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When ESG Meets Uncertainty: Financing Cost Effects Under Regulatory Fragmentation and Rating Divergence

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Abstract: As ESG practices become increasingly embedded in global capital markets, their impact on firm financing costs remains an open question in emerging economies, where regulatory divergence and rating inconsistency complicate investor perceptions, particularly in China's rapidly evolving financial environment. This study examines the impact of Environmental, Social, and Governance (ESG) performance on financing costs among Chinese non-financial listed firms, with a focus on the moderating roles of financial regulation and ESG rating divergence. Using a panel dataset of 4493 firms across 33,773 firm-year observations from 2011 to 2022, we employ a two-way fixed effects model, along with Propensity Score Matching and Difference-in-Differences (PSM-DID) techniques, to address endogeneity concerns and enhance causal inference. The findings reveal that improvements in ESG performance significantly reduce financing costs, substantially affecting debt relative to equity. Moreover, the cost-saving benefits of ESG are amplified in industries with stronger regulatory oversight, while high ESG rating divergence undermines these benefits by increasing uncertainty. These results highlight the importance of standardizing ESG rating systems and enhancing regulatory consistency. Such efforts can lower capital costs and improve financial access for firms, particularly in capital-intensive and environmentally sensitive sectors, offering actionable guidance for policymakers shaping disclosure frameworks and corporate managers optimizing ESG investment strategies.

Keywords: ESG performance; financing costs; financial regulation; ESG rating divergence; China



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1. Introduction

Environmental, social, and governance-related factors (ESG) have become crucial in influencing corporate financing approaches, marking a global shift toward sustainable development. By 2024, ESG-related investments are expected to account for half of all professionally managed assets worldwide, reflecting the increasing integration of sustainability into corporate governance [1]. In the Chinese context, this trend is closely tied to the nation's "dual carbon" goals and its commitment to achieving carbon neutrality by 2060. Listed firms in China place significant importance on ESG performance, which serves as a vital measure of corporate responsibility and plays a crucial role in securing capital access and enhancing market competitiveness [2,3]. Robust ESG practices are often associated with superior risk management capabilities and improved corporate reputation, which help firms secure greater opportunities in the capital markets [3]. However, the linkage between ESG performance and financing costs in China remains underexplored, marked by regulatory challenges and inconsistencies in rating methodologies [4,5]. These gaps are exacerbated by the nation's evolving regulatory framework and significant divergence in ESG ratings. For instance, while the energy and manufacturing industries face stricter ESG disclosure mandates, other sectors operate under less unified standards, resulting in substantial variability

in disclosure practices [6]. This fragmentation complicates investors' ability to evaluate corporate risks and returns, introducing ambiguity into the financial benefits of ESG adoption [7,8]. Compounding this challenge, ESG rating divergence—arising from discrepancies in assessment criteria among rating agencies—intensifies informational uncertainty, weakening the presumed financial advantages of robust ESG performance [9,10].

The existing literature predominantly focuses on developed markets, such as the United States and the European Union, where mature regulatory systems and standardized disclosure requirements underpin ESG frameworks. In contrast, emerging markets like China present a distinct institutional context in which ESG-financing linkages are shaped by fragmented regulatory oversight and heterogeneous enforcement. China's ESG landscape is characterized by notable sectoral and regional disparities, stemming from uneven regulatory intensity, differentiated policy mandates, and variations in local institutional capacity. For instance, high-emission industries such as energy and heavy manufacturing are subject to stricter ESG disclosure requirements under state-led environmental targets. At the same time, service-oriented sectors often operate under weaker or voluntary guidelines [11]. Regionally, first-tier cities such as Beijing and Shanghai benefit from more comprehensive regulatory enforcement and ESG infrastructure, whereas inland provinces lag in disclosure quality and third-party ESG verification mechanisms [12]. These disparities introduce significant information asymmetry and rating inconsistency, complicating capital providers' ability to assess firm-level ESG risks and returns.

While these studies suggest that strong ESG performance can lower financing costs through improved risk management and enhanced investor confidence [13,14], they often assume unified rating systems and stable regulatory environments. Few have examined how ESG-financing relationships evolve under conditions of regulatory fragmentation or rating inconsistency, particularly in emerging markets. This study aims to fill this gap by providing empirical evidence from China's institutional context, where disclosure regimes and ESG scoring systems vary substantially.

Against this backdrop, understanding the financial consequences of ESG performance in China becomes critical. Clarifying these relationships holds important implications for capital market development, as it may guide regulatory improvements in ESG disclosure, reduce information asymmetry for investors, and encourage the strategic allocation of capital toward more sustainable and transparent firms. Figure 1 illustrates how ESG performance affects financing costs. Based on MSCI ESG Research, the figure compares monthly capital costs across quintiles of firms ranked by their ESG ratings from 2015 to 2024. Firms in the top quintile consistently demonstrate lower financing costs than those in the bottom quintile, with a statistically significant disparity (Mann–Whitney U test, $p < 0.01$). These findings highlight the potential financial benefits of superior ESG performance, particularly in emerging markets such as China, where regulatory frameworks and rating methodologies are still in development.



Figure 1. Monthly cost of capital differences across MSCI ESG rating quintiles (2015–2024). Source: MSCI ESG Research.

This research examines the relationship between ESG performance and financing costs among Chinese publicly listed companies, aiming to bridge existing gaps in the literature. It analyzes data from A-share firms collected between 2011 and 2022, using a two-way fixed effects model to assess the influence of ESG practices on the costs of debt and equity financing. The study also examines how financial regulations and variations in ESG ratings influence these relationships. Advanced econometric techniques, such as Propensity Score Matching (PSM), Difference-in-Differences (DID), and instrumental variable methods, are employed to ensure robust results.

This study makes a significant contribution to the literature in three key ways. First, it provides one of the first large-scale empirical investigations of how ESG performance affects both debt and equity financing costs in China, incorporating institutional fragmentation into the analysis. Second, it develops a novel divergence-based framework to quantify inconsistencies across ESG rating agencies and examines the moderating effects of these inconsistencies. Third, it applies a robust econometric design that combines PSM, DID, and IV approaches to address potential endogeneity and enhance causal inference. The paper is structured as follows: Section 2 reviews the literature and theoretical framework; Section 3 details the dataset and methodology; Section 4 presents the findings; and Section 5 offers conclusions and policy suggestions.

2. Literature Review and Hypothesis Development

Existing research on the link between ESG performance and corporate financing costs falls into three main streams: (i) studies examining whether ESG performance reduces firms' debt or equity financing costs, conducted mainly in developed markets with stable regulatory environments; (ii) analyses exploring underlying mechanisms such as reduced information asymmetry, enhanced governance, and stakeholder signaling effects; and (iii) investigations into ESG rating divergence and regulatory fragmentation, which primarily focus on their influence on ESG adoption or disclosure. However, few studies integrate these institutional factors into empirical models of financing outcomes. In transitional markets like China, ESG regulations are fragmented, and rating methodologies vary significantly across agencies, creating noise in ESG signals [15]. These structural frictions are rarely taken into account in financing cost analyses. To address this gap, our study examines how ESG performance influences both debt and equity financing costs in Chinese listed firms while explicitly considering the effects of regulatory divergence and rating inconsistencies. The following sections review the theoretical foundations and empirical findings to guide hypothesis development.

2.1. ESG Performance and Firms' Financing Costs

ESG performance reflects a firm's effectiveness in managing environmental, social, and governance matters, serving as a forward-looking indicator of corporate sustainability and risk management. Robust ESG practices have been associated with superior risk mitigation [16], operational efficiency [17], and reputational resilience [18], thereby enhancing investor confidence and reducing capital costs [19]. Consequently, firms with high ESG performance often enjoy favorable financing conditions, including lower interest rates, improved loan terms, and reduced equity risk premiums [20]. However, the relationship between ESG performance and financing costs in emerging markets, such as China, is more heterogeneous and context-dependent due to the evolving institutional infrastructure. Specifically, (1) the absence of a unified ESG disclosure regime leads to voluntary and inconsistent reporting across firms and industries [21]; (2) ESG rating agencies employ divergent methodologies and weighting schemes, producing inconsistent evaluations for the same firm [22]; and (3) regulatory enforcement varies widely across sectors and regions, resulting

in disparate expectations for ESG compliance [23]. These institutional and informational frictions jointly undermine the credibility and comparability of ESG disclosures, reducing the consistency with which ESG improvements translate into financing cost advantages.

