

The effect of ESG performance on corporate green innovation

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Abstract

Purpose – The transition to green growth goals requires the concerted efforts of the whole society. Enterprises, as important players in the market, play a key role in promoting green and sustainable development. The rise of the concept of sustainable development has enabled more enterprises to disclose environmental, social and governance (ESG) information, and ESG behaviour is regarded as a positive strategic behaviour to implement the new development concept. This paper aims to explore the influence of ESG performance on enterprise green innovation.

Design/methodology/approach – This study applies a fixed effect model and the regulation effect of empirical analysis to explore the influence of ESG performance on enterprise green innovation. The object of investigation is 2014–2021 Shanghai and Shenzhen A-share listed companies.

Findings – The results of an empirical analysis outline the following conclusions: (1) ESG performance has a significant effect on enterprise green innovation, mainly by easing the pressure of the financing enterprise, fitting stakeholders' environmental protection concept and obtaining employee organizational identity that influences enterprise green innovation. (2) Government regulation positively regulates the role of ESG performance in promoting the green innovation of enterprises. (3) Heterogeneity analysis found that the strengthening role of ESG performance on the green innovation of enterprises is stronger in green invention patents, state-owned enterprises and nonheavily polluting industries.

Research limitations/implications – Despite the valuable findings, this study has a few limitations. Thus, it is necessary to extend the object of investigation by adding other Asian countries, which allows for comparison analysis and allocating best practices for promoting green innovation. Besides, innovation and ESG performance depend on the quality of institutions. In this case, the future study should incorporate the indicators that reveal the quality of institutions (corruption, transparency, digitalisation, voice, accountability, etc.).

Practical implications – According to the above conclusions, this paper proposes suggestions at the level of enterprises, government and investors. At the enterprise level, ESG responsibility should be strengthened, ESG information should be consciously disclosed and the quality of ESG disclosure should be improved. Government departments should play the role of supervisors, improve the construction of ESG information disclosure systems and promote the formation of ESG systems. At the social level, investors should improve the ESG information status and pay more attention to the ESG performance of enterprises.

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Originality/value – This study fills the scientific gaps in the analysis impact of ESG performance on the green innovation of enterprises. This paper contributes to the theoretical landscape of ESG efficiency by developing approaches based on two empirical models: testing the impact of enterprise ESG performance on green innovation and testing whether government regulation plays a regulatory role in the relationship between ESG performance and green innovation. Besides, this study analysed the ESG performance and green innovation within the following categories: heavy and nonheavy polluter industries; state and nonstate-owned enterprise groups.

Keywords ESG performance, Green innovation, Government regulation, Sustainable development

Paper type Research paper

Introduction

Since the reform and opening up, China has developed rapidly with an extensive model, but a series of problems have emerged at this historic moment. The contradiction between economic and social development and ecological and environmental protection has intensified and the carrying capacity of resources and the environment has approached the limit (Gajdzik *et al.*, 2021). These problems have attracted great attention from the state, enterprises and the public. The party central committee began to continue to focus on green development for high-quality development in a series of long-term projects. It could be realized by extending green technology innovation (Arefieva *et al.*, 2021), which is an important driver of energy conservation, declining emissions reduction (Kolosok *et al.*, 2022; Gavkalova *et al.*, 2022) and improving the green low carbon cycle development economic system (Veckalne and Tamboveeva, 2021). As the “master” of the market, enterprises have an indispensable responsibility in promoting green and sustainable development, and they should work hard on the research of green technology innovation and produce real results (Vaničková and Szczepańska-Woszczyna, 2020). Companies should not only make a difference in their actions but also change their ideas. With the rise of the concept of sustainable development, enterprises gradually form public knowledge of assuming social responsibilities and begin to pay attention to how to coordinate their relationships with stakeholders (Soleimani *et al.*, 2021). Since the China Securities Regulatory Commission issued the “Listed Company Governance Guidelines” required listed companies have been required to disclose environmental, social and governance (ESG) information (Listed Company Governance Guidelines, 2023). Listed companies gradually improve their awareness of ESG and a considerable number of listed companies begin to disclose ESG information so that stakeholders have a deeper understanding of listed companies.

In the context of double-carbon enterprises, enterprises actively fulfil their ESG responsibilities to determine whether their ESG performance will have an impact on the green development of enterprises and whether it will encourage enterprises to carry out green innovation activities (Solesvik *et al.*, 2022). From an economic perspective, good ESG information disclosure will increase the cost of environmental governance, thus squeezing the input cost of green innovation. However, from the perspective of stakeholders, it may be supported by stakeholders for ESG information disclosure, thus benefiting enterprises in making green innovations. Therefore, it is necessary to explore the impact of ESG performance on the green innovation of enterprises.

This research undertakes an in-depth exploration of how ESG performance influences green innovation across enterprises, introducing empirical models to dissect the multifaceted dynamics of this relationship. This study makes a departure from prior studies (Soleimani *et al.*, 2021; Solesvik *et al.*, 2022) that often isolated the effects of the E, S or G dimensions individually. Besides, this investigation distinguishes itself by intricately examining the moderating effects of government regulations on the ESG performance-green innovation nexus, offering a novel perspective on how external policy environments shape corporate innovation trajectories. Further originality emerges in the paper’s segmentation of enterprises into distinct categories – heavy versus nonheavy-polluting industries and state-owned versus nonstate-owned entities –

allowing for a granular analysis that unveils the differential impacts of ESG performance. Such segmentation is critical for analysing ESG performance's impact on green innovation in China due to the distinct regulatory, operational and market dynamics that characterize these groups. Heavy-polluting industries face stringent environmental regulations and greater public scrutiny, compelling them to prioritize ESG initiatives and green innovation as compliance and risk management strategies. Conversely, nonheavy polluting industries might engage in green innovation more for competitive advantage and to meet consumer demands than regulatory pressures. Similarly, state-owned enterprises (SOEs), with their closer ties to the government and access to resources, may align their ESG and green innovation strategies with national policy goals, including sustainability and pollution reduction. In contrast, nonstate-owned enterprises, driven by market dynamics and the need for agility, might adopt green innovations to differentiate themselves and cater to a growing consumer base concerned with environmental sustainability. Understanding these distinctions is essential for comprehending how different sectors and ownership types contribute to China's broader sustainability and environmental goals. For heavy industries and SOEs, which have historically contributed significantly to environmental degradation, effective ESG practices and green innovation are crucial for mitigating their impact and helping China achieve its sustainability targets. This comprehensive approach not only enriches the theoretical understanding of ESG efficiency but also provides targeted insights for policymakers and business leaders looking to navigate the complexities of sustainable innovation.

