

The Impact of ESG Performance on Innovation Research

-- Empirical evidence from A-share listed manufacturing industry

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Abstract. High-quality economic and social development has become the main theme of the current era, and the promotion of corporate ESG development is of great significance to the implementation of the new development concept of "innovation, harmony, greenness, openness and sharing". This paper takes 3,784 listed companies in Shanghai and Shenzhen A-shares from 2011 to 2021 as research samples, and conducts research on ESG performance and corporate innovation with the help of Stata17.0 software, based on which it further examines the roles of financing constraints, the proportion of QFII, and the characteristics of senior executives in this influence path. The study finds that: (1) ESG performance has a significant role in promoting corporate innovation; (2) ESG performance can alleviate financing constraints and increase the QFII ratio, thus enhancing corporate innovation; (3) executives with academic background and overseas study background can positively regulate the relationship between ESG performance and corporate innovation. (4) Firms in the eastern and central regions can promote R&D investment by improving ESG performance, and firms in the central region can promote corporate innovation performance more significantly by improving ESG performance. (5) Firms in the national region are able to promote innovation output by improving ESG performance, but state-owned enterprises are unable to improve R&D investment through ESG performance. The findings provide some empirical basis for further promoting corporate strategy development and improving corporate governance mechanisms.

Keywords: ESG Performance; Innovation Activity; Mediating Effect; Executive Characteristics.

1. Introduction

1.1. Background to the Study

The ESG performance of the manufacturing industry in the post epidemic era has received more attention from all walks of life. High-quality economic and social development has become the main theme of the current era, and the performance of enterprises in terms of Environmental, Social and Governance has been valued by countries all over the world. Promoting corporate ESG development is of great significance to the implementation of the new development concept of "Innovation, Harmony, Green, Openness and Sharing", which is conducive to the construction of a new pattern of China's economic "double-cycle" development, and the realisation of the "double-carbon" development goal as a national strategy. It is a national strategy to achieve the goal of "dual carbon" development.

Science and technology innovation will become the fundamental source of China's economic growth. The Twentieth National Congress report states that "high-quality development is the primary task of building a modern socialist country in all aspects". China needs to keep pace with the world's scientific and technological progress, but also need to make up for the historical legacy of insufficient innovation "debt". Active innovation on the basis of the original, break the original competitive pattern of mature industries, and the global market to amplify the economic results of innovation, which will be conducive to the promotion of sustained economic growth.

Therefore, can ESG performance help firms drive innovation? Does the relationship between the two change under different heterogeneous divisions, and through what path does ESG performance improve corporate innovation? Clarifying these questions will help investors and business operators

to consider ESG factors in their decision-making and promote sustainable development of enterprises and society.

The main contributions of this paper are: (1) The research results of this project will provide important theoretical and technical support for promoting the development of corporate innovation, improving the efficiency of corporate operations, and promoting the healthy development of the economy and society. (2) The project will explore the mechanism of ESG performance to improve corporate innovation from the perspective of financing constraints, and accordingly improve and expand the mechanism of ESG performance to improve corporate innovation, which provides a new way of thinking for enterprises to empower corporate innovation in the field of sustainable development, and optimises the strategic decision-making of enterprises, and provides a realistic path to achieve the expansion of domestic demand. (3) It puts forward corresponding countermeasures and suggestions from the three levels of government, industry and enterprise, contributing to the government's further construction of a good business environment and the industry association's promotion of enterprise innovation and development, and providing useful reference for enterprises to better use ESG performance to enhance enterprise innovation.

2. Literature Review

2.1. Literature Review on ESG Performance

At present, domestic and foreign scholars have basically formed a consensus on ESG-related research. Zhang Fuwei et al. (2021)[1] By analysing the current situation of ESG insurance and the pain points of ESG green insurance services, they propose to establish a professional ESG green insurance underwriting model, so as to promote the change of global production methods and lifestyles. Gao Jieying et al. (2021)[2] examined the impact of ESG on corporate investment efficiency and found that good ESG can improve corporate investment efficiency, but the impact of ESG on overinvestment and underinvestment is different. Li Jinglin et al. (2021)[3] used panel data of listed companies from 2010-2017 and found that good ESG ratings can help firms improve their financial performance. Yuan Yehu et al. (2021)[4] found that firms with high ESG ratings are more inclined to exhibit better performance levels. Wang Bo et al. (2021)[5] Found that ESG performance has a significant effect on both book value and market value of firms, and realises value effects through different channels of action. Bai Xueshi et al. (2021)[6] Propose that ESG investment by insurance organisations can bring multiple benefits, including ESG risk management, excess returns and positive environmental and social impacts. Zhang Changjiang et al. (2021)[7] Taking listed companies on the main board of Shanghai and Shenzhen in 2018-2020 as the research object, the study shows that good ESG performance can improve the market performance and financial performance of listed companies; compared with financial performance, investor confidence plays a more important positive transmission role in the market performance improvement of ESG performance. Aman Jin et al. (2022)[8] (2022) found that high ESG performance companies have higher green innovation capability and higher investment in green innovation; institutional investors will tolerate lower current excess return of listed companies with green innovation capability through China's institutional investors' investment in green innovation companies from 2010 to 2020.

Dimson et al. (2016)[9] Incorporating ESG issues into corporate ownership policies and practices from an active investor ownership perspective can drive long-term corporate performance on ESG issues, improve corporate social image and reputation, and emphasise the importance of long-term value creation. Li Chao et al. (2022)[11] found that ESG ratings can enhance corporate innovation in listed companies. Liu et al. (2022)[12] Introduced a data-driven ESG assessment method based on blockchain technology and stochastic multi-criteria acceptability analysis (SMAA-2) to address data opacity and assessment subjectivity. Chen et al. (2023)[13] demonstrated that Chinese ESG investors can be rewarded for doing good by constructing a comprehensive ESG score at the Chinese firm level covering all A-share stocks with China-specific ESG-related issues and NLP technology.

2.2. Literature Review on Corporate Innovation

There are also different views in the academic community on the impact of business performance on enterprise innovation. Some scholars believe that business performance is the "core pillar" of enterprise innovation, and good business operation can promote enterprise innovation. Zhu Yihong et al.[14] Taking the tenth survey of private enterprises of the National Federation of Industry and Commerce in 2012 as a sample, the OLS regression model was used to empirically test the impact of the return on total assets on the long-term technological innovation of enterprises, and it was found that there is a positive promotional effect. Guo Shengqing et al. (2020)[15] Selected 2011-2017 A-share private listed enterprises as a sample, constructed a multiple linear regression model for analysis, and found that a lower gearing ratio can significantly enhance the innovation investment of private enterprises. Luo Zhengtian et al. (2020)[16] Using the fuzzy set qualitative comparison method, confirmed that the return on total assets plays a key role in corporate innovation investment. Yan Ruosen et al. (2022)[17] found that good ESG performance can help firms enhance corporate green innovation through cash flow ratio, and He Jinan et al. (2022)[18] selected A-share listed state-owned enterprises from 2008-2019 for empirical analysis and found that the introduction of politically connected private shareholders by state-owned enterprises can further enhance corporate innovation.

Different scholars also hold different views on the study of the impact of enterprise size on enterprise innovation. One view is that enterprise size has a positive relationship with enterprise innovation. Wu Qiang et al. (2014)[19] examined the impact of different ways of government subsidies on enterprise technological innovation, and found that relative to SMEs, fixed subsidies and rate subsidies are more significant in improving the innovation level of large enterprises. Zheng Jianghuai et al. (2019)[20] found that firm size is positively related to the effect of government R&D subsidies.

One view is that firm size is negatively related to firm innovation, Bronzini et al. (2016)[21] found that government R&D subsidies have a significantly greater positive impact on SMEs than on large firms in Northern Italy. Cai Shaohong et al. (2019)[22] concluded that firm size is negatively related to government R&D subsidies, and that SMEs have more opportunities than large firms in terms of innovation policies. Shu Duan et al. (2020)[23] empirically examined private science and technology enterprises listed on SMEs from 2013-2017, and concluded that enterprise size plays a moderating role between government subsidies and enterprise innovation, and that the incentive effect of government subsidies diminishes with the growth of enterprise size. Li Dandan et al. (2022)[24] Using the data of A-share listed enterprises from 2010-2019, the study adopts the two-way fixed effects model, panel Tobit and instrumental variables method, and concludes that the effect of innovation policies and the incentive effect of government R&D subsidies on corporate innovation varies according to the size of the enterprise, and that the incentive effect is stronger for small- and medium-sized enterprises than for large-sized enterprises. Therefore, medium-sized enterprises are more likely to promote enterprise R&D innovation.

