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The unintended effects of green finance development on corporate credit risk: a dual-channel analysis of financing and investment

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Green finance, as a core market-oriented tool linking financial resource allocation and ecological transformation, has delivered remarkable environmental benefits in China. However, the capital reallocation driven by ecological transition goals may trigger micro-level economic feedback and affect firms' adaptive capacity amid transition. Using panel data of Chinese listed manufacturing firms from 2010 to 2024, this paper explores how green finance development affects corporate credit risk. The empirical results reveal that green finance elevates manufacturing firms' credit risk via two channels: the financing volatility effect and the over-incentive effect. Further heterogeneity analysis reveals that the risk-amplifying effect is more pronounced in firms with poor environmental information disclosure, enterprises in capital-intensive and technology-intensive industries, firms with low external market attention, and enterprises located in low-human-capital regions, reflecting the differentiated adaptation capacity of micro entities under ecological transition. In addition, higher financial slack and mature regional technology markets can effectively mitigate the risk-amplifying effect of green finance, which helps to enhance firms' resilience in the process of ecological transition. These findings enrich the micro-level evidence of the interaction between financial dynamics and ecosystems, and provide empirical support and decision-making references for balancing ecological transition goals and microeconomic stability, and designing green financial policies that coordinate sustainable development and risk prevention.

KEYWORDS
credit risk, financial slack, green finance, risk-amplifying effect, technology market development

1 Introduction

Green finance has emerged as an important market-oriented mechanism for reallocating financial resources toward environmentally sustainable activities. While such financial reallocation is generally expected to facilitate firms' green transformation and promote long-term sustainable development, its implications for firms' financial stability are less straightforward.

The reallocation of financial resources toward green activities may also reshape firms' financing conditions and investment incentives, potentially generating financial pressures or investment inefficiencies that could affect their ability to meet debt obligations. This tension

raises an important question: does the development of green finance uniformly safeguard corporate sustainability, or can it generate unintended risk-amplifying effects? This question is particularly important for manufacturing firms, which, as the backbone of the real economy, require substantial upfront capital for their green transition (Jing and Liu, 2024) while simultaneously facing heightened default exposure. For instance, according to the *Quarterly Report on Credit Research of China A-share Listed Companies (2024Q2)* by Tsinghua University, the median one-year-ahead probability of default (PD) for A-share listed manufacturing firms reached 0.5825%, marking a notable quarter-on-quarter increase of 0.1119%. Given that credit conditions often deteriorate well before actual default occurs, understanding whether and how the expansion of green finance inadvertently magnifies firms' credit risk is of vital policy and empirical urgency.

To contextualize this inquiry, existing literature has evolved with distinct focuses, leaving the potential financial stability trade-offs of green finance under-examined. The first strand extensively praises the positive environmental and economic dividends of green finance, demonstrating its role in spurring green innovation (Chen et al., 2025), promoting energy efficiency (Shi and Yang, 2024; Xu et al., 2023), and supporting corporate environmental investment (Ma et al., 2024; Praveen et al., 2025). Some studies have touched upon firm-level risk-taking (Hao et al., 2025; Deng et al., 2023). However, this literature predominantly operates under a resource-provision assumption, largely overlooking the potential destabilizing costs that rigid green screening may impose on corporate capital structures. The second strand focuses on the determinants of corporate credit risk, identifying firm-level financial fundamentals—such as asset volatility, leverage, and profitability (Lafuerza and Galán, 2025), as well as governance characteristics (Li et al., 2025; Zhong and He, 2025) and macroeconomic conditions (Wei et al., 2026; He et al., 2023). Nevertheless, this literature has remained detached from green macro-policy shifts. Consequently, existing scholarship has yet to reconcile whether green finance, beyond its environmental goals, acts as an unintended catalyst for corporate credit risk.

Theoretically, this unintended risk-amplifying effect may materialize through two interconnected channels. On the financing side, green finance may reshape firms' financing environments by changing investors' perceptions and the conditions under which firms obtain external capital, thereby affecting their financial stability. On the investment side, the allocation of green financial resources and associated incentives may alter firms' investment decisions and increase the likelihood of inefficient or excessive investment, which may in turn undermine firms' debt-servicing capacity.

China provides an informative institutional setting to examine these dynamics. Its state-led, top-down approach to green finance, while effective in mobilizing resources, may also amplify the unintended credit risks by creating policy-induced investment distortions and uniform screening criteria that overlook firm-specific financial realities. This reality is underscored by the *Guiding Opinions on Financial Support for New Industrialization*, jointly issued by seven Chinese authorities in 2025, which explicitly mandates balancing financial support for manufacturing transformation with proactive risk prevention. Against this institutional background, examining whether the development of green finance has unintended risk implications for manufacturing firms is relevant to both financial risk management and sustainable industrial transformation.

Accordingly, this study addresses three related questions. First, does green finance development affect the credit risk of manufacturing firms? Second, through what financing and investment channels does this effect arise? Third, which internal and external conditions can effectively mitigate such potential adverse impacts, so as to enhance firms' adaptive capacity and transition resilience under ecological governance? To answer these questions, this paper examines the effect of green finance development on corporate credit risk, investigates two interconnected mechanisms: financing volatility and excessive investment incentives, further examines whether this relationship varies with firms' internal resource endowments and the external regional development environment.

Compared with existing studies, the marginal contributions of this paper are as follows.

First, this paper offers a counter-narrative to the prevailing literature by systematically uncovering the unintended credit risk-amplifying effect of green finance. While prior studies mainly examine the facilitating effect of green finance on corporate green transformation from the perspective of capital incentives (Wang et al., 2025; Lu et al., 2022), we show that green finance development can inadvertently heighten corporate credit risk, shortening the distance to default. This reveals the latent financial stability costs of green finance development, broadening the boundary of green finance's real economic consequences.

Second, this paper provides a mechanism-based explanation for this unintended effect by examining two interconnected channels: financing volatility and excessive investment incentives. We reveal how green finance reshapes corporate financial decisions from both sides: The financing channel emphasizes changes in investor perceptions and financing uncertainty, whereas the investment channel emphasizes firms' incentives to expand investment and the potential emergence of excessive investment. Examining these channels jointly helps explain why and how changes in financial resource allocation associated with green finance may translate into changes in corporate credit risk, thereby providing a more integrated understanding of the underlying relationship.

Third, this paper delineates the specific boundary conditions and adaptive buffers of this unintended effect. We demonstrate that corporate financial slack and mature regional technology markets can buffer the adverse effect of green finance. Furthermore, through multi-dimensional heterogeneity tests across environmental disclosure, industrial factor intensity, media attention, and regional human capital, we identify precisely when and for whom green finance poses the greater risk, offering implications for regulators and corporate managers seeking to balance green transformation with financial stability.