From the perspective of information asymmetry theory [24], strong ESG performance reduces informational gaps between firms and their investors, signaling a decrease in operational and reputational risks [25]. This signaling mechanism is well supported in developed markets with established ESG ecosystems [19,26]. In China, this effect is substantially weakened by ESG rating fragmentation. The lack of standardization enables rating agencies to adopt conflicting assessment criteria and disclosure requirements [24], resulting in considerable dispersion in ESG scores for the same firm [27]. These inconsistencies generate conflicting signals, impair investor comparability, and weaken the reliability of ESG as a pricing instrument. As a result, firms may fail to convert superior ESG performance into measurable reductions in financing costs. In many cases, investors discount ESG ratings or require additional due diligence, which increases transaction costs and delays capital access [28].

While information asymmetry theory captures ESG's external signaling function, agency theory [29] highlights its role in improving internal governance. Strong ESG performance can align managerial decisions with shareholder interests, curb overinvestment, and reduce agency costs, lowering debt and equity financing costs [30,31]. However, the effectiveness of this governance-enhancing role in China is constrained by uneven corporate governance practices. In particular, small and medium-sized enterprises (SMEs) and firms in less-regulated sectors often lack the internal oversight infrastructure necessary to implement ESG frameworks fully, thereby limiting their ability to translate ESG efforts into credible governance improvements. Complementing these perspectives, sustainable development theory [32] argues that integrating environmental and social objectives into business strategy enhances long-term financial resilience. Firms internalizing ESG goals tend to be more adaptable, socially responsible, and stakeholder-aligned, contributing to stable financing conditions. While such benefits are well documented in developed economies, empirical evidence in emerging markets remains limited. In China, a small but growing body of research has begun to explore the ESG–finance nexus. For instance, Liu (2024) investigates the impact of firm ESG performance on bond financing costs in the Chinese bond market and finds that better ESG performance significantly reduces debt costs [33]. However, existing studies tend to focus primarily on debt channels and often overlook the moderating role of institutional fragmentation, as well as the role of equity financing. In particular, few studies have integrated regulatory quality, rating divergence, and enforcement heterogeneity into a unified framework when analyzing the financial consequences of ESG.

This study addresses this gap by examining whether and how ESG performance affects debt and equity financing costs in China while accounting for regulatory divergence and institutional complexity. Accordingly, we propose the following hypotheses:

H1a: *Enhanced ESG performance reduces debt financing costs.*

H1b: *Enhanced ESG performance reduces equity financing costs.*

2.2. Impact of ESG Rating Divergence on the Relationship Between ESG and Financing Costs

Divergence in ESG ratings arises from differences in methodologies, data sources, and weighting systems among various rating agencies [34]. This issue is particularly pronounced in China, where ESG disclosure standards are evolving, resulting in substantial discrepancies in ESG ratings. This disparity undermines the trustworthiness of ESG scores as reliable measures of corporate performance, leading to uncertainty for investors and

lenders, which in turn increases financing costs. Firms experiencing substantial ESG rating divergence are often viewed as higher risk, contributing to stock price fluctuations and elevated costs of both debt and equity [35]. Conversely, consistent ESG ratings enhance investor confidence, often resulting in lower financing costs and increased trust in a firm's sustainability initiatives [36].

Theoretically, ESG performance should act as a positive signal that mitigates information asymmetry and enhances access to capital. However, when ESG ratings are inconsistent across agencies, this signal becomes noisy or ambiguous. Drawing from information asymmetry theory and stakeholder uncertainty literature, inconsistent ESG evaluations are likely to increase investor skepticism, elevate risk premiums, and weaken the expected financial benefits of ESG efforts. In China's transitioning financial landscape, these inconsistencies erode the economic benefits of strong ESG performance. When ESG ratings exhibit significant divergence, they lose their signaling effectiveness, heightening risk perceptions among investors and lenders [36]. This effect undermines the financial benefits associated with robust ESG performance, increasing perceived risks and reducing cost advantages [35,37]. Such dynamics highlight the importance of signal clarity in capital markets and underscore the moderating role of ESG rating divergence in the relationship between ESG and financing costs. These challenges underscore broader systemic issues in aligning ESG principles with financial strategies in emerging markets, such as China, highlighting the urgent need for more standardized and transparent ESG evaluation mechanisms.

To quantify ESG rating divergence across firms, we construct rank-based measures that capture inconsistencies among third-party ESG assessments. Given the heterogeneity of ESG scoring systems across rating agencies—each with distinct criteria, weighting schemes, and varying reliance on disclosure—we transform raw ESG scores into ordinal ranks to ensure cross-agency comparability. Each firm's ESG score is assigned a rank from 1 (lowest) to 6 (highest) when six agencies are available, or from 1 to 4 when only domestic agencies are present. This standardized ranking approach eliminates differences in scale and preserves relative evaluation.

Two primary indicators are derived to measure divergence:

Standard Deviation of Ranks (ESGdif):

$$ESG_{dif} = \sqrt{\frac{\sum (R_i - \bar{R})^2}{n}}$$

where R_i is the rank assigned by each agency, $\bar{R}$ is the rank for the firm, and n is the number of agencies (6 for ESGdif6, or 4 for ESGdif4). This measure captures the dispersion of agency assessments around the average score, indicating how much individual agency ratings deviate from consensus.

Range (ESGrange6 or ESGrange4):

$$ESG_{range} = \text{Highest Rank} - \text{Lowest Rank}$$

This metric reflects the extent of disagreement among agencies by calculating the difference between the highest and lowest ranks. A higher value indicates greater inconsistency in ESG assessments.

These measures are computed using ESG evaluations from six prominent agencies, comprising four domestic and two international ones. Their methodological characteristics and inclusion rationale are presented in Table 1.

Table 1. Overview of ESG rating agencies used in ESG divergence measurement.

Agency	Origin	Focus Area	Methodology	Reason for Inclusion
Wind	China	ESG reporting	Based on firm disclosures, regulatory filings, and financial metrics.	Leading Chinese data vendor; represents domestic institutional standards.
Huazheng	China	E, S, G subscores	Combines international indicators with China-specific adjustments.	Officially recognized ESG provider with broad firm coverage.
SynTao Green Finance	China	Climate and ESG integration	ESG scores plus climate transition risk indicators.	Aligned with China's green finance and carbon transition initiatives.
MiLiang	China	Local ESG analytics	Proprietary ESG scoring methodology based on firm reports and news.	Adds depth to local ESG insights and rating diversity.
FTSE Russell	International	ESG and climate risks	ESG and climate metrics integrated with global financial benchmarks.	High comparability; influential in passive ESG investing strategies.
Bloomberg	International	Comprehensive ESG	ESG scores derived from structured and unstructured global datasets.	Global benchmark; widely used by institutional investors worldwide.

Note: These agencies were selected to reflect both global and local ESG rating standards, enabling a nuanced assessment of rating inconsistencies within the Chinese market context.

If a firm receives fewer than two valid ESG scores in a given year, both ESGdif and ESGrange are set to zero. This ensures consistent treatment across firms and avoids imputation bias. Table 2 summarizes the operationalization of the four ESG rating divergence variables used in the analysis.

Table 2. Measurement of ESG rating divergence variables.

Variable	Definition	Measurement
ESGdif6	The standard deviation of ranks from six ESG agencies	Calculated from rankings by Bloomberg, Wind, Huazheng, FTSE Russell, SynTao Green Finance, and MiLiang.
ESGrange6	Range of ranks from six ESG agencies	Difference between the highest and lowest ranks across the six agencies.
ESGdif4	The standard deviation of ranks from four domestic ESG agencies	Calculated from rankings by Wind, Huazheng, SynTao Green Finance, and MiLiang.
ESGrange4	Range of ranks from four domestic ESG agencies	Difference between the highest and lowest ranks among the four domestic agencies.

Note: Larger values of ESGdif or ESGrange indicate greater disagreement among agencies, signaling greater uncertainty in ESG evaluation.

Based on the preceding analysis, this study formulates the following hypotheses:

H2a: *ESG rating divergence weakens the negative relationship between ESG performance and debt financing costs.*

H2b: *ESG rating divergence weakens the negative relationship between ESG performance and equity financing costs.*

2.3. Influence of Financial Regulation on the ESG–Financing Cost Relationship

Financial regulation refers to institutional policies designed to enhance market transparency, reduce information asymmetry, and improve investor protection [38]. In the ESG context, well-designed regulatory frameworks enforce standardized disclosures, thereby increasing the credibility of sustainability claims and shaping firms' access to external capital [39,40]. In China, regulatory initiatives such as the China Securities Regulatory Commission's (CSRC) *Basic Norms for Internal Control of Enterprises* have been introduced to improve ESG-related risk reporting, particularly for listed firms. However, the effectiveness of these regulations varies across sectors and regions. For example, financial institutions and state-owned enterprises (SOEs) are subject to increasingly stringent ESG mandates. In contrast, ESG reporting remains largely voluntary among private-sector firms, particularly in emerging sectors such as technology and e-commerce [41]. Regionally, pilot ESG frameworks have been explored in state-owned enterprises, while many inland provinces still lack consistent regulatory enforcement [42].