In terms of shareholding structure, some scholars have found that shareholding concentration positively affects corporate innovation. Maury et al. (2005)[25] found through research that the coexistence of multiple large shareholders will occur when shareholders collude with each other and make unfavourable decisions for the enterprise, thus inhibiting the innovative behaviour of the enterprise. Zhu Bing et al. (2018)[26] The study concluded that multiple large shareholders have the problem of excessive monitoring and make decisions that are too conservative, which affects the innovative activities of enterprises. Zhao Hongjiang et al. (2008)[27] used the WLS method to study the relationship between the governance structure of listed companies and technological innovation, and found that the more concentrated the shareholding, the stronger the technological innovation. Some scholars also hold a different view that equity concentration has a negative impact on corporate innovation. Li Xiaoqing et al. (2020)[28] concluded that in state-owned enterprises, equity diversity promotes corporate innovation performance. Wu Linrong et al. (2022)[29] Taking A-share listed enterprises from 2009 to 2020 as a research sample, the empirical study found that the equity structure of multiple major shareholders can significantly increase corporate innovation investment.

2.3. Literature Review on ESG and Corporate Innovation

In the traditional view of economics, the main business objective of a firm is considered to be maximising the value of the firm. And innovation is seen as one of the main ways to extend the life cycle of the firm and to achieve excess economic profits. However, in modern management mechanisms, such as the existence of separation of powers, there is often a principal-agent problem between owners and managers due to information asymmetry and other reasons (Zheng et al., 2021)[30]. Under asymmetric information conditions, investors and financial institutions tend to lack risk tolerance for firms as they are unable to form an effective supervision over the majority shareholders or management, and therefore prefer to invest in conventional projects with short cycle and low risk (Amore et al., 2013)[31].

With the increase in social issues and public concern over CSR, the ESG concept has gradually gained widespread attention and importance. ESG (Environmental, Social and Governance) is a sustainability concept that aims to balance the economic interests of enterprises with social values. The ESG concept emphasises positive corporate actions in environmental protection, social responsibility and good governance. By actively adopting environmentally friendly practices, companies can reduce their negative impact on the environment and be in line with societal expectations. In terms of social responsibility, companies can focus on employee welfare, community involvement, charity and philanthropy to meet the needs and expectations of society. Good governance practices can increase the transparency, accountability and stability of the firm and build a good reputation among investors and stakeholders (Ma et al., 2022)[32].

Therefore, ESG (environmental, social and governance) building does have certain costs and externalities. It involves corporate investment and action in environmental protection, social responsibility and good governance. However, the question of whether there is a conflict with the economic interests of the firm involves different views and theories, with the traditional neoclassical school of economics arguing that ESG construction may increase the costs of the firm and reduce its profitability, thus conflicting with the goal of maximising the value of the firm. According to this view, firms' investment in ESG construction may reduce resources for innovation and growth, limiting firms' potential for economic growth. However, stakeholder theory views ESG construction from a different perspective. Stakeholder theory suggests that firms should move from a single pursuit of entrepreneurial and investor interests to a broader balance of interests that takes into account the interests of stakeholders other than owners and managers. In this context, ESG construction is seen as a way to change the objectives and operations of the firm to achieve a balance between economic and social value. (Donaldson et al., 1995)[33].

3. Theoretical Analysis and Research Hypotheses

3.1. ESG Performance and Corporate Innovation

Based on stakeholder theory, the success and sustainability of a firm does not only depend on the maximisation of shareholders' interests, but also takes into account the interactions and relationships between the firm and its various stakeholders. Secondly, good ESG performance can increase a firm's access to innovative resources. For example, recognition of an enterprise's performance in environmental protection and sustainable development may attract more resource providers such as R&D partners and sponsors of technological innovations, further promoting the enterprise's innovation activities. In addition, some investors and financial institutions are increasingly inclined to invest their funds in enterprises with good ESG performance, providing more financing support for their innovation.

Overall, through good ESG performance, companies can gain stakeholder support, innovation resources, market opportunities and brand value, while also meeting regulatory and institutional requirements. Together, these factors drive companies to be more proactive and productive in innovation.

3.2. Path Analysis of ESG Performance and Corporate Innovation

(i) ESG Performance, Financing Constraints and corporate innovation

Financing constraints are indeed an important impediment to business innovation. Compared to conventional investments, innovation investments tend to have higher risks, longer payback periods and higher sunk costs. This requires firms to have greater stability and patience in their capital investments. The ESG strengths of companies offer new and viable solutions to this problem. Disclosing higher-quality financial information while building ESG also sends a positive signal to the outside world that firms are doing well (Huang et al., 2022).[35] . Although Rezaee et al. (2019)[36] argue that ESG disclosure can effectively reduce management's surplus management and opportunistic behaviours in financial disclosure, this paper argues that most firms are proactive and positive in considering ESG performance in terms of with corporate development. Improving the overall strength of enterprises, financing constraints are the core issues they focus on, and environmental and social concerns and commitments help reduce corporate environmental and social risks. This can reduce investors' and financial institutions' worries about the future business risks of enterprises and increase their trust. At the same time, good environmental and social performance by enterprises can also reduce possible legal and reputational risks, making them more favourable to suppliers of finance, which is the logic of the question itself.

(ii) ESG performance, QFII shareholding and corporate innovation

Globally, more and more institutional investors are taking ESG factors into account in their investment decisions. It is because ESG ratings are the new standard for foreign investors for domestic enterprises, so this paper argues that domestic enterprises' emphasis on ESG performance is more biased towards foreign qualified investors. ESG performance can help enterprises gain recognition from foreign institutional investors, which can enhance their innovation drive. Through good ESG performance, enterprises can obtain more investment opportunities, enhance investors' trust and recognition, attract long-term capital injection, and promote corporate innovation and change.

(iii) ESG performance, executive characteristics and corporate innovation

According to the innovation incentive theory, executives with academic backgrounds usually have rich professional knowledge and research experience, and can lead and promote innovation within the firm. They can apply their academic knowledge to the actual business and provide innovative ideas and methods for the organisation (Zhu Bing et al., 2018)[26] . Executives with overseas study backgrounds develop cross-cultural perspectives and global thinking through exposure to different countries and cultures. With a deeper understanding of different markets and business environments, they are able to introduce global best practices into their organisations and innovate with local contexts. They may have accumulated rich business networks and resources in different countries or regions, and are able to seek out more partners and opportunities for innovation, further driving up the ESG performance and innovation capability of the organisation. Executives with academic backgrounds and overseas studies usually focus on long-term planning and continuous development, and have a deeper knowledge of sustainability. They may pay more attention to environmental protection, social responsibility and good corporate governance, incorporating these factors into corporate strategies and decisions (Donaldson et al., 1995)[33] .

In short, executives with academic backgrounds and overseas study can help companies innovate. Their academic background gives them a wealth of knowledge and expertise in the field of innovation and enables them to provide insights and guidance. Overseas study gives them a cross-cultural and international perspective and ability to integrate innovation practices from different regions and countries into the firm's innovation strategy.

3.3. Formulation of Hypotheses

In this chapter, based on stakeholder theory, innovation incentive theory, and resource dependence theory, the relationship and path between ESG performance and corporate innovation are analysed in terms of mechanisms, and finally the following hypotheses are proposed:

Hypothesis H1: Other things being equal, good ESG performance drives firm innovation.

Hypothesis H2: Other things being equal, good ESG performance mitigates financing constraints and thus promotes firm innovation.

Hypothesis H3: Other things being equal, good ESG performance attracts foreign qualified investors (QFII ratio) and thus promotes corporate innovation.

Hypothesis H4: Other things being equal, executives with academic versus overseas background moderates the relationship between ESG performance and firm innovation.

4. Empirical Design

4.1. Study Sample Selection and Data Sources

The empirical data collection source channels of this paper mainly come from Cathay Pacific database, Wind, Resset database and CNRDS database, and the panel data of Shanghai and Shenzhen A-share listed manufacturing companies from 2011-2021 are selected as the research samples. In order to make the research results more realistic and objective, when screening the samples, this paper draws on the existing studies (Li Zongze et al., 2023)[37] treatment, including: 1) Excluding delisted, marked as *ST and ST enterprises, because the enterprises have been maintained in the loss status for two years, so the reference value of financial data is small, if used will have an impact on the reliability of the results. 2) Excluding observations with missing data. 3) Take the way of shrinking the tail to deal with all continuous variables, and the quantile standard is set to 1% and 99%. Finally, 3,784 listed manufacturing enterprises in Shanghai and Shenzhen A-shares are selected for this paper. In order to eliminate the effect of heteroskedasticity, this paper does logarithmic treatment to the data of the indicators that are absolute quantities in the variables involved in the empirical analysis.

