



(RESEARCH ARTICLE)



## Unveiling the Impact of ESG rating divergence on corporate carbon performance: the mediating role of green innovation

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### Abstract

Environmental, Social, and Governance (ESG) investing has emerged as a critical trend in global financial markets. However, the persistent disparity in ESG ratings undermines their reliability and utility, posing challenges for stakeholders in assessing corporate sustainability. To validate how ESG rating divergence meaningfully impact on aggregate outcomes. To answer this question, present study investigates the impact of ESG rating divergence on corporate carbon performance, emphasizing the mediating role of corporate green innovation. Using Chinese A-share listed firms, the findings reveal that ESG rating divergence significantly reduces corporate carbon performance. The study identifies a novel mechanism where ESG rating divergence hampers green innovation, which subsequently weakens corporate carbon performance. Robustness checks using instrumental variables, and alternative measures confirm the reliability of the findings. Notably, the adverse impact of ESG rating divergence intensified after the COVID-19 pandemic, reflecting the evolving dynamics of corporate sustainability challenges. This study is among the first to explore the intricate relationship between ESG rating divergence, green innovation, and carbon performance in the context of a major emerging economy. The findings underscore the urgent need for standardized ESG disclosure practices and harmonized rating methodologies to minimize divergence and enhance transparency. Policymakers, regulators, and investors are urged to address these issues to foster innovation, meet stakeholder expectations, and support the global transition to a low-carbon economy, ensuring sustainable corporate growth.

**Keywords:** ESG rating divergence; Green innovation; Corporate carbon performance; Climate action; Sustainable development

### 1. Introduction

Sustainable investments considering environmental, social, and governance (ESG) considerations have grown steadily in recent years. The existing research agrees that ESG aspects are important for businesses' financial performance and investment decision-making process [24]. According to research by the United Nations Principles for Responsible Investment, 5319 institutions have committed to taking ESG factors into account when making investment decisions as of 2022, contributing to a total of \$121 trillion in assets managed by sustainable investments. Researchers' attention has lately been drawn to the problem of ESG rating discrepancy across diverse suppliers because of its significant influence on a range of financial consequences. At the same time, more and more market players are using third-party rating agencies' ESG ratings to evaluate businesses' ESG performance and inform their investment decisions. Increasingly, market players use ESG ratings from third-party agencies to assess firms' performance and make informed decisions [3]. However, as there are no reliable standards for evaluating ESG performance, rating agencies must deal with substantial incomplete and opaque ESG data when quantifying ESG performance. This causes notable differences in ESG ratings for the same firms across several rating agencies [4], [11], [29], as well as substantial uncertainty in ESG rating for institutions [2]. The results of financial markets are greatly impacted by the dynamic nature of ESG rating

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divergence. There is currently little study on the impact of ESG ratings divergence on carbon performance. Previous research focuses on how ESG rating discrepancies affect stock returns, asset pricing, portfolio management, corporate innovation, stock return, corporate value, and cost of equity [2], [6], [23], [21]. However, the literature on how ESG rating divergence impacts corporate carbon performance is nascent. Hence, this study explores whether and how ESG rating divergence affects corporate carbon performance, evaluating Chinese A-share listed firms from 2013 to 2022 as the research sample to answer this question. This paper explores the impact of ESG rating divergence on corporate carbon performance, exploring the mediating mechanism of green innovation.

The study finds that ESG rating divergence significantly reduces corporate carbon performance. Moreover, corporate green innovation mediates the relationship since ESG rating divergence negatively influences green innovation, while green innovation positively mediates corporate carbon performance. After controlling for endogenous problems and a series of robustness tests, the results remain consistent. Moreover, analyses reveal that ESG rating divergence negatively affects corporate carbon performance, but the magnitude and significance vary across contexts. Such as the effect is more pronounced after the COVID-19 pandemic than before 2020. Reflecting the evolving dynamics of standardizing ESG disclosure practices and rating methodologies to minimize divergence, enhance transparency, and support sustainable corporate growth. Addressing these challenges is essential for meeting stakeholder's expectations, fostering innovation, and advancing the global transition to a low-carbon economy.

Our study has made several contributions. First, this study is among the pioneers in examining the influence of ESG rating divergence on corporate carbon performance, exploring both heterogeneity and mechanism, hence expanding research in ESG rating divergence and energy. Second, this study expanded the growing literature on ESG from the lens of rating divergence. The existing literature mainly focuses on the determinants of divergence, innovation, stock return, corporate value, cost of equity, and volatility [13],[21],[25]. This paper contributes a new insight into how ESG rating divergence impacts corporate carbon performance. This study established a direct relationship between ESG rating divergence and corporate carbon performance, revealing that inconsistencies in ESG ratings negatively affect firms' ability to achieve carbon reduction targets [5]. This highlights the critical role of consistent ESG metrics in driving sustainability. Third, prior literature, such as strongly focuses on carbon emissions, ignoring the carbon performance indicator. This study focuses on the carbon performance indicators, comprehensively incorporating revenue and carbon emissions. [16], suggest that during evaluating carbon emissions, economic growth should be considered. [10], argued that emissions depletion may be due to other passive factors, such as reduced production instead of technological advancement or rating divergence. While these factors can achieve carbon-neutral goals, they may harm economic development. Hence, this study has taken carbon performance because it allows a comprehensive examination of rating divergence, ensuring emission enhancement while promoting economic benefits. Fourth, the study introduces corporate green innovation as a mediating factor, revealing that ESG rating divergence directly impacts corporate carbon performance and indirectly hinders it by suppressing green innovation activities. This underscores the importance of fostering green innovation to enhance carbon performance. This dual-pathway analysis advances the understanding of the link between ESG metrics and sustainability outcomes. Fifth, the study identifies a heightened impact of ESG rating divergence on corporate carbon performance in the post-COVID-19 period, highlighting how global crises exacerbate sustainability challenges and the importance of resilience in ESG practices. Furthermore, the findings provide actionable implications for standardizing ESG disclosure and aligning rating methodologies, offering valuable guidance to regulators, policymakers, investors, and other stakeholders to improve transparency, foster innovation, and enhance corporate carbon performance, aligning with global carbon reduction goals including sustainable development goal (SDG) 13. This study provides actionable insights into how resolving ESG rating divergence and fostering green innovation can empower firms to take meaningful climate action. By improving carbon performance, the study aligns corporate strategies with SDG 13, promoting a transition to a low-carbon economy and reinforcing the private sector's role in addressing global climate challenges. The study identifies green innovation as a pathway through which firms overcome ESG rating challenges and improve carbon performance. Green innovation drives technological advancements and sustainable practices, enabling firms to achieve lower emissions and enhanced energy efficiency, which are essential for meeting SDG 13 targets. Addressing this divergence by standardizing ESG ratings provides more reliable benchmarks, encouraging firms to adopt robust climate strategies aligned with SDG 13 goals. Moreover, the study highlights the importance of clear and consistent metrics for evaluating corporate contributions to climate action. By demonstrating how ESG rating divergence undermines stakeholder trust and increases financial risks, the study contributes to the literature on stakeholders [19-20] and signaling theory [15], emphasizing the role of disseminating transparent and consistent ESG practices in meeting stakeholder expectations.

