“Examining the relationship between environmental management accounting practices and return on equity in the South African chemical industry”

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EXAMINING THE RELATIONSHIP BETWEEN ENVIRONMENTAL MANAGEMENT ACCOUNTING PRACTICES AND RETURN ON EQUITY IN THE SOUTH AFRICAN CHEMICAL INDUSTRY

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Abstract

Environmental management accounting practices (EMAPs) have become pervasive, and continued efforts to ensure universal implementation across various sectors often represent financial implications for organizations. Despite many studies that examined the relationship between EMAPs and financial performance, the debate is still inconclusive. Therefore, the study paves the way for chemical firms to explore the effectiveness of EMAPs' implementation for both financial and environmental gain. The study used purposive sampling to gather quantitative secondary data from annual integrated reports of chemical firms to examine the relationship between EMAPs and financial performance in the South African chemical industries during 2016–2022. Following the results from the regression estimations, two of the EMAPs – water and energy usage – have had a positive relationship with financial performance, with the latter being highly significant. Contradictorily, carbon emissions and environmental expenditure adversely and insignificantly influenced financial performance. The results suggest that chemical firms have in place ineffective carbon management strategies that fail to generate sustainable returns. Overall, the results acknowledge the efforts of chemical industries in making substantial contributions to enhance environmental performance and encourage environmentalists and policymakers to reconfigure environmental policies for improved environmental and financial performance. Further research on environmental management accounting (EMA) barriers in chemical industries is imperative to achieving environmental sustainability.

Keywords carbon emissions, environmental accounting, energy, financial performance, water

JEL Classification M41, Q01, Q56

INTRODUCTION

While EMAPs' implementation worldwide continues to create endless debate, concern for the availability of resources remains a bone of contention in sustainable development repertoires (Mukwarami et al., 2023). Despite challenges to EMAPs' implementation, pressure on businesses to balance the financial objective and environmental needs is a contentious issue. EMA involves activities, techniques, and systems related to the recording, analyzing, and reporting environmentally influenced financial and ecological impacts within a specified economic system (Burritt et al., 2019). Studies conducted both globally and nationally acknowledge that EMA implementation has led to most organizations making crucial environmentally sensitive decisions (Gunarathne et al., 2023; Van der Poll, 2022), with others urging that EMA is a catalyst for financial and environmental performance (Nyahuna & Doorasamy, 2023).

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While EMA development in South Africa remains in the relatively early stages of development (Nyahuna & Doorasamy, 2022), the steady growth of EMA implementation in many sectors across the country is regarded as a positive move. The extant literature mainly concerns mining (Nyahuna & Doorsamy, 2023; Nyirenda et al., 2013) and manufacturing (Mukwarami et al., 2023; Ganda & Milondzo, 2018); however, evidence shows that only a few studies have focused on the chemical industry (Smit & Kotzee, 2016; Nyahuna & Doorsamy, 2023) in the context of South Africa. This leaves chemical firms without adequate empirical rationale on how their operating activities and efforts to manage environmental impacts affect financial performance.

The existing evidence suggests that EMA implementation can either result in a positive or negative financial performance (Nyahuna & Swanepoel, 2022; Dobre et al., 2015; Mukwarami & van der Poll, 2023), thus justifying a need for further debate. Additionally, in the context of South African chemical firms, no study examined the relationship between EMAPs' implementation and financial performance. It remains unclear how EMAPs influence financial performance. Considering the centrality of the chemical industry in the South African economy (Smit & Kotzee, 2016; Majozi & Veldhuizen, 2015) and the contribution toward environmental challenges through water, energy, and material usage resulting in increased carbon emissions (Nyahuna & Doorasamy, 2023; Moodley, 2015), revealing empirical evidence on the financial implication of EMAPs is imperative to achieving better financial performance. Smit and Kotzee (2016) confirm the comprehension and recognition of EMA within the South African chemical industry.

1. LITERATURE REVIEW

Environmental management accounting (EMA) refers to the management of both environmental and economic outcomes via the development and implementation of appropriate accounting systems and practices related to the environment (IFAC, 2005). EMA tools include water management accounting, energy management accounting, carbon management accounting, biodiversity accounting, energy accounting, and material flow accounting (Mukwarami et al., 2023; Gunarathne et al., 2023). Burritt et al. (2019) suggest that EMA is a relatively recent concept that includes many tools providing managers with information to facilitate environmentally conscious decision-making across diverse organizational settings. The studies conducted globally acknowledge that EMA implementation has led to most organizations making crucial environmentally sensitive decisions (Gunarathne et al., 2023; van der Poll, 2022), with others urging that EMA is a catalyst for financial and environmental performance (Nyahuna & Doorasamy, 2023; Mukwarami et al., 2023). Contrary to the benefits, evidence suggests that EMA implementation is costly and could lead to poor financial performance if not strategically planned (Martí-Ballester, 2017). Therefore, a debate concerning the impacts of EMAPs' implementation on financial performance is inconclusive as the situation differs from organization to organization.

