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The Impact of ESG on Corporate Carbon Performance

-- A Case Study based on the Comparison between CATL and SANY Heavy Energy

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Abstract: Global carbon neutrality roadmaps are being steadily delivered, alongside the enforcement of the EU CBAM carbon tariff policy, which makes the correlation between listed firms' ESG levels and carbon efficiency a worthy research subject. This work collects 15,128 valid observation records of domestic A-share corporations from 2019 through 2023. A two-way fixed-effects panel model is applied to conduct empirical tests on the heterogeneous influence of comprehensive ESG as well as E, S, G separate indicators on unit-output carbon emissions. Additionally, two industry-leading renewable energy firms, CATL and SANY Heavy Energy, are picked to implement a comparative dual-case study The research finds that: the comprehensive ESG performance significantly reduces the corporate carbon emission intensity, among which the emission reduction effect of the governance (G) dimension is the strongest, followed by the environmental (E) dimension, and the social (S) dimension is no longer significant after controlling other dimensions; the conclusion is basically the same after using the individual fixed-effect model for the robustness test, and the significance of the environmental dimension is even enhanced. The case analysis shows that CATL forms a differential advantage in the E dimension relying on supply chain carbon management and battery recycling system, while SANY Heavy Energy performs outstandingly in the G dimension through a complete governance structure and full-life cycle carbon accounting. This paper expands the mechanism research on the impact of ESG sub-dimensions on carbon performance, and provides practical reference for new energy enterprises to cope with overseas carbon barriers.

Keywords: ESG; Carbon Performance; Dual-case Comparison; Carbon Border Adjustment Mechanism (CBAM).

1. Introduction

The global climate governance system is accelerating its reconstruction, and carbon neutrality has become the strategic consensus of most countries. In October 2023, the EU's Carbon Border Adjustment Mechanism (CBAM) officially entered the transition period, and from 2026, carbon tariffs will be levied on imported products such as steel, aluminum, cement, fertilizers, electricity, and hydrogen; the EU's New Battery Law, which came into effect during the same period, puts forward mandatory accounting requirements for the carbon footprint of the entire life cycle of power batteries. For Chinese new energy export enterprises, carbon performance is no longer simply a social responsibility issue, but a hard constraint directly related to market access and cost competitiveness. Under this background, exploring how ESG performance affects corporate carbon performance and the differences in the action paths of different sub-sectors has important theoretical value and practical significance[1-3].

Existing research has preliminarily explored the relationship between ESG and carbon performance. Sun Na and Qu Weihua (2026) found that ESG performance promotes carbon emission reduction through two paths: green technology innovation and improvement of total factor productivity. However, this study regarded ESG as an overall construct and failed to disassemble the differential contributions of the three dimensions of environment (E), society (S), and governance (G). He Yong and Bai Ye (2026) verified the positive impact of ESG on carbon performance from the perspective of "patient capital", and also did not involve dimensional analysis. Zhang Yong (2026) started from the perspective of managerial myopia and found that factors at the governance level would significantly hinder the improvement of carbon performance, indirectly confirming the importance of the G dimension, but lacking a systematic dimension comparison [4].

In terms of research methods, most existing literature uses large-sample panel regression. Although it can reveal the average effect, it is difficult to deeply analyze the specific action mechanism and industry heterogeneity within enterprises [3, 5]. In terms of case studies, Wang Li et al. (2025) took the steel industry as an example to explore ESG rating methods, and Shi Jia (2025) analyzed a single case of a green financial technology platform, but both lacked a dual-case comparison design within the new energy industry [6,7]. Gong Guangming and Chen Ruohua (2013) used the comparative case analysis of ConocoPhillips and BP to analyze ecological responsibility, providing a paradigm reference for dual-case studies. However, their research object was traditional energy enterprises, which had essential differences from the policy environment and technological characteristics of the new energy track [8].

