LEX LOCALIS-JOURNAL OF LOCAL SELF-GOVERNMENT
ISSN:1581-5374 E-ISSN:1855-363X
VOL. 23, NO. 11(2025)

EXPLORING THE ROLE OF CORPORATE SOCIAL RESPONSIBILITY AND FIRM'S MANAGEMENT TO HANDLE THE ENVIRONMENTAL EMISSIONS: FIRM LEVEL ANALYSIS

Nouf Awadallah Alsulamy[1]

[1]Business Administration Department, University of Jeddah, Jeddah, Saudi Arabia

NALSULAMI@uj.edu.sa[1]

Abstract
This study uses corporate data to explore the relationship between CSR and environmental emissions. It aims to fill the knowledge gap by using the Chinese context to investigate the role of CSR indicators and female directors in CSR's relationship with environmental emissions. The results show that CSR's effect on environmental emissions is not very strong. Moreover, one can observe that it is only the social aspects of CSR that moderate this relationship, while the presence of female directors specifically moderates the association between CSR and sulfur emissions. These revelations could be very useful for policymakers seeking to improve the performance of CSR and also for management policies aimed at reducing environmental emissions from companies.

Keywords: CSR; environmental emissions; firm analysis; China

1. Introduction

The world is currently grappling with a myriad of environmental challenges that pose significant threats to the planet and its inhabitants. However, one of the most pressing environmental challenges is climate change, driven primarily by greenhouse gas emissions. Hence, the Intergovernmental Panel on Climate Change (IPCC) warns that rising global temperatures will lead to severe consequences, including more frequent and intense heat waves, extreme weather events, and rising sea levels (IPCC, 2021). Besides this, the impacts on ecosystems, food security, and human health are immense. Likewise, the loss of biodiversity is another critical issue facing the world, and human activities such as deforestation, habitat destruction, and pollution have led to a rapid decline in species populations (Scanes, 2018). This biodiversity loss has far-reaching consequences, including the disruption of ecosystems, reduced resilience to environmental changes, and the potential loss of valuable genetic resources. Similarly, environmental pollution, particularly air and water pollution, poses significant challenges. Also, the World Health Organization (WHO) estimates that 4.2 million premature deaths occur annually due to outdoor air pollution (Vohra et al., 2021). Moreover, water pollution affects marine and freshwater ecosystems, impacting biodiversity, human health, and economic activities reliant on clean water sources (Prakash, 2021).

Even though environmental issues are related to all countries however, China's greenhouse gas emissions have reached alarming levels, significantly contributing to global climate change. According to data from the Global Carbon Atlas, China is the world's largest emitter of carbon dioxide (CO2), accounting for approximately 28% of global emissions in 2020 (Z. Liu et al., 2022). It should be noted that this is more than the combined emissions of the United States, the European Union, and India (Friedlingstein et al., 2022). There are several factors which contribute to China's high greenhouse gas emissions including rapid industrialization, extensive coal consumption, and a growing population have fueled the country's economic growth but also led to increased emissions. The reliance on coal for energy production, particularly in power plants, is a major

source of CO2 emissions. China's expanding transportation and manufacturing industries also generate significant greenhouse gas emissions. The scale and pace of China's emissions growth are alarming due to their impact on global climate change. Rising CO2 levels contribute to the greenhouse effect, resulting in higher global temperatures and associated consequences such as extreme weather events, sea-level rise, and ecosystem disruption (Dandotiya & Sharma, 2020). These effects are detrimental to China and have wide-ranging implications for the entire planet.

Recognizing the situation's urgency, China has taken steps to address its emissions. The country has committed to peaking its carbon emissions by 2030 and achieving carbon neutrality by 2060 (Zhao et al., 2022). Implementing renewable energy sources, such as solar and wind power, and promoting energy efficiency measures are part of China's efforts to transition to a low-carbon economy (Okoh & Okpanachi, 2023). However, the sheer magnitude of China's emissions and the need for rapid and substantial reductions pose a significant challenge. Global cooperation and sustained efforts from China and other nations are crucial in mitigating the alarming situation and achieving the necessary emissions reductions to combat climate change effectively.

Previous studies focused on solutions to excessive GHG emissions and advised some meaningful solutions. In this regard, (Peng et al., 2022) suggest that green financing is the best solution for firms to reduce carbon emissions. Another study by (Ding et al., 2020) asserts that firms' excessive GHG emissions can be controlled through a carbon tax. From the point of view of (Forslid et al., 2011), technology can be used by firms to reduce carbon emissions. However, according to (K. H. Lee & Min, 2015), eco-innovation is the most viable solution for firms that want to reduce emissions. However, it is also a fact that the problem of emissions at the firm level is still prevailing. Hence, we will provide some practical solutions to be added to the existing literature.

Based on the above discussion, the current study has the following major contributions: Firstly, previous studies used firm-level carbon emissions, whereas this study is the first to use firm-level sulfur, nitrogen, and phosphorus emission. Utilizing firm-level sulfur, nitrogen, and phosphorus emissions data is crucial for targeted policy interventions, fostering accountability and transparency, facilitating performance benchmarking, optimizing resource allocation and efficiency, and tracking environmental progress. By employing this data, policymakers, regulators, and companies can work collaboratively to achieve sustainable and environmentally responsible business practices. Secondly, this is the first study to use firm-level CSR indicators (CSR, CSDR consumer, CSR environment, and CSR social) to investigate firm-level emissions. Measuring and monitoring a company's carbon footprint is an essential CSR indicator. This includes quantifying the greenhouse gas emissions generated by the organization's operations, supply chain, and product lifecycle. Companies can identify emission hotspots and implement targeted reduction strategies by understanding their carbon footprint. Also, increasing the share of renewable energy in a company's energy mix is an effective CSR indicator for emissions reduction. Setting targets for renewable energy consumption or investing in on-site renewable energy generation can help organizations transition to cleaner energy sources and reduce reliance on fossil fuels. The current study examines the firm director's role in managing environmental emissions. Research suggests that women, on average, exhibit greater environmental awareness and concern than men. Female directors bring diverse perspectives and values to boardroom discussions, which may include a stronger focus on sustainability and environmental stewardship (Galletta et al., 2022). Their perspectives can influence decision-making processes and foster a greater commitment to emissions reduction.