Water usage is one of the contributing factors toward environmental pollution and, therefore, remains an area of further concern across the business spectrum (Lavery & Ross, 2023). However, the effective and efficient water usage strategies through EMA implementation have resulted in many benefits, but not forgetting cost implications that have led to poor financial performance. Sudha (2020) examined the relationship between environmental and financial performance using eco-efficiency measures involving Indian companies. Despite most of the eco-efficiency measures having had a positive impact on return on assets and return on sales (ROS), water energy intensity hurt the financial performance. The study suggests that corporate managers across the business spectrum should continue implementing environmental sustainability strategies for improved financial and environmental performance.

In support of the results above, Fu and Jacobs (2022) examined the relationship between water usage and financial performance. The study involved 155 firms operating in the United States of America, with the data sourced from Bloomberg.

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The panel data regression suggests that operationally efficient firms improved profitability and reduced risk through increasing water usage. However, in the case of operationally inefficient firms, increasing water usage adversely affected profitability. The study further recommends that firms benefit optimally from water usage after reaching a certain level of operational efficiency.

Similarly, Ji et al. (2023) examined the relationship between water resource management and financial performance involving 259 A-share-listed manufacturing companies in China. The study findings suggested that poor water management harmed financial performance, and companies with insufficient water-related actions faced more significant financial downturns. Additionally, the study highlighted that while good water resource management is necessary, it alone cannot ensure high financial performance. Dobre et al.'s (2015) study on listed entities across various industries in Romania produced a significant negative effect of increasing water protection on financial performance measured by ROE. This implies that the costs associated with improving water efficiencies might be too high, negatively impacting financial performance. Therefore, this further proves that water usage might not necessarily translate to better financial performance.

Inconsistent with negative results, Dzomonda and Fatoki (2021) evaluated the link between sustainability and financial performance of 32 Johannesburg Stock Exchange (JSE)-listed firms. The outcomes from the study exhibit a positive linkage between water sustainability and firm performance measured through share prices. The study recommends that managers increase awareness of water sustainability to ensure proactive implementation of water usage strategies to eliminate water scarcity risks and improve financial performance. Oberholzer and Prinsloo's (2011) investigation into the South African mining industry presented a variation in findings. The study employed water usage as an environmental indicator to establish a connection with return on equity (ROE) as a financial performance indicator. While the results showed a negative but significant relationship between water usage in the gold environment and ROE, energy usage positively influenced financial performance. Similarly, results indicated a negative and statistically insignificant correlation between GHG emissions and the ROE gold sector. However, the relationship was negative in the coal and platinum environments. This implies that the profitability of gold-mining companies may not be significantly affected by being environmentally friendly.

The debate concerning the relationship between energy usage and financial performance continues to attract endless attention, with various studies failing to conclude. Iliemena (2020) focused on listed oil and gas companies in Nigeria, examining the relationship between energy management accounting practices represented by energy accounting and financial performance measured by return on capital employed (ROCE), revenue turnover, and net profit. The results indicated a positive effect of energy management on ROCE, a positive and significant relationship with turnover, and a positive but insignificant relationship with net profit. This led to the recommendation that organizations implement EMAPs for improved long-term corporate sustainability.

Similarly, Fan et al. (2017) evaluated the nexus between energy efficiency and financial performance involving Chinese energy-intensive firms. The analysis of the data collected from the Chinese National Bureau of Statistics produced evidence of the positive correlation between energy efficiency and various financial performance indicators, including return on equity (ROE), return on assets (ROA), return on investment (ROI), return on invested capital (ROIC), and return on sales (ROS). Furthermore, the study employed firm growth as an interactive variable between energy efficiency and financial performance and found the same results. Thus, firms should implement proactive measures to reduce energy usage and carbon emissions.

