to measure firms' CSD. Ordinary least squares (OLS) regression and quantile regression (QR) methods are utilized to conduct the empirical research, supplemented by instrumental variables tests and propensity score matching (PSM) methods to address concerns regarding potential endogeneity problems.

The concave-convex relationship between ESG performance and CSD is proven via the research results. On further analysis, it is evident the individual ESG components have a differing impact on CSD. The relationship between the environmental component (ESGE) and CSD follows a concave (or half-concave) form, as does the relationship between the social component (ESGS) and CSD. However, the connection between the governance component (ESGG) and CSD has a concave-convex pattern. These results remain robust after using alternative measures of CSD, instrumental variables tests, and PSM tests.

To further clarify if the relationship between ESG performance and CSD varies for environmentally sensitive (ES) industries, a series of heterogeneity tests were administered. The QR results confirm a concave (inverted U-shape) ESG-CSD nexus in ES industries, and a concave-convex (inverted U-shape and half U-shape) ESG-CSD nexus in non-environmentally sensitive (NES) industries. Hence, this study demonstrates ESG performance can have both positive and negative effects on CSD and offers empirical evidence to encourage Chinese listed manufacturing firms to beneficially incorporate ESG practices.

This article is structured as follows: section two examines existing literature and discusses the hypotheses; section three outlines the research design and methodology; section four presents the model design; section five presents the results, including robustness tests and cross-sectional heterogeneity assessments; section six provides a summary of the results and discussions; and the final section offers the conclusions.

Literature review and hypotheses development

Theoretical overview

As simplified below, this study attempts to explain the ESG-CSD relationship with two conflicting theories, the stakeholder theory and the signaling theory.

Based on the stakeholder theory, corporate environmental and social responsibility can reduce transaction costs with stakeholders and increase their participation in creating firm value (Freeman & Evan, 1990). ESG performance is increasingly becoming a means of communication between companies and their stakeholders, as well as a way for companies to enhance their corporate value (Arvidsson & Dumay, 2022). Companies that exhibit exceptional ESG performance can obtain greater financial funding and tax benefits from the government (Jonwall *et al*., 2023), which enhances their competitive positioning and reputation in the marketplace (Muhmad *et al*., 2021). ESG performance can also help investors understand the company’s operations, reducing information asymmetries between inside and external investors, and laying the groundwork for sustainable growth (Wang *et al*., 2022). Simultaneously, disclosing ESG data, according to stakeholders' expectations (Ma *et al*., 2022), can improve employees' work environment and sense of belonging. This, in turn, contributes toward attracting and retaining superior employees and maintaining business stability (Gu *et al*., 2020; Wang & Jin, 2023). Thus, maximizing ESG performance is often considered a CSD strategy.

Drawing on the signaling theory (Spence, 1973), managers can reduce information asymmetries by disclosing information to external stakeholders (Hahn & Kühnen, 2013). By investing in disclosing positive information about their sustainability commitments, businesses can provide stakeholders with unique insights that cannot be obtained elsewhere (Maas *et al*., 2014; Wang *et al*., 2018). However, the signaling theory suggests that disclosing ESG information could hinder CSD by increasing certain expenses, leading to the perception of greenwashing and escalating operational costs (Wang *et al*., 2022). Companies behaving irresponsibly are likely to be ostracized by the market, as suggested by Carnini Pulino *et al*. (2022) and Connelly *et al*. (2011), which is reflected by their lower performance and EBIT (Earnings Before Interest and Tax) (Carnini Pulino *et al*., 2022), thus inhibiting the company's sustainable development. As a result, ESG performance ultimately negatively affects CSD (Christensen *et al*., 2022; Deng *et al*., 2023).

The preceding discussion confirms the stakeholder theory proposes a positive linear relationship between ESG performance and CSD, whereas the signaling theory supports a negative linear relationship between ESG performance and CSD. Despite the disparate findings, the results advance the understanding of the connections between ESG performance and CSD; however, the combined effect of the stakeholder and signaling theory on the ESG-CSD relationship is relatively unknown. It is possible this theoretical relationship is inherently nonlinear, meaning the model requires a nonlinear specification to clarify the diverse findings observed in prior research (Li *et al*., 2024).

ESG-CSD nexus

In current literature, opinions on how ESG and CSD relate to each other are diverse. Research aligned with the stakeholder theory proposes ESG performance is a control mechanism intended to fulfil both investor and non-investor stakeholders' interests. There is also evidence suggesting a positive relationship between ESG and CSD. For instance, Oprean *et al*. (2020) demonstrate European companies implementing ESG to a greater extent generate higher CSD. Similarly, ESG positively affects CSD within Chinese companies (Chai *et al*., 2023; Lee, 2023; Wang *et al*., 2022; Wang & Jin, 2023). These findings infer firms with superior ESG performance are more likely to exhibit greater CSD aspirations.

As Christensen *et al*. (2022) suggest, different interpretations of ESG information increase as the number of disclosures increase, leading to greater disagreement regarding ESG scores. Accordingly, doubts surrounding a firm's sustainability are provoked, hindering its access to external financing. In addition, the disclosure of ESG information might reinforce managers' irrational behavior to showcase their competency and gain from the company's resources, resulting in an increased probability of over-regulation by shareholders (Hahn & Kühnen, 2013). This may make it hard for managers and shareholders to trust each other, and thus discourage investment in expensive innovative initiatives and ultimately harm CSD (Wang *et al*., 2022).

Zhang (2022, 2023) argues some companies take only token actions to obtain higher ESG scores, but do not consider stakeholders' ESG concerns. Such disclosures of selected ESG information may have adverse effects due to artificial distortions. Hence, ESG disclosures may be subject to corporate greenwashing, which distorts the true ESG performance and deepens the information asymmetry between companies and external stakeholders. Despite positive ESG scores, companies accused of greenwashing may simply disclose more information without truly achieving any improvement in environmental and financial performance (Basu *et al*., 2022). Briefly, disclosing ESG information may hinder CSD due to raised specialization costs, greenwashing perceptions, and increased operating expenses (Wang *et al*., 2022).

It is evident the outcomes of studies employing linear methodologies yield disparate results when there is an inherently nonlinear ESG-CSD relationship. The presence of the too much of a good thing (TMGT) and too little of a good thing (TLGT) effect, as outlined by Trumpp and Guenther (2017), suggest there are both positive and negative associations between ESG performance and CSD. According to the TMGT (TLGT) perspective, positive antecedents (ESG) can lead to positive (or negative) outcomes (CSD) when their levels remain under a specific threshold. This indicates when the threshold is surpassed, there is a negative (or positive) correlation between ESG performance and CSD. This phenomenon results in an inverted U-shaped (U-shaped) pattern. Bagh *et al*. (2024) examine the relationship between ESG performance and CSD in the USA and China, with the findings indicating the existence of an inverted U-shaped nexus. Accordingly, the first research hypothesis is proposed.

Hypothesis 1: *There is a curvilinear relationship between ESG performance and CSD.*

Among the extensive literature investigating the relationships between ESG performance and CSD, there is increasing acknowledgement that the impact of the individual ESG components on CSD (proxied by SGR) are potentially non-linear. Chai *et al*. (2023) and Lee (2023) predominantly focus on overall ESG performance, demonstrating its influence on SGR; however, as sustainability practices become more granular, Teng *et al*. (2022), Wu and Chang (2022), and Pu (2023) suggest separating ESG into its individual components may reveal non-linear patterns in their effects on corporate financial outcomes. Recently, Bagh *et al*. (2024) evidence the relationship between ESG performance, as well as the individual ESG components, and CSD is a nonlinear (inverted U-shaped) pattern. Based on the findings of previous research, the following is hypothesized:

Hypothesis 2: *There is a curvilinear relationship between individual ESG components' (ESGE, ESGS, and ESGG) performance and CSD.*

In summary, the literature review reveals empirical studies addressing the relationship between ESG performance and CSD yield inconclusive results thus far, and a discrepancy between the two opposing arguments. One argument suggests a linear (positive or negative) ESG-CSD relationship, while the opposing argument supports a nonlinear (convex or concave) ESG-CSD relationship. This investigation addresses the nonlinear effect of ESG performance on CSD for Chinese manufacturing industry firms, thereby addressing the gap in extant literature.

The next section details the research methodology and data analysis used to validate and refine this study's theoretical framework. Through empirical research, the findings will contribute to CSD strategies and the corresponding implications for long-term value creation.

Research design and methods

Sample and data

This research uses a data sample from Chinese listed manufacturing firms with voluntary ESG disclosure between 2010 and 2020, provided by Bloomberg. The Bloomberg database was selected as it covers ESG information on listed companies more comprehensively than any other database (Avramov *et al*., 2022). The company-level data (e.g., company size and financial leverage) are taken from China Stock Market & Accounting Research (CSMAR). After eliminating firms with missing data for the main variables or special treatment, the final data set includes unbalanced data from 697 Chinese listed manufacturing firms, with a total of 5699 observations from 2010 to 2020. Table 1 presents the frequency distribution of firm-year observations across years and major industry groups. Approximately 66% of firm-year observations occur between 2015 and 2020, which reflects the increase in ESG coverage. Machinery and electronic manufacturing (55.71%) and resource processing (29.27%) are the dominant industry sectors.

Measure of variables

The dependent variable is a firm's CSD score. According to previous studies (Arora *et al*., 2018; Kuo & Chang, 2021; Teng *et al*., 2021), the measure of CSD is proxied by SGR and is calculated as the return on equity (ROE) multiplied by the retention rate (RR), where RR is computed by 1-firm's dividend payout ratio.

The independent variable is a firm's ESG score. The ESG disclosure scores, ranging from 0.1 (minimum) to 100 (maximum), are obtained from Bloomberg. Bloomberg was selected as it has a greater amount of company

ESG scores in comparison to other ESG score providers, it is extensively used in previous ESG literature (Avramov *et al*., 2022; Teng *et al*., 2023; Wu & Chang, 2022), and, unlike other ESG rating providers, Bloomberg ratings are industry-specific. The more ESG data that a company releases, the higher its ESG disclosure score is.

In accordance with the research of Chang and Wu (2021), Kuo and Chang (2021), and Saygili *et al*. (2022), the model also incorporates control variables which may impact SGR (or ROE). Specifically, firm size (SIZE) corresponds to the natural logarithm of firms' total assets; financial leverage (LEV) is measured through the total debt/total assets ratio; firm age (AGE) as measured by number of years the company has been incorporated; net profit margin (NPM) is calculated from the ratio of net profit to sales; and the owner's equity growth rate (OEG) is equivalent to the percentage change in equity from the prior period.

