Corporate Carbon Emissions and Firm Performance in South Africa

Review of Integrative Business & Economics Research

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ABSTRACT

This study examines the relationship between corporate carbon emissions and financial performance measures of South African firms. Using panel fixed effects regression, the study analyses a sample of 111 companies from 2010 to 2022. The results show that firms with larger profitability ratios, efficiency ratios, price-to-book value, and lower leverage have smaller carbon emissions. In contrast, Tobin's Q has a positive effect on carbon emissions. The study finds a negative relationship between GHG emissions and financial performance, which aligns with the environmental and financial performance paradigm. GHG Scope 3 emissions have a negative but statistically insignificant impact on financial performance metrics. On the other hand, total emissions and GHG Scopes 1, 2, and 3 have a positive effect on Tobin's Q. The differential impact of GHG emissions across varying scopes suggests that financial performance may be influenced differently by specific sources and activities of emissions.

Keywords: Carbon emissions; Corporate financial performance; South Africa.

Received 5 July 2023 | Revised 2 December 2023 | Accepted 8 January 2024.

1. INTRODUCTION

Climate change is not just a future concern; its effects are already being felt worldwide. It's important to examine how country-led efforts, particularly in developing countries like South Africa, are making a difference. Carbon dioxide emissions (CO2) can harm a company's reputation and financial performance, so companies must implement green strategies (Laufer, 2003; Kumarasiri and Jubb, 2016; Ganda, 2018; Miah *et al*., 2021).

Firms have a significant impact on carbon emissions due to their energy consumption during production. Governmental and policymaker pressures are increasingly compelling corporations to reduce their carbon footprint while improving their economic performance (Alam *et al*., 2019). The natural resource-based view theory claims that corporations with higher environmental activities will have a competitive advantage (Hart, 1995). However, neoclassical economic theory argues that an increase in economic performance leads to increasing costs, hindering financial performance (Palmer *et al*., 1995). This study

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

contributes to the understanding of the relationship between corporate carbon and financial performance in South Africa. The objectives are to investigate the relationship between a firm's carbon emissions and its financial performance and to determine if this relationship is positive or negative.

Environmentally responsible firms have access to crucial resources (Zeidan *et al*., 2015) and are regarded as trustworthy by stakeholders, even in unfavorable economic conditions (Lins *et al*., 2017). The competitive advantage and stakeholders' trust gained by environmentally responsible corporations are valuable, especially in times of turmoil (Godfrey, 2005). Firms that exhibit enhanced economic performance can develop favorable relationships with their stakeholders, optimizing resource deployment and augmenting overall economic gain (Branco and Rodrigues, 2008).

Given the ambiguous nature of the relationship between economic performance and financial performance (Brahmana and Kontesa, 2021), this article aims to bridge the gap in the literature on climate risk mitigation and financial performance. We examine the effect of Greenhouse Gas (GHG) scope levels on financial performance, represented by key financial metrics like return on assets (ROA), return on equity (ROE), Tobin's Q (TQ), and return on investment capital (ROIC). South African firms were chosen as our sample for three main reasons. First, South Africa has a carbon-intensive economy due to its reliance on coal-based energy production and mining sectors. Second, South Africa faces challenges posed by climate change, and understanding the relationship between GHG emissions and financial performance can help identify economic risks and opportunities. Third, South Africa passed the Carbon Tax Act in 2019 to align with its commitments under international climate agreements and sustainable development goals. The carbon tax system is an important step in reducing emissions at the national level. A panel of 111 South African publicly listed firms from 2010 to 2022 was analyzed using fixed-effects regression, with carbon output variable-total emissions- added to ensure the robustness of the results.

This paper contributes to the debate on the relationship between corporate carbon emissions and financial performance. Limited research has been done on this relationship; findings differ by region, country, and industry. Many studies focus on highly industrialized countries, with less attention given to emerging economies like South Africa. Thus, this study sheds light on South Africa based on investigating the relationship between carbon and financial performance using accounting and market-based indicators.

The remainder of our paper proceeds as follows. Section 2 reviews relevant literature. Section 3 describes the data and methodology. Section 4 presents empirical results. Section 5 presents implications and section 6 concludes.

2. LITERATURE REVIEW

Due to the adverse impacts of climate change on the world economy (Stern, 2007), companies are under pressure from regulatory authorities and stakeholders to reduce carbon emissions as observed by Kolk and Pinkse (2005). Cao, Chaiwan *et al*. (2023) on the other hand in response to rising climate policy awareness in China, found that economic growth, industrialization, and carbon intensity have a catalytic role in promoting the decoupling states, while energy consumption structure and consumer price index have a suppressive influence. Therefore, companies are expected to play a critical role in lowering GHG emissions and stabilizing climate change as addressed by Luo & Tang (2014). Previous studies on the relationship between carbon performance and corporate financial performance and/or the financial value used diverse samples and methodologies. However, they produced mixed findings, and consensus has not yet been reached on the nature of this relationship. Ashraf *et al*.'s (2020) analysis of South Asian cement manufacturing firms demonstrates that

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

financial slack generates a positive relationship with carbon performance and that this link is moderated through carbon prices in a negative direction. However, company density was found to positively moderate this association. In this regard, companies are increasingly required to publish carbon disclosures to alleviate stakeholders' concerns. Carbon disclosure enables stakeholders to monitor a company's carbon emissions, leading to improved corporate carbon performance.