Debt financing is particularly sensitive to financial regulation, as creditors depend heavily on verifiable disclosures to evaluate firm-specific environmental and social risks. In China, sectors such as energy, chemicals, and heavy manufacturing are subject to mandatory ESG reporting and strict environmental audits enforced by the Ministry of Ecology and Environment (MEE) and local regulatory authorities [43]. These mechanisms reduce information asymmetry by compelling firms to disclose pollution levels, carbon intensity, and regulatory compliance, thereby enabling lenders to assess default probabilities and environmental liabilities more accurately. Consequently, firms operating in these industries often benefit from lower borrowing costs. Empirical studies further confirm that firms in highly regulated sectors experience more pronounced reductions in debt financing costs compared to those in loosely regulated industries, such as retail or light manufacturing [44].

Financial regulation also plays a critical role in shaping equity financing outcomes. By improving the transparency and credibility of ESG disclosures, particularly for publicly listed firms, robust enforcement reduces equity risk premiums by enhancing investor trust and aligning corporate behavior with market expectations [45]. Investors with sustainability mandates or long-term environmental concerns are more likely to allocate capital to firms with consistent and audited ESG reports. In contrast, weak or non-binding ESG disclosure requirements—standard in parts of the digital economy or among small private enterprises—result in inconsistent reporting practices, which generate skepticism, elevate perceived risk, and increase the cost of equity [14]. Thus, financial regulation serves as a critical transmission channel through which ESG performance influences debt and equity financing.

These disparities underscore the importance of establishing consistent and enforceable regulatory frameworks that effectively translate ESG practices into tangible financial benefits [46]. Firms operating in highly regulated industries, such as energy or manufacturing, are more likely to convert ESG engagement into lower financing costs. In contrast, those in weakly regulated environments may struggle to realize comparable benefits. Unequal regulatory enforcement thus contributes to fragmented ESG outcomes and capital accessibility. Thus, this study hypothesizes:

H3a: *Financial regulation strengthens the relationship between ESG practices and debt financing costs.*

H3b: *Financial regulation strengthens the relationship between ESG practices and equity financing costs.*

3. Methodology

This research investigates the influence of ESG ratings on financing costs, as well as the moderating effects of ESG rating divergence and financial regulations on this relationship. The methodology includes sample selection, data collection, variable definition, and model construction. The conceptual framework and research design are illustrated in Figure 2, which visually represents the relationships among ESG ratings, financing costs, and moderating factors, as well as the validation techniques employed.

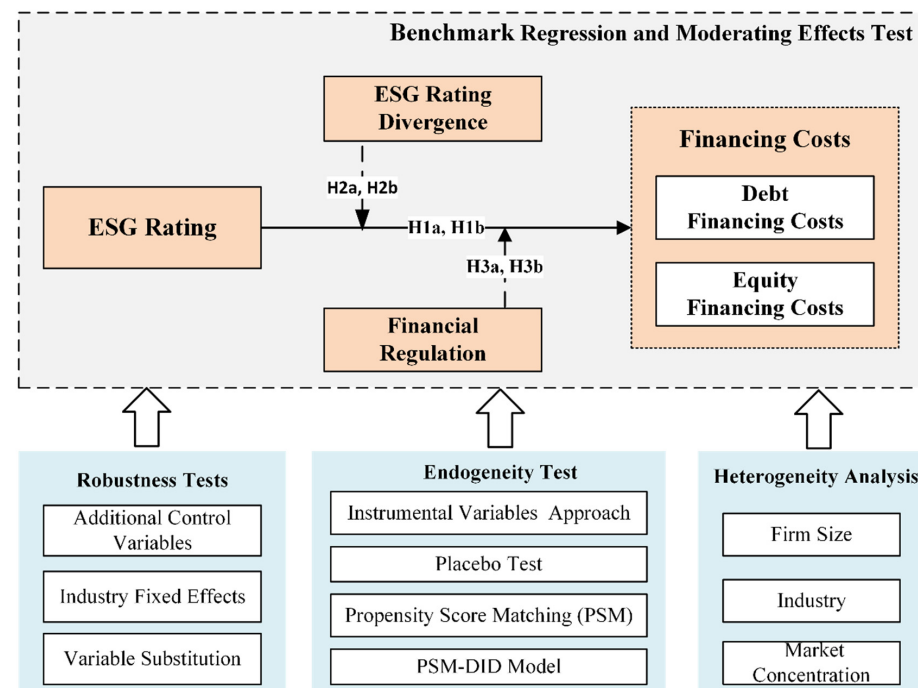


Figure 2. Conceptual framework and methodological approach.

3.1. Sample Selection and Data Collection

This research examines A-share companies listed on the Shanghai and Shenzhen Stock Exchanges from 2011 to 2022, constituting a significant segment of China's publicly listed corporations. These companies comply with the ESG disclosure standards established by the China Securities Regulatory Commission (CSRC). The focus on A-shares underscores the growing integration of ESG practices into domestic investment strategies. The sample excludes firms labeled with special treatment (ST and ST*), financial institutions, and those lacking complete data to ensure precision and reduce bias. These exclusions mitigate potential distortions arising from regulatory and structural inconsistencies [47]. The final dataset comprises 33,833 observations spanning multiple years for various firms. Continuous variables are adjusted at the 1% and 99% levels to account for outliers and improve reliability.

To improve transparency, we report the temporal and industry distributions of firm-year observations. Appendix A Table A1 shows a relatively balanced sample from 2011 to 2021, with growth after 2015 reflecting the rise of ESG disclosures in China. Appendix A Table A2 presents industry-level coverage based on CSRC codes. Manufacturing firms (code C) dominate the sample, representing approximately 66% of the observations. Other key sectors include information technology (I), construction (E), wholesale and retail (F), and real estate (K). This broad distribution highlights the representativeness of the dataset and supports robust empirical analysis of ESG-financing dynamics across diverse industrial and temporal settings.

3.2. Definition of Main Variables

Dependent Variables:

Debt Financing Cost (De_cost): The ratio of total interest expenses to total liabilities reflects borrowing costs [48]. This accounting-based measure is widely used in empirical studies [49,50] and ensures consistent coverage across firms and periods. Due to the limited availability of firm-level market-priced debt data in China, this proxy remains the most practical and comparable indicator for large-sample panel analysis.

Equity Financing Cost (Eq_cost): Calculated using the Capital Asset Pricing Model (CAPM): $r_i = r_f + \beta_i(r_m - r_f)$, where r_f is the risk-free rate, β_i reflects the stock's sensitivity to market risk and $r_m - r_f$ represents the equity risk premium [49,50]. We adopt the standard Sharpe-Lintner CAPM framework in line with mainstream practice in ESG-finance research, particularly in emerging markets. This approach enables robust theoretical interpretation and comparability with prior studies while reflecting the long-term risk-adjusted cost of capital.

Explanatory Variables:

ESG Rating (ESG): Firms are evaluated based on environmental, social, and governance dimensions using scores from the Huazheng Index, which range from AAA (9) to C (1). These ratings adhere to national and international standards [51].

Moderating Variables:

ESG rating divergence (ESG_dis): Calculated using the standard deviation (ESGdif) and range (ESGrange) of ESG ratings provided by six agencies: Wind, Huazheng, Bloomberg, FTSE Russell, SynTao Green Finance, and MiLiang. This measure captures inconsistencies in evaluation across agencies [34,52].

Financial regulation (FRI): Expressed as the proportion of regulatory spending by local government to the financial industry's added value, reflecting the strength of regional regulatory oversight [53].

Control Variables:

Control variables include various firm-specific attributes, such as asset liquidity (Liquidity), operational cash flow (Cashflow), firm size (Size), board size (Board), leverage (Lev), firm age (FirmAge), return on equity (ROE), revenue growth (Growth), and the proportion of independent directors (Indep) [54]. These variables control external factors influencing financing costs beyond ESG performance.

Table 3 provides a comprehensive overview of each variable's classification, definition, measurement method, and data source.

Table 3. Variable definition.