The paper has the following structure: literature review – exploring the theoretical background on the analysis of linking between ESG performance and green innovation and identifying the role of government regulation in ESG performance and green innovation; materials and methods – describing data for analysis, explaining the selected methods and instruments to check the research hypotheses; results – explaining the findings obtained under the study; discussion and conclusions – analysis of the core study's results, developing the policy implication considering the empirical results.

Literature review

Research on ESG performance

ESG is the acronym for the English words environment (Environment), social responsibility (Social) and corporate governance (Governance). The Environmental aspect of ESG focuses on a company's ecological impact, pushing for innovations like renewable energy and sustainable materials (). This encourages firms to explore green technologies, such as the auto industry's shift to electric vehicles, driven by consumer demand and regulatory pressures (Soleimani *et al.*, 2021; Solesvik *et al.*, 2022). The Social dimension examines relationships with employees, customers and communities, influencing a company's innovation capacity. Companies with strong social practices are likely to foster a creative environment, leading to products that address societal needs, like renewable energy access in underserved regions (Soleimani *et al.*, 2021; Solesvik *et al.*, 2022). Governance, the third pillar, involves management quality and ethical business practices, ensuring companies make decisions that align with sustainability goals (Soleimani *et al.*, 2021; Solesvik *et al.*, 2022). In 2006, Goldman Sachs Group (2023) for the first time put environment, society and corporate governance in the same framework; major financial institutions around the world responded and ESG investment gradually emerged. Enterprises disclose information to society in three aspects: environment, society and corporate governance. All organizations collect enterprise ESG information through various channels and score and rate it according to certain evaluation standards. ESG ratings make companies comparable and companies with higher ESG ratings have more advantages.

The construction of the ESG framework started late in China, but there are also some research results. Ma *et al.* (2016) suggested that China adopt the semi-mandatory ESG

information disclosure system by drawing on the experience of the international ESG disclosure system. [Zhang et al. \(2017\)](#) established the first ESG green rating system in China, considering the national conditions and the characteristics of domestic enterprises and providing ideas for the methodology of the ESG rating. [Zhang et al. \(2017\)](#) provide a reference for the establishment of a scientific, systematic and complete ESG system in China through combining the international experience of ESG system development. [Yan et al. \(2020\)](#) proposed the establishment and application of an ESG investment system, which will help the financial market “shield” the bad behaviour orientation of enterprises.

The scholars ([Zhao, 2021](#)) mostly focus on the economic effects of ESG, mainly including financial performance, debt cost, corporate value and stock market performance. [Hillman and Keim \(2001\)](#) concluded that effective ESG implementation can improve corporate financial performance. [Friede et al. \(2015\)](#) noted that the positive effect of ESG on CFP did not change over time. [Li et al. \(2021\)](#) extended the research scope to the three dimensions of ESG performance and found that enterprise ESG performance and its three dimensions can significantly improve enterprise performance through the intermediary role of enterprise innovation. [Gigante and Manglaviti \(2022\)](#) showed through empirical research that ESG performance could reduce the cost of corporate debt. Based on the data on Korean corporate bonds, [Jang et al. \(2020\)](#) found that the high environmental score in the three dimensions of the ESG score reduced the debt financing costs of small enterprises. [Qiu and Yin \(2019\)](#) empirically tested the impact of corporate environmental, social responsibility and corporate governance performance on financing costs and financing capacity based on the panel data model and found that the financing costs of enterprises with good environmental and corporate governance performance will be significantly reduced. [Fatemi et al. \(2018\)](#) found that ESG advantages will increase the value of the company, but concerns about ESG performance will reduce the value of the company. When ESG concerns are diminished, ESG disclosure reduces company value. [Bai et al. \(2022\)](#) studied 3,400 listed companies in Shanghai and Shenzhen and pointed out that ESG has the function of value creation and the good ESG performance of listed companies can significantly enhance corporate value. [Octaviani and Utama \(2022\)](#) studied the impact of corporate hedging and ESG on the risk of a stock price crash at Indonesian Energy Company and failed to detect the impact of ESG on the risk of a stock price crash. However, [Xi and Wang \(2022\)](#) found that corporate ESG information disclosure can reduce the risk of a stock price crash. It shows that there is heterogeneity in the impact of enterprise ESG on enterprises in different countries, which also further expands the research on the economic consequences of enterprise ESG information disclosure.

Research on green innovation

Green innovation is a term of management science and technology put forward earlier, which is an abstract and broad expression. If an innovation behaviour has novelty and value and can save resources and improve the environment, it can be classified as green innovation, but this seems to be confused with ecological innovation and sustainable innovation ([Us et al., 2022](#); [Shpak et al., 2021](#)). Green innovation can be divided into two categories. One focuses on process and content ([Dzwigol, 2022](#); [Yang, 2003](#)). [Yang \(2003\)](#) believes that green innovation refers to the greening of innovation design, innovation process, innovation goal and innovation achievements in innovation activities. [Porter \(1991\)](#) believes that the process of optimizing production and operation based on the internal and external environment and using green and clean technologies to maximize energy conservation and emission reduction and improve the environment is green innovation. The other is focusing on results and goals ([Szczepańska-Woszczyzna and Gatnar, 2022](#)). [Chen and Wang \(1998\)](#) outline that human society attaches importance to the coordinated development of the environment, economy and society and strives to achieve this goal, which can be called green innovation. [Driessen et al. \(2013\)](#) believe that green innovation should aim at improving environmental benefits

rather than reducing environmental damage. Although a vast range of scholars (Dzwigol *et al.*, 2020; Kuzior and Kwilinski, 2022) have different definitions and priorities for green innovation, they generally emphasize that the protection or improvement of the environment is achieved through enterprise activities. Due to the uncertainty and bubble of green innovation, it is difficult to determine the effect (Hojnik and Ruzzier, 2016). How to obtain a win-win situation between the environment and economy and explore how to drive green innovation has become a hot topic in academic circles. Regarding the influencing factors of green innovation, there are mainly internal and external factors. First, from the outside, the relevant stakeholders, government intervention and social supervision have an impact on the green innovation of enterprises. Hojnik and Ruzzier (2016) found that the behaviours of the government, shareholders, consumers and other subjects play a driving role in the green innovation of enterprises. Li and Xiao (2020) found that sewage charges “squeeze out” the green innovation ability of enterprises, but environmental protection subsidies “squeeze out” the green innovation ability of enterprises. Wang and Li (2021) found that government supervision and media attention have an impact on the performance of green innovation. The stronger the local government supervises pollution sources, the more the media reports to enterprises and the better the green innovation performance of enterprises. Irfan *et al.* (2022) studied the impact of policy intervention on green innovation of enterprises and found that green finance significantly promotes green innovation and industrial structure, economic growth and R&D investment are the core transmission channels. Second, from an internal point of view, the internal structure, organizational culture, management style and cognitive status of the enterprise will affect its green innovation. Zhao *et al.* (2022) found that more board members were conducive to the implementation of green innovation strategies, expanding the breadth of innovation openness, acquiring external knowledge and resources and promoting green innovation. Siswanti and Muafi (2022) found that green organization culture positively affects innovative behaviour, and ethical leadership plays a regulatory role in it. Huang and Yuan (2022) found that green mergers and acquisitions of enterprises will promote green innovation through the intermediary role of stakeholders. Wu and Hua (2021) found that the more attention the senior management team allocates to environmental protection issues and solutions, the more corporate green innovation patents.