The remainder of this paper proceeds as follows. Section 2 elaborates on the theoretical framework and develops the research hypotheses. Section 3 outlines the empirical design and data sources. Section 4 presents and discusses the baseline effects, underlying mechanisms, buffer conditions and heterogeneous group differences of green finance on corporate credit risk. Section 5 summarizes the core conclusions and corresponding policy implications.

2 Theoretical framework and hypothesis development

In the process of green finance development, financial markets reprice corporate value based on green standards criteria. Such a process raises uncertainty in firms' investment and financing conditions. As a result, firms' financing channels and investment fields have undergone substantial changes, thereby affecting their credit risk.

2.1 The impact mechanism of green finance development on corporate credit risk

In terms of capital acquisition, green finance can heighten corporate credit risk through the financing volatility channel. According to information asymmetry theory, a gap exists between investors' acquired information and a firm's real operating conditions. In the context of green finance, this information asymmetry is exacerbated. The push for green finance outpaces the formation of globally harmonized green standards, forcing creditors to assess firms based on a new, non-financial dimension. However, the evaluation tools themselves, such as ESG ratings, which are gaining prominence, are characterized by significant divergence and rely on non-standardized corporate disclosures (Zhang J. L. et al., 2025). This uncertainty surrounding a firm's true green credentials naturally leads to greater divergence of opinion among creditors regarding its long-term prospects.

Crucially, this environment of heightened uncertainty and opinion divergence can influence the behavior of risk-averse creditors. When lenders face difficulty in assessing a firm's true risk profile due to opaque and inconsistent green information, creditors' standard response is to adopt more cautious lending strategies. They may demand higher risk premiums, which increases financing costs (Alessi et al., 2023; Zhou et al., 2022). More severely, based on the credit rationing theory (Stiglitz and Weiss, 1981), they may tighten lending standards or reduce credit supply altogether when facing high, unquantifiable risk (Zhang J. L. et al., 2024). This resulting instability in a firm's ability to obtain external financing, characterized by higher costs and reduced availability, impairs its capacity to manage its liquidity and service its debt obligations, thus increasing its overall credit risk.

In terms of capital investment, green finance can elevate corporate credit risk through an over-incentive effect, which manifests as strengthening incentives for rent-seeking and excessive investment. According to agency cost theory, there are conflicts of interest between management and shareholders. Against the backdrop of green finance development, such interest conflicts also manifest in firms' capital investment aimed at acquiring green policy resources. Strategic rent-seeking investment motives are further strengthened for two reasons: the assessment of firms' eligibility for green projects and their priority in accessing green funds may involve considerable subjectivity, and manufacturing firms inherently face large fixed-asset investment demands. After accessing green capital, driven by green project constraints and managers' incentives to boost personal and corporate reputations via green certifications, firms tend to adopt aggressive investment strategies to secure continuous resource support (Wang et al., 2024).

Crucially, such over-incentive effect can elevate firms' credit risk. From the rent-seeking perspective, as China's regulatory intensity grows, firms face higher risks of rent-seeking conduct being exposed, alongside greater litigation and judicial hazards (Xiong et al., 2026). At the same time, corporate rent-seeking activities increase cash-flow pressure (Bi et al., 2023) and reduce external incentives for operational improvement and survival-driven innovation, eroding firms' core competitiveness (Liu et al., 2018) and threatening their long-term viability (Zhang M. D. et al., 2024). From the excessive investment perspective, excessive investment represents inefficient capital allocation (Zhu and Chen, 2025), which may intensify shareholder–management agency conflicts (Wei et al., 2019), ultimately elevating firms' credit risk (Zhang H. et al., 2025).

H1. Green finance raises corporate credit risk through financing volatility and excessive incentive effects.

2.2 The moderating role of firm internal resources

As an internal corporate resource, financial slack acts as a buffer against sudden, unforeseen risks. It serves as a strategic reserve that helps firms sustain stable operations amid transformation pressure and financing uncertainty induced by green finance.

Based on the existence form, usage constraints and strategic significance of resources, financial slack can be divided into available slack and potential slack (Myers and Majluf, 1984). Available redundancy refers to firms' existing surplus liquid resources that can be called at any time, and the use of available redundancy will not increase the financial leverage of the enterprise and is not subject to external supervision. Potential slack refers to untapped financing capacity that a firm can obtain at a reasonable cost when capital demands arise. It represents conditional future resource options, primarily manifested as a firm's unused credit lines.

On the one hand, financial slack can provide financial support for enterprises to cope with environmental pressure and carry out green innovation (Guo et al., 2025). It also enables firms to rely on internal funds to sustain operations, mitigate liquidity risks under external financing constraints, and reduce their cash flow sensitivity. On the other hand, since financial slack inherently provides stability, it reduces the urgency of companies seeking external rents, reducing their reliance on green rents, making them more likely to use financial slack for productive investments (Ashwin et al., 2016) rather than rent-seeking. In addition, the policy-driven nature of green finance can introduce uncertainty, exacerbating information asymmetry between the firm and its lenders. From a creditor's perspective, this opacity makes it difficult to assess the true risk-return profile of a firm's green transition. However, a strong financial slack reduces its reliance on external financing to navigate short-term shocks and sends a powerful signal, making creditors' more willing to maintain stable credit lines (Costa et al., 2026). Thus, financial slack can shore up a firm's debt-servicing capacity.

H2. In terms of internal resources, high financial slack can dampen the upward effect of green finance development on corporate credit risks.

2.3 The moderating role of firm external development environment

From the perspective of firms' external development environment, the level of regional technology market development exerts a mitigating effect on the risk shocks induced by green finance development. As a formal market support system, technology markets allow the separation of professional technology developers and efficient product adopters (Arora and Nandkumar, 2012). Such markets can alleviate the micro risk effects caused by green finance by cutting firms' green innovation and investment decisions costs and empowering green financial resources to achieve better allocation.

On the one hand, patent transaction prices and technology licensing fees within technology markets provide data support for investors to assess firms' green technology asset value, a mechanism that transform the value of a firm's green technology assets from opaque, firm-specific projects into assets with a discernible market valuation, thus improves environmental information transparency that creditors face (Greenaway and Kneller, 2007) and effectively restrains volatility of financing conditions. On the other hand, in areas with mature technology markets, enterprises can quickly obtain mature green technologies through technology licensing and patent purchase (Arora et al., 2001). Firms have weaker incentives to pursue blind R&D spending solely for green financial support. By acquiring mature technologies, firms can lower green transformation costs, reduce the probability of investment failure, and improve the overall efficiency of their capital expenditure (Hu et al., 2024). This reduction in internal project risk, in turn, translates into a more stable cash flow projection and debt-servicing capacity.

