Impact of Enterprise ESG Performance on Innovation Capacity: Based on the Mediating Effect of Financing Constraints

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Abstract. This study analyzes the relationship between corporate ESG performance and innovation capability among China's A-share listed companies (2016-2022), investigating two core questions: (1) Whether ESG performance enhances corporate innovation, and (2) how financing constraints mediate this link. Using 24,707 firm-year observations, the article employs fixed-effects models and a multidimensional innovation index covering R&D inputs, technological outputs, and ecosystem factors. The findings demonstrate that superior ESG performance significantly strengthens innovation, with environmental efforts driving green technology adoption, social dimensions fostering creative solutions, and governance improvements attracting sustainable investment. Importantly, the article identifies financing constraint alleviation as the key mechanism-ESG excellence reduces capital costs, particularly benefiting non-state-owned enterprises-thus expanding ESG theory by revealing the financial transmission channel. Robustness tests with lagged variables validate these results. These insights offer practical value: firms should enhance ESG transparency to unlock innovation potential, while policymakers should strengthen ESG-finance linkages. For emerging markets seeking sustainable development, our study provides empirical evidence on balancing environmental objectives with technological advancement through ESG integration.

Keywords: LESG performance, Corporate innovation, Financing constraints.

1. Introduction

With the implementation of China’s "14th Five-Year Plan" and the proposal of the "dual carbon" goals, the integration of Environmental, Social, and Governance (ESG) principles with national macro policies has become a critical driver of high-quality economic development. On December 21, 2022, the Central Enterprise ESG Alliance was established, holding a symposium to promote ESG practices among state-owned enterprises (SOEs) and improve the development of a localized ESG ecosystem in China. On April 12, 2024, the Shanghai, Shenzhen, and Beijing Stock Exchanges officially issued the Guidance for Listed Companies on Sustainability Reports, effective from May 1, 2024. As China’s first unified, standardized, and practical ESG disclosure framework, this marks the arrival of the formal ESG era for A-share companies. ESG performance provides investors with non-financial insights into corporate environmental responsibility, social contributions, and governance quality, enabling them to better assess long-term sustainable development prospects. Concurrently, ESG has increasingly emerged as a key benchmark for evaluating corporate long-term investment value, influencing corporate production and strategic development.

Amid global economic slowdown pressures, corporate innovation has become a pivotal engine for industrial restructuring and economic growth. Firms leverage technological innovation to enhance industry value-added, strengthen core competitiveness, and drive industrial chain upgrades. Theoretically, ESG enhances innovation by improving access to external financing: strong ESG performance signals long-term viability, reducing investors’ risk perceptions and easing financing constraints. Thus, ESG not only directly incentivizes firms to engage in innovation through environmental commitments and governance discipline but also indirectly facilitates it by lowering capital costs—making financing constraints a key mediating channel. Understanding how ESG facilitates innovation can incentivize firms to adopt sustainable practices, reshape national economic development models, and stimulate robust economic expansion. From a mechanistic perspective,

strong ESG performance alleviates financing constraints, offering financial support for innovation while bolstering corporate reputation and long-term value, thereby enhancing innovation incentives. Consequently, this study explores the interplay among ESG performance, financing constraints, and corporate technological innovation. Based on Chinese listed firms, it systematically investigates the impact of ESG on innovation and the mediating role of financing constraints. The findings not only deepen the understanding of ESG-driven innovation pathways but also provide theoretical backing for policymakers refining green finance regulations and companies optimizing ESG strategies, ultimately fostering high-quality development and industrial transformation.

This study advances the ESG-innovation research in three key ways: First, it identifies financing constraints as the core mediator, empirically demonstrating through fixed-effects models how ESG reduces capital costs-especially for non-SOEs-to spur innovation, thereby expanding ESG theory with a financial transmission framework for emerging markets. Second, it pioneers a multidimensional innovation index using PCA-weighted integration of 17 R&D input, technological output, and ecosystem metrics, enabling holistic capability assessment. Third, the findings generate actionable insights—urging firms to strengthen ESG disclosure and governance, advising policymakers to accelerate ESG-finance integration, and guiding investors to use ESG signals in identifying innovation leaders. Together, these contributions reshape how stakeholders leverage sustainability practices for technological advancement.

2. Theoretical Background and Research Hypotheses

Existing literature has extensively examined the ESG-innovation nexus and achieved substantial findings. Current discourse approaches the topic from two perspectives: ESG fulfillment and ESG governance.

