Analysis of the Effect of Eco-Efficiency on Asset Return in Food and Beverage Manufacturing Companies Listed at the Johannesburg Stock Exchange

Dimakatso Hellen Malapa
University of Limpopo, South Africa
dimakatso.malapa@ul.ac.za

Collins C. Ngwakwe
University of Limpopo, South Africa
Collins.Ngwakwe@ul.ac.za

This article examines the effect of eco-efficiency on corporate return on assets (ROA). The paper aimed to analyse whether corporate eco-efficiency performance (represented by energy consumption, water consumption, carbon emission and waste generation) affects the performance of ROA. Data on the eco-efficiency and ROA was collected from fourteen food and beverage companies listed in the Johannesburg Stock Exchange for a period of ten years (2012 to 2021). Using the STATA Software, the data was analysed by applying the Generalised Method of Moment (GMM) statistical technique, which enhanced the statistical analysis robustness. Findings from the GMM analysis showed different results. On the one hand, the results indicate that energy and water consumption in the food and beverage companies have a positive (but insignificant) effect on ROA. On the other hand, the results show that waste generation has a negative (but insignificant) effect on ROA; and that carbon emission has a negative and significant effect on ROA.

Keywords: environmental accounting, return on assets, financial performance, eco-efficiency, energy consumption, water consumption, carbon emission, waste generation, sales revenue
JEL *Classification:* Q56, M41, M21

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Introduction

Manufacturing industries are generally seen as the greatest polluter, and as a result, there is a growing concern about environmental problems resulting from their production activities. For instance, in their process of production, energy consumption, sound emission and waste generat-

ed contribute to industry environmental pollution (Gebreeyessus et al. 2021). In addition, numerous challenges, including global warming, air pollution and water scarcity among others, pose significant dangers to environmental preservation (Novera et al. 2024). South Africa is among the countries known for their global environmental sustainability advocacy (Younis et al. 2021). The country joined other nations in developing its national environmental regulations that guide environmental operations of manufacturing industries in the country (Hoffmann 2019; Bag et al. 2021). Nonetheless, industries continue to pollute the environment through carbon emissions, excessive use of water and energy, and unsustainable use of available natural resources, affecting the planet in a negative way (Patnaik 2018; Zelazna et al. 2020; Arzova and Sahin 2023). It therefore becomes necessary to find alternative strategies to overcome the environmental challenges faced by businesses in carrying out production activities (Adhikari and Ozarska 2018; Malek and Desai 2020).

Eco-efficiency is one avenue that can reposition industry operations and activities to minimise the negative environmental impact of businesses (Sala-Garrido et al. 2021; Eder et al. 2021). As industries commit to environmental protection activities such as engagement in activities that promote eco-efficiency, financial performance can be improved (Meutia et al. 2019; Safitri and Nani 2021). This study will examine the effect that eco-efficiency variables (energy consumption, water consumption, carbon emission and waste generation) have on return on assets.

Due to its potential to minimise exhaustion of resources and to lessen pollution, eco-efficiency is considered a practical tool for sustainable development (Matsumoto and Chen 2021). The Paris Agreement was signed at the United Nations Climate Change Conference with the goals to limit global warming by minimising greenhouse gas emissions and to set net zero emission targets within industries' operations (Streck et al. 2016). However, without addressing the issue of industry environmental sustainability by becoming eco-efficient, achieving the objectives of Sustainable Development Goal 12 (SDG 12) will remain a buzzword. Some researchers have tested the relationship between eco-efficiency and financial performance and found positive and negative relationships (Miroshnychenko et al. 2017; Alheet 2019; Chukwuma et al. 2019; Pham et al. 2021). Several studies conducted relating to eco-efficiency in the South African context focused on cleaner production, environmental sustainability commitment, sustainability practices and their impact on financial

performance (Olalekan and Jumoke 2017; Masocha 2019; Dzomonda and Fatoki 2020; Maama et al. 2021).