The remainder of this paper is structured as follows: Section 2 presents the literature and hypotheses development. Section 3 material and methods. Section 4 indicates the empirical result. Section 5 presents conclusions and policy implications.

## 2. Literature Review and Hypothesis

### 2.1. ESG Rating Divergence and Corporate Carbon Performance

The divergence in ESG ratings has significant implications for corporate carbon emissions. The inconsistency among various ESG rating agencies can signal [20] that negative information leads to confusion and misalignment in corporate strategies to reduce carbon footprints [6]. The divergence in ESG ratings can result in firms adopting multiple ratings to gauge their performance, complicating the assessment of their actual environmental impact [4]. Inconsistency creates a scenario where firms may not prioritize carbon reduction if they perceive their ESG ratings as satisfactory despite the underlying discrepancies in evaluation criteria. Empirical studies have shown that higher ESG ratings correlate with lower carbon emissions. This finding underscores the potential of ESG ratings to drive corporate behavior towards more sustainable practices. ESG disclosure positively influences corporate carbon performance, suggesting that transparency in ESG practices enhances a firm's commitment to reducing emissions. ESG reporting motivates a firm to alter its decisions and behaviors toward carbon mitigation. Conversely, divergence in ESG ratings creates confusion, resulting in reduced corporate carbon performance. Strategic alignment of ESG ratings with corporate goals plays a crucial role in determining how firms respond to these ratings. [14] argues that firms are more likely to engage positively with ESG ratings when they perceive them as aligned with their strategic objective. Conversely, when firms view ESG ratings as irrelevant to their core business strategies, they may dismiss them, potentially undermining efforts to reduce carbon emissions. Integrating ESG considerations into the broader corporate strategy motivates firms to act on their ratings. ESG investing is driving firms to adopt more environmentally friendly practices, including carbon emission reductions [30].

However, the divergence in ESG ratings leads to increased information asymmetry among stakeholders, resulting in greater corporate value volatility. This volatility deters firms from long-term investments in sustainability initiatives, including carbon reduction strategies. Inconsistency in ratings causes firms to question the validity of their ESG performance, leading to a lack of confidence in the benefits of improving their ratings. As a result, businesses put short-term financial results ahead of long-term sustainability objectives, potentially hindering their carbon reduction efforts. ESG rating divergence creates confusion among investors and stakeholders regarding firms' true value of environmental performance. Firms with high ESG ratings experience less backlash from investors and regulations, which protects against volatility. However, rating divergence diminishes this protective effect as stakeholders become more uncertain about firms' true commitment towards sustainability. This uncertainty led to a reluctance among firms to invest in carbon reduction initiatives as they may fear that their efforts will not be recognized or rewarded in the marketplace. Therefore, ESG rating divergence creates uncertainty in a firm's ESG profile, which may lead to inefficiency in resource allocation, reduced stakeholder trust, and poor carbon management outcomes. Thus, we propose the following hypothesis:

H1: ESG rating divergence negatively affects corporate carbon performance

### 2.2. Corporate Innovation as a Mediator between ESG Rating Divergence and Carbon Performance

ESG rating divergence inhibits corporate carbon performance by decreasing corporate green innovation, which is vital for sustainability. The main goal of green innovation is to lessen environmental burdens to accomplish the ecological goals of sustainable development. Some innovations, such as carbon capture and storage technology used in the fossil fuel system, can directly reduce carbon emissions. Replacing old equipment can encourage recycling and increase resource usage efficiency [1]. A variety of efforts to lower carbon emissions and improve overall environmental performance are included in carbon green innovation. Firms engaging in sustainability initiatives and environmental innovation experience significant improvement in their carbon performance by reducing greenhouse gas emission intensity [28] [30] by enhancing the efficiency of carbon emission. External pressures motivate firms to adopt green innovation and practices, contributing to improved carbon performance. High carbon awareness within firms fosters green innovation, improving carbon performance and the quality of carbon information disclosure. By encouraging cleaner production and lowering dependency on fossil fuels, green innovation enhances carbon performance [30]. Moreover, green innovation enhances the industrial structure by promoting the expansion of low-pollution and ecologically friendly enterprises [17]. Furthermore, firms with better ESG ratings are more likely to invest in environmentally friendly technologies and practices. Firms improve their ESG ratings to enhance their reputation and actively contribute towards carbon reduction through innovation. ESG ratings are associated with lower carbon emissions, as firms with higher ratings tend to adopt more sustainable practices. Firms with higher ESG ratings are motivated to engage in green innovation initiatives that reduce carbon emissions. On the other hand, the disparity in ESG rating is thought to lessen the accuracy of ESG rating data, causing uncertainty for outside investors and employees when determining a company's actual ESG performance, resulting in reduced corporate innovation. Furthermore, ESG