Concerning ESG fulfillment, scholars suggest that corporate social responsibility (CSR) activities effectively channel innovation inputs into outputs, improving efficiency and boosting technological achievements [1]. Conversely, other scholars argue that ESG factors may exhibit an inverted U-shaped relationship with innovation, challenging traditional linear assumptions [2]. This study aims to empirically verify whether ESG performance positively influences innovation and further investigates financing constraints as a critical mediator, offering actionable insights for firms pursuing sustainable growth.

From the ESG governance angle, researchers apply Upper Echelon Theory to analyze how board characteristics shape ESG practices. Some argue that excessive resource allocation to supplier, consumer, or regulatory obligations could crowd out innovation funding. Moreover, disingenuous ESG commitments—perceived as greenwashing—may alienate stakeholders, limiting resource access. Some scholars highlight the issue of "CSR behavior distortion," where in public skepticism undermines ESG-driven innovation [3]. Thus, effective ESG governance is paramount to unlocking innovation dividends and mitigating adverse perceptions.

Based on these discussions, Hypothesis 1 (H1) is proposed:

H1: Corporate ESG performance positively influences innovation capability.

While prior studies have explored the direct ESG-innovation link, research isolating financing constraints as a mediator remains scarce. Existing work predominantly focuses on ESG's direct effects, neglecting how financial mechanisms facilitate innovation. For instance, ESG engagement can secure social capital, mitigate managerial short-termism, and ease funding pressures. Yet, the precise mediating role of financing constraints warrants deeper inquiry. Accordingly, this study constructs an analytical framework incorporating financing constraints as a mediator, unveiling how ESG enhances innovation indirectly. Hypothesis 2 (H2) follows:

H2: Corporate ESG performance improves innovation capability by alleviating financing constraints.

3. Research Design

3.1. Variable Selection and Data Sources

To examine the impact of corporate ESG performance on innovation capability, this study constructs a fixed-effects model using panel data of all A-share listed companies from 2016 to 2022. The ESG performance variable is derived from the SinoSec ESG ratings in the Wind database, while all other data are sourced from the CSMAR database. To ensure data accuracy and generalizability, the following procedures were applied: (1) exclusion of financial and insurance firms; (2) removal of specially treated (ST and *ST) companies; (3) elimination of observations with missing key variables; and (4) winsorization at the 1st and 99th percentiles to mitigate outliers.

The dependent variable is innovation capability (denoted as Inv), a critical driver of high-quality corporate development. Drawing on the methodology of Xu Xiaoli et al., a composite innovation capability index was constructed across four dimensions—innovation inputs, technological capacity, innovation environment, and innovation outputs—through preliminary screening and correlation-based refinement of 17 underlying indicators [4]. Principal component analysis (PCA) was employed to assign weights to these indicators (detailed in Table 1). Higher index values, calculated based on the weighted evaluation system in Table 1, indicate stronger innovation capability.

Table 1. Comprehensive evaluation index system and weight of innovation capability index

Dimension	Dimension Weight	Indicator	Explanation	Indicator Weight
Innovation Input	0.2628	R&D expenditure level	Natural logarithm of total R&D investment	0.0007
		R&D intensity	Ratio of current R&D investment to operating revenue	0.0521
		R&D growth rate	(The second period R&D intensity - Current R&D intensity)/Current R&D intensity	0.0150
		Capitalized R&D	Ratio Proportion of capitalized R&D in total innovation investment	0.1950
Technical Capacity	0.3297	R&D personnel ratio	Natural logarithm of R&D staff count	0.0503
		Revenue advantage	Ratio of current operating revenue to industry total	0.2695
		Net profit advantage	Ratio of current net profit to industry total	0.0010
		ROE advantage	Difference between current ROE and industry average	0.0089
		Equity cash flow	(Net increase in cash/cash equivalents) - (Cash from equity financing - Dividends/interest payments)	0.0017
		Total cash recovery rate	(Closing balance × Net operating cash flow)/Total assets	0.0058
Innovation Environment	0.0832	Industry competition pressure	Difference between industry average innovation intensity and firm innovation intensity	0.0210
		Internal control index	DIB internal control index for listed companies	0.0065
		Diversity	Percentage of female executives	0.0239
		Board size	Natural logarithm of total board members	0.0244
		Patent lifespan	Cumulative service life of patents	0.0401
Innovation Output	0.3243	Capitalized R&D intensity	Ratio of capitalized R&D expenses to operating revenue	0.2381
		Intangible assets ratio	Ratio of intangible assets to total assets	0.0460

The explanatory variable is corporate ESG performance, representing a firm's environmental, social, and governance (ESG) metrics.