H3. In terms of the external development environment, the maturity of regional technology markets can mitigate the upward effect of green finance development on corporate credit risks.

3 Research design

3.1 Sample selection and model specification

3.1.1 Sample selection

This paper selects annual data of Chinese A-share listed manufacturing firms from 2010 to 2024 as the sample and processes them as follows:

1. Exclude ST and *ST-listed firms

Following the sample selection criteria, we exclude ST and *ST-listed firms from the baseline sample because their special treatment status reflects relatively abnormal financial conditions, which may affect the comparability and reliability of the financial and market-based information required for constructing the Merton distance-to-default measure. To address the potential sample-selection concern arising from this exclusion, we further conduct a robustness test by including ST and *ST-listed firms with valid observations, with the results reported in Section 3, *Supplementary Material* (Supplementary Table SC3).

2. Apply 1% winsorization at both tails to all continuous variables.

To mitigate the influence of extreme observations and reduce the potential impact of outliers on the regression estimates, we winsorize all continuous variables at the 1% level in both tails.

3. Drop observations missing core variable values.

We exclude observations with missing values for the core variables because these observations cannot be consistently included in the regression analysis.

After the above screening, the final sample contains 32,480 firm-year observations of manufacturing firms. As for data sources, firm-level data are mainly retrieved from the China Stock Market & Accounting Research (CSMAR) Database and *China Industrial Statistical Yearbook*, while regional macroeconomic data are obtained from the *China Statistical Yearbook*, *China Insurance Yearbook* and Easy Professional Superior (EPS) Database.

3.1.2 Model specification

We construct the baseline regression model to examine the overall impact of green finance development on corporate credit risks, which is specified as follows:

$$DD_{it} = \alpha + \beta GF_{pt} + \gamma\ Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

$$Med_{it} = \alpha + \beta GF_{pt} + \gamma\ Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

$$DD_{it} = \alpha + \beta GF_{pt} + \beta_1 FS_{it} + \beta_2 GF_{pt} \times FS_{it} + \gamma\ Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Equation 1 serves as our baseline regression model, Equation 2 is constructed for mechanism tests, and Equation 3 is adopted to examine the moderating effect.

Among them, *DD* is the proxy for corporate credit risk, measured as the distance to default of manufacturing firm i in year t. A larger distance to default corresponds to lower corporate credit risk. *GF* denotes the green finance development index of province p, where firm i is located in year t. Med stands for the mechanism variable, and *FS* refers to the moderating variable. *GF*FS* is the interaction term between green finance development and the moderating variable. Controls denote a set of control variables. Subscripts i, t, and p represent firm, year, and province fixed effects, respectively. ε is the disturbance term.

3.2 Variable definitions

3.2.1 Dependent variable: corporate credit risk

The 2023 revised version of Enterprise Credit Evaluation Indicators clearly states that corporate credit risk shall be assessed from operational capacity and financial conditions, highlighting its vital role in market transactions and financial regulation. Corporate credit risk stems from debtors' failure to

TABLE 1 Descriptive statistics for each variable.

Variable	Sample size	Mean	Standard deviation	min	Max
DD	32,480	0.076	0.035	0.024	0.202
GF	32,480	0.248	0.053	0.133	0.398
Lev	32,480	0.387	0.196	0.050	0.880
FIXA	32,480	0.219	0.132	0.014	0.610
BAL	32,480	0.785	0.610	0.036	2.817
SOE	32,480	0.247	0.431	0.000	1.000
Salary	32,480	14.613	0.721	12.899	16.591
Growth	32,480	0.142	0.353	−0.616	1.936
Size	32,480	7.594	1.146	5.165	10.784

fulfill their contractual obligations, which may cause economic losses to creditors. In terms of corporate operations, such risk is mainly reflected in the objective possibility that a firm cannot repay the principal and interest of its debts in full and on time due to internal and external factors, thereby exposing its creditors to real economic losses. Therefore, following the mainstream approach proposed by Merton (Merton, 1974), this study adopts the Merton model to calculate the distance to default, as illustrated in Equation 4.

$$DD_{Merton} = \frac{\ln\left(\frac{V}{F}\right) + \left(\mu - \frac{1}{2}\sigma_v^2\right)T}{\sigma_v\sqrt{T}} \quad (4)$$

The firm's asset value (V) and asset-value volatility (σ_V) are jointly estimated from the equity pricing equation and the equity volatility equation using observable information such as equity market value, equity volatility, debt face value, debt maturity, and the risk-free rate. We use MATLAB to numerically solve the two equations and obtain V and σ_V. The detailed estimation procedure and definitions of the parameters are provided in Section 1, *Supplementary Material*. To improve readability and facilitate the interpretation of regression coefficients, we divide the Merton distance-to-default measure (DD_{Merton}) by 100 and use the rescaled measure as an inverse measure of corporate credit risk, denoted as DD. In our sample, the rescaled DD ranges from 0.024 to 0.202 (see Table 1). A higher DD indicates that the firm's asset value is farther from the default point and is therefore associated with lower corporate credit risk, whereas a lower DD indicates higher corporate credit risk.

3.2.2 Independent variable: green finance development

Green finance development refers to the allocation of financial resources toward environmentally friendly and sustainable activities through market mechanisms and policy incentives, with the objectives of promoting environmental improvement, resource conservation, and sustainable economic development.

Following the existing literature on the measurement of regional green finance development in China (He and Liu, 2023; Yang et al., 2026), this study constructs a provincial green finance development index using the entropy-weighting method. The index comprises four dimensions: green credit, green securities, green investment, and green insurance, each of which is measured using multiple complementary indicators. A higher green finance development index indicates a stronger capacity for green resource allocation and a more developed local green market within the province in a given year. The detailed indicator definitions, indicator directions, entropy-derived weights, and data sources are reported in Table 2, Panel B, while the complete entropy-weighting procedure is provided in Section 2 *Supplementary Table 1*.

Green credit is measured using the share of loans to environmentally friendly enterprises and the share of interest expenses of high-energy-consuming industries. The former is a positive indicator, directly capturing the extent to which credit resources are directed toward environmentally friendly activities. The latter is a negative indicator: a higher share indicates that a greater proportion of credit resources is allocated to high-polluting and high-energy-consuming industries, implying weaker financial constraints on environmentally intensive activities and, consequently, a lower level of green credit development. These two complementary indicators jointly capture both the supportive and constraining functions of green credit.

