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

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Xiaodong Teng
Shandong University of Finance and Economics, China
orcid.org/0000-0001-5187-1533

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

Lopin Kuo
Tamkang University, Taiwan
orcid.org/0000-0002-7714-6126

Bao-Guang Chang
Tamkang University, Taiwan
orcid.org/0000-0001-9352-8012

Investigating the double-edged sword effect of environmental, social and governance practices on corporate risk-taking in the high-tech industry

JEL Classification: *G28; G32; G3*

Keywords: *ESG; corporate risk-taking; quantile regression; sustainable development*

Abstract

Research background: Corporate risk-taking (CRT) is crucial to a business's survival and performance and is a driving force for sustainable development. Environmental, social and governance (ESG) practices are critical to firm profits when considering sustainable economic growth; however, they can also be the cause of financial burdens. It is, therefore, crucial to assess the relationship between a company's ESG performance and its risk-taking.
Purpose of the article: Considering the controversial results of empirical studies on the relationship between ESG and CRT, this study aims to theoretically and empirically investigate the curvilinear nexus between ESG practices and CRT within Taiwan's high-tech industry.
Methods: Ordinary least square regression and quantile regression analysis was applied to investigate the curvilinear ESG-CRT relationship. The empirical studies were conducted in 38 high-tech companies on the Taiwan Stock Exchange that disclosed ESG information between 2005 and 2020, with a total of 437 firm-year observations.
Findings & value added: Quantile regression estimation results reveal the ESG-CRT nexus is U-shaped (convex). Both the environmental and social pillar's relationship with CRT is non-linear and U-shaped, whereas the governance pillar has no significant relationship with CRT. Overall, a comprehensive view is provided that shows ESG practices can have a double-edged sword effect on CRT. It is suggested that high-tech companies in Taiwan should avoid ESG practices becoming a tool for managements' self-interest. More information of ESG practices should be disclosed to stakeholders to ensure they are given full credit for the positive impact they have on capital allocation. Regulators guide firms to surpass the threshold of the U-shaped effect and take into consideration the whole benefits of stakeholders when they allocate existing resources toward environmental and social endeavors.

Introduction

Faced with the global sustainability agenda, climate change mitigation, and transitioning to a low-carbon economy (Folqué *et al*., 2021), effective risk management, which focuses not only on traditional financial risks but also ESG (environmental, social, and governance) risks, is critical for all enterprises (Iazzolino *et al*., 2023). ESG practices positively contribute to the prevention of damage to the firm reputation, reduce the risk of financial crises and litigation (Reber *et al*., 2022), and are crucial to fulfil corporate social responsibility (Qoyum *et al*., 2022). The emergence of ESG practices as a control mechanism for risk-taking and enhancing corporate value suggests that managers use environmental and social responsibility in their decision-making to design the overall strategy of the company (Harjoto & Laksmana, 2018).

Risk-taking refers to the risks a firm actively chooses to take to obtain high returns (Li *et al*., 2022a). Corporate risk-taking (CRT) is important to financial decision-making and is a prominent strategy adopted by companies for value enhancement and business expansion (Younas & Zafar, 2019). The reinforcement of CRT is beneficial to the improvement of firm value (Faccio *et al.*, 2016; Nguyen, 2011), which is the driving force of firm sustainable development. However, imperfect capital markets and information asymmetry may lead to agency problems, thus reducing CRT level (Abad *et al.*, 2018) and damaging firm value. In addition, enterprise risk management (ERM) represents a significant change in the way in which companies manage their risks. ERM adoption is associated with higher firm values both developing and developed economies (Anton, 2018; Anton & Nucu, 2020).

The question as to how CRT is affected by ESG practices has yet to receive a definitive answer. Although some research explores the nexus between ESG and CRT in different countries, the findings are still inconsistent. The stakeholder theory posits that greater investment in ESG behavior creates goodwill or moral capital among stakeholders (El Ghoul *et al.*, 2011), which provokes insurance-like protection that can enhance risk-taking ability. Consequently, the outcome of other research reveals a positive ESG-CRT interrelationship (Ayadi *et al.*, 2015; Gangi *et al.*, 2020; Nguyen & Nguyen, 2015; Rao *et al.*, 2022; Yarram & Adapa, 2022). Alternatively, the overinvestment view (Barnea & Rubin, 2010), based on the agency theory (Jensen & Meckling, 1976), considers ESG fulfillment may be a waste of firm resources which could generate greater risks, inferring it has a negative relationship with CRT (Chen *et al.*, 2021; Di Tommaso & Thornton, 2020; Harjoto & Laksmana, 2018; He *et al.*, 2023; Mulia & Joni, 2019).

Based on research thus far, it is still debatable whether ESG increases or decreases CRT. The inconsistencies in extant research results suggest the possibility of curvilinear relationships and could be due to the "too-little-of-a-good-thing (TLGT)" effect (Trumpp & Guenther, 2017), which indicates that both a positive and a negative relationship between ESG and CRT. More precisely, companies with low levels of ESG negatively affect CRT but high levels of ESG increase CRT accordingly. The change in CRT results from negative to positive may be due to the orientation of the implementation of ESG, as suggested by Li *et al.* (2022b). ESG practices with "self-interested" instrumentalization may have more costs than benefits and are likely to be detrimental to the enhancement of CRT. In contrast, if ESG practices actively respond to stakeholders' demands they may have higher benefits than costs and can enhance CRT (Li *et al.*, 2022b). Recently, some literatures has also referenced the U-shaped ESG-CFT nexus (Korinth &

Lueg, 2022; Li *et al*., 2022a), however, none of the research provides definitive results evidencing it exists. Furthermore, the above-mentioned discussion outlines the impact of ESG on CRT in research that methodologically utilizes ordinary least square (OLS) regression-based models. The motivation behind this study is to revisit and investigate the curvilinear ESG-CRT nexus using a quantile regression (QR) method.

This study chooses high-tech industry in Taiwan due to the following reasons. First, with the rapid development of digital manufacturing and services, high-tech industries are changing the production processes of companies as well as the way of life of human beings (Chen *et al*., 2023). The emergence of high-tech companies dominates and guides economic development, with far-reaching implications for national security, the social welfare of citizens, and the environment (Okafor *et al*., 2021; Wu & Chang, 2022). In Taiwan, technology companies account for 62% of the total market capitalization of all Taiwan publicly listed companies (Wu & Chang, 2022). Second, high-tech companies have a significant impact on carbon emissions due to their logistics, supply chains and factories operating worldwide (Varro & Kamiya, 2021). Ovide (2020) suggests that high-tech companies are taking a more leading role in minimizing the impact of climate change. It is argued that high-tech companies are keen on environmental issues because they can adopt new 'environmental protection measures' than companies in other industries (Al-Najjar & Salama, 2022). Given the higher risk appetite that characterizes the high-tech industry (Collevecchio *et al*., 2023), studying the effect of ESG on CRT is both essential and interesting.

This study has two objectives. Initially, its aim is to expand the existing scope of previous research by clarifying the ESG-CRT nexus and contribute to the current gap in the existing literature by uncovering how ESG influences CRT, and the specific effect ESG has on CRT. The second objective is to further evaluate the nexus between ESG and CRT by examining the individual impact of the ESG pillars on CRT. The study contains empirical research on the ESG-CRT relationship from 38 high-tech companies on the Taiwan Stock Exchange (TSE) over 2005 to 2020. OLS regression and QR models are utilized to investigate the curvilinear effect ESG (including the individual ESG pillars) has on CRT.

The findings reveal a significant curvilinear (U-shaped pattern) relationship between ESG and CRT (proxied by standard deviation of return on assets, named RISK) for all RISK quantiles except the 90th quantile. Further investigation reveals the environmental pillar (ESGE) has a convex (U-shaped) influence on CRT for all RISK quantiles except the 90th quantile, and a U-shaped nexus between the social pillar (ESGS) and CRT in the 75th quantile. ESGG (governance pillar) has insignificant impact on CRT. Overall, the results provide a comprehensive view supporting the theory that ESG practices can have a double-edged sword effect and provide empirical evidence to encourage high-tech firms to effectively engage in ESG practices.