Yacob et al. (2019) found that reusing water can enhance water conservation in manufacturing companies. Furthermore, other scholars suggest that manufacturing industries can also benefit financially from eco-efficiency practices. For example, Meutia et al. (2019) assert that, if manufacturing companies engage in the production of goods and services that promote environmental protection, thereby enhancing eco-efficiency, they will achieve better financial performance. In addition, Safitri and Nani (2021) postulate that, in carrying out efficiency in the ecological field, companies' profitability can increase. Moreover, Kurnianta and Dianawati (2021) also postulate that the minimisation of emissions, which resembles the application of eco-efficiency, will boost the image of the company in the eyes of the public, which will in turn have an impact on the value of the company, thereby influencing investors to become interested in the company. However, there is no evidence of any study that has analysed the effect of the combined eco-efficiency variables, namely, energy consumption, water consumption, carbon emission and waste generation, on return on assets in the South African context. Hence, this study aims to investigate the effects of eco-efficiency (using these variables) on return on assets (ROA) growth for selected Johannesburg Stock Exchange (JSE)-listed food and beverage manufacturing companies. Given that there is no evidence of a similar study in the South African context, it will therefore pave the way for future studies. In addition, it will add to literature and the body of knowledge on the financial implications of eco-efficiency practices. Moreover, findings of this study may increase society's awareness of the part that some manufacturing companies play in protecting the environment and may improve corporate legitimacy and consumer relations.

The second section provides a review of the theories and related empirical studies. The third section introduces the methodological approach of this study. The fourth section presents and discusses the empirical results. The fifth section discusses the findings, while the sixth section concludes the study.

Theoretical Framework and Literature Review

The theoretical framework is presented, followed by a review of literature on energy consumption and ROA, water consumption and ROA, carbon emission and ROA, and waste generation and ROA.

THE STAKEHOLDER THEORY

The stakeholder theory posits that companies should meet the expectations of their stakeholders as a way of creating value (Huge-Brodin et al. 2020; Tran and Adomako 2021). This theory postulates that business activities and operations should be conceptualised as stakeholder relationships that can serve as ways for creating value (Freeman et al. 2020). One of the ways for creating such value to stakeholders can be engagement in eco-efficiency activities, which might in turn benefit both the stakeholders and the company. Such benefits include, among others, less environmental pollution, customer loyalty, competitive advantage and enhanced financial performance.

We adopted the stakeholder theory because stakeholders, such as consumers, suppliers, shareholders, and the environment can put more pressure on companies to produce eco-friendly products. These pressures are the firms' motivating factors to produce green or environmentally friendly products to meet the demand of these corporate stakeholders. Additionally, to recognise the environment as one of the corporate stakeholders, industries should engage in eco-efficient activities, as the firms' survival is dependent on meeting societal and environmental expectations. In contrast, if manufacturing companies are known for pollutants and cannot implement eco-efficient practices in their processes of production, they might lose green-minded suppliers and customers and that will affect their financial performance.

THE INSTITUTIONAL THEORY

The institutional theory is applied when examining whether companies adopt environmentally friendly practices in their businesses (Berrone et al. 2013; Parada et al. 2020). This theory postulates that the social context from which organisations operate influences firms' behaviour, causing them to adopt related practices and structures (Hinings et al. 2018; Z. Li et al. 2020). In other words, this theory proclaims that firms should adopt green initiatives to gain acceptance from the society within which they operate. This theory further states that developing formal structures in an organisation can be affected by the environment and social surroundings, which are stronger compared with pressures from the market (Ebrahimi and Koh 2021). This implies that, beside social and environmental pressures, there are other institutional pressures causing the organisation to adopt good practices. This study adopted the insti-

tutional theory to elucidate the way in which manufacturing companies utilise natural resources to avoid depletion and pollution and improve eco-efficient practices and achieve a competitive edge and enhance financial performance.

ENERGY CONSUMPTION AND ROA

Energy is needed for contemporary manufacturing although it produces massive emissions; thus, developing and implementing energy conservation strategies to minimise the use of energy in the manufacturing sector have become crucial (L. Li et al. 2020; Clairand et al. 2020). Energy consumption and conservation has become a subject of interest that has resulted in a plethora of studies on the relationship between energy consumption and profitability proxied by ROA. Over the years, different hypotheses and research questions have emerged from researchers, aimed at addressing the effect that energy consumption has on financial performance. These hypotheses and questions suggest a negative, weak, neutral, positive, or strong relationship between the above-mentioned variables.