Research on linking between ESG performance and green innovation

ESG performance has an impact on the green innovation of enterprises by alleviating the financing pressure of enterprises (Chouaibi and Chouaibi, 2021; Li *et al.*, 2023; Liu and Lyu, 2022). Based on the theory of information asymmetry, external investors often cannot grasp all the effective information within the enterprise in real time and facing the high risk caused by the uncertainty of investment will cause financing constraints. Under the background of dual carbon, investors not only pay attention to the financial situation of enterprises but also pay more attention to the nonfinancial aspects of enterprises, such as environmental and social responsibility and corporate governance. Enterprises actively disclose their ESG information, which is conducive to investors obtaining information related to the company and reducing the information asymmetry between enterprises and investors (Han *et al.*, 2023; Meles *et al.*, 2023; Zhai *et al.*, 2022; Zhang, 2022). Investors can selectively invest in enterprises consistent with their own development concept, effectively alleviating the financing constraints of enterprises and providing financial support for the green innovation of enterprises. Therefore, enterprises can disclose ESG information to ease the financing constraints faced by enterprises and improve the level of green innovation.

ESG performance has an impact on the green innovation of enterprises by fitting the environmental concept of stakeholders. Based on the stakeholder theory (Gu *et al.*, 2019), the modern corporate governance mechanism requires that enterprises should not only be

satisfied with protecting the interests of shareholders but also pay attention to multiple external stakeholders. Enterprises disclose good ESG information to create a good image for the outside world to fulfil their social responsibilities, so as to send a positive signal to stakeholders and gain support for green innovation. With the improvement of public environmental awareness, more and more stakeholders began to pay attention to the environmental protection of enterprises, the enterprise sustainable development concept, enterprises to cater to the stakeholders of “taste”, may actively request the production of products more environmental protection, make the disclosure of ESG performance well and drive self-green innovation (Ayub Khan *et al.*, 2022; Dacko-Pikiewicz, 2019).

ESG performance has an impact on the green innovation of enterprises by gaining the recognition of employees and organizations (Ayub Khan *et al.*, 2022; Dacko-Pikiewicz, 2019). Green innovation activities are the most important part of the research and development personnel. Enterprise development capital is the funds of research and development personnel. Due to the green innovation activities compared with general green innovation behaviour, the cycle is longer, requiring more investment and research and development difficulty. If R&D personnel lose, it will hit the enterprise’s green innovation ability and bring huge losses to the enterprise. Therefore, improving the stability of R&D personnel is crucial to the green innovation activities of enterprises (Ayub Khan *et al.*, 2022; Dacko-Pikiewicz, 2019). The behaviour of enterprises in fulfilling social responsibility has a positive impact on employees’ attitudes and behaviours, which can improve the recognition and degree of employees’ organization and reduce the employee turnover rate (Zhang *et al.*, 2015). The good performance of enterprise ESG means that enterprises are fulfilling their social responsibilities, promoting the stability and innovation of R&D personnel and improving the green innovation ability of enterprises. On the one hand, the performance of corporate social responsibility strengthens the organizational identity of employees, enhances the loyalty of employees to the enterprise, reduces the risk of employee turnover and indirectly improves the stability of enterprise green innovation. On the other hand, enterprises actively fulfil social responsibility and create a good social image, which can attract more high-quality talents and increase intellectual capital (Kuzior, 2022; Trzeciak *et al.*, 2022). Accordingly, enterprises with good ESG performance will humanistic care and pay attention to the development of their employees. A good working environment is conducive to the improvement of work efficiency (Ayub Khan *et al.*, 2022), learning ability (Trzeciak *et al.*, 2022) and innovation ability of R&D personnel and to promote the enhancement of green innovation ability of enterprises (Ayub Khan *et al.*, 2022; Dacko-Pikiewicz, 2019). While there’s a growing consensus on the positive link between ESG performance and green innovation, divergent views highlight several complexities and challenges in this relationship. However, critics point to the potential misallocation of resources, asserting that the funds directed towards ESG compliance might be better spent on direct innovation activities, especially in industries where green technology development is resource-intensive (Cheng and Wu, 2024; Kowalska-Styczeń *et al.*, 2023). Sceptics also question the depth and effectiveness of ESG initiatives, suggesting that without stringent standards, companies might engage in greenwashing, thus creating an illusion of green innovation without substantial environmental impact (Richardson, 2019; Williams, 2024). Concerns about the actual integration of ESG principles into corporate innovation strategies are raised, especially in sectors traditionally associated with high pollution, where the pathway to green technology is fraught with technical and financial hurdles (Cort and Esty, 2020). For state-owned enterprises, the bureaucratic environment may dampen the agility needed for rapid green innovation, despite apparent ESG adherence. These enterprises might prioritize ESG compliance for its reputational benefits rather than as a driver of true innovation due to their often-complex governance structures and the balancing act between political objectives and market pressures (Crifo *et al.*, 2019). On the other hand, nonstate-owned enterprises, while

potentially more responsive to market forces and customer preferences, may focus on short-term ESG performance gains that appeal to consumers and investors rather than committing to the long-term R&D that green innovation typically requires (Tang, 2022). Moreover, linking ESG performance with green innovation presumes a level of uniformity in both investor behaviour and company response that may not exist in reality. Some investors indeed favour companies with strong ESG records, but others might prioritize short-term financial returns over long-term sustainability impacts (Balp and Strampelli, 2022). The divergent views call for an approach to ESG integration, advocating for regulatory frameworks and incentives that genuinely promote green innovation as well as for transparency and accountability in ESG reporting that goes beyond ticking boxes. These debates underscore the need for ongoing research and dialogue to ensure that ESG initiatives effectively contribute to sustainable innovation and are not merely a corporate veneer.

Based on the above analysis, the influence mechanism of ESG performance on the green innovation of enterprises is shown in Figure 1.

This paper puts forward the assumptions.

H1. ESG performance can promote the green innovation of enterprises.