Based on the above research gaps, this paper adopts a mixed research design of "large-sample empirical study + dual-case analysis". The main contributions are reflected in three aspects: First, at the theoretical level, systematically disassembling the differential impact paths of the three dimensions of ESG on carbon performance to the limitation of "dimension merging" in existing research; Second, at the methodological level, combining macro-empirical laws with micro-enterprise practices to reveal industry heterogeneity through horizontal comparison between CATL and SANY Heavy Energy; Third, at the practical level, combining the phased progress of EU carbon policies to provide an implementable ESG optimization plan for new energy

enterprises going global.

2. Research Design and Data Sources

2.1. Sample Selection and Data Sources

All Chinese A-share listed companies during 2019 to 2023 form the initial sample pool of this research. Three sorting restrictions are set for sample cleanup: financial industry listed entities are discarded; enterprises with ST, *ST risk labels or that have completed delisting are ruled out; sample entries without complete core variable records are also excluded. Following the above screening steps, the finalized sample includes 15,128 firm-year observations.

The carbon emission data is calculated based on the accounting method of Wang Hao et al. (2022), which is obtained by measuring the consumption of fossil energy and carbon emission factors of enterprises; the ESG score adopts the comprehensive score and sub - dimension scores of the Huazheng ESG Rating Database; the financial data comes from the CSMAR database. To eliminate the influence of extreme values, all continuous variables are winsorized at the 1% and 99% percentiles.

2.2. Variable Definitions

2.2.1. Explained Variable: Carbon Emission Intensity (In_{ci})

The carbon emission intensity is measured by the ratio of the total annual carbon emissions of an enterprise to its operating income, and the natural logarithm is taken to alleviate the problem of skewed distribution. This indicator reflects the carbon emission level per unit of output value, and the lower the value, the better the carbon performance.

2.2.2. Core Explained Variable: ESG Performance

It includes the ESG comprehensive score (esg_{score}) and three sub - variables: the environmental dimension score (e_{score}), the social dimension score (s_{score}), and the governance dimension score (g_{score}). The higher the score, the better the ESG performance in the corresponding dimension.

2.2.3. Control Variables

Referring to existing literature [4,9], the following control variables are selected:

Asset - liability ratio (lev): Total liabilities / Total assets, which measures the financial leverage level of an enterprise

Revenue growth rate (growth): (Current year's revenue - Previous year's revenue) / Previous year's revenue, which measures the growth ability of an enterprise

Ratio of R & D investment (rd_{ratio}): R & D expenditure / Operating income, which measures the intensity of an enterprise's innovation investment

Enterprise size (In_{asset}): Natural logarithm of total assets, which measures the scale of an enterprise

2.3. Model Specification

To test the impact of ESG performance on the carbon emission intensity of enterprises, the following benchmark regression model is constructed:

$$ln_c i_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum \beta_k \text{Controls}_{i,t} + \mu_j + \lambda_t + \varepsilon_{i,t}$$

Among them, i represents the enterprise, t represents the year, j represents the industry; ESG $_{i,t}$ is replaced by the ESG comprehensive score and the E, S, G sub - dimension scores respectively;

Controls is the set of control variables; μ_j is the industry fixed effect, λ_t is the year fixed effect; $\varepsilon_{i,t}$ is the random disturbance term. The standard errors are clustered and adjusted at the company level.

To further verify the robustness of the conclusions, we re-estimated using the individual-time two-way fixed effects model:

$$ln_c i_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum \beta_k \text{Controls}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

Among them, μ_i is the individual fixed effect of the enterprise, which is used to control the enterprise heterogeneity characteristics that do not change over time.

2.4. Case Study Design

Based on the large-sample empirical evidence, we selected CATL (lithium battery track) and SANY Heavy Energy (wind power track) for a dual-case comparative analysis. Both enterprises are leaders in the new energy sub-sectors, and are equally affected by EU carbon policies. However, there are significant differences in their industrial chain positions, product characteristics, and ESG strategic priorities, making them suitable for comparative case studies.

The research period is divided into three stages: (1) Policy Window Period (September 2021 - 2023): The EU carbon policy has not been substantially implemented;

(2) CBAM Transition Period (October 2023 - December 2024): CBAM enters the transition period, and enterprises start to declare carbon data; (3) Dual-Policy Overlay Preparation Period (2025): With the approaching of the dual constraints of CBAM and the New Battery Law, enterprises are accelerating the construction of their carbon management systems.

