The Impact of ESG (Environmental, Social and Governance) Scores on Corporate Substantive and Strategic Green Innovation

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Abstract

In recent years, there has been a global increase in attention toward ESG (Environmental, Social, and Governance) policies, with different countries developing unique frameworks based on their national conditions and development stages. Concurrently, green innovation has emerged as a focal point for governments worldwide, leading to the establishment of green innovation policies as vital strategies for tackling climate change and promoting sustainable development. However, research on the effects of enterprise ESG scores—including E, S, and G scores—on substantive and strategic green innovation remains limited. This study empirically examines the impact of ESG scores on green innovation, substantive green innovation, and strategic green innovation in Chinese listed companies from 2007 to 2022. Findings reveal that a one standard deviation increase in ESG scores correlates with increases of approximately 38.24% in green innovation (gpat), 22.01% in substantive green innovation (ginpat), and 35.52% in strategic green innovation. ESG scores influence green innovation primarily through R&D expenditure, human capital, and information transparency. Additionally, the positive impact of ESG scores is amplified by higher asset-liability ratios, major shareholder influence, larger boards, and state ownership. Meanwhile, it was found that only the E-score significantly impacts green innovation, with effects evident within a 1 to 3-year lag, offering policy recommendations for enhancing corporate green innovation.

Keywords: Environmental, Social and Governance (ESG), Green Innovation, Substantive Green Innovation, Strategic Green Innovation, R&D Expense

Objective

1. To empirically test the impact of ESG scores on green innovation, substantive green innovation, and strategic green innovation.
2. To reveal the mechanisms by which ESG scores affect corporate green innovation, substantive green innovation, and strategic green innovation.

3. To assess the heterogeneous effects of ESG scores on corporate green innovation, substantive green innovation, and strategic green innovation under different scenarios, including asset liability ratio, first shareholder shareholding ratio, institutional investor shareholding ratio, board size, and property rights nature.

4. To assess the impact of individual E-scores, S-scores, and G-scores on corporate green innovation, substantive green innovation, and strategic green innovation.

5. To assess the long-term effects of ESG scores on corporate green innovation, substantive green innovation, and strategic green innovation.

Literature Review

In recent years, academics have conducted extensive research on ESG, focusing mainly on the drivers and economic consequences of corporate ESG ratings. In terms of the influencing factors of corporate ESG ratings, scholars have found that the institutional environment and corporate characteristics are important factors influencing ESG performance.

Sun, Zhou & Gan (2023) assert that green finance policies significantly enhance corporate ESG performance, while Yan et al. (2023) find that government environmental regulations also improve ESG outcomes (Lu & Cheng, 2023a). Research on green innovation influencing factors focuses on environmental regulations, financial development, corporate governance, and managerial characteristics (Tian et al., 2023; Xu et al., 2023). Government regulations are critical in driving green decisions (Castellacci & Lie, 2017; Lian et al., 2022; Mickwitz et al., 2008). Z. Huang et al. (2019) reports that green loans and subsidies positively impact green innovation. Wen et al. (2023) highlights that financial risk negatively affects green innovation by reducing relevant patent applications and limiting foreign direct investment. Amore & Bennedsen (2016) noted that ineffective corporate governance impedes green innovation, particularly in firms with lower institutional shareholdings and green patent stocks. Song & Yu (2018) highlighted that managers acknowledge the importance of green innovation for sustainable development and competitive advantage.

From the perspective of enterprises themselves, in addition to fulfilling their energy-saving and emission reduction responsibilities and complying with environmental protection laws and regulations, they should also increase their independent research and development and green innovation in energy-saving and emission reduction projects and promote the sustainable development of the green economy (Zhang et al., 2024). In the past few decades, the literature on green innovation has been continuously developing and expanding, as green products and applications have received widespread and necessary applications with the provision of environmental awareness and services. This study provides a systematic literature review of articles related to green innovation, with the aim of improving conceptual clarity and consistency, thereby advancing theory and research (Xu, Sun, & Kong, 2024).

A literature review on R&D human capital aims to provide a comprehensive analysis and summary of existing research on the concept, characteristics, and impact of human capital in research and development (R&D) activities (Xu & Li, 2023). Concept helps to clarify the definition and scope of R&D human capital, which typically refers to the knowledge, skills, experience, and abilities of individuals involved in R&D activities. At present, most scholars focus on studying the impact of information asymmetry on corporate financing, investment, mergers and acquisitions, innovation, and other aspects (Dierkens, 1991).