However, not always energy efficiency strategies result in corporate financial performance. Martí-Ballester (2017) examined the impact of sustainable energy systems on financial performance of 574 transnational companies operating in 36 countries. The results reveal that a surge in energy efficiency and the use of renewable energy sources have not affected corporate financial performance. On the same note, integrating energy efficiency

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systems and renewable energy sources failed to bring meaningful change to the CFP (corporate financial performance). Ultimately, the results showed adopting sustainable energy efficiency strategies leads to short-term gains but with an eventual neutral effect.

Consistently, Moon and Min (2020) evaluated the connection between energy efficiency and financial performance for energy-intensive firms in Korea. Although the study confirmed a significant relationship between energy efficiency and financial performance, firms whose pure-energy efficiency did not achieve better financial performance. The discrepancy is possibly due to variations in the companies' energy management activities over short and long-term periods.

In the context of South Africa, Nyahuna and Doorasamy (2023) examined the relationship between EMAPs and the financial performance of 45 JSE-listed companies involved in cement and mining operations. While the study found that ROA and net profit margin had no significant effect on EMAPs, a significantly positive influence was established between EMAP measured through energy savings and carbon emissions and return on equity (ROE). However, mixed results suggest that EMA is in the early stages in South Africa, and more efforts are needed to accomplish sustainability. Contrary to the results, Ganda and Milondzo (2018) examined the impact of carbon emissions on the CFP in 63 South African CDP companies. Through conducting multiple regression techniques, the paper found a negative relationship between carbon emission and CFP as measured through ROE, ROI, and ROS. Further, the study recommends that integrating green investment strategies aimed at carbon emissions reduction potentially results in sustained financial performance.

Van Emous et al. (2021) analyzed the link between carbon emissions reduction and corporate financial performance by considering 1785 firms across 53 countries. The fixed effect model's results suggest that the reduction in carbon emission positively influenced financial performance measured through ROS, ROE, and ROS. While there was no effect between Tobin's Q and carbon emission measures, companies with higher responsibility scores proved to show better financial performance. Based on evidence from selected 22 emerging economies, Miah et al. (2021) studied the relationship between carbon emission and financial performance, involving data from 104 financial and 328 non-financial firms. While the study observed that financial firms emit less carbon than non-financial firms, the results show that carbon emission negatively impacted financial performance measured through ROE and Tobin's Q, in addition to the credit rating.

While efforts are made to counter increasing carbon emissions, the debate on the financial implications of De-carbonization strategies on organizational performance remains unresolved. Nichita et al. (2021) investigated the effect of GHG emissions on companies' financial performance in 34 Central-Eastern Europe's chemical companies. A multiple linear regression model designed and applied showed that a decrease in carbon emission directly influences the return on sales positively, thus resulting in better financial performance. In line with the same results, Chen et al. (2018) conducted a cross-country analysis of the relationship between green and financial performance. The results reveal that green initiatives positively affect green performance, leading to better financial performance, particularly in European countries, Canada, the USA, and Japan. This implies that green initiatives can be beneficial, particularly when implementing long-term plans to deal with countries' specific effects.

To support the positive effects of carbon reduction strategies on financial performance from a broader perspective, Galama and Scholtens (2021) conducted a meta-analysis study on the relationship between companies' greenhouse gas emissions and financial performance, involving 74 effect sizes from 34 studies. While the study findings suggest a significant relationship between carbon emission and financial performance, factors like industry type and type of emission do not affect the relationship. The study further establishes that a strong relationship between two variables is more pronounced in countries with stringent carbon policies; this also symbolizes the influence of legal institutions on carbon reduction policies.

To ensure the success of sustainability efforts, most organizations started channeling financial resources toward implementing EMAPs. However, businesses continue to exercise caution in increasing environmental expenditure to ensure the profit objective is not affected. Mukwarami and van der Poll (2023) examined the relationship between environmental management expenditure and fiscal sustainability in 30 South African Urban Municipalities using feasible generalized least squares. The study found that wastewater and environmental protection expenditures positively impacted fiscal sustainability, with solid waste management expenditure influencing fiscal sustainability negatively. Therefore, based on aggregate results, the environmental expenditure had a neutral effect on financial sustainability in local municipalities.

Consistent with the results, Al-Waeli et al. (2020) investigated the relationship between environmental cost and the financial performance of 25 industrial companies in the Iraq stock exchange. The results suggest that environmental costs represented by conventional potential hidden and external social costs adversely impacted financial performance. Given the results, industrial companies are encouraged to promote efficiency in environmental costing to ensure improved corporate financial performance.