rating divergence influences corporate carbon performance by reducing corporate green innovation in the following ways. Investors, creditors, financial institutions, and other capital providers' assessments of a firm's true ESG performance are muddled by ESG rating divergence, which first increases information asymmetry between firms and external capital markets. This makes it more difficult for the firm to obtain external financing [12]. Second, divergence in ESG ratings raises perceived risks in the market [2] and increases volatility in profits. Because external capital sources want higher risk premiums than loan interest rates or original investment returns, the firm's external financing costs therefore rise [2]. Additionally, rating divergence speeds up the spread of unfavorable information by drawing greater attention from analysts, new media, and the general public. Resultantly, capital providers become less inclined to invest in or lend money to the company due to their worries about its operations and future growth. Hence, disagreements over ESG ratings increase a company's financial limitations. Furthermore, it becomes increasingly difficult and expensive for businesses to receive funding as they encounter more severe financial restrictions, which makes it harder for them to obtain sufficient and ongoing financial assistance. Consequently, this forces businesses to scale down their innovative endeavors [26], subsequently affecting corporate green innovation.

Thus, ESG rating divergence negatively impacts corporate innovation by enhancing firms' financing constraints and reducing human capital, subsequently lowering corporate carbon performance. Therefore, we may hypothesize that;

H2: ESG rating divergence negatively affects corporate carbon performance through lightened corporate green innovation.

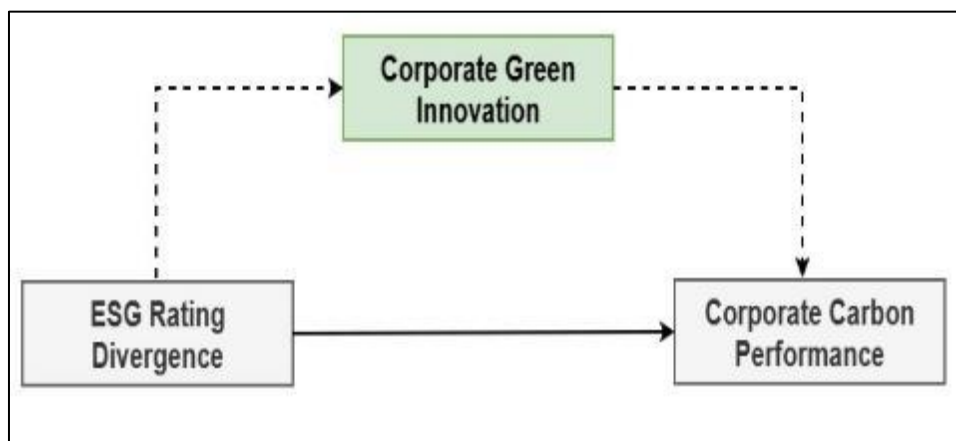


Figure 1 The theoretical framework of the study

### 3. Material and Methods

#### 3.1. Data and Sample

We used 2013–2022 data from Chinese A-share listed companies. The China Stock Market and Accounting Research (CSMAR) database is the source of all financial information. Corporate carbon performance data from companies' annual reports, and innovation (green patent) data are sourced from the China Research Data Services Platform (CNRDS). However, ESG ratings, data are sourced from the Bloomberg, CNRDS and Refinitive databases. according to the standards used for sample selection in earlier research [22]. Enterprises getting special treatment (ST, SST, \*ST), those with less than a year of listing, samples with incomplete data, and samples from the banking sector were all excluded. Winsorize truncation was used on all continuous variables at the 1% level to lessen the effect of outliers.

#### 3.2. Model Specification

To investigate the direct effects of ESG rating divergence on CCP, we apply the following econometric models:

$$CCP_{i,t} = \beta_0 + \beta_1 ESG\_RD_{i,t} + \beta_2 X_{i,t} + Year + Firm + \varepsilon_{i,t} \quad (1)$$

$$GCI_{i,t} = \gamma_0 + \gamma_1 ESG\_RD_{i,t} + \gamma_2 X_{i,t} + Year + Firm + \varepsilon_{i,t} \quad (2)$$

$$CCP_{i,t} = \delta_0 + \delta_1 GCI_{i,t} + \delta_2 ESG\_RD_{i,t} + \delta_3 X_{i,t} + Year + Firm + \varepsilon_{i,t} \quad (3)$$

Where  $t$  is a year, and  $i$  is firm and  $\epsilon_{i,t}$  error term.  $CCP_{i,t}$  and  $CGI_{i,t}$  represent corporate carbon performance and corporate green innovation respectively.  $ESG\_RD_{i,t}$  stand for firm's  $i$ 's ESG divergence in year  $t$ .  $X_{i,t}$  contains a set of control variables. In addition, this study includes the year and firm fixed effects to control the unobserved specific heterogeneity and employ-firm level clustered standard errors. Equation 1 presents the base model to analyze the direct impact of ESG\_RD on CCP, and equations 2 and 3 present the mediation model, where GCI is the mediator in equation 2. In equation 3,  $\delta_1$  coefficient captures the effect of GCI on CCP (mediating effect) and  $\delta_2$  captures the residual direct effect of ESG\_RD on CCP after accounting for mediation.