Variables	Variable Name	Definition	Measurement
Independent variable	ESG Performance (ESG)	Indicates the firm's overall ESG performance, reflecting its ESG initiatives and strategies.	It is measured using Huazheng Index scores, ranging from AAA (9) to C (1), based on ESG practices. Source: Huazheng ESG database.
Dependent variable	Debt Financing Cost (De_cost)	Refers to the firm's cost incurred for obtaining debt financing.	Calculated as the proportion of total interest costs, fees, and financial charges in relation to liabilities. Source: CSMAR database
	Equity Financing Cost (Eq_cost)	Represents the cost a firm faces when raising equity capital.	Calculated using CAPM: $r_i = r_f + \beta_i(r_m - r_f)$. Source: CSMAR database
Moderator	Financial Regulation (FRI)	The inconsistencies in ESG scores assigned to a company by different rating agencies.	Employs two measures: the standard deviation and the range of a company's ESG scores across six key rating agencies. Source: Huazheng ESG database.
	ESG Rating Divergence (ESG_dis)	Discrepancies in ESG scores by rating agencies indicate inconsistency.	Calculated by assessing the variation of ESG scores among various rating agencies. Source: Huazheng ESG database.

Table 3. Cont.

Variables	Variable Name	Definition	Measurement
Control variable	Firm Size (Size)	The size of the firm influences its financial stability and access to resources.	It is measured as the logarithm of total assets. Source: CSMAR database
	Leverage Ratio (Lev)	Reflects the firm's debt burden relative to the total assets, indicating leverage.	Total liabilities are divided by total assets. Source: CSMAR database
	Firm Age (FirmAge)	The length of time the company has been in business.	Measured as the number of years since the firm's establishment. Source: CSMAR database
	Return on Equity (ROE)	Reflects the firm's profitability for shareholders.	Net profit divided by total equity. Source: CSMAR database
	Asset Liquidity (Liquid)	Measures the firm's ability to meet short-term obligations.	Current assets minus current liabilities, divided by total assets. Source: CSMAR database
	Operational Cash Flow (Cashflow)	The firm's ability to generate cash from core operations.	Operating cash flow is divided by total assets. Source: CSMAR database
	Growth (Growth)	The firm's revenue growth over time.	Year-over-year growth in operating revenue. Source: CSMAR database
	Board Size (Board)	Size of the firm's board, influencing governance and decision-making.	Measured as the logarithm of the number of board members. Source: CSMAR database
	Independent Directors (Indep)	Proportion of independent directors, ensuring external oversight on the board.	The proportion of independent directors on the board. Source: CSMAR database

3.3. Model Construction

A two-way fixed effects model examines how ESG performance affects financing costs while controlling for firm-specific characteristics and temporal variations. This approach mitigates potential biases from unobserved heterogeneity related to firm characteristics (e.g., governance) and ESG performance [55]. The model is specified as:

$$FC_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \alpha_2 Controls_{i,t} + \delta_{Id} + \theta_{Year} + \varepsilon_{i,t} \quad (1)$$

where $FC_{i,t}$ represents financing costs (De_cost or Eq_cost). $ESG_{i,t}$ is the ESG score for firm i at time t . $Controls_{i,t}$ includes the control variables. δ_{Id} and θ_{Year} account for firm-specific and time-fixed effects. $\varepsilon_{i,t}$ is the error term clustered at the firm level to address biases in standard errors.

To strengthen causal identification, we employ a multi-method approach that combines two-way fixed effects, propensity score matching with difference-in-differences (PSM-DID), and instrumental variable (IV) estimation. Compared to conventional OLS or standalone DiD models, this approach offers several advantages: fixed effects control for unobserved heterogeneity; PSM enhances group comparability and mitigates selection bias; and IV addresses potential endogeneity between ESG and financing costs. While PSM-DID depends on the parallel trend assumption and IV relies on instrument validity, we conduct robustness checks to verify both. This integrated framework is particularly suitable for examining ESG-financing linkages in transitional regulatory environments, such as China, where institutional and rating fragmentation pose significant econometric challenges.

4. Results

4.1. Descriptive Statistics of Variables

Table 4 presents statistical descriptions of the primary variables. The mean cost of debt financing (De_cost) is 0.00523 (0.523% of liabilities), ranging from -0.170 to 0.070 . This wide range reflects the diverse fiscal incentives and financial conditions across firms, indicating substantial variation in borrowing costs. The equity financing cost (Eq_cost) averages 9.09%, ranging from -0.589 to 0.379 , highlighting market volatility and firm-specific risks. The mean ESG score of 4.139 (range: 1–8) indicates significant variability,

providing a robust basis for analyzing the impact of ESG on financing costs under different regulatory and market conditions.

Table 4. Descriptive statistics analysis.

Variable	N	Mean	SD	Min	p25	p50	p75	Max
De_cost	33833	0.00523	0.0356	−0.170	−0.00375	0.0110	0.0251	0.0700
Eq_cost	33833	0.0909	0.0261	−0.589	0.0748	0.0930	0.108	0.379
ESG	33833	4.139	1.037	1	3.500	4	5	8
Size	33833	22.26	1.295	19.58	21.33	22.07	22.99	26.45
Lev	33833	0.424	0.205	0.0319	0.260	0.417	0.577	0.908
FirmAge	33833	2.927	0.333	1.386	2.708	2.996	3.178	3.611
ROE	33833	0.0600	0.136	−0.926	0.0265	0.0699	0.120	0.437
Liquid	33833	2.485	2.613	0.268	1.158	1.675	2.747	29.92
Cashflow	33833	0.0465	0.0686	−0.199	0.00791	0.0454	0.0861	0.267
Growth	33833	0.163	0.405	−0.658	−0.0306	0.102	0.263	4.024
Board	33833	2.120	0.197	1.609	1.946	2.197	2.197	2.708
Indep	33833	37.68	5.382	28.57	33.33	36.36	42.86	60

4.2. Multiple Covariate Analysis

Table 5 presents the Pearson and Spearman correlation matrices to examine the relationships between key variables, with a focus on potential multicollinearity. Significant correlations are observed, such as the debt financing cost (De_cost) with ESG ratings (−0.173 ***) and Leverage (Lev) (0.511 **). While some variables exhibit correlations, they do not exceed the threshold, indicating the absence of multicollinearity. To further confirm this, a Variance Inflation Factor (VIF) test was performed, and all VIF values were significantly below the limit of 10 (Appendix A Table A3). These results verify the absence of multicollinearity, supporting the reliability of the regression estimates.

Table 5. Multiple covariate analysis.

	De_cost	Eq_cost	ESG	Size	Lev	FirmAge	ROE	Liquid	Cashflow	Growth	Board	Indep
De_cost		−0.036 ***	−0.173 ***	0.230 ***	0.511 ***	0.062 ***	−0.211 ***	−0.577 ***	−0.069 ***	−0.043 ***	0.078 ***	−0.019 ***
Eq_cost	−0.070 ***		−0.019 ***	−0.182 ***	−0.046 ***	−0.294 ***	−0.020 ***	0.067 ***	−0.101 ***	0.009 *	0.012 **	−0.024 ***
ESG	−0.130 ***	−0.003		0.196 ***	−0.052 ***	−0.013 **	0.221 ***	0.116 ***	0.097 ***	0.066 ***	0.023 ***	0.072 ***
Size	0.229 ***	−0.181 ***	0.234 ***		0.506 ***	0.203 ***	0.136 ***	−0.442 ***	0.079 ***	0.040 ***	0.243 ***	−0.033 ***
Lev	0.513 ***	−0.049 ***	−0.064 ***	0.500 ***		0.156 ***	−0.104 ***	−0.809 ***	−0.155 ***	0.002	0.138 ***	−0.016 ***
FirmAge	0.140 ***	−0.282 ***	−0.025 ***	0.179 ***	0.168 ***		−0.064 ***	−0.143 ***	0.014 ***	−0.107 ***	0.036 ***	−0.009 *
ROE	−0.151 ***	0.024 ***	0.222 ***	0.111 ***	−0.204 ***	−0.067 ***		0.144 ***	0.394 ***	0.389 ***	0.033 ***	−0.017 ***
Liquid	−0.687 ***	0.075 ***	0.052 ***	−0.335 ***	−0.632 ***	−0.160 ***	0.090 ***		0.026 ***	0.029 ***	−0.160 ***	0.025 ***
Cashflow	−0.065 ***	−0.080 ***	0.090 ***	0.080 ***	−0.163 ***	0.027 ***	0.327 ***	0.030 ***		0.065 ***	0.042 ***	−0.012 **
Growth	0.012 **	0.015 ***	0.003	0.041 ***	0.024 ***	−0.063 ***	0.269 ***	−0.033 ***	0.031 ***		−0.009	0.001
Board	0.084 ***	0.010 *	0.032 ***	0.260 ***	0.146 ***	0.030 ***	0.041 ***	−0.120 ***	0.038 ***	−0.010 *		−0.615 ***
Indep	−0.016 ***	−0.025 ***	0.071 ***	−0.002	−0.010 *	−0.008	−0.016 ***	0.019 ***	−0.004	−0.001	−0.552 ***	

t-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.3. Benchmark Regression Analysis

The findings from the two-way fixed effects model, detailed in Table 6, highlight the substantial impact of ESG performance on financing costs. Specifically, for debt financing costs (De_cost), a one-point enhancement in ESG scores results in a 1.3% decrease ($\beta = -0.013$ ***), which adjusts to -0.005 *** after including additional control variables. These results underscore the significant cost-saving benefits of robust ESG practices for debt financing. For equity financing costs (Eq_cost), the relationship shifts from positive to slightly negative ($\beta = -0.002$ **) after controlling for other variables, indicating that enhanced ESG performance strengthens investor confidence, albeit with a minor effect on debt financing. Overall, the analysis confirms that higher ESG performance is associated with lower financing costs, particularly in the debt market, underscoring the financial benefits of sustainability. Firms with superior ESG scores, especially those operating under stringent regulatory conditions, achieve notable cost savings in debt and equity financing.

