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Article

Greenhouse Gas (GHG) Emissions and Firm Financial Performance

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Abstract

The impact of greenhouse gas (GHG) emission reduction on firm financial performance is increasingly contested in prior research and there remains a lack of agreement regarding this relationship. This highlights the unanswered question of whether environmental protection investment pays off. This study investigates the association between greenhouse gas (GHG) emission and firm financial performance of 58 high-polluting companies listed on the Johannesburg Stock Exchange (JSE). The study employed a two-step system generalized method of moment (SGMM) to analyse the relationship between GHG emissions and firm financial performance. Our study reports no statistical association between greenhouse gas (GHG) emission reduction initiatives and firm financial performance of high-polluting companies listed on the Johannesburg Stock Exchange. This paper recommends that firms in high polluting intensify carbon emission reduction initiatives as a long-term investment that can improve competitive advantage and resilience to greenhouse gas emission related risks. We suggest that tax incentives and supportive regulatory mechanisms to offset the short-term financial costs associated with adoption of carbon emission reduction strategies to align firm pollution abatement practices with sustainable development goals.

Keywords: environmental protection investment; financial performance; greenhouse gas emissions; pollution abatement practices; sustainable development goals

1. Introduction

With escalating global temperature due to climate change, there is growing global threat to both human health and firm sustainability [1,2]. Greenhouse gas (GHG) released into the atmosphere by companies' operations cause global climate change [2]. Climate change is associated with adverse consequences including increased public health stress, reduced availability and quality of portable water, the spread of infectious diseases, damage to infrastructure, and food insecurity [3]. The corporate intensity GHG emissions may also expose companies to financial vulnerability through regulatory penalties, operation disruptions, reputational risks and increase adaptation costs, thereby negatively impacting firm financial performance [4].

GHG emissions reduction is an environmental responsibility practice to protect environment and address worst impacts of climate change. According to [5,6], one of the goals of United Nations sustainable development goals (SDGs) is to decrease the global carbon dioxide emission to 45% by 2030 and reach net zero by 2050 to control global warming to 1.5°C above preindustrial levels. Companies are increasingly implementing carbon emission reduction strategies to mitigate GHG emissions. Firms are now aware of their environmental responsibilities towards the planet before considering profit maximization, due to their substantial impact of their operation on the

environment [7]. This awareness has led the firm to focus on GHG emission reduction strategies to address global concern over climate change.

Liu et al. [8] asserts that implementation of GHG emission reduction strategies significantly influences firm financial performance. However, it is important to take cognisance of initial investment costs associated with the implementation of GHG emissions reduction strategies that may be expensive and may not immediately translate into tangible financial benefits [9]. Given the importance of financial benefits expected from investment in GHG emissions reduction practices, the impact of GHG emissions intensity on firm financial performance remains a subject of interest.

Despite considerable number of studies support financial benefits of adopting GHG emissions reduction strategies, its effects on financial performance of South African high polluting firms listed on the JSE have received little attention [10]. Moreover, the research conducted by Ganda and Milondzo [10] only focused on one year period (2015) and employed regression models that do not capture unobserved variables. It is also observed from prior research that many studies focus on developed countries, little attention has been paid on developing countries, particularly in South African polluting companies. These limitations can influence the credibility of the results. For instance, a one-year analysis may not adequately represent nature of this relationship over time, and simple econometric models may not control unobserved variables, leading to overstated or understated relationship between GHG emission reduction strategies and firm performance. This study seeks to investigate the impact of GHG emission intensity on financial performance while addressing limitations observed in prior research. This study contributes to the body of knowledge by addressing shortcomings in prior research by applying a two-step systems GMM to establish the effects of GHG emission intensity on firm financial performance over a period of 9 years (2015-2023). Our study analyses dataset of 522 firm-year observation using annual reports of 58 polluting companies listed on the JSE in South Africa.

Previous studies have produced both negative and positive relationship between GHG emission reduction and firm financial performance [11–14]. Given these contradictory results, the consensus has not reached on whether the implementation of GHG emission reduction investment is profitable. These conflicting results may be attributed to firm characteristic, methodological approaches and employing different financial indicators and time dimensions.

Our study contributes to the literature regarding GHG emission-firm financial performance nexus in the following aspects. First, this study offers empirical insights into the impact of GHG emission on firm financial performance of high polluting companies listed on the JSE. Second, to the best of our knowledge, our study is one of the few investigating this relationship in South African high polluting companies using a three-stage structured MSCI and LSEG ESG scoring methodology to estimate GHG emission performance. The study's results highlight that the firm engaging in GHG emission reduction strategies may not immediately realise financial gains due to upfront costs associated with its implementation. We encourage companies to consider environmental responsible initiatives as a strategic asset that contributes to long-term financial stability, especially if it is not viewed as compliance exercise. This paper also encourages policymakers to introduce tax incentives that can offset short term costs of implementing GHG reduction initiatives to encourage its greater acceptance and implementation.

The remainder of this paper is structured as follows: Section 2 presents theoretical framework underpinning the study, the relevant literature on the impact of GHG emission intensity on firm financial performance and proposes hypothesis. Section 3 discusses research methodology. Section 4 provides empirical findings and section 5 concludes the paper.