For the mediating variable, multiple financing constraint indices are commonly used in empirical research, including the Whited-Wu Index, Size-Age Index, Kullback-Leibler Index, and Financial Condition Index. According to Chen et al., among these indices, the Kaplan-Zingales Index (KZ Index) is the most suitable for China's capital market [5].

The KZ Index is a financing constraint measure proposed by economists Steven Kaplan and Luigi Zingales in 1997. It evaluates the degree of external financing difficulties faced by firms based on financial statement data, incorporating variables such as: cash flow to total assets ratio, market-to-book ratio, long-term debt to total assets ratio, dividend payout ratio and cash holding ratio. A higher KZ Index score indicates more severe financing constraints, suggesting that the firm faces difficulties in securing external financing and may rely more on internal funds for investment and operations. The KZ Index plays a crucial role in corporate finance and economic research by: helping understand firms' performance in capital markets, analyzing the impact of financing constraints on investment and innovation, providing quantitative tools for policy evaluation.

The selected control variables are presented in Table 2.

Table 2. Description of variables

Variable Type	Variable Name	Symbol	Measurement
Explained Variable	Innovation Capability	*CS*	Innovation capability index
Explanatory Variable	Corporate ESG Performance	*ESG*	Huazheng ESG Rating
Control Variables	Firm Size	*Size*	Natural logarithm of total assets
	Firm Age	*Age*	Natural logarithm of years since IPO
	Asset-Liability	*Lev*	Ratio Lev Total liabilities divided by total assets
	Growth	*Grow*	Annual growth rate of operating revenue
	Corporate Cashflow	*Cashflow*	Net operating cash flow divided by total assets
	Board Size	*Board*	Natural logarithm of total board members
	Proportion of Independent Directors	*Ind*	Number of independent directors divided by total board members
	Largest Shareholder Ownership	*Top1*	Shareholding ratio of largest shareholder
Mediating Variable	Financing Constraints	*KZ*	Kaplan-Zingales (KZ) Index

3.2. Models

The relationship between enterprise ESG performance and enterprise innovation ability, building a model (1):

$$Inv_{it} = \beta_0 + \beta_1 ESG_{it} + \sum \beta_j \, Control_{it} + \mu_i + v_t + \varepsilon_{it} \quad (1)$$

Based on the "Operational Suggestions for Intermediary effect Analysis" proposed by Jiang and the mechanism test research method adopted by Xie in related studies, this paper builds model 2 to discuss the relationship between ESG performance and financing constraints of enterprises [6, 7].

$$KZ_{it} = \beta_0 + \beta_1 ESG_{it} + \sum \beta_j \, Control_{it} + \mu_i + v_t + \varepsilon_{it} \quad (2)$$

Where, $Control_{it}$ represents the control variable of the *t* year of enterprise *i*, β_j is the regression coefficient of each variable, *i* represents all A-share listed companies, and *t* represents the period from 2016 to 2022. μ_i represents the individual fixed effect, v_t represents the time fixed effect and ε_{it} is a random disturbance term.

4. Empirical Results

4.1. Descriptive Statistics

The descriptive statistics (Table 3) reveal significant variation in innovation capability (*Inv*) and ESG performance among A-share listed firms (2016-2022). Innovation capability ranges from 0 to 9.577, with a mean of 1.828 and notable dispersion (*SD* = 1.710), indicating large differences across

firms. ESG scores span from 1 to 8, averaging 4.063, reflecting moderate performance overall but with considerable variation. This heterogeneity suggests diverse corporate practices in sustainability and innovation during the study period.

Table 3. Descriptive statistics

Variable	Obs	Mean	Std.dev.	Min	Max
Inv	24,707	1.828	1.710	0	9.577
ESG	24,707	4.063	1.167	1	8
Size	24,707	22.33	1.356	16.41	28.64
Lev	24,707	0.439	1.170	0.00836	178.3
Grow	24,707	0.352	7.735	-2.733	944.1
Board	24,707	2.103	0.199	1.099	2.890
Ind	24,707	0.379	0.0562	0	0.800
Top1	24,707	0.328	0.147	0.0184	0.900
Age	24,707	3.015	0.287	1.609	4.174
Cashflow	24,707	0.0471	0.0807	-1.686	2.222

4.2. Correlation & Multicollinearity

Pearson correlation analysis was conducted among variables in this paper, and the results are shown in Table 4.