For example, Mdasha et al. (2024) have found energy efficiency to have a significant positive influence on financial performance proxied by ROA. On the other hand, Makridou et al. (2024) found a negative and insignificant relationship between ESG with energy use as one of the variables, and financial performance with ROA as one of the variables. Regardless of the difference in results from the aforementioned studies, publicly listed manufacturing companies should consider investing in energy efficiency initiatives for reasons other than just compliance, but also for improving operational efficiency and driving positive financial performance. The following hypotheses were developed:

$H1_0$ *There is no significant relationship between energy consumption and return on assets in JSE-listed food and beverage manufacturing companies.*

$H1_A$ *There is a significant relationship between energy consumption and return on assets in JSE-listed food and beverage manufacturing companies.*

WATER CONSUMPTION AND ROA

Manufacturing companies consume huge amounts of water while converting raw material into goods that are ready for consumption (Sharma

et al. 2020; Revollo-Fernández et al. 2020; Chamberland et al. 2020). Rosegrant et al. (2020) and Marulanda-Grisales and Figueroa-Duarte (2021) suggest that manufacturing companies can overcome the challenge of water scarcity by investing in technologies that save water and training the companies' employees on how to use water effectively in the production process. While some researchers suggest strategies for conserving water, others posit that water conservation yields great benefits such as better financial performance.

For example, Emmanuel et al. (2024) found sustainability indicators measured by energy consumption, water consumption, waste management and carbon emission to have an impact on ROA. In addition, Sudha (2020) has found water efficiency to have a positive and significant effect on financial performance, represented by ROA among other variables. In contrast, the study of Khan et al. (2021) found a negative association between green process innovation represented by water efficiency, and financial performance. Azeez et al. (2024) revealed a negative and insignificant relationship between environmental conservation practices and ROA, with waste usage as one of the proxies. However, despite the different directions of relationships found and the costs associated with the creation and execution of water conservation plans, manufacturing firms should not be discouraged, but instead, should invest more in water conservation to minimise water use in an attempt to avoid water scarcity and pollution. The following hypotheses were developed:

$H2_0$ *There is no significant relationship between water consumption and return on assets in JSE-listed food and beverage manufacturing companies.*

$H2_A$ *There is a significant relationship between water consumption and return on assets in JSE-listed food and beverage manufacturing companies.*

CARBON EMISSION AND ROA

Carbon emissions refer to unwanted output resulting from an immoderate use of energy (Lv et al. 2021). In their production processes, manufacturing industries continue to contribute to environmental pollution through huge amounts of carbon emission, posing menaces to the environment such as global warming. These emissions are generated through various sources in the course of using a unit of electricity and

during combustion (Adebayo et al. 2021). Carbon emission reduction as one of the variables of eco-efficiency is presumed to have a relationship with financial performance. Previous researchers have found carbon reduction to have an association with financial performance, although the direction of the relationships is different. For example, the study of Emmanuel et al. (2024) found carbon emission to be one of the sustainability indicators to have an impact on ROA. In addition, Kumari and Patel (2020), Aslam et al. (2021) and Rodríguez-García et al. (2022) suggest that a relationship exists between carbon emission reduction and ROA among other variables. Menicucci and Paolucci (2023) found a positive and significant relationship between environmental management represented by carbon emission and waste reduction and ROA as one of the proxies for financial performance. The study of Azeez et al. (2024) found a negative and insignificant relationship between environmental conservation practices and ROA, with carbon as one of the proxies.

All the aforementioned studies agree that there is a relationship between carbon emission reduction and financial performance, but they disagree on the negative or positive direction of the effect of carbon reduction on financial performance. Notwithstanding the fact that competitive advantage and better financial performance might be achieved through reduced carbon emissions, manufacturing companies need to avoid climatological changes and global warming resulting from their production activities by being socially responsible. The following hypotheses were developed:

$H3_0$ *There is no significant relationship between carbon emission and return on assets in JSE-listed food and beverage manufacturing companies.*

$H3_A$ *There is a significant relationship between carbon emission and return on assets in JSE-listed food and beverage manufacturing companies.*

WASTE GENERATION AND ROA

Waste refers to the rejected materials that have been generated by residential and production activities, which comes at an economic and environmental cost for their treatment and removal (Nazari et al. 2021). La Scalia et al. (2021) assert that an enormous amount of waste is generated in carrying out business activities, causing immense problems in its

treatment and disposal and causing economic losses. Kim et al. (2020) therefore suggest that manufacturing companies can use waste generation as a corporate strategy. While Shirvanimoghaddam et al. (2020) propose reuse and recycle strategies as long-term solutions for reducing waste, Kabirifar et al. (2020) and Kakwani and Kalbar (2020) propose strategies such as reduce, reuse, recycle, reclaim, recover, and restore for managing waste generated. There has been extensive research on the association between waste reduction and financial performance, with varying conclusions about which way the variables should be aligned.