Stakeholder Theory

Stakeholder theory is based on the idea that firms should consider the interests of stakeholders and shareholders by creating value for all stakeholders [15]. Firms are required to consider any individual which influences or is influenced by the achievements of firm's objectives and their associated consequences [16]. This theory asserts that while firms operate to provide benefits for themselves, they must also provide benefits to stakeholders [17]. Communities are also considered

stakeholders, and their interests in the company is related to environmental considerations [18]. Given the increased expectations and pressures from stakeholders, companies are facing challenges to enhance climate change performance while achieving financial goals [19].

This theory suggests that by addressing the needs and concerns of these diverse stakeholders, companies can build stronger relationships, reduce conflict, and improve their long-term performance. In environmental, social and governance (ESG) research, stakeholder theory emerges as theoretical bridge, connecting and constructing with other influencing factors, contributing significantly to the academic realm. The relationship between GHG emissions reduction and financial performance can be explained via the adoption of stakeholder theory.

Literature Review and Hypothesis development

The impact of corporate environmental performance on firm financial performance has been a crucial point of continuous debate during the second half of the 20th century. At the center of this scholarly debate is Porter's influential postulation, which claims that environmental protection investment (EPI) enhances firm financial performance [20,21]. This proposition is often referred to as "Porter Hypothesis" and remains crucial in ESG research. Prior research supports this postulation by emphasizing the environmental pollution reduction costs should be considered as innovative investment in environmental technologies rather financial burdens [22]. These EPIs may improve firm competitive advantage and contribute to corporate financial performance [23].

From this point of view, EPIs should not be considered as regulatory compliance measures imposed by external pressures. According to Ziegler et al. [24], firm that adopt and implement environmental pollution abatement practices (EPAP) into their core corporate strategies may curb input consumption, reduce operational expenditures, and maintain competitive advantage over their competitors. EPIs may also lower environmental compliance costs, decrease environmental liabilities and help to reduce capital costs [25]. This implies that companies that adopt GHG emission reduction strategies can enhance firm reputation, build stakeholder trust and differentiate themselves in the market, which ultimately improve corporate profitability [27].

However, prior research contests this optimistic perspective, suggesting that high-upfront costs associated with investment in environmental pollution control technologies can adversely impact firm financial performance, especially in the short run [28]. This indicates that environmental protection practices require significant capital expenditure, and without tax incentives financial gains may only earn in long term. This implies that immediate financial benefits of GHG emission reduction investments may not offset short-term costs of EPIs, challenging their financial stability.

Given this disagreement in existing literature, there has been high interest in the relationship between carbon emissions performance and firm financial performance. Some studies concur with the Porter Hypothesis, revealing a positive relationship between GHG emission reduction and financial performance [29–37]. These researchers suggest that investment in GHG emissions reduction technologies improve firm financial performance. For instance, [29] adopted fixed effects (FE) and random effects (RE) models to explore the impact of environmental protection practices on firm financial performance (measured by return on assets (ROA) and Tobin's Q (TQ)) of 293 Chinese polluting firms for the period 2015 to 2019, revealing positive relationship. Similarly [30] investigated this relationship using 127 international firm for the period 2007 to 2013, founding a positive association. Al-Mari and Mardini [31] applied ordinary least squares (OLS) regression to analyse the relationship between carbon emission performance and firm financial performance of 177 FTSE-350-listed firms, reporting a positive association. Siddique et al. [32] employed a two-stage least squares (2SLS) to explore the correlation between carbon disclosure and firm financial performance of 187 international firms, revealing a positive relationship. Similarly, [33] employed a 2SLS to explore the association between carbon disclosure and firm financial performance among world's 500 largest international firm from both developed and developing economies for the period 2011 to 2015 and found a positive relationship. Although the study adopted both accounting (ROA) and market-based (TQ) indicators, its focused on global aggregated data may mask firm-level and sector-specific dynamics within developing economies such as South Africa. In the same vein, [34] employed RE

model to establish the relationship between carbon emission performance and financial performance of 89 international firm from 2006 to 2009.

In South African context, there is limited research analysing this relationship. Worae and Ngwakwe [35] explored the correlation between environmental performance and financial performance (measured by ROA and ROS) for 14 manufacturing and mining firm listed on the JSE during 2008-2014 employing Granger causality. Although these researchers reported a positive relationship, their very small sample (98 firm-year observation) and reliance on limited short-term financial indicators limit the applicability and robustness of the results. Extending this research, [36] adopted feasible generalized least squares (FGLS) to investigate the relationship between carbon emission reduction and firm financial performance (measured by EPS and share price) of 32 JSE-listed firm for the period of 2011-2018. Although this research focuses on South African polluting companies, its relatively short-time frame and methodological constraints its ability to measure dynamic long-term effects, leaving room for more robust dynamic panel analysis. More recently, [37] explored the relationship between carbon performance and financial value (ROA) and firm value (FIV) and TQ using a two-step system GMM in 107 JSE-listed firms during 2014-2018. However, this study ignored earnings per share (EPS) which is crucial indicator to capture shareholder perspectives and used short-five year period limited longitudinal analysis. Madwe et al. [38] observed that negative relationship in polluting companies and noted that environmental protection practices negatively influence firm financial performance.

Prior research from developed countries further supports the positive relationship. For example, [39] applied the generalized method of moments (GMM) to 2 745 firm-year observations of 305 U.S. firms listed on the Standard and Poor's (S&P) during 2015 to 2023, reporting a positive correlation between environmental performance and financial performance (ROA and TQ). This study is methodological rigorous, however, its exclusive concentration on developed countries, leaves unanswered questions about whether the same dynamic hold in emerging countries with high GHG emission intensity, such as South Africa. The positive relationship indicates that GHG emission reduction strategies may impact EPS through compliance costs, reputational effects and operational efficiency.

