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THE IMPACT OF CORPORATE ESG PERFORMANCE ON URBAN CARBON EMISSIONS

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Abstract: With the rapid advancement of urbanization in our country, cities, as the main places for human activities, have always been the focus of the government and all sectors of society for their sustainable and green development. ESG, as a framework for sustainable investment and enterprise management, aligns with China's new development concept of coordinating ecological civilization with economic growth. It helps enterprises enhance their green technological innovation capabilities, thereby promoting the carbon reduction and green transformation of cities. Based on the long-term panel data of A-share listed companies in China from 2011 to 2023, this article deeply explores how the ESG performance of enterprises contributes to urban carbon reduction and the underlying mechanism. The empirical research results show that the improvement of enterprises' ESG performance has a significant positive impact on urban carbon emissions, and this conclusion still holds after the robustness test, further verifying its reliability. The results of the mediating effect indicate that enterprises can significantly enhance the level of green technological innovation by improving ESG performance, thereby reducing urban carbon emissions. The research conclusion of this paper can not only provide an important theoretical basis for the sustainable development of enterprises, but also offer policy inspirations for promoting and building low-carbon and green cities nationwide.
Keywords: Corporate ESG performance; Urban carbon reduction; Green technological innovation; Sustainable development

1 INTRODUCTION

"ESG performance" and "urban carbon emissions" have been hot topics in discussions about economic development in recent years. As China's economy enters a stage of high-quality development, its economic growth model is shifting from traditional aggregate expansion to sustainable development. In this transformation process, developing a green economy and promoting a comprehensive green and low-carbon transformation of the economy and society has become an inevitable choice for China to keep pace with the times and achieve long-term development. Against the backdrop of intensifying global warming and the advancement of "dual carbon" targets, cities, as one of the main sources of carbon emissions, play a crucial role in achieving a low-carbon and green transformation [1]. While China's economy is developing rapidly, the current state of urban carbon emissions also faces severe challenges. Under the "dual carbon" targets, it is urgent to explore pathways for promoting low-carbon and green development in cities. Therefore, whether corporate ESG performance can significantly reduce urban carbon emission intensity is of great significance for studying the sustainable development of China's economy.

Green development is the foundation of high-quality economic development. As a populous country, China faces numerous challenges, including high pressure on resource and energy supply and prominent ecological degradation. Therefore, balancing economic development with ecological environment protection is a matter of ongoing concern for all sectors of society. ESG , as a standard for measuring corporate performance in environmental protection, social responsibility, and corporate governance, breaks away from the past focus solely on corporate financial performance and aligns closely with China's current green development philosophy, making it an important tool for promoting high-quality economic development [2]. Gao Jieying et al. (2021) argue that companies with good ESG performance can reduce internal management problems [3], raise funds more easily, and invest more effectively, ultimately enhancing corporate value. Wang Lu et al. (2024) show that improving corporate ESG levels can help companies achieve green transformation [4]. Wu Xia et al. (2024) believe that companies with good ESG performance often excel in green technology research and development and resource utilization efficiency improvement [5], thus promoting their own sustainable development while also contributing to the green transformation of local cities. Therefore, under the premise of pursuing green and sustainable economic development, studying the relationship between corporate ESG performance and carbon reduction in local cities is of great significance.

2 RESEARCH APPROACH AND CONTENT

First, this paper reviews relevant literature on both domestic and international sources, focusing on corporate ESG performance and urban carbon emissions. Second, building upon this foundation, while exploring the positive impact of corporate ESG performance on urban carbon reduction, this paper further analyzes the mechanism by which corporate ESG performance affects urban carbon reduction and proposes corresponding research hypotheses. Third, by

constructing a standardized regression model, this paper examines the relationship between corporate ESG performance and urban carbon emissions, introducing green technology innovation as a mediating variable into the mediation mechanism model to verify whether corporate ESG performance influences urban carbon emissions by improving the level of green technology innovation. Finally, based on the empirical analysis results, targeted policy recommendations are proposed.