The asset-liability ratio is a crucial financial metric that impacts various aspects of a company's operations and performance (Zhao et al, 2024). Zhang, Li, and Wang (2024) discuss the concept of the liability asset, highlighting the importance of understanding the relationship

between assets and liabilities. Tang and Geng (2024) found that the asset-liability ratio has a significant negative relationship with investment expenditure in Chinese power listed companies, indicating that debt can constrain investment.

Controlling shareholders may play a role by influencing the first type of agency problem and the second type of agency problem, namely the "synergy of interests" effect or the "tunnel" effect (Ho, Huang, & Karuna, 2020). Institutional investors play a significant role in the financial markets, impacting various aspects of stock returns, volatility, and corporate governance (Wang & Luo, 2024).

Zhang, Li, and Long (2024) explore the relationship between institutional investor ownership and security price variability at earnings announcement dates. The literature on the big four audit firms covers various aspects related to audit quality, audit fees, client satisfaction, and the impact of audit firm size on audit outcomes (Abdelwahed, Abu-Musa, Moubarak, & Badawy, 2024). Tran and Tran (2023) found that client satisfaction plays a role in explaining cross-sectional variation in Big 6 audit fees. Suryani, Winarningsih, Avianti, Sofia, and Dewi (2023) highlighted the selectivity bias in audit fee studies, showing that large audit firms earn significantly higher fees than small firms.

Literature on board size and composition has been a subject of extensive research over the years (Treepongkaruna, Kyaw, & Jiraporn, 2024). Shah et al. (2024) discusses the size and composition of corporate boards of directors and their relationship with the organization and its environment.

The property rights of state-owned enterprises have a double-edged sword effect on their impact on companies (Sun, Cappa, Zhu, & Peruffo, 2023). On the one hand, state-owned enterprises have close connections with the government and banks, and can obtain policy support and bank loan support, thereby reducing the financial risk of state-owned enterprises (Su & Xue, 2023).

Research Methodology

This paper uses two indicators to measure ESG ratings: (1) ESG scores divided by 100 (esgs) and (2) ESG ratings (1-10) divided by 10 (esgr). In this article, the three sub-dimensions of ESG (environmental rating, social rating, and governance rating) are used instead of ESG scores for empirical testing. (3) The E scores (escore) are calculated by dividing the E scores by 100, (4) the S scores (sscore) are calculated by dividing the S scores by 100, and (5) the G scores (gscore) are calculated by dividing the G scores by 100.

This paper examines three mediating variables: R&D expense (rdc), R&D human capital (rdper), and information transparency (itrans) (Balakrishnan, Blouin, & Guay, 2019; Shen & Hou, 2021). According to existing literatures, to eliminate the impact of firm size, R&D expense is calculated as R&D expenses divided by total assets (Shen & Hou, 2021). According to existing literatures, R&D human capital is the number of R&D persons divided by the total number of employees (Chemmanur, Kong, Krishnan, & Yu, 2019; Meng, Shi, & Wang, 2023). According to existing literatures, this paper uses the rating of information transparency of listed companies disclosed by Shenzhen Stock Exchange and Shanghai Stock Exchange to measure information transparency (itrans) (Han, Tang, & Tang, 2020; S. Zhang, Zhang, Qiao, Li, & Li, 2022). Based on relevant literatures (Fosu, Yi, & Asiedu, 2024), this paper controls the following variables: fsize, debtr, mbr, roa, large, three, iisr, bsize, idr, four, same, soe, year, and industry (ind).

Based on the scientific and availability of data, this article intends to select Chinese listed companies from 2007 to 2022 as the sample. Excluding samples with missing values in certain variables such as ESG scores and green innovation, we obtained 33,637 firm-year matching samples.

The study used mainly includes correlation analysis, panel fixed effects regression, panel mediating effects regression, panel moderating effects regression for analyzing the data based on the research purposes.

Research Finding

1. Empirical Results of the Impact Mechanism Using R&D Personnel Capital (Rdper)
ESG scores significantly influence R&D personnel capital and various green innovation measures (gpat, ginpat, gprpat), with R&D personnel capital serving as a partial mediator. Mediating effects were validated through Sobel, Goodman tests, and bootstrap analysis, supporting H3 at both the 1% and 5% levels.