While in the context of South Africa, many empirical studies were conducted mainly on extractive and manufacturing companies, chemical industries remained sidelined (Smit & Kotzee, 2016; Nyahuna & Swanepoel, 2022). Hence, the need to examine the relationship between EMAPs remains imperative to achieving better financial and environmental performance. Therefore, the study examines the relationship between EMAPs and financial performance in the South African chemical industry to confirm if environmental management efforts result in accrued financial benefits.

Given the discussion above, evidence suggests the relationship between EMAPs and financial performance. However, the relationship is characterized by mixed results (neutral, positive, and negative), implying that the debate remains inconclusive. Therefore, the existence of the literature confirming a positive connection between EMAP and financial performance provides the basis for formulating the following hypotheses:

H_1: *There is a significant and positive relationship between efficient water usage and return on equity (ROE) in the South African chemical industry.*

H_2: *There is a significant and positive relationship between efficient energy usage and return on equity (ROE) in the South African chemical industry.*

H_3: *There is a significant and positive relationship between reduced carbon emissions and return on equity (ROE) in the South African chemical industry.*

H_4: *There is a significant and positive relationship between environmental expenditure and return on equity (ROE) in the South African chemical industry.*

2. METHOD

The study population comprises 354 listed firms registered on the Johannesburg Stock Exchange (JSE) as of June 30, 2023. The study utilized a purposive sampling technique to select ten chemical firms. This study employed an archival research strategy, primarily utilizing administrative records and documents as its primary data source. The secondary data were collected using quantitative content analysis from chemical companies' annual integrated reports (audited) for the period spanning from 2016 to 2022.

The regression equation is employed to forecast the values of a dependent variable based on the values of one or more independent variables (Saunders et al., 2009). The multiple regression approach offers benefits such as examining many factors, including creating more sophisticated graphs that depict relationships through regression lines, which are easy to present (Sweet & Grace-Martin, 2010). The study examines the relationship between EMAPs (water usage, energy consumption, carbon emissions, and environmental expenditure) and financial performance (return on equity) in the chemical sector. Therefore, the basic regression equation used to analyze the relationship between EMAPs and FP in South African chemical firms is as follows:

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$$Y_{it} = \alpha_i + \beta X_{it1} + \mu_{it} + V_i + E_{it}, \quad (1)$$

where Y_{it} represents the dependent variable for entity i in period t, β represents coefficients for the independent variables, X represents the predictor variables, μ presents the response variable, α is the intercept for each entity, β represents the within-entity error term, V_i is the specific error term for each firm which various between firms but has a constant value for any particular firm; E is the overall error term. The real empirical model is written in full:

$$ROE_{it} = \alpha_i + \beta \cdot WATUSA_{it1} + \beta \cdot ENEUSA_{it2} + \beta \cdot GREGAS_{it3} + \beta \cdot ENEXP_{it4} + \beta \cdot TOTASS_{it5} + \beta \cdot NOOEMP_{it6} + V_i + E_i, \quad (2)$$

where ROE_{it} (%) is the financial performance measure for the firm, a measure of i in year t; $WATUSA_{it1}$ represents water usage (m3) firm i in year t; $ENEUSA_{it2}$ is the energy consumption (GJ) firm i in year t; $NOSM$ is the net operating surplus margin, a proxy for FP for firm i in year t; $CAREM_{it3}$ stands for carbon emission (CO_2) firm i in year t; $ENEXP_{it4}$ represents environmental expenditure (ZAR) for firm i in year t; $TOTASS_{it5}$ represents the total value of assets (ZAR) for $TOTASS_{it5}$; $NOOEMP_{it6}$ is the number of employees for firm i in year t.

2.1. Justification of variables

2.1.1. *Return on equity*

Return on equity (ROE) is an effective measure to assess the profitability achieved by shareholders on the equity capital invested in the business. Over time, it evaluates shifts in a company's financial position (Calamar, 2016). For this reason, ROE was chosen as it measures company profitability based on shareholders' earning and it also reflect an outcome shareholders' decision on invest in environmental performance that could result in better financial performance. The calculation of ROE is as follows:

$$Return\ On\ Equity = \frac{Annual\ Net\ Income}{Shareholder's\ Equity} \cdot 100. \quad (3)$$

2.1.2. *Water usage (cubic meters, m3)*

The environmental effects of water consumption can be diverse, including negative impacts on ecosystems, water depletion, and reduced water availability (Mukwarami & van der Poll, 2024). Following previous studies (Nyirenda et al., 2013; Oberholzer & Prinsloo, 2011; Dobre et al., 2015; Fu & Jacobs, 2022), this study utilized water usage as a vital environmental indicator for environmental performance.