3 INNOVATIONS AND SHORTCOMINGS

Existing research indicates a correlation between corporate ESG performance and urban carbon emissions. Many scholars have proposed improving corporate ESG performance to reduce urban carbon intensity and promote sustainable urban economic development. However, there are still shortcomings: First, there is limited research on the relationship between corporate ESG performance and urban carbon reduction. Existing literature mainly focuses on the impact of corporate ESG performance on their own value, neglecting the meso-level role of cities as the interaction hub of "corporation-industry-policy." Second, the mediating role of green technology innovation has not been quantified. Although green technology innovation is widely considered a key path for ESG- driven emission reduction, existing literature largely remains at the theoretical deduction level, lacking quantitative verification of its mediating effect. Therefore, this paper analyzes the impact of corporate ESG on urban carbon emissions from the perspective of corporate ESG , studies the mediating mechanism of green technology innovation on urban carbon reduction, summarizes the empirical results, and proposes targeted policy recommendations to enrich the theoretical research on the relationship between corporate ESG performance and urban carbon reduction.

The innovations of this paper are as follows: First, innovation in research perspective. Traditional ESG research often focuses on the emission reduction behavior of individual enterprises, neglecting the impact of corporate ESG performance on urban carbon emissions. Therefore, this paper breaks through the limitations of traditional ESG research that focuses on the micro-level of enterprises, incorporating cities as a meso-level unit of "interaction between corporate behavior and regional policies." Second, at the theoretical level, this paper comprehensively discusses the mechanism by which corporate ESG performance contributes to urban carbon reduction and sustainable development from both direct and indirect effects , providing a basis for future related analyses and research. Third, at the data processing level, this paper incorporates corporate ESG performance and urban carbon reduction into the same analytical system to construct a regression model, and uses the logarithm of the total number of processed green patent applications to measure the level of urban green technology innovation, thus providing empirical evidence that corporate ESG performance reduces urban carbon emissions by influencing green technology innovation.

4 LITERATURE REVIEW

4.1 Corporate ESG Performance

As the concept of green development gains widespread acceptance, the academic community is paying increasing attention to corporate ESG performance. Current research on ESG performance mainly focuses on its impact on corporate value. However, scholars have not yet reached a unified consensus. One view holds that ESG performance enhances corporate value. This view emphasizes that ESG performance not only increases corporate transparency and market trust but also creates long-term benefits for companies by optimizing resource allocation and improving management efficiency. E1 et al. (2018) pointed out that by actively fulfilling their environmental responsibilities through increased environmental investment and improved environmental risk management [6], companies can effectively reduce investors' perception of risk, thus gaining a cost advantage in debt and equity financing. Godfrey (2005) research shows that ESG performance can enhance corporate market competitiveness by strengthening brand value and accumulating intangible assets [7], thereby increasing corporate value. Pan Haiying et al. (2024) believe that improving corporate ESG performance can significantly reduce corporate financing costs, especially the impact on corporate debt financing costs [8], which is beneficial for optimizing investment structure and increasing corporate value. Another view, however, argues that ESG performance reduces corporate value. Bénabou et al. (2010) argue that public disclosure of ESG information may reduce corporate efficiency and instead become a profit-making tool for managers [9], thereby further hindering corporate value growth. Sethi (1975) believes that companies may not truthfully disclose their actual corporate social responsibility reports in order to cover up misconduct by management [10]. Quan Xiaofeng et al. (2015) argue that corporate social responsibility may significantly increase management costs because it exacerbates the conflict of interest between shareholders and managers [11] , thereby reducing the overall value of the company.

4.2 Corporate ESG Performance and Urban Carbon Emissions

Current research on corporate ESG performance and urban carbon emissions mainly revolves around two aspects. First, improved corporate ESG performance can drive urban carbon emission reduction. Good ESG performance can promote the low-carbon transformation of enterprises directly or indirectly, which is conducive to reducing urban carbon emissions. Zhang Xiaoxi et al. (2022) demonstrated, based on data from A- share listed manufacturing companies in Shanghai and Shenzhen from 2012 to 2020 , that good corporate ESG performance (especially non-state-owned enterprises) can reduce carbon emissions by increasing green investment and technological innovation [12]. In addition,

by improving their ESG performance, enterprises can better address environmental challenges, thereby improving urban environmental quality and promoting urban green and low-carbon transformation [13]. Second, urban policies can reduce urban carbon emissions by promoting corporate ESG practices. Liu Xin et al. (2023) demonstrated, based on data from A- share listed companies in China from 2011 to 2019 [14], that low-carbon pilot policies can incentivize enterprises to carry out green technology innovation, which is conducive to enterprises optimizing resource allocation, thereby improving corporate ESG performance and ultimately having a positive impact on urban carbon emission reduction. The study by Wang Zhi et al. (2022) also shows that low-carbon city pilot policies have a positive effect on improving corporate ESG performance [15], especially in terms of green investment and technological innovation.