Table 6. Benchmark regression results.

VARIABLES	(1) De_Cost	(2) De_Cost	(3) Eq_Cost	(4) Eq_Cost
ESG	−0.013 *** (−18.22)	−0.005 *** (−9.11)	0.007 *** (10.25)	−0.001 ** (−2.24)
Controls	No	Yes	No	Yes
Control Id	Yes	Yes	Yes	Yes
Control Year	Yes	Yes	Yes	Yes
Constant	0.024 *** (23.17)	−0.070 *** (−7.71)	0.081 *** (84.76)	0.067 *** (9.65)
Observations	33,773	33,773	33,773	33,773
R-squared	0.011	0.385	0.004	0.593
Number of stocks	4493	4493	4493	4493
r2_a	−0.141	0.290	−0.149	0.530
F	332.1	870.9	105.1	2028

t-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$.

4.4. Robustness Tests

Multiple robustness checks were performed to confirm the dependability of the findings (Table 7). (1) Two additional control variables were introduced: ownership concentration (Top1), reflecting the influence of large shareholders, and market valuation (TobinQ), capturing growth opportunities and firm value. The findings presented in Table 7 (Columns 1 and 2) strengthen the reliability of the results, suggesting that a one-point increase in the ESG score reduces both debt costs (De_Cost = -0.005 ***) and equity costs (Eq_Cost = -0.001 **). This further underscores the negative correlation between ESG performance and financing costs. (2) A three-way fixed effects model was utilized to account for unobserved variations related to firms, industries, and time. As illustrated in Columns (3) and (4), the substantial negative association between ESG and financing costs persists (De_Cost = -0.006 *** and Eq_Cost = -0.001 **), suggesting that industry-related elements do not influence the outcomes. (3) Alternative indicators of financing costs (De_Cost2 and Eq_Cost2) were used to mitigate measurement inaccuracies. Columns (5) and (6) show consistent findings, with decreases in debt costs (De_Cost2 = -0.003 ***) and equity costs (Eq_Cost2 = -0.007 ***), further affirming the robustness of the results. In summary, the consistent outcomes across all assessments underscore the practical importance of ESG performance in reducing financing costs and enhancing firms' financial flexibility and access to capital.

Table 7. Robustness test results.

VARIABLES	Add Control Variables (Top1, TobinQ)		Add Industry Control Factors		Variable Substitution	
	(1) De_Cost	(2) Eq_Cost	(3) De_Cost	(4) Eq_Cost	(5) De_Cost2	(6) Eq_Cost2
ESG	−0.005 *** (−8.79)	−0.001 ** (−2.06)	−0.006 *** (−9.26)	−0.001 ** (−2.27)	−0.003 *** (−12.61)	−0.007 *** (3.88)
Top1	−0.000 *** (−5.91)	−0.000 *** (−2.86)				
TobinQ	−0.000 (−0.98)	0.000 ** (2.22)				
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Control Year	Yes	Yes	Yes	Yes	Yes	Yes
Control Id	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	Yes	Yes	No	No
Observations	33,773	33,773	33,773	33,773	33,773	33,773
R-squared	0.385	0.593	0.387	0.594	0.123	0.179
Number of stocks	4493	4493	4493	4493	4493	4493
r2_a	0.291	0.530	0.291	0.531	−0.0123	−0.0133
F	797.7	1853	275.4	638.2	205.0	180.8

t-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$.

4.5. Endogeneity Test

(1) Instrumental Variables (IV) Approach

To tackle possible endogeneity concerns, a two-stage least squares (2SLS) regression analysis was performed, employing two instrumental variables: (1) the mean ESG score of comparable firms situated in the same city (IV1) and (2) the firm's earliest recorded ESG score (IV2). The first-stage results (IV1 = 0.078 ***, IV2 = 0.113 ***, shown in Table 8, Columns (1 and 3), confirm the vital relevance of the chosen instruments. In the second stage, ESG performance significantly lowered debt financing costs (De_Cost = −0.014 ***) and equity financing costs (Eq_Cost = −0.008 ***), as shown in columns 2 and 4. Instrument validity was further corroborated through the Kleibergen-Paap rk LM statistic (3934.024 ***) and the Cragg-Donald Wald F statistic (2225.555), providing robust evidence. These findings highlight the consistent financial advantages of ESG performance, even after accounting for endogeneity, underscoring its critical role in reducing financing costs.

Table 8. Instrumental variables method.

VARIABLES	(1) First-Stage ESG	(2) Second-Stage De_cost	(3) First-Stage ESG	(4) Second-Stage Eq_cost
IV1	0.078 *** (20.31)		0.078 *** (20.31)	
IV2	0.113 *** (59.24)		0.113 *** (59.24)	
ESG		−0.014 *** (−9.41)		−0.008 *** (−5.76)
Control variables	YES	YES	YES	YES
Control Year	YES	YES	YES	YES
Control Id	YES	YES	YES	YES
Observations	33,773	33,773	33,773	33,773
Kleibergen–Paaprk LM	3934.024 ***			
Cragg–Donald Wald F	2225.555			
Stock–Yogo wear ID	19.93			

t-statistics in parentheses *** $p < 0.01$.

(2) Placebo Test

To confirm that the outcomes were not affected by random variation, a placebo test was conducted [56,57]. This involved generating a “pseudo-policy dummy variable” using 500 randomly selected samples for regression analysis. Figure 3 illustrates the distribution of coefficients, with averages near zero and the majority of p -values exceeding 0.10. These findings demonstrate that the impact of ESG on financing costs is not attributable to random variation, providing strong support for the model’s validity.

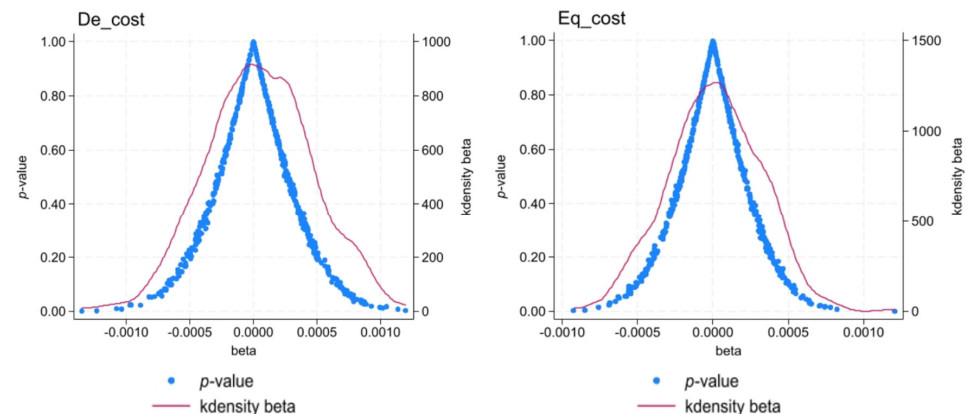


Figure 3. Placebo test.

(3) Propensity Score Matching (PSM)

Propensity Score Matching (PSM) was applied to mitigate endogeneity caused by sample selection bias [58,59]. Firms were classified into the treatment group (subject to green credit policies) and the control group (not subject). Key covariates for matching include firm size, leverage, return on equity (ROE), and board structure. Nearest neighbors ensure covariate balance. Table 9 shows that, before matching, significant differences exist between the groups (high t -values). Standardized differences decreased by over 75% post-matching, with most t -values becoming insignificant, confirming balance. Kernel density plots (Appendix A Figure A1) further validate this, showing aligned propensity score distributions post-matching. These results attribute differences in financing costs to ESG performance rather than firm characteristics.