Researchers such as Yu et al. (2020) have found that companies that manage waste through these strategies have improved their financial performance. For example, Menicucci and Paolucci (2023) found a positive and significant relationship between environmental management represented by waste reduction and carbon emission and financial performance represented by ROA. Emmanuel et al. (2024) found waste management to be one of the sustainability indicators that have an impact on ROA. In addition, the study of Azeez et al. (2024) established a relationship between environmental conservation practices and ROA, with waste management as one of the proxies. Baah et al. (2021) found a negative and insignificant association between environmental management, with waste as one of the proxies, and financial performance. The following hypotheses were formulated:

$H4_o$ *There is no significant relationship between waste generation and return on assets in JSE-listed food and beverage manufacturing companies.*

$H4_A$ *There is a significant relationship between waste generation and return on assets in JSE-listed food and beverage manufacturing companies.*

Methodology

This section attempts to determine a probable association between eco-efficiency variables and ROA growth of 14 food and beverage manufacturing companies listed at the JSE, as these companies' production activities contribute to environmental pollution. The researcher planned to use all 16 food and beverage manufacturing companies listed in the JSE at the time the study was conducted. However, 2 of the companies did not have complete year to year data, therefore the researcher used

TABLE 1 Description of Variables

Acronym	Name of the acronym	Measurement of data	Source of data
ROA	Return on assets	In rand amounts per year	Annual integrated reports
ENRCON	Energy consumption	In kilowatts of energy per year	Annual integrated reports
WATCON	Water consumption	In kilolitres of water per year	Annual integrated reports
CAREMM	Carbon emission	In tonnes per year	Annual integrated reports
WASGEN	Waste generation	In kilograms per year	Annual integrated reports
SALREV	Sales Revenue	In rand amounts per year	Annual integrated reports

the 14 compa nies which had complete data for all the variables for all the years to be studi ed. Data for this study was obtained from the published annual integrated reports of a sample of companies for the period 2012–2021(Johannesburg Stock Exchange 2023). This time frame was chosen because it is believed that any amendments to legislation and regulations regarding eco-efficiency may have been effected. The multiple linear regression analysis was used to establish the relationship between eco-efficiency variables and ROA growth and to determine the relationship.

For analysis, the study made use of the model regressions below:

$$ROA_{it} = \alpha_i + \beta_1 \text{ ENRCON}_{it} + \beta_2 \text{ WATCON}_{it} + \beta_3 \text{ CAREMM}_{it} + \beta_4 \text{ WASGEN}_{it} + \beta_5 \text{ SALREV}_{it} + \varepsilon_{it}, \quad (1)$$

where ε is error term, α is constant, β represents coefficients explaining the partial elasticities of explanatory variable, and it the represents company and the t represents the year.

Empirical Results and Discussion

DESCRIPTIVE ANALYSIS

Th ere were 140 annual integrated reports observed for 14 JSE-listed food and beverage manufacturing companies for a period of 10 years, as table 2 demonstrates (2012 to 2021). The mean which explains the central tendency or value in the data set is found to be 11.770 for ROA and 17.968, 13.358, 12.755, 14.730, and 18.298 for energy consumption, water consumption, carbon emission, waste generation and sales revenue, respectively.

TABLE 2 Summary Statistics

	ROA	ENRCON	WATCON	CAREMM	WASGEN	SALREV
Mean	11.770	17.968	13.358	12.755	14.730	18.298
Standard Error	0.935	0.222	0.444	0.159	0.254	0.233
Median	9.020	18.084	13.894	12.701	14.314	17.149
Std Dev	11.057	2.629	5.252	1.876	3.011	2.751
Kurtosis	3.504	−0.064	5.910	2.907	1.086	−0.907
Skewness	1.411	−0.025	−2.310	0.270	0.560	0.603
Range	75.630	11.991	25.824	11.330	15.130	9.173
Minimum	−13.380	12.210	−5.032	6.995	7.837	14.436
Maximum	62.250	24.201	20.792	18.325	22.968	23.609
Count	140	140	140	140	140	140

Descriptive statistics also include standard deviation that provides an estimation of the spread of values around the sample mean, therefore describing the sample. When a standard deviation exceeds the mean, it is considered widely dispersed. Table 2 demonstrates a standard deviation of 11.057 which is below the mean of 11.770 for ROA. This therefore means that ROA is not widely dispersed. In addition, the standard deviation for energy consumption, water consumption, carbon emission, and waste generation were 2.629, 5.252, 1.876, and 3.011, respectively, which were also less than their mean. This is an indication that independent variables as well are not widely dispersed.