On the other hand, there are contrasting findings suggesting that environmental protection investments (EPIs) may not always produce firm financial benefits. For instance, [40] employed 2SLS on 1095 companies in U.S. between 2004 and 2008 and reported a negative relationship between carbon performance (measured by change rates of carbon emission) and firm financial performance measured by ROA and TQ. Similarly, [41] explored the correlation between carbon emission performance and firm financial performance (ROA and TQ) using ordinary least squares and FE model, revealing a negative relationship. In support of these results, [40] explored the impact of carbon emission on corporate financial performance (measured by TQ) using 640 high-tech Taiwanese manufacturing firms for the period 2012 to 2018, revealing a negative relationship. Study from Asian developing countries is consistent with these findings, for example, [42] explored the correlation between carbon performance and firm performance (ROS) of 10 manufacturing firms in Indonesian market for the period of 2011. These researchers applied regression analysis and revealed a negative relationship. Similarly, [43] also explored the effect of carbon emission on financial performance of Indonesian-listed firms and revealed a negative relationship between these two variables. Zhang et al. [44] investigated the between carbon performance and financial performance in high energy-consumption China, and reported that negative relationship, suggesting that improvement in carbon emission and energy-saving targets could not bring overall firm performance. Furthermore, [45] examined the relationship between environmental performance and firm performance in the top 100 Italian firms and reported a negative relationship. These researchers indicated that the negative impact means that GHG emission reduction strategies may increase operational costs, leading to a low returns on these investment in both short and long run.

Some researchers believe that GHG emission reduction has no direct association with firm financial performance. For instance [46], examined the impact of firm environmental performance is

inconclusive. This disagreement may stem from different study periods, different financial measures (short term and long term), sample sizes, and regression models [50,51]. Noteworthy, the limited studies conducted in South Africa, a developing country with high GHG emission intensity highlights the urgent need for extending body of knowledge in context specific that addresses methodological limitation, short study period and ignored financial indicators such as EPS.

Building on this research gap, the authors of this study posit that firms that adopt and implement environmental responsible practices into their core business strategies are more likely to maintain stakeholder confidence, avoid unbearable penalties and fines emanating from environmentally irresponsible behaviour, thereby enhancing firm performance. Environmental compliant firms align with environmental compliance-oriented stakeholders who value sustainability, even if tangible financial benefits are not immediately realised. Therefore, our study proposes the following hypothesis:

Hypothesis H1: There is a significant positive relationship between GHG emission reduction and firm financial performance (measured by EPS and TQ).

Materials and Methods

This study applied a two-step system GMM to explore the impact of GHG emission reduction on firm financial performance. We follow [45] by capturing GHG emission reduction using GHG emission reduction ratio calculated on a year-over-year basis. In consistent with [40] our study focuses on scope 1 and scope 2 of GHG emission, since scope 3 is not affected by environmental regulation and not significant cost-driver.

Sample selection and data collection

This present study follows [26,30,51,52] by using data sourced from company’s annual reports and sustainability/ESG reports available on the websites of polluting companies listed on the JSE over the period of 2015 to 2023. GHG emission data was extracted from companies’ sustainability/ESG reports. An initial sample comprises 114 JSE-listed polluting companies, however, only 50% of the top companies in each sectors are selected based on market capitalisation, revenues and profits margins. Table 1 shows the final sample comprising 58 pollution companies listed on the JSE over a period of nine years (2015-2023). Table 1 categorises sample into four sectors namely, basic material/mining, industrial, oil & gas production and consumer goods. The sectors were included in the sample due to their significant carbon emission generated from their operation or production, thereby making GHG emission reduction strategies more applicable in the firm performance. The study period (2013-2023) is selected to address the sample period limitation observed in prior research, where many researchers focused either before the 2015 Paris Agreement or over short sample period that limit analysis of long-term impact [26,27,31,42].

Table 1. Polluting companies listed on the JSE included in the sample.

Sector	Number of companies per sector	50% of the top companies in the population	Companies included in the sample
Basic Material/Mining	45	50%	23
Consumer Goods	20	50%	10
Industrial	46	50%	23
Oil & Gas Production	3	50%	2
Total	114	50%	58

* Tables may have a footer.

Variable Measurement

Financial performance as the dependent variable was measured by earnings per share (EPS) and Tobin’s Q (TQ). In line with prior research [54–57] EPS was employed to reflect changes in

profitability and shares. EPS was adopted to capture short-term financial performance and to offer insight into profits attributable to each outstanding shareholder financial returns. TQ is widely applied as one of market-based performance indicators which captures the expected firm performance [58]. TQ is essential financial indicator to measure investor perceptions and market expectations. TQ is calculated by dividing the market value of the firm by the replacement value of its assets.

In line with the prior research, our study includes firm size, age, growth and leverage as the control variables [56,65–68]. These variables, their description and formula are shown in Table 2.

Table 2. Variable description and formulas.