Model

The use of QR in corporate finance literature has increased in recent years (Anton, 2021; Wu & Chang, 2022; Teng *et al*., 2023). QR is used in this study as it provides more information about the relationship between ESG performance and SGR. This econometric approach is robust to outliers (Maiti, 2021) and non-Gaussian error distributions (Coad & Rao, 2008). Bootstrapped cluster standard errors are obtained using 100 bootstrap replications. This method is robust for smaller samples (Maçãs Nunes *et al*., 2007), is valid for many forms of heterogeneity (Buchinsky, 1995), and generates more suitable estimations for standard errors than the asymptotic approach (Hao & Naiman, 2007).

This research uses Koenker and Bassett's QR approach (1978) to investigate the nonlinear ESG-CSD effect over multiple SGR quantiles, as shown below in Equation (1).

$$\begin{gathered} Q_{\tau}(CSD_{it}|X_{it}) = \beta_{0\tau} + \beta_{1\tau}ESG_{it} + \beta_{2\tau}ESG2_{it} + \\ + \sum_{s=1}^{k} \delta_{s\tau}CON_{sit} + \mu_{\tau t} + \gamma_{\tau j} + \varepsilon_{\tau it} \end{gathered} \tag{1}$$

where i and t denote company and year, respectively, s indexes control variables, and j is the industry index. $Q_{\tau}(CSD_{it}|X_{it})$ is the τ-th QR function; CSD_{it} indicates the CSD of company i at year t; ESG_{it} indicates the ESG of company i at year t; and $ESG2_{it}$ indicates the $ESG_{it} * ESG_{it}$. The control variables are denoted as CON_{it}, $\mu_{\tau t}$ and represent the fixed effect of time,

$\gamma_{\tau t}$ represents an industry unobservable effect, and $\varepsilon_{\tau it}$ is the random disturbance item.

Guided by previous research concerning the U-shaped association (Lind & Mehlum, 2010; Haans *et al*. 2016), this study conducts further investigation into the curvilinear association between ESG performance and CSD via the U-test.

Results

Descriptive statistics

Descriptive statistics for the sample companies are presented in Table 2. The CSD mean (median) is 4.278 (4.996), with a minimum of -63.893 and a maximum of 27.03. The mean value of CSD is lower than the median, and the distribution of CSD exhibits a wide range. The skewness value (-3.163) and kurtosis value (18.268) indicate the CSD distribution is negatively skewed and heavily left-tailed. Based on the Jacque-Bera statistic (=65,000, p<0.01), there is sufficient evidence to reject the null hypothesis that CSD follows a normal distribution. The CSD distributions support the use and efficacy of QR analysis (Anton, 2021).

As shown via Bloomberg's ESG ratings, Chinese companies excel in ESGG but score the lowest in ESGE, which indicates efforts to implement environmental management policies are still insufficient within China’s manufacturing industry.

The VIF (variance inflation factor) values range between 1.15 and 1.87, which is below the threshold of 5 and indicates multicollinearity is not a concern (Table 3).

Baseline regression results

As the null hypothesis is rejected by the results of the Hausman test (1978) (chi-square value = 143.12, p<0.01), a fixed-effect model is used to run the regression. The results, with White's (1980) adjustment for heteroscedasticity, are presented in Table 4. To further support the validation of the curvilinear ESG-CSD relationship, this study also conducts the U-test (Lind & Mehlum, 2010) and Haans *et al*.’s (2016) three-step procedure.

The OLS estimation shows the ESG coefficient (p<0.01) is positively significant and the ESG2 coefficient is negatively significant (p<0.05), suggesting a concave ESG-CSD relationship. Specifically, the ESG_L slope is positive (β=0.1783) and significant (p<0.01), while the ESG_H slope is negative (β= -0.0184) and insignificant (p>0.1). Although the ESG threshold (40.929) is within the data range [9.091, 44.215] (Table 2), the upper limit (224.68) of the 95% Fieller (1954) confidence interval (CI) extends beyond the data range, suggesting a half-inverted U-shaped ESG-CSD relationship (Haans *et al*., 2016).

Using the QR approach, a concave ESG-CSD relationship is evident in companies in the lower (10th and 25th) SGR quantiles, where the ESG coefficient is positively significant (p<0.01) and the ESG2 coefficient is negatively significant (p<0.05). Via the U-test, an inverted U-shaped ESG-CSD nexus in the 10th SGR quantile firms is further proved by: (1) a positively significant slope at the lower bound (ESG_L) (0.7675, p<0.01); (2) a negatively significant slope at the upper bound (ESG_H) (-0.2651, p<0.01); and (3) both the ESG threshold (35.197) and 95% Fieller CI are located within the data range [9.091, 44.215]. Following this methodology identically, it is confirmed there is a half-inverted U-shaped correlation between ESG and CSD in firms in the 25th SGR quantile as the ESG threshold (41.815) is within the data range, but the upper limit of the 95% Fieller CI extends beyond the data range.

In contrast, there is a convex ESG-CSD relationship in the highest (90th) SGR quantile firms, as evidenced by the negatively significant ESG coefficient (p<0.01) and the positively significant ESG2 coefficient (p<0.05). The ESG_L slope is negatively significant (-0.1159, p<0.05), the ESG_H slope is positively significant (0.0808, p<0.05), and the inflection point (29.786) is located within the ESG range. Thus, the ESG-CSD relationship in firms located in the 90th SGR quantile is U-shaped.

Based on the results confirming the ESG-CSD relationship follows either an inverted U-shaped or a U-shaped curve for firms in different SGR quantiles, Hypothesis 1 is supported. As the OLS results show in Table 4, the effects the control variables have on CSD are all significantly positive; however, QR estimation results indicate the effects vary within firms in different quantiles. For example, SIZE has a substantial effect on CSD only among the 10th and 75th quantile firms, and AGE negatively affects CSD in the 10th quantile firms but has a positively significant influence on CSD in the upper (75th and 90th) quantile firms.

Inter-quantile difference

Empirical evidence confirms the influence of ESG performance on CSD varies among diverse CSD distributions. To determine whether these variations hold statistical significance, this study utilizes inter-quantile regression to investigate the uniformity of slopes across all quantiles. Table 5 displays the results of the F test and their respective p values, solely examining the homogeneity of coefficients between the lower and upper SGR quantiles using 200 bootstrap replications.

Figure 1 illustrates the influence of the covariates across quantiles and compares it to the OLS regression estimates of the independent variables. The estimates from both QR and OLS approaches have been validated through their corresponding 95% confidence intervals. The graph reveals a marked contrast between the QR and OLS results, particularly for the symmetric quantiles.

Curvilinear ESGE-CSD, ESGS-CSD, and ESGG-CSD relationships

This research investigates the curvilinear relationship between ESG performance and CSD by analyzing the three individual components of ESG: ESGE, ESGS, and ESGG.

In terms of ESGE (Table 6), the results of the QR estimation reveal a concave relationship between ESGE and CSD in firms in the lower and median (50th) SGR quantiles. More specifically, through the U-test, the $ESGE_L$ slope is positively significant, whereas the $ESGE_H$ slope is negatively significant, and the threshold (31.647) is located within the ESGE range [2.083, 42.636] (Table 2), clarifying the existence of the inverted U-shaped ESGE-CSD nexus for companies located in the 10th SGR quantile. As for companies in the 25th SGR quantile, the $ESGE_L$ slope is positively significant, whereas the $ESGE_H$ slope is negative but insignificant. ESGE's threshold (38.029) is within the ESGE range, while the upper limit of the 95% Fieller CI is outside the ESGE range, suggesting the true ESGE-CSD relationship may be a half-inverted U-shape for firms in the 25th SGR quantile. Using the same methodology, it is also confirmed that a half-inverted U-shaped relationship exists between ESGE and CSD for firms located in the 50th SGR quantile (Table 6).

With regard to ESGS (Table 7), the $ESGS_L$ slope is positive (0.4275) and significant ($p<0.01$), whereas the $ESGS_H$ slope is negative (-0.2209) and significant ($p<0.05$) in the 10th quantile firms. Both the ESGS threshold (39.4) and Fieller's 95% CI [34.97,52.42] are located within the ESGS range [7.017, 56.14] (Table 2), indicating the existence of a concave relationship between ESGS and CSD in companies in the 10th SGR quantile. In the 25th quantile firms, the $ESGS_L$ slope is positively significant, whereas the $ESGS_H$ slope is negative but insignificant. The ESGS threshold (48.82) falls within the ESGS range, while the upper bound of the 95% Fieller CI is outside the data range, suggesting the ESGS-CSD relationship for 25th quantile firms is a half-inverted U-shape.

Regarding ESGG (Table 8), in 10th quantile firms, the $ESGG_L$ slope is negatively significant and the $ESGG_H$ slope is positively significant ($p<0.01$). Both the ESGG threshold (42.47) and the 95% Fieller CI [38.42, 44.56] fall within the ESGG range [33.929, 57.143] (Table 2), evidencing a convex ESGG-CSD relationship among firms in the 10th SGR quantile. Applying the same methodology, a concave ESGG-CSD nexus exists in the 90th SGR quantile firms. The $ESGG_L$ slope is positively significant, whereas the $ESGG_H$ slope is negative but insignificant for the 75th quantile firms. The ESGG threshold (48.68) is inside the ESGG range, while the 95% Fieller CI is outside the data range, confirming the ESGG-CSD relationship is a half-inverted U-shape in 75th quantile firms.

Robustness testing

The aforementioned findings reveal ESG, as well as its three components (ESGE, ESGS, and ESGG), have a curvilinear effect on CSD. However, the results may be influenced by potential endogeneity issues, omitted factors, and biased sample selection. To ensure the reliability of the results, a series of robustness tests were performed.

Alternative CSD measure

For sensitivity checks, as an alternative measure of CSD, SGR_1 is considered as the rate of ROE multiplied by the retention rate (RR), and subsequently divided by one minus the ROE*RR (Kuo & Chang, 2021; Yu & Tsai, 2018), i.e., SGR_1 = ROE*RR/[1-ROE*RR]. The findings of the robustness tests align with the previously explained results, thus confirming the curvilinear relationship between ESG performance and CSD, notably within the lower and 90th quantiles. The U-test results for SGR_1 confirm a concave ESG-CSD relationship among firms within the 10th SGR_1 quantile and a convex ESG-CSD relationship among firms within the 90th SGR_1 quantile. These findings align with the baseline curvilinear regression (Table 9).