### 3.3. Variables Measurement

#### 3.3.1. Dependent Variable

Consistent with [7], Corporate carbon performance (CCP) is used as a measure of corporate carbon usage, which is the natural logarithm of revenue divided by the total carbon emissions of a firm in the year. An elevated value of this indicator denotes reduced carbon emissions per revenue unit, reflecting superior carbon performance as per the greenhouse gas accounting standards established by the Greenhouse Gas Protocol. This assessment of corporate carbon emissions predominantly relies on self-reported data from companies in China, encompassing social responsibility reports, sustainability reports, or environmental reports.

#### 3.3.2. Independent Variables

ESG rating divergence (ESG\_RD). Regarding the uniqueness of Chinese listed firms and the authority of rating agencies, this paper refers to [21],[30] and employs ESG rating data from (3) agencies, including the Bloomberg database, Refinitive database, and Chinese Research Data Services (CNRDS) to calculate ESG rating divergence. This paper concerted the ESG ratings provided by agencies into number formats ranging from 1 to 100. Consequently, this study draws on the method [12] and uses the standard deviation of a given firm's ESG ratings from (3) agencies to portray ESG rating divergence.

#### 3.3.3. Mediating Variable

We follow previous studies [29] and measure corporate green innovation (CGI) as the natural logarithm of one plus the total number of green patents granted by a firm in the year. The study analyzes the mediating role of corporate green innovation with ESG rating divergence and corporate carbon performance.

#### 3.3.4. Control Variables

To mitigate the confounding impact of other factors that may affect corporate carbon performance [4] and be consistent with existing ESG rating divergence studies [13],[22], we control firm-specific factors to rule out alternative explanations for variance of ESG\_RD and firm performance across firms, including firm size (Size), leverage (Lev), firm age (Age), return on assets (ROA), property-plant-equipment (PPE), largest shareholder (Top), board size (BSize), and Tobin Q (Tobin's Q). Size is the natural logarithm of total assets. Lev is measured by total debts over total assets. Age is operationalized as the natural logarithm of the years since the firm was incorporated. PPE proportion of fixed assets to its total assets. BSize is the natural logarithm of the total number of board members. ROA presents profitability scaled by net income to total assets. Tobin's Q is the ratio of firm market value to assets replacement value, and Top is the proportion of shareholding held by the largest shareholder.

## 4. Empirical Results

### 4.1. Summary Statistics

Table 1 reports the descriptive statistics. The results show that CCP has an average value of 8.192 across the sample firms, with a minimum value of 3.883 and a maximum value of 12.070, which reflects varying carbon management practices across sample firms. ESG\_RD has a mean and standard deviation of 18.651 and 3.619, respectively. This suggests ESG\_RD has moderate variability, indicating the difference in ESG assessment across firms. Firms with an average size of 22.731 suggesting large firms often correlated with resource availability that will better perform on CCP to greater capacity for investment in green initiatives. A corporate green innovation average of 0.984 indicates moderate firm engagement in innovation with substantial variation (1.235) in green innovation efforts across firms. The high variability and concentration of low values suggest that while a few firms are heavily committed to green innovation, the majority are still at a nascent stage.

**Table 1** Summary of descriptive statistics

Variables	N	Mean	SD	Min	P25	P50	P75	Max
CCP	12480	8.192	0.497	3.883	7.977	8.054	8.145	12.070
ESG_RD	9464	18.651	3.619	6.725	16.007	18.826	21.272	31.871
Size	12480	22.731	1.349	19.585	21.756	21.756	23.553	26.452
Lev	12480	0.440	0.199	0.046	0.283	0.283	0.590	0.908
ROA	12480	0.041	0.057	-0.373	0.014	0.041	0.067	0.247
POPE	12480	0.233	0.163	0.002	0.108	0.108	0.328	0.719
Age	12480	2.979	0.304	1.792	2.883	2.833	3.178	3.611
Tobin's Q	12480	1.927	1.241	0.802	1.149	1.149	2.220	15.607
B_Size	12480	2.141	0.196	1.609	1.946	1.946	2.197	2.708
Top	12480	34.466	14.750	8.020	22.808	22.808	44.843	75.525
CGI	12480	0.984	1.235	0.000	0.000	0.693	1.609	6.955

Note: The researcher's computation

**4.2. Correlation Analysis**

Table 2 presents the pairwise correlation result. The result indicates that CCP and ESG\_RD are negatively correlated, implying that higher ESG rating divergence is associated with poor carbon performance. CCP and firm size are positively associated, indicating that larger firms have better carbon performance. CCP and age had a positive relationship, suggesting that older firms perform better in carbon management. CGI had a weak positive correlation with ESG\_RD, suggesting a marginal relationship between them, while divergence might not directly drive green innovations. Moreover, the average variance inflation factor (VIF) of 1.37 indicates low multicollinearity across the model.