Table 1: Empirical Results of the Impact Mechanism Using R&D Personnel Capital (Rdper)

	rdper	gpat	ginpat	gprpat
esgs	0.0195***	1.0903***	0.7340***	0.7744***
	(3.101)	(16.792)	(13.333)	(14.795)
rdper		1.3132***	1.2404***	0.5845***
		(23.317)	(25.978)	(12.875)
fsize	0.0085***	0.4122***	0.3399***	0.2860***
	(12.610)	(59.410)	(57.784)	(51.131)
debtr	-0.0515***	0.0965***	0.0141	0.1193***
	(-15.598)	(2.822)	(0.487)	(4.327)
mbr	-0.0988***	-0.2123***	-0.2526***	-0.0592**
	(-31.330)	(-6.431)	(-9.027)	(-2.223)
roa	-0.0989***	-0.2511*	-0.3428***	-0.0490
	(-6.875)	(-1.690)	(-2.721)	(-0.409)
large	-0.0188***	-0.0304	-0.0344	0.0118
	(-5.203)	(-0.813)	(-1.086)	(0.392)
three	0.0042***	0.0750***	0.0396***	0.0586***
	(2.896)	(5.050)	(3.150)	(4.898)
iisr	-0.0417***	-0.0985***	-0.0854***	-0.0773***
	(-15.805)	(-3.602)	(-3.685)	(-3.508)
bsize	-0.0011***	-0.0054	-0.0015	-0.0079***
	(-3.209)	(-1.455)	(-0.484)	(-2.672)
idr	0.0000	0.0009	0.0020**	0.0009
	(0.083)	(0.815)	(2.162)	(0.970)
four	0.0009	0.0770***	0.1351***	0.0368**
	(0.406)	(3.402)	(7.044)	(2.017)
same	0.0076***	0.0341***	0.0503***	0.0093
	(6.478)	(2.819)	(4.902)	(0.952)
soe	-0.0012	0.0846***	0.0906***	0.0341***
	(-0.992)	(6.551)	(8.275)	(3.271)

cons	-0.1287*** (-9.207)	-9.1301*** (-63.184)	-7.3850*** (-60.283)	-6.5299*** (-56.061)
ind / year	yes	yes	yes	yes
N	33,637	33,637	33,637	33,637
Adj-R2	0.4872	0.3622	0.3171	0.3225
F-value	678.9696	397.3130	324.9501	333.0644
Sobel test		Z=3.074 ,**	Z= 3.079 ,**	Z= 3.015,**
Goodman-1 (Aroian) test		Z= 3.071 ,**	Z= 3.077,**	Z= 3.006,**
Goodman-2 test		Z= 3.077,**	Z= 3.082,**	Z= 3.024,**
Proportion of total effect that is mediated		0.02295371	0.0319133	0.01450989
Ratio of indirect to direct effect		0.02349296	0.03296533	0.01472352
Bootstrap 1000 times test		r(ind_eff), Z=11.05, ***;r(dir_eff),Z= 8.49,***	r(ind_eff),Z=10.96,** **;r(dir_eff),Z=4.81 , ***	r(ind_eff),Z=10.66,* **;r(dir_eff),Z=8.42 , ***

Note: *, **, and 1% in the table indicate correlation at the 10%, 5%, and 1% significance levels, respectively.

2. Empirical Results of the Impact Mechanism Using Information Transparency

The moderating effects of debt-to-asset ratio (debtr) and the largest shareholder's shareholding ratio (large) on the relationship between ESG scores (esgs) and corporate green innovation. There is a significant positive correlation between the interaction of esgs and debtr with green innovation metrics (gpat, ginpat, gprpat), indicating that higher debt levels amplify the positive impact of esgs on innovation (coefficients: 1.656, 1.292, 1.625). Similarly, columns (4)-(6) show that a higher shareholding ratio positively influences the effect of esgs on green innovation.

3. Results of Moderating Effect Models Using Iisr and Four

The moderating effects of external governance on the relationship between ESG scores (esgs) and corporate green innovation. There is a significant positive correlation between the interaction of esgs and institutional investor shareholding ratio (iisr) with green innovation metrics (gpat, ginpat, gprpat), indicating that higher institutional ownership enhances the positive impact of esgs (coefficients: 1.163, 0.976, 0.953). There is a positive correlation between esgs and green innovation when associated with one of the four major auditing firms,

4. Results of Moderating Effect Models Using Soe and Bsize

The impact of ESG scores (esgs) on corporate green innovation in relation to property rights and board size. There is a significant positive correlation between the interaction of esgs and state-owned enterprise status (soe) with green innovation measures (gpat, ginpat, gprpat), suggesting that state-owned enterprises benefit more from ESG scores (coefficients: 0.659, 0.540, 0.582). There is a positive correlation between esgs and green innovation as board size (bsize) increases (coefficients: 0.115, 0.102, 0.066), enhancing the positive effects of ESG scores.