CORRELATION MATRIX

This section illustrates the correlation matrix. The correlation matrix determines the association between an independent variable and its corresponding values, as well as the relationship among independent variables (Gogtay and Thatte 2017). Table 3 presents the correlation matrix.

Table 3 shows that energy consumption has a positive yet extremely weak correlation with ROA, shown as 0.093. In addition, water consumption is positively correlated with ROA, shown as 0.177, although the correlation is weak. The correlation between carbon emission and ROA is also positive but weak, shown as 0.146. Results further revealed a positive yet weak correlation between waste generation and ROA, shown as 0.151. Lastly, sales revenue showed a negative and weak correlation with ROA, shown as −0.219.

TABLE 3 Pearson Correlation

	ROA	ENRCON	WATCON	CAREMM	WASGEN	SALREV
ROA	1					
ENRCON	0.093	1				
WATCON	0.177	−0.148	1			
CAREMM	0.146	0.181	−0.075	1		
WASGEN	0.151	0.251	−0.120	0.235	1	
SALREV	−0.219	0.039	0.173	−0.044	0.004	1

TABLE 4 Unit Root Test for Stationarity

Panels	ENRCON	WATCON	CAREMM	WASGEN	SALREV
P-Value	0.0000	0.0946	0.0000	0.0000	0.0000

UNIT ROOT TEST

The study uses the Levin-Lin-Chu unit root test to test the stationarity of the panels used in the analysis. The results are presented in table 4. Panels are non-stationary according to the null hypothesis, while panels are stationary according to the alternative. The significance level is set at 0.05 (5%). Any value under 5% is deemed significant, leading to the acceptance of the alternative hypothesis and the rejection of the null hypothesis.

Table 4 demonstrates that p-values for all panels except for water consumption are below 5%. According to the prevalence of support for the alternative hypothesis that the panels are stationary, the null hypothesis should be rejected. The existence of stationarity implies that there is no unit root, which is preferred because the data set that contains unit root usually leads to misleading interpretations (Brooks 2019).

COINTEGRATION TESTS

The Pedroni panel cointegration test employs eleven statistics to test the alternative hypothesis of cointegration among the variables in the estimated model against the null hypothesis of no cointegration (Gómez Rodríguez et al. 2022). Seven panels are classified as statistics while four are classified as weighted statistics. Table 5 shows results for eleven statistics.

The critical value is set at 5%. Cointegration is acknowledged by the alternative hypothesis, whereas the null hypothesis asserts that it is not. In the case the value is below 0.05, the cointegration alternative hypothesis is accepted. Reading from table 5, six statistics out of eleven are less than 0.05. Predominance makes it impossible to accept the null hypothesis

TABLE 5 Summary of Pedroni Panel Cointegration Test

Panel	Probability	
	Statistics	Weighted statistics
Panel		
Panel v-Statistics"	0.9882	0.9683
Panel rho-Statistics"	1.0000	0.9999
Panel PP-Statistics"	0.0003	0.0001
Panel ADF Statistics"	0.0384	0.0096
Group		
Group rho-Statistics	1.0000	-
Group-PP-Statistics	0.0000	-
Group ADF Statistics	0.0102	-

that supports non-cointegration. Therefore, it is concluded that there is a long-term relationship as the alternative hypothesis supporting cointegration is accepted.

DIAGNOSTIC TESTS

Diagnostic tests are necessary because panel data models can produce inaccurate results, especially when there is failure to evaluate the implications of threats resulting from failure to pay attention to regression assumptions on model findings. In line with other studies such as those of Mogashwa (2023) and Rahman and Anis (2023), the researcher performed diagnostic tests on panel data to identify existing abnormalities as well as misspecifications that could cause estimators to be unreliable and biased. In this study, the researcher checked for heteroscedasticity, the Wooldridge test for autocorrelation and the Jarque-Bera test in collaboration with the kurtosis for normality testing.