Choi *et al*. (2013) found that corporations are motivated to respond to the challenges posed by global warming from the environment, economy, and politics. Stakeholders view Carbon emission disclosure as a concrete action taken by companies to face an emissions reduction strategy, and larger companies tend to provide more detailed carbon disclosures. Dam and Scholtens (2015) suggest that there are many ways in which company carbon emission reductions may affect financial performance. Delmas *et al*. (2015) used regression analysis to determine the association between corporate carbon performance and financial success, their findings indicate that increased carbon emissions are associated with higher ROA, while investors anticipate the long-term risks of high carbon emissions as seen by a lower level of Tobin's q. Reducing carbon emissions may harm financial performance in the short term but benefit it in the long run.

Research has shown that reducing carbon emissions can have a detrimental impact on short-term financial performance (Busch *et al*. 2018; Iwata & Okada, 2011; Lee *et al*., 2015; Wang *et al*., 2014). One explanation is that competitors may gain from avoiding investments in carbon mitigation technology (Misani and Pogutz, 2015). Ashraf *et al*. (2020) found that financial slack generates a positive relationship with carbon performance, moderated negatively by carbon prices and positively by company density. Okafor *et al*. (2021) found that firms that spend more on socially responsible initiatives achieve increased revenue and profit. Trinks *et al*. (2020) found that carbon-efficient firms achieve superior financial performance. Wang *et al*. (2020) examined 289 Chinese companies and concluded that environmental information reporting positively influences corporate financial performance directly and indirectly (through analyst coverage, the number of reports, and several analysts). A survey of 201 quoted small and medium enterprises (SMEs) in the UK (Boakye *et al*. 2021) found that SMEs that optimise environmental management achieve improved financial performance. Velte *et al*.'s (2020) quantitative review of 73 previous studies demonstrates that carbon performance improves financial performance, that carbon performance and carbon disclosure are positively associated, and that both are positively affected by the composition of the corporate board. Zhang and Vigne (2021) highlight that a financing-emission reduction policy punishes firms responsible for high levels of pollution and that such firms also suffer low levels of total factor productivity, sales growth, and firm profitability. Abban and Hasan's (2021) analysis establishes that improved environmental performance enhances financial performance and points to bi-directional causality between the former and the latter. Lin *et al*. (2019) evaluated 163 international automotive companies and determined that a green innovation strategy (GIS) positively affects firm financial performance. Fernández-Cuesta *et al*.'s (2019) investigation of 428 listed firms in 16 European countries shows that carbon risk alongside capital expenditure is the major causes of financial debt. The positive effect of carbon emissions on debt (driven by the role of emissions) was minimised by the companies' environmental performance. Ganda *et al*. (2018) found that companies that integrate green investment initiatives to reduce carbon emissions can effectively manage financial performance. Cucchiella *et al*. (2017) found that incorporating an environmental management system and improving emissions management helped companies gain profitability. Lucas and Noordewier (2016) found that environmental management practices had a positive impact on financial performance when pollution reduction activities were implemented, with a stronger effect in dirty industries.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Lee *et al*. (2015) found a negative relationship between green research and development investment and carbon emissions in Japanese manufacturing companies. Gallego-Álvarez *et al*. (2015) found that reducing carbon emissions increased corporate financial returns. Lee *et al*. (2015) reported that an increase in carbon emissions lowered a company's value. Zhang and Wang (2014) found that reporting and activities that reduce carbon emissions improved economic performance in Chinese energy-intensive industries. Prior research has found a curvilinear relationship between corporate carbon and financial performance, with the relationship starting as negative but eventually becoming positive (Misani and Pogutz, 2015; Tatsuo, 2010; Trumpp and Guether, 2015]. Tzouvanas *et al*. (2020) surveyed 288 European manufacturing firms and concluded that improved environmental performance results in firm financial gain. Therefore, the association between environmental and financial performance is positive, although the magnitude is different in different quantile ranges. Finally, Agyabeng-Mensah *et al*.'s (2020) research on 240 firms in Ghana supports the notion that integration of green logistics management has less impact in improving communities' social wellbeing and health, while it does improve corporate financial performance (through environmental and market initiatives). In view of the review above, evidence confirm the validity of support of both sides about the influence of carbon performance on firm performance. In light of this complexity, a company's participation and/or nonengagement is, to a greater extent, the management concern. Saka and Oshika (2014) found evidence of a link between carbon emissions and company value in Japan. Matsumura *et al*. (2013) found a significant negative association between carbon emissions and corporate value. Clarkson *et al*. (2011) found that companies that improve their environmental performance have higher future Tobin's Q, profitability, liquidity, and sales growth. Ganda *et al*. (2018) found that carbon disclosure is positively related to ROA in South African companies. High carbon efficiency may affect profitability as it reflects efficient resource usage.