The results of the firm fixed effects regression. Columns (1) to (3) show that esgs has a significant positive effect on gpat, ginpat, and gprpat at the 1% level. Columns (4) to (6) show the results of the firm-year clustering, indicating a significant positive effect of esgs at the 1% level.

Table 2: Results of Firm Fixed Effect Model and Firm-year Clustering Model

variable	(1)	(2)	(3)	(4)	(5)	(6)
	Firm fixed effect (reghdfe)			Firm and year clustering		
	gpat	ginpat	gprpat	gpat1	ginpat1	gprpat1
esgs	0.257***	0.022***	0.018***	1.395***	0.958***	0.915***
	(4.221)	(3.384)	(2.768)	(5.890)	(7.072)	(3.951)
fsize	0.312***	-0.002**	-0.007***	0.439***	0.356***	0.301***
	(30.377)	(-2.115)	(-6.553)	(14.513)	(12.629)	(12.156)
debtr	0.049	0.010**	0.013***	-0.078	-0.114*	0.020
	(1.201)	(2.211)	(3.059)	(-0.892)	(-1.802)	(0.277)
mbr	0.014	-0.014***	-0.002	-0.196**	-0.242***	-0.037
	(0.418)	(-4.121)	(-0.513)	(-2.144)	(-3.487)	(-0.528)
roa	0.011	-0.043***	-0.003	-0.356	-0.360	-0.158
	(0.077)	(-2.786)	(-0.202)	(-1.296)	(-1.480)	(-0.848)
large	-0.205***	-0.004	-0.005	-0.153	-0.130	-0.054
	(-3.231)	(-0.527)	(-0.713)	(-1.491)	(-1.565)	(-0.671)
three	0.042***	-0.003	0.002	0.044	0.022	0.039
	(2.922)	(-1.641)	(1.254)	(1.515)	(0.969)	(1.635)
iisr	-0.068**	-0.004	-0.004	-0.081	-0.080	-0.058
	(-2.568)	(-1.336)	(-1.295)	(-1.360)	(-1.610)	(-1.409)
bsize	-0.000	0.002***	0.000	-0.018*	-0.010	-0.015*
	(-0.043)	(3.187)	(0.424)	(-1.677)	(-1.196)	(-1.735)
idr	0.003**	0.000**	0.000**	0.001	0.002	0.001
	(2.238)	(2.282)	(2.013)	(0.337)	(1.011)	(0.461)
four	-0.160***	0.007*	-0.000	0.053	0.122*	0.021
	(-4.567)	(1.936)	(-0.026)	(0.717)	(1.888)	(0.346)
same	-0.011	0.003*	-0.002	0.060**	0.071***	0.022
	(-0.807)	(1.762)	(-1.048)	(2.446)	(3.527)	(1.223)
soe	0.015	0.003	-0.004	0.042	0.063*	0.009
	(0.577)	(0.961)	(-1.504)	(1.047)	(1.848)	(0.299)
cons	-6.317***	0.072***	0.171***	-9.224***	-7.444***	-6.551***
	(-28.739)	(3.038)	(7.372)	(-13.737)	(-11.816)	(-12.291)
ind/year/firm	yes	yes	yes	yes	yes	yes
N	33,138	33,138	33,138	33,637	33,637	33,637
Overall_R^2	0.716	0.599	0.538	0.334	0.293	0.298

Note: *, **, and 1% in the table indicate correlation at the 10%, 5%, and 1% significance levels, respectively.

5. Results of Robustness Test

In order to solve the endogeneity problems such as missing variables and reverse causality in the model, this paper will use the two-stage model of instrumental variables, differential models, the panel random effect and OLS model, the substitution of independent and dependent variables, the firm-level fixed-effect model, and the double clustering model to test the robustness.

To address endogeneity issues, this study employs the Durbin-Wu-Hausman test, revealing significant endogeneity across all models (chi2(1) = 64.72 for gpat; chi2(1) = 150.81 for ginpat; chi2(1) = 3.07 for gprpat). The mean ESG score of industry peers (esgsyi) is used as an instrumental variable. First-stage results indicate a significant positive effect of esgsyi on ESG scores (coefficient = 0.964, t-value = 34.424). Second-stage regressions confirm significant positive impacts of ESG scores on green innovations (gpat: 2.466, ginpat: 1.426, gprpat: 1.905).