VAR RESIDUAL HETEROSCEDASTICITY TESTS

The study used the VAR residual heteroscedasticity tests to check if the data is not affected by heteroscedasticity. The VAR residual heteroscedasticity tests have a null hypothesis of heteroscedasticity pitted in contradiction to the alternative hypothesis of homoscedasticity. It is worth noting that the desired outcome is homoscedasticity in the estimated model, and that is achieved when the computed probability value is above 0.05. However, reading from the results in table 6, the null hypothesis of heteroscedasticity is accepted given that the computed probability value is less than 0.05.

TABLE 6 Results of Heteroscedasticity

Test name	Probability value	Decision
Heteroscedasticity with Cross Terms ROA	0.0000	Accept Null

TABLE 7 Wooldridge Test Results in Panel Data

F(1.13)	12.333
Prob > F	0.0033

AUTOCORRELATION TESTS

If the p-value exceeds 0.05, the null hypothesis is accepted. Conversely, if the p-value is below 0.05, it is rejected. The null hypothesis posits the absence of first-order autocorrelation and is contradicted by the alternative hypothesis claiming the existence of such autocorrelation. The p-value is 0.0033 which is less than 0.05, making the alternative hypothesis of autocorrelation to be accepted. Consequently, the null hypothesis suggesting the absence of first-order autocorrelation is rejected.

NORMALITY TESTS

Figure 1 presents normality tests results.

For normal distribution of results, the probability value of the Jarque-Bera should be insignificant and Kurtosis should take a value of approximately 3. Reading from figure 1 it is revealed that the residuals are not normally distributed.

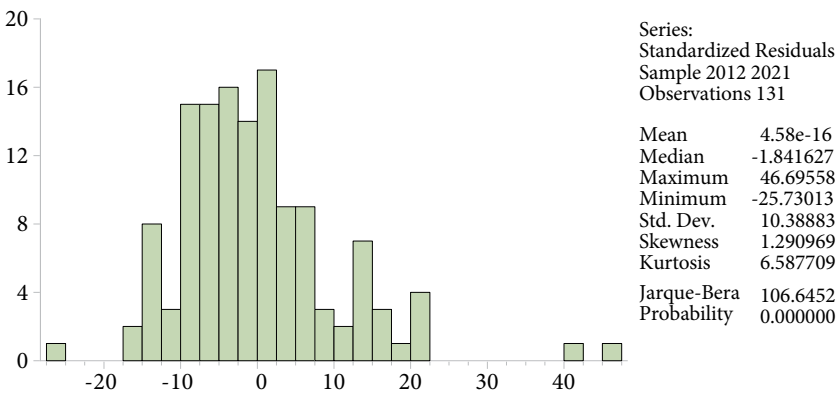

FIGURE 1 Normality test results

TABLE 8 Hausman Test

	Coefficients (b) FE	(B) RE	(b-B) Difference	Standard Error
ENRCON	-.1219149	.0545564	-.0673586	.0947721
WATCON	1.142282	.6063437	.5359385	.5713364
CAREMM	.1527403	.3672574	-.2145171	.1984118
WASGEN	-.587264	-.2323592	-.3549048	.1984118
SALREV	-.8578007	-.9909188	.133118	.8665627

NOTE b = consistency with the Ho and Ha, B = inconsistency with the Ha and efficient within Ho, Test: Ho: the null hypothesis is accepted, $chi^{2(3)}$ = (b-B)'[(V_b-V_B).^(−1)](b-B) = 3.75, Prob:>chi^2 = 0.5857

HAUSMAN TESTS

Hausman distinguishes between FE and RE models in panel data. Table 8 presents the Hausman test results.

If the p-value is less than 0.05, it is appropriate to reject the null hypothesis. If the p-value exceeds 0.05, it is appropriate to accept the null hypothesis. According to the alternative hypothesis, the fixed effects model is preferred, while the null hypothesis advocates for the random effects model. Hausman test results show a p-value of 0.5857, suggesting that the random effects model is preferred.

RANDOM EFFECT RESULTS

The findings indicate that there is a negative and statistically insignificant relationship between energy consumption and the dependent variable (ROA). On the other hand, water consumption is positively related to ROA, but the relationship is also statistically insignificant. Carbon emission is positively and yet insignificantly related to ROA while waste generation is negatively and insignificantly associated with ROA. Sales revenue as a controlling variable has an insignificant negative impact on ROA.