(i) Explained variable: innovation (Inv)

This paper selects enterprise innovation as the explanatory variable. Enterprise innovation is mainly manifested as enterprise R&D investment and the number of invention patent applications owned by enterprises, and the innovation input aspect is manifested as enterprise R&D investment, while the innovation output is manifested as the total number of annual company invention patent applications. In the benchmark regression part, this paper refers to Qing Tao et al. (2021)[38], Zhang Dong et al. (2022)[39] 's research methodology to measure the level of corporate R&D input, and the natural logarithm of the company's annual R&D expenditure to measure the level of corporate R&D (Inv1). In terms of corporate innovation output, this paper draws on Wang Xianlu et al. (2022)[40] 's approach to measure corporate R&D output with the total number of annual company invention patent applications (Inv2). In the robustness test, this paper draws on Zhang Dong et al. (2022)[39] choosing R&D investment capacity (InvW) to replace the core explanatory variables for validation.

(ii) Explanatory variables: ESG performance (ESG)

Corporate ESG Performance (ESG). This paper draws on Xie Hongjun et al. (2022)[41], Wang Yu et al. (2022)[42] 's data sources and uses the CSI ESG rating system data as the explanatory variables of this paper in the benchmark model. The CSI ESG rating system classifies firms' ESG performance into nine levels, and the ratings are conducted four times a year. This paper assigns scores from 1 to 9 to these levels from C to AAA and calculates the average of the rating scores for each year as a firm's ESG performance for that year.

(iii) Control variables

Summarising previous studies in the relevant literature on innovation in listed companies, the control variables selected in this paper mainly include: firm size, return on total assets, gearing ratio, cash flow ratio, proportion of independent directors, proportion of shares held by the first largest shareholder and Tobin's Q.

(iv) Mediating variables

The first mediating variable: financing constraints, academics have used many different methods to measure financing constraints, the main ones often seen are indicators such as WW, KZ, and cash flow sensitivity. This paper draws on (Xu Yude, 2022)[43] The following formula is used to determine the value of the KZ index, and the variables used in the calculation include cash holdings of listed companies, dividend payout ratio, Tobin's Q, and operating cash flow, as shown below.

$$KZ_{i,t} = -\frac{1.002CF_{i,t}}{A_{i,t-1}} + 0.283Q_{i,t} + 3.139LEV_{i,t} - \frac{1.315C_{i,t}}{A_{i,t-1}} - \frac{39.368DIV_{i,t}}{A_{i,t-1}} \quad (1)$$

The smaller the KZ index, the lower the level of financing constraints, if the value of the index is relatively large, then it indicates a higher level of financing constraints.

The second mediating variable: QFII shareholdings, a number of countries and regions have implemented or are in the process of implementing ESG-related regulations and standards that foreign institutional investors must comply with. For example, the Sustainable Finance Action Plan implemented by the EU and the mandatory ESG reporting requirements in some countries have prompted foreign institutional investors to focus on the ESG performance of firms. This paper draws on Xiang Hailing (2022)[44] approach, the QFII shareholding ratio of listed companies is used as a measure of QFII shareholding, and the statistical calibre is the ratio of the market value of QFII shareholding to the total market value in circulation;

(v) Moderator variable: executive characteristics (Executive_H)

The senior management team is an important participant and decision maker in the selection of corporate strategy, the organisation of technological development, and the allocation of corporate resources, and is crucial to the promotion of corporate business performance. Senior management team refers to the operators who are entrusted by shareholders to manage corporate assets and receive compensation. Due to the dispersed nature of corporate equity, the senior management team plays an important role in strategic decision-making. This study examines senior management characteristics as moderating variables.

The main variables are defined in Table 1.

4.2. Modelling

(i) Baseline regression models

This paper collects all the above variables from the Cathay Pacific database and Wind database notes. In order to test the main hypothesis of this paper, i.e., research hypothesis 1, the following model is chosen for the empirical estimation process of this study. Since heteroskedasticity may have an impact on the results, robust standard errors are introduced to adjust for this situation.

$$RD_{i,t} = \beta_0 + \beta_1 Perfor_ESG_{i,t} + \beta_x \sum Controls_{i,t} + Ind + Year + Pov + \varepsilon_{i,t} \quad (2)$$

where i and t represent firms and time, respectively, $Perfor_ESG$ is ESG performance, RD denotes innovation performance, $Controls$ represents the ensemble of control variables, and $\varepsilon_{i,t}$ belongs to the residual term, is independent of the right-hand side variables and satisfies the normal distribution. Ind $Year$ is a dummy variable for industry, is a dummy variable for year (firms in the industry or year take 1, otherwise take 0), and Pov is a dummy variable for region. This paper

controls for year fixed effects, region fixed effects and industry fixed effects in the course of the study to improve the reliability of the conclusions.

Table 1. List of variable indicators

variant form	variable name	Variable Definition	Source of variables
explanatory variable	Level of R&D investment (Inv1)	The natural logarithm of the company's annual R&D expenses;	Cathay Pacific Database
	Level of R&D output (Inv2)	The natural logarithm of the number of patents owned by a firm;	
	R&D investment capacity (InvW)	The company's annual R&D outlay as a percentage of total assets;	
account for variant	ESG performance (ESG)	Calculated by the formula below;	Wind database
intermediary variable	Financing constraints (Kz)	Calculated by the formula below;	
	QFII holdings (QFII)	Market capitalisation of QFII holdings as a percentage of total market capitalisation outstanding;	
moderator variable	Proportion of executives with overseas background (Oversea_Ratio)	Ratio of executives with overseas background to the number of executives;	Resset database
	Proportion of executives with an academic background (Acade_Ratio)	Ratio of executives with academic backgrounds to the number of executives;	
containment variant	Enterprise size (Size)	The natural logarithm of a firm's total assets;	Cathay Pacific Database
	return on total assets (Roa)	Net profit of the enterprise as a proportion of the total assets of the enterprise.	
	gearing (Lev)	Total liabilities/total assets.	
	Total asset turnover (Ato)	Business income/average total assets of the enterprise for the year; and	
	Cash flow ratio (Cashflow)	Net cash flows from operating activities/operating income.	
	Proportion of independent directors (Indep)	Independent directors divided by the number of directors.	
	Percentage of shares held by the largest shareholder (Top1)	Total number of shares held by the first largest shareholder of the enterprise/total number of shares.	
	Tobin Q (TobinQ)	(Market value of outstanding shares + number of non-outstanding shares x net assets per share + book value of liabilities)/total assets.	
	vintages (year)	Observations are in the current year, Year is taken as 1, otherwise it is taken as 0, with 2011 as the base period.	
	district (not necessarily formal administrative unit) (Location)	The region where the sample is located, Location takes 1, otherwise it takes 0.	

Note: Organised by the author

(ii) Mediation effects test

In order to test the mediating mechanism of the impact of ESG performance on innovation, this paper tests the main effect by using financing constraints (Kz) and QFII shareholding (QFII) as mediating variables and constructs a corresponding research model.

$$Medor_{i,t} = \partial_0 + \partial_1 Perfor_ESG_{i,t} + \partial_x \sum Controls_{i,t} + Ind + Year + Pov + \varepsilon_{i,t} \quad (3)$$

$$RD_{i,t} = \lambda_0 + \lambda_1 Perfor_ESG_{i,t} + \lambda_2 Medor_{i,t} + \lambda_x \sum Controls_{i,t} + Ind + Year + Pov + \varepsilon_{i,t} \quad (4)$$

When the coefficients ∂_1 , λ_2 of $Perfor_ESG$ in (3) and (4) are significant and the coefficients of the mediating variables in (3) are significant, it means that the financing constraints of the firms and QFII play a mediating role.

(iii) Moderating effects test

In order to analyse the differences in the impact of ESG performance under different executive background characteristics, this paper adds the cross-multiplier term between the moderating variables and ESG performance to conduct the test. The specific model is as follows:

$$RD_{i,t} = \mu_0 + \mu_1 Perfor_ESG_{i,t} + \mu_2 Perfor_ESG \times X_Ratio + \mu_x \sum Controls_{i,t} + Ind + Year + Pov + \varepsilon_{i,t} \quad (5)$$

where i and t represent firms and time, respectively, and $Perfor_ESG$ is ESG performance. RD represents innovation performance, and $Controls$ is the control variable, where X_Ratio represents the interaction term between ESG performance and executive background, respectively, where the proportion of executive background includes: executive academic background ($Oversea_Ratio$) and executive overseas background ($Acade_Ratio$). In the process of empirical analysis, $\varepsilon_{i,t}$ is the residual term, which satisfies the normal distribution. Ind is the industry dummy variable, and $Year$ is the year dummy variable (enterprises in the industry, region or year take 1, otherwise take 0). This paper controls for year fixed effects, region fixed effects and industry fixed effects in the course of the research to improve the reliability of the conclusions.

(iv) Correlation test

This paper uses Pearson correlation coefficient analysis to test the correlation between ESG performance and corporate innovation activities, and also analyses the main variables in the model. The Pearson correlation coefficients are detailed in the Pearson correlation coefficient matrix in Table 2. The correlation coefficients of ESG performance (ESG), R&D input level (Inv1), R&D output level (Inv2) and R&D input capacity (InvW) correlation coefficients are all positive, and they all pass the 1% significance level test, indicating that there is a significant correlation between ESG performance and innovation behaviour, which preliminarily verifies the first hypothesis of this paper, and which lays the foundation for the following econometric regression test.