To mitigate omitted variable bias and time trends, this study employs differential regression models, using first-order differences (Δ) for dependent, independent, and control variables. Δesgs positively affects Δgpat at the 1% level (coefficient = 0.206, t-value = 3.039). This significant positive impact on Δgpat. Δesgs also positively influences Δginpat and Δgprpat at the 1% level. The results of the panel random effects models and OLS models. Esgs has a significant positive effect on gpat, ginpat, and gprpat at the 1% level when using panel random models. Esgs has a significant positive effect on gpat, ginpat, and gprpat at the 1% level when using panel OLS models.

Egression analysis using the independent variable esgr instead of esgs. The results indicate that esgr has a significant positive effect on gpat, ginpat, and gprpat at the 1% level. Similarly, esgs has a significant positive effect on gpat1, ginpat1, and gprpat1 at the 1% level. To address the issue of standard error bias resulting from intra-group correlation, this study aims to employ double cluster regression analysis at both the firm and year levels. The results of the firm fixed effects regression, found that esgs has a significant positive effect on gpat, ginpat, and gprpat at the 1% level, also showed the results of the firm-year clustering, indicating a significant positive effect of esgs at the 1% level.

Discussion

This paper explores the impact of ESG (Environmental, Social, and Governance) scores on the green innovation activities of Chinese listed companies from 2007 to 2022. ESG scores have emerged as a significant metric for assessing a company's sustainability practices, encompassing environmental responsibility, social impact, and governance quality.

The growing importance of ESG scores is reflected in the way they influence corporate behavior, particularly in areas related to green innovation. Green innovation refers to the development and implementation of environmentally friendly processes, products, and technologies aimed at reducing a company's ecological footprint while enhancing long-term sustainability.

ESG scores are a comprehensive indicator of non-financial performance, integrating a company's environmental, social, and governance dimensions. In particular, the environmental aspect of ESG directly impacts a company's green innovation activities. High ESG scores signal strong environmental management practices, such as waste reduction, energy efficiency, and reduced carbon emissions, which create a conducive environment for innovation. Studies have shown that companies with robust environmental practices are more likely to invest in green technologies and sustainable business models (Chen et al., 2023). As

a result, ESG scores can act as a catalyst for companies to pursue innovations that align with environmental sustainability goals.

Governance, another key component of ESG, also plays a pivotal role in driving green innovation. Good governance practices, including board diversity, transparent decision-making, and long-term strategic planning, provide the necessary structure for companies to pursue sustainable innovation. When corporate governance is strong, decision-makers are more likely to prioritize long-term environmental and social outcomes alongside financial performance (Wang et al., 2023). This forward-thinking governance encourages investment in green technologies and innovation, fostering a culture of sustainability that permeates the entire organization.

Moreover, market recognition of ESG performance incentivizes companies to enhance their green innovation efforts. Investors, customers, and regulators are increasingly placing value on companies with high ESG scores, recognizing them as leaders in sustainability. For instance, higher ESG scores are often associated with lower risks and greater financial stability, making companies more attractive to socially conscious investors (Fang et al., 2023). As companies seek to improve their ESG ratings to attract investment, they are compelled to innovate in areas like energy efficiency, renewable energy, and sustainable supply chains. This market-driven motivation creates a positive feedback loop, where enhanced ESG performance leads to increased green innovation, which in turn bolsters ESG scores.

Additionally, the regulatory environment in China has become increasingly supportive of ESG-focused activities, further amplifying the impact of ESG scores on green innovation. Since the mid-2000s, Chinese regulators have introduced several policies aimed at promoting corporate environmental responsibility and reducing the country's carbon footprint (Li et al., 2023). These regulations have created both opportunities and pressures for Chinese listed companies to adopt sustainable practices and innovate in ways that comply with these evolving standards. Companies with higher ESG scores are typically better positioned to meet regulatory requirements, as they are more likely to have already integrated environmental considerations into their business models.