2.1.3. *Energy usage (gigajoules (GJ))*

Excessive energy use has resulted in air, water, and thermal pollution, not desirable for environmental sustainability (Gworek et al., 2016). Using energy usage to measure environmental performance metrics is consistent with Nyirenda et al. (2013) and Fan et al. (2017), who used energy efficiency to establish the relationship with financial performance.

2.1.4. *Carbon emissions (CO2e)*

Carbon emissions contribute to environmental damage through increasing global warming and variations in climate change (Mukwarami et al., 2023). Therefore, establishing measurements of the total emissions serves to quantify the impact on the environment, thus serving environmental performance.

2.1.5. *Environmental expenditure (ZAR)*

The environmental expenditure constitutes environment-related costs and earnings that include materials costs of non-product outputs, materials costs of product outputs, waste and emission control costs, prevention and other environmental management costs, research and development costs, and less tangible costs (IFAC, 2005).

2.1.6. *Firm size*

According to Fujii et al. (2013), company characteristics like size influence the relationship between financial performance and environmental sustainability. For the study, firm size was measured through the number of employees per individual firm and the total value of assets owned by each firm formed the control variable for the study.

3. RESULTS

3.1. Descriptive statistics

Table 1 shows the descriptive statistics. The values provide an overview of the distribution and central tendencies of the variables within the dataset.

The average *ROE* is 20.959%, and compared with the data standard deviation, there is slight variability in the *ROE* across the dataset, implying that overall, companies remain profitable. The variable water usage (*WATUSA*) has a wide range of values, as indicated by the difference between the minimum and maximum values. The average water usage (*WATUSA*) is 34,300,000 m^3, but the large standard deviation of 80,500,000 m^3 suggests significant variability in the *WATUSA* values across the dataset. Energy usage (*ENEUSA*) averages 26,200,000 GJ with a substantial standard deviation of 46,100,000 GJ, indicating considerable variability in *ENEUSA*. Carbon emissions (*CAREM*) exhibit a broad spectrum of values, which is evident in the minimum and maximum values range. While the average *CAREM* is around 600,612.1 CO_2e, the standard deviation of 1,391,392 CO_2e indicates noteworthy variability in *CAREM* emissions. Environmental expenditure (*ENVEXP*) has a mean of 1,980,000,000 ZAR with a standard deviation of 5,240,000,000 ZAR exhibiting high variability. The high variability in the descriptive statistics was due to the firm's nature, characterized by different sizes. Various processing techniques could also result in elevated carbon emissions. Variability in *ROE* and *ENVEXP* could be due to the size of the firm and amounts available to allocate to environmental expenditure; obviously, smaller firms require less than larger firms.

3.2. Correlation matrix

The correlation matrix shows the linear relationship between variables, indicating how one variable behaves relative to another (Table 2).

As shown in Table 2, water usage (*WATUSA*) exhibits a negative correlation with ROE, represented by a correlation of negative –0.067. While energy usage (*ENEUSA*) is positively correlated with ROE, as shown by a positive value of 0.5701*, this relationship between energy usage and ROE is also highly significant. Carbon emissions (*CAREM*) exhibit an insignificant negative correlation with ROE, illustrated by –0.1611. The correlation between environmental expenditure (*ENVEXP*) and ROE produced an insignificant positive correlation (0.2038). Water usage positively correlates with carbon emissions, but this relationship indicates low significance, represented by 0.8108*. Energy usage shows a negative correlation with

Table 1. Descriptive statistics

Variable	Obs	Mean	Std dev.	Min	Max
ROE	70	20.959	18.62821	0.7	82.28
WATUSA	70	34,300,000	80,500,000	1,044	301,000,000
ENEUSA	70	26,200,000	46,100,000	644.4	139,000,000
CAREM	70	600,612.1	1,391,392	1,053	5,927,458
ENVEXP	70	1,980,000,000	5,240,000,000	500,000	21,800,000,000
TOTASS	70	64,000,000,000	123,000,000,000	114,000,000	479,000,000,000
NOOEMP	70	8,818.571	14,039.96	18	113,112

