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The Relation Between ESG Performance, Financing Constraints, and Innovation Output: Empirical Evidence from Chinese Listed Companies

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Abstract:

As environmental, social, and governance (ESG) considerations increasingly shape corporate strategy, the link between ESG and innovation has drawn growing attention. Focusing on Chinese A-share listed firms, this paper examines whether ESG performance promotes innovation by easing financing constraints. Using a balanced panel comprising around 5,000 firms and 41,649 firm-year observations from 2012 to 2024, this report estimates fixed-effects models, measure innovation by patent applications (log) and R&D investment, capture financing constraints with the SA index, and implement mediation and robustness tests. ESG data are drawn from Huazheng ESG ratings. The results show that, first, ESG performance is positively and significantly associated with innovation output. Second, financing constraints partially mediate this relationship: stronger ESG practices alleviate external financing pressure, thereby fostering R&D and patenting. Third, hetero-genetic analyses indicate stronger effects among non-state-owned firms and technology-intensive industries. These findings suggest that firms should align ESG initiatives with innovation strategies to reduce financing frictions, while policymakers can strengthen green finance and disclosure regimes to channel capital toward firms with superior ESG and innovation potential.

Keywords: ESG; financing constraints; innovation output; Chinese listed companies.

1. Introduction

Environmental, Social, and Governance (ESG) performance has become a crucial strategic factor in China's capital markets, driven by government policies promoting green development and reforms in

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ESG disclosure frameworks [1]. ESG performance now plays a vital role as a non-financial indicator influencing firms‘ access to external financing and innovation output. Non-state-owned and small-to-medium-sized enterprises in China, facing high financing costs and limited funding options, can ease these constraints through superior ESG performance by enhancing transparency, building trust with stakeholders, and reducing environmental risk premiums [2]. Empirical studies show that ESG performance significantly drives green innovation, with financing constraints and managerial environmental awareness mediating this relationship. However, gaps remain, particularly in how ownership type and industry technology influence this relationship, and in the broader measurement of innovation beyond green innovation. This study focuses on Chinese A-share listed companies from 2012 to 2024, exploring how ESG performance impacts innovation output by alleviating financing constraints. Using data from around 5,000 firms and 41,649 firm-year observations, ESG performance is measured via Huazheng ESG ratings, and financing constraints are captured using the SA index. Innovation output is assessed through R&D expenditure and patent applications. The results show that ESG performance enhances innovation indirectly by easing financing constraints, with the strength of this effect varying across different ownership structures and industries [3].

2. Literature Review

2.1 Theoretical Foundations and Mechanism Pathways

Within the framework of stakeholder theory, superior ESG performance is regarded as a positive signal of firms' commitment to environmental and social responsibilities, thereby strengthening relational capital with investors, regulators, and the public. Based on Chinese A-share firms, ESG performance significantly alleviates financing constraints, mainly by improving corporate reputation and external relationships that enhance access to capital markets. From the lens of information asymmetry theory, ESG disclosure functions as a credible signal that reduces investors' uncertainty regarding firm risks and future cash flows [4]. Using data from Chinese manufacturing firms, it is demonstrated that financing constraints mediate the link between ESG and green innovation, indicating that higher ESG transparency reduces external financing frictions and facilitates innovation [5]. The resource-based view highlights that ESG embodies intangible strategic resources, such as governance quality, environmental investments, and human capital, which are difficult to imitate and crucial for sustainable innovation. Investor attention improves ESG performance, which in turn eases financing constraints and stimulates R&D investment, ultimately enhancing innovation output [6]. This finding aligns with the RBV notion that rare and inimitable resources provide long-term competitive advantage. In summary, the mechanism pathway can be summarized as follows: by enhancing ESG performance, firms strengthen stakeholder trust, improve information transparency, and accumulate unique strategic resources, which jointly alleviate financing constraints and foster innovation activities.