5 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

5.1 Corporate ESG and Urban Carbon Emissions

As a crucial component of the urban economic system, enterprises' ESG performance significantly impacts urban carbon emissions and serves as a key driver for local urban low-carbon transformation. Positive corporate ESG performance can reduce overall urban carbon emissions and promote urban low-carbon transformation. The positive impact of corporate ESG performance on urban carbon reduction is mainly reflected in the following three aspects: First, from an energy conservation perspective, enterprises directly reduce their own energy consumption and carbon emissions by adopting energy-saving technologies, improving energy efficiency, and promoting clean energy, further accelerating the green upgrading of industries and promoting the transformation of the urban economy towards a high-quality development model, thus injecting strong momentum into the city's carbon reduction efforts. Second, from a supply chain management perspective, the supply chain is a vital link in enterprise operations and a major source of carbon emissions. Strengthening green supply chain management not only encourages suppliers to adopt green production and logistics methods but also helps reduce carbon emissions at each stage of the supply chain, improving the carbon emission situation of the city where the enterprise is located. Finally, from a corporate reputation perspective, to enhance their image, enterprises will actively fulfill their social responsibilities and focus on employee welfare, which not only strengthens their core competitiveness but also provides a solid foundation for their long-term development. Furthermore, businesses can raise employees' environmental awareness and participation by carrying out environmental protection activities and promoting low-carbon lifestyles, thereby encouraging more businesses and individuals to participate in urban carbon reduction efforts, creating a positive atmosphere of shared responsibility across society, and ultimately improving the city's overall carbon emissions. In addition, to avoid the negative impact of a poor reputation, businesses will also improve their ESG performance by establishing green management systems, which also helps cities reduce carbon emissions.

Based on the above analysis, this paper proposes the following hypotheses.

Hypothesis 1: Improved corporate ESG performance can reduce urban carbon emissions.

5.2 The Impact Mechanism between Corporate ESG Performance and Urban Carbon Emissions

corporate ESG performance and green technology innovation has gradually gained attention from the academic community. Green technology innovation, as a crucial means of achieving urban carbon reduction, reduces urban carbon emission intensity by replacing traditional high-carbon technologies with clean and low-carbon ones. It is not only a key driver of green economic transformation but also a significant breakthrough in building climate-resilient cities [16]. Against the backdrop of pursuing high-quality economic development, scholars are increasingly focusing on the synergistic mechanism between ESG performance and green technology innovation, exploring their positive impact on urban carbon reduction. Some argue that corporate ESG performance can significantly promote increased investment in green technology R&D by market-incentive-based environmental regulations (such as carbon emission trading mechanisms), guiding enterprises towards low-carbon production and operations [17]. Aghazadeh Ardebili et al. (2024) believe that companies with excellent ESG performance are more inclined to adopt technologies such as digital twins and artificial intelligence to optimize energy management systems [18], reducing resource consumption and carbon emissions per unit of output through technological innovation. Meanwhile, ESG performance can encourage companies to incorporate carbon neutrality and technology R&D into their long-term strategies, and leverage technologies such as blockchain and the Internet of Things to build a full life-cycle carbon footprint tracking system, thereby promoting collaborative innovation in green technologies across the supply chain [19]. Empirical research by Wang Jianxin et al. (2024) shows that improved ESG performance can enhance the efficiency of companies' green patent output, prompting clean technologies to penetrate high-carbon sectors such as construction and transportation [20], thus reducing total urban carbon emissions. Green technology innovation not only effectively allocates corporate resources but also drives the decarbonization and greening of regional urban economies through technology spillover effects, forming a transmission mechanism of " ESG practice—technological innovation—carbon reduction."

Based on the above analysis, Hypothesis 2 is proposed:

Corporate ESG performance can reduce urban carbon emissions by improving green technology innovation.

6 RESEARCH DESIGN

6.1 Variables and Data Description

6.1.1 Dependent variable: carbon emission intensity (CIDO)

This paper refers to the measurement method of Wang Hao et al. (2022) and measures the carbon emission level of listed companies by calculating the total carbon emissions generated by combustion emissions [21], production process emissions, waste emissions and land use changes (such as forests being converted into industrial land).