Table 2. Study variables' correlation matrix

Variables	ROE	WATUSA	ENEUSA	CAREM	ENVEXP	TOTASS	NOOEMP
ROE	1	–	–	–	–	–	–
WATUSA	–0.067	1	–	–	–	–	–
ENEUSA	0.5701*	–0.0798	1	–	–	–	–
CAREM	–0.1611	0.8108*	–0.1578	1	–	–	–
ENVEXP	0.2038	–0.1319	0.3134*	–0.1644	1	–	–
TOTASS	0.1244	0.7323*	0.2403*	0.7378*	0.2460*	1	–
NOOEMP	–0.0635	0.1514	–0.036	0.1527	0.1225	0.2373*	1

Note: Statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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carbon emissions, which is insignificant. In contrast, a positive correlation was established between energy usage, environmental expenditure, and total assets, as represented by 0.3134* and 0.2403*, respectively. Although there is a positive correlation, the relationship is of low significance. Carbon emissions positively correlate with total assets, as shown by 0.7378*, but the relationship is insignificant.

3.3. Diagnostic test results

Pre-tests applied in this study included heteroscedasticity, normality, and multicollinearity tests. Applying these tests is critical to ensuring the robustness and validity of regression models. The application of these tests improves the accuracy of the statistical inferences and enhances the reliability of the model's predictions.

3.4. Heteroscedasticity

Homoscedasticity refers to the extent to which the data values for the dependent and independent variables have equal variances. The panel dataset must have homoscedasticity when the *p*-value is less than the significance level of 0.05, implying that the hypothesis of constant variance, i.e., homoscedasticity, should be rejected. Table 3 depicts the heteroscedasticity test explicitly conducted using the Breusch-Pagan/Cook-Weisberg test.

Table 3. Heteroscedasticity test

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity H_0: Constant variance Variables: fitted values of ROE	
chi2(1) =	14.34
Prob. > chi2 =	0.0002

The panel data have heteroscedasticity, as shown by the *p*-value of 0.0002 in Table 3. Therefore, from these results, there is statistical evidence to reject the null hypothesis of constant variance (homoscedasticity), thus suggesting that heteroscedasticity is present in the regression model concerning the fitted values of ROE. This implies that results from ordinary least squares can be completely biased, and imprecision exists. Therefore, after performing the OLS model, the study suppressed the heteroscedasticity problem using feasible generalized least squares (FGLS).

3.4.1. Normality

A normality test is a statistical method to assess whether a data set follows a normal distribution. Table 4 shows the results of the Doornik-Hansen test for normality.

Table 4. Normality test

mv test normality ROE	WATUSA, ENEUSA, CAREM, ENVEXP, NOOEMP, TOTASS		
Test for multivariate	Normality		
Doornik-Hansen	chi2(12) = 4.15	Prob. > chi2	0.1148

The results from Table 4 show that the *p*-value is 0.1148, more significant than the ordinary significance level of 0.05. This suggests that the data are consistent with the assumption of normal distribution, which is desirable.

3.4.2. Multicollinearity

In multiple regression analysis, multicollinearity signifies the existence of linear relationships among the independent variables (Shrestha, 2020). The multicollinearity test performed in this study is the variance inflation factor (VIF). The variance inflation factor (VIF) detects the presence of linear associations, often referred to as collinearity, among two or more independent variables within a multiple linear regression model (Salmerón Gómez et al., 2016). The variance inflation factor (VIF) tests were conducted to confirm multicollinearity in the panel data. Table 5 illustrates the results of the variance inflation factor test.

Table 5. Multicollinearity test

Variable	VIF	1/VIF
CAREM	3.01	0.33177
WATUSA	2.95	0.339009
ENVEXP	1.16	0.863996
ENEUSA	1.14	0.879842
NOOEMP	1.05	0.948132
Mean VIF	1.86	–

Generally, a VIF below 10 is acceptable (García et al., 2015) as it indicates low to no multicollinearity. In this case, the VIF is 1.86, below 10, indicating that multicollinearity does not exist in the panel data. Therefore, this suggests that statistical results are free from bias arising from multicollinearity.

3.5. The relationship between EMAPS and financial performance

The main aim of this study was to establish the relationship between EMAPs (*WATUSA*, *ENEUSA*, *CAREM*, and *ENVEXP*) and financial performance (ROE). Table 6 shows the results of OLS and FGLS models. The strength of the relationship is indicated by asterisks based on the following alpha levels: ***$p < 0.01$ (high significance), **$p < 0.05$ (average significance), and *$p < 0.01$ (low significance).