Green securities dimension is measured using the respective market-value shares of environmentally friendly enterprises and high-energy-consuming industries. The market-value share of environmentally friendly enterprises is a positive indicator, reflecting the support provided by capital markets to green enterprises. In contrast, the market-value share of high-energy-consuming industries is a negative indicator, reflecting the extent to which capital-market resources remain concentrated in environmentally intensive industries. A higher value therefore indicates a lower degree of greening in the securities market.

Green investment is measured using the proportion of investment in environmental pollution control and fiscal expenditure on energy conservation and environmental protection. These indicators capture the scale of financial resources devoted to environmental protection, pollution control, energy conservation, and related green activities at the regional level. Environmental pollution control investment reflects the overall investment in pollution prevention and environmental improvement by various economic agents, while fiscal

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TABLE 2 Main variable definitions and green finance index construction.

Variable type	Variable name	Symbol	Variable explanation
Panel A. Definitions of main variables			
Dependent variable	Corporate credit risk	*DD*	$DD_{Merton}/100$
Independent variable	Green finance development	*GF*	Constructed via the entropy weight method
Control variables	Debt-to-asset ratio	*Lev*	Total liabilities/Total assets
	Fixed asset ratio	*FIXA*	Net fixed assets/Total assets
	Equity restriction	*BAL*	Shareholding ratio of the 2nd-5th largest shareholders/ shareholding ratio of the largest shareholder
	Ownership nature	*SOE*	Dummy variable based on the ultimate controller's nature
	Operating revenue growth rate	*Growth*	(Current period operating revenue - lagged operating revenue)/ Lagged operating income
	Managerial compensation	*Salary*	Natural logarithm of total compensation for the top three executives
	Firm size	*Size*	Natural logarithm of the number of employees
Mediating variables	Investor disagreement	*Divergence*	Annual average stock turnover ratio
	Corporate rent-seeking cost	*SR*	Excess administrative expenses
	Overinvestment	*OverInv*	Values of inefficient investment greater than zero
Moderating variables	Available slack	*AS*	Current assets/Current liabilities
	Potential slack	*PS*	Total long-term liabilities/Owners' equity
	Regional technology market development	*TEC*	Technology market transaction volume/Regional GDP

Primary indicator	Secondary indicator	Indicator definition	Direction	Weight
Panel B. Green finance index construction and weights				
Green credit	Proportion of loans to environmentally friendly enterprises	Total loans to environmentally friendly listed enterprises/Total loans to listed companies	+	24.8
	Proportion of interest expenses in energy-intensive industries	Interest expenses of the six energy-intensive industries/ Interest expenses of the industrial	-	1.3
Green securities	Proportion of market capitalization of environmentally friendly enterprises	Total market capitalization of environmentally friendly enterprises/Total market capitalization of A-share listed companies	+	21.7
	Proportion of market capitalization of energy-intensive industries	Total market capitalization of the six energy-intensive industries/Total market capitalization of A-share listed companies	-	5.3
Green investment	Proportion of environmental pollution control investment	Investment in environmental pollution control/GDP	+	21.6
	Proportion of energy conservation and environmental protection expenditure	Fiscal expenditure on energy conservation and environmental protection/Total fiscal expenditure	+	9
Green insurance	Proportion of environmental pollution liability insurance	Premium income from environmental pollution liability insurance/Total premium income	+	8.6
	Agricultural insurance claim ratio	Agricultural insurance claims/Agricultural insurance premium income	+	7.7

See Section 2, Supplementary material for detailed definitions and data sources for all indicators.

expenditure on energy conservation and environmental protection captures the public-sector financial support for green and environmentally sustainable activities. Together, these indicators capture the scale of regional investment in environmental protection and the role of public financial support in promoting green development.

Green insurance is measured using the share of environmental pollution liability insurance and the agricultural insurance payout ratio. Environmental pollution liability insurance is a typical green insurance product that directly provides market-based protection against environmental pollution risks and therefore captures the development of environmental risk management through insurance markets. As a supplement, while strictly defined green insurance is limited to categories like eco-friendly agriculture, data availability at the provincial level necessitates the use of a broader proxy. We argue that agricultural insurance's ecological protection function is realized by buffering natural disaster risks to deter destructive agricultural practices, enhancing climate resilience against environmental shocks, and reducing risk barriers to adopting green agricultural technologies (Amarnath et al., 2023). Furthermore, using the payout ratio reflects the actual realization of insurance protection and market maturity (Aglasan et al., 2024).

3.2.3 Control variables

Following existing research on corporate credit risk (Li et al., 2025; Wei et al., 2026), this study selects the following control variables: asset-liability ratio, firm size, fixed asset ratio, equity restriction, ownership nature, operating revenue growth rate, and managerial compensation.

3.2.4 Mediating variables

Drawing on existing literature (Liu et al., 2018; Harris and Raviv, 1993), this study adopts the annual average stock turnover ratio as the proxy for investor disagreement, excess administrative expenses as the proxy for corporate rent-seeking costs, and identifies overinvestment based on the residual from the investment efficiency model.

Specifically, a positive residual indicates that a firm's actual investment exceeds the level predicted by the investment model and is therefore interpreted as overinvestment. Accordingly, the baseline mediation analysis using *OverInv* is restricted to observations with positive residuals. The resulting reduction in the sample size reflects the definition of overinvestment rather than an arbitrary exclusion of observations. Nevertheless, to address the potential sample-selection concern associated with restricting the analysis to observations with positive residuals, we conduct an additional robustness test using the full sample. Specifically, positive residuals are retained as the measure of overinvestment, while observations with non-positive residuals are assigned a value of zero. The results are reported in Section 3 (Supplementary Table SC1) and remain broadly consistent with the baseline mediation findings.

3.2.5 Moderating variables

Drawing on existing literature (Myers and Majluf, 1984; Bourgeois and Singh, 1983; Zhao, 2022), this study adopts the current asset-current liability ratio to measure firms' available slack, and the long-term debt-to-equity ratio to capture firms' potential slack. A higher long-term debt-to-equity ratio indicates lower potential slack. Accordingly, we hypothesize that the interaction term between potential slack and green finance development is positively associated with corporate credit risk, whereas the interaction term between the long-term debt-to-equity ratio and green finance development is negatively associated with corporate credit risk. In addition, regional technology market development is measured by the ratio of regional technology market transaction volume to regional GDP.

3.3 Descriptive statistics and correlation analysis

Table 1 presents the descriptive statistics of all variables, including the number of observations, mean, standard deviation, minimum and maximum values. Table 3 reports the pairwise correlation coefficients among variables. All correlation coefficients are below 0.5, indicating that severe multicollinearity is not a concern in our empirical model.