Omitted variables

To avoid potential endogeneity issues caused by unobserved variables, this research uses year fixed and firm fixed effects, as well as robust standard errors clustered at the firm level. The findings demonstrate, despite controlling for firm fixed effects, there is still a curvilinear relationship between ESG performance and CSD (Table 10).

Sample selection bias

To address potential sample selection bias, this article utilizes the PSM method. Companies with ESG scores above the 70th percentile are assigned to the treated group, while the remaining companies form the control group. The matching variables for PSM include all control variables listed in Table 10. The PSM process utilizes logit regression to estimate the propensity score and the final control group sample is analyzed using one-to-one nearest neighbor matching. The results of the PSM matching and regression, which indicate a curvilinear ESG-CSD nexus, are presented in Table 10.

Instrumental variable approach —2SLS (two-stage least-squares) estimation

To mitigate potential endogeneity, this article refers to Ge *et al*. (2022) and uses the average ESG score for the industry minus the company's ESG score as an instrumental variable. Table 10 presents the findings. The first-stage regression exhibits a negative association between the current ESG score and instrumental variable ($p<0.01$). The second-stage regression indicates a curvilinear nexus between ESG performance and CSD, which is consistent with the previous findings.

Industry heterogeneity

The potential impact of ESG practices may vary among companies operating in ES or NES industries (Qureshi *et al*., 2019). To examine whether the ESG-CSD nexus differs, the sample firms are divided into companies functioning in ES sectors and NES sectors. ES industries (including chemicals, gas, metal manufacturing, oil, and paper) are often regarded as high-polluting industries and pose significant environmental risks (Amor-Esteban *et al*. 2018), as their operations can directly affect ESG issues. The ES subsample includes 1822 firm-years and the NES subsample includes 3876 firm-years. Tables 11 and 12 display the estimation results for these subsets.

Concerning ES companies (Table 11), the OLS estimate suggests the coefficients of ESG and ESG2 do not exert a significant influence on CSD. However, the QR approach results via the U-test identify a positively significant ESG_L slope (0.4514, $p<0.05$) and a negatively significant ESG_H slope (-0.4205, $p<0.05$), evidencing a concave ESG-CSD relationship in the 10th SGR quantile ES firms.

Regarding NES companies (Table 12), the OLS analysis indicates a significantly positive ESG coefficient and a significantly negative ESG2 coefficient ($p<0.01$). Further checked via the U-test, a positively significant ESG_L slope (0.2085, $p<0.01$), and a negative but insignificant ESG_H slope (-0.0655, $p>0.1$) infers there is a half concave ESG-CSD relationship. Through the QR approach and the U-test, the concave ESG-CSD connection is confirmed in the lower (10th and 25th) SGR quantile firms. For NES firms located at the 90th SGR quantile, the ESG_L slope is negatively significant (-0.1972, $p<0.01$) and the ESG_H slope is positive (0.0487), but not statistically significant ($p>0.1$), suggesting a half convex ESG-CSD relationship.

Discussion

This study examines whether and, more specifically, how ESG performance impacts CSD. To answer the research question, ESG data from 2010 to 2020 were collected from Chinese listed manufacturing firms. The findings were obtained using the U-test.

Concave and convex ESG-CSD nexus

The OLS estimates confirm the ESG-CSD relationship is a half-inverted U-shape, demonstrating the predominant impact of ESG performance on CSD is significantly positive. The influence of ESG performance on CSD grows as ESG levels increase and subsequently peaks at the optimal ESG level. As the ESG threshold (40.929) exceeds the ESG sample mean (20.869), it is obvious the majority of Chinese manufacturing companies operate on the left side of the inflection point (Figure 2A). Overall, these companies are highly likely to benefit from ESG practices and should aim for higher ESG scores for greater CSD.

The QR analyses elicit the curvilinear ESG-CSD relationships among companies located at different quantiles, among which a half-inverted U-shape is also found in 25th SGR quantile firms (Figure 2C). In 10th SGR quantile firms an inverted U-shaped nexus between ESG performance and CSD exists, which signifies CSD initially rises as ESG increases, but begins to decline as ESG further increases. This result implies that for most manufacturing firms in the lowest SGR quantile, investing in ESG activities has a positive impact on their reputation and ensures a greater CSD in the short term. However, persistent investments in unprofitable ESG activities over an extended period can have harmful consequences rather than benefits, which aligns with the TMGT viewpoint (Trumpp & Guenther, 2017).

Given the fact that the ESG threshold (35.197) surpasses the sample mean of ESG (20.869), manufacturing companies in the 10th quantile are mainly situated on the left side of the inflection point (Figure 2B). This means they are able to profit from ESG investments; however, it is recommended they maintain the optimal ESG score in order to attain maximum CSD.

Finally, in 90th SGR quantile companies there is a convex (U-shaped) association between ESG performance and CSD, meaning CSD initially declines as ESG increases, but begins to rise as ESG further increases (Figure 2D). The average ESG value (29.786) is lower than the ESG threshold (27.833), suggesting most manufacturing firms within the highest (90th) SGR quantile are to the left side of the extreme point and are investing in ESG practices beyond stakeholder requirements.

The findings validate the significance of ESG performance in the corporate decision-making process and provide empirical support for the TMGT and TLGT recommendations. Hence, Chinese manufacturing firms should optimize their proficiency in impactful ESG strategies and consider the balance between costs and benefits.

Concave-Convex nexus between individual ESG components and CSD

Regarding the lowest (10th) SGR quantile firms, ESGE and ESGS have the inverted U-shaped effect on CSD, where CSD initially rises as ESGE/ESGS increase, but declines as they further increase (Figure 3A and 4A). Both the ESGE and ESGS thresholds exceed the sample mean values, indicating most 10th SGR quantile companies are situated to the left side of the extreme point. Therefore, manufacturing firms within the 10th SGR quantile can gain advantages from ESGE and ESGS practices and should cautiously strive for optimal ESGE and ESGS levels to maximize CSD.

Regarding firms in the 25th SGR quantile, the ESGE-CSD nexus is a half-inverted U-shape, as is the ESGS-CSD nexus (Figure 3B and 4B). The ESGE and ESGS thresholds surpass the sample mean values, suggesting most of these companies are situated to the left side of the extreme point. Manufacturing companies located in the 25th SGR quantile can benefit from ESGE and ESGS investments and should aim for higher ESGE and ESGS scores to obtain greater CSD. The ESGE-CSD relationship for firms in the 50th SGR quantile and the ESGG-CSD relationship for firms in the 75th SGR quantile are identical to that of firms in the 25th quantile, as shown in Figure 3C and 5B.

Figure 5A shows ESGG has a U-shaped effect on CSD in the lowest (10th) SGR quantile. The ESGG threshold (42.47) is lower than the ESGG sample mean (44.413), which means most companies are situated to the right of the optimal value. Thus, the majority of Chinese manufacturing companies in the 10th SGR quantile are currently benefiting from ESGG investments and should engage in the maximum amount of ESG practices in order to achieve a greater CSD.

Figure 5C reveals a concave ESGG-CSD nexus for companies in the 90th quantile; however, the ESGG threshold (41.81) is smaller than the ESGG sample mean (44.413), meaning most of these companies are situated to the right of the inflection point. This result shows the majority of manufacturing companies within the highest (90th) SGR quantile invest in ESGG practices beyond stakeholder requirements.

In summary, the results support the perspective that the impact of ESG performance on CSD is an important mechanism through which ESG affects the future value of enterprises. Although most previous studies use linear positive models (Oprean *et al*., 2020; Wang *et al*., 2022; Chai *et al*., 2023; Lee, 2023; Wang & Jin, 2023) or linear negative models (Basu *et al*., 2022; Wang *et al*., 2022; Zhang, 2022, 2023), this is not adequate given the complexity, trade-offs, and conflicts between ESG performance and CSD.

The findings evidence curvilinear patterns in ESG performance and offer a novel insight into its relationship with CSD, emphasizing the importance of curvilinear modelling for more accurate assessments of this relationship. These results align with extant literature, including Bagh *et al*. (2024), de la Fuente *et al*. (2022), Pu (2023), Teng *et al*. (2022), and Wu and Chang (2022), confirming the non-linear relationships between ESG, and its individual components, on firm values (Tobin's Q and ROE).

Conclusions

Based on a Chinese manufacturing data sample comprising 5699 firm-year observations from 2010 to 2020 and using the QR approach and U-test, this research evidences a concave and convex relationship between ESG performance and CSD, proxied by SGR, after also controlling for variables that could impact this relationship. The findings confirm each individual ESG component has a differing effect on CSD. ESGE and ESGS exhibit a concave influence on CSD in firms in the lower SGR quantiles, as does ESGG on firms in the upper SGR quantiles. However, ESGG has a convex impact on CSD in firms within the 10th SGR quantile. These findings align with the double-edged effect and are still proven after a series of robustness tests, such as changing the measure of CSD, instrumental variables tests, and PSM tests. The heterogeneity analysis substantiates a concave ESG-CSD relationship in ES industries. In terms of NES industries, a concave ESG-CSD relationship also exists in firms within the lower quantiles; however, there is a convex ESG-CSD relationship among firms within the 90th SGR quantile.

Theoretical implications

As awareness of ESG increases, new research prospects are presented. Conducted using the QR approach for unbalanced panel data, this research contributes to the scope of extant studies.

The findings confirm ESG performance impacts CSD and advances the conceptual ESG arguments by proposing a concave-convex (inverted U-shaped or U-shaped) ESG-CSD relationship in Chinese listed manufacturing firms in different SGR quantiles. The non-linear impact of the individual ESG components on firm performance and their distinct effect on CSD is also analyzed. In terms of methodology, the QR method is used to analyze the data and perform the robustness checks across alternative CSD measures, instrumental variables tests, and PSM tests. In addition, the heterogeneous subgroups are also examined.

Drawing from the extant literature on U-shaped association analysis (Haans *et al*., 2016; Lind & Mehlum, 2010), the findings support not only the existence of the curvilinear ESG-CSD relationship, but also the perspectives of the TMGT and TLGT effects. The way ESG affects CSD depends on the performance level of ESG practices. Consistent with the findings presented by Lahouel *et al*. (2022), this study reinforces the importance of accounting for nonlinear effects between variables when investigating the connection between ESG performance and CSD in corporate research.