**Table 2** VIF and PWC

No.	Variables	1	2	3	4	5	6	7	8	9	10	11	VIF
1	CCP	1.0000											
2	ESG_RD	-0.1097 <sup>a</sup>	1.0000										1.07
3	Size	0.1041 <sup>a</sup>	0.0230 <sup>a</sup>	1.0000									2.35
4	Lev	0.0454 <sup>a</sup>	0.0699 <sup>a</sup>	0.5663 <sup>a</sup>	1.0000								1.89
5	ROA	-0.0504 <sup>a</sup>	-0.0354 <sup>a</sup>	0.0229 <sup>a</sup>	-0.3340 <sup>a</sup>	1.0000							1.33
6	POPE	-0.0422 <sup>a</sup>	-0.2195 <sup>a</sup>	0.0600 <sup>a</sup>	0.0019	-0.0301 <sup>a</sup>	1.0000						1.08
7	Age	0.2209 <sup>a</sup>	-0.0721 <sup>a</sup>	0.1930 <sup>a</sup>	0.1663 <sup>a</sup>	-0.0489 <sup>a</sup>	-0.0201 <sup>a</sup>	1.0000					1.09
8	Tobin's Q	-0.0862 <sup>a</sup>	-0.0383 <sup>a</sup>	-0.4154 <sup>a</sup>	-0.3647 <sup>a</sup>	0.2723 <sup>a</sup>	-0.0967 <sup>a</sup>	-0.1105 <sup>a</sup>	1.0000				1.36
9	B_Size	-0.0153 <sup>a</sup>	-0.0356 <sup>a</sup>	0.2566 <sup>a</sup>	0.1462 <sup>a</sup>	0.0536 <sup>a</sup>	0.1642 <sup>a</sup>	0.0626 <sup>a</sup>	-0.1254 <sup>a</sup>	1.0000			1.07
10	Top	-0.0631 <sup>a</sup>	0.0276 <sup>a</sup>	0.2420 <sup>a</sup>	0.0908 <sup>a</sup>	0.1099 <sup>a</sup>	0.0762 <sup>a</sup>	-0.0851 <sup>a</sup>	-0.0724 <sup>a</sup>	0.0460 <sup>a</sup>	1.0000		1.09
11	CGI	0.0524 <sup>a</sup>	0.0433 <sup>a</sup>	0.4667 <sup>a</sup>	0.2632 <sup>a</sup>	-0.0036	-0.0048	0.0087	-0.1568 <sup>a</sup>	0.0736 <sup>a</sup>	0.0576 <sup>a</sup>	1.0000	1.34
	<b>Mean VIF</b>												<b>1.37</b>

Note: Own calculation "a" indicates significance at a 5% level.

**4.3. Benchmark Results**

The regression results are reported in Table 3. The influence coefficients for ESG\_RD are negatively significantly (-0.015) associated with CCP at the 1% level. This is consistent in M1 (without control), M2 (with control), and M3 (with control, including firm fixed effect), respectively. Moreover, in model (M4) with year fixed effect, ESG\_RD significantly reduced

(-0.0018) CCP at the 5% level, and 10% level significance for model (M5 and M6) with industry and province fixed effect included. This indicates that higher ESG rating divergence is consistently associated with lesser corporate carbon performance, even after accounting for various fixed effects; this supports hypothesis 1. These findings complement [3] that divergence in rating creates confusion among investors, which may deter investment in technologies and initiatives aimed at reducing carbon emissions. Uncertain stakeholders are unlikely to support and commit to sustainability projects that could enhance carbon performance. Similarly, ESG rating divergence leads to agency problems as firms may prioritize short-term financial performance over long-term sustainability goals. Consistently, divergent ratings may signal inconsistencies in a firm's commitment towards sustainability, potentially undermining its credibility and hindering innovation efforts as stakeholders may question the firm genuine commitment to reducing carbon emissions.

**Table 3** Relationship between ESG Rating Divergence (ESG\_RD) and Corporate Carbon Performance (CCP)

	Univariate regression	Add control variable	Add Firm FE	Add Year FE	Add industry FE	Add province FE
	(M1)	(M2)	(M3)	(M4)	(M5)	(M6)
	CCP	CCP	CCP	CCP	CCP	CCP
ESG_RD	-0.015*** (0.001)	-0.015*** (0.001)	-0.015*** (0.002)	-0.0018** (0.0008)	-0.0015* (0.0008)	-0.0014* (0.0008)
Size	-	0.046*** (0.005)	0.033** (0.016)	0.034*** (0.006)	0.023*** (0.006)	0.018*** (0.007)
Lev	-	-0.201*** (0.035)	0.023 (0.064)	0.040 (0.025)	0.028 (0.025)	0.032 (0.025)
ROA	-	-0.393*** (0.103)	-0.085 (0.122)	0.127*** (0.048)	0.135*** (0.047)	0.141*** (0.047)
POPE	-	-0.203*** (0.034)	-0.021 (0.090)	0.0304 (0.035)	0.028 (0.035)	0.023 (0.035)
Age	-	0.309*** (0.015)	1.230*** (0.045)	-0.039 (0.043)	-0.035 (0.042)	-0.029 (0.043)
Tobin's Q	-	-0.020*** (0.003)	-0.032*** (0.005)	-0.002 (0.002)	-0.002 (0.002)	-0.003 (0.002)
B_Size	-	-0.108*** (0.026)	0.065 (0.052)	-0.035* (0.020)	-0.015 (0.020)	-0.020 (0.020)
Top	-	-0.001*** (0.000)	0.002*** (0.001)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Constant	8.472*** (0.026)	6.971*** (0.126)	3.887*** (0.333)	7.450*** (0.187)	7.883*** (0.249)	7.762*** (0.278)
Firm FE	No	No	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes
Industry FE	No	No	No	No	Yes	Yes
Province FE	No	No	No	No	No	Yes
Adjusted R <sup>2</sup>	0.012	0.077	0.200	0.880	0.884	0.885
Obs.	9,464	9,464	9,464	9,464	9,464	9,464

Note: \*\*\*, \*\*, and \* show that the correlation is significant at 1%, 5%, and 10% respectively. However, the parenthesis contains the value of robust standard errors in all columns.

The result report in column (M4) indicates that control variables Size, ROA, and Board size are statistically significant, whereas lev, POPE, firm age, Tobin's Q, and Top are statistically insignificant with corporate carbon performance. The estimated coefficient of firm size is significant with CCP, demonstrating that larger firms are more efficient in resource utilization and energy usage. Similarly, ROA is positively significant, recommending that firms that earn more profit by selling their produced goods improve corporate carbon performance. In summary, the result reveals that ESG rating divergence can significantly inhibit CCP. These impediments may be due to lower installation of corporate green innovation technologies in firms, which could assist firms in upgrading production processes, decreasing resource waste, and enhancing energy efficiency [27].