TABLE 3 Correlation analysis of each variable.

Variable	*DD*	*GF*	*Lev*	*FIXA*	*BAL*	*SOE*	*Salary*	*Growth*	*Size*
DD	1.000								
GF	−0.141	1.000							
Lev	−0.415	0.034	1.000						
FIXA	−0.059	0.031	0.207	1.000					
BAL	−0.029	−0.010	−0.103	−0.090	1.000				
SOE	0.021	0.034	0.261	0.146	−0.211	1.000			
Salary	−0.101	0.010	0.052	−0.066	0.094	−0.043	1.000		
Growth	−0.065	−0.008	0.037	−0.047	0.029	−0.046	0.026	1.000	
Size	−0.130	0.007	0.447	0.229	−0.137	0.294	0.341	0.040	1.000

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4 Empirical results and analysis

4.1 Baseline regression and influence mechanism test

To account for unobserved heterogeneity and obtain robust statistical inference, we control for firm and year fixed effects and cluster standard errors at the provincial level in all baseline regressions. Columns (1) and (2) of Table 4 show that the coefficient on green finance development is negative and statistically significant at the 5% and 1% levels, respectively. This result indicates that green finance development is negatively associated with DD and exacerbates corporate credit risk. To further explore the impact of green finance development on corporate credit risk, this study takes investor disagreement as a proxy for financing volatility effects, and corporate rent-seeking and overinvestment as proxies for excessive investment incentive effects. To directly assess the statistical significance of the indirect effects, we further conduct Sobel tests and report the corresponding Sobel Z-statistics and indirect effects in the mediation analysis tables.

As shown in Column (2) of Panel A in Table 5, green finance development is positively associated with investor disagreement at the 5% significance level, suggesting that green finance development increases investor disagreement and may generate a financing volatility effect. In Column (3), green finance development has a significantly negative effect on DD at the 5% level, while investor disagreement is also negatively associated with DD at the 1% level in Column. These results suggest that green finance development may affect corporate credit risk through investor disagreement. The Sobel test further confirms the significance of the indirect effect, with a Sobel Z-statistic of −2.391 and an indirect effect of −0.0045, which is significant at the 5% level. Similarly, Column (4) shows that green finance development has a significantly positive effect on SR at the 1% level, whereas Column (5) indicates that SR is significantly negatively associated with DD at the 1% level. The Sobel test yields a Z-statistic of −3.324 and an indirect effect of −0.0013, significant at the 1% level. These findings provide further evidence that green finance development affects corporate credit risk through the SR channel.

Panel B of Table 5 further examines the overinvestment channel. Column (2) shows that green finance development has a significantly negative effect on DD at the 5% level, while Column (3) indicates that green finance development significantly increases overinvestment at the 5% level. When both green finance development and overinvestment are included in Column (4), the coefficient on overinvestment is significantly negative at the 1% level. The Sobel test produces a Z-statistic of −1.961 and an indirect effect of −0.0007, significant at the 5% level, providing additional evidence that overinvestment mediates the effect of green finance development on corporate credit risk.

TABLE 4 Main regression results.

Variable	(1)DD	(2)DD
GF	−0.012**	−0.017***
	(0.005)	(0.005)
Lev		−0.066***
		(0.002)
FIXA		−0.002
		(0.003)
BAL		−0.000
		(0.000)
SOE		0.003**
		(0.001)
Salary		−0.001**
		(0.000)
Growth		−0.006***
		(0.000)
Size		−0.002***
		(0.000)
Constant	0.093***	0.146***
	(0.002)	(0.007)
Enterprises-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes
N	32,480	32,480
R^2	0.297	0.358

*, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Figures in parentheses represent cluster-robust standard errors. The same notation applies to all subsequent tables.

4.2 Endogeneity and robustness tests

4.2.1 Endogeneity test

Corporate credit risk may affect firms' financing and investment decisions, which may in turn influence the development of green finance, giving rise to potential reverse causality. To address this concern, we employ an instrumental variable (IV) approach and conduct a two-stage least squares (2SLS) estimation.

Specifically, drawing on the identification strategy of Habib et al. (2025), who employ environmental policy stringency as an instrumental variable for green finance, we construct an instrumental variable based on the interaction between the historical environmental regulatory foundation during 2000–2008 and the share of green finance pilot cities within each province. The historical environmental regulatory foundation is measured by the cumulative number of environmental regulations issued in each province during 2000–2008, while the share of green finance pilot cities captures the extent of a province's exposure to the green finance pilot program. The instrumental variable is therefore defined as:

$$IV_{pt} = HistoricalEnvironmentalRegulation_{p,2000-2008} \times PilotCityShare_{pt}$$

From the perspective of relevance, the historical environmental regulatory foundation reflects the institutional and administrative basis for environmental governance, which may affect a province's capacity to implement and diffuse subsequent green finance policies.

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TABLE 5 The results of the mechanism.

Variable	(1) DD	(2) Divergence	(3) DD	(4) SR	(5) DD
Panel A. Mediation effects of divergence and SR					
GF	−0.017***	3.326**	−0.013**	0.050***	−0.016***
	(0.005)	(1.287)	(0.005)	(0.012)	(0.006)
Divergence			−0.001***		
			(0.000)		
SR					−0.027***
					(0.005)
Constant	0.146***	10.939***	0.161***	−0.142***	0.142***
	(0.007)	(0.739)	(0.007)	(0.014)	(0.007)
Control variables	Yes	Yes	Yes	Yes	Yes
Enterprises-fixed effect	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes
N	32,480	32,480	32,480	32,480	32,480
R^2	0.358	0.185	0.370	0.154	0.358
Sobel Z		−2.391		−3.324	
Indirect effect		−0.0045**		−0.0013***	

Variable	(1) DD	(2) DD	(3) OverInv	(4) DD
Panel B. Mediation effects of OverInv				
GF	−0.017***	−0.016**	0.052**	−0.015**
	(0.005)	(0.006)	(0.023)	(0.006)
OverInv				−0.014***
				(0.004)
Constant	0.146***	0.109***	0.084***	0.110***
	(0.007)	(0.011)	(0.022)	(0.011)
Control variables	Yes	Yes	Yes	Yes
Enterprises-fixed effect	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes
N	32,480	10,427	10,427	10,427
R^2	0.358	0.457	0.093	0.458
Sobel Z			−1.961	
Indirect effect			−0.0007**	

Consistent with this argument, Xu et al. (2022) and Mamun et al. (2025) document significant theoretical and empirical associations between environmental regulation and green finance development. Meanwhile, the share of green finance pilot cities captures the degree of a province's exposure to the green finance pilot program. The interaction between these two components is therefore expected to be systematically associated with provincial green finance development, providing a basis for the relevance of the instrumental variable.