Hence, the current study intends to fulfill the following objectives:

1- Examine the role of CSR in minimizing sulfur, nitrogen, and phosphorus emissions.
2- Examine the role of CSR consumers in minimizing sulfur, nitrogen, and phosphorus emissions.
3- Examine the role of the CSR environment in minimizing sulfur, nitrogen, and phosphorus emissions.
4- Examine the role of CSR social in minimizing sulfur, nitrogen, and phosphorus emissions.
5- Investigate the significance of directors' role in countering firm-level environmental challenges.
6- Investigate the significance of female directors' role in countering firm-level environmental challenges.

The structure of the paper consists of distinct sections, beginning with a literature review that provides an overview of existing research on the topic. Following the literature review, the paper describes the data sources used and outlines the variables employed in the study. This section also elucidates the methodology applied to analyze the data. The next part presents the analysis findings and engages in a detailed discussion of the results. Finally, the paper summarizes the key findings and offers recommendations based on the research work.

2. Literature Review

2.1. Firm-Level Analysis of the Environment

Few studies explore environmental emissions at the firm level. In this regard, (Wang et al., 2023) tried to check the impact of political connections on firm-level carbon emissions. Their analysis suggests that political connections promote emissions in the sample firms. Another study by (Alam et al., 2022) investigated if the firm's cash holdings can affect its emissions. Their results proved that firms with high cash holdings also have higher emissions. However, they also suggest that firms with low leverage as well as lower financial constraints are under more pressure in this sense. Likewise, (X. Liu et al., 2021) explored if firm-level emissions can be affected by the sustainable development goals in China. Their results confirm that in China, carbon emission is significantly reduced through energy conservation and reduction in energy consumption under sustainable development goals. In the same line, (C. C. Lee et al., 2022) checked if the green credit policy affects highly polluting firms' carbon emissions. They assert that in these companies, green credit policy has significantly reduced their carbon emission.

2.2 .Impact of CSR on the Environment

The impact of Corporate Social Responsibility (CSR) on the environment has been a topic of significant interest and research in recent years. This literature review provides an overview of studies that have examined the relationship between CSR and environmental outcomes. There are several studies which highlighted the positive impact of CSR practices on environmental performance. Also, research has shown that firms implementing environmental management systems, such as ISO 14001 certification, tend to achieve better environmental outcomes (Biscotti et al., 2018). Additionally, these systems help organizations formalize and enhance their environmental management practices, leading to reduced resource consumption, waste generation, and emissions. Moreover, there are studies which explored the association between CSR disclosure and environmental performance. According to these studies, firms that voluntarily disclose their environmental practices and performance are often seen as more transparent and accountable, leading to improved environmental performance (Mungai et al., 2020). Because, such disclosure

acts as a signal to stakeholders, including consumers, investors, and regulators, indicating a commitment to environmental sustainability.

It is worth mentioning that in addition to directly impacting environmental performance, CSR initiatives can shape stakeholders' attitudes and behaviors towards the environment. Also, research has shown that companies engaging in CSR activities related to the environment can influence consumer perceptions and purchasing decisions (Swaen et al., 2021). Additionally, consumers are more likely to support and purchase products or services from companies that demonstrate environmental responsibility. Moreover, the impact of CSR on the environment extends beyond individual firms. Studies have explored the influence of CSR practices on industry-level environmental outcomes. For instance, firms within industries with higher levels of CSR engagement tend to exhibit lower pollution levels and environmental impacts (Amores□Salvadó et al., 2023). This suggests that industry-wide CSR initiatives and collaborations can improve environmental performance and sustainability across sectors. While most studies indicate a positive relationship between CSR and environmental outcomes, some research has identified certain contextual factors that may moderate this relationship. Factors such as firm size, industry characteristics, and the regulatory environment can influence the effectiveness of CSR initiatives in mitigating environmental impacts (Secinaro et al., 2020).

2.2. Impact of Directors on the Environment

Directors play a pivotal role in shaping the environmental impact of organizations through their decision-making processes and strategic planning. Numerous studies have highlighted the importance of board composition in influencing environmental outcomes. For instance, research (Naciti, 2019) found that the presence of independent directors positively correlates with better environmental performance. Independent directors bring diverse perspectives and are more likely to challenge management decisions, leading to improved environmental stewardship. Board diversity, particularly gender, has also been associated with positive environmental outcomes. A study by (Elmagrhi et al., 2019) demonstrated that companies with more women on their boards tend to have stronger environmental management systems and better environmental performance. This suggests that gender diversity in boardrooms can contribute to more comprehensively considering environmental issues.

The expertise of directors is another crucial factor in determining their impact on the environment. Research by (Masud et al., 2018) revealed that boards with directors possessing environmental expertise are more likely to adopt sustainable practices and prioritize environmental concerns. Such directors bring valuable knowledge and experience, enabling the board to make informed decisions that align with environmental objectives. Board structures and processes also influence environmental outcomes. A study by (Berrone et al., 2017) found that organizations with dedicated environmental committees on their boards exhibit better environmental performance. Environmental committees oversee and advise on environmental matters, ensuring a more focused and systematic approach to environmental management.

Regulatory frameworks and external pressures also shape the impact of directors on the environment. Government regulations can incentivize directors to adopt sustainable practices and reduce environmental risks. Research by (Bednárová et al., 2019) indicated that stricter environmental regulations are associated with enhanced environmental performance among organizations. Furthermore, the influence of institutional factors, such as industry norms and peer pressure, cannot be ignored. A study (Wei et al., 2017) emphasized that environmental investment

is higher in companies with more female directors. Hence, the environmental performance of these companies is higher.

In short, this literature review suggests that few studies utilized firm-level sulfur, nitrogen, and phosphorus emissions as indicators of environmental emissions. Studies have used only carbon emissions as a proxy. Our study fills this gap by utilizing Chinese firms' firm-level sulfur, nitrogen, and phosphorus emissions. Also, it can be extracted from the literature that firm-level CSR indicators, including CSR, CSR consumer, and CSR environment, are still not explored as a predictor of firm-level emissions. Hence, this research gap is filled by our study. Likewise, the role of a firm's directors in managing firm-level environmental emissions is unexplored in the existing literature. Hence, we are exploring the role of the firm's director in managing environmental emissions.