We used the policy text analysis method to sort out the core requirements of EU carbon regulations, and extracted the ESG practices and carbon performance data of the two enterprises through public materials such as enterprise annual reports, ESG reports, and sustainable development reports, tracking the changes in each stage longitudinally and comparing the differences horizontally.

3. Empirical Results and Analysis

3.1. Descriptive Statistics

Table 1 reports the descriptive statistics results of the main variables. During the sample period, the mean of the logarithm of carbon emission intensity is 0.659, and the standard deviation is 0.685, indicating that there are significant differences in carbon performance among different enterprises. The mean of the comprehensive ESG score is 73.454. Among them, the scores of the social dimension (76.712) and the governance dimension (78.249) are generally high, while the score of the environmental dimension (62.772) is relatively low, reflecting that there is still much room for improvement in the environmental performance of listed companies. In terms of control variables, the mean of the asset-liability ratio is 41.905%, the mean of the revenue growth rate is 10.479%, and the mean of the R & D investment ratio is 4.891%, all of which are in line with the overall characteristics of A-share listed companies.

Table 1. Descriptive Statistics

Variable	Sample size	Mean	Standard deviation	Minimum value	Median	Maximum value
In (Carbon emission intensity)	15128	0.659	0.685	-0.691	-	1.324
ESG Composite Score	15128	73.454	4.819	41.190	-	90.930
E (Environmental) Score	15128	62.772	6.787	34.440	-	92.300
S (Social) Score	15128	76.712	7. 258	14. 180	-	100.000
G (Governance) Score	15128	78.249	6.578	19.600	-	94.930
Asset-liability ratio (%)	15128	41.905	18.737	11. 103	-	75.860
Revenue growth rate (%)	15128	10.479	24.297	-30.797	-	67.143
R&D investment ratio (%)	15128	4.891	3.545	0.330	-	14.578
In (Total assets)	15128	13. 204	1.215	11.439	-	15.800

Note: The sample period is from 2019 to 2023; Data source: Carbon emission data is calculated according to the method of Wang Hao et al. [10], ESG data comes from the Huazheng ESG database, and financial data comes from CSMAR

3.2. Correlation Analysis

Table 2 reports the Pearson correlation coefficient matrix of the main variables. The results show that the comprehensive ESG score is significantly negatively correlated with the carbon emission intensity at the 1% level (the coefficient is -0.054), initially verifying the hypothesis that the better the ESG performance, the lower the carbon emission intensity . From the perspective of different dimensions, the environmental dimension (-0.114), social dimension (-0.072), and governance dimension (-0.086) are all significantly negatively correlated with the carbon emission intensity, and the absolute value of the correlation coefficient of the environmental dimension is the largest, which is in line with intuition.[9]

When analyzing control variable correlations, two variables including firm scale and R&D investment ratio are negatively and significantly associated with carbon emission intensity. Higher revenue growth corresponds to significantly greater carbon emission intensity. Meanwhile, the asset-liability ratio fails to generate a significant linear correlation with the explained variable The correlation coefficients between the explanatory variables are mostly lower than 0.5, indicating that the problem of multicollinearity is not serious.

Table 2. Correlation Coefficient Matrix

Variable	In Carbon Emission Intensity	ESG Comprehensive	E (Environment)	S (Society)	G (Governance)	Asset - Liability Ratio	Revenue Growth Rate	R&D Proportion	In Total Assets
In Carbon Emission Intensity	1.000								
ESG Comprehensive	- 0.054* **	1.000							
E (Environment)	- 0.114* **	0.617* **	1.000						
S (Society)	- 0.072* **	0.660* **	0.370* **	1.000					
G (Governance)	- 0.086* **	0.719* **	0.155* **	0.149* **	1.000				
Asset - Liability Ratio	-0.005	- 0.115* **	0.136* **	0.062* **	- 0.320* **	1.000			
Revenue Growth Rate	0.042* **	0.056* **	- 0.023* *	0.089* **	0.068* **	0.041* **	1.000		
R&D Proportion	- 0.045* **	0.092* **	- 0.058* **	0.027* **	0.099* **	- 0.284* **	- 0.040* **	1.000	
In Total Assets	- 0.038* **	0.224* **	0.331* **	0.172* **	0.036* **	0.481* **	0.053* **	- 0.278* **	1.000

Note: *p < 0.05, **p < 0.01, ***p < 0.001.