Practical implications

The findings provide vital implications for businesses, investors, and stakeholders. Regarding businesses, as the confirmed presence of a concave-convex connection between ESG performance and CSD implies ESG strategies with an emphasis on stakeholder requirements effectively enhance CSD, the incorporation of ESG into a company's differentiation strategy can promote stakeholders' acceptance and become a profitable resource. However, companies should be aware of the double-edged effect of ESG practices and avoid using ESG as a self-interested management tool.

It is vital for managers to establish a firm's optimal ESG level, considering the presence of TMGT (or TLGT) effects and the possibility that ESG expenditure may not always lead to benefits. Maintaining equilibrium between supply and demand of ESG practices is necessary, as a company's resources are finite. Hence, it is crucial for managers of companies in inferior SGR quantiles to carefully monitor the TMGT impact of ESG and establish ESG thresholds.

As for investors and stakeholders, these findings can help evaluate the investment portfolio of companies listed in China. Comparing a company's ESG disclosure performance to predetermined thresholds can assist in the prediction of its future CSD.

Research limitations/future research

This paper has potential limitations. Initially, it exclusively analyzes a sample of Chinese listed companies with ESG disclosure, excluding companies without ESG disclosure or those not listed. Future research should expand data collection to incorporate unlisted companies and those without ESG disclosure.

Second, due to data availability, this research was conducted on a limited sample size which restricts the generalizability of the findings to a broader context. It is essential to recognize the necessity for further research to use a larger and more diverse sample to validate the results. This study focuses on the period from 2010 to 2020, which may not capture the long-term impact of ESG initiatives. Future studies can extend the timespan to potentially elicit long-term effects.

The data were collected through Bloomberg's database; however, ESG metrics are multifaceted and subject to varying measurement methodologies. To further determine how comparable the findings and potential differences are, future researchers should consider similar studies utilizing alternative databases, such as Thomson Reuter, Refinitiv, and MSCI.

Lastly, an area for future research could involve conducting a comparative analysis across different industries, countries, or regions to offer valuable insights into the circumstantial influences that stimulate the relationship between ESG performance and CSD. By addressing these knowledge gaps in future studies, researchers can further advance the awareness of the ESG-CSD relationship and provide more comprehensive guidance for businesses aiming to effectively integrate ESG.

References

Ammar Zahid, R. M., Saleem, A., & Maqsood, U. S. (2023). ESG performance, capital financing decisions, and audit quality: Empirical evidence from Chinese state-owned enterprises. *Environmental Science and Pollution Research*, *30*, 44086–44099. https://doi.org/10.1007/s11356-023-25345-6.

Amor-Esteban, V., Galindo-Villardón, M. P., & García-Sánchez, I. M. (2018). Useful information for stakeholder engagement: A multivariate proposal of an industrial corporate social responsibility practices index. *Sustainable Development*, *26*(6), 620–637. https://doi.org/10.1002/sd.1732.

Anton, S. G. (2021). The impact of temperature increase on firm profitability. Empirical evidence from the European energy and gas sectors. *Applied Energy*, *295*, 117051. https://doi.org/10.1016/j.apenergy.2021.117051.

Arora, L., Kumar, S., & Verma, P. (2018). The anatomy of sustainable growth rate of Indian manufacturing firms. *Global Business Review*, *19*, 1050–1071. https://doi.org/10.1177/0972150918773002.

Arvidsson, S., & Dumay, J. (2022). Corporate ESG reporting quantity, quality and performance: Where to now for environmental policy and practice? *Business Strategy and the Environment*, *31*(3), 1091–1110. https://doi.org/10.1002/bse.2937.

Avramov, D., Cheng, S., Lioui, A., & Tarelli, A. (2022). Sustainable investing with ESG rating uncertainty. *Journal of Financial Economics*, *145*(2), 642–664. https://doi.org/10.1016/j.jfineco.2021.09.009.

Bagh, T., Fuwei, J., & Khan, M. A. (2024). Corporate ESG investments and firm's value under the real-option framework: Evidence from two world-leading economies. *Borsa Istanbul Review*, *24*(2), 324–340. https://doi.org/10.1016/j.bir.2024.01.002.

Basu, R., Naughton, J. P., & Wang, C. (2022). The regulatory role of credit ratings and voluntary disclosure. *Accounting Review*, *97*(2), 25–50. https://doi.org/10.2308/TAR-2018-0286.

Buchinsky, M. (1995). Estimating the asymptotic covariance matrix for quantile regression models a Monte Carlo study. *Journal of Econometrics*, *68*(2), 303–338. https://doi.org/10.1016/0304-4076(94)01652-G.

Cao, S., Nie, L., Sun, H., Sun, W., & Taghizadeh-Hesary, F. (2021). Digital finance, green technological innovation and energy-environmental performance: Evidence from China's regional economies. *Journal of Cleaner Production*, *327*, 129458. https://doi.org/10.1016/j.jclepro.2021.129458.

Carnini Pulino, S., Ciaburri, M., Magnanelli, B. S., & Nasta, L. (2022). Does ESG disclosure influence firm performance? *Sustainability*, *14*, 7595. https://doi.org/10.3390/su14137595.

Chai, S., Cao, M., Li, Q., Ji, Q., & Liu, Z. (2023). Exploring the nexus between ESG disclosure and corporate sustainable growth: Moderating role of media attention. *Finance Research Letters*, *58*, 104519. https://doi.org/10.1016/j.frl.2023.104519.

Chang, B. G., & Wu, K. S. (2021). The nonlinear relationship between financial flexibility and enterprise risk-taking during the COVID-19 pandemic in Taiwan's semiconductor industry. *Oeconomia Copernicana*, *12*(2), 307–333. https://doi.org/10.24136/oc.2021.011.

Chen, Z., & Xie, G. (2022). ESG disclosure and financial performance: Moderating role of ESG investors. *International Review of Financial Analysis*, *83*, 102291. https://doi.org/10.1016/j.irfa.2022.102291.

Christensen, D. M., Serafeim, G., & Sikochi, A. (2022). Why is corporate virtue in the eye of the beholder? The case of ESG ratings. *Accounting Review*, *97*(1), 147–175. https://doi.org/10. 2308/tar-2019-0506.

Coad, A., & Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research Policy*, *37*(4), 633–648. https://doi.org/10.1016/j.respol.2008.01.003.

Connelly, B. L., Ketchen, D. J., & Slater, S. F. (2011). Toward a "theoretical toolbox" for sustainability research in marketing. *Journal of the Academy of Marketing Science*, *39*, 86–100. https://doi.org/10.1007/s11747-010-0199-0.

de la Fuente, G., Ortiz, M., & Velasco, P. (2022). The value of a firm's engagement in ESG practices: Are we looking at the right side? *Long Range Planning*, *55*(4), 102143. https://doi.org/10.1016/j.lrp.2021.102143.

Deng, X., Li, W., & Ren, X. (2023). More sustainable, more productive: Evidence from ESG ratings and total factor productivity among listed Chinese firms. *Finance Research Letters*, *51*, 103439. https://doi.org/10.1016/j.frl.2022.103439.

El Ghoul, S., Guedhami, O., Kwok, C. C., & Mishra, D. R. (2011). Does corporate social responsibility affect the cost of capital? *Journal of Banking & Finance*, *35*(9), 2388–2406. https://doi.org/10.1016/j.jbankfin.2011.02.007.

Fieller, E. C. (1954). Some problems in interval estimation. *Journal of the Royal Statistical Society*, *B16*, 175–185.

Freeman, R. E., & Evan, W. M. (1990). Corporate governance: A stakeholder interpretation. *Journal of Behavioral Economics*, *19*(4), 337–359. https://doi.org/10.1016/0090-5720(90)90022-Y.

Ge, G., Xiao, X., Li, Z., & Dai, Q. (2022). Does ESG performance promote high-quality development of enterprises in China? The mediating role of innovation input. *Sustainability*, *14*, 3843. https://doi.org/10.3390/su14073843.

Gu, Y., Yang, Y., & Wang, J. (2020). Research on employee sense of gain: The development of scale and influence mechanism. *Frontiers in Psychology*, *11*, 568609. https://doi.org/10.3389/fpsyg.2020.568609.

Haans, R. F. J., Pieters, C., & He, Z. L. (2016). Thinking about U: Theorizing and testing U- and inverted U-shaped relationships in strategy research. *Strategic Management Journal*, *37*(7), 1177–1195. https://doi.org/10.1002/smj.2399.

Hahn, R., & Kühnen, M. (2013). Determinants of sustainability reporting: A review of results, trends, theory, and opportunities in an expanding field of research. *Journal of Cleaner Production*, *59*, 5–21. https://doi.org/10.1016/j.jclepro.2013.07.005.

Hao, J, & He, F. (2022). Corporate social responsibility (CSR) performance and green innovation: Evidence from China. *Finance Research Letters*, *48*, 102889. https://doi.org/10.1016/j.frl.2022.102889.

Hao, L., & Naiman, D. Q. (2007). *Quantile regression*. London: Sage Publications Inc.

Hausman, J. (1978). Specification tests in econometrics. *Econometrica*, *46*, 1251–1271. https://doi.org/10.2307/1913827.

Higgins, R. C. (1977). How much growth can a firm afford? *Financial Management*, *6*(3), 7–16. https://doi.org/10.2307/3665251.

Jonwall, R., Gupta, S., & Pahuja, S. (2023). Socially responsible investment behavior: A study of individual investors from India. *Review of Behavioral Finance*, *15*(6), 865–888. https://doi.org/10.1108/RBF-05-2021-0099.

Koenker, R., & Bassett, G. (1978). Regression quantiles. *Econometrica*, *46*(1), 33–50. https://doi.org/10.2307/1913643.

Kuo, L., & Chang, B. G. (2021). The affecting factors of circular economy information and its impact on corporate economic sustainability-Evidence from China. *Sustainable Production and Consumption*, *27*, 986–997. https://doi.org/10.1016/j.spc.2021.02.014.

L´opez, B., & Monfort, A. (2017). Creating shared value in the context of sustainability: The communication strategy of MNCs. In *Corporate governance and strategic decision making* (pp. 119–135). InTech. http://dx.doi.org/10.5772/intechopen.70177.