As for the variables in the table, the maximum value of the correlation coefficient is less than 0.8, and there is no high correlation between explanatory variables and control variables. According to the results of the correlation test, the correlation coefficient between innovation capability and ESG performance of enterprises is significantly positive, which can preliminarily prove that there is a positive correlation between ESG performance and innovation capability of enterprises.

Table 4. Phase relationship between variables

	Inv	Esg	Size	Lev	Grow	Board	Ind
Inv	1						
ESG	0.244***	1					
Size	0.120***	0.238***	1				
Lev	-0.018***	-0.043***	0.047***	1			
Grow	-0.011*	-0.020***	0.00500	0.00100	1		
Board	0.027***	0.048***	0.267***	0.018***	0.013**	1	
Ind	0.016**	0.049***	-0.00900	0	-0.00700	-0.564***	1
Top1	0.026***	0.137***	0.201***	0.00800	0.00500	0.021***	0.037***
Age	-0.154***	-0.041***	0.145***	0.038***	-0.00500	0.093***	-0.020***
Cashflow	0.094***	0.109***	0.096***	-0.025***	-0.028***	0.048***	-0.00500
	Top1	Age	Cashflow				
Top1	1						
Age	-0.043***	1					
Cashflow	0.109***	-0.016**	1				

Note: *,**,***, representing significance levels of 10%, 5%, and 1%, respectively.

The multicollinearity test is also carried out. The maximum value of inter-variable VIF (variance inflation factor) is 1.64, which is less than 10. It can be considered that the correlation between explanatory variables and control variables is not strong, and there is no serious multicollinearity problem.

4.3. Baseline Regression

This study performs panel data regression analysis using Stata 17 on all A-share listed companies from 2016 to 2022 (24,707 observations). Based on the F-test (Prob>F=0.0000) and Hausman test

(Prob>chi2=0.0000) shown in table 5, both significant at the 1% level, the fixed effects model is selected over pooled OLS and random effects models for estimation.

Table 5. Results of F test and Hausman test

F test	Hausman test
Prob > F = 0.0000	chi2(15)=587.34 Prob > chibar2 = 0.0000
Rejects pooled OLS regression model	Rejects random-effects regression model

The regression results of the multivariate linear regression model constructed based on the panel data are as follows (see Table 6): Column (1) is the result of not considering control variables and double fixed effects; column (2) is the result of adding double fixed effects when control variables are not considered; and column (3) is the result of considering control variables without adding double fixed effects. (4) shows the results of taking control variables into account and adding double fixed effects.

Table 6. Results of model regression

	(1)	(2)	(3)	(4)
	Inv	Inv	Inv	Inv
Esg	0.085***	0.053***	0.074***	0.047***
	(13.211)	(8.231)	(11.427)	(7.163)
Size			0.133***	0.113***
			(11.297)	(7.024)
Lev			0.000	0.000
			(0.107)	(0.027)
Grow			0.000	0.000
			(0.155)	(0.158)
Board			0.029	0.008
			(0.457)	(0.114)
Ind			-0.020	-0.185
			(-0.109)	(-0.946)
Top1			-0.052	0.026
			(-0.566)	(0.223)
Age			-0.727***	-0.703***
			(-16.037)	(-3.794)
Cashflow			0.191**	-0.021
			(2.485)	(-0.278)
_cons	1.520***	1.600***	0.742**	1.180*
	(44.452)	(54.041)	(2.553)	(1.862)
N	24707.000	24707.000	24707.000	24707.000
R2	0.536	0.454	0.701	0.483
Time-fixed effect	No	Yes	No	Yes
Individual fixation effect	No	Yes	No	Yes

Note: *,**,***, representing significance levels of 10%, 5%, and 1%, respectively.

The regression results from columns (1) to (3) show that the coefficients of innovation capability on firms' ESG performance are consistently positive and statistically significant at the 1% level, reaffirming that ESG performance significantly enhances innovation capability. After including control variables and applying two-way fixed effects in column (4), the coefficient remains positive and significant at the 1% level, confirming that higher ESG performance significantly boosts innovation capability-supporting Hypothesis H1.