This research contributes to extant literature and theories and offers several significant insights for enterprise managers. First, by utilizing QR analysis, the research confronts the tail information of CRT and identifies the effect of ESG on the different quantiles of CRT. Second, Lind and Mehlum's (2010) U-test, and Haans *et al.*'s (2016) three-stage procedure were also utilized to evidence whether the non-linear ESG-CRT relationship exists. Third, the identified U-shaped ESG-CRT nexus provides empirical evidence of TLGT effect. The type of ESG practice may vary in different settings (Aray *et al.*, 2021). ESG practices with "self-interested" instrumentalization are likely to be detrimental to the enhancement of CRT. In contrast, if ESG practices actively respond to stakeholders' demands they can enhance CRT (Li *et al.*, 2022b). Fourth, it is suggested that high-tech companies in Taiwan should avoid ESG practices becoming a tool for managements' self-interest. More information of ESG practices should be disclosed to stakeholders to ensure they are given full credit for the positive impact they have on capital allocation. Regulators guide firms to surpass the threshold of the U-shaped effect and take into consideration the whole benefits of stakeholders when they allocate existing resources toward environmental and social endeavors.

Following the introduction, the rest of this article is organized as follows. Section 2 provides a brief review of existing literature on FR and CRT and proposes the research hypotheses. Section 3 describes the methodology utilized for hypothesis testing. Empirical results are described and discussed in Section 4. Discussion and compares the findings with those of previous articles are in Section 5. The last section contains the conclusions and implications, provides the future directions and limitations of this study.

Literature review and hypothesis development

Theoretical overview

There are two competing theories regarding the relationship between ESG and CRT: the stakeholder theory and agency theory, which are simplified below.

The stakeholder theory (Freeman, 1984) claims risk mitigation is enhanced by corporate social responsibility (CSR) (Bruna & Nicolò, 2020) and posits greater investments in ESG act as insurance for firms by creating moral capital or goodwill among stakeholders (El Ghoul & Karoui, 2017). ESG practices are conducive to improving corporate reputation, thus long-term can improve an enterprise's visibility and competitiveness to improve its performance and ability to avoid risks (Saeidi *et al*., 2015; Sun & Cui, 2014).

Investment in ESG can be regarded as a risk management strategy (Porter & Kramer, 2006). ESG practices can be viewed as a 'value tool', which responds to the value needs of stakeholders so as to gain continuous trust of stakeholders and enhance the level of CRT (Li *et al*., 2022b).

Based on the agency theory, managers engage in ESG practices to go after their own interests (Testa *et al*., 2018). According to this argument, Barnea and Rubin (2010) speculate that those managers may look for over-invest in ESG practices to increase their reputations (Behl *et al*., 2022). When ESG practices become 'self-interest tools' for management instead of 'value tools' for shareholders, they will not be perceived positively. Accordingly, the fulfillment ESG practices of this nature may be a waste of firm resources and further generate greater risks. Consequently, the 'self-interest' instrumentalization of ESG practice weakens CRT.

ESG-CRT nexus

Extant literature provides mixed evidence on the nexus between CSR/ESG and CRT. The view aligning with the stakeholder theory suggests CSR/ESG is a control mechanism to satisfy the interest of investing stakeholders (shareholders) and non-investing stakeholders and proposes there is a positive CSR/ESG-CRT nexus. For example, Ayadi *et al.* (2015) document a positive nexus between CSR and CRT for US firms, i.e., firms with higher CSR performance tend to also display an increased desire for CRT.

Nguyen and Nguyen (2015) evidence that U.S. companies with greater CSR implementation experience higher CRT. Gangi *et al*. (2020) argue that while ESG activities increase corporate reputation, which has a positive impact on corporate risk-adjusted profitability and corporate risk Z-score. Similarly, Rao *et al.* (2022) and Yarram and Adapa (2022) prove that CSR significantly positively impact on CRT.

Another theory, again in line with the agency theory, suggests CSR/ESG negatively influences CRT. Harjoto and Laksmana (2018) evidence a negative CSR-CRT nexus. On extending this finding, they show CSR helps reduce deviations from optimal CRT by curtailing excessive and unnecessary risk avoidance. Mulia and Joni (2019) investigate the impact of CSR on CRT for Indonesian publicly listed companies and suggest that CSR practice is negatively related to CRT. Furthermore, Di Tommaso and Thornton (2020) found that high ESG scores are linked to a moderate reduction in risk-taking for European banks that are high or low risk-takers. Chen *et al*. (2021) explores the impact of ESG on CRT over a 10-year period, between 1999 and 2019. They found that firms with better ESG practices significantly mitigate their CRT. More recently, He *et al*. (2023) investigated the effect of ESG on CRT for Chinese listed firms over 2010 to 2020, and revealed that ESG performance (proxies by CSR score which released by Hexun.com) significantly reduces CRT.

The inconsistencies in existing research findings suggest the possibility of curvilinear relationships and could be due to the TLGT effect (Trumpp & Guenther, 2017), which suggests both a positive and negative relationship between ESG and CRT. TLGT effects explain why beneficial antecedents (ESG) may cause negative outcomes (CRT) when their levels are below a certain threshold. The TLGT effect implies that the relationship between ESG and CRT is negative when the ESG is below the threshold, then starts to rise after reaching the optimal ESG number. This means ESG causes positive changes in CRT when the threshold is surpassed. The TLGT effect would result in a U-shaped functional form. Recently, some literatures also referenced the U-shaped ESG-CFT nexus. For example, Korinth and Lueg (2022) investigate the nexus between ESG rating and firm risk in German and found a U-shaped relationship between ESG and firm risk. Li *et al.* (2022b) explores the effect of CSR fulfillment on CRT and discovered there is a U-shaped relationship. When the management takes ESG as a self-interested tool, ESG practice will fall below a certain threshold, at which point risk-taking will be significantly weakened. Conversely, when enterprises actively respond to the value demands of its stakeholders, they earnestly fulfill ESG practices beyond a certain threshold, and ESG practices will significantly enhance CRT. Based on the abovementioned discussion, the first hypothesis is:

Hypothesis 1. *There is a U-shaped curvilinear relationship between ESG and CRT.*

Individual ESG pillars-CRT nexus

Existing academic literature has competing views on the impacts of each individual ESG component on CRT. Some articles state that a company's active involvement toward reducing carbon emissions and pollution, and mitigating the risk of litigation, helps enterprises improve financial performance and reduce financial risk (Gangi *et al.*, 2019). The additional cost of environmental targets would partially displace other risky investment options, leading to a reduction in risk-taking (Preston & O'bannon, 1997). In addition, good environmental performance creates a good reputation for managers, but may also increase potential agency conflicts between managers and shareholders. Managers who maintain good reputations and stable careers tend to avoid risk-taking (Chen *et al.*, 2015).

Recently, Zhu *et al.* (2022) investigated the nexus between environmental performance and CRT between 2010 and 2016. They found that environmental performance significantly negatively influences on CRT. In contrast, Banerjee and Gupta (2017) found that sustainable environmental practices significantly positively impact on CRT under different legal frameworks and institutional setups.

Corporate environmental and social responsibility has a considerable influence on the reduction of default risk (Sun & Cui, 2014). Salehi *et al.* (2020) document that socially responsible enterprises are more resilient to market shocks and less exposed to risk. Participation in social and environmental activities helps to reduce the risk of additional costs and as a result, gain a sustainable competitive advantage (Gangi *et al.*, 2021). Therefore, investment in social practices can increase corporate profitability and reduce CRT. Chen *et al*. (2021) also found that the individual ESG components, environmental (ESGE), social (ESGS), and governance (ESGG), have a significantly negative relationship with CRT. Izcan and Bektas (2022) explored the nexus between CSR and the idiosyncratic risk of

Eurozone banks and found ESGS has no significant relationship with idiosyncratic risk.

Some studies posit a positive ESGG-CRT relationship. For example, John *et al.* (2008) evidence CRT is higher in firms who operate in better governed environments. Other studies report a negative ESGG-CRT relationship. For example, Claessens *et al.* (2000) show that firms in common law countries with stronger property rights protection and firms in market-based financial systems incur less risk. Izcan and Bektas (2022) explore the nexus between CSR and the idiosyncratic risk of Eurozone banks and found that both ESGE and ESGG's relationship with idiosyncratic risk is negative.

It is apparent that the research findings on the nexus between the individual ESG pillars (ESGE, ESGS, and ESGG) and CRT are not consistent. As Trumpp and Guenther (2017) argued, such inconsistent results arise because of the TLGT effect, which has both positive and negative effects suggest a curvilinear relationship between ESGE (ESGS, ESGG) and CRT. Similar inferences to the first hypothesis, we obtain the following hypotheses.

Hypothesis 2. *There is a U-shaped curvilinear ESGE-CRT relationship.*

Hypothesis 3. *There is a U-shaped curvilinear ESGS-CRT relationship.*

Hypothesis 4. *There is a U-shaped curvilinear ESGG-CRT relationship.*

Research design and methods

Sample and data

A data sample from high-tech industries publicly listed on TSE with voluntary ESG disclosure from 2005 to 2020 was utilized. The frequency distribution of high-tech industries is shown in Table 1. All ESG practices are voluntary in Taiwan as sustainability awareness is not currently legislation and therefore, not mandatory. The final data set includes 38 high-tech companies with 437 firm-year observations from 2005 to 2020. All financial data are taken from the Taiwan Economic Journal (TEJ) database, and the ESG scores data are gathered from Bloomberg. By using an exhaustive dataset of high-tech industries from TEJ and Bloomberg, this study sourced samples of three types of high-tech industries for follow-up research and avoided selection bias.