Improvements in carbon performance are linearly related to financial performance, with reducing carbon emissions being positively related to profitability but negatively related to stock market performance. These contradicting findings may explain why firms have been hesitant to respond to regulatory pressure with effective climate change action. Previous studies have found that improvements in carbon performance have a significantly positive effect on firms' financial performance.

3. DATA AND METHODOLOGY

3.1 Data

To examine the impact of greenhouse gas emissions (GHG) on firm performance, our research employs firm-level data that accounts for both firm and market-based financial measures' fixed effects from the DataStream database. We specify a sample of panel data that consists of 111 companies from South Africa for the period between 2010-2022. As for the GHG emission variables, we employ the total CO2 emissions (CE), as well as the following three categories of Scope 1 (S1), Scope 2 (S2), and Scope 3 (S3) CO2 emissions for the Eikon ESG database. In the following empirical analysis, we examine the effects of GHG emissions on firm performance by those categories.

The accounting-based indicators are: return on equity (ROE) measured as the annual return on the firm's equity and represent the income generated by the stakeholders' money from stockholders' investments. Return on assets (ROA) is measured as the return on annual assets and provides a more balanced view of profitability compared to traditional metrics, return on invested capital (ROIC) is defined as the annual return on invested capital, Tobin's q (TQ) is the ratio between a physical asset's market value and its replacement value. We use ROA to measure short-term financial performance and Tobin's q as a measurement of long-

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

term financial performance.

Other control variables like market value (MV) is measured as the market value of common stock plus the book value of debt, firm size is measured as the natural log of the total asset (Size), Price to tangible book value (PTBV) is measured as a company's market value relative to its hard or tangible assets, leverage (Leverage) is measured as the ratio of long term liabilities plus current liabilities to book value of total firm assets, net sales (NS), and capital intensity (CI) is measured as a firm's total assets divided by its net sales.

Table 1 provides an exposition of the summary statistics of the variables. During this period, it is noted that the average total emissions exhibit a positive trend. The current study encompasses a sample size of about 768 observations. The Scope 2 greenhouse gas (GHG) emissions are observed to be higher compared to Scopes 1 and 3. The average market value (Tobin's Q) for the firms within our sample exhibits a value of 1.25%. The mean market value is 37457.65. The ROA representative measure for the operating efficiency of a company based on the firm's generated profits from its total assets is 6.47 and 6.13 is the median, the lower 25% is 1.8, while the higher 75% is 10.28 indicating a diverse pool of firms in terms of accounting performance. The value of shareholders' rate of return on their investment in the company is 13.74. The return on invested capital (ROIC) has a mean score of 11.88 and a standard deviation of 9.98. We report a mean Tobin's q of 1.25 which indicates that most companies are overvalued. The mean of Tobin's q is greater than 1 which indicates that the market value of the companies is on average higher than the recorded value of the assets. This shows that the firms in the sample are being overvalued by the market.

Table 1. Descriptive statistics

				Percentile	
	Mean	Median	SD	25%	75%
TE	564629.7	215743.9	777972.9	50085.5	688453
S1	145319.4	28020.5	202359.7	2884.5	250081.5
S2	317165.2	145549.5	385760.5	32984.5	467887.5
S3	166441.5	29844.98	265711.6	7583.875	176856.5
ROA	6.47	6.13	8.46	1.80	10.28
ROE	13.74	14.13	24.44	5.27	22.68
TQ	1.25	0.95	1.18	0.61	1.49
ROIC	11.88	9.98	14.87	4.84	16.07
MV	37457.65	21358.25	37942.74	8432.75	56870.85
Size	17.46	17.30	1.47	16.44	18.21
PTBV	2.81	1.66	3.32	1.06	2.99
Leverage	21.48	18.60	17.14	7.80	32.55
NS	16.83	16.95	1.29	15.86	17.89
CI	3.63	1.56	4.20	0.85	4.85

The correlation results in Table 2 demonstrate the existence of a one-to-one relationship and the level of strength between the variables considered in this study. The correlation values play a pivotal role in determining the strength of associations between variables. A correlation value that falls within the range of less than or equal to 0.20 is widely considered to be weak, while a value that is less than or equal to 0.40 but greater than 0.20 is regarded as less. A correlation value that lies between the range of 0.40 and 0.60 is classified as having a moderate correlation. A correlation coefficient exceeding 0.80 indicates a strong correlation. The first strong positive relationship is between Total emissions and GHG Scopes 1 and 2, with a very strong relationship also observed between GHG Scopes 1 and 2. There is also a positive significant relationship between ROA, ROE, and Tobin's Q, with

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

ROE being strongly correlated with MV. MV is strongly correlated with NS, and lastly, TA is moderately correlated with NS.