Table 6. Relationship between EMAPs and financial performance

Variable	Ordinary least squares	Feasible generalized least square
	ROE	ROE
WATUSA	0.000144	0.000144
	–0.32	–0.34
ENEUSA	0.00205***	0.00205***
	–4.05	–4.27
CAREM	–0.0314	–0.0314
	(–1.08)	(–1.14)
ENVEXP	–0.0000385	–0.0000385
	(–0.11)	(–0.12)
TOTASS (Control Variable)	0.0000119	0.0000119
	–0.63	–0.67
NOOEMP (Control Variable)	–0.0000687	–0.0000687
	(–0.49)	(–0.51)
_cons	14.72***	14.72***
	–4.71	–4.97
N	70	70

Note: Statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As shown in Table 6, the relationship between ROE and water usage (*WATUSA*) is positive and insignificant, as shown by the regression coefficient of 0.000144 in columns 1 and 2 representing OLS and FGLS, respectively. Although WATUSA has positively influenced ROE, the relationship is insignificant, thus implying that water usage as an EMA practice has little to no influence on the financial performance of chemical firms. Therefore, the hypothesis about a significant and positive relationship between efficient water usage and return on equity in the South African chemical industry cannot be accepted as the relationship was insignificant.

Regarding energy usage (*ENEUSA*), the results show a positive relationship with ROE indicated by the positive regression coefficient of 0.00205***, as illustrated in columns 1 and 2 in Table 6. Additionally, this relationship proves to have an average significance. Therefore, chemical firms that employed energy usage as an EMA practice measure effectively addressed environmental challenges while improving financial performance. This implies that the hypothesis about a significant and positive relationship between efficient energy usage and return on equity in the South African chemical industry cannot be rejected. This is because the results confirm both the direction and the strength as positive and significant.

Carbon emissions (*CAREM*) exhibit a negative relationship with ROE, as shown by the negative regression coefficient of –0.0314 in Table 6. The negative relationship also proves insignificant, indicating that carbon emissions have had adverse effects. The negative and insignificant relationship between carbon emission and ROE suggests that the proposed hypotheses cannot accepted. The relationship between environmental expenditure (*ENVEXP*) proved negative, as shown by the negative regression coefficient of 0.0000385. Furthermore, the relationship was established as insignificant, indicating that environmental expenditure negatively influenced firm financial performance; however, the impact is insignificant. This, therefore, implies that a hypothesis about a significant and positive relationship between environmental expenditure and return on equity in the South African chemical industry can be rejected. Table 7 summarizes the outcomes from OLS and FGLS models and provides evidence of hypothesis validation.

Table 7. Summary of OLS and FGLS results

Variable	Negative/ Positive	Significant/ Insignificant	Decision
WATUSA	Positive	Insignificant	Reject
ENEUSA	Positive	Significant	Accept
CAREM	Negative	Insignificant	Reject
ENVEXP	Negative	Insignificant	Reject

Given the information shown in Table 7, it is clear that only one out of four hypotheses was confirmed, as per the results in Table 6. Therefore, this implies that EMAPs implemented by the chemical industries have not had much impact on financial performance as the relationship was insignificant.

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4. DISCUSSION

The relationship between EMAPs and financial performance in the chemical industry produced mixed results at the aggregate level. To further break down the results based on the effects of individual variables on financial performance, the linkage between water usage (*WATUSA*) and ROE produced is positive but insignificant. These results are consistent with previous studies that established a positive relationship between water usage and financial performance (Dobre et al., 2015; Fu & Jacobs, 2022; Ji et al., 2023). Sudha (2020) examined the link between water sustainability and financial performance in South Africa; the results confirmed a positive relationship. The result could be due to the organizations not doing enough to optimize water use, thus using large amounts lacking energy-saving efficiency measures. Additionally, failure to implement EMAPs could have resulted in water costing inaccuracies, resulting in water usage having a positive (with less impact) influence on financial performance. On the other hand, the results could be due to a lack of adequate resources to accurately capture data on water usage, resulting in inefficiency in water usage costing. Therefore, it is crucial to ensure continued efforts toward improving the efficiency of water usage to yield financial benefits.

Regarding the relationship between energy usage (ENEUSA) and ROE, the results show a positive and significant relationship. Therefore, this implies that chemical industries in South Africa implemented the right energy usage strategies that led to financial benefits. In line with the results, Iliemena (2020) examined the relationship between energy management measured through energy accounting and financial performance and established a positive and significant relationship. Additionally, Fan et al. (2017) found the same positive results when examining the relationship between energy efficiency and financial performance involving Chinese energy-intensive firms. Sudha (2020) and Nyahuna and Doorsamy (2023) also found a positive relationship between energy usage and financial performance include.