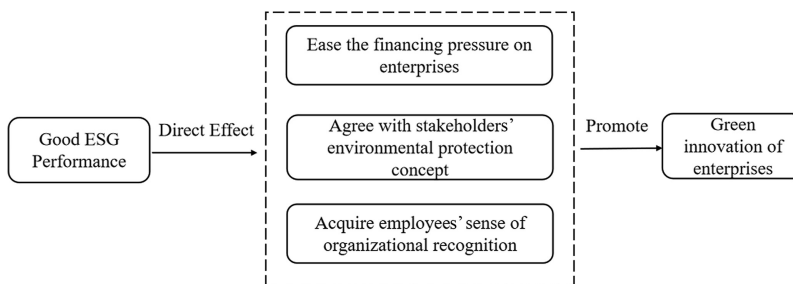
H1a. Good ESG performance has a direct effect on easing the financing pressure on enterprises, which in turn promotes green innovation activities within the enterprises.

H1b. Good ESG performance aligns enterprise operations with stakeholders' environmental protection concepts, leading to the promotion of green innovation within enterprises.

H1c. Good ESG performance enhances employees' sense of organizational recognition, which subsequently fosters an environment conducive to green innovation within enterprises.

The role of government regulation

According to Porter's hypothesis, environmental regulation will bring external pressure on enterprises and promote their technological innovation. Ambec and Barle (2002) outline that environmental regulation effectively overcomes organizational inertia through the external pressure exerted on enterprises, complements the internal governance mechanism of enterprises and transforms the external pressure into the internal impetus to promote enterprise innovation. As a means of environmental regulation, government regulation is bound to have an impact on enterprise innovation. On the one hand, with the increasing importance of environmental protection in China, local governments continue to strengthen



Source(s): Developed by the authors

Figure 1.
Impact mechanism
diagram of ESG
performance on
enterprise green
innovation

the supervision of the environment (Wang and Sun, 2022; Yao *et al.*, 2023). If enterprises ignore environmental pollution behaviour, the cost of environmental violations caused by enterprises will continue to increase (Naeem *et al.*, 2023). According to the theory of enterprise competitiveness (Yuan *et al.*, 2022), external pressure helps to overcome the inertia of enterprise organizations and encourage innovative thinking. In order to avoid the cost of environmental violations, enterprises can improve production technology through green innovation, reduce the emission of pollutants and save resources (Xiang and Wei, 2022). On the other hand, green innovation can effectively coordinate government supervision and enterprise performance. Green innovation enables enterprises to produce more environmentally friendly products, which can not only improve enterprise performance and reduce the cost of environmental violations but also make enterprises have stronger competitiveness and gain the advantage of competing for the market (Fuadah *et al.*, 2022). Under the supervision of the government, enterprises face increasing institutional pressure. In order to reduce the risk of violations, the legitimacy of corporate behaviour will be enhanced, contributing to the performance of ESG. The enterprises hope to achieve good ESG performance, which complements the pressure of external government supervision to promote green innovation in enterprises. Based on the above analysis, this paper proposes the hypothesis.

H2. The strength of the positive relationship between ESG performance and green innovation is amplified by the efficacy of government regulation.

Material and methods

Sample selection and data source

This paper takes the listed companies that obtained the ESG rating in the Shanghai and Shenzhen A-share markets from 2014 to 2021 as the research sample. In order to better guarantee the stability of the data and the validity of the research results, the samples were screened according to the following criteria: excluding listed financial and insurance companies; excluding ST and *ST companies; excluding sample companies with missing data on major variables and finally, obtaining 11,530 samples. In order to exclude the influence of outliers on the model results, the main continuous variable was reduced to 1%. The data sources of this paper are as follows: ESG rating data from commercial and green databases, green patent data from the CNRDS (2023) database, government regulatory data and other financial data from the Guotaian database.

Model setting

In order to test study hypothesis 1 and study hypothesis 2, the following models are constructed for empirical testing:

$$GI_{i,t} = a_0 + a_1ESG_{i,t-1} + a_2Control_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

$$GI_{i,t} = a_0 + a_1ESG_{i,t-1} + a_2Gov_{i,t-1} + a_3Interact + a_4Control_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

where model (1) tests the impact of enterprise ESG performance on green innovation (i.e. H1), mainly observing the interaction term coefficient α_1 significance level; model (2) tests whether government regulation plays a regulatory role in the relationship between ESG performance and green innovation (i.e. H2), mainly by observing the interaction term coefficient α_3 ; ESG is the explanatory variable ; Gov indicates that the regulatory variable is government regulation; Interact represents the interaction item between enterprise ESG performance and government regulation; Control is the set of control variables: enterprise age (Age), enterprise size (Size), asset-liability ratio (Lev), enterprise growth capacity (Growth), director structure

(Indep), enterprise value (TobinQ), integration (Duality), R&D investment (R&D), Year (Year), Industry (Ind); ε is a random disturbance term.

Variable definitions

Interpreted variable – green innovation. Based on past studies (Wang and Wang, 2019; Li and Xiao, 2020) this study used the number of green patents to measure the green innovation ability of enterprises. Green patents include green invention patents and green utility model patents. The application of green patents generally takes 1–2 years, but enterprises should also be striving for green innovation at this stage, so the number of enterprise green patent applications is selected as the agent variable of enterprise green innovation. To solve the problem of data deviation, the number of patent applications is 1 and a logarithm is used in the empirical analysis.

Explanatory variables – ESG performance. The prior studies (Lu *et al.*, 2022; Lian *et al.*, 2023) applied two methods: one is to build a multi-dimensional index system, and the other is to score by third-party institutions. Considering the studies (Lu *et al.*, 2022; Lian *et al.*, 2023), this study applies the ESG rating of listed companies disclosed by the third-party agency. It conducts quantitative evaluation data on enterprise ESG performance and divides ESG rating into nine levels, from good to bad to A+, A, A-, B+, B, B-, C+, C, C-. This study assigns 9-1 from good to bad.

Adjustment variables – government supervision. Considering Pan and Guo (2018), the study analyses the list of national key monitoring enterprises for assessment of government supervision. Thus, set virtual variables, included as 1, not included as 0.

Control variables. Based on the past studies (Lu *et al.*, 2022; Lian *et al.*, 2023), this paper selects the following variables that may affect the green innovation.