3. Data and methodology

For this study, we used data from Chinese companies from 2007 to 2022. The financial data for the companies in this study were sourced from the China Stock Market & Accounting Research Database (CSMAR). To measure managerial myopia, the researchers utilized the methodology proposed by Hu et al. (2021). Additionally, to assess firms' involvement in sustainable growth, the study employed the corporate social responsibility (CSR) rating and its five sub-categories provided by Hexun.com as alternative indicators. This was done to ensure the robustness of the results obtained.

To clean the sample data, certain criteria were applied. Firstly, special treatment (ST) firms were excluded from the sample. This decision was made since ST firms are subject to stricter regulations, which could impact their engagement in environmental, social, and governance (ESG) practices as well as managerial decision-making. Financial firms were also excluded from the sample due to their unique business operations and financial reporting, which may not be directly comparable to non-financial firms. Lastly, firms with debt exceeding their total assets were removed to ensure the inclusion of financially stable firms more likely to engage in sustainable activities. Following these exclusions, an unbalanced panel dataset comprising 283 firms spanning 2007 to 2022 was obtained.

3.1. Theoretical Reasoning

Corporate Social Responsibility (CSR) minimizes environmental emissions through various channels. Firstly, CSR encourages companies to adopt sustainable practices and technologies. Companies can effectively reduce their environmental emissions by investing in energy-efficient technologies, optimizing resource consumption, and reducing waste generation (Oloruntobi et al., 2023). Secondly, CSR promotes implementing robust environmental management systems (EMS) (Yousaf et al., 2021). An EMS provides a structured framework for identifying, monitoring, and managing environmental aspects within an organization. By integrating EMS, companies can track and reduce emissions, manage waste effectively, and continuously improve their environmental performance (Daddi et al., 2011). Thirdly, CSR drives companies to innovate in their products and processes. Because, by investing in research and development, companies can create innovative, environmentally friendly products and develop cleaner production technologies (K. H. Lee & Min, 2015). Furthermore, CSR initiatives encourage companies to collaborate with stakeholders, including suppliers, customers, and local communities, to work collectively towards environmental sustainability (Parviainen et al., 2018). Hence, these collaborative efforts can lead to shared goals, knowledge sharing, and the development of sustainable supply chains. It can be said that overall, CSR is a powerful driver for

companies to minimize environmental emissions by promoting sustainable practices, implementing effective management systems, fostering innovation, and encouraging stakeholder collaboration.

It is also a fact that directors, particularly females, play a significant role in minimizing environmental emissions through various channels. In this regard, research has shown that gender-diverse boards are more likely to prioritize environmental sustainability and engage in environmentally responsible decision-making (Issa, 2023). Female directors bring diverse perspectives, skills, and experiences that contribute to better environmental outcomes. Their presence on boards enhances corporate governance practices and fosters a more careful consideration of environmental issues. Female directors have been found to positively influence environmental strategies, promote sustainable practices, and improve environmental performance (Glass et al., 2016).

Furthermore, female directors tend to have higher levels of environmental awareness (Issa et al., 2022). They are more likely to champion corporate social responsibility initiatives, including those aimed at reducing environmental emissions. Overall, female directors on boards are a valuable asset in driving environmental sustainability and minimizing emissions through their unique perspectives, expertise, and commitment to CSR.

Models:

$$Sulfur_{it} = \rho_0 + \rho_1 CSR_{it} + \rho_2 Directors_{it} + \rho_3 Goodwill_{it} + \rho_4 RD_{it} + \rho_5 BM_{it} + \rho_6 Cash_{it} + \varepsilon_{it} \quad \text{Eq-1}$$

$$Nitrogen_{it} = \rho_0 + \rho_1 CSR_{it} + \rho_2 Directors_{it} + \rho_3 Goodwill_{it} + \rho_4 RD_{it} + \rho_5 BM_{it} + \rho_6 Cash_{it} + \varepsilon_{it} \quad \text{Eq-2}$$

$$Phosphorus_{it} = \rho_0 + \rho_1 CSR_{it} + \rho_2 Directors_{it} + \rho_3 Goodwill_{it} + \rho_4 RD_{it} + \rho_5 BM_{it} + \rho_6 Cash_{it} + \varepsilon_{it} \quad \text{Eq-3}$$

Dependent variables used in this study are sulfur, nitrogen, and phosphorus emissions in selected Chinese firms. The explanatory variable used in this study is corporate social responsibility. The management variable used in this study is directors, measured as the number of directors in the firm. There are two moderating variables used in this study. The first moderating variable is different measures of CSR, including CSR_Consumer, CSR_Environment, and CSR_Social. The second moderating variable used in this study is female directors. Some variables can affect the emissions and are used in this study. These control variables are the firm's goodwill, research and development, book-to-market value, and cash position at the end of the year.

4. Results

4.1. Descriptive

Table 1 provides the results of descriptive statistics. The highest mean value is for cash, whereas the lowest mean is for female directors. In terms of volatility, research, and development proved to be highly volatile, but directors are the least volatile.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Sulfur	160	6.939	0.346	6.190	7.440
Nitrogen	160	7.317	0.348	6.604	7.829
Phosphorus	160	6.426	0.355	5.690	6.934
CSR	160	3.062	1.189	-2.996	4.331
CSR_Consumer	160	2.535	0.218	1.946	3.135
CSR_Environment	160	2.558	0.466	1.609	3.416
CSR_Social	160	1.746	1.183	-3.912	3.109
Directors	160	2.214	0.094	1.992	2.485
Female_Directors	160	-0.037	0.513	-2.079	2.963
Goodwill	160	18.664	2.563	10.228	23.476
RD	160	18.379	4.342	-1.682	30.340
BM	160	-0.286	0.497	-1.176	1.081
Cash	160	21.566	1.176	19.317	24.753

4.2. Correlation Analysis

The correlation results presented in the table provide insights into the relationships among the variables. Firstly, sulfur, nitrogen, and phosphorus exhibit strong positive correlations, suggesting a close association between emissions of these gasses. This finding indicates that one of these may indicate changes in the others. When it comes to Corporate Social Responsibility (CSR) shows weak positive correlations with sulfur, nitrogen, and phosphorus, indicating a slight relationship between CSR and these elements. However, CSR demonstrates a moderate positive correlation with CSR_Consumer and CSR_Environment, implying a stronger association between CSR and consumer and environmental aspects of social responsibility.