Lahouel, B. B., Zaied, Y. B., Managi, S., & Taleb, L. (2022). Re-thinking about U: The relevance of regime-switching model in the relationship between environmental corporate social responsibility and financial performance. *Journal of Business Research*, *140*, 498–519. https://doi.org/ 10.1016/j.jbusres.2021.11.019.

Lazar, N., & Chithra, K. (2022). Role of culture in sustainable development and sustainable built environment: A review. *Environment, Development and Sustainability*, *24*(5), 5991–6031. https://doi.org/10.1007/s10668-021-01691-8.

Lee, M. S. (2023). The relationship between green innovation and sustainable growth in Korean companies: Moderated mediation effect of ESG score by industry. *Sustainable Development*. https://doi.org/10.1002/sd.2807.

Li, W., Padmanabhan, P., & Huang, C. H. (2024). ESG and debt structure: Is the nature of this relationship nonlinear? *International Review of Financial Analysis*, *91*, 103027. https://doi.org/10.1016/j.irfa.2023.103027.

Li, X., Liu, G., Fu, Q., Abdul Rahman, A. A., Meero, A., & Sial, M.S. (2022). Does corporate social responsibility impact on corporate risk-taking? Evidence from emerging economy. *Sustainability*, *14*, 531. https://doi.org/10.3390/su14010531.

Liao, Y., Qiu, X., Wu, A., Sun, Q., Shen, H., & Li, P. (2022). Assessing the impact of green innovation on corporate sustainable development. *Frontiers in Energy Research*, *9*, 800848. http://dx.doi.org/10.3389/fenrg.2021.800848.

Lind, J. T., & Mehlum, H. (2010). With or without U? The appropriate test for a U-shaped relationship. *Oxford Bulletin of Economics and Statistics*, *72*(1), 109–118. https://doi.org/10.1111/j.1468-0084.2009.00569.x.

Litvinenko, V., Bowbrick, I., Naumov, I., & Zaitseva, Z. (2022). Global guidelines and requirements for professional competencies of Natural Resource Extraction Engineers: Implications for ESG principles and sustainable development goals. *Journal of Cleaner Production*, *338*, 130530. https://doi.org/10.1016/j.jclepro.2022.130530.

Luo, C., Wei, D., & He, F. (2023). Corporate ESG performance and trade credit financing – Evidence from China. *International Review of Economics and Finance*, *85*, 337–351. https://doi.org/10.1016/j.iref.2023.01.021.

Ma, A., Rm, A., B. B., & Bosek-Rak, D. (2022). Do institutional investors encourage firm to social disclosure? The stakeholder salience perspective. *Journal of Business Research*, *142*, 674–682. https://doi.org/10.1016/j.jbusres.2021.12.064.

Maas, S., Schuster, T., & Hartmann, E. (2014). Pollution prevention and service stewardship strategies in the third-party logistics industry: Effects on firm differentiation and the moderating role of environmental communication. *Business Strategy and the Environment*, *23*(1), 38–55. https://doi.org/10.1002/bse.1759.

Maçãs Nunes, P., Neves Sequeira, T., & Serrasqueiro, Z. (2007). Firms' leverage and labour productivity: A quantile approach in Portuguese firms. *Apply Economics*, *39*(14), 1783–1788. https://doi.org/10.1080/00036840600707076.

Maiti, M. (2021). Quantile regression, asset pricing and investment decision. *IIMB Management Review*, *33*, 28–37. https://doi.org/10.1016/j.iimb.2021.03.005.

Mamilla, R. (2019). A study on sustainable growth rate for firm survival. *Strategic Change*, *28*(4), 273–277. https://doi.org/10.1002/jsc.2269.

Muhmad, S. N., Ariff, A. M., Majid, N. A., & Kamarudin, K. A. (2021). Product market competition, corporate governance and ESG. *Asian Academy of Management Journal of Accounting & Finance*, *17*(1), 63–91. https://doi.org/10.21315/aamjaf2021.17.1.3.

Naseer, M. M., & Bagh, T. (2024). Building a sustainable future: The impact of corporate social responsibility on firms' sustainable development. In A. I. Hunjra & K. Hussainey (Eds.). *The Emerald handbook of ethical finance and corporate social responsibility* (pp. 623–646). Emerald. http://dx.doi.org/10.1108/978-1-80455-406-720241028.

Oprean-Stan, C., Oncioiu, I., Iuga, I. C., & Stan, S. (2020). Impact of sustainability reporting and inadequate management of ESG factors on corporate performance and sustainable growth. *Sustainability*, *12*, 8536. https://doi.org/10.3390/su12208536.

Pu, G. (2023). A non-linear assessment of ESG and firm performance relationship: Evidence from China. *Economic Research-Ekonomska Istraživanja*, *36*(1), 2113336. https://doi.org/10.1080/1331677X.2022.2113336.

Qureshi, M. A., Kirkerud, S., Theresa, K., & Ahsan, T. (2019). The impact of sustainability (environmental, social, and governance) disclosure and board diversity on firm value: The moderating role of industry sensitivity. *Business Strategy and the Environment*, *29*(3), 1199–1214. https://doi.org/10.1002/bse.2427.

Sanoran, K. (2023). Corporate sustainability and sustainable growth: The role of industry sensitivity. *Finance Research Letters*, *53*, 103596. https://doi.org/10.1016/j.frl.2022.103596.

Sasabuchi, S. (1980). A test of a multivariate normal mean with composite hypotheses determined by linear inequalities. *Biometrika*, *67*(2), 429–439. https://doi.org/10.2307/2335486.

Saygili, E., Arslan, S., & Birkan, A.O. (2022). ESG practices and corporate financial performance: Evidence from Borsa Istanbul. *Borsa Istanbul Review*, *22*(3), 525–533. https://doi.org/10.1016/j.bir.2021.07.001.

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics*, *87*, 355–374. https://doi.org/10.2307/1882010.

Teng, X., Ge, Y., Wu, K. S., Chang, B. G., Kuo, L., & Zhang, X. (2022). Too little or too much? Exploring the inverted U-shaped nexus between voluntary environmental, social and governance and corporate financial performance. *Frontiers in Environmental Science*, *10*, 969721. https://doi.org/10.3389/fenvs.2022.969721.

Teng, X., Wang, Y., Wang, A., Chang, B. G., & Wu, K. S. (2021). Environmental, social, governance risk and corporate sustainable growth nexus: Quantile regression approach. *International Journal of Environmental Research and Public Health*, *18*, 10865. https://doi.org/10.3390/ijerph182010865.

Teng, X., Wu, K.S., Kuo, L., & Chang, B. G. (2023). Investigating the double-edged sword effect of environmental, social and governance practices on corporate risk-taking in the high-tech industry. *Oeconomia Copernicana*, *14*(2), 511–549. https://doi.org/ 10.24136/oc.2023.014.

Trumpp, C., & Guenther, T. (2017). Too little or too much? Exploring U-shaped relationships between corporate environmental performance and corporate financial performance. *Business Strategy and the Environment*, *26*(1), 49–68. https://doi.org/10.1002/bse.1900.

Wang, N., Li, D., Cui, D., & Ma, X. (2022). Environmental, social, governance disclosure and corporate sustainable growth: Evidence from China. *Frontiers in Environmental Science*, *10*, 1015764. https://doi.org/10.3389/fenvs.2022.1015764.

Wang, X., & Jin, S. (2023). Environmental, social, and governance performance and corporate sustainable development in China. *Journal of Global Business and Trade*, *19*(1), 91–107. http://dx.doi.org/10.20294/jgbt.2023.19.1.91.

Wang, Z., Hsieh, T. S., & Sarkis, J. (2018). CSR performance and the readability of CSR reports: Too good to be true? *Corporate Social Responsibility and Environmental Management*, *25*(1), 66–79. https://doi.org/10.1002/csr.1440.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity. *Econometrica*, *48*(4), 817–838. https://doi.org/10.2307/1912934.

Wu, H., Xue, Y., Hao, Y., & Ren, S. (2021). How does internet development affect energy-saving and emission reduction? Evidence from China. *Energy Economics*, *103*, 105577. https://doi.org/10.1016/j.eneco.2021.105577.

Wu, K. S., & Chang, B. G. (2022). The concave-convex effects of environmental, social and governance on high-tech firm value: Quantile regression approach. *Corporate Social Responsibility and Environmental Management*, *29*(5), 1527–1545. https://doi.org/10.1002/csr.2289.

Yu, H. C., & Tsai, B. Y. (2018). Environmental policy and sustainable development: An empirical study on carbon reduction among Chinese enterprises. *Corporate Society Responsibility and Environmental Management*, *25*(5), 1019–1026. https://doi.org/10.1002/csr.1499.

Zhang, D. (2022). Do heterogenous subsides work differently on environmental innovation? A mechanism exploration approach. *Energy Economics*, *114*, 106233. https://doi.org/10.1016/j.eneco.2022.106233.

Zhang, D. (2023). Subsidy expiration and greenwashing decision: Is there a role of bankruptcy risk? *Energy Economics*, *118*, 106530. https://doi.org/10.1016/j.eneco.2023.106530.

Zhao, S., Cao, Y., Feng, C., Guo, K., & Zhang, J. (2022). How do heterogeneous R&D investments affect Chinas green productivity: Revisiting the Porter hypothesis. *Science of The Total Environment*, *825*, 154090. https://doi.org/10.1016/j.scitotenv.2022.154090.

Ministry of Education and Science
Republic of Poland

The journal is co-financed in the years 2022–2024 by the Ministry of Education and Science of the Republic of Poland in the framework of the ministerial programme "Development of Scientific Journals" (RCN) on the basis of contract no. RCN/SN/0697/2021/1 concluded on 29 September 2022 and being in force until 28 September 2024.