Measure of variables

Table 2 contains the description of all the variables used in this study. The first set of variables relate to CRT measures. The measure of CRT, *RISK*, is estimated based on the standard deviation of industry-adjusted return on assets (ROA) over a five-year period, where ROA is computed as the ratio of a company's earnings before interest and taxes (EBIT) to total assets (Boubakri *et al.*, 2013). To calculate the volatility, the firm's ROA for each year by the industry average is adjusted first, then the standard deviation of ROA adjusted by the industry during each observation period is calculated. The computation formula is

$$RISK = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}\left(AdjROA_{ijt} - \frac{1}{T}\sum_{t=1}^{T} AdjROA_{ijt}\right)^2}, T = 5 \tag{1}$$

$$AdjROA_{ijt} = ROA_{ijt} - \frac{1}{n_{jt}}\sum_{i=1}^{n_{jt}} ROA_{ijt}. \tag{2}$$

where, ROA_{ijt} is the ROA of firm i in industry j at the end of t year, $AdjROA_{ijt}$ is the ROA adjusted by the yearly average of the industry. The CRT measures are similar to those used in earlier studies (Andries *et al.*, 2020; Azevedo *et al.*, 2022; Chang & Wu, 2021; Rossi & Harjoto, 2020; Yarram & Adapa, 2022).

The second set of variables used relate to ESG and its three individual pillars (EGSE, ESGS, and ESGG). In this study, a firm's level of ESG practice is measured through their ESG rating (ESG scores). The ESG ratings were sourced from the Bloomberg database as it holds more companies' ESG ratings than any other rating provides, which has been widely used in previous ESG/CSR literature (Avramov *et al.*, 2022; Fang *et al.*, 2023). The Bloomberg ESG scores cover the three pillars of ESG, environmental score (ESGE), social score (ESGS), and governance score (ESGG). Unlike other ESG/CSR ratings, the Bloomberg ESG score is also tailored to different industries. Each firm is evaluated only on data relevant to its industry sector. ESG disclosure scores range from a minimum of 0.1 to a maximum of 100, and the higher the disclosure score, the more information is disclosed.

The third set of variables used relate to the control variables. This study measured five factors: SIZE, LEV, NPM, AGE and OEG (see Table 2). Previous articles suggest these variables may determine CRT (Teng *et al*., 2022; Wu & Chang, 2022).

Methods

The ordinary least square (OLS) regression method minimizes the sum of squares error and approximates the mean function of the conditional distribution of response variables (Li *et al*., 2015). Nevertheless, focusing on central effects could cause under- or over-estimation of correlation coefficients and significant associations remaining undetected, which can generate false positives and allow information at the tail end of the distribution to be ignored (Chiang *et al*., 2010).

As QR is more robust and able to capture outliers effectively (Maiti, 2021), researchers focusing on corporate governance use this regression model (Chang & Wu, 2021; Chang & Wu, 2022a, 2022b; Wu & Chang, 2022; Zaiane *et al*., 2022). Chang and Wu (2021) use the QR method to examine the financial flexibility and CRT nexus. Wu and Chang (2022) utilize the QR model to assess the impact of ESG on firm value. Zaiane *et al.* (2022) explore the nexus between stock options compensation and firm strategic risk-taking using the QR technique. This article applies Koenker and Bassett's (1978) QR model, Equation (3), to investigate the nonlinear effect of ESG on CRT across various risk quantiles.

$$\begin{gathered} Q_p(RISK_{it}|X_{it}) = \beta_{0p} + \beta_{1p}ESG_{it} + \beta_{2p}ESG2_{it} + \\ +\beta_{3p}CON_{it} + \mu_{pt}+\gamma_{pt} + \varepsilon_{pit} \end{gathered} \tag{3}$$

where $Q_p(RISK_{it}|X_{it})$ refers to the p-th QR function; $RISK_{it}$ refers to the CRT of *I* company in *t* year; ESG_{it} refers to the ESG for *i* company in *t* year; $ESG2_{it}$ represents the ESG_{it} to the power 2; CON_{it} represents the control variables; μ_{pt} represents the time-fixed effects; γ_{pt} is an industry unobservable effect; and ε_{pit} signifies the error term.

Furthermore, this research also employs the U-test proposed by Lind and Mehlum (2010) and follows the three-stage procedure suggested by Haans *et al*.'s (2016) to assess the viability of the curvilinear ESG-CRT relationship. In addition, all data observations are utilized to construct each QR estimate thus avoiding a sample selection bias (Gallego-Álvareza & Ortas, 2017).

Empirical results

Descriptive statistics

Table 3 represents data description of the variables. Regarding CRT (dependent variable), the mean is 2.851%, median 1.889%, and minimum (maximum) value 0.198% (26.246%). The skewness is 3.714 and Kurtosis 22.901, with the distribution of CRT skewed to the right and heavily tailed. The CRT normality test confirms its Jacque-Bera statistic (=8,160, $p<0.01$), rejecting the null hypothesis that the CRT is normally distributed.

ESG disclosure scores range from 0.1 to 100, with an average of 38.711. ESGG scored the highest mean, followed by ESGS. ESGE has a mean value equal to 36.602, indicating there is insufficient effort to incorporate environmental management policies from high-tech industries in Taiwan (Table 3).

The correlations of all variables reveal that none of the independent variables applied in this research are highly correlated (Table 4), which implies multicollinearity is not an issue. The variance inflation factor (VIF) results for the independent variables are shown in Table 4. The highest VIF is 1.90 and the lowest is 1.04, which is lower than the threshold value of 10 recommended by Hair et al. (2017). Thus, multi-collinearity is not considered to be a problem.

Nonlinear nexus between ESG and CRT

The Hausman test (1978) was utilized to select either a fixed effect or random effect model. The chi-square value was identified as 72.87 ($p<0.01$), meaning the null hypothesis could be rejected and as a result, a fixed-effect model used for this research. Table 5 summarizes the fixed-effect regression results of the unbalanced panel data, including White (1980) adjustment for heteroscedasticity.

The estimation results for the OLS regression model show the nexus between ESG and CRT is insignificant. For CRT, the ESG slope is significantly negative and the ESG2 slope is significantly positive ($p<0.01$) in the lower

(10th and 25th), median (50th), and 75th quantiles. This indicates a nonlinear ESG-CRT relationship exists (Table 5).

For the control variables, the OLS and QR estimations show that SIZE significantly negatively effects CRT. The OLS results reveal LEV has an insignificant impact on CRT, whereas QR results reveal LEV positively effects CRT in the 25th and 75th quantiles, and negatively effects CRT in the 90th quantile. Both the results of OLS and QR method evidence that NPM has insignificant influence on CRT. QR estimations reveal AGE significantly negatively effects CRT in the lower and median quantiles. Both OLS and QR analysis confirm OEG significantly positively impacts CRT (Table 5).

This study also utilizes the U-test (Lind & Mehlum, 2010) and the three-stage procedure suggested by Haans *et al.* (2016) to accurately test for the presence of a quadratic (U-shaped pattern) relationship. Table 5 displays these findings.

The U-test (Lind & Mehlum, 2010) and the three-stage procedure (Haans *et al*., 2016) confirm the ESG-CRT nexus is U-shaped as: (1) the slope at ESG_{low} is significant and negative (–0.0262, p<0.01); (2) the slope at ESG_{high} is significant and positive (0.0389, p< 0.01); and (3) both (1) and (2) co-exist. Both the threshold (34) and the 95% Fieller (1954) confidence interval [25.7, 46.3] are within the data range, which verifies the existence of a U-shaped nexus between ESG and CRT in the 10th quantile (Table 5).

Following the same procedure, a curvilinear (U-shaped) relationship between ESG and CRT is evidenced in the 25th, 50th, and 75th quantile firms. In summary, ESG and CRT present a curvilinear (U-shaped pattern) relationship in the lower, median, and 75th quantiles, only when ESG practices reach a certain level (threshold point) can incorporates multiple stakeholders' continuous trust and thus improving CRT. As such, Hypothesis 1 is verified.