Female_Directors positively correlate with sulfur, nitrogen, phosphorus, and goodwill. This suggests that the presence of female directors might be associated with higher levels of these variables. It highlights the potential influence of gender diversity in the decision-making processes and strategic choices within organizations. Furthermore, variables like goodwill, research and development, book-to-market value, and cash exhibit positive correlations. This indicates a potential relationship between these factors, implying that higher levels of goodwill, research and development investments, book-to-market value, and cash might be associated with one another.

Table 2: Correlation

	Sulfur	Nitrogen	Phosphorus	CSR	CSR_Consumer	CSR_Environment	CSR_Social	Directors	Female_Directors	Goodwill	RD	BM	Cash
Sulfur	1.000												
Nitrogen	0.994	1.000											
Phosphorus	0.987	0.987	1.000										
CSR	0.035	0.038	0.050	1.000									
CSR_Consumer	-0.129	-0.115	-0.113	0.148	1.000								
CSR_Environment	0.081	0.084	0.079	-0.020	0.182	1.000							
CSR_Social	0.002	0.007	0.000	0.554	0.067	-0.278	1.000						
Directors	-0.428	-0.431	-0.418	0.184	0.404	0.250	-0.016	1.000					
Female_Directors	0.219	0.221	0.212	0.077	-0.175	-0.064	0.041	-0.226	1.000				
Goodwill	0.543	0.547	0.550	0.242	0.125	0.303	0.002	0.253	0.288	1.000			
RD	0.175	0.175	0.177	0.035	-0.338	0.115	-0.062	-0.031	0.183	0.273	1.000		
BM	-0.282	-0.281	-0.290	0.062	0.139	0.198	0.013	0.538	-0.128	0.138	0.136	1.000	
Cash	0.208	0.217	0.215	0.079	0.219	0.411	-0.157	0.594	0.017	0.636	0.229	0.489	1.000

4.3. Hausman Test

The Hausman test results are presented in Table 3. The chi-square statistic is calculated for each model (Model 1, Model 2, and Model 3), and the corresponding p-values are provided. The p-value for each model is reported as 0.000, which means that the p-value is less than 0.05 (assuming a significance level of 0.05). This indicates strong evidence to reject the null hypothesis that the random effects model is consistent and efficient in favor of the alternative hypothesis that the fixed effects model is more appropriate. Based on these results, the fixed effects method should be used for estimations in this context. The fixed effects model considers individual-specific effects, providing more accurate and reliable parameter estimates. The significant p-values suggest that the individual-specific effects are significant and cannot be ignored, reinforcing the need for the fixed effects model to capture these effects appropriately.

Table 3: Hausman test

Hausman	Model 1	Model 2	Model 3
chi2	60.500	64.760	66.250
p-value	0.000	0.000	0.000

Notes: The *p*-value is less than 0.05, however, the fixed effect method is the appropriate for estimations

4.4. Baseline Regression

The results from the baseline regression estimation using the fixed effect method (Model 1, Model 2, and Model 3) are presented in Table 4. Regarding the variable CSR (Corporate Social Responsibility), the coefficients are 0.004, 0.007, and 0.008 for Model 1, Model 2, and Model 3, respectively. However, none of these coefficients are statistically significant at conventional levels ($p>0.05$). Therefore, including additional variables in the models did not yield a significant relationship between CSR and the dependent variable. The variable directors consistently show a negative coefficient in all three models. The coefficients are -2.797, -2.857, and -2.808 for Model 1, Model 2, and Model 3, respectively. Moreover, these coefficients are statistically significant at the $p<0.001$ level, indicating that an increase in directors is associated with a decrease in the dependent variable.

Goodwill demonstrates a positive relationship with the dependent variable. The coefficients are 0.072, 0.072, and 0.075 for Model 1, Model 2, and Model 3, respectively. These coefficients are statistically significant at the $p<0.001$ level, suggesting that higher levels of goodwill are associated with an increase in the dependent variable. For the variables RD (Research and Development) and BM (Book to Market value), the coefficients are not statistically significant in any of the models, indicating that these variables do not have a significant relationship with the dependent variable. Finally, the variable cash shows a positive relationship with the dependent variable. The coefficients are 0.237, 0.245, and 0.259 for Model 1, Model 2, and Model 3, respectively. These coefficients are statistically significant at the $p<0.001$ level, indicating that higher cash levels are associated with an increase in the dependent variable.

Table 4: Baseline regression estimation through fixed effect method

	Model 1	Model 2	Model 3
CSR	0.004	0.007	0.008
Directors	-2.797***	-2.857***	-2.808***
Goodwill	0.072***	0.072***	0.075***
RD	0.006	0.006	0.007
BM	-0.041	-0.048	-0.042

Cash	0.237***	0.245***	0.259***
Constant	6.517**	6.861**	5.490**
N	160	160	160

Notes: * p<0.05, ** p<0.01, *** p<0.001

4.5. Examining the Presence of Non-linearity

The non-linear model is run to check if there is a non-linear relationship between CSR and GHG emissions, and the results are reported in Table 5. Here a new variable, CSR-Square (CSR^2), is added to the equation. The coefficient of CSR-square is insignificant in all models, suggesting that there is no evidence of non-linearity and a linear relationship between CSR and GHG emissions.

Table 5: Nonlinearity

	Model 1	Model 2	Model 3
CSR	0.040	0.047*	0.044*
CSR_Square	-0.011	-0.012	-0.011
Directors	-2.823***	-2.885***	-2.834***
Goodwill	0.074***	0.075***	0.077***
RD	0.006	0.006	0.007
BM	-0.029	-0.035	-0.030
Cash	0.230**	0.237***	0.252***
Constant	6.710**	7.072**	5.684**
N	160	160	160

Notes: * p<0.05, ** p<0.01, *** p<0.001

4.6. Moderating Effect of CSR Indicators

In order to check the moderating effect of CSR indicators on the association between CSR and environmental emissions, interaction terms are added to the equation, and the analysis results are provided in Table 6. Considering the moderating effect of CSR-Consumer on the association between CSR and sulfur emissions, it can be seen that the coefficient of the interaction term is insignificant, suggesting that CSR-Consumer does not moderate the association between CSR and Sulfur emissions. Also, CSR-Consumer has no role between the nexus of CSR and nitrogen emission as well as Phosphorus emission. Similarly, in the case of CSR-Environment, it also has no moderating role in the impact of CSR on environmental emissions. The same is true for CSR-Social because the coefficient of interaction terms is insignificant for all environmental emissions. Hence, CSR indicators do not moderate the association between CSR and environmental emissions.