From the perspective of exogeneity, the historical environmental regulatory foundation is constructed using environmental regulations issued during 2000–2008, substantially predating the sample period beginning in 2010. Therefore, this predetermined institutional characteristic is unlikely to be affected by contemporaneous green finance development or firms' current credit risk. The interaction with the share of green finance pilot cities captures provinces' differential exposure to subsequent green finance policy implementation.

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TABLE 6 Endogeneity test results.

Variable	(1) First-stage regression	(2) Second-stage regression
GF		−0.183***
		(0.053)
IV	−0.000***	
	(0.000)	
Kleibergen-paap rk LM	81.741***	
Kleibergen-paap rk wald F	49.753	
Stock–Yogo 10% critical value	16.38	
Constant	0.287***	
	(0.014)	
Control variables	Yes	Yes
Enterprises-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes
N	32,480	32,480
R^2	0.688	0.044

The dependent variable in column (1) is GF, while the dependent variable in column (2) is DD.

Although the exclusion restriction is ultimately an identifying assumption that cannot be directly tested, the predetermined nature of the historical environmental regulatory foundation and the policy exposure captured by the interaction term provide supporting evidence for the exogeneity of the instrumental variable.

Table 6 reports the results of the instrumental variable estimation. Column (1) presents the first-stage regression, where the dependent variable is the green finance index. The coefficient on the instrumental variable is statistically significant, indicating that the instrument is significantly associated with green finance development and therefore satisfies the relevance condition. Notably, the first-stage coefficient on the instrumental variable is negative. To understand this empirical pattern, we further explore its potential underlying reasons under the policy substitution and regional catch-up frameworks. Specifically, provinces with stronger historical regulations (2000-2008) are highly likely to prompt preemptive industrial restructuring and the gradual relocation of pollution-intensive activities (Wu et al., 2017). Consequently, during 2010–2024, these regions possessed a cleaner industrial baseline and lower incremental demand for green finance. Conversely, historically lagging provinces faced intense environmental accountability and catch-up pressure, prompting more aggressive mobilization of green finance instruments during the sample period. The Kleibergen–Paap rk LM statistic is 81.741 and statistically significant at the 1% level, further rejecting the null hypothesis of underidentification. Moreover, the Kleibergen–Paap rk Wald F statistic is 49.753, which is higher than the Stock–Yogo 10% critical value of 16.38, alleviating concerns regarding weak identification.

Column (2) reports the second-stage estimation results. The coefficient on green finance is −0.183, statistically significant at the 1% level. The negative coefficient indicates that an increase in green finance development is associated with a reduction in firms' distance to default, implying a higher level of corporate credit risk. This result is consistent with the baseline findings, suggesting that the adverse effect of green finance development on corporate credit risk is unlikely to be driven entirely by reverse causality. Although the 2SLS estimate (−0.183) shows a larger magnitude than the OLS estimate (−0.017), this difference may be driven by the correction of measurement-induced attenuation bias in the synthesized index and the capture of Local Average Treatment Effects. Nevertheless, historical environmental regulation may be correlated with persistent regional characteristics, such as economic development, industrial structure, institutional capacity, and financial development. To mitigate concerns that the instrumental variable may capture such broader regional differences, our empirical specification includes firm fixed effects, year fixed effects, and the full set of baseline control variables. Furthermore, we conduct an additional robustness analysis by controlling for province-level GDP, labor force conditions, and financial development (see Section 3, *Supplementary Material*, Supplementary Table SC2). The results remain qualitatively consistent, suggesting that the estimated relationship is not primarily driven by observable differences in regional economic and financial development.

Overall, the instrumental variable results provide additional evidence that our baseline findings are not solely attributable to reverse causality. The consistency between the IV estimates and the baseline results provides further support for the adverse effect of green finance development on firms' credit risk.

4.2.2 Robustness test

To further verify the robustness of our baseline regression results, we conduct a series of robustness checks, with corresponding findings presented in Table 7.

4.2.2.1 Alternative measurement of the dependent variable

For the measurement of corporate credit risk, we re-measure distance to default by replacing the Merton model with the KMV

TABLE 7 Robustness test.

Variable	(1) DD	(2) DD	(2) DD	(4) DD	(5) DD
GF	−0.882***	−0.008***	−0.017***	−0.017***	−0.016**
	(0.230)	(0.003)	(0.005)	(0.005)	(0.006)
Constant	3.391***		0.146***	0.147***	0.147***
	(0.313)		(0.007)	(0.006)	(0.009)
Control variables	Yes	Yes	Yes	Yes	Yes
Enterprises-fixed effect	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes
Clustered by firms			Yes		
Industry-fixed effect				Yes	
N	32,480	32,480	32,480	32,480	23,825
R^2	0.216	0.358	0.358	0.359	0.395

The baseline results are also robust to the inclusion of time-varying provincial controls and the use of province fixed effects. Detailed results are available in Section 3, *Supplementary Material* (Supplementary Table SC4) due to space constraints.

model and use the newly constructed *DD* as the dependent variable to re-estimate the baseline model. As reported in Column (1) of Table 7, the coefficient of green finance development remains significantly negative, indicating that green finance development is associated with higher corporate credit risk. This outcome aligns closely with our baseline regression findings, verifying the robustness of our core conclusion.

4.2.2.2 Alternative measurement of the independent variable

A potential methodological artifact of entropy weight method is the use of full-sample minimum and maximum values for normalization, which may introduce a look-ahead bias. To ensure our results are not driven by this, we perform a robustness check by constructing a time-varying index using a year-by-year entropy method. As shown in Column (2) of Table 7, the coefficient on this alternative Green Finance index remains significantly negative, confirming that our core findings are robust to the specific measurement of our key independent variable.

4.2.2.3 Adjustment of clustering standard errors

We re-estimate the baseline model using firm-level clustered standard errors instead of province-level clustered standard errors. This alternative specification tests whether the main findings are sensitive to the clustering level. As shown in Column (3) of Table 7, the coefficient on green finance development remains negative and statistically significant, confirming the robustness of our main findings.

4.2.2.4 Higher-order fixed effects specification

Considering the differences between industries, we add industry fixed effects on top of firm and year fixed effects. Column (4) of Table 7 yields results consistent with the baseline regression, demonstrating a significantly positive association between green finance development and corporate credit risk.