3.3. Benchmark Regression Results

Table 3 reports the regression results of the industry-year two-way fixed effects model. Model 1 shows that the coefficient of the ESG composite score is -0.0022, significantly negative at the 1% level, indicating that for every 1-point increase in the overall ESG performance, the corporate carbon emission intensity decreases by approximately 0.22%, verifying the hypothesis [2,9] .

Models 2 to 4 respectively examine the independent effects of the three dimensions of E, S, and G. The results show that the coefficients of all three dimensions are significantly negative at the 1% level as follows: the coefficient of the environmental dimension is -0.0010, the coefficient of the social dimension is -0.0007, and the coefficient of the governance dimension is -0.0015. It is worth noting that the emission reduction effect of the governance dimension is the strongest, even exceeding the directly related environmental dimension. This finding echoes the conclusion of Zhang Yong (2026) on the impact of governance factors on carbon performance, indicating that a sound corporate governance mechanism can systematically promote carbon emission reduction at the decision-making level, and its role may be more profound than simple environmental investment [4].

When Model 5 incorporates all three dimensions into the regression (joint model), the results change significantly: the coefficient of the environmental dimension drops to -0.0007, only significant at the 10% level; the coefficient of the social dimension becomes -0.0004 and is no longer significant; the coefficient of the governance dimension is -0.0014, still significant at the 1% level. This shows that the impact of the social dimension on carbon performance may be mainly achieved through synergy with other dimensions, with limited independent explanatory power; while the emission reduction effect of the governance dimension has strong independence and is the core factor driving the improvement of carbon performance[10].

Regarding control variables, the revenue growth rate is significantly positive, indicating that the rapid expansion stage of enterprises is often accompanied by an increase in carbon emission intensity; the proportion of R&D investment is significantly positive, contrary to the expected direction, probably because R&D investment itself consumes energy and resources, pushing up carbon emission intensity in the short term, and the long-term emission reduction effect lags; the enterprise size is significantly negative, indicating that large enterprises are more likely to achieve carbon emission reduction by virtue of economies of scale and technological advantages [9, 11]. The adjusted R^2 of all models is 0.813, and the overall explanatory power of the models is relatively

strong.

Table 3. The Impact of ESG Performance on Carbon Emission Intensity (Industry + Year Two-Way Fixed Effects)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5 (Combined)
ESG Composite Score	-0.0022***				
	(-4.540)				
E (Environmental) Score		-0.0010***			-0.0007*
		(-2.914)			(-1.871)
S (Social) Score			-0.0007***		-0.0004
			(-2.880)		(-1.400)
G (Governance) Score				-0.0015***	-0.0014***
				(-3.938)	(-3.555)
Asset - Liability Ratio	-0.0002	-0.0001	-0.0001	-0.0003*	-0.0003
	(-1.335)	(-0.496)	(-0.497)	(-1.664)	(-1.630)
Revenue Growth Rate	-0.0019***	-0.0019***	-0.0019***	-0.0019***	-0.0019***
	(-14.632)	(-14.971)	(-14.725)	(-14.598)	(-14.551)
Ratio of R & D Investment	0.0021**	0.0019*	0.0019*	0.0020*	0.0020**
	(2.043)	(1.850)	(1.895)	(1.930)	(1.994)
In (Total assets)	-0.0126***	-0.0142***	-0.0152***	-0.0142***	-0.0123***
	(-4.750)	(-5.331)	(-5.852)	(-5.440)	(-4.601)
N	15128	15128	15128	15128	15128
Adj. R^2	0.813	0.813	0.813	0.813	0.813
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: The values in parentheses are t-values, using firm-level clustered robust standard errors; *//* indicate the 1%/5%/10% significance levels respectively; all models control for industry and year fixed effects.