3.2 Methodology

To investigate the effect of GHG emissions, this study employed the Fixed Effect Model, where industry-specific effects are used to control heterogeneity within the industry.

$$CE_{i,t} = \alpha_{i,t} + \beta_1 (FP)_{i,t} + \beta_2 \sum(FLC)_{i,t} + \beta_3 \sum(Industry\ effects)_i + \beta_4 \sum(Year\ effects)_t + \boldsymbol{\varepsilon_{it}} \tag{1}$$

$$FP_{i,t} = \alpha_{i,t} + \beta_1 (CE)_{i,t} + \beta_2 \sum(FLC)_{i,t} + \beta_3 \sum(Industry\ effects)_i + \beta_4 \sum(Year\ effects)_t + \boldsymbol{\varepsilon_{it}} \tag{2}$$

With $CE = \begin{pmatrix} TE \\ S1 \\ S2 \\ S3 \end{pmatrix}, FP = \begin{pmatrix} ROA_{it} \\ ROE_{it} \\ ROIC_{it} \\ Tobin'sQ_{it} \end{pmatrix}$

Where $CE_{i,t}$ refers to the total (*TE*), direct (*S1*), and indirect (*S2*, *S3*) carbon emissions. *FP* represents financial performance, which is a vector containing a range of different financial performance indicators. We use four proxies for financial performance, which are *ROA, ROE, ROIC,* and *Tobin's Q*. FLC stands for firm-level control variables. We control the firm size, price-to-book value, net sales, leverage, and capital intensity.

4. ESTIMATION RESULTS

4.1 The impact of financial performance on total carbon emissions

First, focusing on the financial performance of firms' carbon emissions across all industries in South Africa, we employ the financial metrics as independent variables. Table 3 provides estimation results with firm fixed effects. Columns 1 to 4 provide 7 estimation results that focus on total carbon emissions (TE), columns 5 to 8 focus on scope 1 direct GHG emission (S1), columns 9 to 12 focus on scope 2 indirect GHG emission (S2), columns 13 to 16 focus on scop3 indirect GHG emissions (S3). The results from columns 1 to 4 indicate that firms with larger profitability ratios (ROA and ROE), the efficiency ratio (ROIC), PTBV, and Leverage have smaller carbon emissions and are statistically significant which is consistent with study by Delmas, Nairn-Birch *et al*. (2015). Hypothetically, it is reasonable to assume that profitable firms and those with lower debt levels may have the financial resources to invest in sustainability measures. However, to draw meaningful conclusions, it is essential to conduct industry-specific analyses to account for external factors such as regulations and industry norms that may impact carbon emissions. On the contrary, in column 3, Tobin's Q has a positive effect on carbon emissions. This can be interpreted based on firms operating in carbon-intensive industries, such as energy generation, or heavy manufacturing in South Africa, which may have higher Tobin's Q due to the value associated with their substantial resource reserves, infrastructure, or market position. These industries tend to have higher total carbon emissions, as well as Scope 2 indirect GHG emissions for the organization's energy use, as an inherent part of their operations.

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Table 2 Correlation coefficients

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	TE	1													
2	S1	0.994***	1												
3	S2	0.785***	0.712***	1											
4	S3	0.144***	0.143***	0.115**	1										
5	ROA	-0.003	-0.001	-0.013	0.234***	1									
6	ROE	-0.028	-0.024	-0.048	0.134***	0.771***	1								
7	TQ	-0.025	-0.024	-0.022	0.057	0.427***	0.291***	1							
8	ROIC	-0.042	-0.034	-0.078*	0.141***	0.783***	0.773***	0.291***	1						
9	MV	0.255***	0.234***	0.310***	0.176***	0.150***	0.195***	-0.019	0.128***	1					
10	Size	0.088*	0.096**	0.019	-0.029	-0.185***	0.018	-0.304***	-0.073*	0.602***	1				
11	PTBV	-0.061	-0.052	-0.092**	-0.001	0.226***	0.186***	0.328***	0.291***	0.005	-0.142***	1			
12	Leverage	-0.008	0.001	-0.056	-0.098**	-0.106**	-0.260***	0.088*	-0.308***	-0.168***	-0.200***	0.259***	1		
13	NS	0.343***	0.331***	0.323***	0.047	-0.027	0.119***	-0.123***	0.011	0.712***	0.646***	-0.025	-0.099**	1	
14	CI	-0.075*	-0.056	-0.161***	-0.072*	-0.210***	-0.082*	-0.365***	0.041	0.140***	0.484***	-0.148***	-0.022	-0.014	1