4.2.2.5 Excluding the COVID-19 pandemic years

The COVID-19 pandemic may have substantially affected firms' financing conditions, investment decisions, and credit risk, potentially confounding the relationship between green finance development and corporate credit risk. To mitigate the potential influence of the pandemic on our findings, we re-estimate the baseline model after excluding observations from 2020 to 2022. As reported in Column (5) of Table 7, the coefficient of green finance development remains significantly negative, indicating that green finance development increases corporate credit risk.

4.3 Moderating effect analysis

4.3.1 Moderating effect of corporate internal resources

To examine the moderating role of corporate financial slack in the relationship between green finance development and corporate credit risk, we introduce two interaction terms into the baseline regression: the interaction between current ratio and green finance development ($Inter_1$), and the interaction between debt-to-equity ratio and green finance development ($Inter_2$). The corresponding estimation results are reported in Table 8.

The coefficient of $Inter_1$ is significantly positive at the 5% level, while the coefficient of $Inter_2$ is significantly negative at the 5% level. This finding reveals that corporate financial slack exerts a mitigating moderating effect on the positive association between green finance development and corporate credit risk, which verifies the second hypothesis of this study. Firms with high financial slack generally enjoy broader financing channels and sufficient cash flow. Thus, the financing volatility induced by green finance development is muted, which further alleviates the risk-amplifying effect of green finance on corporate credit risk.

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TABLE 8 Test of the moderating effect of corporate Internal Resources.

Variable	(1) DD	(2) DD	(3) DD
GF	−0.017***	−0.015***	−0.017***
	(0.005)	(0.005)	(0.005)
AS		0.001***	
		(0.000)	
$Inter_1$		0.008**	
		(0.003)	
PS			0.008***
			(0.002)
$Inter_2$			−0.027**
			(0.010)
Constant	0.146***	0.139***	0.149***
	(0.007)	(0.007)	(0.007)
Control variables	Yes	Yes	Yes
Enterprises-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
N	32,480	32,480	32,480
R^2	0.358	0.360	0.359

4.3.2 Moderating effect of firms' external development environment

To examine the moderating role of firms' external development environment in the relationship between green finance development and corporate credit risk, we incorporate the interaction term between regional technology market development and green finance development ($Inter_3$) into the baseline regression. The corresponding results are reported in Table 9.

The coefficient of $Inter_3$ is significantly positive at the 5% level. This finding suggests that the risk-amplifying effect of green finance development on corporate credit risk is mitigated in regions with mature technology markets, which verifies the third hypothesis of this study. Regions with mature technology markets feature an external environment with superior resource endowments and higher technology transaction efficiency. Meanwhile, information asymmetry between investors and firms is reduced, and multiple market participants jointly build a risk-sharing mechanism. Accordingly, the risk-amplifying effect of green finance development on corporate credit risk is mitigated.

4.4 Heterogeneity analysis

4.4.1 Corporate information transparency

Differences in corporate environmental information disclosure status can reshape how green finance affects firms' capital allocation and fund utilization behaviors, thereby generating heterogeneous impacts on corporate credit risk. Accordingly, we examine the heterogeneous impact of green finance on corporate credit risk based on firms' environmental information disclosure status. Firms with environmental information disclosure scores above the annual mean are classified as high-transparency enterprises, whereas those with scores below the annual mean are classified as low-transparency enterprises. The regression results are presented in Columns (1)–(2) of Table 10. For firms with low environmental information transparency, green finance significantly increases corporate credit risk, whereas its coefficient is statistically insignificant for high-transparency firms.

TABLE 9 Test of the moderating effect of the corporate external development environment.

Variable	(1) DD	(2) DD
GF	−0.017***	−0.017***
	(0.005)	(0.005)
TEC		0.001
		(0.001)
$Inter_3$		0.014**
		(0.005)
Constant	0.146***	0.145***
	(0.007)	(0.007)
Control variables	Yes	Yes
Enterprises-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes
N	32,480	32,480
R^2	0.358	0.358

According to information asymmetry theory, insufficient environmental information hinders accurate market pricing of corporate green transformation behaviors. Severe information friction triggers inefficient capital allocation, intensifies creditors' judgment divergence, and raises corporate financing volatility. In this context, the capital reallocation induced by green finance easily amplifies corporate default risk. Conversely, firms that actively disclose environmental information effectively reduce information asymmetry. Detailed disclosure of environmental compliance status and green innovation progress helps stabilize external investors' and creditors' expectations. Such transparent information constraints inefficient investment behaviors and smooth financing fluctuations, thereby offsetting the risk-amplifying effect of green finance.

4.4.2 Factor intensity of manufacturing industries

Differences in industrial factor endowments and production structures fundamentally determine firms' capital demand for low-carbon transformation, investment risk, and reliance on green credit, thereby generating heterogeneous responses to green finance shocks. Accordingly, this paper classifies manufacturing firms into labor-intensive, capital-intensive, and technology-intensive groups based on their industry attributes for grouped regression analysis. The corresponding results are presented in

TABLE 10 Heterogeneity Analysis-1.

Variable	(1) Low-transparency	(2) High-transparency	(3) Labor-intensive	(4) Capital-intensive	(5) Technology-intensive
GF	−0.021***	−0.013	−0.009	−0.013*	−0.021***
	(0.007)	(0.008)	(0.012)	(0.007)	(0.007)
Constant	0.156***	0.151***	0.112***	0.152***	0.144***
	(0.010)	(0.013)	(0.019)	(0.010)	(0.009)
Control variables	Yes	Yes	Yes	Yes	Yes
Enterprises-fixed effect	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes
N	17,736	14,744	3,436	9,357	19,687
R^2	0.366	0.333	0.400	0.383	0.341

Columns (3)–(5) of Table 10. The GF coefficient is statistically insignificant among labor-intensive firms. In contrast, green finance significantly elevates credit risk for both capital-intensive and technology-intensive enterprises, with the strongest effect observed in technology-intensive firms. The results further indicate that the GF coefficients differ across firms with different factor intensities.

In terms of theoretical mechanism, capital-intensive and technology-intensive industries require large-scale and long-term capital investment for low-carbon upgrading, making them highly dependent on green credit resources. Conversely, labor-intensive firms incur low green-transformation costs and rarely conduct large-scale long-term investment, which weakens their sensitivity to green finance policies. Such firms are less likely to generate over-investment incentives, resulting in an insignificant risk effect. Furthermore, capital-intensive firms mainly invest in fixed-asset renovation and equipment upgrading, which features predictable returns and relatively smooth capital fluctuations. However, technology-intensive firms focus heavily on green R&D activities with uncertain cycles and high failure risks. Access to abundant green financial resources easily triggers irrational investment expansion and severe financing volatility. Consequently, the risk-amplifying effect of green finance is most pronounced in technology-intensive enterprises.