Although RE was preferred, there were problems of abnormality and heteroscedasticity in panel data which are not catered for in RE. The analysis was then extended to GMM for robustness of the analysis and to cater for abnormality and heteroscedasticity.

TABLE 9 Random Effect Results

	ROA
ENRCON	−0.055 (0.321)
WATCON	0.606 (0.376)
CAREMM	0.367 (0.596)
WASGEN	−0.232 (0.357)
SALREV	−0.991 (0.688)
_cons	21.521 (16.123)
Number of obs	140
Number of groups	14
R-sq	0.1313
Prob>chi2	0.4256
Prob>F	"0.0386
Prob>chibar2	0.0000

EXTENDED ANALYSIS USING GENERALISED METHODS 4OF MOMENTS

GMM is renowned for eliminating all indigeneity from the panel model, taking into consideration unobserved time-invariant country-specific effects (Barros et al. 2020). Despite RE being a preferred model over FE as revealed by Hausman tests, it holds some limitations. For instance, it is assumed that the RES are normally distributed; however, this is not always the situation. In this study, normality was violated as the residuals were not normally distributed. In addition, reading from the VAR tests for heteroscedasticity results in table 6, it shows that the panel is heteroscedastic, which is not preferred. To counter these problems of abnormality and heteroscedasticity in panel data, the study employs GMM which has an advantage of handling serial correlation, heteroscedasticity, and non-normal distribution problems (Xaisongkham and Liu 2022). Moreover, this estimator is believed to eliminate standard errors and is more robust to heteroscedasticity in panel data (Akinbode and Bolarinwa 2020). GMM provides a straightforward way to test the specification of the model and therefore provide a high level of reliability.

GENERALIZED METHOD OF MOMENTS RESULTS

This section presents GMM results.

Results in table 10 show that energy consumption is positively and insignificantly related to ROA. Water consumption is also positively related to ROA. This relationship is statistically insignificant. However, the results show that carbon emission and waste generation are negatively

TABLE 10 GMM Results

	ROA
Dependent (constant)	0.251** (0.115)
ENRCON	0.384 (0.424)
WATCON	1.454 (1.126)
CAREMM	−1.469* (0.866)
WASGEN	0.735 (0.489)
SALREV	−0.463 (1.909)
_cons	20.292 (39.014)
Number of obs	140
Number of groups	14
R-sq	0.0471
Prob>chi2	0.0295
Prob>F	0.0462
Prob>chibar2	0.0235

NOTES Standard errors are shown in parenthesis, while *, **, *** represent significance at 1%, 5%, and 10% levels, respectively.

associated with ROA. The relationship between carbon emission and ROA is statistically significant while for waste generated and ROA, the relationship is insignificant. The control variable, sales revenue, has a negative and insignificant impact on ROA.

Discussion Findings

Energy Consumption and ROA

Results show that energy consumption is positively yet insignificantly associated with ROA. Despite the insignificant relationship revealed from GMM, these results are in line with those of Mdasha et al. (2024), which found energy consumption to have a positive influence on financial performance, although the influence in this study was insignificant. Furthermore, these results are in agreement with the stakeholder theory which posits that companies should meet the expectations of their stakeholders as a way of creating value. Conserving energy can be used as one of the strategies for creating such value to stakeholders, which will in turn benefit both the stakeholders and the company in the form of less environmental pollution, increased customer loyalty, competitive advantage, and enhanced financial performance. Additionally, the results agree with the institutional theory which postulates that companies should engage in green production in the pursuit of attaining a sustained competitive advantage and greater financial performance. In contrast,

Makridou et al. (2024) found that attaining energy efficiency negatively and insignificantly influence financial performance represented by ROA.

The null hypothesis, $H1_o$, stated that there is no significant relationship between energy consumption and return on assets (ROA), whereas the alternative hypothesis, $H1_a$, proposes the opposite. Although the results show a positive effect of energy consumption on ROA, the acceptance of the null hypothesis is warranted given that the relationship is statistically insignificant. Despite the insignificant relationship found between energy consumption and financial performance, food and beverage manufacturing companies need to guard the natural environment against pollution and degradation to protect human health and also ensure that both the current and the future generation benefit. Furthermore, some goals, specifically for social and economic development, hinge on the health of ecosystems and natural resources.