Independent Variable: GHG Emission			
Variable	Description	Formula	Prior research
GHG Emission	Measures extent to which the firm reduces its GHG emission overtime (GRI 305 and CDP Climate reporting)	$\frac{GHG_{t-1} - GHG_t}{GHG_{t-1}}$	[36,61,62]
	Sectoral normalisation	$\frac{\chi_{i,GHG} \cdot \frac{GHG_{i,t} - \min_{j \in P(s)} GHG_{j,t}}{\max_{j \in P(s)} GHG_{j,t} - \min_{j \in P(s)} GHG_{j,t}}}{\chi_{i,GHG}}$	[59,60]
	Weight assignment and aggregation	$\varpi_{GHG} = \frac{\varpi_{GHG}}{\varpi_{GHG} + \varpi_{Innov} + \varpi_{Res}}$	[59,60]
	GHG emission score	$\frac{0.16}{0.16 + 0.03 + 0.16} = 0.4571$ $GHG_{i,t} = \varpi_{GHG} \cdot \chi_{i,GHG}$	[59,60]
	Dependent Variable: Financial Performance		
Variable	Description	Formula	Prior Research
EPS	measures shareholder value and firm profitability on a per-share basis	$\frac{EPS}{\frac{Net\ Income - Preference\ Dividends}{Weighted\ Average\ number\ of\ Shares}}$	[52,56]
TQ	Measures the firm's market value and reflects the firm's future growth prospects.	$\frac{TQ}{\frac{Market\ Value\ of\ the\ Firm}{Replacement\ cost\ oof\ Assets}}$	[63,64]
Variable	Description	Formula	Prior Research
Lev	measures extent to which a company is financed by debts relative to equity.	$\frac{Lev}{\frac{Total\ Debt}{Total\ Equity}}$	[65]
Firm Size	measures a firm's capacity to engage in ESG initiatives.	$FS = \ln(\text{Number of Employees})$	[56,66]
Growth	measures a firm's reinvestment capacity and expansion potential	$\frac{Growth}{\frac{Equity_t - Equity_{t-1}}{Equity_{t-1}}}$	[67]
Firm Age	measures firm maturity, historical resilience, and firm experience.	$FA = \frac{Current\ Year - Founding\ Year}{...}$	[68]

Sectoral normalization: Normalised each company's annual GHG ratio relative to its sectoral peer group through a min-max method; P_s : the set of peer firms in the sector; ϖ_{GHG} : normalised GHG to other environmental protection performance indicators within the same industry (basic material: 0.4571). ϖ_{GHG} , ϖ_{Innov} , ϖ_{Res} : Environmental protection indicators representing a sector-specific weights.

Model specification

This study employed a dynamic regression model to test relationship between GHG emissions and firm financial performance. The models were estimated using the following equations.

$$FS_{it} = \delta FS_{it-1} + \beta_1 GHG_{it} + B_2 Size_{it} + \beta_3 Age_{it} + \beta_4 Lev_{it} + \beta_5 Growth_{it} + \mu_i + \lambda_i + \varepsilon_{it} \tag{1}$$

Model 1: EPS formula:

$$EPS_{it} = \delta EPS_{it-1} + \beta_1 GHG_{it} + B_2 Size_{it} + \beta_3 Age_{it} + \beta_4 Lev_{it} + \beta_5 Growth_{it} + \mu_i + \lambda_i + \varepsilon_{it} \tag{1.1}$$

Model 2: TQ formula

$$TQ_{it} = \delta TQ_{it-1} + \beta_1 GHG_{it} + B_2 Size_{it} + \beta_3 Age_{it} + \beta_4 Lev_{it} + \beta_5 Growth_{it} + \mu_i + \lambda_i + \varepsilon_{it} \tag{1.2}$$

where:

FS_{it-1} = Lagged dependent variable to account for financial inertia, GHG_{it} = GHG score of $Firm_i$ for t , μ_i = Firm-specific effects (unobserved heterogeneity) , λ_i =Time-specific effects, ε_{it} = Idiosyncratic error term.

Results and Discussion

This study employs Stata 18.0 software to perform descriptive statistics on the sample data. Table 3 shows the descriptive statistics results of all variables. The EPS mean value of 5.78 indicated that on average the companies included in the sample are profitable. However, the sample consists of both loss-making and profitable firms (Min=-69.91, max=147.45). The TQ mean of 122, indicates that favourable market valuation of the sample to their assets. The wide range values indicated that the sample is operating under different market conditions. The GHG emissions mean value of 0.031 indicates that on average the sample is making a progress in mitigating GHG emissions in the operations. The wide range also indicated that these firms have differing levels of success in addressing the issue of GHG emissions.

The firm age mean of 56 years, indicates that many firms in the sample are well established with operational maturity. The leverage mean value of 34.89, shows that on average firms in the sample adopt a well-balanced financing structure that combines both debts and equity. The growth mean value of 2.14, suggests that on average the polluting companies listed on the JSE are expanding and strengthening their equity. Firm size with a mean of 10.82, shows that polluting companies consists of comparable scale with different organisational capacity.

Table 3. Descriptive Statistics of Variables.

Variable	Obs	Mean	Std.dev	Min	Maz
EPS	522	5.780411	13.99408	-69.91	147.45
TQ	522	122.2019	326.9612	-4.398693	4738.099
GHG	522	.030773	.0812517	-.1253568	.5068067
AGE	522	56.21839	51.9175	-699	138
LEV	522	34.89178	255.8497	-21.52504	2429.801
GROWTH	522	2.139053	47.01545	-2.010088	1072.106
SIZE	522	10.82522	0.8437611	9.385805	12.02345

Table 4 indicates that lagged financial performance measured by EPS is positive (0.63), but statistically insufficient, indicating that past financial performance does not influence current year firm financial performance. GHG emission performance with negative coefficient of -3.327, suggest that environmental protection investment may not translate into financial benefits in the short run. These results align with [46–49], who reported no relationship between carbon emission management and financial performance. Table 4 indicates that firm characteristics (age, leverage, growth and size)

do not affect carbon emission performance. This may indicate that earnings per share may only measure short-term performance.