Table 6: Moderating effect of CSR indicators on the association between CSR and environmental emissions

	Sulfur as Dependent			Nitrogen as Dependent			Phosphorus as Dependent		
CSR	-0.071	-0.028	-0.005	0.020	-0.031	-0.003	-0.015	-0.006	-0.003
CSR_Consumer	-0.222			-0.072			-0.134		
CSRxCSR_Consumer	0.030			-0.005			0.009		
CSR_Environment		-0.065			-0.067			-0.049	
CSRxCSR_Environment		0.012			0.015			0.005	
CSR_Social			0.0458*			0.0477*			0.0369*
CSRxCSR_Social			-0.008			-0.008			-0.005
Directors	-2.741***	-2.827***	-2.795***	-2.822***	-2.883***	-2.856***	-2.763***	-2.840***	-2.811***
Goodwill	0.0753***	0.0733***	0.0728***	0.0745***	0.0729***	0.0727***	0.0772***	0.0762***	0.0750***
RD	0.004	0.006	0.007	0.004	0.005	0.006	0.005	0.006	0.007
BM	-0.039	-0.038	-0.057	-0.045	-0.048	-0.065	-0.040	-0.036	-0.055
Cash	0.234***	0.241***	0.239***	0.241***	0.249***	0.247***	0.256***	0.262***	0.262***
Constant	7.014***	6.669***	6.463***	7.043***	7.006***	6.800***	5.804***	5.628*	5.430*
N	160	160	160	160	160	160	160	160	160

Notes: * p<0.05, ** p<0.01, *** p<0.001

Table 7: Moderating effect of female directors on the association between CSR and environmental emissions

	Sulfur as Dependent			Nitrogen as Dependent			Phosphorus as Dependent		
CSR	0.004	0.005	0.008	0.007	0.009	0.009	0.008	0.009	0.009
Directors	-2.797***	-2.860***	-2.776***	-2.857***	-2.918***	-2.917***	-2.808***	-2.873***	-2.872***
Female_Directors		-0.070	1.874*		-0.069			-0.072	
Directors x Female_Directors			-0.844**			-0.031			-0.033
Goodwill	0.0728***	0.0787***	0.0733***	0.0727***	0.0785***	0.0785***	0.0751***	0.0811***	0.0812***
RD	0.006	0.007	0.009	0.006	0.006	0.006	0.007	0.007	0.008
BM	-0.041	-0.032	-0.011	-0.048	-0.040	-0.039	-0.043	-0.034	-0.033
Cash	0.237***	0.238***	0.236***	0.245***	0.246***	0.246***	0.259***	0.260***	0.260***
Constant	6.517***	6.510***	6.433***	6.861***	6.854***	6.851***	5.490***	5.483***	5.480***
N	160	160	160	160	160	160	160	160	160

Notes: * p<0.05, ** p<0.01, *** p<0.001

4.7. Moderating Effect of Female Directors

The second moderating variable is female directors, and results for moderation analysis are presented in Table 7. The effect of directors on all emissions is significant and negative, suggesting that directors play a major role in reducing sulfur, nitrogen, and phosphorus emissions. However, the impact of female directors is only significant and negative in the case of sulfur emission. The same is true for the moderating effect of female directors. Because the moderating role of female directors is significant and negative for sulfur emissions, female directors can effectively reduce sulfur emissions. Still, they have no role in reducing nitrogen and phosphorus emissions.

4.8. Discussion

Examine the role of CSR in minimizing sulfur, nitrogen, and phosphorus emissions.

The results suggest that CSR has no effect on environmental emissions in Chine. In China, CSR's (Corporate Social Responsibility) insignificance in controlling environmental emissions can be attributed to various factors. Firstly, inadequate enforcement and regulation of environmental standards and regulations contribute to the problem (Yamineva & Romppanen, 2017). Companies may not face significant penalties for non-compliance, which reduces their incentive to prioritize emissions reduction. Inconsistent enforcement across regions and regulatory loopholes further hinder the effectiveness of CSR initiatives. Limited stakeholder engagement is another factor. Without active involvement from businesses, the government, civil society organizations, and local communities, CSR strategies lack the necessary support and monitoring mechanisms (Hamann & Acutt, 2010). This limits the impact of CSR on emissions control.

Economic priorities and growth pressures also take precedence over environmental concerns (Van den Bergh, 2011). China's rapid economic growth and industrialization have led companies to prioritize economic performance, often overlooking sustainability. Meeting production targets and ensuring economic stability outweigh the integration of environmental considerations into business operations. The prevalence of greenwashing, where companies make superficial or misleading claims about environmental efforts, further diminishes the effectiveness of CSR (Torelli et al., 2020). This undermines genuine sustainability measures and fails to address the root causes of emissions.

Examine the role of CSR consumers and CSR_Envirnment to minimize sulfur, nitrogen, and phosphorus emissions.

It is also noted that CSR_Consumer and CSR_Envirnmnet do not impact environmental emissions. The insignificance of CSR-consumer and CSR-environment variables in controlling environmental emissions in China can be attributed to several reasons. Firstly, the complex and fragmented nature of supply chains in China's manufacturing sector (Fan, 2021) poses challenges for companies to effectively implement and monitor CSR initiatives related to environmental emissions. With a vast network of suppliers and subcontractors, ensuring consistent adherence to environmental standards throughout the supply chain becomes difficult. This complexity can weaken the impact of CSR efforts on emissions reduction.

Additionally, enforcing environmental regulations in China may be uneven, leading to lax implementation and compliance. While there are regulations to control environmental emissions, enforcement can vary across regions, and some companies may take advantage of loopholes or engage in non-compliant practices. In such cases, the influence of CSR-consumer and CSR-environment variables in controlling emissions becomes limited. Moreover, economic considerations and growth pressures often precede environmental concerns in China. As the country has experienced rapid economic growth and industrialization, companies may prioritize

meeting production targets and ensuring economic stability over investing in extensive CSR measures for emissions control.