#### 4.4. Robustness Tests

##### 4.4.1. Alternative measure of the independent variable

To ensure the credibility and robustness of the findings, the first independent variable is altered. We follow [21] methods to measure independent variables that may affect the basic result. Thus, we use the standard deviation of all variables, without creating groups, as an alternative variable and then conduct a regression analysis. The result presented in Table 4 column (M1) shows that ESG rating divergence ( $\beta = -0.043$ ) has a negatively significant association at the 10% level, while in column (M2), it is also negative and significant at the 10% level. This indicates that even with a different measured method, greater divergence in ESG ratings might lead to reduced corporate carbon performance.

**Table 4** Robustness tests- an alternative measure of ESG Rating Divergence, Corporate Carbon Performance, and time grouping COVID-19 sampling year

$\Delta$ Variable	ESG_RD		Carbon Emissions		Time Grouping	
	(M1)	(M2)	(M3)	(M4)	Before 2020	After 2020
ESG_RD	-0.0433* (0.0225)	-0.0392* (0.0225)	0.0035* (0.0018)	0.0023* (0.0013)	-0.000 (0.000)	-0.0042* (0.0023)
Size	-	0.034*** (0.006)	-	0.819*** (0.011)	0.051*** (0.007)	-0.009 (0.042)
Lev	-	0.041 (0.025)	-	0.372*** (0.043)	-0.049* (0.027)	0.223* (0.120)
ROA	-	0.126*** (0.048)	-	1.844*** (0.080)	0.139*** (0.053)	0.438*** (0.144)
POPE	-	0.031 (0.035)	-	0.448*** (0.059)	0.024 (0.038)	-0.148 (0.177)
Age	-	-0.039 (0.043)	-	0.279*** (0.072)	-0.039 (0.051)	0.080 (0.560)
Tobin's Q	-	-0.002 (0.002)	-	0.027*** (0.004)	-0.004 (0.002)	0.002 (0.010)
B_Size	-	-0.035* (0.020)	-	0.036 (0.034)	-0.040* (0.022)	-0.012 (0.076)
Top	-	0.000 (0.000)	-	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.002)
Constant	8.059*** (0.012)	7.441*** (0.188)	12.254*** (0.375)	-6.605*** (0.420)	7.127*** (0.220)	8.039*** (1.989)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	Yes	Yes	No	No
Adjusted	0.880	0.880	0.554	0.759	0.013	0.933
Obs.	9,464	9,464	9,464	9,464	6,658	2,806

The results present in columns M1 and M2 show the result of Panel regressions by analysing the alternative proxy of the independent variable, i.e., (Taking std of all variables without creating groups). Similarly, columns M3 and M4 exhibit the findings of panel regressions using alternative measures of CCP (i.e., firms' total carbon emissions). Additionally, columns M5 and M6 demonstrate the comparison of results before and after COVID-19 time period. Finally, \*\*\*, \*\*, and \* show that the correlation is significant at 1%, 5%, and 10% respectively. However, the parenthesis contains the value of robust standard errors in all columns.

##### 4.4.2. Alternative Measure of Dependent Variable

Second, the measurement of the dependent variable is changed. We run equation 1 with the natural logarithm of firm total carbon emission as an alternative measure for the dependent variable (CCP) following the precedent set by [3-4]. Table 4 presents the result. The result in column (M3) reveals a significant positive ( $\beta = 0.0035$ ) at the 10% level, showing ESG rating divergence increased carbon emissions, as well as a column (M4) with control incorporated, significant positive influence ( $\beta = 0.0023$ ) at the 10% level, reinforcing the robustness of the association. The results support baseline results that ESG rating divergence reduces corporate carbon performance.

#### 4.4.3. Time Grouping

Time grouping is also used for the robustness test. Significant differences were found in the ESG evaluations of companies' performance before and after the COVID-19 pandemic [9]. ESG performance might be interpreted by investors as a forecast of future company success. Businesses with strong ESG performance are less likely to take risks during a crisis or are more risk-averse in the case of a market-wide financial catastrophe. Thus, the samples are divided into two groups: those collected before the COVID-19 pandemic (2020) and those collected after it (2020), with the COVID-19 pandemic serving as a border. With a ( $\beta = -0.0042$ ) significant effect at the 10% level, Table 5's column (5), which is categorized before 2020 and column (6) after 2020, demonstrates that differences in ESG ratings have a more negative and significant effect on carbon performance after 2020 than they did previously. This is because investors will be paying more attention to and depending on ESG rating information for decision-making, and their response to ESG rating divergence analysis will be more important. This is because the COVID-19 epidemic has made firms more conscious of the importance of ESG.

**Table 5** Endogeneity issue

Variable	ESG_RD	CCP	Lagged <sub>(t-1)</sub>
	M1	M2	M3
Instrument variable (IV)	0.736*** (0.015)	-	-
ESG_RD	-	-0.094*** (0.005)	-0.0014** (0.0007)
Size	-0.017 (0.031)	0.036*** (0.006)	0.014*** (0.004)
Lev	-1.213*** (0.199)	-0.267*** (0.042)	0.000 (0.022)
ROA	2.085*** (0.556)	-0.152 (0.118)	-0.090* (0.047)
POPE	-0.484* (0.253)	-0.241*** (0.050)	0.052* (0.027)
Age	-0.343*** (0.099)	0.248*** (0.018)	0.000 (0.023)
Tobin's Q	-0.016 (0.023)	-0.026*** (0.004)	0.000 (0.002)
B_Size	-0.092 (0.152)	-0.102*** (0.030)	-0.031* (0.017)
Top	-0.002 (0.002)	-0.001*** (0.000)	0.000 (0.000)
Constant	8.669*** (0.987)	8.821*** (0.211)	-
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	No
Province FE	Yes	Yes	No
Adjusted R <sup>2</sup>	0.090	0.996	0.883
Anderson canon. corr.LM statistics	835.35	[0.000]	-

Cragg-Donald Wald F statistics	1698.36	[16.38]	-
Anderson-Rubin Wald statistics	371.82	[0.000]	-
Obs.	9,464	9,464	9,463

The results presented in column M1 indicate the first stage result of the instrument variable. Meanwhile, M2 shows the panel regression of the estimated variable. In comparison, Column M3 demonstrates results by analyzing the difference of independent and all control variables for one period back. Finally, \*\*\*, \*\*, and \* show that the correlation is significant at 1%, 5%, and 10% respectively. However, the parenthesis contains the value of robust standard errors in all columns.