For model 2 (TQ), the study indicates that lagged TQ is positive and statistically significant, suggesting some persistence in market valuation. Leverage ($p<0.01$) and growth ($p<0.01$) indicate investors reward companies that pursue growth strategies and employ well-balanced financing structure. The negative relationship was observed between TQ ($P<0.05$) and firm size. This shows that larger firms are penalised by the market when engaging in GHG emission reduction strategies. These findings are consistent with [69] who reported a negative relationship between firm size and ESG performance. This study reports that EPS does not measure the financial impact of environmental protection investments in South African polluters listed on the JSE. On the other hand, firm characteristics such as leverage, growth and firm size influence the firm value measured by TQ. However, both models reported statistical insignificant relationship between GHG emission performance and firm financial performance.

Table 4. GHG emissions and financial performance via a two-step system GMM.

Model 1: EPS		Model 2: TQ	
L.EPS	0.263 (0.232)	L.TQ	0.202* (0.117)
GHG	-3.277 (3.905)	GHG	-31.981 (98.412)
Age	0.006 (0.008)	Age	0.051 (0.112)
Lev	0.0003 (0.001)	Lev	0.285*** (0.041)
Growth	-0.0001 (0.002)	Growth	0.587*** (0.088)
Size	-1.075 (1.179)	Size	-40.753*** (18.873)
_Cons	14.951 (13.590)	_Cons	491.031*** (218,175)
Test Statistics	Value	Test Statistics	Value
AR (1)	-1.21 (0.224)	AR (1)	-1.03 (0.305)
AR (2)	0.48 (0.633)	AR (2)	0.56 (0.573)
Hansen Test	$\chi^2 (7) = 8.78$ (0.269)	Hansen Test	$\chi^2 (7) = 5.36$ (0.616)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

This paper employed Hansen test to test for overidentifying restrictions [70]. This test was applied to determine whether the instruments employed in models are valid. The instruments are valid if the p-value is greater than 0.05 [71]. All models in Table 4 passed the Hansen test, with model 1 having a value of 0.269 and model 2 having a p-value of 0.616. Our study concludes that the instruments applied in the two models in the are valid and uncorrelated with the error term.

The Arellano-Bond test shows that both models (EPS & TQ) do not suffer from second-order autocorrelation, as the AR (2) test is insignificant in both models ($p>0.05$). Although AR (1) test insignificant in EPS and TQ, both models meet the key conditions of the GMM methodology, as the absence of significant second-order autocorrelation ((AR(2)) indicates that the instruments remain valid.

Conclusions

This study provides original and significant contributions by exploring the impact of GHG emission reduction on firm financial performance of polluting companies in South Africa. This study is underpinned by stakeholder theory, which posits that companies are accountable to wide range of stakeholders, including those concerned with environmental impacts. Our study found no significant relationship between GHG emission reduction practices and firm financial performance both in short and long term. The findings of this study do not support the proposed hypothesis that there is a significant positive relationship between GHG emission reduction and firm financial performance (measured by EPS and TQ).

This study adds to the existing literature by focusing on polluters in South Africa which is ignored by prior research. This study uniquely applied three-stage scoring methodology to estimate the GHG emissions score in emerging country. This study challenges stakeholder theory by reporting no relationship between GHG emission performance and financial performance among 58 JSE-listed polluters and emitters. The study's results underscore the importance of tax policy consideration for GHG emission reduction strategies. The adoption and implementation of GHG emission reduction practices would demand supportive tax incentives for environmental protection investment, such as accelerated capital allowance and tax rebates.

While our study provides valuable insights, there are certain shortcomings to consider. Future researcher could extend this research by applying alternative methodologies, used alternative data sources to validate the results. Investigating other factors such as tax incentives, leadership and firm culture could offer comprehensive understanding of this relationship. Future research could examine both developed and developing countries and expand the study period to 2025 to validate and extend these findings.

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References

1. Parums, D. V. A review of the increasing global impact of climate change on human health and approaches to medical preparedness. *Med. Sci Monit.* **2024**, *11*. <https://doi.org/10.12659/MSM.945763>
2. Psistaki, K.; Tsantopoulos, G.; Paschalidou, A. Overview of the forests in climate change mitigation. *Sustainability* **2024**, *16*(14), 6089. <https://doi.org/10.3390/su16146089>
3. Van Emous, R.; Krusinskas, R.; Westerman, W. Carbon emission reduction and corporate financial performance: The Influence of country-level characteristics. *Energies* **2021**, *14*, 6029. <https://doi.org/10.3390/en14196029>
4. Abbass, K.; Qasim, M. Z.; Song, H.; Murshed, M.; Mahmood, H.; Younis, I. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environ. Sci. Pollut. Res.* **2022**, *29*, 42539–42559.
5. Rogelj, J.; Popp, A.; Calvin, K. V.; Luderer, G.; Emmerlig, J.; Gernaat, D.; Fujimori, S.; Strefler, J.; Hasegawa, T.; Marangoni, G.; et al. Scenarios towards limiting global mean temperature increase below 1.5 C. *Nat. Clim. Change*. **2018**, *8*. 325–332.
6. United Nations. Ahead of Climate Action Summit, UN Secretariat Adopts Plan to Slash Own Emission by almost half by 2030. <https://www.un.org/sustainabledevelopment/blog/2019/09/un-secretariat-climate-action-plan/> (Accessed 10 August 2025)