Annex

Table 1. Sample distribution by year and major sectors

Panel A: Distribution of firm-year observations by year		
Year	**Number of observations**	**Percentage of observations**
2011	434	7.62
2012	480	8.42
2013	510	8.95
2014	521	9.14
2015	626	10.98
2016	623	10.93
2017	625	10.97
2018	632	11.09
2019	629	11.04
2020	619	10.86
Total	5699	100
Panel B: Distribution of firm-year observations by major sector		
	Number of observations	**Percentage of observations**
Light and textile	731	12.83
Resource processing	1668	29.27
Machinery and electronic manufacturing	3175	55.71
Other manufacturing	125	2.19
Total	5699	100

Table 2. Summary of statistics

Variable	Observations	Mean	SD	Min	Max	Q10	Q25	Median	Q75	Q90	Skewness	Kurtosis
CSD	5699	4.278	11.688	-63.893	27.03	-0.979	1.718	4.996	9.411	14.150	-3.163	18.268
ESG	5699	20.869	6.737	9.091	44.215	13.223	16.529	20.248	23.554	28.659	1.179	5.139
ESGE	4969	11.55	7.928	2.083	42.636	3.101	6.977	9.302	13.954	20.155	1.888	7.249
ESGS	5552	23.318	9.028	7.017	56.14	12.281	17.544	22.806	28.070	33.333	1.072	5.155
ESGG	5699	44.413	4.959	33.929	57.143	39.286	39.286	44.643	48.214	51.786	0.118	2.867
AGE	5699	13.249	6.569	0	29	5	8	13	18	22	0.096	2.064
LEV	5699	0.446	0.193	0.069	0.868	0.175	0.298	0.451	0.594	0.692	-0.026	2.184
NPM	5699	0.074	0.137	-0.653	0.523	0.002	0.023	0.064	0.128	0.215	-1.358	11.885
OEG	5698	0.152	0.316	-0.416	1.892	-0.042	0.016	0.074	0.173	0.414	3.094	15.528
SIZE	5699	22.885	1.227	20.458	26.961	21.437	21.982	22.758	23.674	24.577	0.451	2.937

Note: SD = Standard deviation.

Table 3. Correlation matrix and VIFs

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) CSD							
(2) ESG	0.050*						
(3) AGE	-0.069*	0.272*					
(4) LEV	-0.244*	0.152*	0.258*				
(5) NPM	0.736*	-0.027*	-0.149*	-0.470*			
(6) OEG	0.349*	-0.074*	-0.177*	-0.156*	0.326*		
(7) SIZE	0.066*	0.421*	0.352*	0.511*	-0.055*	-0.019	
VIF	-	1.26	1.22	1.87	1.49	1.15	1.81

Note: * statistical significance at 10%.

Table 4. The curvilinear effect of ESG performance on CSD

Variable	CSD (proxied by SGR)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	0.2292***	1.0348***	0.2258***	0.0840**	-0.0500	-0.1668***
	(0.0719)	(0.1878)	(0.0611)	(0.0368)	(0.0498)	(0.0613)
ESG2	-0.0028**	-0.0147***	-0.0027**	-0.0007	0.0014	0.0028**
	(0.0013)	(0.0031)	(0.0011)	(0.0007)	(0.0009)	(0.0011)
AGE	0.0444**	-0.0724**	0.0095	0.0118	0.0251**	0.0638***
	(0.0178)	(0.0369)	(0.0115)	(0.0092)	(0.0115)	(0.0162)
LEV	5.1822***	8.0237***	7.9031***	7.3510***	9.3972***	11.2642***
	(1.0656)	(2.0001)	(0.5296)	(0.3701)	(0.4524)	(0.7247)
NPM	62.8632***	62.7327***	52.8666***	57.1228***	60.8926***	52.1906***
	(1.8163)	(2.2445)	(0.7069)	(0.7205)	(0.5332)	(1.2366)
OEG	4.8205***	3.5800***	1.8532***	2.5863***	5.3821***	13.1078***
	(0.5020)	(0.6556)	(0.1608)	(0.2488)	(0.6080)	(1.0054)
SIZE	0.4282***	0.4305*	-0.0831	0.0450	0.1514**	0.1277
	(0.1332)	(0.2349)	(0.0693)	(0.0610)	(0.0739)	(0.1017)
Constant	-17.2533***	-34.9564***	-6.7850***	-5.5243***	-5.2115***	-1.4182
	(2.8674)	(5.2779)	(1.5505)	(1.3100)	(1.6655)	(2.1067)
Observations	5,698	5,698	5,698	5,698	5,698	5,698
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.577	0.344	0.285	0.304	0.312	0.307
Slope at lower bound X_L (β_1+2*β_2*X_L)	0.1783***	0.7675***	0.1767***	—	—	-0.1159**
Slope at upper bound X_H (β_1+2*β_2*X_H)	-0.0184	-0.2651***	-0.0130	—	—	0.0808**
Sasabuchi (1980) test statistic	0.37	2.68***	0.22	—	—	1.74**
95% confidence interval (Fieller method)	[32.99,224.68]	[32.80,40.29]	[34.59,119.17]	—	—	[24.37,52.41]
Inflection point	40.929	35.197	41.815	—	—	29.786

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Table 5. Inter-quantile regression results

		CSD (proxied by SGR)	
		Quantile (90/10)	**Quantile (75/25)**
ESG	F-statistics	32.36***	4.78**
	Significance	0.0000	0.0288
ESG2	F-statistics	19.34***	2.16
	Significance	0.0000	0.1420
AGE	F-statistics	15.11***	2.90*
	Significance	0.0001	0.0886
LEV	F-statistics	12.13***	31.78***
	Significance	0.0005	0.0000
NPM	F-statistics	13.73***	21.00***
	Significance	0.0002	0.0000
OEG	F-statistics	69.97***	30.64***
	Significance	0.0000	0.0000
SIZE	F-statistics	11.03***	0.15
	Significance	0.0009	0.7029

Note: (1) Quantile(90/10) = 90th Quantile(y) - 10th Quantile (y); Quantile(75/25) = 75th Quantile (y) - 25th Quantile (y); (2) *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Table 6. Curvilinear ESGE-CSD nexus

Variable	CSD (proxied by SGR)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	0.0696*	0.3671***	0.1293***	0.0742***	0.0344	-0.0199
	(0.0401)	(0.0923)	(0.0313)	(0.0205)	(0.0211)	(0.0346)
ESG2	-0.0004	-0.0058***	-0.0017**	-0.0009*	-0.0000	0.0005
	(0.0009)	(0.0020)	(0.0008)	(0.0005)	(0.0004)	(0.0008)
AGE	0.0530***	-0.0379	0.0261**	0.0188**	0.0284***	0.0621***
	(0.0184)	(0.0395)	(0.0123)	(0.0086)	(0.0089)	(0.0147)
LEV	5.3074***	8.6914***	8.3365***	6.9057***	8.5890***	10.1675***
	(1.1149)	(2.1653)	(0.5719)	(0.3540)	(0.4199)	(0.6832)
NPM	63.4737***	62.2423***	54.3462***	57.4041***	60.0509***	50.7028***
	(2.0268)	(2.2576)	(0.8397)	(0.4958)	(0.5377)	(1.2452)
OEG	6.3125***	4.2338***	2.5964***	3.4801***	8.2389***	16.4731***
	(0.6469)	(0.3676)	(0.2675)	(0.2032)	(0.7002)	(1.1094)
SIZE	0.3788***	0.3289	-0.0889	0.0541	0.1549**	0.1425*
	(0.1325)	(0.2733)	(0.0750)	(0.0574)	(0.0679)	(0.0845)
Constant	-13.7351***	-21.2916***	-4.8599***	-4.9510***	-6.0009***	-3.7610**
	(2.6250)	(5.5783)	(1.5413)	(1.1579)	(1.3916)	(1.8140)
Observations	4,968	4,968	4,968	4,968	4,968	4,968
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.587	0.345	0.293	0.315	0.329	0.330
Slope at lower bound X_L ($\beta_1+2*\beta_2*X_L$)	—	0.3429***	0.1222***	0.0705***	—	—
Slope at upper bound X_H ($\beta_1+2*\beta_2*X_H$)	—	-0.1275**	-0.0157	-0.0025	—	—
Sasabuchi (1980) test statistic	—	1.46*	0.34	0.27	—	—
95% confidence interval (Fieller method)	—	[26.11,54.14]	[28.43,227.36]	$(-\infty, 27.9) \cup (-750, \infty)$	—	—
Inflection point	—	31.647	38.029	41.22	—	—

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Table 7. Curvilinear ESGS-CSD nexus

Variables	CSD (proxied by SGR)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	0.0901**	0.5201***	0.1074***	0.0513**	0.0169	-0.0348
	(0.0431)	(0.1396)	(0.0339)	(0.0225)	(0.0329)	(0.0328)
ESG2	-0.0009	-0.0066***	-0.0011**	-0.0006	-0.0001	0.0006
	(0.0007)	(0.0021)	(0.0005)	(0.0004)	(0.0006)	(0.0005)
AGE	0.0524***	-0.0110	0.0215*	0.0231***	0.0293**	0.0613***
	(0.0176)	(0.0430)	(0.0121)	(0.0082)	(0.0116)	(0.0154)
LEV	5.0254***	8.0325***	7.6742***	7.0167***	8.9590***	10.9932***
	(1.0679)	(2.0121)	(0.5509)	(0.2301)	(0.4482)	(0.6465)
NPM	62.5593***	62.0863***	52.9954***	56.9921***	60.1616***	51.2355***
	(1.8532)	(2.6183)	(0.7689)	(0.4140)	(0.4395)	(1.5565)
OEG	5.3392***	3.9366***	1.8854***	2.7582***	6.0009***	14.3870***
	(0.5389)	(0.5276)	(0.1844)	(0.2989)	(0.5991)	(1.3441)
SIZE	0.4983***	0.5973**	0.0639	0.1097**	0.2162***	0.0765
	(0.1288)	(0.2696)	(0.0730)	(0.0460)	(0.0739)	(0.0852)
Constant	-17.0292***	-33.0682***	-8.5705***	-6.4514***	-7.3054***	-1.9564
	(2.7161)	(5.6385)	(1.5595)	(1.0338)	(1.6057)	(1.9180)
Observations	5,551	5,551	5,551	5,551	5,551	5,551
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.581	0.342	0.286	0.307	0.317	0.314
Slope at lower bound X_L ($\beta_1+2*\beta_2*X_L$)	—	0.4275***	0.0920***	—	—	—
Slope at upper bound X_H ($\beta_1+2*\beta_2*X_H$)	—	-0.2209**	-0.0161	—	—	—
Sasabuchi (1980) test statistic	—	2.15**	0.67	—	—	—
95% confidence interval (Fieller method)	—	[34.97,52.42]	[37.48,331.92]	—	—	—
Inflection point	—	39.4	48.82	—	—	—

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Table 8. Curvilinear ESGG-CSD nexus