Examine the role of CSR social in minimizing sulfur, nitrogen, and phosphorus emissions.

In the case of CSR_Social, results show that it is significantly and positively associated with environmental emissions. It is uncommon for CSR_Social initiatives to increase environmental emissions directly in China. However, there could be certain circumstances or factors that might inadvertently lead to this outcome. One possible reason is the misalignment or lack of coordination between CSR_Social initiatives and environmental goals. While CSR_Social activities may focus on social and community development, they may not prioritize or adequately address environmental concerns. This can result in companies investing heavily in CSR_Social initiatives while neglecting their environmental responsibilities. In such cases, the positive impact of CSR_Social on emissions reduction may be overshadowed by the lack of concerted efforts toward environmental sustainability.

Additionally, some CSR_Social activities, such as community development projects or infrastructure investments, may inadvertently lead to increased environmental emissions. For example, constructing new facilities or expanding operations to support community development can result in higher energy consumption and increased emissions. If the environmental impact assessment and mitigation measures are not properly integrated into CSR_Social initiatives, the net effect in environmental emissions may increase. Furthermore, there could be instances where companies engage in greenwashing, giving the impression of strong CSR_Social commitments while neglecting actual environmental performance. This can create a false perception of environmental responsibility and divert attention from genuine emissions reduction efforts.

Investigate the significance of directors' roles in countering firm-level environmental challenges.

The results suggest of the study suggest that directors play a vital role in countering firm-level environmental challenges. Their role is vital in reducing firm-level environmental emissions by setting clear goals, implementing policies, allocating resources, monitoring progress, promoting innovation, engaging stakeholders, and incorporating environmental considerations into board decisions (Lokuwaduge & Heenetigala, 2017). Because, they establish environmental objectives, develop comprehensive policies, and allocate resources to support sustainability initiatives. Directors monitor and report on environmental performance, foster a culture of sustainability, and promote innovation (Khan et al., 2021). Also, they engage stakeholders to raise awareness and garner support for emissions reduction and by integrating environmental considerations into board decisions, directors ensure that sustainability remains a key priority. Hence, their leadership is essential in driving emissions reduction efforts and fostering a greener, more sustainable future for the organization.

Investigate the significance of female directors' roles in countering firm-level environmental challenges.

Results of the study proved that the role of female directors in countering firm-level environmental challenges is significant only in the case of a reduction in Sulphur emissions. However, they have no significance in reducing nitrogen and phosphorus emissions. The reason behind the significant role of female directors in reducing sulfur emissions, but their lack of significance in reducing nitrogen and phosphorus emissions, can be attributed to various factors. Since their knowledge and skills may be tied to those in particular sectors or industries more closely related to sulfur emissions (Lu & Herremans, 2019). Additionally, they could be

knowledgeable about the legislation, technology, and pollution control methods associated with sulfur, allowing them to reduce emissions in this sector efficiently.

Similarly, the nature of these pollutants and the businesses involved may impact the lack of relevance of female directors in lowering nitrogen and phosphorus emissions. In contrast to sulfur emissions, nitrogen, and phosphorus emissions are frequently linked to distinct sources and processes (Johnson et al., 2013). Additionally, sectors that contribute significantly to nitrogen and phosphorus emissions include agriculture, wastewater treatment, and chemical manufacturing. These industries may have historically been dominated by men or face unique issues that the presence of only female directors cannot resolve. Additionally, the overall representation of female directors in companies and their level of influence within decision-making processes may vary across different industries and regions. If female directors are underrepresented, or lack decision-making power in sectors associated with nitrogen and phosphorus emissions, their impact on addressing these specific environmental challenges may be limited.

5. Conclusion

This study explores CSR's impact on environmental emissions in Chinese firms. Also, it explores the moderating role of CSR indicators and female directors in the nexus between CSR and environmental emissions. Results suggest that although CSR has no direct effect on environmental emissions, CSR_social has a positive impact on environmental emissions. Also, none of the CSR indicators moderate the nexus between CSR and environmental emissions. Similarly, female directors only have a negative effect on sulfur emissions.

5.1. Policy Implication

In China, CSR is not vital to controlling environmental issues. To address this problem, comprehensive and stringent environmental regulations, effective enforcement mechanisms, increased stakeholder engagement, and a shift towards viewing environmental sustainability as integral to long-term success are necessary. CSR can only play a more significant role in controlling environmental emissions in China through these efforts. Also, to address the insignificance of CSR-consumer and CSR-environment variables in controlling environmental emissions in China, it is crucial to raise consumer awareness and demand for sustainable products, strengthen the enforcement of environmental regulations, enhance transparency in supply chains, and integrate environmental considerations more firmly into business practices. By creating a favorable ecosystem that encourages and rewards environmentally responsible behavior, CSR can significantly drive emissions reduction efforts in China.

Similarly, to avoid CSR_Social initiatives from inadvertently leading to increased environmental emissions in China, it is important to ensure that these activities are aligned with environmental goals, integrate environmental considerations into their planning and implementation, and undergo rigorous monitoring and evaluation. By adopting a holistic approach to corporate social responsibility that encompasses both social and environmental aspects, companies can effectively mitigate the risk of CSR_Social initiatives inadvertently contributing to increased environmental emissions. To address the disparity regarding the impact of female directors on environmental emissions, it is important to encourage diversity and gender equality in leadership positions across all industries. By promoting inclusivity and ensuring equal opportunities for women to participate in decision-making processes, their expertise and perspectives can be effectively utilized to tackle a wider range of environmental challenges, including reducing nitrogen and phosphorus emissions.

5.2. Limitations and Future Directions

The current study has a few limitations that can be addressed in future research. The generalizability of the results is difficult because the study was done only in one country. Results may vary if the same research is repeated in another country. Hence, it is advised that the same type of analysis be done in other countries where environmental emissions are high. This can validate the results. Likewise, comprehensive data can be utilized to confirm the results further. Also, other methodologies can be applied to the same data so that it can be confirmed that the results are accurate.

Declaration of Interest Statement

Authors Contributions: Nouf did the writing of the manuscript, analyzed the results and review the manuscript.
Funding: There is no funding for this project.