6.1.2 Core explanatory variable: Corporate ESG performance (ESG)

ESG is an evaluation standard that reflects a company's performance in environmental, social responsibility, and self-management aspects. It emphasizes that while pursuing economic benefits, companies should also pay attention to social and environmental benefits and make positive contributions to the sustainable development of society. This paper adopts the research model of Wang Linlin et al. (2022) for measurement [22]. Based on the Huazheng ESG evaluation system, scores of "9" and "1" are assigned in descending order of level.

6.1.3 Mediating variable: green technology innovation (DIGI)

This paper calculates the total number of green applications for the year by summing up the data on independently filed green inventions and green utility models, and uses this to measure green technology innovation. Given the large sample size, to avoid the influence of extreme values on the analysis results, the logarithm of the total number of green patent applications is used as the metric.

6.1.4. Control variables

The study introduces enterprise asset size (TA) , carbon performance method (TJX) , cost of goods sold (CO) , free average fixed asset ratio (FAR) , and return on assets (ROA) as control variables. *TA* is calculated using the sum of current assets and non-current assets; *TJX* is expressed as the reciprocal of total carbon emissions per million yuan of net sales; *CO* is measured using the logarithm of cost of goods sold; *FAR* is expressed as the ratio of net fixed assets to total assets; and *ROA* is measured as the ratio of net profit to average total assets.

Based on data availability, this study focuses on A- share listed companies in China, spanning from 2011 to 2023. The ESG data used in this paper comes from the rating results of the Huazheng ESG Evaluation System, with relevant data sourced from the Wind database, and other data from the CSMAR database. During data processing, linear interpolation was used to impute missing values to ensure data integrity. Furthermore, to reduce the volatility of the sample data, logarithmic processing was applied to non-ratio indicators (Table 1).

Table 1 Variable Description

variable type	variable name	variable conform to	Variable measurement
Explained variable	carbon emission intensity	*CIDO*	Carbon emissions from listed companies = emissions from combustion and escape + emissions from production processes + emissions from waste + land use conversion (forests converted to industrial land)
Explanatory variables	Corporate ESG performance	*ESG*	According to the Huazheng ESG evaluation system, scores are assigned from highest to lowest as "9" and "1" points respectively.
control variables	Enterprise asset size	*TA*	Logarithm of current assets + non-current assets
	Carbon performance approach	*TJX*	The reciprocal of total carbon emissions per million yuan of net sales
	Operating costs	*CO*	Using the logarithm of operating costs
	Fixed asset ratio	*FAR*	The proportion of net fixed assets to total assets
	Return on assets	*ROA*	Net profit as a percentage of average total assets

6.1.5 Descriptive statistics

Before conducting correlation analysis among variables and estimating basic regression results, descriptive statistics need to be performed on the explained variable, core explanatory variables, and control variables to understand the basic situation of the impact of corporate ESG performance on control variables such as urban carbon emissions. The specific results for each variable after descriptive statistical analysis are shown in Table 2.

Table 2 Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	mean	sd	min	max
CIDO	31853	2.872	1.676	0.0 1 0	8.941
ESG	31853	5.600	1. 900	1.000	9.000
TA	31853	21.487	1. 5 36	18. 10	2 6.527

CO	31853	11.988	1.636	9.824	19.651
TJX	31853	0.724	1.182	0.05	2.79
FAR	31853	0.282	0.124	0.020	0.923
ROA	31853	0.058	0.025	-0.032	0.157

6.2 Model and Setting

To effectively verify the relationship between corporate ESG performance and urban carbon reduction involved in the above hypothetical analysis, this paper incorporates corporate ESG performance (ESG) and urban carbon reduction (CIDO) into the same analytical framework, and constructs the following regression model based on the work of Sun Hongmei et al. (2024) [23]:

$$CIDO_{it} = \beta_0 + \beta_2 ESG_{it} + \beta_3 \text{control} + \mu_t + \delta_i + \varepsilon_{it} \quad (1)$$

In model (1), the core explanatory variable is corporate ESG performance (ESG) , and the explained variable is carbon emission intensity (CIDO). Here, $CIDO_{it}$ represents the carbon emission intensity of city i in year t, and ESG_{it} represents the ESG performance of company i in year t. $Controls$ represents a series of control variables, including company asset size (TA) , carbon performance method (TJX) , operating costs (CO) , fixed asset ratio (FAR) , and return on assets (ROA). μ_t and δ_i represent individual fixed effects and time fixed effects, respectively. ε_{it} represents the random disturbance term.