(v) Descriptive statistics

Firstly, the variables are analysed by descriptive statistics, and the following table shows the results of descriptive statistical analysis of the variables required for the study of this paper. Table 3 demonstrates the data of this paper with the data of the indicators of the national listed companies from 2011 to 2021.

Table 2. Pearson Correlation Coefficients

RD inv1	RD inv1	RD inv2	RD invW	Perfor~G	KZ	QFII	Overse~o
RD inv1	1						
RD inv2	0.605***	1					
RD invW	0.503***	0.288***	1				
Perfor ESG	0.183***	0.166***	-0.025***	1			
KZ	-0.070***	0.00300	-0.164***	-0.082***	1		
QFII	-0.361***	-0.296***	0.229***	-0.318***	-0.210***	1	
Oversea Ra~o	-0.022***	-0.020***	0	-0.025***	0.019***	0.015**	1
Acade Ratio	-0.018***	-0.015**	0.006	-0.015**	0.009	0.017***	0.856***
Size	0.516***	0.390***	-0.224***	0.352***	0.135***	-0.834***	-0.027***
Lev	0.153***	0.153***	-0.222***	0.057***	0.637***	-0.560***	-0.00500
ROA	0.123***	0.069***	0.134***	0.160***	-0.555***	0.082***	-0.053***
ATO	0.152***	0.038***	0.095***	0.064***	0.00400	-0.089***	-0.030***
Cashflow	0.024***	-0.010*	-0.004	0.092***	-0.502***	-0.062***	-0.016***
Indep	0.025***	0.015**	0.034***	-0.0100	-0.00500	-0.021***	0.00200
Top1	0.028***	0.00600	-0.125***	0.146***	-0.076***	-0.203***	-0.011*
TobinQ	-0.090***	-0.084***	0.260***	-0.065***	-0.063***	0.205***	-0.025***
	Acade ~o	Size	Lev	ROA	ATO	Cashflow	Indep
Acade Ratio	1						
Size	-0.024***	1					
Lev	-0.011*	0.515***	1				
ROA	-0.039***	0.008	-0.357***	1			
ATO	-0.022***	0.097***	0.180***	0.179***	1		
Cashflow	-0.014**	0.088***	-0.175***	0.300***	-0.153***	1	
Indep	0.004	-0.003	-0.011*	-0.013**	-0.028***	0.00700	1
Top1	-0.007	0.189***	0.057***	0.109***	0.096***	0.058***	0.045***
TobinQ	-0.024***	-0.349***	-0.281***	0.206***	-0.036***	0.096***	0.041***
	Top1	TobinQ					
Top1	1						
TobinQ	-0.094***	1					

Remarks: Stata 17.0 exported

From the statistical results, for the explanatory variables, the mean value of R&D input level (Inv1) is 17.87 with a standard deviation of 1.543, the mean value of R&D output level (Inv2) is 2.060 with a standard deviation of 1.481, and the mean value of R&D input capacity (InvW) is 0.023 with a standard deviation of 0.0200, and for the core explanatory variables, the mean value of ESG performance (ESG) has a mean value of 6.472 and a standard deviation of 1.130, with a maximum value of 9 and a minimum value of 3, indicating the existence of a better ESG performance among the sample firms.

As for the control variables, the mean value of the natural logarithm of enterprise size (Size) is 22.22, the standard deviation is 1.258, the maximum value is 25.89, and the minimum value is 20.04, which

indicates that the sample is evenly distributed; the mean value of the gearing ratio (Lev) is 0.414, and the standard deviation is 0.199, which indicates that the gearing ratio in the manufacturing enterprises is low.

Table 3. Descriptive Analysis

variable name	Number of variables	mean value	(statistics) standard deviation	minimum value	p25	p50	p75	maximum values
Inv1	25089	17.87	1.543	13.38	16.98	17.88	18.80	21.93
Inv2	25089	2.060	1.481	0	0.693	1.946	3.045	6.066
InvW	25089	0.023	0.020	0	0.009	0.019	0.030	0.101
ESG	25089	6.472	1.130	3	6	6	7	9
KZ	25089	0.879	2.353	-5.795	-0.501	1.135	2.466	6.528
QFII	25089	0.088	0.025	0	0.082	0.099	0.105	0.109
Oversea Ratio	25089	0.014	0.036	0	0	0	0.0100	0.526
Acade Ratio	25089	0.011	0.023	0	0	0	0.0100	0.295
Size	25089	22.22	1.258	20.04	21.31	22.03	22.93	25.89
Lev	25089	0.414	0.199	0.008	0.254	0.406	0.560	0.871
ROA	25089	0.040	0.065	-0.247	0.0140	0.0390	0.0720	0.214
ATO	25089	0.650	0.412	0.0650	0.386	0.560	0.797	2.577
Cashflow	25089	0.091	0.158	-0.706	0.0160	0.0820	0.163	0.695
Indep	25089	37.66	5.386	33.33	33.33	36.36	42.86	57.14
Top1	25089	33.83	14.03	9.880	23.11	32.98	42.59	70.29
TobinQ	25089	2.086	1.338	0.852	1.263	1.659	2.389	9.059

Data from: Cathay Pacific database, Wind and CNRDS database

The mean value of return on total assets (Roa) is 0.040 and the standard deviation is 0.065, with the maximum value of 0.214 and the minimum value of -0.247, which indicates that the overall profitability is low in the sample enterprises; the mean value of total asset turnover (Ato) is 0.650 and the standard deviation is 0.412, and the mean value of cash flow ratio (Cashflow) is 0.091 and the standard deviation is 0.158, indicating that the cash flow of manufacturing enterprises is relatively healthy. In terms of shareholders' shareholding, the average value of the proportion of independent directors (Indep) is 37.66, and the average value of the proportion of shares held by the first largest shareholder (Top1) is 33.83, which indicates that the proportion of directors in manufacturing enterprises are all around 30%. In terms of enterprise value, the average value of Tobin's Q (TobinQ) is 2.086, and the standard deviation is 1.338, both of which are in the range of 2-3, indicating that the value of manufacturing enterprises fluctuates less.

For mechanism variables, financing constraints (Kz) acts as a mediating variable, the mean value of financing constraints (Kz) is 0.879, and the standard deviation is 2.353. it indicates that there is a big problem of financing constraints in the operation of the sample firms. for the proportion of QFIIs, the mean is 0.088, and the standard deviation is 0.025. it indicates that the proportion of foreign qualified investors is still relatively low for the listed firms. The proportion of executives with academic background (Oversea_Ratio) and the proportion of executives with overseas background (Acade_Ratio) serve as moderating variables. The mean value of Oversea_Ratio is 0.014 with a standard deviation of 0.036, and the mean value of Acade_Ratio is 0.011 with a standard deviation of 0.023, which indicates that most of the enterprises in the manufacturing industry will improve the

financing efficiency and R&D level efficiency of the enterprises in the secondary market by recruiting the executives with the background of finance and academia. financing efficiency and R&D level efficiency.

5. Empirical Analysis of ESG Performance and Innovation Performance

5.1. Base Effect Regressions

As mentioned earlier, this chapter controls for year fixed effects and industry fixed effects. In evaluating the R&D innovation of listed firms, this chapter uses two indicators, the level of R&D inputs (Inv1) and the level of R&D outputs (Inv2), i.e. there are two explanatory variables examined in this chapter. Therefore, this section analyses the impact of firms' ESG performance on listed firms' innovation performance by establishing a two-way fixed effects model (model (2) above), and the control variables are selected as Size, Lev, ROA, ATO, Cashflow, Indep, TobinQ and Top1, and the specific empirical results are shown in Table 4.

The regression results show that the regression coefficients of the explanatory variable ESG performance (ESG) with the explanatory variables level of R&D input (Inv1) and level of R&D output (Inv2) are all positive and significant at the 1% level (Column (1): $\beta = 0.353, p < 0.01$; column (2): $\beta = 0.317, p < 0.01$), indicating that each unit increase in ESG performance will increase the level of R&D input by about 0.353 unit of R&D investment level or about 0.317 units of R&D investment intensity. This is a good proof that firms' ESG performance indeed promotes the improvement of innovation performance, which is consistent with the research hypothesis 1.