Variable	CSD (proxied by SGR)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	-0.1895	-1.9111***	-0.1390	0.0180	0.3602**	0.4515***
	(0.2779)	(0.4752)	(0.1455)	(0.1208)	(0.1788)	(0.1696)
ESG2	0.0026	0.0225***	0.0023	0.0003	-0.0037*	-0.0054***
	(0.0031)	(0.0051)	(0.0015)	(0.0013)	(0.0020)	(0.0019)
AGE	0.0504***	-0.0093	0.0096	0.0098	0.0148	0.0648***
	(0.0181)	(0.0443)	(0.0102)	(0.0083)	(0.0121)	(0.0136)
LEV	4.8801***	5.2854**	7.5416***	7.1128***	9.2179***	11.8866***
	(1.0598)	(2.1929)	(0.4984)	(0.3261)	(0.5014)	(0.6622)
NPM	62.8440***	59.9841***	53.1695***	56.9112***	60.6608***	53.1996***
	(1.8164)	(2.2104)	(0.6384)	(0.5317)	(0.6617)	(1.0681)
OEG	4.6961***	3.5153***	1.7446***	2.4053***	5.4440***	12.6610***
	(0.5042)	(0.5197)	(0.1363)	(0.2966)	(0.6406)	(1.1320)
SIZE	0.5596***	0.8558***	0.0587	0.1060**	0.2083***	0.1183
	(0.1327)	(0.2973)	(0.0630)	(0.0508)	(0.0784)	(0.0744)
Constant	-13.6167**	10.5223	-4.7047	-6.7865**	-15.2882***	-13.0112***
	(6.7469)	(11.7681)	(3.8716)	(3.0246)	(4.4168)	(4.2427)
Observations	5,698	5,698	5,698	5,698	5,698	5,698
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.575	0.334	0.282	0.303	0.312	0.307
Slope at lower bound X_L ($\beta_1+2*\beta_2*X_L$)	—	-0.3843***	—	—	0.1091***	0.0851**
Slope at upper bound X_H ($\beta_1+2*\beta_2*X_H$)	—	0.6603***	—	—	-0.0627	-0.1656***
Sasabuchi (1980) test statistic	—	2.86***	—	—	1.18	2.18**
95% confidence interval (Fieller method)	—	[38.42,44.56]	—	—	$(-\infty,45)\cup(-23.4,\infty)$	[36.30,44.92]
Inflection point	—	42.47	—	—	48.68	41.81

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Table 9. Curvilinear nexus between ESG and CSD (proxied by SGR1)

Variable	CSD (proxied by SGR1)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	0.1590**	0.6884***	0.2016***	0.0735*	-0.0795	-0.3461***
	(0.0667)	(0.1322)	(0.0541)	(0.0422)	(0.0730)	(0.0927)
ESG2	-0.0017	-0.0093***	-0.0022**	-0.0005	0.0020	0.0058***
	(0.0013)	(0.0024)	(0.0010)	(0.0008)	(0.0014)	(0.0018)
AGE	0.0411**	-0.0374	0.0060	0.0111	0.0197	0.0983***
	(0.0169)	(0.0245)	(0.0108)	(0.0103)	(0.0161)	(0.0217)
LEV	7.1894***	4.5000***	6.7806***	6.9562***	9.5007***	11.7396***
	(0.9236)	(1.0615)	(0.4812)	(0.4367)	(0.6604)	(1.0569)
NPM	55.3754***	51.5604***	52.2653***	59.1941***	60.6156***	51.9952***
	(1.3009)	(1.2214)	(0.6013)	(1.0383)	(0.8602)	(1.1428)
OEG	4.7071***	2.9385***	1.9075***	2.9405***	8.2615***	19.7428***
	(0.4726)	(0.5504)	(0.1696)	(0.3843)	(0.8728)	(1.2987)
SIZE	0.2465**	0.3681**	-0.0505	0.0644	0.2251**	0.2140
	(0.1184)	(0.1745)	(0.0672)	(0.0683)	(0.1075)	(0.1437)
Constant	-11.0358***	-25.1292***	-6.3423***	-5.5364***	-5.9331**	-0.6232
	(2.5637)	(3.8562)	(1.4905)	(1.4636)	(2.3974)	(3.1933)
Observations	5,698	5,698	5,698	5,698	5,698	5,698
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.557	0.386	0.318	0.316	0.310	0.309
Slope at lower bound X_L ($\beta_1+2*\beta_2*X_L$)	—	0.5193***	0.1616	—	—	-0.2406***
Slope at upper bound X_H ($\beta_1+2*\beta_2*X_H$)	—	-0.1340*	0.0071	—	—	0.1668**
Sasabuchi (1980) test statistic	—	1.49*	NA	—	—	2.30**
95% confidence interval (Fieller method)	—	[32.56,48.84]	[35.87,193.25]	—	—	[26.21,39.11]
Inflection point	—	37.01	45.82	—	—	29.84

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Table 10. Endogeneity problem tests

Variable	Firm-level Fixed	PSM		2SLS	
	SGR	Treat (1)	SGR (2)	ESG	SGR
ESG	0.1954***		0.2343***		
	(0.0723)		(0.0718)		
ESG2	-0.0023*		-0.0029**		
	(0.0013)		(0.0013)		
ESG_IV				-0.9635***	
				(0.0038)	
ESG_hat					0.3748***
					(0.0803)
ESG_hat2					-0.0056***
					(0.0015)
AGE	0.0221	-0.0195***	0.0460***	0.0842***	0.1546
	(0.0170)	(0.0033)	(0.0178)	(0.0035)	(0.0179)
LEV	5.9817***	-1.8959***	5.5153***	-2.3577***	5.8972***
	(1.0503)	(0.1460)	(1.0583)	(0.1512)	(1.0567)
NPM	63.5744***	-2.8422***	63.5125***	-0.7512***	63.6508***
	(1.8191)	(0.1970)	(1.8129)	(0.1961)	(1.8194)
OEG	4.7657***	0.1448*	4.7955***	-0.4242***	4.8086***
	(0.4879)	(0.0759)	(0.5012)	(0.0692)	(0.4887)
SIZE	0.3422***	-0.1620***	0.4129***	0.4213***	0.3171**
	(0.1311)	(0.0196)	(0.1328)	(0.0237)	(0.1304)
Constant	-14.5974***	5.5147***	-17.1840***	11.7041***	-15.5392***
	(2.803)	(0.4160)	(2.8656)	(0.5211)	(2.9491)
Firm fixed	Yes	No	No	No	No
Industry fixed	No	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes
Observations	5698	9732	5,695	5698	5698
Adjusted R-squared/ Pseudo R-squared	0.5735	0.0560	0.5783	0.9409	0.5767

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Table 11. Curvilinear model using SGR: ES industries

Variable	CSD (proxied by SGR)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	0.0605	0.6318*	0.0215	-0.0182	-0.0094	-0.1207
	(0.1502)	(0.3476)	(0.1156)	(0.0415)	(0.0762)	(0.0923)
ESG2	0.0002	-0.0119*	0.0016	0.0017**	0.0018	0.0036**
	(0.0028)	(0.0063)	(0.0019)	(0.0007)	(0.0014)	(0.0015)
AGE	0.0939***	0.1040*	0.0811***	0.0319***	0.0451***	0.0780***
	(0.0352)	(0.0542)	(0.0224)	(0.0115)	(0.0153)	(0.0269)
LEV	0.5513	-7.9181***	8.2949***	5.6933***	8.2023***	10.9975***
	(1.8850)	(2.8629)	(1.1620)	(0.4083)	(0.6894)	(1.0582)
NPM	74.4101***	75.3809***	76.8821***	74.4037***	74.5983***	60.4023***
	(3.5986)	(3.6722)	(1.5008)	(0.4959)	(1.4516)	(1.9834)
OEG	6.1082***	4.1505***	2.8078***	2.6921***	6.4087***	13.6076***
	(0.9503)	(0.4001)	(0.4901)	(0.4333)	(1.0046)	(1.4657)
SIZE	0.1664	1.2241***	-0.2037	-0.2085***	-0.4407***	-0.6059***
	(0.2556)	(0.3404)	(0.1567)	(0.0647)	(0.0874)	(0.1515)
Constant	-8.2793	-42.6258***	-4.0084	1.1147	6.6799***	12.9636***
	(5.8979)	(8.2930)	(3.5597)	(1.3987)	(2.0313)	(3.2512)
Observations	1,822	1,822	1,822	1,822	1,822	1,822
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.616	0.420	0.340	0.361	0.374	0.373
Slope at lower bound X_L ($\beta_1+2*\beta_2*X_L$)	—	0.4154**	—	—	—	—
Slope at upper bound X_H ($\beta_1+2*\beta_2*X_H$)	—	-0.4205**	—	—	—	—
Sasabuchi (1980) test statistic	—	1.77**	—	—	—	—
95% confidence interval (Fieller method)	—	$(-\infty,\infty)$	—	—	—	—
Inflection point	—	26.55	—	—	—	—

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Table 12. Curvilinear model using SGR: NES industries

Variable	CSD (proxied by SGR)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	0.2794***	1.0576***	0.2795***	0.0752*	-0.0790	-0.2608***
	(0.0823)	(0.1610)	(0.0574)	(0.0398)	(0.0720)	(0.0746)
ESG2	-0.0039***	-0.0148***	-0.0039***	-0.0009	0.0010	0.0035***
	(0.0015)	(0.0028)	(0.0010)	(0.0007)	(0.0014)	(0.0013)
AGE	0.0311	-0.0597*	-0.0013	-0.0006	0.0099	0.0626***
	(0.0199)	(0.0321)	(0.0118)	(0.0100)	(0.0164)	(0.0199)
LEV	8.2022***	14.1250***	9.6699***	8.5645***	11.1862***	13.0460***
	(1.2689)	(1.6793)	(0.5882)	(0.3437)	(0.6874)	(1.0177)
NPM	59.1416***	58.6995***	47.3483***	50.1531***	54.7832***	49.4610***
	(2.1499)	(1.6745)	(0.8768)	(0.5503)	(0.7943)	(1.4434)
OEG	3.6473***	2.5961***	1.8621***	1.9711***	3.9363***	10.5864***
	(0.5517)	(0.5132)	(0.2149)	(0.2537)	(0.6015)	(1.1689)
SIZE	0.6194***	-0.0804	-0.0919	0.2151***	0.4537***	0.5674***
	(0.1475)	(0.1862)	(0.0666)	(0.0712)	(0.1139)	(0.1184)
Constant	-22.6947***	-25.0500***	-7.4299***	-8.9931***	-11.2137***	-9.8734***
	(3.0482)	(4.1243)	(1.4729)	(1.5811)	(2.5005)	(2.2928)
Observations	3,876	3,876	3,876	3,876	3,876	3,876
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.583	0.335	0.282	0.295	0.297	0.289
Slope at lower bound X_L ($\beta_1+2*\beta_2*X_L$)	0.2085***	0.7885***	0.2086***	—	—	-0.1972***
Slope at upper bound X_H ($\beta_1+2*\beta_2*X_H$)	-0.0655	-0.2512***	-0.0654**	—	—	0.0487
Sasabuchi (1980) test statistic	1.27	2.64***	1.79**	—	—	1.08
95% confidence interval (Fieller method)	[30.50,61.83]	[33.06,40.80]	[32.69,45.7]	—	—	[32.59,61.60]
Inflection point	35.82	35.73	35.83	—	—	37.26

Note: * statistical significance at 10%; ** statistical significance at 5%; *** statistical significance at 1%.