2.2 Empirical Evidence: ESG and Financing Constraints

A growing body of empirical research demonstrates that superior ESG performance significantly alleviates financing constraints among Chinese listed firms. Using data from A-share non-financial companies, a robust negative relationship is identified between ESG and financing constraints, particularly among non-state-owned firms, low-leverage firms, and those with higher board independence. Further evidence highlights the linkage between ESG, financing, and innovation. An analysis of A-share firms from 2010 to 2021 shows that ESG performance improves investment efficiency mainly by reducing under-investment, while its effect on curbing over-investment is weaker but still observable. Recent findings highlight digital transformation as a key moderating variable [7, 8]. In firms with higher levels of digital advancement, ESG performance is more effective in alleviating financing constraints, thus contributing to high-quality corporate development.

2.3 ESG Performance and Innovation Output

Empirical studies increasingly suggest that ESG performance supports innovation output, beyond its role in alleviating financing constraints. Evidence from Chinese A-share listed firms between 2011 and 2021 indicates that superior ESG performance significantly enhances technological innovation [9]. The mechanisms include external factors such as improving a firm's position in corporate networks and increasing institutional shareholding, and internal factors such as reducing labor costs and easing financing constraints . Furthermore, a positive association between ESG performance and green technological innovation (GTI) has been confirmed [6]. The effect is particularly pronounced in state-owned enterprises and in industries outside the high-tech sector. These studies underline ESG as a strategic enabler for innovation, not merely reflecting social responsibility but serving as a driver of firm innovation activities.

2.4 Integrated Mechanisms

Existing studies consistently confirm that financing constraints play a mediating role in the ESG–innovation

nexus. ESG performance promotes green innovation by easing financing constraints and strengthening human capital, with the governance component being most influential [10]. Similarly, based on a panel of 1,038 A-share companies from 2013 to 2023, ESG performance is shown to significantly reduce financing constraints by improving transparency, lowering financial risk, and enhancing access to credit [11], thereby fostering green innovation. Moreover, financing constraints are confirmed to serve as a significant mediating mechanism between ESG performance and corporate green innovation [12]. Collectively, these findings substantiate a coherent causal chain: ESG performance → mitigated financing constraints → enhanced innovation investment and output. Nevertheless, gaps remain. Most existing studies focus predominantly on green innovation, while broader innovation measures such as patenting and R&D investment have received less attention. In addition, evidence on heterogeneity across ownership structures, industry attributes, and regional contexts remains fragmented and inconclusive [13]. Thus, further empirical investigation is needed to assess how ESG performance alleviates financing constraints to stimulate innovation in a broader sense, while accounting for contextual differences. This constitutes the research gap that the present study seeks to address.

3. Methodology

3.1 Data and Sample Selection

This study investigates Chinese A-share listed firms during the period 2012–2024. The choice of this timeframe is based on two considerations. First, since 2012, China's ESG evaluation system has become increasingly standardized, with Huazheng ESG ratings offering reliable and consistent data for long-span panel research. Second, this period coincides with the government's growing emphasis on sustainable development and green transition, providing an appropriate institutional context to examine the link between ESG performance, financing constraints, and innovation. Several steps are taken to construct the final sample. First, financial firms, including banks, insurance companies, and securities firms, are excluded because their asset structures and regulatory frameworks differ substantially from those of non-financial enterprises. Second, firms under special treatment (ST and *ST) are removed, as they are typically subject to abnormal operations or potential delisting risks, which could bias the results. Third, firm-year observations with missing values in ESG ratings, patent data, or key financial indicators are deleted to ensure data integrity. Finally, all continuous variables are winsorized at the 1 percent and 99 percent levels to mitigate the influence of extreme values. After applying these criteria, the final dataset consists of approximately 5,000 listed firms and 41,649 firm-year observations, forming a balanced panel suitable for empirical analysis.