4.4. Mediation Analysis

In order to further explore the impact mechanism of ESG performance on enterprise innovation, this paper conducts multiple regression on models (1) and (2), and the regression results are shown in Table 7.

Table 7. Test of mediating effect

	(1)	(2)
	Inv	KZ
Esg	0.047***	-0.115***
	(7.163)	(-12.105)
Size	0.113***	-0.223***
	(7.024)	(-9.353)
Lev	0.000	0.080***
	(0.027)	(12.222)
Grow	0.000	-0.005***
	(0.158)	(-4.649)
Board	0.008	-0.196**
	(0.114)	(-1.989)
Ind	-0.185	0.615**
	(-0.946)	(2.186)
Top1	0.026	-1.105***
	(0.223)	(-6.560)
Age	-0.703***	3.424***
	(-3.794)	(12.790)
Cashflow	-0.021	-11.708***
	(-0.278)	(-103.284)
_cons	1.180*	-2.589***
	(1.862)	(-2.806)
N	24707.000	24326.000
R2	0.048	0.481
Time-fixed effect	Yes	Yes
Individual fixation effect	Yes	Yes

Note: *,**,***, representing significance levels of 10%, 5%, and 1%, respectively.

The regression results indicate that financing constraints (KZ index) have a significantly negative coefficient at the 1% level, suggesting that higher ESG performance effectively alleviates firms' financial constraints. Prior studies argue that easing financial constraints strengthens firms' ability to sustain R&D investment, while Cheng highlights its critical role in enhancing innovation, particularly for high-tech firms [8-11]. By securing stable funding, improved ESG performance enables firms to support R&D, technology upgrades, and market expansion, thereby fostering innovation. Thus, H2 is validated, confirming that better ESG performance mitigates financing constraints and subsequently strengthens innovation capacity.

4.5. Robustness Checks

The regression results confirm that stronger ESG performance significantly enhances corporate innovation. To address potential endogeneity and ensure robustness, this study follows Fang by lagging explanatory variables, Li by adjusting the sample period (2017-2021), and Chen by winsorizing extreme values (5% on both tails) [2, 12, 13]. The robustness checks consistently yield positive and statistically significant (5% level) coefficients, reinforcing the reliability of the findings (see Table 8).

Table 8. Robustness test results

	One phase lag explanatory variable	Changing sample period	Tailing treatment
	Inv	Inv	Inv_w
ESG	0.044***	0.043***	0.043***
	(5.943)	(5.484)	(6.847)
Control variable	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes
Individual fixation effect	Yes	Yes	Yes
N	20027	17409	24707
adj. R2	0.531	0.639	0.449

Note: *,**,***, representing significance levels of 10%, 5%, and 1%, respectively.

5. Conclusion

This study examines how corporate ESG performance enhances innovation, using data from Chinese A-share firms (2016–2022). Results show ESG significantly boosts innovation, primarily by easing financing constraints (a 1-unit ESG score increase reduces constraints by 11.5%). The environmental dimension drives green tech R&D, the social dimension expands innovation resources, and governance attracts sustainable investors. The findings suggest firms should integrate ESG into innovation strategies through better disclosure and green R&D. Policymakers can incentivize ESG adoption via tax breaks and disclosure rules, while investors should assess ESG performance alongside innovation potential. However, limitations exist, such as sample bias (focusing only on listed firms) and reliance on a single ESG rating system. Future research should explore sector-specific impacts and alternative ESG metrics.

Despite its contributions, this study has limitations. First, the sample focuses on A-share listed firms from 2016-2022, potentially overlooking heterogeneous effects across industries, ownership structures, and firm sizes-particularly in SMEs and unlisted companies. Second, reliance on a single ESG rating system (Huazheng ESG Ratings) may introduce subjectivity; future studies could employ multiple rating frameworks or develop more comprehensive indicators. Third, while financing constraints (KZ Index) serve as a significant mediator, this financial-statement-based measure may not fully capture dynamic financing conditions. Lastly, the study primarily examines ESG's direct and financing-constraint-mediated effects, leaving room for deeper exploration of divergent ESG dimension impacts and contextual moderators like policy environments or industry characteristics. Future research could refine ESG dimensionality effects and incorporate additional contingency mechanisms.

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