Note: *, ** and *** represent significance levels at 0.10, 0.05, and 0.01 respectively.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Table 3 The fixed-effect regression of impact factors to carbon emissions/ Firm characteristics on carbon emissions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	TE				S1				S2				S3			
ROA	-0.0066**				-0.0065*				-0.0071**				-0.0045			
	(-3.24)				(-2.13)				(-3.20)				(-0.67)			
ROE		-0.0023**				-0.0022*				-0.0026***				-0.0011		
		(-3.30)				(-2.04)				(-3.38)				(-0.44)		
TQ			0.108***				0.0135				0.143***				0.110	
			(3.39)				(0.28)				(4.10)				(1.03)	
ROIC				-0.0041**				-0.0043*				-0.0047***				-0.0058
				(-3.21)				(-2.23)				(-3.32)				(-1.37)
MV	0.0461	0.0408	-0.0840	0.0365	0.0377	0.0297	-0.0218	0.0303	0.0904	0.0864	-0.0704	0.0819	-0.274	-0.288*	-0.389*	-0.251
	(1.08)	(0.97)	(-1.81)	(0.88)	(0.58)	(0.47)	(-0.31)	(0.48)	(1.93)	(1.87)	(-1.39)	(1.79)	(-1.93)	(-2.06)	(-2.52)	(-1.81)
Size	0.0008	0.0114	0.207*	-0.0031	0.242	0.255	0.309*	0.236	-0.0748	-0.0647	0.188	-0.0815	0.860**	0.876**	1.055**	0.821**
	(0.01)	(0.13)	(2.07)	(-0.03)	(1.78)	(1.88)	(2.02)	(1.73)	(-0.76)	(-0.66)	(1.71)	(-0.82)	(2.88)	(2.95)	(3.16)	(2.74)
PTBV	-0.0048**	-0.0065***	-0.0051**	-0.0047**	-0.0047	-0.0064*	-0.0048	-0.0046	-0.0054**	-0.0074***	-0.0057**	-0.0053**	0.0017	0.0009	0.0014	0.0018
	(-2.66)	(-3.50)	(-2.80)	(-2.61)	(-1.72)	(-2.24)	(-1.75)	(-1.69)	(-2.74)	(-3.59)	(-2.91)	(-2.68)	(0.28)	(0.15)	(0.24)	(0.31)
Leverage	-0.0054**	-0.0057**	-0.0058**	-0.0058**	-0.0043	-0.0045	-0.0041	-0.0047	-0.0027	-0.0031	-0.0033	-0.0031	0.0045	0.0044	0.0041	0.0038
	(-2.76)	(-2.91)	(-2.97)	(-2.96)	(-1.44)	(-1.53)	(-1.37)	(-1.59)	(-1.26)	(-1.42)	(-1.55)	(-1.47)	(0.70)	(0.69)	(0.62)	(0.58)
NS	0.271**	0.269**	0.196*	0.279**	0.406**	0.404**	0.399**	0.414**	0.205*	0.202*	0.105	0.214*	0.120	0.120	0.0432	0.129
	(3.21)	(3.18)	(2.25)	(3.30)	(3.17)	(3.15)	(2.99)	(3.23)	(2.20)	(2.18)	(1.09)	(2.30)	(0.43)	(0.43)	(0.15)	(0.46)
CI	-0.0274	-0.0282	-0.0419*	-0.0243	-0.0192	-0.0200	-0.0216	-0.0159	-0.0021	-0.0029	-0.0213	0.0014	0.0853	0.0848	0.0707	0.0902
	(-1.38)	(-1.43)	(-2.08)	(-1.23)	(-0.64)	(-0.67)	(-0.70)	(-0.53)	(-0.10)	(-0.14)	(-0.96)	(0.07)	(1.30)	(1.29)	(1.05)	(1.37)
Constant	7.494***	7.406***	6.324***	7.530***	-1.123	-1.229	-1.621	-1.062	8.856***	8.773***	7.401***	8.917***	-4.152	-4.289	-5.206	-3.804
	(9.05)	(8.98)	(7.45)	(9.07)	(-0.89)	(-0.98)	(-1.25)	(-0.84)	(9.71)	(9.68)	(7.95)	(9.76)	(-1.50)	(-1.56)	(-1.84)	(-1.38)
R-squared	0.3628	0.3686	0.3415	0.3776	0.1893	0.1913	0.1843	0.1980	0.3255	0.3392	0.2784	0.3455	0.0766	0.0763	0.0775	0.0787
Observations	762	762	762	762	762	762	762	762	762	762	762	762	762	762	762	762

Note: *, ** and *** represent significance levels at 0.10, 0.05, and 0.01 respectively, t-statistics are in parentheses.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

4.2 Does the Scope of GHG Emissions Matter?

All three emission variables from scopes 1 to 3 show varying results when used as dependent variables in columns 4 up to 16. Under Scope 1, covering columns 4 to 8, we notice that three key firm financial metrics have statistically significant coefficients. In addition, the effect of profitability ratios (ROA and ROE) and the efficiency ratio (ROIC) are economically significant. For example, a 1 % decrease in ROA, ROE, and ROIC on average leads to a 0.00659 % (0.00223 %, 0.00436%) decrease in GHG of Scope 1. In addition, the effect of Tobin's Q on GHG Scope 1 is economically significant but not statistically significant.

In columns 9 to 12 of Table 3, we observe that our four main independent financial metrics: ROA, ROE, Tobin's Q, and ROIC have statistically significant coefficients with Tobin's Q having a greater economically significant coefficient than the rest. Scope 2 emissions refer to indirect emissions from the generation of purchased electricity consumed. Interpreting these findings indicates that the financial metrics mentioned are related to the level of GHG Scope 2 emissions. The statistically significant coefficients suggest that there is a meaningful relationship between these financial metrics and GHG Scope 2 emissions. This result is interesting as an accounting-based performance measure represented by return on assets (ROA) whereas Tobin's Q stands for the market-based measure of performance or firm value illustrated by different impacts on firms' Scope 2 emissions. Since Tobin's Q coefficient is highlighted as having a greater economically significant coefficient than the other metrics, it implies that Tobin's Q might have a stronger influence or correlation with GHG Scope 2 emissions compared to ROA, ROE, and ROIC. This result aligns with Delmas, Nairn-Birch *et al*. (2015) study on 1200 American firms and found that GHG emissions negatively affects Tobin's Q, so much so that a 1% decrease in carbon emissions increases a firm's Tobin's q by 0.0075. The higher coefficient suggests that firms with higher Tobin's Q values may have a larger impact on GHG Scope 2 emissions.