7. Carbon dioxide emission and the economic growth: Competitiveness and economic development view, *Competitiveness Review: An Intern. Bus. J.* **2023**, 34 (4), 761-785. <https://doi.org/10.1108/cr-04-2023-0087>
8. Liu, M.; Zhou, C.; Lu, F.; Hu, X. Impact of the implementation of carbon emission trading on corporate financial performance: evidence from listed companies in China. *PLOS ONE* **2021**, 16. <https://doi.org/10.1371/journal.pone.0253460>
9. Le, H.; Nguyen-Phung, H. Assessing the impact of environmental performance on corporate financial performance: A firm-level study of GHG emission in Africa, *Sustain. Prod and Consum.* **2024**, 47, 644-654. <https://doi.org/10.1016/j.spc.2024.04.024>
10. Ganda, F.; Milondzo, K. S. The impact of carbon emission on corporate financial performance: Evidence from the South African firms. *Sustainability* **2018**, 10(7), 2398. <https://doi.org/10.3390/su10072398>
11. Busch, T.; Lewandowski, S. Corporate carbon and financial performance: A Meta-analysis. *J. Industr. Ecol.* **2018**, 22(4). <https://doi.org/10.1111/jiec.12591>
12. Busch, T.; Bassen, A.; Lewandowski, S.; Sump, F. Corporate carbon and financial performance revisited. *Organ & Environ* **2020**. <https://doi.org/10.1177/1086026620935638>
13. Trinks, A.; Mulder, M.; Scholtens, B. An efficiency perspective on carbon emission and financial performance. *Ecol. Econ.* **2020**, 175. <https://doi.org/10.1016/j.ecolecon.2020.106632>
14. Galama, J. T.; Scholtens, B. A meta-analysis of the relationship between companies' greenhouse gas emissions and financial performance. *Environ. Res. Lett* **2021**, 16(4). <https://doi.org/10.1088/1748-9326/abd08>
15. Mahajani, R.; Lim, W. M.; Sareen, M.; Kumar, S. Stakeholder theory. *J. Busin. Res.* **2023**, 166. <https://doi.org/10.1016/j.jbusres.2023.114104>
16. Awa, H. O.; Etim, W.; Ogbonda, E. Stakeholders, stakeholder theory and corporate social responsibility (CSR). *Int J. Corp. Respon.* **2024**, 9(11). <https://doi.org/10.1186/s40991-024-00094-y>
17. Freeman, R. E.; Dmytriiev, S. D.; Phillips, R. A. Stakeholder theory and the resource-based view of the firm. *J. Manag.* **2021**, 47(7), 1757-1770. <https://doi.org/10.1177/0149206321993576>
18. Seroka-Stolka, O. Enhancing environmental sustainability: Stakeholder pressure and corporate Co2 - related performance: An examination of the mediating and moderating effects of corporate decarbonisation strategies. *Sustainability* **2023**, 15(19), 14257. <https://doi.org/10.3390/su151914257>
19. Mardini, G. H.; Lahyani, F. E. The relevance of carbon performance and board characteristics on carbon disclosure. *Stud. Econ and Fina* **2023**, 41(3). <https://doi.org/10.1108/sef-02-2023-0056>
20. Porter, M. E. Towards a dynamic theory of strategy. *Strateg. Manag. J.* **1991**, 12 (S2), 95-117. <https://doi.org/10.1002/smj.4250121008>
21. Porter, M. E.; Linde, C. V. D. Toward a new conception of environmental-competitiveness relationship. *J. Econ. Perspect* **1995**, 9(4), 97-118. <https://doi.org/10.1257/jep.9.4.97>
22. Le, H.; Nguyen-Phung, H. T. Assessing the impact of environmental performance on corporate financial performance: A firm-level study of GHG emissions in Africa. *Sustan. Prod and Consum.* **2024**, 47, 644-654. <https://doi.org/10.1016/j.spc.2024.04.024>
23. Sarfraz, M.; Ozturk, I.; Yoo, S.; Raza, M. A.; Han, H. Toward a new understanding of environmental and financial performance through corporate social responsibility, green responsibility, green innovation, and sustainable development. *Humanit. Soc. Sci. Commun.* **2023**, 10(1). <https://doi.org/10.1057/s41599-023-01799-4>
24. Ziegler, A.; Busch, T.; Hoffmann, V. H. Disclosed corporate responses to climate change and stock performance: An international empirical analysis. *Energ. Econ.* **2011**, 33(6), 1283-1294. <https://doi.org/10.1016/j.eneco.2011.03.007>
25. Pang, Y. Profitable pollution abatement? A worker productivity perspective. *Resour. Energy Econ.* **2018**, 52. <https://doi.org/10.1016/j.reseneeco.2017.12.003>
26. Dechezlepretre, A.; Kozluk, T.; Kruse, T.; Nachtigall, D.; De Serres, A. Do environmental and economic performance go together? A review of micro-level empirical evidence from the past decade or so. *Intern. Rev. Environ and Resour. Econ.* **2019**, 13(1-2). <http://dx.doi.org/10.1561/101.00000106>