In the regression results of control variables, the positive effect of Size on R&D1 passes the 1% significance test, indicating that the enterprise size can increase the amount of enterprise R&D, and at this stage, China's large enterprises invest more in R&D innovation. However, the positive impact of Size on R&D2 passed the 1% significance test, indicating that from an overall point of view, the larger the enterprise scale, the more abundant funds, the higher the market share, the greater the demand for research and development of new products and technologies, the greater the amount of R&D invested in the R&D. The negative impact of Lev on R&D1 passed the 1% significance test, indicating that when the greater the corporate gearing, the smaller the amount of corporate R&D investment; Lev is the most important factor in the development of the R&D industry, the more important is the amount of corporate R&D investment. The negative impact of Lev on R&D2 passes the 1% significance test, indicating that from the overall point of view, listed companies belong to the need to finance the industry, the higher gearing is the necessary process of most enterprises, technological innovation is the fundamental driving force of enterprise development, R & D innovation is not the reason for enterprises to improve financial leverage. The positive impact of ROA on R&D1 All passed the 1% significance test, indicating that the higher the return on assets, the higher the level of R&D investment. The positive impact of ROA on R&D2 passed the 1% significance test, which may be due to the fact that some of the large enterprises can rely on their own reputation, through self-sourced financing to enhance the strength of the funds, the funds into R & D production, and strive to improve the market share by improving product technology. The positive effect of ATO on R&D1 passes the 1% significance test, and the positive effect of ATO on R&D2 passes the 10% significance test, which indicates that the faster the capital turnover rate of the enterprise, the higher the level of R&D. Cashflow on R&D1 fails to pass the significance test, and the negative effect of Cashflow on R&D2 passes the 1% significance test. Indep fails the significance test for R&D1 and R&D2. Top1 fails the significance test for R&D1 and Top1 passes the 5% significance test for negative correlation for R&D2. TobinQ passes the 1% significance test for the positive effect of R&D1 and R&D2, indicating that higher corporate Higher value means better operation and more sufficient funds for R&D investment.

The corrected decidable coefficients of the model are 60.3% and 38.7%, indicating that the overall fit of the model is better and the overall results are more reliable. In summary, the regression results

validate Hypothesis 1, indicating that corporate ESG performance can improve the innovation of listed companies.

Table 4. Base Effects Regression

	(1)	(2)	(3)	(4)
	a1	a2	a3	a4
VARIABLES	Inv1	Inv1	Inv2	Inv2
ESG	0.353***	0.0495***	0.317***	0.110***
	(20.16)	(4.194)	(19.46)	(8.157)
Size		0.845***		0.594***
		(53.91)		(31.53)
Lev		-0.780***		-0.175*
		(-8.244)		(-1.719)
ROA		0.519***		0.736***
		(2.776)		(3.593)
ATO		0.575***		0.0894*
		(11.29)		(1.848)
Cashflow		-0.0871		-0.346***
		(-1.071)		(-4.298)
Indep		-0.000923		-0.00118
		(-0.400)		(-0.427)
Top1		-0.00176		-0.00261**
		(-1.639)		(-2.102)
TobinQ		0.0505***		0.0415***
		(4.792)		(3.826)
Constant	15.59***	-1.307***	0.00891	-11.79***
	(139.5)	(-3.780)	(0.0867)	(-28.82)
Observations	25,089	25,089	25,089	25,089
R-squared	0.311	0.605	0.233	0.390
IND FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Pov FE	YES	YES	YES	YES
r2_a	0.309	0.603	0.230	0.387

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

5.2. Robustness Tests

Sample self-selection bias is a common phenomenon, and the regression samples in this paper are not the result of "random" selection, so there may be sample self-selection bias and the endogeneity

problem of omitted variables. In this paper, the instrumental variables method, replacement of explanatory variables and lagged one period are used to test for endogeneity.

(i) Instrumental variables

Table 5. Instrumental variables regression table

	(1)	(2)	(3)
	first stage	second stage	second stage
VARIABLES	Perfor_ESG	RD_inv1	RD_inv2
IV_ESG	0.133*** (5.322)		
Perfor_ESG		1.590*** (4.142)	2.315*** (4.683)
Size	0.366*** (54.87)	0.198 (1.400)	-0.314* (-1.728)
Lev	-0.655*** (-14.86)	-0.178 (-0.658)	1.172*** (3.358)
ROA	1.647*** (13.61)	-1.372** (-2.007)	-2.161** (-2.454)
ATO	0.0659*** (3.800)	0.323*** (7.501)	-0.197*** (-3.549)
Cashflow	0.0367 (0.763)	-0.682*** (-6.902)	-0.898*** (-7.058)
Indep	-0.00297** (-2.441)	0.0130*** (4.844)	0.0113*** (3.269)
Top1	0.00495*** (10.21)	-0.0184*** (-8.116)	-0.0203*** (-6.949)
TobinQ	0.0270*** (4.918)	0.0469*** (3.052)	-0.0128 (-0.649)
Constant	-1.114*** (-6.244)	3.200*** (4.570)	-5.835*** (-6.473)
Observations	25,089	25,089	25,089
R-squared	0.163		
IND FE	YES	YES	YES
Year FE	YES	YES	YES
Pov FE	YES	YES	YES

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

In order to address the problem of bi-directional causality and omitted variables, this paper uses instrumental variables for validation. This paper draws on Fang Xianming et al. (2023)[49] study, ESG fund shareholding data is selected as an instrumental variable for ESG performance. The reasons are as follows: ESG fund holdings are closely associated with the development of ESG performance

through ESG performance of the company's investment in the company; on the other hand, there is no direct path of influence between ESG fund holdings and firms' return on total assets. Therefore, ESG fund holdings are suitable as an instrumental variable for ESG performance. The regression method used is two-stage least squares (2SLS).

Table 6. Replacement of explanatory variables

	(1)	(2)
	a1	a2
VARIABLES	InvW	InvW
ESG	0.000675***	0.00102***
	(3.404)	(5.581)
Size		-0.00122***
		(-4.728)
Lev		-0.00636***
		(-4.650)
ROA		0.0113***
		(3.454)
ATO		0.00900***
		(12.19)
Cashflow		-0.000243
		(-0.234)
Indep		-1.58e-05
		(-0.442)
Top1		-3.44e-05**
		(-2.181)
TobinQ		0.00199***
		(8.212)
Constant	0.0182***	0.0370***
	(14.13)	(6.581)
Observations	25,089	25,089
R-squared	0.342	0.406
IND FE	YES	YES
Year FE	YES	YES
Pov FE	YES	YES
r2_a	0.340	0.403

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

Table 5 demonstrates the instrumental variables regression results, Column (1) demonstrates the results of the first stage regression, the coefficient of IV_ESG is significantly positive at the 1 per cent level, indicating that the correlation requirement of the instrumental variables is met. According to the results in Column (2), the coefficient of IV_ESG is 0.133, which is significant at the 1 per cent level, indicating that ESG performance improves firm innovation, and the regression using 2SLS yields largely consistent results. This is generally consistent with the previous findings. The results of the remaining dimensional variables in the regression using 2SLS also remain consistent and will not be repeated here.

Table 7. Lag phase

	(1)	(2)	(3)	(4)
	a1	a2	a3	a4
VARIABLES	Inv1	Inv1	Inv2	Inv2
L.ESG	0.356***	0.0460***	0.326***	0.106***
	(18.92)	(3.658)	(18.21)	(7.242)
Size		0.855***		0.619***
		(52.96)		(31.15)
Lev		-0.652***		-0.174
		(-6.574)		(-1.564)
ROA		0.548***		0.859***
		(2.860)		(3.995)
ATO		0.586***		0.110**
		(10.66)		(2.079)
Cashflow		-0.0420		-0.392***
		(-0.479)		(-4.311)
Indep		-0.000642		-0.00113
		(-0.269)		(-0.382)
Top1		-0.00200*		-0.00279**
		(-1.789)		(-2.080)
TobinQ		0.0554***		0.0443***
		(5.059)		(3.711)
Constant	15.72***	-1.503***	0.0456	-12.30***
	(130.6)	(-4.229)	(0.402)	(-28.63)
Observations	20,643	20,643	20,643	20,643
R-squared	0.301	0.620	0.230	0.398
IND FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Pov FE	YES	YES	YES	YES
r2_a	0.298	0.619	0.227	0.395

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

(ii) Substitution of explanatory variables

In order to further verify the robustness of the findings, the explanatory variables are replaced with the R&D investment capacity (InvW) below, which is the natural logarithm of the firm's annual R&D outlay as a percentage of total assets, and then the regression is re-run in accordance with model (1). Table 6 demonstrates the regression results, the coefficient of ESG performance (ESG) is still significantly positive, in general, after replacing the explanatory variables, ESG performance still promotes R&D and innovation of listed firms, which verifies the robustness of the benchmark regression conclusions.

(iii) One period behind

To further verify the robustness of the findings, the core explanatory variable is lagged by one period below, denoted as L.ESG. and the regression is re-run using Model 1. Table 7 demonstrates the regression results. In the two columns of results, the regression coefficients of L.ESG with Inv1 and Inv2 are 0.0460 and 0.106 respectively, which are significantly positive and pass the 1% significance test respectively, and the significance remains unchanged. Overall, Hypothesis 1 still holds after replacing the core explanatory variables, indicating that the findings of the benchmark regression are robust and reliable. In conclusion, ESG performance can promote corporate innovation.