3.4. Robustness Checks:

To verify the reliability of the benchmark regression results, a two-way fixed effects model of individuals and time is used for robustness checks, and the results are shown in Table 4.

In Model 1, the coefficient of the ESG composite score is -0.0020, which is significantly negative at the 1% level and very close to -0.0022 in the benchmark regression, indicating the robustness of the conclusion.

Looking at the dimensions separately, the coefficient of the environmental dimension in the joint model is -0.0014, maintaining significance at the 1% level, and the absolute value of the coefficient is greater than that in the benchmark regression, indicating that after controlling for firm individual fixed effects, the independent impact of the environmental dimension on carbon performance is more prominent. The social dimension is not significant in both the separate regression and the joint regression, which is consistent with the non-significant result of the joint model in the benchmark regression, further indicating that the direct effect of the S dimension on carbon performance is weak [4,9].

The governance dimension is only significant at the 10% level in the separate regression and is no longer significant in the joint regression, which is different from the highly significant result of the G dimension in the benchmark regression. The possible reason is that governance characteristics have strong time stability within the firm, and the individual fixed effects absorb most of the variation in the governance dimension, resulting in an underestimation of its coefficient.

Overall, the core conclusions of the robustness checks are consistent with the benchmark regression: ESG performance significantly reduces carbon emission intensity, with the environmental and governance dimensions playing a major role, and the independent impact of the social dimension being insignificant. The within-group R^2 of the model reaches 0.844, indicating a good fitting effect.

Table 4. Robustness Checks: Two-way Fixed Effects of Individuals + Time (xtreg fe)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5 (Combined)
ESG Composite Score	-0.0020***				
	(-2.775)				
E (Environmental) Score		-0.0015***			-0.0014***
		(-3.172)			(-2.937)
S (Social) Score			-0.0004		-0.0000
			(-0.955)		(-0.066)
G (Governance) Score				-0.0010*	-0.0009
				(-1.663)	(-1.486)
Asset-liability ratio	-0.0007	-0.0007	-0.0006	-0.0007	-0.0007
	(-1.391)	(-1.317)	(-1.252)	(-1.365)	(-1.420)
Revenue growth rate	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(-0.526)	(-0.587)	(-0.455)	(-0.493)	(-0.605)
Proportion of R&D investment	0.0229***	0.0228***	0.0229***	0.0229***	0.0228***
	(8.040)	(7.998)	(8.018)	(8.014)	(7.999)
In (Total assets)	-0.3266***	-0.3265***	-0.3280***	-0.3274***	-0.3259***
	(-17.375)	(-17.393)	(-17.457)	(-17.422)	(-17.361)
N	15128	15128	15128	15128	15128
R2 (within)	0.844	0.844	0.844	0.844	0.844
Individual FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: The values in parentheses are t-values, using firm-level clustered robust standard errors; *//* indicate the 1%/5%/10% significance levels respectively; the constant term is absorbed by individual fixed effects and not reported

3.5. Case Analysis: Comparison between CATL and SANY Heavy Energy

3.5.1. Policy Background and Industry Differences

There are significant differences in the impact paths of EU carbon policies on the two enterprises. For CATL, the EU's New Battery Law is the most direct policy constraint. Annex III of this regulation constructs a life-cycle-based carbon footprint accounting framework, requiring that carbon emission data for the entire chain of battery products from raw material extraction, manufacturing, transportation to recycling be traceable, and products with a carbon footprint exceeding the threshold will be prohibited from entering the EU market. This means that CATL's carbon performance no longer depends on a single production link, but on the overall management capabilities of the entire chain from upstream minerals, cathode and anode materials, manufacturing energy consumption to recycling.

For SANY Heavy Energy, the impact of CBAM is more direct. The core raw materials of wind power equipment, steel and aluminum, are both among the first batch of controlled categories under CBAM. Although wind turbine generators are not currently on the initial list, the EU's plan clearly states that CBAM will be expanded to steel and aluminum-intensive downstream products such as machinery and automobiles in 2028. In the short term, SANY Heavy Energy needs to manage the carbon data of upstream steel and aluminum suppliers; in the long term, it will itself become a controlled entity after exporting wind turbine generators to the EU and must build a carbon ledger for the entire supply chain in advance.