27. Shmelev, S. E.; Gilardi, E. Corporate environmental, social, and governance performance: The impacts on financial returns, business model innovation, and social transformation. *Sustainability* **2025**, *17*(3), 1286. <https://doi.org/10.3390/su17031286>
28. Kraus, S.; Rehman, S. U.; Garcia, F. J. S. Corporate social responsibility and environmental performance: the mediating role of environmental strategy and green innovation. *Technol. Forecast. Soc. Chang.* **2020**, *160*. <https://doi.org/10.1016/j.techfore.2020.120262>
29. Tang, Y.; Yue, S.; Ma, W.; Zhang, L. How doe environmental protection expenditure and green technology innovation affect synergistically the financial performance of heavy polluting enterprises? Evidence from China. *Environ. Sci. Control Ser.* **2022**. <https://doi.org/10.1007/s11356-022-21908-1>
30. Misani, N.; Porgutz, S. Unravelling the effects of environmental outcomes and processes on financial performance: A non-linear approach. *Ecolog. Econom.* **2015**, *109*(C). <https://ideas.repec.org/a/eee/ecolec/v109y2015icp150-160.html>
31. Al-Mari, J. R.; Mardini, G. H. Financial performance and carbon emissions disclosure. *J. Busin and Socio-econ. Develop.* **2024**, *4* (4), 293-307. <https://doi.org/10.1108/JBSED-03-2024-0023>
32. Siddique, M. A.; Akhtaruzzaman, M.; Rashid, A.; Hammami, A. Carbon disclosure, carbon performance and financial performance: International evidence. *Intern. Rev of Financ. Analy.* **2021**, *75*. <https://doi.org/10.1016/j.irfa.2021.101734>
33. Gallego-Alvarez, 1.; Segura.; Martinez-Ferrero, J. Carbon emission reduction: The impact of financial and operational performance of international companies. *J. Clean. Prod.* **2015**.
34. Worae, T. A.; Ngwakwe, C. C. Environmental responsibility and financial performance nexus in South Africa: Panel Grander causality analysis. *Environ. Econ.* **2017**, *8*
35. Dzomonda, O.; Fatoki, O. Environmental sustainability commitment and financial performance of firms listed on the Johannesburg Stock Exchange (JSE). *Int. Environ. Res. Public Health.* **2020**, *17*(20). <https://doi.org/10.3390/ijerph17207504>
36. Ganda, F. Carbon performance, company financial performance, financial value, and transmission channel: An analysis of South African listed companies. *Environ. Sci and Pollut. Res.* **2022**, *29*(19).
37. van Emous, R.; Krusinskas, R.; Westerman, W. Carbon Emissions Reduction and corporate financial performance: The influence of country-level characteristics. *Energies* **2021**, *14*(19), 6029. <https://doi.org/10.3390/en14196029>
38. Alyahya, M. and Agag, G. How Does Corporate Environmental Performance Contribute to Firm Performance and Customer Satisfaction? A Longitudinal Investigation. *Sustainability* **2025**, *17* (4), 1644. <https://doi.org/10.3390/su17041644>
39. Madwe, M.; Nzuza, Z.; Olarewaju, O. How does corporate environmental responsibility (CER) contribute to corporate financial performance (CFP)? *Intern. J. Appl. Res in Busin & Manag.* **2025**, *6*(2). <https://doi.org/10.51137/wrp.ijarbm.2025.mmhd.45870>
40. Delmas, M. A.; Nairn-Birch, N.; Lim, J. Dynamics of environmental and financial performance: The greenhouse gas emission. *Organ & Environ.* **2016**, *28*(4), 374-393. <https://doi.org/10.1177/1086026615620238>
41. Busch, T.; Bassen, A.; Lewandowski, S.; Sump, F. Corporate carbon and financial performance revisited. *Organis & Environ* **2020**, *35*(1), 154-171. <https://doi.org/10.1177/1086026620935638>
42. Chou, C.; Yang, K.; Schwarz, G. M. The paradox of increased carbon emission and firm performance. *Austr. J. Manag.* **2025**, *0*(0). <https://doi.org/10.1177/03128962251319714>
43. Liu, Z.; Zhu, J.; Sun, J. Research on the correlation between environmental performance and financial performance in China's heavy pollution industries based on Raga-PP model. *Pol. J. Environ. Stud.* **2022**, *31*(4). <https://doi.org/10.15244/pjoes/146558>
44. Zhang, Y.; Zhao, X.; Fu, B. Impact of energy saving on financial performance of industrial enterprises in China: An empirical analysis based on propensity score matching. *J. Environ. Mang.* **2022**, *317*.
45. Pulino, S. C.; Mirella, C.; Barbara, S. M.; Luigi, N. Does ESG disclosure influence firm performance? *Sustainability* **2022**, *14*.
46. Dai, L.; Wang, M. Study on the influence of carbon emission constraints on the performance of thermal power enterprises. *Environ. Sci. Pollut. Res. Int.* **2020**, *27*(24).