3.2 Variable Selection

This paper focuses on the variables used in the analysis of corporate innovation output. The dependent variable is the corporate innovation output, measured by the natural logarithm of the total number of patent applications (Patent). This measure serves as a comprehensive proxy for a firm's innovation capacity and output. For robustness checks, R&D expenditure (R&D) is also used as an alternative measure. The key independent variable of interest is the corporate ESG performance, which is measured by the Huazheng ESG rating, ranging from 1 to 9. A higher ESG score indicates better performance in the areas of environment, social responsibility, and corporate governance. Financing constraints serve as the mediating variable, measured by the SA index. A lower SA value indicates less severe financing constraints. In addition, several control variables are included in the model to mitigate omitted variable bias. These include firm size (Size), measured by the logarithm of total assets; leverage ratio (Lev), calculated as total debt to total assets; return on assets (ROA), which captures profitability; asset turnover ratio (ATO), reflecting efficiency in asset utilization; operating cash flow to total assets ratio (Cashflow), reflecting liquidity; ratio of fixed assets to total assets (FIXED), representing asset structure; board size (Board); a dummy variable for CEO-chairman duality (Dual), which equals 1 if the CEO and chairman are the same person and 0 otherwise; and the shareholding ratio of the largest shareholder (Top1), representing ownership concentration.

3.3 Model Specification

To examine the effect of ESG performance on corporate innovation output, the following baseline regression model is specified:

$$Patent_{it} = \alpha_0 + \alpha_1 ESG_{it} + \sum_k \beta_k Control_{k,it} + \mu_i + \lambda_t + \epsilon_{it} \quad (1)$$

Where $Patent_{it}$ denotes the innovation output of firm i in year t, measured by the logarithm of the number of patent applications. ESG_{it} represents the ESG performance score, $\mathrm{Control}_k$, it is a set of control variables, μ_i and λ_t denote firm and year fixed effects, respectively, and ϵ_{it} is the error term. To test the mediating role of financing constraints, the following stepwise models are constructed. First, this report estimates the impact of ESG performance on financing constraints:

$$SA_{it} = \gamma_0 + \gamma_1 ESG_{it} + \sum_k \delta_k Control_{k,it} + \mu_i + \lambda_t + \epsilon_{it} \quad (2)$$

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Where SA_{it} denotes the financing constraint index of firm i in year t, measured by the SA index. Second, this report incorporates financing constraints into the innovation regression model:

$$Patent_{it} = \theta_0 + \theta_1 ESG_{it} + \theta_2 SA_{it} + \sum_k \varphi_k Control_{k,it} + \mu_i + \lambda_t + \epsilon_{it}] \quad (3)$$

If θ_2 is statistically significant and the coefficient of $\theta_1 \mathrm{ESG}_{it}$, decreases in magnitude compared to the baseline model, this would suggest that financing constraints mediate the relationship between ESG performance and innovation output.

4. Analysis

4.1 Descriptive Statistics and Variable Characteristics

Based on the descriptive statistics reported in Table 1, there exists considerable variation across the main variables in the sample. Innovation output (Patent, measured as the logarithm of patent applications) has a mean of 1.694, a median of 1.609, with a maximum of 6.111 and a minimum of 0, suggesting substantial heterogeneity across firms and a right-skewed distribution. The average ESG rating is 4.123 with a standard deviation of 1.084, ranging from 1 to 9, which indicates notable differences in ESG performance among firms. Regarding control variables, firm size (Size) averages 22.180, implying that most firms are of medium scale; leverage (Lev) averages 0.409, reflecting a moderate overall debt level; return on assets (ROA) has a mean of 0.037 but ranges from -0.375 to 0.255, indicating large disparities in profitability. Asset turnover (ATO) averages 0.623, while cash flow ratio (Cashflow) averages 0.048, showing relatively low liquidity in many firms. The ratio of fixed assets (FIXED) has a means of 0.205, suggesting limited reliance on fixed assets. Board size (Board), measured in logarithmic form, averages 2.105, showing limited variation across firms. The duality of CEO and chair positions (Dual) averages 0.313, meaning that about 31.3% of firms combine the two roles. The largest shareholder's ownership (Top1) averages 0.332, indicating a relatively concentrated ownership structure. Overall, the descriptive statistics reveal substantial heterogeneity in firms' innovation output, governance structure, and financial conditions, providing the cross-sectional variation required for subsequent empirical analyses, as shown in Table 1.