Overall, this information implies that financial performance and market valuation metrics have some association with GHG Scope 2 emissions, with Tobin's Q being the most economically significant among the mentioned metrics. In addition, we observe that Net Sales have approximately the same level of statistical and economic significance under GHG Scope 2 for all estimations of the main financial metrics. This implies that the company's revenue-generating activities are in some way linked to its greenhouse gas emissions.

In the last columns 13 to 16 of Table 4, we observe that our four main independent financial metrics: ROA, ROE, Tobin's Q, and ROIC are economically significant but not statistically significant. Surprisingly size shows a strong positive statistical and economic significance for GHG Scope 3. The large positive statistical and economic significance observed in size concerning GHG Scope 3 emissions can be attributed to the plausible rationale that entities with greater total assets generally tend to have expanded supply chains, sophisticated manufacturing processes, or operations with high resource consumption and resultant emissions, thereby contributing to higher GHG Scope 3 emissions.

In summary, the findings of this study in Table 3 are consistent with the notion that a company's environmental footprint may be influenced by its financial performance and market valuation metrics. The results indicate that a larger market size, as measured by Total Assets, is positively associated with GHG Scope 3 emissions. Conversely, market valuation, represented by Tobin's Q, exerts a more pronounced impact on GHG Scope 2 emissions. Moreover, the assessment and evaluation of GHG Scope 1 emissions are notably influenced by key financial performance indicators such as profitability ratios, namely the ROA and the ROE, and the efficiency ratio, known as ROIC. The findings suggest that integrating sustainability factors into financial analysis and decision-making has the potential to yield significant benefits. According to the literature, financial metrics and performance indicators can shed light on a

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

company's environmental performance and facilitate the identification of improvement opportunities to mitigate greenhouse gas emissions.

4.3 Regression of Carbon Emissions on firm financial performance

In Table 4, all three GHG Scopes 1 and 2, in addition to total emissions show a negative impact and are all both statistically and economically significant when regressed on dependent variables: ROA, ROE, and ROIC in columns 1 to 8 as well as columns 13 to 16. Similarly, Busch, Bassen *et al*. (2022) also found that the linkage between corporate carbon and financial performance is negative and statistically significant for both ROA and Tobin's q for European firms, however in our study only ROA is negative. More precisely, a 1% increase in carbon performance is, on average, associated with a 0.055% decrease in ROA and a 0.033% change in Tobin's q. Our finding aligns with the theory of environmental performance and the financial performance paradigm. The negative relationship between GHG emissions and financial performance can be attributed to several factors, such as cost of compliance, where higher emissions often result in increased costs related to regulatory compliance, such as carbon taxes for example. This can directly impact profitability and financial performance. Another factor that can be considered relates to operational inefficiencies, where higher emissions may indicate inefficient use of resources, energy, or production processes, which can lead to higher costs and lower profitability.

Overall, in line with the above findings, we can see that environmental and financial performance follow the natural resource view (NRBV) which works on the principle that a company's competitive advantage fundamentally depends upon its relationship with the natural environment. The NRBV framework identifies how companies can generate competitive advantage based on capabilities that support sustainable development. To apply to the above results, the environmental performance and financial performance paradigm posits that firms prioritizing environmental sustainability and having lower environmental impacts are more likely to achieve better financial performance. This theory suggests that firms with effective environmental management systems, energy efficiency measures, and emission reduction strategies are more likely to enhance operational efficiency, reduce costs, and improve overall financial performance. The statistically and economically significant relationship between GHG emissions and financial performance indicators supports the idea that companies with lower emissions tend to exhibit better financial performance. This finding reinforces the notion that integrating sustainability practices, including emissions reduction, can contribute positively to a firm's overall performance and competitiveness.

4.4 Does Different Impacts of GHG Scopes Matter?

GHG scope 3 shows a negative impact though statistically insignificant for dependent variables: ROA, ROE, and ROIC. On the contrary, we observe positive effects of total emissions and GHG Scopes 1, 2, and 3 to Tobin's Q contrary to Busch, Bassen *et al*. (2022) who estimates negative effect for both ROA and Tobin's Q. In terms of significance, only total emissions and GHG Scope 2 are statistically significant in columns 9 to 12. We also observe that MV and size are highly significant in all columns in Table 4 with bigger coefficients, again our result contradicts Busch, Bassen *et al*. (2022), in our study size has a negative effect only for GHG Scope 2.

The differential impact of Greenhouse Gas (GHG) emissions across varying scopes suggests that financial performance may be influenced differently by specific sources and activities of emissions. The first scope of GHG pertains to emissions that arise directly from a company's operations. Scope 1 emissions have the potential to positively influence Tobin's Q, a measure of market valuation that is associated with industries or asset types demonstrating higher levels of emissions.