5.3. Heterogeneity Analysis

(i) Geographical division

Considering the unbalanced level of economic development, this paper adopts Chen Aizhen (2023)[47] regional sample classification method. The 31 prefecture-level cities in the sample (excluding Tibet) are divided into three regions: eastern, central and western for regression analysis. The specific provinces are divided as follows: the eastern region includes 11 provinces such as Beijing, the central region includes 8 provinces such as Hubei, and the western region includes 11 provinces such as Yunnan.

Table 8 reports the regression results for R&D investment: the regression coefficients of ESG performance (ESG) and the level of R&D investment (Inv1) are significantly positive when the Eastern region (Column (1): $\beta = 0.0365, p < 0.1$), i.e., the regression coefficients are 0.0365, both significant at the 1% level, and the above results are generally consistent with the existing literature. The regression coefficient of ESG performance (ESG) on the level of R&D investment (Inv1) is significantly positive among firms in the central region (Column (2): $\beta = 0.0984, p < 0.01$), Column (3) is for the western region sample and the results show that the regression coefficient of ESG performance (ESG) on the level of R&D investment (Inv1) is not significant (Column (3): $\beta = 0.0472, p > 0.1$), Column (4) is the national sample and the regression coefficient of ESG performance (ESG) on the level of R&D investment (Inv1) is significantly positive (Column (4): $\beta = 0.0495, p < 0.01$). In conclusion, firms in the Eastern and Central regions are able to promote R&D investment by improving ESG performance.

Tables 9 report the regression results for R&D output: the regression coefficients of ESG performance (ESG) and the level of R&D output (Inv2) are significantly positive when the Eastern region (Column (1): $\beta = 0.109, p < 0.1$), i.e., the regression coefficients are 0.109, both significant at the 1% level, and the above results are generally consistent with the existing literature. Among the firms in the central region, the regression coefficient of ESG performance (ESG) on the level of R&D output (Inv2) is significantly positive (Column (2): $\beta = 0.120, p < 0.01$), Column (3) is for the Western region sample, and the results show that the regression coefficient of ESG performance (ESG) on the level of R&D output (Inv2) is also significantly positive (Column (3): $\beta = 0.0901, p < 0.01$), Column (4) is the national sample and the regression coefficient of ESG performance (ESG) on the level of R&D output (Inv2) is significantly positive (Column (4): $\beta = 0.110, p < 0.01$). In conclusion, in the central region firms are able to promote innovation output best by improving ESG performance.

Table 8. Heterogeneity Analysis1

	(1)	(2)	(3)	(4)
	the east	central section	western part	nationwide
VARIABLES	Inv1	Inv1	Inv1	Inv1
ESG	0.0365***	0.0984***	0.0472	0.0495***
	(2.757)	(3.514)	(1.168)	(4.194)
Size	0.841***	0.875***	0.851***	0.845***
	(46.17)	(19.74)	(18.45)	(53.91)
Lev	-0.678***	-0.719***	-1.035***	-0.780***
	(-6.032)	(-3.222)	(-3.713)	(-8.244)
ROA	0.725***	-0.243	0.733	0.519***
	(3.474)	(-0.523)	(1.135)	(2.776)
ATO	0.517***	0.649***	0.898***	0.575***
	(8.382)	(5.767)	(6.320)	(11.29)
Cashflow	-0.151	0.282	-0.165	-0.0871
	(-1.566)	(1.296)	(-0.803)	(-1.071)
Indep	-0.000389	-0.000293	-0.000889	-0.000923
	(-0.156)	(-0.0546)	(-1.073)	(-0.400)
Top1	-0.00353***	0.00491	-0.00202	-0.00176
	(-2.941)	(1.626)	(-0.599)	(-1.639)
TobinQ	0.0649***	0.00304	0.0233	0.0505***
	(5.356)	(0.103)	(0.854)	(4.792)
Constant	-0.990**	-2.573***	-1.674	-1.307***
	(-2.466)	(-2.628)	(-1.620)	(-3.780)
Observations	17,444	3,525	3,075	25,089
R-squared	0.619	0.642	0.606	0.605
IND FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Pov FE	YES	YES	YES	YES
r2_a	0.617	0.635	0.597	0.603

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

Table 9. Heterogeneity Analysis2

	(1)	(2)	(3)	(4)
	the east	central section	western part	nationwide
VARIABLES	Inv2	Inv2	Inv2	Inv2
ESG	0.109***	0.120***	0.0901***	0.110***
	(6.401)	(3.735)	(2.649)	(8.157)
Size	0.610***	0.531***	0.554***	0.594***
	(26.92)	(10.87)	(11.85)	(31.53)
Lev	-0.112	0.00176	-0.145	-0.175*
	(-0.890)	(0.00716)	(-0.590)	(-1.719)
ROA	0.991***	0.0182	0.228	0.736***
	(4.102)	(0.0337)	(0.390)	(3.593)
ATO	0.0491	0.0809	0.584***	0.0894*
	(0.812)	(0.734)	(4.711)	(1.848)
Cashflow	-0.370***	-0.0600	-0.368**	-0.346***
	(-3.633)	(-0.309)	(-2.064)	(-4.298)
Indep	-0.000819	-0.00327	-0.00445	-0.00118
	(-0.247)	(-0.480)	(-0.630)	(-0.427)
Top1	-0.00359**	0.00105	-1.78e-05	-0.00261**
	(-2.313)	(0.358)	(-0.00579)	(-2.102)
TobinQ	0.0486***	0.0188	0.0220	0.0415***
	(3.814)	(0.608)	(0.698)	(3.826)
Constant	-12.08***	-10.51***	-11.21***	-11.79***
	(-24.81)	(-9.761)	(-10.96)	(-28.82)
Observations	17,444	3,525	3,075	25,089
R-squared	0.385	0.463	0.448	0.390
IND FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Pov FE	YES	YES	YES	YES
r2_a	0.382	0.452	0.435	0.387

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

(ii) Nature of the enterprise

Tables 10 report the regression results by firm nature: when it comes to R&D investment, the regression coefficients between ESG performance (ESG) and the level of R&D investment (Inv1) are insignificant for state-owned firms (Column (1): $\beta = 0.0380$, $p > 0.1$), but for non-state-owned firms, the regression coefficient between ESG performance (ESG) and the level of R&D investment (Inv1) is significant (Column (2): $\beta = 0.0699$, $p < 0.1$), i.e., the regression coefficients are 0.0699 , all of which are significant at the 1 per cent level, and the above results are generally consistent with the existing literature.

Table 10. Heterogeneity Analysis3

	(1)	(2)	(3)	(4)
	state-owned business	non-state enterprise	state-owned business	non-state enterprise
VARIABLES	Inv1	Inv1	Inv2	Inv2
ESG	0.0380	0.0699***	0.105***	0.102***
	(1.603)	(5.639)	(4.075)	(6.723)
Size	0.848***	0.855***	0.610***	0.565***
	(27.97)	(47.67)	(17.48)	(24.89)
Lev	-0.838***	-0.667***	-0.313	-0.0827
	(-4.533)	(-6.240)	(-1.535)	(-0.724)
ROA	0.952**	0.276	1.285***	0.719***
	(1.996)	(1.480)	(2.704)	(3.317)
ATO	0.498***	0.575***	0.0551	0.0455
	(6.256)	(9.496)	(0.661)	(0.801)
Cashflow	-0.283	0.0472	-0.641***	-0.248***
	(-1.543)	(0.562)	(-3.748)	(-2.786)
Indep	0.00320	-0.00317	0.00919*	-0.00607**
	(0.668)	(-1.344)	(1.785)	(-1.983)
Top1	0.000688	-0.00103	-0.00298	-0.00294**
	(0.309)	(-0.916)	(-1.249)	(-2.081)
TobinQ	0.0219	0.0613***	0.0853***	0.0300**
	(0.927)	(5.353)	(3.210)	(2.547)
Constant	-1.813***	-1.462***	-12.64***	-10.83***
	(-2.722)	(-3.648)	(-16.86)	(-21.44)
Observations	7,673	17,415	7,673	17,415
R-squared	0.649	0.603	0.503	0.336
IND FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Pov FE	YES	YES	YES	YES
r2_a	0.645	0.601	0.497	0.332

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

When it comes to R&D output, the regression coefficients of ESG performance (ESG) on the level of R&D output (Inv2) are significantly positive for all firms (Column (3): $\beta = 0.105$, $p < 0.01$; Column (4) $\beta = 0.102$, $p < 0.01$). In summary, firms in the national region are able to promote innovation output by improving ESG performance, but R&D investment cannot be improved by ESG performance among state-owned firms.