Inter-quantile difference

The empirical results verify that across the CRT distributions, the effect of ESG on CRT is heterogeneous. To confirm whether these diversities are statistically significant, inter-quantile regressions were applied to test for slope equality throughout the quantiles (Koenker & Bassett, 1978). Table 6 shows the F-test results and the corresponding p values after analyzing the uniformity of the coefficient only between the lower (10th and 25th) and upper (75th and 90th) quantiles, utilizing 200 bootstrap replications.

Figure 1 reveals how the effect of each covariable varies between quantiles and how they compare to each independent variable's OLS regression estimates. The estimations of QR and OLS models are aided by their respective 95% confidence intervals. The figure verifies the QR estimation results differ from the OLS results, especially for the symmetrical quantiles.

Relationships between the ESG pillars and CRT

By separating ESG into its three individual pillars, this section investigates the non-linear relationship between ESGE, ESGS, ESGG, and CRT. The U-test (Lind & Mehlum, 2010) and the three-stage procedure (Haans *et al*., 2016) were employed to validate the existence of the U-shaped nexus.

First, the OLS estimation results confirm ESGE and ESGE2 do not significantly impact CRT (Table 7). The QR results, however, exhibit a U-shaped ESGE-CRT nexus in all RISK quantiles. The slope of $ESGE_{low}$ is negative and statistically significant (p<0.01), whereas the slope of $ESGE_{high}$ is positive and significant (p<0.01). In addition, the threshold (32.4) falls within Fieller 95% confidence interval [25.3, 41.5] (Table 6). Therefore, the U-test (Lind & Mehlum, 2010) and the three-stage procedure (Haans *et al*., 2016) confirm the ESGE-CRT nexus is U-shaped in 10th quantile firms. Similarly, a curvilinear (U-shaped pattern) ESGE-CRT nexus is evidenced in the 25th, 50th, and 75th quantile firms (Table 7).

Furthermore, the slopes of $ESGE_{low}$ and $ESGE_{high}$ are not significantly negative and positive (p>0.1), indicating the U-shaped ESGE-CRT relationship does not exist in the 90th quantile (Haans *et al.*, 2016; Lind & Mehlum, 2010). To sum up, the QR approach confirms the curvilinear (U-shaped pattern) ESGE-CRT nexus exists in all RISK quantiles except the 90th, which supports Hypothesis 2.

Second, regarding ESGS, OLS analysis indicates that ESGS and ESGS2 do not significantly impact CRT (Table 8). However, the QR estimation results show that in the 75th quantile, the ESGS slope is significantly negative and the ESGS2 slope is significantly positive (p<0.05). This result reveals the U-shaped relationship between ESGS and CRT (Table 8).

Furthermore, the coefficient of $ESGS_{low}$ is significant and negative (p<0.05), whereas the coefficient of $ESGS_{high}$ is significant and positive (p<0.05). The threshold point of ESGS is 48.571 with a 95% Fieller confidence interval [34.1, 87.7], which confirms the U-shaped nexus between ESGS and CRT for firms in the 75th RISK quantile (Table 8). These findings evidence a curvilinear (U-shaped) nexus between ESGS and CRT in the 75th RISK quantiles, which supports Hypothesis 3.

Lastly, both the results of OLS and QR estimations demonstrate the impact of ESGG on CRT is not significant (Table 9), which does not support Hypothesis 4.

Robustness check

For robustness analysis, as another measure of operational risk, $RISK_1$ is the estimated standard deviation of industry-adjusted return on equity over a five-year period (Boubakri *et al*., 2013). The robustness check reinforces the main results which confirm the U-shaped nexus between ESG and CRT, and that ESG affects CRT, particularly in the 10th, 25th and 50th quantiles. The findings of the U-test and the three-stage procedure for $RISK_1$ confirm the U-shaped relationship is similar to the results for *RISK* (Table 10).

Furthermore, to address endogeneity concerns, a reverse causality test was completed. Considering the possibility of reverse causality between CRT and ESG, CRT may have a U-shaped impact on ESG. To confirm, regressions were completed with CRT as the independent variable and ESG as the dependent variable. The results of reverse causality test are shown in Table 11. The study found no evidence of the existence of reverse causality between CRT and ESG. Therefore, the relationship between ESG and CRT is unidirectional. Based on these results, there is no reverse causality exists between the independent and dependent variables and all these relationships are unidirectional.

Discussion

The empirical investigation utilizes data from 38 high-tech firms listed on the TSE with voluntary ESG disclosure from 2005 to 2020. Findings were elicited via QR, the U-test (Lind & Mehlum, 2010), and the three-stage procedure (Haans *et al*., 2016).

QR analysis reveals a curvilinear (U-shaped pattern) ESG-CRT nexus in the lower, median, and 75th accounting-measured risk (RISK) firms, implying ESG practice has a double-edged sword effect. If management seriously considers stakeholders' needs, ESG practices can be a resource that enhances CRT. Conversely, if ESG practice is used instrumentally for managers' self-gain, it can have a negative impact on CRT. These findings agree with the propositions of Li *et al*. (2022b).

The ESG sample mean (38.711) is larger than the threshold of ESG (34) in the 10th quantile, indicating most high-tech companies are located on the increasing half of the U-shaped curve, to the right of the threshold value (Table 5 and Figure 2A). This means the dominant effect ESG has on CRT is positive, non-linear, and significant. As a result, most high-tech firms in the 10th quantile benefit from ESG practice and should pursue greater ESG value to improve their own risk-taking.

The threshold values of the 25th, 50th, and 75th RISK quantiles are 38.75, 43.6, and 44.9, respectively, which are higher than the current mean value (38.711) (Table 5, Figure 2B, 2C, and Figure 2D), indicating most high-tech companies are located on the decreasing half of the U-shaped curve and left of the threshold point. This infers the dominant effect ESG has on CRT is significantly negative and non-linear. As a result, most high-tech firms in the 25th, 50th, and 75th RISK quantiles partake in more ESG practice than stakeholders deem necessary and should only pursue the minimum value of ESG in order to obtain greater CRT.

Additionally, the results also show a U-shaped ESGE-CRT relationship in all quantiles. ESGE's impact on CRT decreases initially, but on reaching the optimal value of ESGE, begins to rise. The optimal value of ESGE is 32.4, 41.8, 39, and 46.444 in lower, median, and 75th quantiles, respectively. For the 25th, 50th, and 75th quantiles, the threshold points are above the average ESGE value (36.602), which infers most companies operate in the ESG-low regime. This suggests ESGE has a negative, non-linear, and significant impact on CRT, meaning ESGE practice disadvantages most TSE listed high-tech firms (Table 7 and Figure 3A to 3D).

For ESGS, the research results confirm the curvilinear (U-shaped pattern) ESGS-CRT nexus only in the 75th quantile. ESGS's impact on CRT decreases initially, but on reaching the optimal ESGS value, begins to rise. This indicates that, short-term, most high-tech companies in the 75th RISK quantile who invest in ESGS positively impact the firm's reputation and ensure a lower CRT. On a long-term basis, however, investment in futile ESGS activities is detrimental to CRT.

The optimum value of ESGS is 48.571 in the 75th quantile (Table 8 and Figure 4). The threshold point (48.571) is higher than the average value of ESGS (39.566), indicating most high-tech companies are located on the decreasing half of the U-shaped curve to the left of the threshold value. Consequently, most high-tech companies in the 75th RISK quantiles engage in more ESG practices than stakeholders deem necessary.

Lastly, the non-linear ESGG-CRT nexus is insignificant. Although the implementation of corporate governance plans may not immediately enhance CRT, TSE listed high-tech companies should strive to adopt corporate governance to promote sustainable development and help reduce CRT. This result contradicts John *et al.* (2008) who evidence a negative effect on CRT. These differences could be due to the alternative proxies for CRT, industry attributes, and/or regions.

In sum, the findings support the assertions that ESG's influence on CRT is a crucial mechanism via which ESG impacts firm value. Whereas prior research in most cases uses either linear positive (Gangi *et al*., 2020; Rao *et al*., 2022; Yarram & Adapa, 2022) or linear negative models (Di Tommaso & Thornton, 2020; He *et al*., 2023), this may not be sufficient given the complex nature, trade-offs and conflicts involved in the ESG-CRT nexus. Overall, our findings offer empirical evidence of a U-shaped relationship between ESG and CRT for companies in the high-tech industries.

In terms of the theoretical framework, our results provide evidence that seemingly opposing theories should be integrated, as empirical evidence suggests both a negative and a positive relationship between ESG and CRT, depending on the level of ESG. We confirm the agency problem for firms with low ESG; in addition, we also confirm the stakeholder theory for firms with ESG above a specified minimum level. These theories, known as contrasts, can thus be integrated into the theoretical framework of the 'too little of a good thing' (TLGT) effect in relation to ESG and CRT.