7 BENCHMARK EMPIRICAL RESULTS

7.1 Benchmark Regression

The results of this study indicate that, at a 1% confidence level, for every 1-unit decrease in corporate ESG performance, urban carbon emissions decrease by 0.301 units. This demonstrates that improving corporate ESG performance can effectively reduce urban carbon emissions.

Table 3 presents the baseline regression results of the impact of corporate ESG on urban carbon emissions. Column (1) shows the regression results without considering ESG factors , and column (2) shows the regression results after incorporating ESG factors. As shown in Table 3, after adding the variables, the impact of corporate ESG performance on urban carbon emissions is significantly negative at the 1% confidence level, indicating that improving corporate ESG performance has a significant promoting effect on urban carbon emission reduction. These results demonstrate that corporate ESG has strong robustness in urban carbon reduction, validating research hypothesis 1. Therefore, to promote urban low-carbon transformation, it is necessary to improve corporate ESG performance, improve environmental and social governance mechanisms, promote the synergy of green technology innovation and green investment, guide enterprises to deeply participate in carbon emission reduction through ESG policy tools, and ultimately achieve the organic integration of high-quality economic development and the "dual carbon" goal.

Table 3 Corporate ESG Impacts on Urban Carbon Reduction: Baseline Regression

variable	(1)	(2)
ESG	—	-0.301***
		(-2.945)
TA	0.152	0.128***
	(1.421)	(2.987)
TJX	0.020	0.083***
	(1.279)	(3.757)
co	-1.695***	-1.718***
	(-5.677)	(-4.891)
FAR	-0.045	-0.032
	(-1.603)	(-1.211)
ROA	0.118***	0.096**
	(3.012)	(2.654)
Constant	11.574***	9.350***
	(41.087)	(70.441)
N	31848	31848
R2	0.833	0.673
F	421.633	273.796

Note: The numbers in parentheses represent carbon emission intensity (CIDO) , where ***, **, and * indicate that the coefficient is significant at the 1%, 5%, and 10% confidence levels, respectively. The same applies to subsequent tables.

7.2 Robustness test

there is no accurate method to measure corporate ESG performance, this paper introduces the *ESG1* metric for verification to further test the robustness of the regression results. The results are shown in Table 4. Columns (1) and (2) of Table 4 show that there is no significant difference in the impact of corporate ESG performance on urban carbon reduction targets. This implies that the empirical regression results of the econometric model are highly robust.

Table 4 Robustness Test Results

	CEIC	*CEIC*
ESG1		-0.299***
		(-2.926)
TA	0.152	0.128***
	(1.421)	(2.987)
TJX	0.020	0.083***
	(1.279)	(3.746)
co	-1.695***	-1.718***
	(-5.677)	(-4.891)
FAR	-0.045	-0.032
	(-1.603)	(-1.211)
ROA	0.118***	0.096**
	(3.012)	(2.654)
Constant	0.816**	0.252
	(2.571)	(0.680)
N	31848	31848
R2	0.833	0.673
F	421.633	2 73.796

8 TESTING THE MECHANISM OF CORPORATE ESG IN URBAN CARBON REDUCTION

To examine the impact of corporate ESG performance on urban carbon emission reduction, this paper establishes the following mediation effect model based on the stepwise regression method :

$$CIDO_{it} = \beta_0 + \beta_2 ESG_{it} + \beta_3 \text{control} + \mu_t + \delta_i + \varepsilon_{it} \quad (2)$$

$$DIGI_{it} = \beta_0 + \alpha_1 ESG_{it} + \beta_5 \text{control} + \mu_t + \delta_i + \varepsilon_{it} \quad (3)$$

$$CIDO_{it} = \beta_0 + \mu_1 DIGI_{it} + \alpha_2 ESG_{it} + \beta_6 \text{control} + \mu_t + \delta_i + \varepsilon_{it} \quad (4)$$

Table 5 shows the results of the mediation regression. Column (1) of Table 5 shows that, without the introduction of mediating variables, the impact of corporate ESG performance on urban carbon emissions is significant at the 1% confidence level and is negative, indicating that improved corporate ESG performance can effectively reduce urban carbon emissions. Column (2) of Table 5 shows that the impact of corporate ESG performance on green technology innovation (DIGI) is significant and positive, and is significant at the 5% confidence level, indicating that corporate ESG performance may indirectly affect green technology innovation by inhibiting traditional technology paths or forcing technological transformation. Column (3) of Table 5 shows that when both *ESG* and *DIGI are introduced* , the coefficient of *DIGI's impact* on *ESG* is -0.300, and is significant at the 1% confidence level, indicating that for every unit increase in green technology innovation, urban carbon emission intensity decreases by 0.3 units, while the coefficient of corporate ESG performance is no longer significant, meeting the criteria for a complete mediation effect. Therefore, green technology innovation plays a complete mediating role between corporate ESG performance and urban carbon emissions. Corporate ESG performance primarily achieves carbon reduction by promoting green technology innovation, rather than directly contributing to carbon reduction. Hypothesis 2 is thus verified.