3.5.2. Policy Window Period (2021 - September 2023): Differentiation in ESG Strategic Layout

During the period, the ESG strategic focuses of the two enterprises have shown obvious differentiation. Relying on the technical characteristics of the power battery industry, CATL takes the environmental dimension as the core starting point for ESG construction. The company proposed a "zero-carbon strategy", laid out zero-carbon factories in Ningde, Fujian, Yibin, Sichuan and other places, and promoted the use of green electricity in the production process; at the same time, it launched a supply chain carbon management project, requiring core suppliers to provide carbon emission data, and initially established a carbon data collection system from upstream materials to downstream applications. The score in the E dimension is at a leading level in the industry.

SANY Heavy Energy, on the other hand, focuses more on the system construction of the governance dimension. The company established a sustainable development committee at the board level, incorporated carbon performance into the assessment indicators for senior executives, and formed a top-down carbon governance structure. In the environmental dimension, SANY Heavy Energy focuses on promoting the carbon accounting of the entire product life cycle, introducing international standards to conduct carbon footprint certification for wind turbine products, and accumulating data for subsequent response to CBAM. Overall, during this stage, the carbon performance of both enterprises has improved steadily, but the decline rate of CATL's carbon emission intensity is faster, mainly due to the substitution of green electricity at the production end.

3.5.3. CBAM Transition Period (October 2023 - December 2024): Accelerated Response under Policy Pressure

After CBAM officially entered the transition period in October 2023, the carbon management rhythms of the two enterprises significantly accelerated, but the differences in their coping strategies further widened.

CATL faced the dual pressures of CBAM and the New Battery Law simultaneously and reacted most promptly. The company released its first full - life - cycle carbon footprint report in 2024, making public the carbon footprint data of its main battery products; at the same time, it increased investment in battery recycling business to reduce carbon emissions throughout the life cycle through material regeneration. In terms of the supply chain, CATL promoted core suppliers to join the "Zero - Carbon Alliance", unified the carbon accounting standards, and effectively reduced carbon emissions in the supply chain. During this stage, the E - dimension score of CATL increased significantly, and the improvement in carbon performance exceeded the industry average level.

The focus of Sany Heavy Energy's response was on sorting out carbon data in the upstream supply chain. The company organized carbon inventories for major steel and aluminum suppliers, established a supplier carbon emission database to prepare for CBAM declarations. At the governance level, Sany Heavy Energy further improved its carbon management system, set up a full - time carbon management department, and established a carbon management system covering the entire process of R & D, procurement, production, and operation and maintenance. However, since wind turbine units have not yet been included in CBAM control, Sany Heavy Energy had relatively less motivation for carbon emission reduction at the product end, and the increase in the E - dimension was less than that of CATL.

3.5.4. Preparation Period of Dual - Policy Superposition (2025): The Gap in Systematized Capabilities Appears

Entering 2025, as the official implementation of CBAM and the full effectiveness of the carbon footprint requirements of the New Battery Law approached, the gap in the carbon management systematized capabilities of the two enterprises began to appear.

After several years of layout, CATL has formed a relatively complete full - chain carbon management system. The carbon footprint data of the company's battery products have been certified by a third - party institution in the EU and can meet the compliance requirements of the New Battery Law; the carbon data coverage rate in the supply chain exceeds 80%, meeting the basic conditions for coping with CBAM. More importantly, CATL integrated carbon management into the product R & D process, reduced carbon emissions from the source through material innovation and structural optimization, and formed a complete closed - loop of "governance drive - technology implementation - supply chain coordination", with a good synergistic effect between the G - dimension and the E - dimension.