Table 9. Balance test.

Covariate	Unmatched	Mean		%bias	%Reduce	t -Test	
	Matched	Treated	Control		bias	t	$p > t$
Size	U	23.249	22.207	73.6		33.36	0.000
	M	23.249	23.332	−5.9	92	−1.59	0.112
Lev	U	0.51389	0.41903	47.4		19.03	0.000
	M	0.51389	0.51778	−1.9	95.9	−0.57	0.567
FirmAge	U	3.0007	2.9227	24.1		9.56	0.000
	M	3.0007	3.0102	−2.9	87.8	−0.90	0.367
ROE	U	0.05442	0.06047	−4.4		−1.82	0.068
	M	0.05442	0.03975	10.6	−142.5	2.58	0.010
Liquid	U	1.5559	2.5372	−39.7		−15.37	0.000
	M	1.5559	1.7738	−8.8	77.8	−2.97	0.003
Cashflow	U	0.06725	0.04543	33.5		13.02	0.000
	M	0.06725	0.06794	−1.1	96.8	−0.31	0.754
Growth	U	0.1605	0.16279	−0.5		−0.23	0.818
	M	0.1605	0.15934	0.3	49.2	0.08	0.939
Board	U	2.2149	2.1148	47.6		20.87	0.000
	M	2.2149	2.2006	6.8	85.7	1.94	0.052
Indep	U	37.134	37.711	−11.3		−4.38	0.000
	M	37.134	37.718	−11.5	−1.2	−3.34	0.001

(4) Propensity Score Matching–Difference-in-Differences (PSM-DID) Model

To address endogeneity and selection bias, this study applies the Propensity Score Matching–Difference-in-Differences (PSM-DID) approach [60,61]. Firms from industries affected by green credit restrictions (treatment group) are matched with comparable firms from unaffected industries (control group), using characteristics including size, leverage, and return on equity (ROE) for matching. Following the matching process, a Difference-in-Differences (DID) analysis assesses the effects of the 2018 ESG disclosure reform enacted by the China Securities Regulatory Commission (CSRC). The model is specified as:

$$FC_{i,t} = \beta_0 + \beta_1 time_t + \beta_2 Treated_i \times time_t + \beta_3 Treated_i + \gamma' x_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

where $FC_{i,t}$ represents financing costs, $Treated_i$ is a dummy variable for firms restricted by green credit policies, $time_t$ represents the post-2018 policy period, and $x_{i,t-1}$ includes firm characteristics such as size, leverage, and firm age.

Figure 4 illustrates the parallel trends test based on the PSM-DID framework, verifying the key identifying assumption of the model. Before the 2018 CSRC ESG disclosure reform, the financing cost trends of treated and control firms were statistically indistinguishable, supporting the assumption of parallel trends. Post-policy, debt financing costs (De_cost) declined consistently, while equity financing costs (Eq_cost) dropped sharply in the first year after implementation and continued downward. These dynamic effects suggest that the policy had a sustained impact on debt financing and a strong, albeit slightly diminishing, effect on equity costs. The confidence intervals exclude zero post-event, reinforcing the significance of the treatment effect. Overall, the plots confirm policy exogeneity and provide visual validation for the causal interpretation of subsequent DID results.

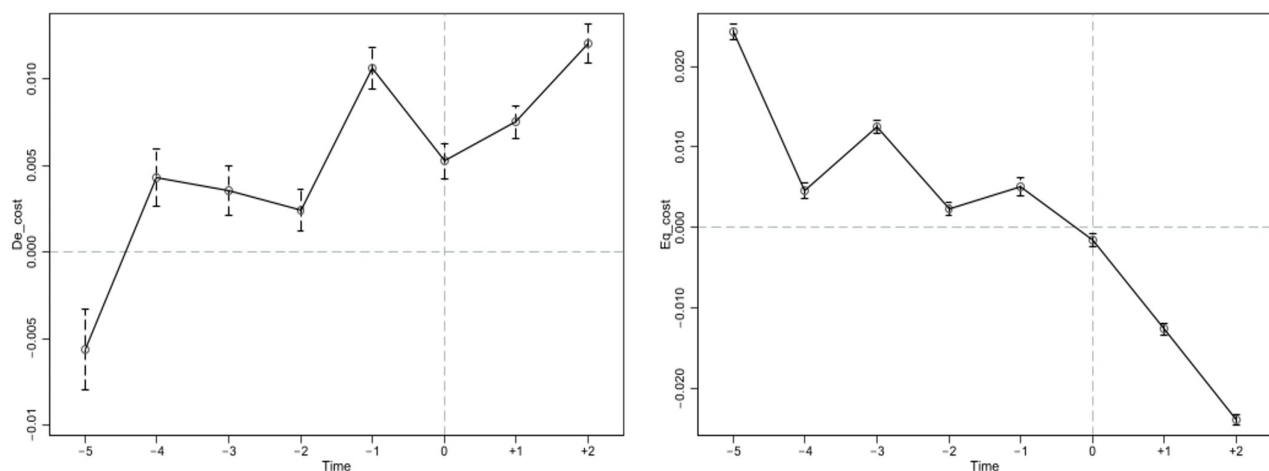


Figure 4. Parallel trends in the impact of ESG disclosure reform on financing costs. Note: This figure presents event-study estimates of the 2018 ESG disclosure policy’s effects on debt and equity financing costs. The left panel plots the impact on debt cost (De_cost), and the right panel shows the effect on equity cost (Eq_cost). Both panels are based on a PSM-DID model. The vertical line at time 0 indicates the year of policy implementation. Pre-treatment coefficients are statistically insignificant, supporting the parallel trends assumption.

Table 10 shows that the 2018 policy significantly reduced debt costs by 0.3% (−0.003, $p < 0.05$) in column 1 and equity costs by 0.6% (−0.006, $p < 0.01$) in column 2. Further analysis reveals that the reduction in debt costs persisted in one-year post-policy (−0.005, $p < 0.01$), while the effect on equity costs diminished slightly in columns 3 and 4. Excluding post-2020 data, as shown in columns 5 and 6, confirms the robustness of these

findings, highlighting ESG transparency's role in reducing financing costs and improving financial flexibility.

Table 10. Endogeneity tests.

VARIABLES	PSM-DID Model		t + 1 Financing Costs		Shorter Sample Intervals (year ≤2020)	
	(1) De_cost	(2)Eq_cost	(3) L.De_cost	(4) L.Eq_cost	(5) De_cost	(6) Eq_cost
ESG1			−0.005 *** (0.001)	−0.001 (0.001)	−0.005 *** (0.001)	−0.001 * (0.001)
DID	−0.003 ** (0.001)	−0.006 *** (0.002)				
time	−0.002 * (0.001)	−0.018 *** (0.001)				
treated	0.009 *** (0.001)	0.002 (0.001)				
Constant	0.015 * (0.009)	0.193 *** (0.009)	−0.209 *** (0.026)	0.090 *** (0.010)	−0.094 *** (0.020)	0.089 *** (0.012)
Observations	33764	33764	25,261	25,261	22,022	22,022
R-squared	0.491	0.254	0.562	0.676	0.760	0.573
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
r2_a	0.491	0.254	0.499	0.629	0.718	0.498
F	2719	958.3	26.60	2.014	204.9	4.668

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Moderation and Heterogeneity Analysis

5.1. Moderating Role of Financial Regulation and ESG Rating Divergence

The significance of financial regulatory intensity (FRI) and ESG rating divergence (ESG_dis) is crucial in examining the relationship between ESG performance and financing costs, underscoring how external factors influence financing outcomes. While previous analyses have shown that higher ESG performance generally leads to lower financing costs, the financial environment may alter the strength and direction of this effect.

To test the moderating effects, the following model is used:

$$FC_{i,t} = \gamma_0 + \gamma_1 ESG_{i,t} + \gamma_2 ESG_{i,t} \times R_{i,t} + \gamma_3 R_{i,t} + \rho X_{i,t} + u_i + \delta_t + \varepsilon_{i,t} \quad (3)$$

where $R_{i,t}$ is the moderating variable, either FRI or ESG_dis.