#### 4.4.4. Endogeneity Test

We acknowledge the possibility of omitted variable bias, measurement error, and reverse causality, even though we account for enterprise-level and provincial-level factors associated with explanatory variables in our baseline model. To make causal inferences, we take advantage of instrument variable (IV) regression and lagged variables to mitigate the issue of omitted variable biases and reverse causality, respectively. We investigate whether an endogeneity problem may have an impact on the results, taking into account the nature of the phenomenon being studied [8],[18]. Notably, firms face peer pressure from other firms' ESG ratings in the same location, which is related to ESG ratings performance. Hence, the ESG rating divergence of firms in the same location may also influence the ESG rating divergence. Therefore, we have utilized the industry average of ESG rating as an IV estimated through the following model.

$$ESG\_RD_{i,t} = \alpha + \beta IV_{i,t} + \delta Controls_{i,t} + \lambda_{i,t} + \lambda_t + \varepsilon_{i,t} \quad (4)$$

$$CCP_{i,t} = \alpha + \beta \widehat{ESG\_RD}_{i,t} + \delta Controls_{i,t} + \lambda_{i,t} + \lambda_t + \varepsilon_{i,t} \quad (5)$$

Here, model (4) is utilized to test the correlation between the instrumental variable and the independent variable. The validity of the correlation between the two underscores the significance of estimated parameters. Based on models (4) and (5), we have estimated the influence of IV to independent variables on corporate carbon performance. Column M1 of Table 5 shows that IV is strongly and positively associated with CCP at a 1% level, indicating that the IV (0.736) is valid and relevant. This implies that the instrument effectively captures the variation in ESG\_RD without directly influencing the dependent variable. This result passes the Anderson Canonical Correlation LM Test (P-value=0.000) and Cragg-Donald Wald F-Test (value=1698.36>16.38 threshold), confirming that the IV is both strong and exogenous.

In M2, ESG\_RD ( $\beta = -0.094$ ), at a 1 % level, indicates a significant negative relationship between ESG\_RD and CCP, implying that higher ESG rating divergence negatively impacts corporate carbon performance. This suggests that inconsistent ESG ratings may hinder firms' ability to improve their carbon footprint. In M3, the lagged relationship between ESG\_RD and CCP is negatively statistically significant at a 5% level, indicating a consistent negative effect of ESG rating divergence on CCP. This lagged approach helps address potential reverse causality. The above results show that the negative relationship between ESG rating divergence and firm carbon performance remains valid, even when accounting for endogeneity.

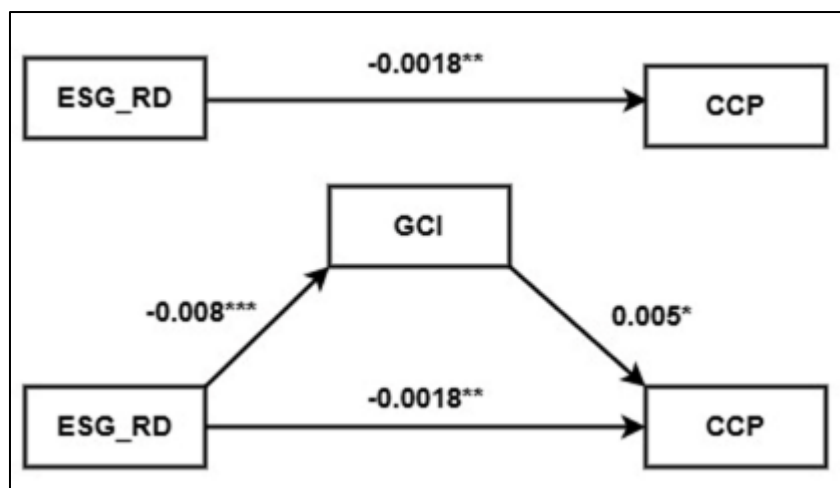
#### 4.5. Mediation Mechanism

Table 6 reports the mechanism results to examine the relationships between ESG rating divergence, green innovation, and corporate carbon performance. In models (M1), the result shows a significant negative relationship with green innovation ( $\beta = -0.008$ ) at a 1% level, and M2 remains constant when control variables are added. In models (M3 and M4), ESG\_RD shows a small negative effect on CCP (-0.001), which is significant at a 5% level. Green innovation has a significant positive impact on CCP in M3 (0.008) at a 1% level and a less significant effect in M4 (0.005) at a 10% level. These findings support hypothesis 2. This implies that ESG rating divergence negatively influences green innovation, while green innovation has a positive mediating effect on corporate carbon performance indicates that ESG rating divergence negatively influences corporate innovation as the firms respond to conflicting ratings by adopting a more conservative approach to innovation. When firms perceive that their ESG performance is not accurately reflected in ratings, they become less inclined to invest in innovative solutions that could enhance their carbon performance. ESG rating divergence leads to negative sentiment that decreases funding for sustainability initiatives. When investors lose confidence in a firm's ESG performance, they may withdraw support for projects to reduce carbon emissions, further exacerbating the challenges associated with achieving sustainability goals. This reluctance stifles the development of new technologies and practices essential for reducing emissions. Additionally, [6] contend that rating divergence leads to divergent corporate strategies, which hinder firms' efforts to align their operations with sustainability objectives, ultimately impacting their carbon performance. See Figure 2 for the mediation mechanism.