Furthermore, the social dimension of ESG also indirectly influences green innovation by shaping public perceptions and consumer behavior. Companies that score highly on social metrics—such as fair labor practices, community engagement, and customer satisfaction—tend to cultivate a more positive brand image, which can translate into competitive advantages (Hong et al., 2024). This favorable market position can provide additional resources for companies to invest in green innovation, as consumer demand for sustainable products and services continues to rise. ESG scores serve as a critical indicator of non-financial performance and directly influence the green innovation potential of Chinese listed companies. By fostering environmental awareness, strengthening governance practices, and enhancing market recognition, ESG scores encourage companies to adopt and invest in green technologies. The interplay between ESG performance and green innovation creates a virtuous cycle where sustainability-driven practices enhance corporate competitiveness and long-term value creation. This highlights the growing importance of ESG as a driver of green innovation in China's evolving corporate landscape.

The study results distinguish between substantive green innovation, which entails significant technological advancements, and strategic innovation, focused on optimizing existing processes. It highlights the relationship between ESG scores, institutional investor shareholding, and green innovation, emphasizing that higher ESG scores attract more investments and enhance innovation capabilities. Additionally, it addresses the influence of

the largest shareholder's stake on green innovation decisions. The findings suggest that state-owned enterprises generally excel in ESG ratings due to their social responsibilities, while private enterprises are increasingly recognizing the importance of ESG performance in driving sustainable development and competitive advantage.

Substantive green innovation tends to be more capital-intensive, requiring significant investment in research and development (R&D) to achieve technological breakthroughs. This type of innovation is often pursued by companies with higher ESG scores, as these firms are better positioned to attract institutional investors who prioritize sustainability. Institutional investors, such as pension funds and socially responsible investment firms, tend to favor companies with strong ESG performance due to the long-term value and reduced risk associated with sustainable practices (Wang et al., 2023). By channeling more capital into companies with high ESG ratings, these investors enable firms to engage in more ambitious, long-term innovation projects aimed at achieving significant environmental benefits (Rahman et al., 2023). The influx of capital also provides these companies with the resources needed to take risks and innovate in ways that may not yield immediate financial returns but are crucial for long-term sustainability.

On the other hand, strategic green innovation is often adopted by firms looking to make incremental improvements to existing operations. While these changes may not be as radical as those seen in substantive innovation, they are still essential for improving a company's environmental performance. Strategic green innovation typically involves optimizing processes like energy consumption, waste management, and supply chain operations. Companies with moderate ESG scores may prioritize this type of innovation, as it allows them to enhance their environmental impact without the same level of resource commitment required for substantive innovations (Li et al., 2023). Importantly, even these incremental changes can help companies improve their ESG scores over time, creating a feedback loop where enhanced ESG performance attracts more investment, which in turn fosters further innovation.

The study also highlights the relationship between ESG scores, institutional investor shareholding, and green innovation. Companies with higher ESG scores tend to attract more institutional investors, who are increasingly integrating ESG factors into their investment decisions. These investors not only provide the capital necessary for innovation but also pressure companies to maintain or improve their ESG performance (Fang et al., 2023). The alignment of investor expectations with corporate sustainability goals creates a dynamic where firms are incentivized to continually innovate in order to meet both environmental targets and investor demands.

Another critical factor influencing green innovation decisions is the role of the largest shareholder's stake. The findings suggest that companies with a dominant shareholder, especially in the case of state-owned enterprises (SOEs), are more likely to excel in ESG performance. This is largely due to the additional social responsibilities that SOEs often carry, such as contributing to national sustainability goals and meeting stringent regulatory requirements (Chen et al., 2023). SOEs, particularly in China, are under greater scrutiny to lead by example in terms of environmental and social governance, which translates into higher ESG scores and more substantive green innovation activities.

In contrast, private enterprises are increasingly recognizing the strategic importance of ESG performance in driving sustainable development and competitive advantage. While private firms historically may have been more focused on short-term financial performance, the growing importance of ESG factors in market valuations and investor preferences is shifting their focus toward long-term sustainability. As private enterprises improve their ESG

practices, they become more competitive, not only in attracting investment but also in appealing to environmentally conscious consumers (Zheng et al., 2023). This shift is particularly evident in sectors like manufacturing and technology, where innovation in sustainable practices is becoming a key differentiator in the marketplace.

The ownership structure also plays a significant role in green innovation decisions. SOEs, with their long-term strategic outlook and greater access to state resources, tend to prioritize substantive green innovations. Private companies, on the other hand, may initially focus more on strategic innovations to gradually improve their ESG scores and position themselves for future growth. However, as ESG performance becomes a more critical factor in competitive markets, even private companies are beginning to invest in more substantive forms of green innovation to stay ahead of regulatory changes and market expectations (Huang et al., 2022).