Table 11 presents the role of financial regulation intensity (FRI) and ESG rating divergence (ESG_dis) on the relationship between ESG performance and financing costs (debt and equity). The findings indicate a negative relationship between ESG performance and the costs of debt financing (De_Cost) and equity financing (Eq_Cost). Specifically, a one-unit increase in ESG performance leads to a reduction in debt financing costs by 0.005 (as shown in column 1) and equity financing costs by 0.001 (indicated in column 2). In column 3, FRI amplifies the negative effect of ESG performance on debt financing costs (−0.008 ***), suggesting that more stringent financial regulations enhance the cost-saving advantages of ESG practices for debt financing. However, in column 4, FRI increases equity financing costs (0.004 ***), suggesting that while financial regulation helps reduce debt financing costs, it may also slightly raise equity financing costs. The interplay between ESG performance and ESG rating divergence (ESG_dis), detailed in columns 5 and 6, demonstrates that a higher level of ESG rating divergence diminishes the effect of ESG performance on debt financing costs (−0.008 ***) and raises equity financing costs (0.005 ***). The results emphasize the importance of consistent ESG ratings to fully capture the financial benefits of strong ESG practices.

Table 11. Moderating effect analysis.

VARIABLES	(1) De_Cost	(2) Eq_Cost	FRI Moderating Effect		ESG_dis Moderating Effect	
			(3) De_cost	(4) Eq_cost	(5) De_cost	(6) Eq_cost
ESG	−0.005 *** (−9.11)	−0.001 ** (−2.24)	−0.008 *** (0.001)	0.004 *** (0.000)	−0.008 *** (0.001)	0.005 *** (0.000)
M1 (c_ESG1 * c_FRI)			0.024 (0.065)	0.161 *** (0.059)		
FRI			−0.140 *** (0.019)	0.920 *** (0.018)		
M2(c_ESG1 * c_ESG_dis)					−0.000 ** (0.000)	−0.000 *** (0.000)
ESG_dis					−0.000 *** (0.000)	−0.000 *** (0.000)
r2_a	0.290	0.530	0.492	0.186	0.492	0.140
F	870.9	2028	2730	642.6	2724	460.5
R-squared	0.385	0.593	0.493	0.186	0.492	0.141
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	33,764	33,764	33,764	33,764	33,764	33,764

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Notably, in the moderation tests (columns 4 and 6), after introducing financial regulation and ESG rating divergence, the effect of ESG performance on equity financing costs shifts from negative to positive. This suggests that the combined effects of these factors offset the beneficial impact of ESG performance on equity financing costs. The models exhibit substantial explanatory power, with R-squared values ranging from 0.186 (column 2) to 0.593 (column 4), thereby reinforcing the reliability of the results.

5.2. Heterogeneity Analysis

In Figure 5, this research examines how ESG performance influences debt and equity financing costs, considering firm characteristics such as size, industry pollution levels, and market concentration (as measured by the Herfindahl–Hirschman Index, or HHI). This analysis helps refine our understanding of how ESG performance affects financing costs in different contexts.

(1) Firm Size Heterogeneity

Figure 5a,b illustrate that smaller firms significantly reduce debt financing costs with improved ESG performance compared to their larger counterparts. For smaller firms, the coefficient for debt costs is more negative, indicating that ESG improvements help mitigate higher perceived credit risks. Larger firms, however, show a less pronounced impact. Similarly, smaller firms benefit more from ESG improvements in equity financing, with a noticeable reduction in equity costs. In contrast, larger firms might face a slight rise in equity costs, potentially driven by increased compliance expenses associated with ESG practices.

(2) Industry Heterogeneity

Figure 5c,d display results for high- and low-pollution industries. Firms in high-pollution industries, such as energy, heavy manufacturing, and materials, benefit more from ESG improvements, with significant reductions in debt financing costs (Figure 5c). This suggests that firms in industries facing higher environmental risks and regulatory scrutiny derive greater benefits from strong ESG performance. For equity costs, high-pollution industries also experience a modest reduction, while low-pollution industries incur slightly higher equity costs as their ESG performance improves (Figure 5d). This may reflect lower regulatory pressure in low-pollution industries, where investors value ESG improvements less.

(3) Market Concentration (HHI) Heterogeneity

Figure 5e,f analyze the effect of market concentration based on the Herfindahl–Hirschman Index (HHI). Firms operating in competitive industries (with a low HHI) experience more significant reductions in debt and equity financing costs as their ESG performance improves. Conversely, firms in concentrated industries (characterized by a high Herfindahl–Hirschman Index, or HHI) exhibit a positive relationship, implying that ESG compliance generates higher expenses in such markets. This may result from reduced market competition in concentrated industries, where capital providers prioritize ESG enhancements less.

The heterogeneity analysis indicates that smaller firms, high-pollution industries, and competitive markets tend to benefit the most from strong ESG performance. These findings align with information asymmetry and agency theory, which suggest that ESG performance signals lower risks, thereby reducing financing costs. The findings provide vital information for investors and policymakers, highlighting the various advantages of ESG practices to different firm characteristics and market environments.

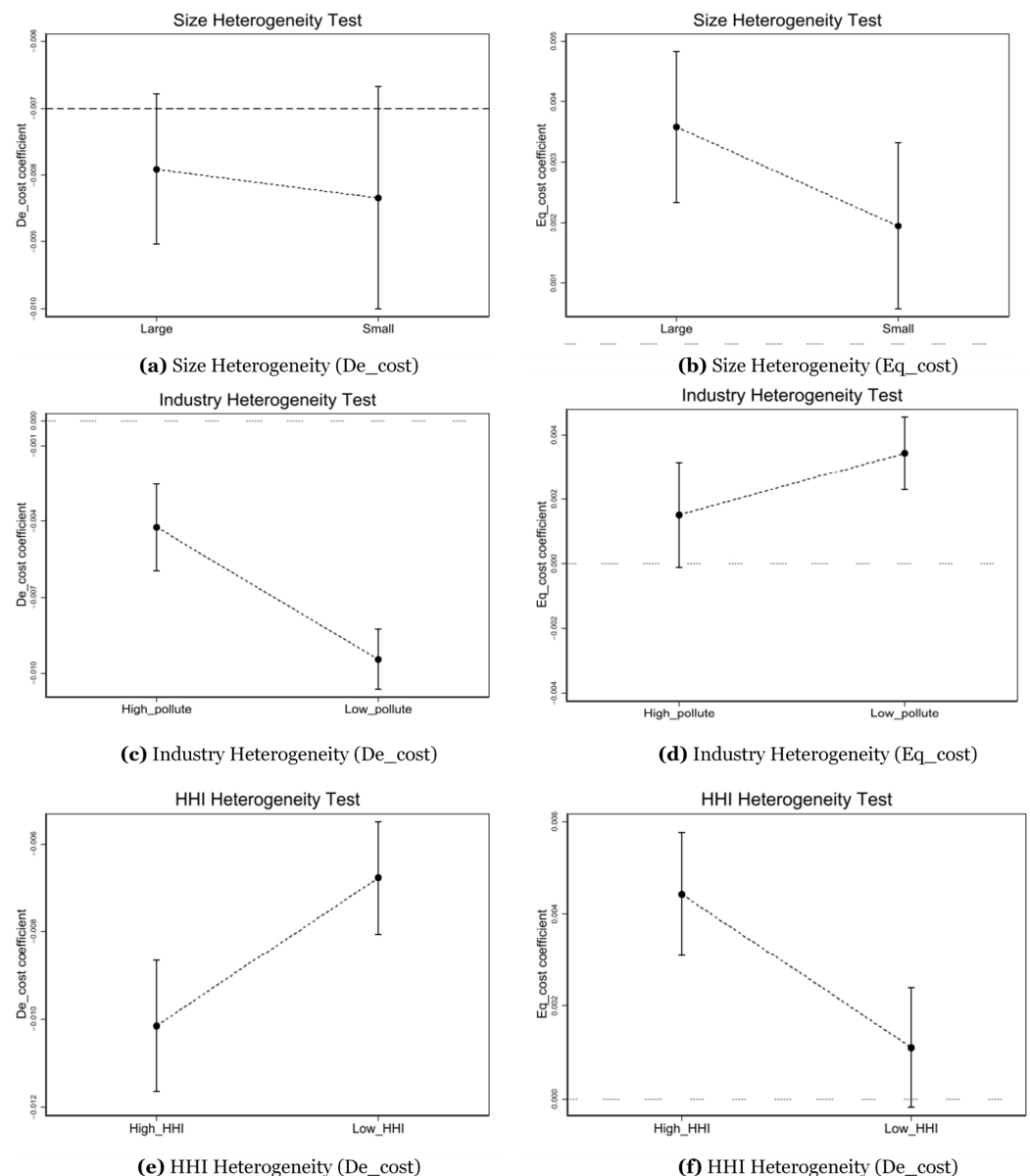


Figure 5. Heterogeneity analysis.