4.4.3 Regional human capital development

Regional human capital endowments exert profound impacts on corporate innovation and sustainable operations, and also determine the implementation effectiveness of green finance policies. Accordingly, this paper explores the heterogeneous influence of green finance contingent on regional human capital levels. We measure regional human capital by the ratio of university students to the total resident population of each province. Samples are divided into high and low human capital groups based on the annual regional average value; regions with values below the average are classified as low-human-capital areas, and the rest are defined as high-human-capital areas. The corresponding heterogeneous regression results are reported in Columns (1)–(2) of Table 11. The results indicate that green finance significantly raises the credit risk of local enterprises located in regions with insufficient human capital, whereas its coefficient is statistically insignificant in areas with abundant human capital. The results further indicate a difference in the GF coefficients between low- and high-human-capital regions.

From the perspective of human capital theory, human capital carries positive externalities: professional talents can boost the overall productivity of market participants and generate cross-firm knowledge spillovers, forming regional comparative advantages. Under the development of green finance, regions with high-level human capital witness faster dissemination of green technologies and environmental knowledge, as well as higher efficiency of green investment. Such advantages reduce uncertainties and transaction costs during firms' low-carbon transformation, and further mitigate the two core transmission channels proposed in this paper, namely, the financing volatility effect and over-incentive effect. In summary, green finance exerts no significant risk-amplifying effect on enterprises in regions with abundant human capital, while the effect remains prominent for firms located in low-human-capital regions.

4.4.4 External market attention

As a typical informal external supervision mechanism, corporate external attention strengthens public monitoring and reputation constraints. So, variations in external attention can alter how green finance shapes firms' financing access and investment decisions, thus generating heterogeneous effects on corporate credit risk. This paper measures external attention by the total number of online news articles covering the listed firm each year. Firms with news counts below the annual industry average are categorized as the low external attention group, while those above the average belong to the high external attention group. The heterogeneous regression results are presented in Columns (3)–(4) of Table 11. The empirical results show that green finance significantly increases credit risk for firms with low

TABLE 11 Heterogeneity Analysis-2.

Variable	(1) Low-human-capital	(2) High-human-capital	(3) Low external attention	(4) High external attention
GF	−0.015***	−0.004	−0.020***	−0.011
	(0.005)	(0.014)	(0.006)	(0.009)
Constant	0.157***	0.142***	0.157***	0.109***
	(0.010)	(0.017)	(0.009)	(0.011)
Control variables	Yes	Yes	Yes	Yes
Enterprises-fixed effect	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes
N	21,079	11,401	22,063	10,417
R^2	0.373	0.326	0.333	0.427

external attention, whereas its impact on credit risk is statistically insignificant for firms receiving high external media coverage. The results further indicate a difference in the GF coefficients between firms with low and high external attention.

High external attention brings stringent public opinion supervision. Restricted by the magnification effect of negative news, enterprises tend to adopt more prudent investment strategies and curb irrational expansion behaviors, which substantially weakens the over-incentive channel triggered by green credit supply. In summary, strong external public monitoring can buffer the risk-amplifying effect of green finance, so green finance exerts no significant upward pressure on credit risk for firms with high external attention, unlike enterprises with limited media exposure.

5 Conclusions and suggestions

Green finance exerts a profound influence on the real economy, particularly the manufacturing sector. Using panel data of Chinese listed manufacturing firms from 2010 to 2024, this paper explores the impact of green finance development on corporate credit risk from the perspectives of financing fluctuation effects and over-incentive effects, and draws the following conclusions.

1. Green finance development raises corporate credit risk via financing fluctuation effects and over-incentive effects. Specifically, it exacerbates investor divergence, pushes up rent-seeking costs, and triggers overinvestment, all of which jointly elevate firms' credit risk.
2. As an internal disposable resource, corporate financial slack negatively moderates the risk-amplifying effect of green finance development. For firms with high available slack or potential slack, the upward impact of green finance development on corporate credit risk is significantly mitigated.
3. Firms' external development environment moderates the relationship between green finance development and corporate credit risk. A mature technology market can mitigate the risk-amplifying effect of green finance on corporate credit risk.
4. The risk-increasing effect of green finance on corporate credit risk is more prominent for four types of firms: enterprises with low environmental information transparency, capital-intensive and technology-intensive manufacturers, firms receiving limited external media attention, and those located in regions with insufficient human capital.

Drawing on the above research findings, this study proposes the following suggestions.

First, regulators should incorporate emerging risks such as financing volatility induced by green finance development into the existing corporate risk prevention and control framework, enabling green finance to better support the sustainable development of the real economy. Local governments need to further refine supporting policy systems, tighten market supervision, and boost information transparency to effectively mitigate information asymmetry and agency conflicts arising from green finance expansion. At the micro level, firms should adapt to the green finance trend, strengthen their capacity to identify and develop green technologies to shore up investor confidence. Meanwhile, they ought to upgrade internal governance and implement rational investment plans tailored to their operational conditions.

Second, policymakers should optimize green policy tools including green subsidies and tax incentives to help firms build financial resilience against risks arising from the green transition. When rolling out policies, local governments need to balance transition progress and fairness while adopting differentiated implementation standards. They should offer a transition buffer period for cash-strapped, highly leveraged brown enterprises, and curb capital market overheating and irrational stock market investment. For their part, firms ought to establish sound internal resource management systems and prioritize equity financing to optimize their debt structures.

Third, all stakeholders need to coordinate efforts to foster a sound external institutional environment for green finance

development. Authorities should incentivize media outlets to launch dedicated green finance investigation and reporting columns via awards and financial support, and promote high-quality supervisory coverage of enterprises, thereby cultivating a favorable atmosphere for green transformation. Meanwhile, strengthening intellectual property protection and rolling out targeted subsidies and tax incentives for green technology transactions can lay a solid foundation for mature technology trading markets.

Four, Regulators and local governments should construct unified public platforms for corporate environmental information disclosure and impose punitive measures on enterprises with missing or false environmental disclosures. Meanwhile, authorities should encourage media and third-party professional institutions to track and disclose the green investment and financing behaviors of manufacturing enterprises, forming continuous external reputational supervision to constrain irrational fund utilization among firms lacking public attention. Furthermore, governments need to establish industry-university-research platforms for the transformation of green technologies, expand the supply of professional green talents, and generate knowledge spillover effects.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

BZ: Visualization, Investigation, Data curation, Software, Writing – original draft, Conceptualization, Resources, Formal Analysis, Methodology. RL: Writing – review and editing, Writing – original draft, Methodology, Investigation, Validation, Project administration. YL: Project administration, Validation, Funding acquisition, Supervision, Writing – review and editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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