The findings exhibit that self-interest instrumentalization of ESG practices exacerbates agency conflict and that ESG practices can weaken risk-taking until a certain threshold is reached. When ESG practices reach a certain threshold, ESG practices can improve risk-taking. Then, ESG and CRT show a U-shaped relationship.

Conclusions

Based on the stakeholder theory and agency theory, this study investigates the impact of ESG on Taiwanese high-tech corporations' risk-taking using the QR method. This research adds to the gap in the extant ESG research by eliciting several impacts ESG has on CRT and proposing a curvilinear (U-shaped pattern) ESG-CRT nexus in the lower, median, and 75th accounting-measured risk (RISK) firms. Furthermore, the findings evidence that each ESG pillar has a differing impact on CRT. ESG (as a whole), ESGE, and ESGS have a U-shaped impact on CRT, aligning with the double-edged sword effect.

The results also show that ESG practices reflect management's self-interest to some extent. The self-interested instrumentalization of ESG practices deepens the agency conflict between shareholders and management, which causes the implementation of ESG to weaken the level of CRT. Only when ESG practices reach a threshold value can companies gain continuous trust from multiple stakeholders, which is conducive to improving the level of CRT.

Theoretical implications

Several theoretical contributions are gleaned from the research findings. Although the current ESG research is in abundance, the topic is constantly growing and creating novel possibilities for research. This study explores the nexus between ESG and CRT using the QR method for unbalanced panel data. The research contributes to the scope of earlier research by clarifying whether a relationship exists. It also helps to make up the shortcomings in extant literature by further investigating the impact of ESG on CRT, and proposing the relationship is U-shaped in the different RISK quantiles for TSE listed high-tech firms. Thus far, and to the authors' knowledge, no previous studies investigate how CRT is affected by ESG in TSE listed high-tech companies, meaning this study contributes new knowledge and information toward this research topic.

Moreover, the results support the double-edged sword effect perspective and empirically confirms the existence of a curvilinear (U-shaped pattern) ESG-CRT nexus via the U-test (Lind & Mehlum, 2010) and the three-stage procedure (Haans *et al.*, 2016). The mechanism with which ESG impacts CRT is reliant on ESG's level of performance. Aligning with Lahouel *et al.* (2022), the findings confirm that in business research, investigating the nonlinear impact between variables should be the rule rather than the exception when exploring the ESG-CRT nexus.

Managerial implication

The research findings elicit significant and appropriately timed implications to assist managers in effectively designing and managing ESG practices, which is an increasingly important issue post COVID-19 pandemic. At a time when ESG investments are becoming increasingly popular, this study's findings evidence that ESG practices are not only external decorations to enhance enterprise reputation and image, but they also have a curvilinear (U-shaped pattern) effect on CRT. Enterprises should fully recognize the double-edge sword effect of ESG practices whereby, if ESG practices are characterized by instrumental self-interest attributes, they are likely to be detrimental to the enhancement of CRT. In contrast, if ESG activities are based on the interests of stakeholders, they can enhance CRT and become a lucrative resource. As a result, it is suggested that TSE listed high-tech companies should avoid ESG practices becoming a tool for managements' self-interest. More information of ESG practices should be disclosed to stakeholders to ensure they are given full credit for the positive impact they have on capital allocation.

Practical implication

The findings of this research have critical implications for enterprises, policymakers, investors, and stakeholders. From an enterprise perspective, the research results imply that firms should effectively manage their ESG activities. The confirmed non-linear U-shaped nexus between ESG (including ESGE and ESGS) and CRT suggests focusing on stakeholder demands via ESG (including ESGE and ESGS) is an effective strategy to lower the firm's risks. That is, ESG (ESGE and ESGS) provides a differentiation strategy to enhance the acceptance of stakeholders.

From the perspective of policymakers, this research identifies ESG as an effective risk management tool; however, engaging in too many ESG activities may increase CRT. Although government and the general public encourage companies to increase their ESG efforts, firms' financial and ESG statuses should be considered. Increasing ESG practices in firms with already high levels of ESG could also increase their CRT. Firms with adequate or increased ESG activity should be given more leniency when they are unable to increase ESG practices any further, or must reduce them (Li *et al.*, 2021).

The research findings are dominated by ESGE and ESGS information disclosure, which indicates stakeholders have more interest in an enterprise's adherence to environmental and social responsibility issues than corporate governance issues. In line with the resource-based view and stakeholder theory, regulators guide firms to surpass the threshold of the U-shaped effect and take into consideration the whole benefits of stakeholders when they allocate existing resources toward environmental and social endeavors.

From an investor or stakeholder perspective, the research findings can be used to gauge the investment portfolios of TSE listed firms. A firm's sustainable performance disclosure can be compared against the identified threshold values to assist in predicting its future CRT.

Research limitations/future research

This study is not free from limitations. The first limitation is that selection bias exists because the sample only includes Taiwan. In Taiwan, ESG reporting is still voluntary, meaning companies that release ESG reports do so willingly. Therefore, companies that do not report ESG activity could not be selected, which can lead to biased results. Additionally, there are only 38 TSE listed high-tech companies whose ESG scores are available on Bloomberg. This means the empirical findings of this research should be interpreted and generalized with some caution, as the results are not generalizable to other countries. Although the universal implications cannot be stated, it enables preliminary suggestions for the 38 TSE listed high-tech firms whose disclosed ESG information could be obtained.

Second, to effectively understand the effects of ESG on CRT in other contexts, future studies should include other firms listed in other countries to investigate how ESG impacts CRT, and whether the U-shaped ESG-CRT nexus exists elsewhere, which may assist in establishing a comparative analysis.

Third, in terms of CRT measurement, there is no consistent standard way of measuring CRT in the literature. This study used standard deviation of industry-adjusted return on assets (ROA) over a five-year period to measure the CRT. Future research may consider systematic risk as the proxy for CRT to increase the richness of the research.

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Annex

Table 1. Sample distribution

	Number of observations	Percentage of observations
Semiconductors	108	24.71
Technology Hardware	291	66.59
Telecommunication	38	8.7
Total	437	100

Table 2. Definitions of variables

Variable	Acronym (units)	Description
Dependent variable		
Corporate risk-taking	CRT	Standard deviation of industry-adjusted ROA for five consecutive quarters, as shown in Formula (1).
Independent variables		
Firm disclosure of its environmental, social, and governance	ESG	The ESG Bloomberg index includes all firm disclosures of ESGE, ESGS, and ESGG indices.
Environmental disclosure	ESGE	The ESGE Bloomberg index measures the disclosure of total greenhouse gas emissions, total energy consumption, total water use, etc.
Social responsibility disclosure	ESGS	The ESGS Bloomberg index measures the disclosure of employee turnover, the percentage of women in the workforce, and community expenditure, etc.
Governance disclosure	ESGG	The ESGG Bloomberg index measures the disclosure of the board tenure and political donations, etc.
Control variables		
Firm size	SIZE	Natural logarithm of total assets
Financial leverage	LEV	Ratio of total debts to total assets
Net profit margin	NPM	Ratio of net income to sales
Firm age	AGE	Age of the firm
Growth rate of owner's equity	OEG	Percentage change in owner's equity over the previous period

Table 3. Summary of descriptive statistics

Variables	Obs	Mean	SD	Min	Max	Q10	Q25	Q50	Q75	Q90	Skewness	Kurtosis
CRT	434	2.851	3.015	0.198	26.246	0.812	1.190	1.889	3.612	5.766	3.714	22.901
ESG	436	38.711	17.178	1.24	82.64	14.46	25.415	39.26	50	61.98	0.215	2.58
ESGE	392	36.602	19.447	2.33	86.82	13.18	19.77	36.43	48.84	65.12	0.432	2.472
ESGS	408	39.566	17.697	3.13	91.23	21.05	26.32	36.84	52.095	63.16	0.468	2.866
ESGG	437	53.652	8.82	5.36	87.42	44.64	48.21	53.57	58..93	64.29	-0.353	4.834
SIZE	437	18.83	1.148	15.512	21.949	17.372	18.014	18.852	19.677	20.156	0.018	3.07
LEV	437	48.306	18	7.14	98.21	21.26	35.41	48.98	62.81	70.86	-0.21	2.223
NPM	437	8.595	15.732	-107.42	73.37	0.82	1.78	6.43	13.28	27.53	-1.982	21.522
AGE	437	24.67	10.117	1	50	11	17	25	32	38	0.059	2.443
OEG	437	127.896	2484.906	-92.09	51950.621	-5.05	-0.21	5.16	12.75	24.53	20.828	434.86

Table 4. Bivariate correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) CRT	1						
(2) ESG	0.034	1					
(3) SIZE	-0.156*	0.420*	1				
(4) LEV	-0.108*	0.168*	0.167*	1			
(5) NPM	0.128*	-0.046	-0.038	-0.585*	1		
(6) AGE	-0.114*	0.145*	0.094	-0.001	0.066	1	
(7) OEG	0.382*	-0.024	0.014	0.001	-0.017	-0.108*	1.
VIF		1.25	1.24	1.73	1.90	1.04	1.25

Note: *p < 0.1.