Competing interests: The authors have declared that no competing interest exists.

Availability of data and materials: The data and codes will be available on demand.

Code availability: The codes are provided on demand.

Ethical approval: We confirm that this manuscript describes original work and is not under consideration by any other journal. Please let us know if you need any other information.

Consent to participate: Not applicable

Consent to publish: Not applicable

References

Alam, M. S., Safiullah, M., & Islam, M. S. (2022). Cash-rich firms and carbon emissions. *International Review of Financial Analysis*, *81*(January), 102106. https://doi.org/10.1016/j.irfa.2022.102106

Amores□Salvadó, J., Gregorio Martin□de Castro, & Elisabeth Albertini. (2023). Walking the talk, but above all, talking the walk: Looking greenfor market stakeholder engagement. *Corporate Social Responsibility and Environmental Management*, *1*, 431–442.

Bednárová, M., Klimko, R., & Rievajová, E. (2019). From environmental reporting to environmental performance. *Sustainability (Switzerland)*, *11*(9), 1–12. https://doi.org/10.3390/su11092549

Berrone, P., Fosfuri, A., & Gelabert, L. (2017). Does Greenwashing Pay Off? Understanding the Relationship Between Environmental Actions and Environmental Legitimacy. *Journal of Business Ethics*, *144*(2), 363–379. https://doi.org/10.1007/s10551-015-2816-9

Biscotti, A. M., D'Amico, E., & Monge, F. (2018). Do environmental management systems affect the knowledge management process? The impact on the learning evolution and the relevance of organisational context. *Journal of Knowledge Management*, *22*(3), 603–620.

https://doi.org/10.1108/JKM-08-2017-0344

Daddi, T., Magistrelli, M., Frey, M., & Iraldo, F. (2011). Do environmental management systems improve environmental performance? Empirical evidence from Italian companies. *Environment, Development and Sustainability*, *13*(5), 845–862. https://doi.org/10.1007/s10668-011-9294-8

Dandotiya, B., & Sharma, H. K. (2020). Climate change and its impact on terrestrial ecosystems. *Impacts of Climate Change on Agriculture and Aquaculture*, *September*, 140–157. https://doi.org/10.4018/978-1-7998-3343-7.ch007

Ding, J., Chen, W., & Wang, W. (2020). Production and carbon emission reduction decisions for remanufacturing firms under carbon tax and take-back legislation. *Computers and Industrial Engineering*, *143*(March), 106419. https://doi.org/10.1016/j.cie.2020.106419

Elmagrhi, M. H., Ntim, C. G., Elamer, A. A., & Zhang, Q. (2019). A study of environmental policies and regulations, governance structures, and environmental performance: the role of female directors. *Business Strategy and the Environment*, *28*(1), 206-220. https://doi.org/10.1002/bse.2250

Fan, L. (2021). The Forming of E-platform-driven Flexible Specialisation: How E-commerce Platforms Have Changed China's Garment Industry Supply Chains and Labour Relations. *China Perspectives*, *2021*(1), 29–37. https://doi.org/10.4000/chinaperspectives.11349

Forslid, R., Okubo, T., & Ulltveit-Moe, K. (2011). International trade, CO2 emissions and heterogeneous firms. *CEPR Discussion Paper*, *8583*. http://www.researchgate.net/publication/228223814_International_Trade_CO2_Emissions_and_Heterogeneous_Firms/file/60b7d51ea8518e15bb.pdf

Friedlingstein, P., Jones, M. W., O'Sullivan, M., Andrew, R. M., & Bakker, D. C. E. (2022). Global Carbon Budget 2021, raport Earth System Science Data. *Earth System Science Data*, *14*, 1917–2005. http://www.globalcarbonatlas.org/en/content/global-carbon-budget

Galletta, S., Mazzù, S., Naciti, V., & Vermiglio, C. (2022). Gender diversity and sustainability performance in the banking industry. *Corporate Social Responsibility and Environmental Management*, *29*(1), 161–174. https://doi.org/10.1002/csr.2191

Glass, C., Cook, A., & Ingersoll, A. R. (2016). Do Women Leaders Promote Sustainability? Analyzing the Effect of Corporate Governance Composition on Environmental Performance. *Business Strategy and the Environment*, *25*(7), 495–511. https://doi.org/10.1002/bse.1879

Hamann, R., & Acutt, N. (2010). How should civil society (and the government) respond to "corporate social responsibility"? A critique of business motivations and the potential for partnerships. *Development Southern Africa*, *20*(2), 255–270. https://doi.org/10.1080/03768350302956

IPCC. (2021). IPCC press release AR6. *Climate Change 2013 - The Physical Science Basis*, *August 2021*, 1–6.

Issa, A. (2023). Shaping a sustainable future: The impact of board gender diversity on clean energy use and the moderating role of environmental, social and governance controversies. *Corporate Social Responsibility and Environmental Management*, *May*. https://doi.org/10.1002/csr.2512

Issa, A., Zaid, M. A. A., & Hanaysha, J. R. (2022). Exploring the relationship between female director's profile and sustainability performance: Evidence from the Middle East. *Managerial and Decision Economics*, *43*(6), 1980–2002. https://doi.org/10.1002/mde.3503

Johnson, M. C., Palou-Rivera, I., & Frank, E. D. (2013). Energy consumption during the

manufacture of nutrients for algae cultivation. *Algal Research*, *2*(4), 426–436. https://doi.org/10.1016/j.algal.2013.08.003

Khan, P. A., Johl, S. K., & Johl, S. K. (2021). Does adoption of ISO 56002-2019 and green innovation reporting enhance the firm sustainable development goal performance? An emerging paradigm. *Business Strategy and the Environment*, *30*(7), 2922–2936. https://doi.org/10.1002/bse.2779

Lee, C. C., Chang, Y. F., & Wang, E. Z. (2022). Crossing the rivers by feeling the stones: The effect of China's green credit policy on manufacturing firms' carbon emission intensity. *Energy Economics*, *116*(October), 106413. https://doi.org/10.1016/j.eneco.2022.106413

Lee, K. H., & Min, B. (2015). Green R&D for eco-innovation and its impact on carbon emissions and firm performance. *Journal of Cleaner Production*, *108*, 534–542. https://doi.org/10.1016/j.jclepro.2015.05.114