- (1) Enterprise age (Age). Older companies may possess established practices, resources and cultures that can either foster or impede innovation. Conversely, younger companies often exhibit greater flexibility and adaptability, enabling them to incorporate ESG principles more readily into their innovation processes;
- (2) Enterprise size (Size). The size of an enterprise typically reflects its resources, market power and innovation capacity. Larger enterprises may boast greater financial resources to invest in green innovation projects and research. However, they may also encounter bureaucratic challenges and inertia, which could hinder innovation compared to smaller, more agile companies;
- (3) Asset–liability ratio (Lev). The financial structure of a company, as indicated by its asset-liability ratio, can significantly impact its risk tolerance and financial flexibility. Companies with lower leverage may have more resources available for innovation initiatives, including those focused on environmental sustainability. Conversely, highly leveraged companies may prioritize short-term financial stability over long-term innovation efforts;
- (4) Enterprise growth ability (Growth). High-growth companies are often more inclined to invest in innovative projects, including those aimed at enhancing their ESG performance, to maintain a competitive edge and attract investors;
- (5) Director structure (Indep). The composition of a company's board of directors, particularly the presence of independent directors, plays a crucial role in influencing its strategic direction and governance practices. Boards with diverse expertise and independent oversight are more likely to prioritize long-term sustainability goals, including green innovation initiatives;

- (6) Enterprise value (TobinQ). A higher enterprise value may signal investor confidence in the company's ability to generate sustainable returns over time, thereby incentivizing investments in green innovation projects;
- (7) Two jobs (development investment (Duality) (R&D)). The allocation of resources to research and development activities directly impacts a company's innovation capabilities. Companies prioritizing R&D investments, especially in environmentally friendly technologies and practices, are more likely to engage in green innovation regardless of their ESG performance;
- (8) And further set year (Year) fixed effect and industry (Ind) fixed effect.

The specific variable definitions are shown in [Table 1](#).

Results

[Table 2](#) shows the descriptive statistical results of the main variables. From this table, the mean value of the explained variable is 1.541, the standard deviation is 1.370, the minimum value is 0 and the maximum value is 7, which shows that the green innovation between different enterprises varies greatly. The median of green innovation among enterprises is 1.386.

On the whole, the green innovation of Chinese enterprises is at a relatively low level. The mean value of the ESG performance of the explanatory variable is 4, the median value is 4, the minimum value is 1 and the maximum value is 7. It is seen that the difference between the mean and the median is not large, and there is no extreme value, indicating that the overall performance of enterprise ESG is at a medium level. The average value of government supervision is 0 and the median is 0, indicating that the number of key monitoring enterprises is small.

The study applies Pearson correlation analysis to verify the relationship between variables. According to the findings in [Table 3](#), the correlation coefficient between green innovation (GI) and ESG performance (ESG) is 0, and through the significance test of 1%

Type	Variable	Symbol	Meaning
Explained variable	Green innovation	GI	The natural logarithm of the number of green patent applications and the sum of 1
Explanatory variable	ESG expression	ESG	1–9 from inferior to good according to ESG ratings
Regulated variable	Government regulation	Gov	If it is the list of national key monitoring enterprises, the value is 1, otherwise it is 0
Controlled variable	Enterprise age	Age	The natural logarithm of the number of years
	Asset–liability ratio	Lev	Total liabilities/total assets
Controlled variable	Enterprise growth ability	Growth	Increase rate of business revenue
	Director structure	Indep	Number of independent directors/directors
Controlled variable	Enterprise value	TobinQ	The Tobin Q value of the enterprise
	Two jobs in one	Duality	The chairman and the general manager are the same person 1, otherwise it is 0
Controlled variable	Research input	R&D	R&D expenditure/operating revenue
	A particular year	Year	Virtual variable, 1 at this period, and 0 otherwise
Controlled variable	Trade	Ind	Virtual variable, 1 in the industry, otherwise 0

Table 1.
Variable
definition table

Source(s): Developed by the authors

Variable	Sample capacity	Average value	Median	Standard error	Least value	Crest value
GI	11,530	1.541	1.386	1.370	0.000	7.364
ESG	11,530	4.146	4.000	1.182	1.000	7.000
Gov	11,530	0.292	0.000	0.455	0.000	1.000
Age	11,530	2.487	2.565	0.597	0.000	3.466
Size	11,530	22.804	22.611	1.385	16.412	28.548
Lev	11,530	0.449	0.445	0.202	0.051	0.917
Growth	11,530	0.174	0.108	0.415	-0.501	2.783
RD	11,530	4.296	3.380	4.676	0.000	26.400
Indep	11,530	0.376	0.364	0.057	0.231	0.800
TobinQ	11,530	2.049	1.575	2.121	0.641	106.132
Duality	11,530	1.756	2.000	0.429	1.000	2.000

Source(s): Developed by the authors

Table 2.
The findings of
descriptive statistics

level, there is a significant positive correlation between green innovation (G) and ESG performance (ESG), ESG performance to enterprise green innovation, preliminary verified [hypothesis 1](#) in this paper. Moreover, the correlation coefficient between variables is less than 0.5, indicating that there is no multicollinearity problem between variables.

To test [Hypothesis 1a, b](#) and [c](#), a fixed-effect model is adopted to test the impact of enterprise ESG performance on green innovation. First, a Hausman test was performed to detect model fit, and the results showed $p < 0$, indicating high model fit. The regression was performed based on the fixed-effect model, and the regression results are shown in [Table 4](#). Column (1) is the regression results of the core explanatory variables on the explained variables and column (2) is the regression results after the addition of the control variables.

Regardless of whether the control variables were added or not, the regression coefficient of the core explanatory variable ESG performance on the green innovation of the explained variable was significantly positive at the level of 1%, indicating that the enterprise ESG performance has a positive effect on promoting green innovation; that is, the better the enterprise ESG performance, the stronger the green innovation ability of the enterprise, and [Hypothesis 1](#) was verified. This may be due to the enterprise's good ESG performance to reduce the information asymmetry with the public and create a good social image, which not only can lead to enterprise financing cost reduction but also can make the enterprise obtain stakeholder support, provide convenience to build a high-quality talent team, provide enterprise green innovation ability development funding and "good" talent.

Among the control variables, the regression coefficient of enterprise age is significantly negative, indicating that the ability of green innovation may decrease with the age of the enterprise. It may be because the enterprise reaches a certain stage, the resources provided by the enterprise for green innovation reach their peak, and it becomes difficult for the enterprise to enhance its innovation ability. The regression coefficient of enterprise scale, asset-liability ratio, enterprise growth ability, R&D investment and company value is significantly positive, and these control variables have a promoting effect on the green innovation of enterprises.

To test whether government regulation plays a regulatory role in ESG performance and the green innovation ability of enterprises. In this paper, the government supervision (Gov) and ESG performance (ESG) and government supervision (Gov) interaction item ESG*Gov (Interact) is introduced into the model for analysis. The results of the analysis are shown in [Table 5](#).