**Table 6** Mechanism analysis

	Univariate regression	Add control	Univariate regression	Add control
	M1	M2	M3	M4
	Green Innovation(GI)	Green Innovation(GI)	CCP	CCP
ESG_RD	-0.008*** (0.001)	-0.008*** (0.001)	-0.0018** (0.0008)	-0.0018** (0.0008)
GI	-	-	0.008*** (0.003)	0.005* (0.003)
Size	-	0.675*** (0.016)	-	0.032*** (0.006)
Lev	-	-0.698*** (0.069)	-	0.041* (0.025)
ROA	-	-0.309** (0.128)	-	0.129*** (0.048)
POPE	-	0.084 (0.085)	-	0.029 (0.035)
Age	-	0.711*** (0.068)	-	-0.041 (0.043)
Tobin's Q	-	0.037*** (0.007)	-	-0.002 (0.002)
B_Size	-	0.340*** (0.036)	-	-0.035* (0.020)
Top	-	-0.003*** (0.000)	-	0.000 (0.000)
Constant	-	-	8.068*** (0.017)	7.503*** (0.190)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Wald Chi2	8086.28	9632.26	-	-
Adjusted R2	-	-	0.880	0.880
Obs.	8,386	8,386	9,464	9,464

The results presented in columns (M1) to (M2) show the influence of ESG rating divergence on mediating variables (i.e. Corporate green innovation) without and with control variables, respectively. While columns (M3) and (M4) represent the mediating influence of CGI on CCP with firm and year-fixed effects without and with control variables, respectively. Finally, \*\*\*, \*\*, and \* show that the correlation is significant at 1%, 5%, and 10% respectively. However, the parenthesis contains the value of robust standard errors in all columns.



**Figure 2** Path between ESG rating divergence, corporate green innovation, and CCP

## 5. Conclusions

ESG investing has emerged as a significant trend in the world's financial markets. However, the disparity in ESG ratings is one of the primary reasons for the ambiguity of ESG information. ESG rating divergence in recent years has been caused by the absence of standards for ESG disclosure of firms and the lack of consistent rating criteria, scope, methodologies, and processes among rating agencies. This has an undetectable effect on the day-to-day operations of enterprises. Thus, how much and under what circumstances can ESG rating divergence impact corporate carbon performance? Using the sample of Chinese A-share listed firms spanning 2013 to 2022, this paper explores the impact of ESG rating divergence on corporate carbon performance with a mediating mechanism of green innovation.

This study finds that ESG rating divergence significantly reduces corporate carbon performance. Moreover, corporate green innovation mediates the relationship since ESG rating divergence negatively influences green innovation, while green innovation positively mediates corporate carbon performance. After controlling for endogenous problems and a series of robustness tests, the results remain unchanged. Moreover, the effect is more pronounced after the COVID-19 pandemic than before 2020. Reflecting the evolving dynamics of standardizing ESG disclosure practices and rating methodologies to minimize divergence, enhance transparency, and support sustainable corporate growth. Addressing these challenges is essential for meeting stakeholder's expectations, fostering innovation, and advancing the global transition to a low-carbon economy and meeting SGD 13.

### 5.1. Policy Implications

Sustainability rating, green innovation, and energy consumption often rise in tandem with the pace of industrialization. Pollutant emissions will immediately increase as energy demand grows. As pollution continues to worsen, more and more governments are placing a higher priority on cutting emissions and pollutants. Governments will actively create pertinent policies to reduce their region's carbon production to meet the "dual carbon" target. As the primary hub for economic production and development, businesses are the primary focus of societal and governmental attention concerning pollution prevention. ESG ratings were created to help businesses actively communicate sustainability practices and attract resources to cut emissions and pollution. The extensive use of consistent ESG ratings and corporate innovation offers vital policy certainty for tackling environmental pollution problems. Together with research findings, this study vintages the following policy recommendations: First, regulators and policymakers should prioritize the development of unified standards for ESG disclosure to reduce rating divergence. Clear guidelines on ESG reporting criteria, methodologies, and metrics can enhance consistency and reliability across rating agencies. Firms better align their operations with global climate action goals, enabling more accurate assessment and accountability of their contributions to reducing greenhouse gas emissions. Moreover, policy incentives for green innovation encourage firms to invest in green innovation to mitigate the negative effect of ESG rating divergence on corporate carbon performance. Fostering a culture of innovation that supports SDG 13 by enhancing energy efficiency and reducing carbon footprints. Recognizing the amplified impact of ESG rating divergence after COVID-19, policies should incorporate resilience-focused strategies to support sustainable corporate growth during global disruptions. Aligning with SDG 13's call for urgent climate action in the face of evolving global challenges.

Second, investors must critically assess ESG ratings and consider multiple sources to mitigate risk associated with rating divergence. Incorporating qualitative assessments and engaging directly with firms can complement existing ESG data and favor green firms to improve long-term sustainability and carbon performance, irrespective of rating inconsistencies. Third, stakeholders should demand greater transparency and accountability in ESG reporting and collaborate with regulatory bodies to advocate for harmonizing ESG rating standards, ensuring fair and consistent evaluations across industries and achieving a carbon economy. Negative effect of rating divergence is more pronounced in high-polluting, low-resource-based, and low-capital-intensive firms, tailored interventions such as subsidies for clean energy and stricter regulations for emissions, are essential to help this firm transition towards sustainable operations, contributing to SDG 13's objectives. In future, studies could extend the scope to compare the impact across different countries, industries, and regulatory environments. Furthermore, studies could evaluate how emerging technologies such as AI and blockchain can address inconsistencies in ESG ratings and improve transparency.

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## Compliance with ethical standards

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The authors declare no financial or non-financial conflicts of interest that could have influenced the conduct, analysis, or reporting of this study.

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