5.4. Mechanism of Action Test

Table 11. Analysis of Intermediation Effects (Financing Constraints KZ)

	(1)	(2)	(3)
	a1	a2	a3
VARIABLES	KZ	Inv1	Inv2
KZ		-0.0436***	-0.0168*
		(-5.614)	(-1.880)
ESG	-0.0230**	0.0485***	0.110***
	(-1.964)	(4.126)	(8.134)
Size	-0.0678***	0.842***	0.593***
	(-4.305)	(53.68)	(31.43)
Lev	6.717***	-0.487***	-0.0623
	(71.15)	(-4.516)	(-0.516)
ROA	-10.13***	0.0773	0.567***
	(-40.57)	(0.404)	(2.764)
ATO	-0.568***	0.550***	0.0799*
	(-13.04)	(10.86)	(1.646)
Cashflow	-4.906***	-0.301***	-0.429***
	(-45.04)	(-3.142)	(-4.595)
Indep	0.00176	-0.000846	-0.00115
	(0.772)	(-0.367)	(-0.417)
Top1	-0.00674***	-0.00206*	-0.00273**
	(-6.756)	(-1.907)	(-2.187)
TobinQ	0.421***	0.0688***	0.0485***
	(30.38)	(6.171)	(4.215)
Constant	0.264	-1.295***	-11.78***
	(0.780)	(-3.753)	(-28.80)
Observations	25,089	25,089	25,089
R-squared	0.723	0.606	0.390
IND FE	YES	YES	YES
Year FE	YES	YES	YES
Pov FE	YES	YES	YES
r2_a	0.722	0.604	0.387

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

(i) Intermediation effects

Table 12. Analysis of Intermediation Effects (QFII Proportion)

	(1)	(2)	(3)
	a1	a2	a3
VARIABLES	QFII	RD_inv1	RD_inv2
QFII		4.876***	0.447
		(4.522)	(0.400)
Perfor_ESG	0.0873***	0.0536***	0.111***
	(7.100)	(4.549)	(8.168)
Size	-0.0157***	0.923***	0.603***
	(-73.16)	(42.64)	(25.67)
Lev	-0.0223***	-0.680***	-0.172
	(-15.37)	(-7.201)	(-1.640)
ROA	0.0302***	0.360*	0.733***
	(13.46)	(1.933)	(3.561)
ATO	0.0163***	0.577***	0.0883*
	(3.163)	(11.36)	(1.806)
Cashflow	-0.0477***	-0.0925	-0.403***
	(-5.001)	(-1.083)	(-4.753)
Indep	-0.0126***	-0.000296	-0.00111
	(-5.151)	(-0.128)	(-0.402)
Top1	-0.0642***	-0.00146	-0.00257**
	(-5.926)	(-1.352)	(-2.063)
TobinQ	-0.0350***	0.0708***	0.0466***
	(-19.58)	(6.859)	(4.083)
Constant	0.464***	-3.611***	-12.04***
	(98.94)	(-6.360)	(-20.12)
Observations	25,089	25,089	25,089
R-squared	0.778	0.606	0.390
IND FE	YES	YES	YES
Year FE	YES	YES	YES
Pov FE	YES	YES	YES
r2_a	0.778	0.605	0.388

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

In this paper, financing constraints (KZ) are used as a mediating variable to analyse and test the ESG performance affecting the innovative R&D path of listed companies.

As can be seen in Tables 11, ESG performance (ESG) is significantly negatively correlated with financing constraints (KZ) in terms of R&D investment (Inv1) (Column (1): $\beta = -0.0230, p < 0.05$). The results of column (2) show that the coefficients of KZ and ESG are significant (column (2): $\beta(KZ) = -0.0436, p < 0.01$; $\beta(Perfor_ESG) = 0.0485, p < 0.01$), which indicates the presence of mediation effect.

In terms of R&D output (Inv2), ESG performance (ESG) is significantly and positively related to financing constraints (KZ) (Column (1): $\beta = -0.0230, p < 0.05$) The results in column (3) show that the coefficients of KZ and Inv2 are significant (column (2): $\beta(KZ) = -0.0168, p < 0.1$; $\beta(RD_inv2) = 0.110, p < 0.01$), which also indicates the presence of mediation effect.

As can be seen in Tables 12, ESG performance (ESG) is significantly and positively correlated with the proportion of QFII (QFII) in terms of R&D investment (Inv1) (Column (1): $\beta = 0.0873, p < 0.01$). The results of column (2) show that the coefficients of QFII and ESG are significant (column (2): $\beta(QFII) = 4.876, p < 0.01$; $\beta(Perfor_ESG) = 0.0536, p < 0.01$), which indicates that the mediation effect exists and is partial.

In terms of R&D output (Inv2), ESG performance (ESG) is significantly and positively related to the proportion of QFII (QFII) (Column (1): $\beta = 0.0873, p < 0.01$) The results in column (3) show that the coefficients of QFII and Inv2 are not significant (column (2): $\beta(QFII) = 0.447, p > 0.1$), which also indicates that the mediation effect does not exist. In summary, it can be seen that ESG performance can indeed attract QFIIs and thus enhance firms' R&D investment, but it does not help firms' innovation output, which is in line with expectations.

(ii) Moderating effects

In this study, executives' overseas study and academic backgrounds are used as moderating variables, which are substituted into the model to obtain Tables 13. The results show that executives' overseas backgrounds positively moderated the positive effect between ESG performance and firms' innovation inputs (Column (1): $c.Perfor_ESG \# c.Oversea_Ratio = 0.374$, $P < 0.05$; $ESG = 0.0439$, $P < 0.01$), Column 2 shows that executive overseas background cannot significantly moderate the positive effect between government subsidies and firms' output level, (Column (2): $c.Perfor_ESG \# c.Oversea_Ratio = 0.199$, $p > 0.1$). Overall, executives' overseas background can bring positive effects on the relationship between firms' ESG performance and innovation investment. Their global perspective, sense of social responsibility, internationalisation of resources and ability to enhance corporate reputation will help to drive firms' ESG performance and further promote innovation inputs.

In terms of executive academic background, the results show that executive academic background positively moderates the positive effect between ESG performance and firms' investment in innovation (Column (1): $c.Perfor_ESG \# c.Acade_Ratio = 0.624$, $p < 0.05$; $ESG = 0.0427$, $p < 0.01$), Column 2 shows that executive academic background cannot significantly moderate the positive effect between government subsidies and firms' output levels, (Column (2): $c.Perfor_ESG \# c.Acade_Ratio = 0.292$, $p > 0.1$).

5.5. Expanding Research

ESG investment helps reduce a company's risk exposure and can effectively prevent the risk of stock price collapse. Due to the lack of a standardised and mandatory ESG disclosure system, the content and calibre of ESG information disclosure has not yet been standardised, and the lack of relevant market regulation has led to the possibility of some companies exaggerating their ESG performance (Fang Xianming, et al. 2023)[49]

Table 13. Analysis of Moderating Effects (Overseas Background of Executives)

	(1)	(2)
	a1	a2
VARIABLES	Inv1	Inv2
ESG	0.0439***	0.107***
	(3.577)	(7.691)
Oversea_Ratio	-2.230**	-1.283
	(-1.997)	(-1.132)
c.ESG#c.Oversea_Ratio	0.374**	0.199
	(2.159)	(1.095)
Size	0.847***	0.596***
	(54.05)	(31.64)
Lev	-0.788***	-0.182*
	(-8.317)	(-1.783)
ROA	0.506***	0.743***
	(2.711)	(3.621)
ATO	0.585***	0.0890*
	(11.50)	(1.822)
Cashflow	-0.115	-0.405***
	(-1.347)	(-4.765)
Indep	-0.000881	-0.00115
	(-0.382)	(-0.416)
Top1	-0.00178*	-0.00261**
	(-1.656)	(-2.098)
TobinQ	0.0538***	0.0450***
	(5.029)	(4.039)
Constant	-1.323***	-11.81***
	(-3.823)	(-28.81)
Observations	25,089	25,089
R-squared	0.605	0.390
IND FE	YES	YES
Year FE	YES	YES
Pov FE	YES	YES
r2_a	0.604	0.388

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

Table 14. Moderating Effects (Executive Academic Background)

	(1)	(2)
	a1	a2
VARIABLES	Inv1	Inv2
ESG	0.0427***	0.107***
	(3.461)	(7.612)
Acade_Ratio	-3.853**	-1.670
	(-2.227)	(-0.938)
c.ESG#c.Acade_Ratio	0.624**	0.292
	(2.334)	(1.037)
Size	0.847***	0.596***
	(54.07)	(31.64)
Lev	-0.789***	-0.182*
	(-8.325)	(-1.783)
ROA	0.505***	0.747***
	(2.705)	(3.642)
ATO	0.585***	0.0891*
	(11.50)	(1.826)
Cashflow	-0.115	-0.405***
	(-1.348)	(-4.766)
Indep	-0.000885	-0.00116
	(-0.383)	(-0.419)
Top1	-0.00178*	-0.00261**
	(-1.657)	(-2.100)
TobinQ	0.0537***	0.0450***
	(5.019)	(4.044)
Constant	-1.312***	-11.81***
	(-3.790)	(-28.78)
Observations	25,089	25,089
R-squared	0.605	0.390
IND FE	YES	YES
Year FE	YES	YES
Pov FE	YES	YES
r2_a	0.604	0.388