Table 5. OLS and QR analysis summary

Variables	ERT (proxied by *RISK*)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	-0.0268	-0.0272***	-0.0310**	-0.0436***	-0.0449*	-0.0591
	(0.0290)	(0.0102)	(0.0128)	(0.0150)	(0.0269)	(0.0750)
ESG2	0.0007**	0.0004***	0.0004***	0.0005***	0.0005*	0.0013
	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0003)	(0.0008)
SIZE	-0.4647***	-0.1352***	-0.1718***	-0.1512**	-0.6439***	-0.9415***
	(0.1101)	(0.0338)	(0.0337)	(0.0728)	(0.1107)	(0.2568)
LEV	-0.0205	0.0007	0.0064*	-0.0000	0.0201**	-0.0547**
	(0.0132)	(0.0042)	(0.0036)	(0.0057)	(0.0082)	(0.0229)
NPM	-0.0132	-0.0089	-0.0009	-0.0101	-0.0020	-0.0480
	(0.0299)	(0.0100)	(0.0057)	(0.0151)	(0.0129)	(0.0328)
AGE	-0.0188	-0.0098**	-0.0100***	-0.0108**	-0.0072	-0.0327
	(0.0133)	(0.0045)	(0.0032)	(0.0055)	(0.0106)	(0.0243)
OEG	0.0396***	0.0169*	0.0176***	0.0285***	0.0246**	0.0699***
	(0.0100)	(0.0090)	(0.0026)	(0.0059)	(0.0102)	(0.0202)
Constant	12.5716***	4.5471***	5.5517***	6.8760***	17.2208***	26.5508***
	(1.7604)	(0.6445)	(0.6855)	(1.4247)	(2.2210)	(4.8972)
Observations	433	433	433	433	433	433
Industry Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.1878	0.133	0.170	0.221	0.271	0.144
Slope at the low end of X-range ($\beta_1+2*\beta_2*X_{low}$)	—	-0.0262***	-0.0300***	-0.0424***	-0.0437	—
Slope at the high end of X-range ($\beta_1+2*\beta_2*X_{high}$)	—	0.0389***	0.0351***	0.0390***	0.0377	—
Sasabuchi (1980) test statistic	—	2.55***	2.42***	2.67***	1.56*	—
95% Fieller confidence interval	—	[25.7, 46.3]	[23.9, 47.7]	[35.2, 55.7]	(-∞, ∞)	—
Threshold/within data range	—	34/Yes	38.75/Yes	43.6/Yes	44.9/Yes	—

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Table 6. Inter-quantile regression results

		ERT (proxied by RISK)	
		Quantile(90/10)	**Quantile(75/25)**
ESG	F-statistics	0.04	0.14
	Significance	0.8511	0.7091
ESG2	F-statistics	0.07	0.06
	Significance	0.7900	0.7991
SIZE	F-statistics	21.07	7.08
	Significance	0.0000	0.0081
LEV	F-statistics	5.41	1.17
	Significance	0.0205	0.2805
NPM	F-statistics	0.53	0.00
	Significance	0.4656	0.9515
AGE	F-statistics	0.01	0.07
	Significance	0.9355	0.7873
OEG	F-statistics	1.99	0.30
	Significance	0.1587	0.5836

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 7. Nonlinear model for ESGE

Variables	ERT (proxied by *RISK*)					
	OLS	**Lower quantiles**		**Median**	**Upper quantiles**	
		10th	**25th**	**50th**	**75th**	**90th**
ESGE	-0.0328	-0.0324***	-0.0418***	-0.0468***	-0.0836***	-0.0927*
	(0.0248)	(0.0093)	(0.0111)	(0.0169)	(0.0229)	(0.0530)
ESGE2	0.0007	0.0005***	0.0005***	0.0006***	0.0009***	0.0014**
	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0006)
SIZE	-0.4093***	-0.1371***	-0.1684***	-0.1138	-0.5668***	-0.8243***
	(0.1276)	(0.0323)	(0.0351)	(0.0744)	(0.1501)	(0.2765)
LEV	-0.0181	0.0065	0.0101**	-0.0068	0.0203**	-0.0613***
	(0.0154)	(0.0041)	(0.0041)	(0.0064)	(0.0103)	(0.0216)
NPM	0.0119	0.0033	0.0102	0.0007	0.0033	-0.0490*
	(0.0339)	(0.0075)	(0.0082)	(0.0099)	(0.0135)	(0.0256)
AGE	-0.0138	-0.0113***	-0.0086**	-0.0077	-0.0043	-0.0457*
	(0.0138)	(0.0038)	(0.0036)	(0.0053)	(0.0094)	(0.0250)
OEG	0.0383***	0.0153*	0.0194***	0.0295***	0.0221*	0.0721***
	(0.0095)	(0.0082)	(0.0029)	(0.0051)	(0.0114)	(0.0250)
Constant	11.3946***	4.1327***	5.1587***	5.7297***	16.6533***	25.9459***
	(1.8450)	(0.6880)	(0.6828)	(1.3867)	(2.7269)	(4.8609)
Observations	389	389	389	389	389	389
Industry Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.2209	0.148	0.182	0.224	0.278	0.170
Slope at the low end of X-range ($\beta_1+2*\beta_2*X_{low}$)	—	-0.0301***	-0.0395***	-0.0440***	-0.0794***	-0.0862

Table 7. Continued

Variables	OLS	ERT (proxied by *RISK*) Lower quantiles 10th	25th	Median 50th	Upper quantiles 75th	90th
Slope at the high end of X-range ($\beta_1+2*\beta_2*X_{high}$)	—	0.0544***	0.0450***	0.0574***	0.0727***	0.1504
Sasabuchi test statistic	—	3.40***	3.48***	2.75***	3.33***	0.52
95% Fieller confidence interval	—	[25.3, 41.5]	[34.2, 48.0]	[30.4, 51.5]	[41.2, 58.4]	(-∞, ∞)
Threshold/within data range	—	32.4/Yes	41.8/Yes	39/Yes	46.444/Yes	33.107/Yes

Note: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table 8. Nonlinear model for ESGS

Variables	OLS	ERT (proxied by *RISK*) Lower quantiles 10th	25th	Median 50th	Upper quantiles 75th	90th
ESGS	-0.0088	-0.0070	-0.0120	-0.0103	-0.0680**	0.0691
	(0.0303)	(0.0105)	(0.0087)	(0.0148)	(0.0303)	(0.1123)
ESGS2	0.0005	0.0001	0.0001	0.0001	0.0007**	-0.0001
	(0.0004)	(0.0001)	(0.0001)	(0.0002)	(0.0003)	(0.0011)
SIZE	-0.5132***	-0.0953*	-0.1471***	-0.1804**	-0.7982***	-1.1468***
	(0.1190)	(0.0510)	(0.0314)	(0.0784)	(0.1295)	(0.2177)
LEV	-0.0081	0.0057	0.0055	-0.0017	0.0263***	-0.0430*
	(0.0161)	(0.0047)	(0.0034)	(0.0062)	(0.0090)	(0.0229)
NPM	0.0179	0.0055	0.0081**	0.0117	-0.0040	-0.0334
	(0.0325)	(0.0103)	(0.0040)	(0.0094)	(0.0110)	(0.0275)
AGE	-0.0119	-0.0094***	-0.0108***	-0.0077	-0.0011	-0.0495
	(0.0131)	(0.0029)	(0.0035)	(0.0056)	(0.0097)	(0.0309)
OEG	0.0367***	0.0152**	0.0166***	0.0290***	0.0289**	0.0619***
	(0.0094)	(0.0074)	(0.0023)	(0.0051)	(0.0133)	(0.0047)
Constant	12.0199***	3.1412***	4.7855***	6.2391***	20.3069***	28.0098***
	(2.0762)	(0.9897)	(0.6107)	(1.6261)	(2.7298)	(3.7969)
Observations	405	405	405	405	405	405
Industry Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.2416	0.134	0.173	0.221	0.280	0.168
Slope at the low end of X-range ($\beta_1+2*\beta_2*X_{low}$)	—	—	—	—	-0.0636**	—
Slope at the high end of X-range ($\beta_1+2*\beta_2*X_{high}$)	—	—	—	—	0.0597**	—