The interaction term was Interact, and the regression coefficient was significantly positive. It shows that government regulation has a positive effect on ESG performance and enterprise green innovation. That is, the stronger the government regulation. The stronger

Table 3.
Correlation analysis

Var	GI	ESG	Gov	Age	Size	Lev	Growth	RD	Indep	TQ	Duality
GI	1										
ESG	0.209***	1									
Gov	0.066***	0.027***	1								
Age	0.067***	0.022**	0.234***	1							
Size	0.422***	0.279***	0.205***	0.359***	1						
Lev	0.204***	-0.033***	0.059***	0.256***	0.452***	1					
Growth	0.017*	-0.017*	-0.0150	-0.051***	0.025***	-0.00200	1				
RD	0.070***	0.00100	-0.151***	-0.224***	-0.287***	-0.328***	-0.040***	1			
Indep	0.054***	0.069***	-0.020**	-0.018**	0.043***	0.00900	-0.00500	0.063***	1		
TQ	-0.136***	-0.096***	-0.123***	-0.076***	-0.346***	-0.162***	0.025***	0.189***	0.033***	1	
Duality	0.029***	0.052***	0.099***	0.195***	0.135***	0.088***	-0.025***	-0.146***	-0.104***	-0.059***	1

Note(s): ***, **, and * indicate significant confidence levels at 1, 5 and 10%, respectively, with robust based standard false *t*-values in parent these similarly here in after; TobinQ – TQ and Var. – variables
Source(s): Developed by the authors

Variables	GI	(1) <i>p</i> -value	GI	(2) <i>p</i> -value
ESG	0.252***	0.010	0.103***	0.010
Age			-0.062**	0.021
Size			0.525***	0.011
Lev			0.189**	0.070
Growth			0.074**	0.026
RD			0.022***	0.003
Indep			0.194	0.193
TobinQ			0.028***	0.005
Duality			-0.012	0.026
_cons	1.069***	0.132	-10.305***	0.261
Ind		Yes		Yes
Year		Yes		Yes
r2		0.246		0.418
r2_a		0.241		0.413
F		42.543		81.577

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively

Source(s): Developed by the authors

Table 4.
Regression results

Variables	GI	<i>p</i> -value
ESG	0.092***	0.011
Gov	-0.031	0.027
Interact	0.046**	0.017
Age	-0.062**	0.021
Size	0.524***	0.011
Lev	0.195**	0.071
Growth	0.070**	0.026
RD	0.022***	0.003
Indep	0.195	0.193
TobinQ	0.027***	0.005
Duality	-0.011	0.026
_cons	-10.464***	0.269
Ind		Yes
Year		Yes
r2		0.419
r2_a		0.414
F		79.892

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively

Source(s): Developed by the authors

Table 5.
The conditioning effect
results

the performance effect of ESG on promoting the green innovation of enterprises, [Hypothesis 2](#) was tested. In practice, the stronger the government supervision, the stricter the requirements on enterprises, and enterprises will spontaneously improve their own behaviour to comply, which is conducive to the enhancement of ESG performance. At the same time, in order to reduce the cost of violations, enterprises will adopt green technology to avoid pollution and enhance the ability of green innovation.

According to the benchmark results, the better the ESG performance, the higher the green innovation level but it may also be that the higher the green innovation level, the stronger the enterprise's management environmental protection consciousness, compared with the green

innovation level of enterprises, the more ability to fulfil social responsibility, environmental responsibility and governance responsibility leads to its ESG performance, so the ESG performance, and there may be a two-way causal relationship between green innovation. Considering that the green innovation level of enterprises does not easily affect the ESG lag variables in the current period, the ESG lag of 2 and 3 periods were used as the explanatory variables. The results are shown in Table 6, and the coefficients of ESG lag in periods 2 and 3 are significantly positive, which eliminates the possibility of two-way causality to some extent. It also shows that ESG performance promotes green innovation in enterprises in the long term and ensures the robustness of the benchmark regression results.

In this paper, the method of green regression is the number of green patent applications. However, considering that the green patent application may not be the application results and becomes the environmental protection products, to ensure the robustness of the research, the number of green patents (Gpat) is taken as the agent variable of green innovation. The results are shown in Table 7, and the regression coefficient of ESG performance (ESG) on the number of green patents granted is significantly positive, indicating that enterprise ESG performance positively affects green innovation, which is consistent with the previous conclusion.

As the economic development level and policy support intensity of different provinces may vary to a certain extent, these factors will affect the development level of green innovation in enterprises in different provinces. The previous benchmark regression model added the fixed effect of industry and the fixed effect of year and controlled the influence of industry and year on the green innovation of enterprises. To reduce the difference in green innovation caused by different provinces, this paper controls the influence of provinces on the green innovation of enterprises and adds the fixed effect of provinces to the regression model. The regression results are shown in Table 8, and the regression coefficient of ESG performance (ESG) is significantly positive, which is consistent with the previous regression results. It also shows that the fixed effect of the control province, the better the ESG performance of listed companies, the better the effect of promoting enterprises to improve the level of green innovation.

Variables	(1)		(2)	
	GI	<i>p</i> -value	GI	<i>p</i> -value
L2.ESG	0.087 ^{***}	0.011		
L3.ESG			0.066 ^{***}	0.012
Age	-0.058 [*]	0.025	-0.035	0.029
Size	0.548 ^{***}	0.012	0.562 ^{***}	0.013
Lev	0.158 [*]	0.076	0.118	0.082
Growth_w	0.064 [*]	0.028	0.057	0.031
RD	0.022 ^{***}	0.003	0.022 ^{***}	0.004
Indep	0.250	0.207	0.232	0.225
TobinQ	0.028 ^{***}	0.006	0.023 ^{***}	0.007
Duality	-0.006	0.028	-0.014	0.030
_cons	-10.687 ^{***}	0.284	-11.200 ^{***}	0.309
Ind		Yes		Yes
Year		Yes		Yes
r2		0.416		0.423
r2_a		0.410		0.416
F		70.103		61.104

Table 6.
The results of
endogeneity test

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively

Source(s): Developed by the authors

Variables	Gpat	<i>p</i> -value	Business Process Management Journal
ESG	0.056***	0.008	
Age	-0.135***	0.018	
Size	0.258***	0.010	
Lev	0.102	0.060	
Growth	-0.009	0.022	
RD	0.008**	0.003	
Indep	-0.089	0.162	
TobinQ	0.014**	0.005	
Duality	-0.069**	0.022	
_cons	-4.387***	0.223	
Ind		Yes	
Year		Yes	
r2		0.310	
r2_a		0.303	
F		48.901	

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively
Source(s): Developed by the authors

Table 7.
Change the green
innovation measure
method

Variables	GI	<i>p</i> -value
ESG	0.101***	0.010
Age	-0.044*	0.022
Size	0.518***	0.012
Lev	0.228**	0.071
Growth	0.077**	0.026
RD	0.021***	0.003
Indep	0.221	0.194
TobinQ	0.027***	0.005
Duality	-0.003	0.026
_cons	-10.197***	0.268
Ind		Yes
Year		Yes
Province		Yes
r2_a		0.427
F		0.420

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively
Source(s): Developed by the authors

Table 8.
The results of controls
the province fixed
effects

Considering the findings (Table 9), the ESG, green invention patent and green utility patent regression coefficients are significantly positive, further proving the influence of ESG performance on green innovation. The regression coefficient of ESG on green invention patents is greater than that of ESG on green utility patents, indicating that ESG performance is different for different green patent types and that ESG performance has a greater impact on green invention patents. Compared with the green utility model patent, the green invention patent has more stringent requirements. It is not only a higher technical level requirement but also a higher science and technology content and practical value that embodies the enterprise's inner real innovation ability. It shows that ESG performance on green inventions is stronger; ESG performance really promotes enterprise green innovation.