6. Discussion and Conclusions

6.1. Findings

This study examines the impact of Environmental, Social, and Governance (ESG) performance on financing costs within China's evolving regulatory framework. Using firm-level panel data from 2011–2022, we find that higher ESG performance is generally associated with lower debt financing costs, particularly among smaller firms and those in pollution-intensive sectors. These results suggest ESG is a credible signal of reduced credit risk, improving firms' access to debt capital. In contrast, the effect on equity financing is more nuanced. While firms in competitive markets or with limited capital resources tend to benefit from ESG improvement, larger firms in concentrated industries may face higher equity costs due to compliance demands and intensified investor scrutiny. These findings reveal the heterogeneous financial implications of ESG, shaped by firm attributes and institutional frictions in a transitional market setting. Overall, the empirical findings provide consistent support for all six proposed hypotheses, confirming both the core effects and contextual contingencies theorized in this study.

6.2. Discussions and Implications

Our findings on debt financing align with prior research, which indicates that ESG enhances creditworthiness by reducing perceived default risk and strengthening risk management [20,62]. We expand this literature by showing that such cost-reducing effects are more pronounced in Chinese firms with high environmental exposure or smaller market capitalization. These results refine the conclusions of Liang and Renneboog (2020), emphasizing that ESG benefits are conditional on financial vulnerability and external financing dependence [52,63]. For equity financing, our results contrast with the prevailing view in developed markets, which typically finds a negative relationship between ESG performance and equity costs [64,65]. In China, we find the relationship to be context dependent. Compliance intensity, investor expectations, and market structure moderate the impact of ESG on equity costs. These findings align with those of Raimo et al. (2021), who report that institutional maturity and firm adaptability are critical determinants of ESG's financial payoff in emerging markets [66].

Financial regulation and ESG rating divergence significantly moderate the relationship between ESG and financing costs. In sectors with strong regulatory oversight, such as energy, manufacturing, and state-owned financial institutions, ESG disclosures are more effective in reducing financing costs. Conversely, in lightly regulated sectors or underdeveloped regions, ESG initiatives deliver fewer financial benefits due to weak monitoring, voluntary reporting, or inconsistent enforcement. Moreover, rating divergence undermines the effectiveness of ESG as a financial signal. Variations in scoring methodologies and data inputs across agencies create inconsistency, which increases investor uncertainty. This supports the findings by Berg et al. (2022) and Christensen et al. (2022), and this research further demonstrates that such divergence has measurable consequences on firms' debt and equity costs in regulatory contexts lacking standardized ESG benchmarks [52,67].

Our findings contribute to the literature by highlighting the conditional nature of ESG's financial value. ESG is not inherently rewarded across all contexts—it depends critically on regulatory strength, rating consistency, and firm-specific factors. This insight is significant for emerging economies where ESG infrastructure remains fragmented. From a policy perspective, our results suggest that regulatory agencies should not only mandate consistent ESG disclosure but also integrate ESG performance into capital allocation mechanisms. For instance, firms with higher ESG ratings could be eligible for preferential interest rates under green credit policies or be prioritized for green bond issuance. Such mechanisms

can effectively incentivize ESG investment by lowering firms' cost of capital through transparent regulatory design.

Moreover, ESG initiatives can enhance governance practices by improving the transparency of information, fostering stakeholder engagement, and strengthening internal control systems. Firms that invest in ESG often exhibit stronger board oversight and disclosure quality, which in turn reduce agency costs and promote long-term investor confidence. These improvements in governance serve as indirect channels through which ESG lowers financing frictions. Therefore, ESG not only functions as a reputational signal but also acts as a governance-enhancing tool with financial implications. For corporate managers, especially in SMEs and risk-prone industries, investing in ESG capabilities under a coherent regulatory framework offers a viable strategy to reduce capital costs and improve competitive advantage in increasingly sustainability-oriented capital markets.

6.3. Limitations and Future Research

This study has limitations. First, it relies on publicly available ESG ratings, which may lack comparability across time and providers. Future research could incorporate alternative ESG measures, including analyst-based scores or text-based indicators. Second, while we control for firm size and industry type, factors such as governance quality, ownership structure, and investor sentiment remain unexplored. Including these variables could enhance understanding of ESG's financial effects. Finally, our focus on Chinese A-share firms may limit the generalizability of our findings. Future work could examine cross-listed firms or comparative studies across other emerging markets to assess ESG–financing linkages in broader institutional contexts.

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Appendix A

Table A1. Frequency distribution of firm–year.

Year	Obs (n)	Percent (%)	Cumulative (%)
2011	1556	7.72	7.72
2012	1541	7.64	15.36
2013	1444	7.16	22.52
2014	1605	7.96	30.48
2015	1843	9.14	39.62
2016	2107	10.45	50.07
2017	2233	11.07	61.14
2018	1806	8.96	70.1
2019	1867	9.26	79.36
2020	1962	9.73	89.09
2021	2201	10.91	100
Total	20,165	100	

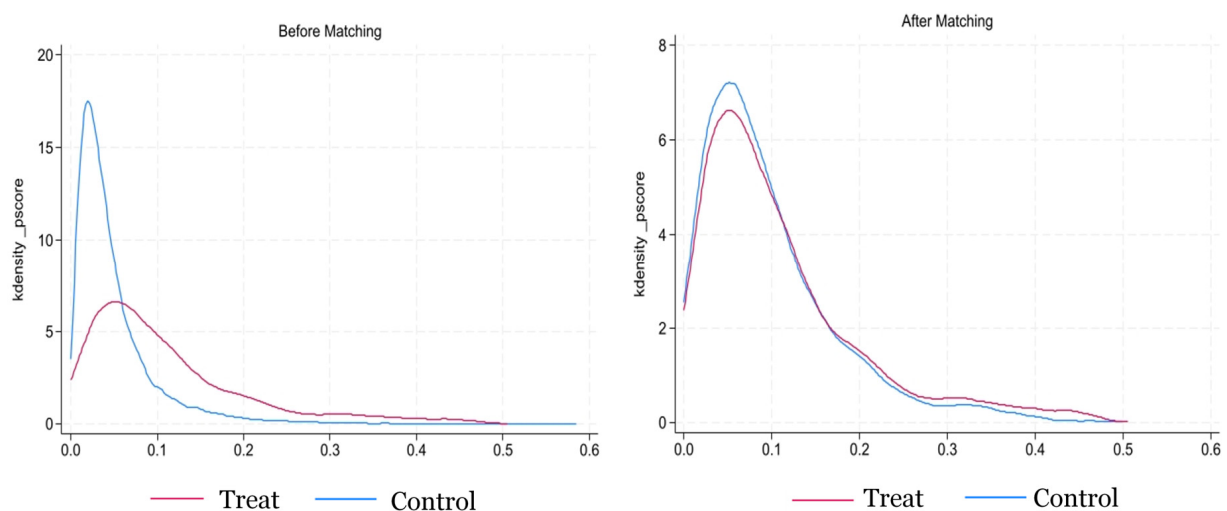
Table A2. Industry distribution of firm–year observations based on CSRC classification (2011–2021).

Industry Code	Industry Name	Obs (n)	Percent (%)	Cumulative (%)
A	Agriculture, Forestry, Animal Husbandry, and Fishery	199	0.99	0.99
B	Mining	539	2.67	3.66
C	Manufacturing	13296	65.94	69.6
D	Electricity, Heat, Gas, and Water Production and Supply	566	2.81	72.41
E	Construction	541	2.68	75.09
F	Wholesale and Retail Trade	906	4.49	79.58
G	Transport, Storage, and Post	578	2.87	82.45
H	Accommodation and Catering	61	0.3	82.75
I	Information Transmission, Software, and IT Services	1534	7.61	90.36
K	Real Estate	700	3.47	93.83
L	Leasing and Commercial Services	237	1.18	95.01
M	Scientific Research and Technical Services	243	1.21	96.22
N	Water Conservancy, Environment, and Public Facilities	310	1.54	97.76
O	Resident Services, Repair, and Other Services	6	0.03	97.79
P	Education	21	0.1	97.89
Q	Health and Social Work	60	0.3	98.19
R	Culture, Sports, and Entertainment	302	1.5	99.69
S	Public Administration, Social Security, and Social Organizations	66	0.33	100.02

Note: Industry classification follows the CSRC taxonomy. The table reports the number and percentage of firm–year observations in each industry over the study period.

Table A3. Variance Inflation Factor (VIF) test.

Variable	VIF	1/VIF
Lev	3.220	0.310
Cashflow	1.800	0.557
Size	1.770	0.567
Liquid	1.730	0.576
Board	1.600	0.624
Indep	1.490	0.669
ROE	1.380	0.727
ESG	1.150	0.870
FirmAge	1.150	0.873
Eq cost	1.140	0.875
Growth	1.110	0.904
Mean VIF	1.730	

**Figure A1.** Kernel density plots.

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