Table 8. Continued

Variables	ERT (proxied by *RISK*)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
Sasabuchi test statistic	—	—	—	—	1.98**	—
95% Fieller confidence interval	—	—	—	—	[34.1, 87.7]	—
Threshold/within data range	—	—	—	—	48.571/Yes	—

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Table 9. Nonlinear model for ESGG

Variables	ERT (proxied by *RISK*)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESGG	-0.0347	-0.0112	-0.0472	-0.0624	0.0457	-0.2007
	(0.0504)	(0.0336)	(0.0946)	(0.0675)	(0.1772)	(0.1677)
ESGG2	0.0005	0.0001	0.0004	0.0005	-0.0004	0.0026
	(0.0004)	(0.0003)	(0.0009)	(0.0007)	(0.0016)	(0.0017)
SIZE	-0.3389***	-0.0971***	-0.1354***	-0.1423*	-0.6983***	-0.9131**
	(0.1011)	(0.0294)	(0.0363)	(0.0740)	(0.1393)	(0.3685)
LEV	-0.0242*	0.0033	0.0017	-0.0056	0.0175*	-0.0593**
	(0.0132)	(0.0027)	(0.0033)	(0.0056)	(0.0092)	(0.0296)
NPM	-0.0158	0.0030	-0.0033	-0.0154**	-0.0018	-0.0546
	(0.0298)	(0.0069)	(0.0063)	(0.0069)	(0.0142)	(0.0430)
AGE	-0.0197	-0.0092***	-0.0125***	-0.0111**	-0.0090	-0.0426
	(0.0134)	(0.0022)	(0.0037)	(0.0054)	(0.0114)	(0.0417)
OEG	0.0395***	0.0119	0.0166***	0.0289***	0.0264***	0.0665**
	(0.0100)	(0.0082)	(0.0026)	(0.0066)	(0.0100)	(0.0297)
Constant	10.9491***	3.6005***	6.1452**	8.1675***	16.3922***	29.6919***
	(1.8840)	(0.9944)	(2.6295)	(1.8656)	(4.9428)	(8.1535)
Observations	434	434	434	434	434	434
Industry Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.1583	0.128	0.164	0.219	0.271	0.111

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Table 10. Nonlinear model using *$RISK_1$*

Variables	ERT (proxied by *$RISK_1$*)					
	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
ESG	-0.1462	-0.0518*	-0.0935***	-0.1162***	-0.2265	0.0557
	(0.1317)	(0.0285)	(0.0179)	(0.0362)	(0.1485)	(0.2440)
ESG2	0.0041**	0.0008**	0.0011***	0.0013***	0.0031	0.0018
	(0.0019)	(0.0004)	(0.0002)	(0.0004)	(0.0020)	(0.0030)
SIZE	-1.6137***	-0.0328	-0.1611***	-0.2955**	-1.0112**	-1.9850**
	(0.6049)	(0.0867)	(0.0554)	(0.1294)	(0.4012)	(0.9196)
LEV	0.0185	-0.0130	0.0069	0.0379***	0.0858**	-0.0914
	(0.0836)	(0.0082)	(0.0068)	(0.0110)	(0.0427)	(0.0824)
NPM	-0.1423	-0.0513***	-0.0427***	-0.0461***	-0.0792	-0.3316***
	(0.2121)	(0.0186)	(0.0078)	(0.0156)	(0.0725)	(0.1094)
AGE	-0.0914*	-0.0274***	-0.0422***	-0.0192	-0.0064	-0.2005*
	(0.0516)	(0.0090)	(0.0077)	(0.0133)	(0.0382)	(0.1102)
OEG	0.3267***	0.0327***	0.0371***	0.0721***	0.1400	0.3358***
	(0.0636)	(0.0086)	(0.0101)	(0.0182)	(0.1055)	(0.0776)
Constant	35.7616***	5.0214***	8.9451***	11.4720***	28.7214***	54.6565***
	(9.7440)	(1.7304)	(1.0291)	(2.4376)	(8.7476)	(18.1389)
Observations	433	433	433	433	433	433
Industry Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.3062	0.0749	0.111	0.121	0.155	0.181
Slope at the low end of X-range ($\beta_1+2*\beta_2*X_{low}$)	—	-0.0498**	-0.0908***	-0.1130***	—	—
Slope at the high end of X-range ($\beta_1+2*\beta_2*X_{high}$)	—	0.0804***	0.0883***	0.0987***	—	—
Sasabuchi test statistic	—	1.80**	5.19***	2.93***	—	—
95% Fieller confidence interval	—	[-13.3, 39.4]	[35.9, 44.5]	[36.7, 54.0]	—	—
Threshold/within data range	—	32.375/Yes	42.5/Yes	44.692/Yes	—	—

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Table 11. Reverse causality test

Variables	OLS	Lower quantiles		Median	Upper quantiles	
		10th	25th	50th	75th	90th
CRT	1.3002**	-1.0943	-0.7904	-1.0390	-0.2741	2.3772
	(0.5080)	(0.7067)	(2.6054)	(1.4613)	(0.4912)	(1.2027)
CRT2	-0.0158	0.0811*	0.0635	0.0682	0.0265	-0.0388
	(0.0217)	(0.0480)	(0.2690)	(0.1023)	(0.0325)	(0.0962)
SIZE	5.8983***	4.9715***	5.6106***	8.4327***	7.5377***	6.7419***
	(0.6955)	(1.0749)	(0.7811)	(1.1228)	(0.5841)	(1.0606)
LEV	0.0763	0.2801***	0.2648***	0.1873*	0.1429**	-0.1576**
	(0.0628)	(0.0772)	(0.0653)	(0.0977)	(0.0664)	(0.0741)
NPM	0.0142	0.2211***	0.1282	0.0518	0.0500	-0.0567
	(0.0724)	(0.0726)	(0.1040)	(0.1054)	(0.1152)	(0.1626)
AGE	0.0115	0.3670***	0.3123***	0.2232**	0.1098	0.0321
	(0.0679)	(0.0725)	(0.0789)	(0.1021)	(0.0839)	(0.0511)
OEG	-0.0984**	-0.1036***	-0.0835	-0.1134*	-0.0819**	-0.1519
	(0.0418)	(0.0395)	(0.0664)	(0.0648)	(0.0365)	(0.0961)
Constant	-78.9608***	-90.0148***	-93.2441***	-127.5482***	-99.2432***	-66.4503***
	(12.4096)	(16.1348)	(15.1859)	(21.1791)	(12.7318)	(19.7424)
Observations	433	433	433	433	433	433
Industry Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.3234	0.271	0.215	0.192	0.213	0.208

Note: CRT2 represents the CRT to the power 2; *p < 0.1; **p < 0.05; ***p < 0.01.