Table 5 Mechanisms by which Corporate ESG Influences Urban Carbon Reduction: Green Technology Innovation

	(1)	(2)	(3)
	CIDO	*DIGI*	*CIDO*
ESG	-0.301***	0.1 0 3 **	0.014
	(-2.945)	(2.123)	(1.353)
DIGI			-0.300***
			(-3.539)
Constant	0.178	0.018***	0.192
	(0.478)	(6.659)	(0.515)
N	31848	31848	31848
R^2	0.698	0.729	0.372

AdjR ^{2}	0.698	0.72 7	0.37 0

9 CONCLUSIONS AND POLICY RECOMMENDATIONS

This study uses data from the Wind Financial Database and the CSMAR Economic and Financial Research Database, selecting Chinese A- share listed companies from 2011 to 2023 as the observation subjects. The aim is to explore the specific pathways through which corporate ESG performance impacts urban carbon emissions. Empirical research demonstrates that: 1. Improved corporate ESG performance can contribute to urban carbon emission reduction, and this conclusion remains reliable after robustness testing. 2. Green technology innovation plays a significant mediating role in how corporate ESG performance contributes to urban carbon emission reduction.

First, based on the baseline regression results of this paper, it can be concluded that good corporate ESG performance can effectively reduce urban carbon emissions. Therefore, to achieve the goal of low-carbon urban development, it is essential to improve corporate ESG performance, making it a significant driver of urban carbon reduction. On the one hand, companies need to build an ESG- driven system by strengthening their own ESG management, optimizing their internal management structure, and enhancing their social responsibility awareness, thereby paying more attention to energy conservation, emission reduction, and resource utilization efficiency in their production and operation processes. On the other hand, the government, as a policymaker and regulator, can guide and regulate corporate ESG performance. Therefore, the government should accelerate the construction of an ESG policy system, improve the ESG information disclosure mechanism, and incentivize companies with good ESG performance through policy tools such as tax breaks and green credit , thereby increasing urban ecological governance efforts and accelerating the green economic transformation process.

Secondly, based on the mediation effect test in this paper, it is known that corporate ESG performance can reduce urban carbon emissions by promoting the improvement of green technology innovation. Therefore, it is necessary to give full play to the mediating mechanism of green technology innovation and accelerate technological reform. First, focus on green technology R&D and application transformation, establish an ESG -oriented clean technology special fund, prioritize support for breakthroughs in key technologies, improve support policies for green patents, and accelerate the application of technological achievements in high-carbon fields such as industry and construction. Second, strengthen collaborative innovation among all sectors of society, encourage schools and enterprises to jointly establish ESG technology innovation organizations, utilize digital technology to build carbon management platforms, monitor corporate carbon emissions and green technology applications in real time, and accurately assess corporate status. Third, establish and improve policy incentive systems, linking the intensity of green technology investment with corporate ESG ratings, providing carbon quota rewards or tax reductions to enterprises using advanced green technologies, and penalizing enterprises using outdated technologies, thereby forcing enterprises to undergo green technological transformation [24].

Finally, the synergistic advancement of corporate ESG performance and urban carbon reduction requires a concerted effort from both technology and talent to address the technological and human resource challenges in the green transition. On the one hand, universities should establish interdisciplinary programs in " ESG + Carbon Reduction" to cultivate well-rounded professionals with expertise in both environmental governance and technological innovation. Simultaneously, local governments can formulate specific talent recruitment policies based on local development needs, ensuring that technological achievements are implemented in urban carbon reduction practices. Furthermore, a long-term and effective incentive mechanism must be established, such as providing equity incentives to leading talents, to create a virtuous cycle of "technological breakthroughs—talent growth—carbon reduction and efficiency improvement," ultimately closely linking corporate ESG performance with urban low-carbon development.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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