Table 1. Descriptive Statistics of Main Variables

VarName	Obs	Mean	SD	Min	Median	Max
Patent	41649	1.694	1.609	0.000	1.609	6.111
ESG	41649	4.123	1.084	1.000	4.000	9.000
Size	41649	22.180	1.248	19.563	21.999	26.452
Lev	41649	0.409	0.205	0.035	0.399	0.935
ROA	41649	0.037	0.068	-0.375	0.037	0.255
ATO	41649	0.623	0.418	0.054	0.533	2.891
Cashflow	41649	0.048	0.067	-0.199	0.047	0.266
FIXED	41649	0.205	0.154	0.002	0.174	0.725
Board	41649	2.105	0.197	1.609	2.197	2.708
Dual	41649	0.313	0.464	0.000	0.000	1.000
Top1	41649	0.332	0.146	0.074	0.309	0.758

4.2 Correlation Analysis and Multicollinearity Test

As reported in Table 2, the correlation coefficient between ESG and innovation output (Patent) is 0.234 and statistically significant at the 1% level, suggesting that firms with higher ESG ratings tend to apply for more patents. This provides preliminary evidence supporting the positive ESG–innovation relationship. Among control variables, firm size (Size, correlation 0.083) and profitability (ROA, correlation 0.149) are both positively and significantly correlated with patent output, while leverage (Lev, correlation -0.067) is negatively and significantly correlated with innovation, consistent with the notion that larger and more profitable firms are more innovative, whereas higher leverage may crowd out R&D investment. By contrast, board size (Board) shows almost no correlation with patent applications, indicating a limited direct effect at the bivariate level.

As shown in Table 2, the correlation results suggest that firms with higher ESG ratings tend to innovate more.

Table 2. Correlation Analysis of Main Variables

Name	Patent	ESG	Size	Lev	ROA	ATO	Cashflow	FIXED	Board	Dual	Top1
Patent	1										
ESG	0.234***	1									
Size	0.083***	0.187***	1								
Lev	-0.067***	-0.128***	0.481***	1							
ROA	0.149***	0.227***	0.006	-0.366***	1						
ATO	0.035***	0.043***	0.080***	0.157***	0.197***	1					
Cash-flow	0.064***	0.106***	0.095***	-0.152***	0.432***	0.138***	1				
FIXED	-0.044***	-0.059***	0.144***	0.119***	-0.069***	-0.002	0.202***	1			
Board	0	0.024***	0.269***	0.147***	0.012**	0.020***	0.033***	0.130***	1		
Dual	0.063***	0.010**	-0.181***	-0.138***	0.040***	-0.023***	-0.011**	-0.097***	-0.182***	1	
Top1	0.033***	0.082***	0.146***	0.015***	0.161***	0.089***	0.115***	0.098***	0.013***	-0.046***	1

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the firm level are reported in parentheses. The same applies to the following tables.

Table 3 further reports the variance in inflation factor (VIF) test. All VIF values are well below the conventional threshold of 10, with a mean VIF of only 1.291. This suggests that multicollinearity is not a concern in the regression models, and the estimated coefficients can be interpreted reliably [14].