Conclusion

This paper empirically examines the influence of ESG scores on green innovation, substantive green innovation, and strategic green innovation in Chinese listed companies from 2007 to 2022. The results indicate a significant positive impact of ESG scores on these forms of innovation, with a one standard deviation increase leading to a 38.24% rise in green innovation (gpat), a 22.01% increase in substantive green innovation (ginpat), and a 35.52% increase in strategic green innovation. The mechanisms of impact reveal that ESG scores enhance green innovation through R&D expenditure, human capital, and information transparency. Additionally, the positive effects are stronger in companies with higher asset-liability ratios, larger boards, and greater institutional ownership. Notably, only the E-score significantly affects green innovation, while the S-score and G-score do not. The ESG score positively influences innovation with a lag of 1 to 3 years, providing essential policy recommendations for enhancing corporate green innovation.

In summary, the findings of this study suggest that ESG scores are a critical driver of both substantive and strategic green innovation, with institutional investor shareholding playing a key role in fostering innovation capabilities. The influence of the largest shareholder's stake, particularly in state-owned enterprises, highlights the role of ownership structure in green innovation decisions. State-owned enterprises generally lead in ESG performance due to their broader social responsibilities, while private enterprises are rapidly catching up, recognizing the importance of ESG in securing long-term sustainability and competitive advantage. This evolving landscape of corporate governance and sustainability underscores the growing importance of integrating ESG into corporate strategies to drive both innovation and financial performance.

References

Amore, M. D., & Bennedsen, M. (2016). Ineffective corporate governance hinders green innovation.

Balakrishnan, K., Blouin, J. L., & Guay, W. R. (2019). The effect of information transparency on the pricing of equity and debt. *The Accounting Review*, 94(4), 1-26.

Castellacci, F., & Lie, C. M. (2017). Government regulations are critical in driving green decisions.

Chemmanur, T. J., Kong, Y., Krishnan, K., & Yu, Z. (2019). The role of R&D in the relationship between corporate governance and firm performance: Evidence from the US. *Journal of Business Finance & Accounting, 46*(1-2), 174-203. https://doi.org/10.1111/jbfa.12367

Chen, J., Liang, Q., Wang, W., Sun, Z., & Wu, H. (2023). Corporate environmental governance and green innovation: *A literature review. Sustainability*, *15*(6), 1041.

Chen, L., & Liang, Y. (2023). Executive characteristics and green innovation: Environmental awareness and sustainable practices in Chinese firms. *Journal of Cleaner Production*, 283, 125324.

Chen, Song, & Gao. (2023). *ESG ratings and corporate financial performance.*

Dierkens, N. (1991). The impact of information asymmetry on corporate financing and innovation.

Fang, Y., Ren, J., & Zhu, K. (2023). Digital finance and ESG performance: A study on corporate digital transformation and sustainability outcomes. *Journal of Corporate Finance*, *78*, 102479.

Fang, Z., Ren, S., Zhou, W., & Wang, J. (2023). Digital finance and corporate ESG performance: Evidence from Chinese listed firms. *Journal of Environmental Management*, *33*(3), 117-124.

Fosu, S., Yi, A., & Asiedu, E. (2024). Control variables in financial studies: A meta-analysis of commonly used variables. *Finance Research Letters*, 50, 103313. https://doi.org/10.1016/j.frl.2023.103313

Han, Y., Tang, J., & Tang, Y. (2020). Information transparency and firm performance: Evidence from Chinese listed companies. *Journal of Business Research*, 120, 255-263. https://doi.org/10.1016/j.jbusres.2019.08.032

Ho, K. Y., Huang, H. H., & Karuna, C. (2020). *Controlling shareholders and agency* problems.

Hong, Z., Luo, X., & Yu, J. (2024). Green innovation and sustainable development: Global incentives and strategies. *International Journal of Sustainable Development and World Ecology, 31*(1), 22-35.

Huang, J., Sun, S., & Liu, H. (2019). Environmental regulations and green innovation: Evidence from China. *Journal of Cleaner Production*, *211*, 333-343.

Huang, Y., Li, S., & Chen, F. (2022). Government-led ESG frameworks in China: Policies and market adaptations. *Asian Business and Management, 21*(4), 582-600.

Huang, Z., Liao, & Li. (2019). *Green loans and government subsidies' impact on green innovation.*

Javed, M., Rafiq, M., & Yu, W. (2023). Environmental awareness and female CEOs: Leadership and corporate environmental responsibility. *Gender, Work, and Organization*, *30*(2), 178-195.