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

The Due to the differences in the rating systems of different institutions, ESG ratings are subject to uncertainty, which can lead to bias in investor judgement. In the capital market, risk events such as "black swans" and "green swans" are common, and uncertainty in ESG ratings will lead to lower investor demand and risk tolerance for green securities, higher risk premiums, and an impact on the daily operations of companies (Avramov et al., 2011). impact (Avramov et al. (2022))[48] . Therefore, in this paper, ESG disconfirmation is used as a moderating variable to validate the relationship between ESG and innovative activities. Referring to Fang Xianming et al. (2023)[49] (2023), first, select two sets of rating data and screen the listed companies with common coverage, sort them by different years, and also calculate their quartiles in the sample of that year; second, calculate the standard deviation of the quartiles of the same company under different ratings; third, repeat steps one and two, and calculate the standard deviation of a total of 10 combinations of the five sets of rating data in turn, and average them to obtain the ESG uncertainty indicator (ESG_Std). The resulting econometric model is as follows.

$$RD_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 ESG_Std_{i,t} + \beta_3 ESG_{i,t} \times ESG_Std_{i,t} + \beta_x \sum Controls_{i,t} + Ind + Year + Pov + \varepsilon_{i,t} \quad (6)$$

Table 15. Moderating Effects (ESG Uncertainty)

	(1)	(2)
	a1	a2
VARIABLES	Inv1	Inv2
ESG	0.0368***	0.0124**
	(3.710)	(2.355)
ESG_Std	0.0708***	0.00424
	(4.232)	(0.477)
c.ESG#c. ESG_Std	-0.0767***	-0.0691***
	(-3.727)	(-5.873)
Constant	-1.312***	-11.81***
	(-3.790)	(-28.78)
Observations	25,089	25,089
R-squared	0.605	0.390
Control FE	YES	YES
IND FE	YES	YES
Year FE	YES	YES
Pov FE	YES	YES

Source: Compiled from Stata17 estimates;

Note: Values in parentheses are T-values. ***, ** and * indicate 1, 5 and 10 per cent significance levels, respectively.

Table 15 shows the results for ESG uncertainty, which negatively moderates the positive effect of ESG and R&D investment when the explanatory variable is R&D investment (Column (1): $c. ESG \# c. ESG_Std = -0.0767$, $p < 0.01$; $ESG = 0.0368$, $p < 0.01$). When the explanatory variable is R&D investment, ESG uncertainty negatively moderates the positive effect of ESG and innovation performance (Column (2): $c. ESG \# c. ESG_Std = -0.0691$, $p < 0.01$; $ESG = 0.0124$, $p < 0.05$). Taken together, this suggests that ESG uncertainty can have an adverse effect on firms' ability to enhance innovation through ESG performance. ESG uncertainty may have an adverse effect on firms' ability to enhance innovation through ESG performance, including financial constraints, regulatory risks, market pressures, and the negative impact of brand image. Firms should recognise the impact of ESG factors on their business and take proactive steps to manage and respond to the associated uncertainty.

6. Conclusion of the Study and Recommendations for Countermeasures

6.1. Conclusion of the Study

This paper takes 3,784 listed companies in Shanghai and Shenzhen A-shares from 2011 to 2021 as research samples, and conducts research on ESG performance and corporate innovation with the help of Stata17.0 software, based on which it further examines the roles of financing constraints, the proportion of QFII, and the characteristics of senior executives in this influence path. The study finds that: (1) ESG performance has a significant role in promoting corporate innovation; (2) ESG performance can alleviate financing constraints and increase the proportion of QFII so as to enhance corporate innovation; (3) executives with academic background and overseas study background can positively regulate the relationship between ESG performance and corporate innovation. (4) Firms in the eastern and central regions can promote R&D investment by improving ESG performance, and firms in the central region can promote corporate innovation performance more significantly by improving ESG performance. (5) Firms in the national region are able to promote innovation output by improving ESG performance, but state-owned enterprises are unable to improve R&D investment through ESG performance. The findings provide some empirical basis for further promoting corporate strategy development and improving corporate governance mechanisms.

6.2. Recommendations for Countermeasures

(i) Government level

Formulate and implement policies and regulations that are conducive to ESG performance improvement: The government can introduce relevant policies, such as providing rewards and incentives, to encourage companies to improve their ESG performance, especially for state-owned enterprises, which can be given more policy support and guidance.

Improving ESG data disclosure and reporting requirements: The government can formulate stricter ESG data disclosure and reporting requirements, and require companies to transparently disclose ESG information in their financial reports, thus promoting companies to pay more attention to ESG performance. First, the government can establish financial and auditing regulations that require companies to disclose ESG-related information in their financial reports. This would increase transparency and prompt companies to pay more attention to ESG issues and provide relevant information to investors and stakeholders. Second, considering that enterprises may need to gradually improve their ESG data collection and reporting capabilities, the government can set phased disclosure requirements. For example, companies could be required to disclose key ESG indicators and risk management measures first, and then gradually expand the scope and depth of disclosure. This will help provide companies with adaptability and feasibility, while prompting them to gradually improve their ESG data disclosure.

Strengthening ESG education and training: The government can help enterprises understand and master ESG concepts, implementation methods and best practices by providing training and education

programmes. First, the government can cooperate with relevant institutions and professional organisations to conduct ESG training courses and seminars to provide enterprises with ESG-related knowledge and skills. The training can cover basic ESG concepts, ESG assessment and reporting methods, ESG management tools and frameworks, etc. These training courses can be conducted either online or offline so that companies can easily participate in the learning process. Second, the government can create incentives to encourage companies to participate in ESG training and education. For example, the government can set up an incentive programme to give awards or certifications to enterprises that participate in training and achieve results in practice. This can increase the participation and motivation of enterprises and promote the effective promotion and application of ESG education and training.

(ii) Industry level

Promote industry associations to establish ESG guidelines: Industry associations can develop and promote ESG standards and guidelines within the industry to help companies better understand the importance of ESG in implementation and provide guidance and support. Firstly, industry associations can set up a specialised ESG working group, comprising experts from the industry and representatives from relevant companies. This working group can be responsible for researching and developing ESG standards and guidelines within the industry, and collaborating with government, academia and other stakeholders to ensure its professionalism and influence. Second, based on industry characteristics and ESG principles, this working group could develop ESG guidelines within the industry to provide guidance and advice on implementing ESG. These guidelines could include the selection of ESG indicators and measurement methods, ESG management and reporting requirements, stakeholder engagement and communication, and so on. The industry association can publish and promote these guidelines to its members and encourage companies to follow the guidelines for ESG implementation.

Promote ESG information sharing and learning platforms within the industry: Industry associations can establish platforms for companies to share ESG practical experience, best practices and innovative ideas in order to promote knowledge exchange and learning within the industry. First, industry associations can set up specialised ESG consulting and support organisations to provide enterprises with consulting and guidance services in ESG implementation. These organisations can be set up by industry associations in cooperation with professional organisations to provide customised consulting and support to help companies solve specific problems and challenges in ESG implementation. Second, industry associations can establish partnerships with other industry associations, government agencies and academia to jointly promote the development and promotion of ESG guidelines within the industry. By exchanging experiences and sharing resources, industry associations can increase the awareness and application of ESG across the industry.

(iii) Enterprise level

Incorporating ESG into innovation strategies: Incorporating ESG factors into a firm's innovation strategy and decision-making process as a key driver of innovation. Incorporate ESG objectives into a company's short- and long-term innovation plans to ensure that the direction and goals of innovation are aligned with ESG values. By integrating ESG factors, companies can reduce adverse impacts and identify more sustainable innovation opportunities with long-term value.

Enhancing ESG data analytics and innovation connectivity: Using big data and analytics to combine ESG data with innovation activities to uncover innovation opportunities related to ESG performance. Data analyses are used to predict consumer and market trends and provide targeted directions and strategies for innovation.

Recruiting executives with academic backgrounds and study abroad backgrounds Recruiting executives with academic backgrounds and study abroad backgrounds can help to enhance a company's innovation capabilities, ESG strategy promotion, expand internationalisation strategy, and develop a management team with a global perspective and leadership. At the same time, there is a

need to ensure that the executives' academic backgrounds and study abroad experiences are compatible with the company's strategic goals and cultural values to ensure that they can truly leverage their strengths and influence.

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