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The GHG Scope 2 category pertains to the measurement of indirect emissions from purchased energy sources. Such emissions are shown to have a notable association with operational efficiency, cost management, and environmental responsibility, resulting in a discernible adverse effect on critical financial performance metrics such as ROA, ROE, and ROIC. On the contrary, the GHG Scope 3 emissions, which result from the value chain and other ancillary activities beyond GHG Scopes 1 and 2, exhibit a complex and less significant relationship with financial performance, owing to their encompassment of a wider spectrum of factors and dependencies. The importance of MV and size is indicative of the fundamental role that a company's financial health and scale have on its financial performance. Companies with large market value may display superior financial performance; and substantial total assets illustrate a negative impact on financial performance, irrespective of their emissions levels.

5. IMPLICATIONS OF THE STUDY: EXAMINING THE CONTEXT OF CARBON PERFORMANCE

This article produced critical findings in the context of carbon performance that has implications for policy development, corporate practice, theory, and future research. It showed that carbon performance develops a negative and significant association with ROA, ROE, and ROIC, except for Tobin’s Q across all GHG Scope levels. Thus, it is apparent that green issues present gaps in the integration of sustainability issues in company policy both in the short term as well as long term. A vivid example are the firms operating in the South African mining sector where carbon emissions may be positively associated with market valuation (Tobin’s Q) due to investor knowledge about coal’s continued demand in South Africa. This suggests that companies with better carbon performance may have lower profitability metrics. Economic policy should encourage businesses to balance profitability with sustainability. In this case, for the South African mining sector, the challenge may come in when transitioning away from coal due to job losses as well as negative economic impacts. The lack of a significant association with Tobin's Q suggests that investors may not be factoring carbon performance into their valuations as strongly as other financial metrics. Therefore, policymakers should encourage companies to adopt a long-term view that incorporates sustainability into their business strategies. This could involve setting carbon reduction targets, implementing carbon pricing mechanisms, or promoting sustainable supply chain practices.

This research has also illustrated in Table 4 that GHG Scope 2 emissions and total carbon emissions show a positive and significant association with Tobin's Q, suggesting that investors may be valuing companies with higher emissions more favorably based on perceived growth potential. This finding underscores the importance of considering environmental performance metrics alongside traditional financial metrics. Policymakers can encourage companies to consider improving the relevance and effectiveness of environmental disclosure standards. The negative associations with traditional financial metrics (ROA, ROE, ROIC) suggest potential financial challenges associated with emissions, policymakers can design incentives and penalties to encourage companies to reduce their emissions while still maintaining or improving their financial performance. These incentives could include carbon pricing mechanisms, subsidies for clean technologies, or tax breaks for sustainable practices. For example, in Europe, carbon pricing mechanisms like the EU Emissions Trading System (EU ETS) have been in place for years. These mechanisms put a price on carbon emissions thereby, companies operating in Europe have had to adapt their managerial practices to account for carbon pricing. They invest in emissions reduction technologies, improve energy efficiency, and factor carbon costs into their business strategies. This is a direct result of the policy-driven relationship between carbon emissions and financial metrics.