Figure 1. Graphical representations of OLS and QR estimates

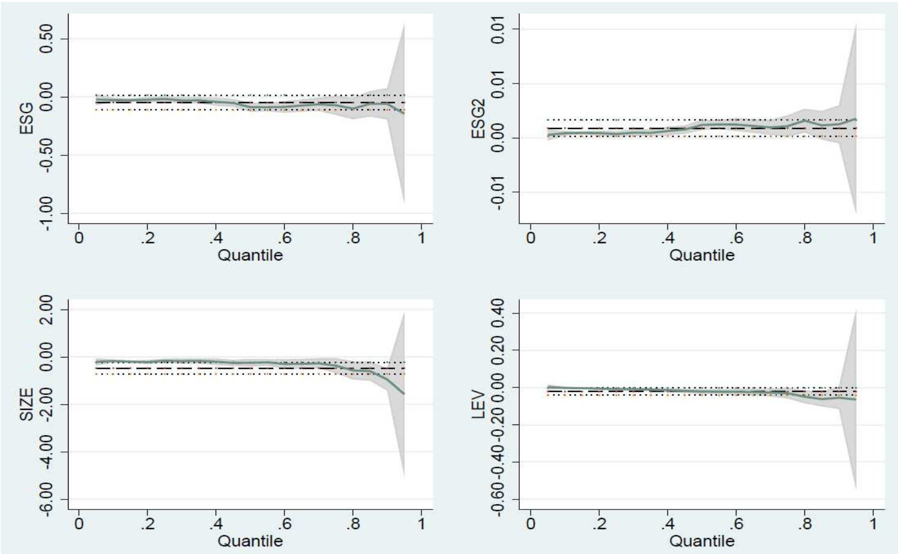

Figure 1. Continued

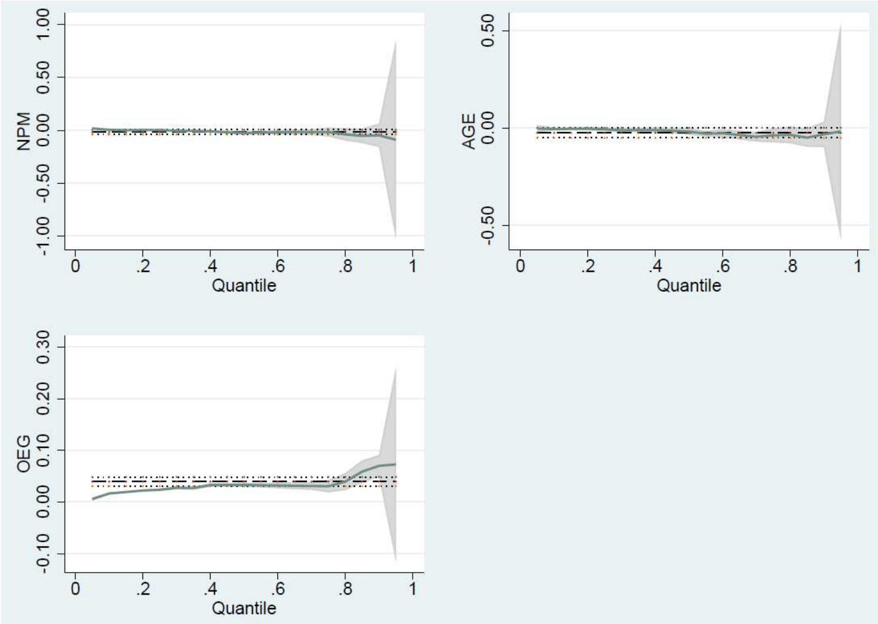

Figure 2. The convex (U-shaped) ESG-CRT nexus in the 10th quantile (A), 25th quantile (B), 50th quantile (C), and 75th quantile (D)

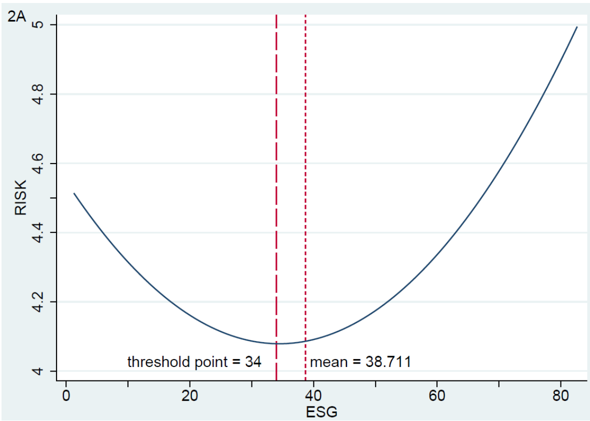

Figure 2. Continued

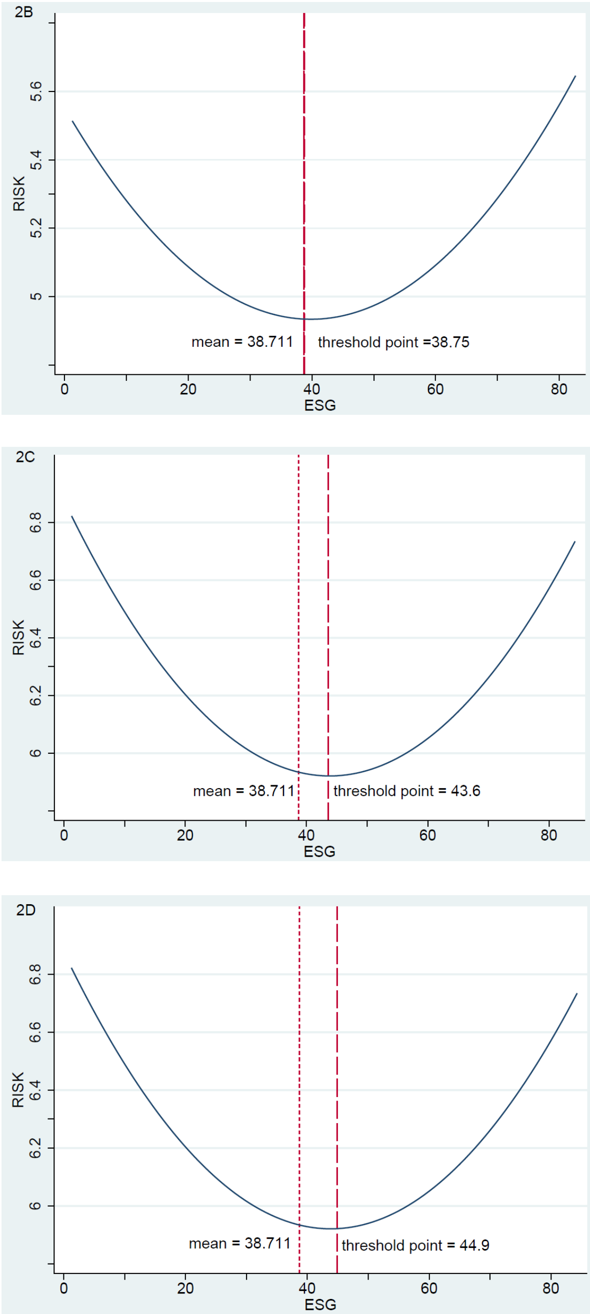

Figure 3. The convex (U-shaped) ESGE-CRT nexus in the 10th quantile (A), 25th quantile (B), 50th quantile (C), and 75th quantile (D)

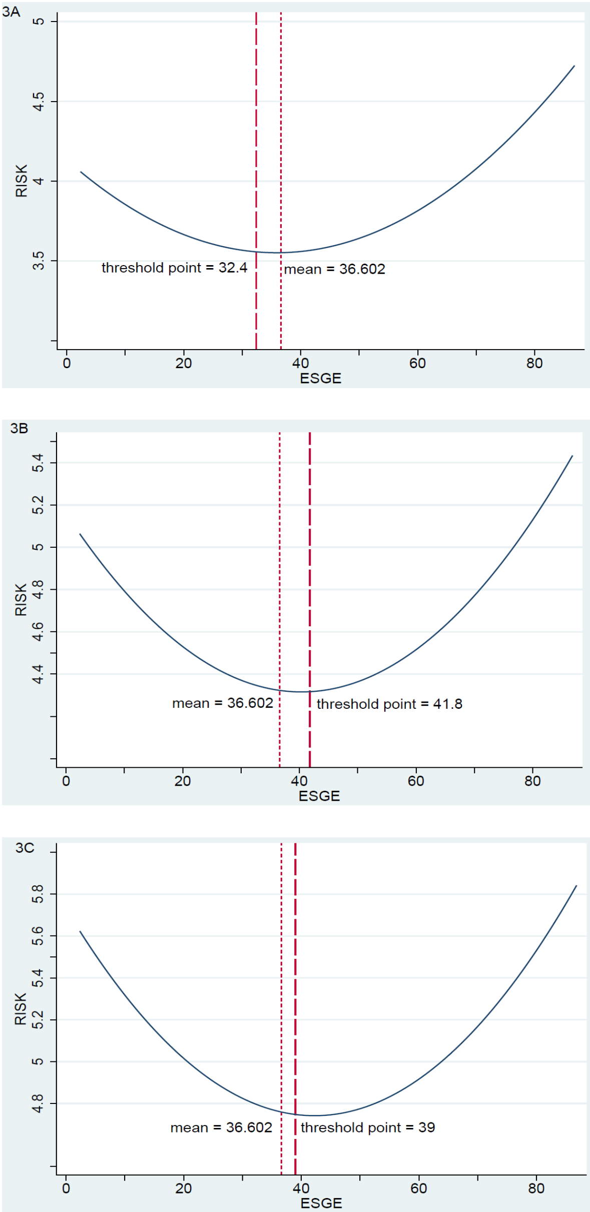

Figure 3. Continued

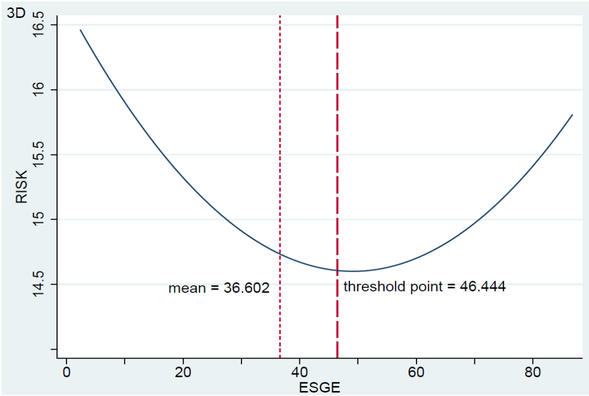

Figure 4. The U-shaped ESGS-CRT nexus in the 75th quantil