Liu, X., Ji, Q., & Yu, J. (2021). Sustainable development goals and firm carbon emissions: Evidence from a quasi-natural experiment in China. *Energy Economics*, *103*(March), 105627. https://doi.org/10.1016/j.eneco.2021.105627

Liu, Z., Deng, Z., He, G., Wang, H., Zhang, X., Lin, J., Qi, Y., & Liang, X. (2022). Challenges and opportunities for carbon neutrality in China. *Nature Reviews Earth and Environment*, *3*(2), 141–155. https://doi.org/10.1038/s43017-021-00244-x

Lokuwaduge, C. S. D. S., & Heenetigala, K. (2017). Integrating Environmental, Social and Governance (ESG) Disclosure for a Sustainable Development: An Australian Study. *Business Strategy and the Environment*, *26*(4), 438–450. https://doi.org/10.1002/bse.1927

Lu, J., & Herremans, I. M. (2019). Board gender diversity and environmental performance: An industries perspective. *Business Strategy and the Environment*, *28*(7), 1449–1464. https://doi.org/10.1002/bse.2326

Masud, A., Nurunnabi, M., & Bae, S. (2018). The effects of corporate governance on environmental sustainability reporting: empirical evidence from South Asian countries. *Asian Journal of Sustainability and Social Responsibility*, *3*(3), 9–15. https://doi.org/10.1177/000331970405500102

Mungai, E. M., Ndiritu, S. W., & Rajwani, T. (2020). Do voluntary environmental management systems improve environmental performance? Evidence from waste management by Kenyan firms. *Journal of Cleaner Production*, *265*, 121636. https://doi.org/10.1016/j.jclepro.2020.121636

Naciti, V. (2019). Corporate governance and board of directors: The effect of a board composition on firm sustainability performance. *Journal of Cleaner Production*, *237*, 117727. https://doi.org/10.1016/j.jclepro.2019.117727

Okoh, A. I. S., & Okpanachi, E. (2023). Transcending Energy Transition Complexities in Building a Carbon-Neutral Economy: The Case of Nigeria. *Cleaner Energy Systems*, 100069. https://doi.org/10.1016/j.cles.2023.100069

Oloruntobi, O., Mokhtar, K., Mohd Rozar, N., Gohari, A., Asif, S., & Chuah, L. F. (2023). Effective technologies and practices for reducing pollution in warehouses - A review. *Cleaner Engineering and Technology*, *13*(February), 100622. https://doi.org/10.1016/j.clet.2023.100622

Parviainen, T., Lehikoinen, A., Kuikka, S., & Haapasaari, P. (2018). How can stakeholders promote environmental and social responsibility in the shipping industry? *WMU Journal of Maritime Affairs*, *17*(1), 49–70. https://doi.org/10.1007/s13437-017-0134-z

Peng, W., Lu, S., & Lu, W. (2022). Green financing for the establishment of renewable resources under carbon emission regulation. *Renewable Energy*, *199*(August), 1210–1225. https://doi.org/10.1016/j.renene.2022.08.140

Prakash, S. (2021). Impact of Climate Change on Aquatic Ecosystem and Its Biodiversity: an Overview. *International Journal Biological Innovations*, *03*(02). https://doi.org/10.46505/ijbi.2021.3210

Scanes, C. G. (2018). Human Activity and Habitat Loss: Destruction, Fragmentation, and Degradation 19.1 IMPACT OF AGRICULTURE 19.1.1 Overview. In *Animals and Human Society*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-805247-1/00026-5

Secinaro, S., Brescia, V., Calandra, D., & Saiti, B. (2020). Impact of climate change mitigation policies on corporate financial performance: Evidence-based on European publicly listed firms. *Corporate Social Responsibility and Environmental Management*, *27*(6), 2491–2501. https://doi.org/10.1002/csr.1971

Swaen, V., Demoulin, N., & Pauwels-Delassus, V. (2021). Impact of customers' perceptions regarding corporate social responsibility and irresponsibility in the grocery retailing industry: The role of corporate reputation. *Journal of Business Research*, *131*(September 2019), 709–721. https://doi.org/10.1016/j.jbusres.2020.12.016

Torelli, R., Balluchi, F., & Lazzini, A. (2020). Greenwashing and environmental communication: Effects on stakeholders' perceptions. *Business Strategy and the Environment*, *29*(2), 407–421. https://doi.org/10.1002/bse.2373

Van den Bergh, J. C. J. M. (2011). Environment versus growth - A criticism of "degrowth" and a plea for "a-growth." *Ecological Economics*, *70*(5), 881–890. https://doi.org/10.1016/j.ecolecon.2010.09.035

Vohra, K., Vodonos, A., Schwartz, J., Marais, E. A., Sulprizio, M. P., & Mickley, L. J. (2021). Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem. *Environmental Research*, *195*, 110754. https://doi.org/10.1016/j.envres.2021.110754

Wang, Z., Fu, H., & Ren, X. (2023). Political connections and corporate carbon emission: New evidence from Chinese industrial firms. *Technological Forecasting and Social Change*, *188*(September 2022), 122326. https://doi.org/10.1016/j.techfore.2023.122326

Wei, F., Ding, B., & Kong, Y. (2017). Female directors and corporate social responsibility: Evidence from the environmental investment of Chinese listed companies. *Sustainability (Switzerland)*, *9*(12). https://doi.org/10.3390/su9122292

Yamineva, Y., & Romppanen, S. (2017). Is law failing to address air pollution? Reflections on international and EU developments. *Review of European, Comparative and International Environmental Law*, *26*(3), 189–200. https://doi.org/10.1111/reel.12223

Yousaf, Z., Radulescu, M., Nassani, A. A., Aldakhil, A. M., & Jianu, E. (2021). Environmental Management System towards Environmental Performance of Hotel Industry: Does Corporate Social Responsibility Authenticity Really Matter? *Engineering Economics*, *32*(5), 484–498. https://doi.org/10.5755/J01.EE.32.5.28619

Zhao, X., Ma, X., Chen, B., Shang, Y., & Song, M. (2022). Challenges toward carbon neutrality in China: Strategies and countermeasures. *Resources, Conservation and Recycling*, *176*(June 2021), 105959. https://doi.org/10.1016/j.resconrec.2021.105959