These results could imply that energy usage in chemical firms seems optimized, which translates to financial benefits for the companies by ensuring that accurate costing in terms of energy cost is affected. However, one must consider that in South Africa, load shedding is a reality that all companies face. Thus, companies faced with untimely power outages for varying periods may not have maintained the production chain running. Similarly, as calls for renewable energy are becoming loud, chemical industries might have transitioned to clean energy like solar and biomass, resulting in improved performance because of cost-saving energy sources.

Concerning a negative and insignificant relationship between carbon emissions and ROE, this implies that chemical companies in South Africa are not operating at optimum efficiency yet to reduce carbon emissions. The results are consistent with those of Miah et al. (2021), who found that carbon emissions negatively influenced financial performance, particularly in non-financial companies. Similarly, the results are not different from those of Ganda and Milondzo (2018), who found a negative relationship between carbon and financial performance in southern African countries. The results could be due to many factors, such as industry type, type of carbon emissions, and the influence of legal institutions on reducing carbon emissions (Galama & Scholtens, 2021). Furthermore, Mukwarami et al. (2023) considered that EMA implementation challenges, such as technological incapability, lack of environmental reposting, lack of training, and inconsistencies in environmental policies, might have influenced the results. Therefore, it is vital to ensure that carbon emission strategies implemented by the firms result in financial benefits, leading to a substantial boost to environmental management investments.

The study results show a negative and insignificant relationship between environmental expenditure and ROE. Hence, the hypothesis regarding a positive relationship between the two variables cannot be accepted. This shows that environmental expenditure harms firms' financial performance in chemical companies. In line with the results, Mukwarami and van der Poll's (2023) investigation between environmental management expenditure and fiscal sustainability in the municipalities found that the expenditure on solid waste negatively impacted financial sustainability. These results align with Al-Waeli et al. (2020), who established that some forms of environmental costs, such as image and relationship costs and contingent environmental costs, proved to have a non-significant impact on a firm's financial performance. However, one must consider that environmental expenditure could appear quite expensive in the short term but yield long-term results. Results may indicate that environmental costs have not yet translated into financial benefits due to varying cost allocations in different organizations, as South Africa has no set guidelines regarding EMAPs. Some organizations could offset CAPEX costs and some OPEX, but this purely depends on the organization. The timeframe of these costs may not show any relationship as the company has not realized any financial benefits due to the short data collection, thus not providing the best representation of company environmental costs.

CONCLUSION

The study examined the relationship between EMAPs and financial performance in South African chemical firms. The empirical evidence following the outcomes of the regression analysis suggests that two of the EMAPs, water and energy usage, have had a positive relationship with ROE, with the latter being highly significant. Contradictorily, carbon emissions and environmental expenditure have adversely and insignificantly influenced ROE. However, the conclusion drawn from the results suggests that chemical firms in South Africa lack a proper strategy to implement EMA to ensure optimal benefits, particularly in carbon reduction management and decisions on managing environmental expenditure.

Examining the linkage between EMAPs and financial performance in the chemical sector provides opportunities for learning what more businesses could do to ensure the implementation of EMA addresses financial and environmental performance. Additionally, allowing the firms' management to reconfigure current strategies ensures efficiency and effectiveness in utilizing energy, water, and material within the production chain for improved formulation of environmentally friendly decisions. The policymakers, as instrumental environmental agencies, are likely to use the results to review the effectiveness of the policies and make provisions for further alignment based on the industrial context. Lastly, the government is responsible for controlling all environmental activities through laws and legislation and has to respond by improving environmental management guidelines in line with international environmental treaties.

The ongoing debate regarding EMAPs and financial performance in developing countries, particularly South Africa, suggests many issues, such as the availability of EMA experts, financial resources, and accurate environmental data. Therefore, it is vital to recommend further studies to ascertain the barriers to EMA implementation in chemical and associated industries within the same sector.

AUTHOR CONTRIBUTIONS

Conceptualization: Tracy Cornellissen.
Data curation: Tracy Cornellissen.
Formal analysis: Tracy Cornellissen, Silas Mukwarami.
Investigation: Tracy Cornellissen.
Methodology: Tracy Cornellissen, Silas Mukwarami.
Project administration: Tracy Cornellissen, Silas Mukwarami.
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Software: Silas Mukwarami.
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Visualization: Tracy Cornellissen.
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Writing – review & editing: Silas Mukwarami.

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