Li, J., Lian, Y., & Xu, Q. (2023). Does ESG performance promote green innovation? Evidence from China. *Journal of Cleaner Production*, *390*, 136-149.

Li, X., & Li, Q. (2023). Global carbon neutrality policies: A comparative analysis of the EU, China, and the U.S. *Journal of Environmental Policy and Planning, 45*(1), 105-121.
Lian, G., Xu, & Zhu. (2022). The role of government regulations in promoting green innovation.
Lu, & Cheng. (2023a). *Government environmental regulations improve ESG outcomes.*
Luo, L., Tang, Q., Sun, Z., & Wang, J. (2023). The impact of ESG on green transformation: Mechanisms and future research directions. *Business Strategy and the Environment*, *32*(3), 1489-1501.
Menicucci, A., & Paolucci, G. (2022). Board diversity and ESG: Assessing governance practices in emerging markets. Corporate Governance: *The International Journal of Business in Society, 22*(3), 321-337.
Meng, Y., Shi, H., & Wang, Y. (2023). Research and development human capital and firm performance: Evidence from China's A-share market. *Economic Modelling*, 119, 105099.
Mickwitz, P., Hyvättinen, K., & Kivimaa, P. (2008). *Government regulations and their impact on green decisions.*
Rahman, S., Zahid, M., & Al-Faryan, M. (2023). Corporate ESG practices and green innovation: An empirical investigation. *Environmental Impact Assessment Review*, 92, 107011.
Sun, H., Cappa, Zhu, & Peruffo. (2023). Property rights of state-owned enterprises and their effects.
Shen, Y., & Hou, W. (2021). How does corporate social responsibility affect financial performance? Evidence from listed companies in China. *Sustainability*, *13*(4), 1872.
Song, Y., & Yu, H. (2018). *The importance of green innovation for sustainable development.*
Sun, W., Wang, L., & Lin, C. (2023). Impact of institutional environment on ESG ratings: Evidence from green finance policies and environmental taxation. *Finance Research Letters, 56*, 103829.
Tang, Y., & Geng, Z. (2024). *The relationship between asset-liability ratio and investment expenditure.*
Tian, H., Siddik, Pertheban, & Rahmand. (2023). *Influencing factors of green innovation*.
Tran, D., & Tran, T. (2023). *Client satisfaction and audit fee variations in Big 6 audit firms.*
Wang, J., Sun, J., Wang, Y., Hua, X., & Wu, C. (2023). The influence of ESG disclosure on corporate environmental innovation. *Journal of Business Ethics*, 185(2), 287-306.
Wasiuzzaman, S., Ibrahim, M., & Baloch, M. A. (2023). Institutional environment and ESG disclosure: Evidence from emerging markets. *Emerging Markets Review*, 55, 107-117.
Wasiuzzaman, S., Mushtaq, A., & Naheed, R. (2023). Financial implications of ESG ratings on bond spreads and market risks. *Journal of Empirical Finance*, 69, 45-59.
Wen, Z., Zhao, W., Fu, L., & Chang, H. (2023). *Financial risk and its effects on green* innovation.
Xu, J., & Li. (2023). *R&D human capital and its impact on innovation.*
Xu, R., Yao, & Zhou. (2023). *Environmental regulations and corporate governance.*
Zahid, A., Uddin, M., & Haider, S. (2023). ESG ratings and corporate performance: Global perspective. *Journal of Business Ethics*, *178*(1), 45-65.
Zhang, S., Zhang, H., Qiao, H., Li, X., & Li, Z. (2022). The impact of information transparency on investment decisions: Evidence from the Chinese stock market. Journal of International Financial Markets, *Institutions and Money, 75*, 101491.
Zhang, J., et al. (2024). Enterprises should promote sustainable development through green

innovation.
Zhao, Liu, Dong, Sun, & Zhang. (2024). The asset-liability ratio and its significance in corporate performance.
Zheng, L., Xu, Q., & Zhou, X. (2023). Future research directions in ESG and green innovation: An analytical perspective. *Business Strategy and the Environment*, *32*(5), 1367-1383.
Zhou, S., Xie, Z., & Wang, Y. (2023). Corporate sustainability in the era of ESG: The integration of social, economic, and environmental goals. *Sustainability Journal*, *15*(3), 123-137.
Zhou, S., Zhang, Y., & Yang, L. (2023). ESG performance and its impact on sustainable economic growth. *Economic Research*, *10*(5), 119-133.