47. Hoppe, H.; Guenther, E. Merging limited perspectives a synopsis of measurement approaches and theories of the relationship between corporate environmental and financial performance. *J. Industr Ecol.* **2014**, *18*(5).
48. Junius, D.; Adisurjo, Y.A.; Rijanto, A.; Elvi, A. Y. The impact of ESG performance and market value. *J. Aplik. Akunt.* **2020**, *5*.
49. Narula, R.; Purnima, R.; Kumar, S.; Rahul, M. ESG scores and firm performance-evidence from emerging markets. *Inter. Rev. Econ & Fina.* **2024**, *89*.
50. Markus, H.; Geyer-Klingeberg, J.; Rathgeber, A.; Stockl, S. Economic development matters: A meta-regression analysis on the relationship between environmental management and financial performance. *J. Industr. Ecol.* **2018**, *22*(4).
51. Khatib, S. F. A.; Ismail, I. H. M.; Salameh, N.; Abbas, A.F.; Bazhair, A. H.; Sulimany, H. G. Carbon emission and firm performance: the moderating role of management environmental training. *Sustainability* **2023**, *15*(13). <https://doi.org/10.3390/su151310485>
52. Setyaningsih, W.; Wibowo, R. S. Does earnings per share contributes to the effect of ESG score on share price of mining sector companies? *Adv. Account. Innov (AAI)*. **2024**, *1* 91. <https://doi.org/10.69725/aai.v1i1.90>
53. Gunawan, J.; Paulina, P.; Fauzi, H. The evolution of sustainability reporting practices in Indonesia. *J. Clean. Prod.* **2022**, *358*.
54. Ahmad, N.; Mobarek, A.; Roni, N. N. Revisiting the impact of ESG on financial performance of FTSE-350 UK firms: Static and dymamci panel data analysis. *Cogen. Busin & Manage.* **2021**, *8*.
55. Chen, Z.; Guanxia, X. ESG disclosure and financial performance: Moderating role of ESG investors. *Intern. Rev. Financ. Analy.* **2022**, *83*.
56. Chawarura, W. I.; Sibanda, M.; Mamvura, K. Impact of ESG on the financial performance of Johannesburg Stock Exchange-Listed Companies. *Risks* **2025**, *13*(6), 144. <https://doi.org/10.3390/risks13060114>
57. Chau, L.; Anh, L.; Duc, V. Valuing ESG: How financial markets respond to corporate sustainability. *Inter. Busin. Rev.* **2025**, *34* (3). <https://doi.org/10.1016/j.ibusrev.2025.102418>
58. Ooi, S. K.; Goh, S.; Yeap, J. A. L.; Loo, K, S. Linking corporate climate change and financial performance: Evidence from Malaysia. *Glob. Busin and Manag. Res* **2018**, *10*(1).
59. MSCI ESG Research LLC. MSCI ESG Ratings methodology **2024**. MSCI Inc. <https://www.msci.com/esg-and-climate-methodologies> (Accessed 5 September 2025).
60. LSEG DATA & ANALYSTICS. Environmental. Social and governance scores from LSEG **2024**. https://www.lseg.com/content/dam/data-analytics/en_us/documents/methodology/lseg-esg-scores-methodology.pdf (Accessed on 1 June 2025)
61. Gerged, A. M.; Beddewela, E.; Cowton, C. J. Does corporate environmental disclosure enhance firm value? Evidence from MENA emerging markets. *Busin. Strateg and the Environ.* **2021**, *31*(3), 1141-1163.
62. Hasan, S. A.; Waghule, S. N.; Al-Koliby, I. S.; Al-Bukhrani.; Al Haifi, M.; Hasan, M. B. Innovating for sustainability: The role of environmental management accounting in driving environmental performance. *Discov. Sustain.* **2024**, *5*. <https://doi.org/10.1007/s43621-024-00389-x>
63. Wu, S.; Li, X.; Li, Z. The impact of ESG performance on firm value: The moderating role of ownership structure. *Sustainability* **2022**, *14*(21), 14507. <https://doi.org/10.3390/su142114507>
64. Al-Tarawneh, A.; Tayeh, M.; Iskandrani, M.; Obeidat. The impact of ESG scores on corpoarete financial performance: A study of non-financial firms listed in the UK. *Asian Econ and Soc. Socie.* **2024**, *14*(11).
65. Hamdi, K.; Guenich, H.; Saada, M. Does corporate governance performance promote ESG: Evidence from US firms. *Coge, Busin & Manag.* **2022**, *9*(1). <https://doi.org/10.1080/23311975.2022.2154053>
66. Pastor, L.; Stambaugh, R. F.; Taylor, L. A. Dissecting green returns. NBER Working Ppaer No. 28940. *J. Financ. Econom.* **2022**, *146*.
67. Shan, X.; Song, Y.; Song, P. How ESG performance impacts corporate financial performance? A DuPoint analysis approach. *Intern. J. Clim. Chan. Strateg and Manag.* **2024**. https://doi.org/10.1108/IJCCSM_07-2024-0125
68. Bamel, N.; Khatri, K.; Bamel, U.; Kumar, S. ESG disclosure and firm performance in global south economy: Does industry profile and board independence moderate the relationship. *Intern. Rev. Econom & Fin.* **2025**, *100*. <https://doi.org/10.1016/j.iref.2025.104093>

69. Zaiane, S.; Dorra, E. Corporate responsibility and firm financial performance: The moderating effects of size and industry sensitivity. *J. Manag and Govern.* **2022**, *27*.
70. Hansen, L. P. Large sample properties of generalized method of moments estimators. *Economet: J. Economet. Socety* **1982**, *50*.
71. Roodman, D. How to do Xtabond2: An introduction to difference and system GMM in Stata. *The Sta. J.* **2009**, *9*.

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