Figure 1. OLS and QR estimates plotted

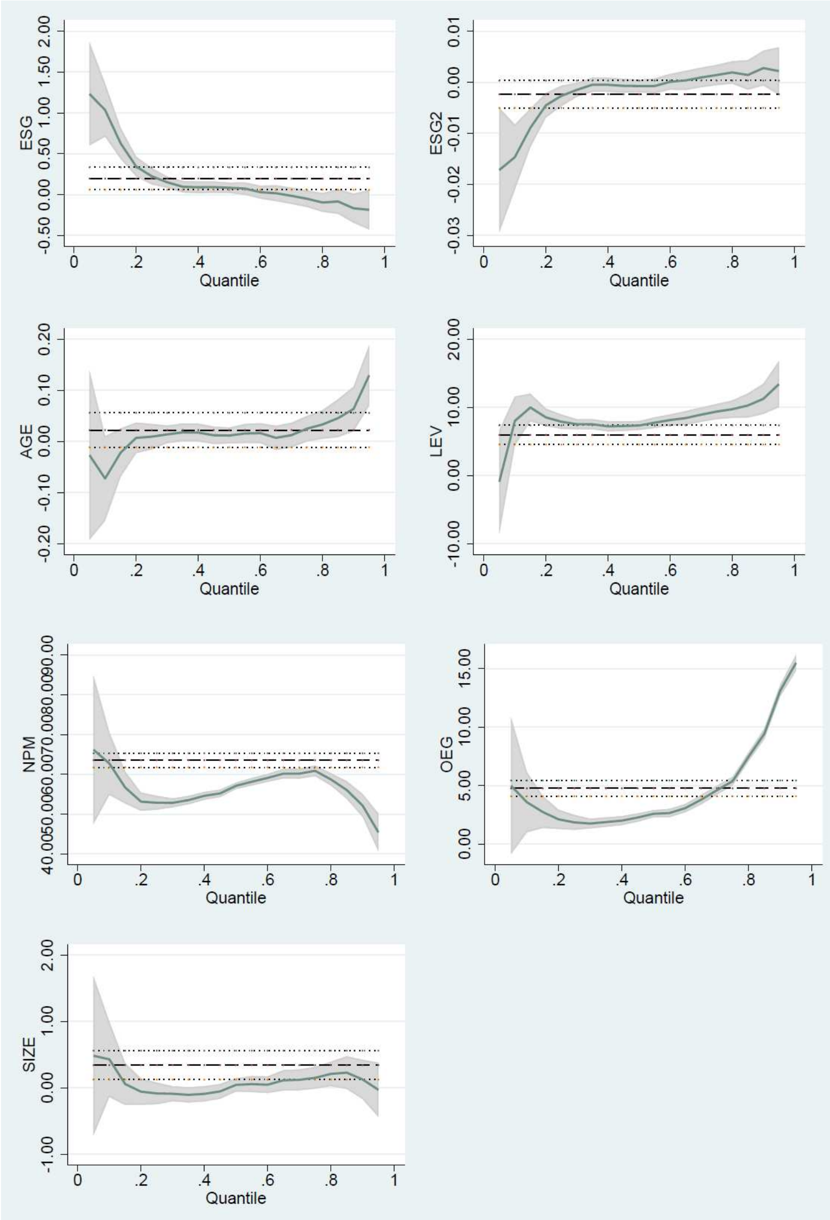

Figure 2. The half-inverted U-shaped ESG-CSD nexus for the OLS method (A), inverted ESG-CSD in the 10th quantile (B), half-inverted U-shaped ESG-CSD nexus in the 25th quantile (C), U-shaped ESG-CSD nexus in the 90th quantile (D)

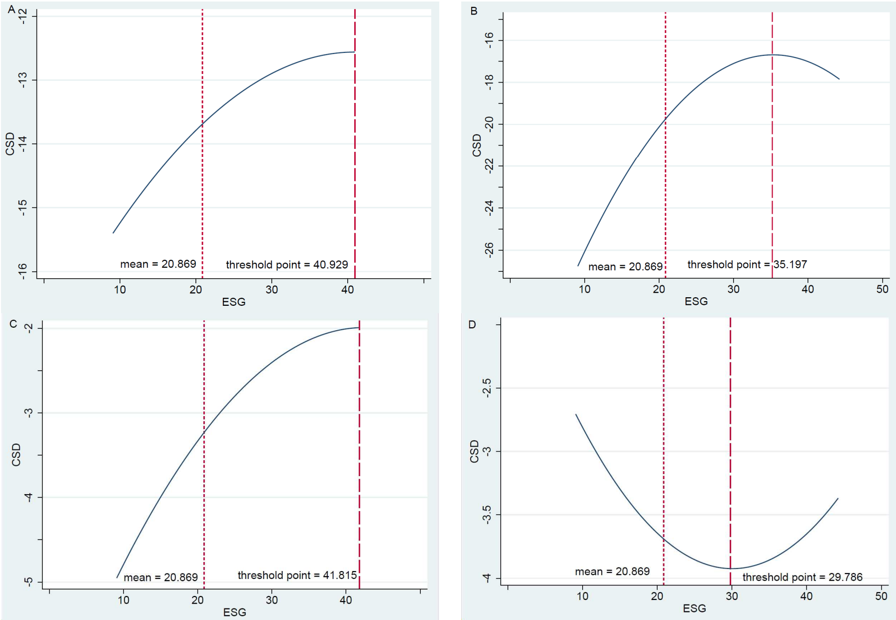

Figure 3. The inverted U-shaped ESGE-CSD nexus in the 10th quantile (A), the half-inverted ESGE-CSD nexus in the 25th quantile (B), and in the 50th quantile (C)

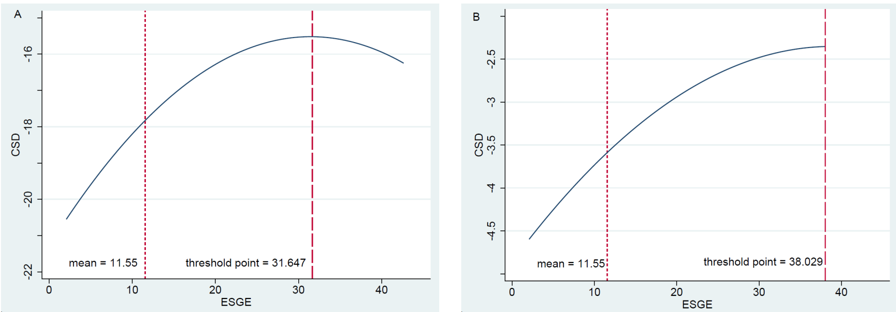

Figure 3. Continued

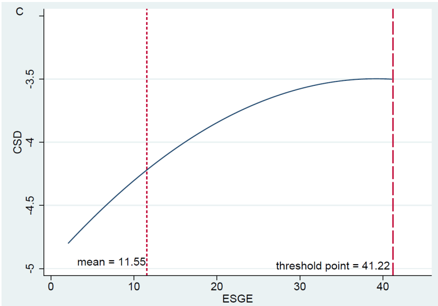

Figure 4. The inverted U-shaped ESGS-CSD nexus in the 10th quantile (A), and the half-inverted ESGS-CSD nexus in the 25th quantile (B)

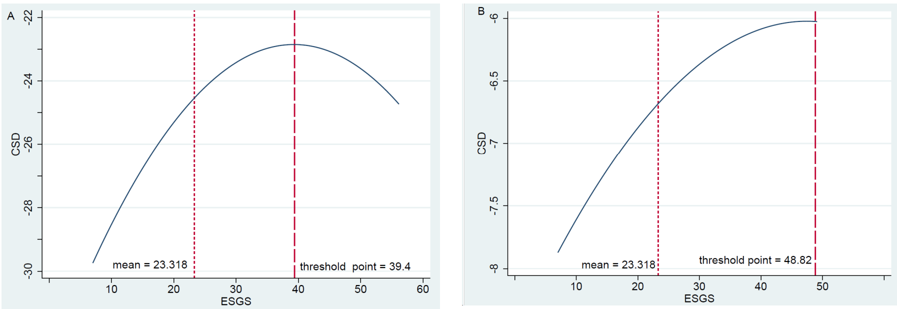

Figure 5. The U-shaped ESGG-CSD nexus in the 10th quantile (A), the half-inverted ESGG-CSD nexus in the 75th quantile (B), and inverted ESGG-CSD nexus in the 90th quantile (C)

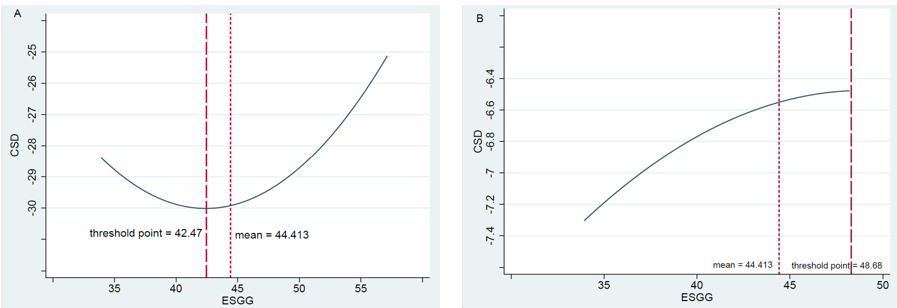

Figure 5. Continued