Table 3. Variance Inflation Factor (VIF) Test Results

Variables	VIF	1/VIF
Lev	1.753	571
Size	1.607	622
ROA	1.586	631
Cashflow	1.336	748
ESG	1.138	878
ATO	1.124	89
FIXED	1.123	891
Board	1.112	899
Top1	1.064	94
Dual	1.063	94
Mean_VIF	1.291	

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4.3 Benchmark Regression Results

Table 4 reports the benchmark regression results examining the impact of ESG on firms' innovation output. Columns (1) and (2) use the logarithm of patent applications as the dependent variable while controlling for firm and year fixed effects. The results indicate that the coefficients of ESG are 0.048 and 0.038, both positive and statistically significant at the 1% level. This suggests that better ESG performance is associated with higher innovation output, even after accounting for firm characteristics and unobserved heterogeneity [15].

Table 4. Benchmark Regression Results Analysis

VARIABLES	(1)	(2)
	Patent	Patent
ESG	0.048***	0.038***
	(0.007)	(0.007)
Size		0.080***
		(0.024)
Lev		-0.208***
		(0.071)
ROA		0.428***
		(0.117)
ATO		-0.008
	(0.035)	
Cashflow		-0.211**
		(0.088)
FIXED		0.061
		(0.102)
Board		-0.020
		(0.066)
Dual		-0.000
		(0.021)
Top1		0.339**
		(0.157)
Constant	1.498***	-0.238
	(0.027)	(0.543)
Firm	YES	YES
Year	YES	YES
Observations	41,649	41,649
R-squared	0.778	0.779

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the firm level are reported in parentheses. The same applies to the following tables.

Regarding control variables, firm size (Size) is positively and significantly related to innovation (coefficient = 0.080), implying that larger firms are more capable of engaging in R&D activities. Leverage (Lev) exerts a significantly negative effect (-0.208), suggesting that high debt levels may crowd out innovative investment. Profitability (ROA) shows a strong positive effect (0.428), consistent with the view that more profitable firms have greater resources for innovation. Cash flow ratio (Cashflow) is negatively significant (-0.211), indicating that liquidity constraints may hinder innovation. Other factors such as asset turnover (ATO), fixed asset ratio (FIXED), board size (Board), and CEO duality (Dual) show no significant effects. The largest shareholder's ownership (Top1), however, is positively significant (0.339 at the 5% level), suggesting that ownership concentration may encourage

innovation.

Overall, the benchmark regression results support the hypothesis that ESG performance positively promotes innovation output [16]. The findings remain robust and statistically significant after controlling firm-level characteristics and fixed effects.

4.4 Robustness Tests

To ensure the reliability of the benchmark results, Table 5 presents a series of robustness checks. First, in column (1), the dependent variable is replaced with R&D expenditure (RD). The ESG coefficient remains positive and significant at the 1% level (0.350), indicating that ESG promotes not only output-oriented innovation (patent applications) but also input-oriented innovation (R&D investment). Second, in column (2), the lagged ESG variable (L.ESG) is used, yielding a coefficient of 0.047, significant at the 1% level, suggesting that the results are robust to potential reverse causality. Third, in column (3), excluding the post-2020 sample to mitigate the potential influence of the COVID-19 pandemic, the ESG coefficient remains positive and significant (0.036). Finally, in column (4), changing the clustering level from the firm to the industry does not alter the results, with ESG remaining positive and significant (0.038 at the 1% level).

In sum, regardless of the specification—whether changing the dependent variable, introducing lags, excluding specific periods, or altering clustering methods—the positive impact of ESG on innovation output remains consistently robust, lending further credibility to the benchmark findings, as shown in Table 5.