Sany Heavy Energy maintains its advantage in the construction of its governance system, but the shortcoming in the environmental dimension has gradually emerged. Since the carbon emissions of wind power products are mainly concentrated in the raw material link, the space for emission reduction in the enterprise's own production link is limited,

and the progress of carbon emission reduction of upstream steel and aluminum enterprises is not controlled by the main engine factory, resulting in relatively slow progress in reducing the carbon footprint of Sany Heavy Energy's products. In addition, the schedule for the expansion of the CBAM for wind turbine complete machines has not been fully clarified, and enterprises have a wait-and-see attitude towards carbon emission reduction investment, which has affected the speed of carbon performance improvement to a certain extent.

3.5.5. Summary of Dual-Case Comparison

Based on the comparative analysis of the three stages, four core research findings are summarized from the comparative analysis:

First, characteristics of the industry determine the focus of ESG strategy. The products of the power battery industry are directly restricted by the New Battery Law, and enterprises have stronger incentives to invest in the E dimension; the wind power industry is indirectly affected by CBAM, and enterprises are more inclined to first improve the governance structure in the G dimension and then gradually promote the construction of the E dimension.

Second, the governance dimension is the underlying support for carbon performance. The practices of both enterprises have shown that a complete governance structure (committee setting, executive assessment, full-time department) is the prerequisite for the effective promotion of carbon management, which corroborates the significant conclusion of the G dimension in the large-sample empirical study [4].

Third, the emission reduction effect in the environmental dimension requires time accumulation. CATL started to layout the carbon management of the supply chain in 2021 and only formed a systematic ability by 2025, indicating that the investment in the E dimension has an obvious lag effect. However, once the ability is formed, its role in improving carbon performance is very significant.

Fourth, the role of carbon emission reduction in the social dimension is relatively indirect. The performances of both enterprises in the S dimension such as employees' rights and interests and community contributions are relatively stable, but the direct correlation with carbon performance is not high, which also explains the reason why the S dimension is not significant in the joint model in the empirical study.

4. Discussion

4.1. Theoretical Explanation of Research Findings

The empirical results of this paper show that the comprehensive performance of ESG significantly reduces the carbon emission intensity of enterprises, which is consistent with the research conclusions of scholars such as Sun Na and Qu Weihua (2026), He Yong and Bai Ye (2026). However, this paper further finds that there are significant differences in the impacts of the three dimensions of ESG on carbon performance: the independent role of the governance dimension is the strongest, the environmental dimension is the second, and the social dimension is not significant. This finding expands the existing research's understanding of the ESG-carbon performance relationship.

The reason why the governance dimension plays a core role can be explained from the perspective of the principal-agent theory. Carbon emission reduction features long-term investment and insignificant short-term benefits. Without an effective governance mechanism, management may reduce carbon emission reduction investment due to short-term performance considerations (Zhang Yong, 2026). Sound corporate governance can, through mechanisms such as board supervision and executive compensation incentives, guide management to focus on long-term sustainable development, thus promoting the improvement of carbon performance. The research results of this paper confirm the logic that "governance is fundamental", and the effectiveness of carbon management ultimately depends on the institutional arrangements at the corporate governance level.

The direct impact of the environmental dimension on carbon performance conforms to intuition, but its significance decreases in the joint model, indicating that the effect of environmental investment to some extent depends on the support of the governance system. Without a good governance mechanism, environmental investment may become a mere formality or be inefficient. The significance of the environmental dimension even increases after controlling for individual fixed effects in the robustness test, which also shows that within the same enterprise, the improvement of environmental performance can indeed bring about an increase in carbon performance, and this effect is masked by governance differences in cross-enterprise comparisons.

The independent impact of the social dimension on carbon performance is not significant, probably due to two reasons: First, social responsibility investment mainly acts on corporate reputation and stakeholder relationships (Zhou Yue et al., 2025), and the transmission chain for carbon emission reduction is relatively long, with a weak direct effect; Second, some investments in the social dimension (such as employee benefits and community donations) themselves consume resources and may push up carbon emissions in the short term, offsetting part of the indirect emission reduction effect.

4.2. Practical Implications from Case Comparisons

The comparison case of CATL and Sany Heavy Energy provides differentiated practical references for different types of new energy enterprises to cope with EU carbon barriers.