Variables	IGpat	<i>p</i> -value	UGpat	<i>p</i> -value
ESG	0.091***	0.010	0.063***	0.009
Age	-0.029	0.020	-0.108***	0.019
Size	0.495***	0.011	0.385***	0.010
Lev	0.050	0.068	0.294***	0.062
Growth	0.050*	0.024	0.082***	0.023
RD	0.027***	0.003	0.001	0.003
Indep	0.320	0.183	0.292	0.169
TobinQ	0.032***	0.005	0.021***	0.005
Duality	-0.026	0.025	-0.005	0.023
_cons	-10.107***	0.252	-7.033***	0.232
Ind		Yes		Yes
Year		Yes		Yes
r2_a		0.383		0.406
F		0.378		0.401

Table 9.
Analysis of the
heterogeneity of green
patent types

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively
Source(s): Developed by the authors

Considering the different equity nature of the sample, it is divided into SOEs and nonstate-owned enterprises to test the impact of the ESG performance of enterprises with different property rights on green innovation. The regression coefficient of ESG performance (Table 10) is not significant for the green innovation of SOEs, but the regression coefficient of nonstate-owned enterprises is significantly positive. This shows that, compared with SOEs, ESG performance plays a stronger role in promoting the green innovation ability of nonstate-owned enterprises, while the improvement of green innovation in SOEs is not strongly dependent on ESG performance.

Nonstate-owned enterprises are facing great market competition pressure and tend to disclose good ESG performance to reduce financing constraints and then, expand investment in green innovation, develop more environmentally friendly products, reduce the cost of violations and gain more market competitive advantages.

Variables	State-owned enterprise group		Nonstate-owned enterprise group	
	GI	<i>p</i> -value	GI	<i>p</i> -value
ESG	-0.199	0.160	0.084***	0.013
Age	0.317	0.342	-0.113***	0.029
Size	0.821*	0.303	0.470***	0.017
Lev	-2.204	1.242	0.481***	0.099
Growth	-0.295	0.449	0.045	0.033
RD	-0.018	0.064	0.019***	0.004
Indep	-1.280	3.601	-0.383	0.260
TobinQ	0.149	0.305	0.022***	0.007
Duality	-0.181	0.590	-0.059*	0.030
_cons	-24.459	27.351	-8.930***	0.385
Ind		Yes		Yes
Year		Yes		Yes
r2_a		0.631		0.373
F		0.186		0.365

Table 10.
Analysis of property
rights and property
heterogeneity

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively
Source(s): Developed by the authors

Therefore, ESG performance has a stronger influence on the green innovation of nonstate-owned enterprises. Influenced by the government, SOEs follow the national policy and line, pay more attention to the goal of sustainable development, consciously improve the green innovation ability and ESG performance is less driven by them. At the same time, compared with nonstate-owned enterprises, SOEs have more policy advantages and financing convenience and have less market competition pressure, which also affects the role of ESG performance between the two on green innovation.

According to the Guidelines on Environmental Information Disclosure of Listed Companies released by the Ministry of Environmental Protection, heavy polluting industries include 16 industries, including thermal power, steel, cement, electrolytic aluminium, coal, metallurgy, chemical, petrochemical, building materials, paper making, brewing, pharmaceutical, fermentation, textile, tanning and mining. Group regression was conducted according to whether the enterprise belongs to a heavy pollution industry, and the regression results are shown in Table 11.

The regression results of these two groups showed that the ESG regression coefficients of both groups were significantly positive, which was basically consistent with the benchmark regression results. The regression coefficient of ESG in heavy pollution industries is 0 and that of ESG in nonheavy pollution industries is 0, indicating that ESG has a more obvious effect on promoting green innovation in nonheavy pollution industries. This may be because heavy polluting enterprises are subject to stricter environmental supervision, and it is difficult for heavy polluting enterprises to improve ESG performance in a short period of time. They cannot quickly change their social image, and they tend to invest more costs to improve ESG performance, which relatively squeezes the funds invested in green innovation. On the other hand, heavy polluting enterprises may start with green innovation and develop more environmentally friendly products to change the public's view of it, resulting in a weaker impact of ESG performance on the green innovation of enterprises in heavy polluting industries.

Discussion and conclusions

This paper focuses on the relationship between ESG performance and enterprise green innovation. Taking Shanghai and Shenzhen A-share listed companies in 2014–2021 as the

Variables	Heavy pollution industry		Nonheavy pollution industries	
	GI	<i>p</i> -value	GI	<i>p</i> -value
ESG	0.066***	0.015	0.126***	0.013
Age	-0.123***	0.034	-0.014	0.028
Size	0.557***	0.017	0.505***	0.016
Lev	-0.130	0.109	0.499**	0.093
Growth	0.078*	0.039	0.066	0.034
RD	0.052***	0.007	0.018***	0.003
Indep	1.067***	0.315	-0.296	0.242
TobinQ	0.074***	0.014	0.018**	0.006
Duality	0.062	0.041	-0.065*	0.033
_cons	-12.922***	0.453	-10.119***	0.346
Ind		Yes		Yes
Year		Yes		Yes
r2_a		0.463		0.393
F		0.459		0.386

Note(s): ***, ** and * indicate significant confidence levels at 1, 5 and 10%, respectively

Source(s): Developed by the authors

Table 11.
Analysis of industry
heterogeneity

research object, the empirical analysis is conducted on the impact of ESG performance on enterprise green innovation and the regulatory effect of government supervision. The following conclusions are drawn based on the empirical results:

- (1) In line with the hypothesis that ESG performance positively influences green innovation, the findings are supported by recent empirical evidence from China's listed companies, which highlights the moderating role of corporate ESG performance on business risk, proposing new ideas to alleviate and avoid risks while promoting green innovation (Chen *et al.*, 2024). This reinforces the strategic importance of ESG in driving the green transformation of businesses, confirming the integral role of ESG in fostering environments conducive to sustainable advancements. The alignment of ESG disclosures with reduced information asymmetry and enhanced access to capital for green initiatives underscores the strategic importance of ESG in driving the green transformation of businesses. By actively disclosing ESG information, enterprises can reduce the information asymmetry, alleviate the financing constraints, squeeze out the capital of green innovation activities and effectively promote the improvement of the green innovation level of enterprises. At the same time, the enterprise ESG performs well, shows a good image of fulfilling social responsibility, attracts and leaves technological innovation talents and drives the enterprise to become a green enterprise with sustainable development.
- (2) Contrary to the hypothesized uniform impact of ESG performance across different sectors, the results reveal a nuanced heterogeneity. Specifically, Wang *et al.* (2024) found that the presence of green funds enhances the green innovation capability of Chinese-listed companies and contributes to the advancement of ESG performance. This differential impact challenges the one-size-fits-all view and suggests a more complex interplay between corporate governance structures and sector-specific challenges.
- (3) The results contradict Smith's (2023) claims that government regulation would dilute the positive effects of ESG on innovation due to increased compliance costs. Instead, the analysis indicates that government regulation acts as a catalysing force, enhancing the influence of ESG on green innovation. This is in line with Rauf *et al.* (2024), who highlighted the critical role of ESG reporting in amplifying the impact of green R&D investment, suggesting a synergistic approach to driving corporate green innovation performance. Under the supervision of the government on enterprises, in order to reduce the adverse factors such as violation costs and other costs caused by government supervision, enterprises consciously strengthen their performance in ESG so as to improve the performance of ESG to a certain extent, thus enhancing the role of ESG performance in promoting green innovation. Therefore, under the role of government supervision, the ESG performance of enterprises has a stronger effect on promoting green innovation.
- (4) For nonstate-owned enterprises, which face intense market competition, disclosing favourable ESG performance can alleviate financing constraints and subsequently stimulate investments in green innovation. This strategy enables them to develop environmentally friendly products, reduce compliance costs and enhance their competitive edge in the market. Therefore, for stakeholders and investors interested in fostering green innovation within the nonstate-owned sector, prioritizing ESG considerations in investment decisions can yield substantial benefits. Conversely, the influence of ESG performance on green innovation in SOEs appears to be less

significant. This phenomenon can be attributed to SOEs' adherence to national policies and sustainability goals, regardless of their ESG performance. Moreover, their relatively privileged position in terms of policy support and access to financing diminishes the imperative to rely on ESG performance as a driver for green innovation. This differentiation resonates with [Zhang *et al.*'s \(2024\)](#), discussion of ESG performance's impact mechanism on the corporate value of heavily polluting listed companies through green technology innovation.

- (5) In heavy pollution industries, where firms face stringent environmental regulations and challenges in improving ESG performance swiftly, the effect of ESG on green innovation is comparatively weaker. Instead, these enterprises may prioritize direct investments in green innovation to alter public perceptions and mitigate environmental impacts. In contrast, nonheavy pollution industries exhibit a stronger positive relationship between ESG performance and green innovation. Here, firms have more flexibility to enhance ESG practices, resulting in a more pronounced effect on fostering green innovation.

Based on these results the following countermeasures and suggestions are recommended:

- (1) For enterprises, proactive ESG disclosure and the elevation of disclosure quality are crucial. Although ESG reporting is not mandatory in China, leading companies like Alibaba and Tencent have set benchmarks by voluntarily enhancing their ESG transparency ([Wang *et al.*, 2023](#)). These corporations have not only established robust ESG frameworks but also integrated green development into their core operations, thereby showcasing the value of a strong ESG ethos in attracting talent, reducing operational risks and fostering innovation. Companies across sectors should emulate such practices, prioritizing environmental protection and social responsibility as core business strategies.
- (2) On the regulatory front, the government's role in shaping an enabling environment for ESG and green innovation is paramount. Drawing inspiration from the European Union Green Deal ([Eckert and Kovalevska, 2021](#)), Chinese regulatory bodies could develop similar comprehensive ESG disclosure requirements and incentive schemes. For instance, providing tax breaks or financial subsidies for businesses that achieve significant advancements in green technologies or meet certain ESG criteria could spur widespread adoption of sustainable practices. Additionally, establishing a stringent penalty system for ESG misreporting, akin to the penalties for financial misreporting, could ensure greater accountability and transparency.
- (3) For investors, the case of green bonds in China offers a compelling example of how financial instruments can be aligned with sustainability goals. By prioritizing investments in companies with strong ESG records or in sustainable projects, investors could drive the market towards greener solutions. The success of green bonds, which finance projects with environmental benefits, illustrates the potential for investors to contribute to environmental and social objectives while also achieving financial returns. This model could be expanded to other investment vehicles, reinforcing the importance of ESG considerations in financial decision-making.

This paper presents novel findings on the relationship between performance and green innovation in Chinese enterprises, highlighting the significant positive impact of ESG on green innovation, particularly in nonstate-owned and nonheavy-polluting industries. It uniquely identifies government regulation as a positive moderator, emphasizing the role of policy in enhancing this relationship. Through the analysis, the study reveals variability in

the impact of ESG across different sectors and enterprise types, providing insights into the conditions under which ESG performance leads to increased green innovation. The research underscores the long-term benefits of ESG performance on sustainable development and offers targeted recommendations for policymakers, corporate leaders and investors to foster a more sustainable innovation ecosystem. These contributions mark a significant step forward in understanding the dynamics of ESG performance and its crucial role in promoting green innovation within the Chinese context.

The findings of the study, derived from examining Shanghai and Shenzhen A-share listed companies, are limited in scope due to its geographical focus on China. To bolster the robustness and applicability of future research, it would be beneficial to broaden the scope to encompass additional Asian countries. Such expansion would not only offer comparative insights but also could help identify best practices for promoting green innovation across different institutional landscapes. Further, considering that the calibre of innovation and ESG performance can be influenced by the quality of institutional frameworks, future research should aim to include metrics that evaluate institutional characteristics, such as levels of corruption, transparency, digitalization and the extent of voice and accountability. Additionally, the study could be enriched by adopting a longitudinal approach to assess how ESG performance impacts green innovation over time. A temporal analysis would account for the evolving nature of ESG criteria and innovation, providing a clearer view of long-term trends and causality. Moreover, supplementing the quantitative data with qualitative insights gained from case studies or executive interviews could offer a deeper, more nuanced understanding of corporate strategies and decision-making processes related to ESG and green innovation, capturing the intricate subtleties that numbers alone cannot convey.

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