Table 5. Robustness Test Results

MODELS	(1)	(2)	(3)	(4)
VARIABLES	RD	Patent	Patent	Patent
ESG	0.350***		0.036***	0.038***
	(0.048)		(0.009)	(0.008)
L.ESG		0.047***		
		(0.008)		
Size	1.858***	0.074***	0.006	0.080**
	(0.158)	(0.027)	(0.030)	(0.033)
Lev	-2.064***	-0.265***	0.025	-0.208**
	(0.340)	(0.078)	(0.093)	(0.084)
ROA	0.813	0.411***	0.532***	0.428***
	(0.577)	(0.123)	(0.161)	(0.136)
ATO	0.853**	0.008	-0.043	-0.008
	(0.331)	(0.037)	(0.046)	(0.036)
Cashflow	0.100	-0.241**	-0.119	-0.211**
	(0.462)	(0.095)	(0.111)	(0.102)
FIXED	1.180*	-0.031	0.338***	0.061
	(0.605)	(0.114)	(0.121)	(0.104)
Board	0.176	-0.035	-0.002	-0.020
	(0.441)	(0.070)	(0.084)	(0.067)
Dual	0.133	-0.002	0.034	-0.000
	(0.098)	(0.022)	(0.029)	(0.023)
Top1	0.400	0.305*	-0.021	0.339*
	(1.538)	(0.160)	(0.193)	(0.192)
Constant	-41.038***	-0.075	1.245*	-0.238
	(3.801)	(0.609)	(0.686)	(0.753)
Firm	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	41,649	35,499	20,602	41,649

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R-squared	0.700	0.796	0.815	0.779
Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the firm level are reported in parentheses. The same applies to the following tables.				

4.5 Mediation Effect Mechanism

To further investigate the mechanism through which ESG enhances firms' innovation, Table 6 incorporates financial constraints (measured by the SA index) as a mediating variable. The results show that ESG is significantly and negatively associated with financial constraints (coefficient = -0.004, significant at the 1% level), indicating that firms with better ESG performance are able to effectively alleviate financing frictions. This is consistent with the argument that strong ESG practices improve corporate reputation and reduce information asymmetry, thereby easing access to external capital. Moreover, financial constraints significantly hinder innovation output. The SA index has a coefficient of -0.415, negative and significant at the 5% level, suggesting that higher financing constraints lead to fewer patent applications. When both ESG and SA are included in the model, the coefficient of ESG remains positive and significant (0.036***), but its magnitude decreases compared to models without SA, implying that part of ESG's effect on innovation operates through the alleviation of financing constraints.

Overall, as shown in Table 6 these results confirm that ESG fosters innovation not only directly but also indirectly by mitigating financial constraints, providing strong evidence for the mediation mechanism.

Table 6. Mediation Effect Test Results

VARIABLES	(1)	(2)
	Patent	Patent
ESG	-0.004***	0.036***
	(0.000)	(0.007)
SA		-0.415**
		(0.182)
Size	0.003	0.081***
	(0.003)	(0.024)
Lev	0.045***	-0.189***
	(0.008)	(0.072)
ROA	-0.016	0.422***
	(0.010)	(0.116)
ATO	0.005	-0.006
	(0.004)	(0.035)
Cashflow	0.012*	-0.206**
	(0.007)	(0.088)
FIXED	-0.013	0.055
	(0.011)	(0.102)
Board	0.007	-0.017
	(0.005)	(0.066)
Dual	-0.003**	-0.002
	(0.001)	(0.021)
Top1	-0.073***	0.309**
	(0.016)	(0.157)
Constant	3.822***	1.349*
	(0.078)	(0.811)
Firm	YES	YES

Year	YES	YES
Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the firm level are reported in parentheses. The same applies to the following tables.		

4.6 Heterogeneity Analysis

To further examine whether the effect of ESG on innovation varies across different contexts, heterogeneity tests are conducted from the perspectives of ownership type and industry attributes.

First, Table 7 presents the results of ownership heterogeneity. The findings suggest that ESG has a stronger and more significant effect on patent output in non-state-owned enterprises (coefficient = 0.051, significant at the 1% level), while the effect in state-owned enterprises is weaker (coefficient = 0.019, less significant). This indicates that non-state-owned firms, facing more intense market competition and financial constraints, rely more heavily on ESG performance to strengthen innovation, whereas state-owned firms, with greater access to resources and policy support, experience limited marginal benefits from ESG practices.