For enterprises whose products are directly subject to carbon regulations (such as power batteries), the strategy of "E first, G supported" should be adopted, giving priority to promoting the construction of environmental dimensions such as product carbon footprint accounting and supply chain carbon management, and at the same time improving the governance framework to ensure implementation. CATL's experience shows that early layout of full-chain carbon management can not only meet compliance requirements but also form a technological barrier and first-mover advantage.

For enterprises indirectly affected by carbon policies (such as wind power equipment), the strategy of "G first, E follow-up" should be adopted. First, establish a sound carbon governance system and data foundation, and then increase environmental investment after the policy becomes clear. Sany Heavy Energy's practice demonstrates that the construction cost of the governance system is comparatively inexpensive, but it can provide institutional guarantee for subsequent carbon emission reduction work and avoid passive response when the policy is implemented.

Regardless of the type of enterprise, it is necessary to pay attention to the dynamic evolution of carbon policies. EU

carbon regulations exhibit the characteristics of "gradually expanding scope and gradually strengthening requirements". Enterprises should establish a policy tracking mechanism, anticipate policy trends in advance, and reserve sufficient preparation time. In particular, the possibility of the expansion of CBAM poses a potential risk to all manufacturing enterprises exporting to the EU, and they should conduct a preliminary investigation of carbon data in the supply chain as early as possible.

4.3. Research Limitations and Outlook

This study has the following limitations: First, the carbon footprint metrics adopted in this study stem from corporate fossil energy consumption accounting standards, which differs from the full-life cycle of EU carbon footprint accounting. Future research can attempt to use more refined carbon footprint data. Second, only two enterprises were selected for the case study, and the universality of the conclusions needs to be verified by more cases. Third, this paper mainly focuses on the direct impact of ESG on carbon performance and does not conduct an in-depth test of the transmission mechanism. In the future, the role of intermediate variables such as green technology innovation and financing constraints can be further explored.

There are multiple promising avenues for follow-up scholarly exploration. In the first place, combined with the actual implementation effect of EU carbon policies, conduct a quasi-natural experiment study to more accurately identify the changes in the impact of ESG on carbon performance under policy shocks. Second, expand the scope of case studies to cover more new energy sub-sectors such as photovoltaic and hydrogen energy, and summarize the ESG-carbon performance paths in different sub-sectors. Third, pay attention to the interaction effects between different dimensions of ESG and explore what kind of E-S-G combination is most conducive to improving carbon performance [12, 13].

5. Conclusion

This study explores the impact of ESG performance on corporate carbon emission intensity through large-sample empirical analysis and a dual-case analysis of CATL and SANY Heavy Energy. The results show that overall ESG performance significantly reduces firms' carbon emission intensity, with substantial heterogeneity across the three sub-dimensions. The governance dimension delivers the strongest and most stable emission-reduction effect, followed by the environmental dimension, while the social dimension exerts no significant influence after controlling for other factors. Challenging the conventional view that prioritizes environmental performance in carbon mitigation, this study confirms that sound governance systems constitute the core driver of corporate low-carbon transformation. Effective board supervision, incentive arrangements and specialized carbon management mechanisms help translate long-term sustainability targets into practical business decisions.

Firms adopt differentiated low-carbon strategies based on heterogeneous policy constraints. Subject to direct EU environmental regulation, CATL focuses on full-chain environmental investment including supply chain carbon tracing and battery recycling. In contrast, SANY Heavy Energy is indirectly affected by carbon border policies through raw material imports and thus adopts a governance-led, phased decarbonization approach. In addition, the environmental dimension's emission-reduction effects are cumulative and lagging, relying on sustained resource investment and institutional support, whereas the social dimension only affects carbon performance indirectly through stakeholder management and corporate reputation. Robustness tests further validate these core findings.

This study provides differentiated strategic implications for new energy exporters and clarifies the heterogeneous mechanisms of ESG sub-dimensions in carbon governance. Future research can expand industry coverage, explore underlying transmission pathways, and adopt quasi-experimental methods to improve the accuracy of causal identification.

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