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Table 4 Carbon emissions and firm financial performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	ROA				ROE				TQ				ROIC			
TE	-2.423**				-6.996**				0.162***				-3.800**			
	(-3.24)				(-3.30)				(3.39)				(-3.21)			
S1		-1.059*				-2.881*				0.009				-1.756*		
		(-2.13)				(-2.04)				(0.28)				(-2.23)		
S2			-2.175**				-6.512***				0.177***				-3.568***	
			(-3.20)				(-3.38)				(4.10)				(-3.32)	
S3				-0.152				-0.282				0.0151				-0.493
				(-0.67)				(-0.44)				(1.03)				(-1.37)
MV	7.480***	7.484***	7.568***	7.442***	18.58***	18.58***	18.84***	18.52***	0.747***	0.747***	0.740***	0.751***	9.616***	9.614***	9.760***	9.478***
	(9.82)	(9.76)	(9.93)	(9.66)	(8.61)	(8.54)	(8.73)	(8.47)	(15.35)	(15.19)	(15.26)	(15.24)	(7.98)	(7.93)	(8.10)	(7.78)
Size	-6.900***	-6.734***	-7.067***	-6.879***	-14.75**	-14.28**	-15.24**	-14.83**	-1.491***	-1.488***	-1.479***	-1.497***	-11.96***	-11.66***	-12.23***	-11.70***
	(-4.07)	(-3.94)	(-4.17)	(-4.00)	(-3.07)	(-2.94)	(-3.17)	(-3.04)	(-13.77)	(-13.55)	(-13.72)	(-13.62)	(-4.46)	(-4.31)	(-4.56)	(-4.31)
PTBV	-0.00264	0.00424	-0.00283	0.00941	-0.752***	-0.732***	-0.754***	-0.718***	0.00260	0.00187	0.00279	0.00179	0.0176	0.0278	0.0164	0.0369
	(-0.08)	(0.12)	(-0.08)	(0.27)	(-7.62)	(-7.39)	(-7.64)	(-7.25)	(1.17)	(0.83)	(1.26)	(0.80)	(0.32)	(0.50)	(0.30)	(0.67)
Leverage	-0.0538	-0.0455	-0.0466	-0.0407	-0.282**	-0.257*	-0.261*	-0.244*	0.00732**	0.00654**	0.00692**	0.00642**	-0.184**	-0.171**	-0.173**	-0.162**
	(-1.43)	(-1.21)	(-1.24)	(-1.08)	(-2.64)	(-2.40)	(-2.46)	(-2.28)	(3.04)	(2.70)	(2.90)	(2.66)	(-3.09)	(-2.87)	(-2.92)	(-2.71)
NS	0.310	0.109	0.0987	-0.334	-0.0449	-0.746	-0.608	-1.924	0.671***	0.714***	0.679***	0.713***	2.364	2.070	2.065	1.385
	(0.19)	(0.07)	(0.06)	(-0.20)	(-0.01)	(-0.16)	(-0.13)	(-0.42)	(6.44)	(6.78)	(6.57)	(6.85)	(0.92)	(0.80)	(0.80)	(0.54)
CI	0.0207	0.0750	0.0826	0.101	-0.294	-0.147	-0.116	-0.0745	0.134***	0.130***	0.130***	0.128***	0.784	0.862	0.881	0.932
	(0.05)	(0.20)	(0.22)	(0.27)	(-0.27)	(-0.14)	(-0.11)	(-0.07)	(5.53)	(5.32)	(5.39)	(5.25)	(1.31)	(1.43)	(1.47)	(1.54)
Constant	78.33***	59.39***	79.46***	60.48***	182.9***	128.7**	188.1***	132.1**	5.938***	7.090***	5.592***	7.152***	133.3***	103.5***	136.4***	104.2***
	(4.73)	(3.76)	(4.76)	(3.82)	(3.90)	(2.87)	(3.98)	(2.94)	(5.61)	(6.99)	(5.26)	(7.07)	(5.09)	(4.14)	(5.17)	(4.16)
R-squared	0.2002	0.2023	0.1999	0.1899	0.2332	0.2252	0.2338	0.1361	0.3997	0.3894	0.4046	0.2838	0.1934	0.1868	0.1943	0.1624
Observations	762	762	762	762	762	762	762	762	762	762	762	762	762	762	762	762

Note: *, ** and *** represent significance levels at 0.10, 0.05, and 0.01 respectively, t-statistics are in parentheses.

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Overall, the positive association between GHG Scope 2 emissions, total carbon emissions, and Tobin's Q, alongside negative associations with traditional financial metrics, suggests a complex interplay between financial markets and sustainability. Economic policies should aim to align market valuations more closely with environmental sustainability goals, and enhance transparency and awareness regarding the environmental performance of firms just like how many American companies have recognized the potential financial risks associated with high carbon emissions. Companies like Google and Apple have committed to 100% renewable energy sourcing for their operations. These managerial practices align with our findings about the impact of emissions on financial metrics and demonstrate how companies are proactively mitigating these risks.

6. CONCLUSION

This paper investigates the relationship between carbon emissions and the financial performance of firms in South Africa. The study collects carbon and financial data for 111 firms from 2010 to 2022 and analyzes it using fixed effects panel regression. The results reveal correlations between greenhouse gas (GHG) emissions and financial performance metrics, supporting the established paradigm of environmental and financial performance. This relationship can be attributed to factors such as the costs associated with compliance and operational inefficiencies. Further, the findings align with the natural resource-based view (NRBV) framework, suggesting that companies prioritizing environmental sustainability are more likely to achieve better financial performance. While GHG Scope 3 emissions have a negative impact on financial performance metrics, it is statistically insignificant. On the other hand, total emissions and GHG Scopes 1, 2, and 3 have a positive effect on Tobin's Q. The variables of market value (MV) and size consistently demonstrate high significance across all columns of Table 4, indicating their fundamental role in a company's financial performance. The varying impacts of GHG emissions across different scopes suggest that specific sources and activities of emissions may influence financial performance differently. GHG Scope 1 emissions have the potential to positively influence Tobin's Q, while GHG Scope 2 emissions are associated with operational efficiency, cost management, and environmental responsibility. GHG Scope 3 emissions exhibit a complex and less significant relationship with financial performance. Overall, the study highlights the importance of a company's financial health and scale in determining its financial performance. Therefore, policymakers should also set long-term priorities for developing green processes and organizations. Promoting and facilitating the adoption of green technologies is vital for economic and environmental benefits. A national commitment to create a low or zero-carbon environment is necessary, and initiatives based on international consensus will be more effective in addressing disparities in carbon performance. Public awareness of climate change needs to be better integrated into greenhouse gas reduction policies. This study has limitations, as it only focused on the impact of carbon emissions on firm performance and covered thirteen years. Future studies could investigate the effects of environmental and social governance on carbon emissions and the impact of the 2019 Carbon Tax Act on South African companies.

ACKNOWLEDGEMENT

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

The authors thank the anonymous referees for their helpful comments.

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