Table 7. Heterogeneity Analysis: Ownership Structure

	(1)	(2)
VARIABLES	Patent	Patent
ESG	0.022**	0.041***
	(0.011)	(0.008)
Size	-0.000	0.138***
	(0.041)	(0.029)
Lev	0.034	-0.276***
	(0.135)	(0.082)
ROA	0.522**	0.316**
	(0.251)	(0.131)
ATO	0.009	-0.013
	(0.061)	(0.042)
Cashflow	-0.167	-0.214**
	(0.154)	(0.107)
FIXED	-0.168	0.249**
	(0.186)	(0.115)
Board	-0.126	0.022
	(0.111)	(0.082)
Dual	0.037	-0.011
	(0.044)	(0.024)
Top1	-0.379	0.676***
	(0.244)	(0.200)
Constant	1.796*	-1.580**
	(0.948)	(0.665)
Firm	YES	YES
Year	YES	YES
Chowtest	0.000	0.000
Observations	13,468	28,181
R-squared	0.792	0.769

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Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the firm level are reported in parentheses. The same applies to the following tables. Column (1) reports the results for state-owned enterprises, and Column (2) reports the results for non-state-owned enterprises.

Second, Table 8 reports the results of industry heterogeneity. The positive relationship between ESG and innovation output is more pronounced in high-tech enterprises (coefficient = 0.062, significant at the 1% level), whereas in non-high-tech firms, the coefficient is only 0.024 and less significant. This suggests that high-tech industries, being more dependent on R&D and patenting activities, are more sensitive to external reputation and financing conditions, making ESG performance more impactful for innovation.

Table 8. Heterogeneity Analysis: Industry Type

	(1)	(2)
VARIABLES	Patent	Patent
ESG	0.044***	0.034***
	(0.009)	(0.009)
Size	0.142***	0.089***
	(0.035)	(0.028)
Lev	-0.178*	-0.204**
	(0.106)	(0.091)
ROA	0.405**	0.231
	(0.158)	(0.173)
ATO	0.045	0.042
	(0.057)	(0.035)
Cashflow	-0.202	-0.215*
	(0.128)	(0.112)
FIXED	0.287**	-0.279*
	(0.143)	(0.143)
Board	-0.004	-0.012
	(0.090)	(0.092)
Dual	-0.018	0.034
	(0.027)	(0.033)
Top1	0.439*	0.147
	(0.231)	(0.216)
Constant	-1.379*	-0.972
	(0.810)	(0.633)
Firm	YES	YES
Year	YES	YES
Chowtest	0.000	0.000
Observations	25,832	15,817
R-squared	0.755	0.779

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the firm level are reported in parentheses. The same applies to the following tables. Column (1) reports the results for state-owned enterprises, and Column (2) reports the results for non-state-owned enterprises.

In summary, as shown in Table7 and Table 8, the heterogeneity analysis not only reinforces the main finding that ESG enhances innovation but also highlights that the effect is particularly salient in non-state-owned and high-

tech firms.

5. Conclusion

This study investigates the relationship between ESG performance, financing constraints, and innovation output using a balanced panel of Chinese A-share listed firms from 2012 to 2024. The empirical findings demonstrate that, first, ESG performance significantly enhances firms' innovation output, whether measured by patent applications or R&D expenditure, and the results remain robust across multiple specifications. Second, financing constraints serve as a partial mediator, whereby strong ESG practices alleviate external financing frictions by improving transparency and reputation, thereby fostering innovation. Third, heterogeneity analysis reveals that the positive ESG–innovation nexus is particularly pronounced among non-state-owned enterprises and technology-intensive firms. These results enrich the literature on ESG and innovation and provide practical implications: firms should integrate ESG initiatives with innovation strategies to reduce financing costs and unlock innovation potential, while policymakers should strengthen green finance mechanisms and disclosure regimes to channel capital toward firms with superior ESG and innovation capabilities, thereby advancing both economic performance and sustainable development.

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