WATER CONSUMPTION AND ROA

Water consumption is also positively and insignificantly related to ROA. The findings in this study align with those of Sudha (2020), who found water efficiency to have a significant positive effect on financial performance represented by ROA. Furthermore, these results support the stakeholder theory which advocates and proposes strategies on how a company ought to be managed to meet expectations of its stakeholders. This theory posits that excessive use of water causes serious problems to the environment such as pollution and water scarcity, which will negatively affect the stakeholders. Additionally, these results support the institutional theory as used by some researchers such as Gupta and Gupta (2021) and Yuan and Cao (2022). The results further support those of Emmanuel et al. (2024) which found water consumption as one of the sustainability indicators to have a positive yet insignificant relation with ROA. However, Khan et al. (2021) revealed a negative association between green process innovation represented by water efficiency among other variables, and financial performance represented by ROA. Moreover, Azeez et al. (2024) found a negative effect of environmental compliance on ROA, with water saving as one of the variables. The null hypothesis, $H2_o$, claims that there is no significant relationship between water consumption and return on assets (ROA), whereas the alternative hypothesis, $H2_a$, proposes otherwise. The null hypothesis is accepted given that the relationship between water consumption and ROA is statistically insignificant.

CARBON EMISSION AND ROA

GMM results further revealed that carbon emission is negatively and significantly related to ROA. These results support those from the study of Kumari and Patel (2020), who found a negative association. These results are also in agreement with the study of Azeez et al. (2024) which found a negative relationship between environmental conservation practices and ROA, with carbon emission reduction as one of the proxies. The findings are different from those of Emmanuel et al. (2024) which found carbon emission as one of the sustainability indicators to have a positive yet insignificant relation with ROA. Moreover, the stakeholder theory postulates that, for companies to maintain good relationships with companies' stakeholders, they should meet their expectations and treat them in the best manner, and carbon reduction can be among the strategies for creating such value.

The null hypothesis, $H3_o$, of no significant relationship between carbon emission and return on assets (ROA), is accepted given that the relationship between carbon reduction and ROA is negative and statistically insignificant. Besides the economic benefits that companies stand to gain, the environment should stand a chance of being free from pollution and degradation, thereby not making the next generation face social, economic, and environmental assets that are degraded, and therefore, diminished wealth.

WASTE GENERATION AND ROA

Results further show that waste generation is negatively and insignificantly related to ROA. The results agree with those of Baah et al. (2021) which found environmental performance to be negatively and insignificantly associated with financial performance. These results are further in agreement with the study of Azeez et al. (2024) which found a negative and insignificant relationship between environmental conservation practices and ROA, with waste management as one of the proxies. However, the findings are different from those of Emmanuel et al. (2024) which found waste generation as one of the sustainability indicators to have a positive yet insignificant relationship with ROA. The null hypothesis, $H4_o$, of no significant relationship between waste generation and ROA, is accepted given that the relationship between waste generation and ROA is negative and statistically insignificant. Despite the insignificant relationship found between the aforementioned variables, food and

beverage manufacturing companies should control the ways in which natural resources are utilised to avoid depletion and pollution, and improve eco-efficient practices in order to gain competitive advantage and enhance financial performance. In addition, different needs of different stakeholders, inclusive of the natural environment, should be addressed.

Conclusion

This paper aimed to analyse the effect of eco-efficiency (represented by energy consumption, water consumption, carbon emission and waste generation) on corporate return on assets (ROA). On the one hand, findings from the regression outputs show that two independent variables, namely energy consumption and water consumption, have a positive (although insignificant) effect on companies return on assets. On the other hand, the other two independent variables, carbon emission and waste generation, including the control variable, sales revenue, showed an insignificant and negative effect on return on assets.

Based on the results, this paper therefore concludes that energy consumption and water consumption in the South African food and beverage manufacturing sector may positively affect the return on assets growth. Furthermore, based on the results, the paper shows that carbon emission and waste generation may have a negative effect on the food and beverage companies' return on assets. At the theoretical level, this study contributes to the gap in literature analysing the effect of eco-efficiency variables on return on assets and other financial indicators for the food and beverage manufacturing sector. At the practical level, it is believed that the results of this study will motivate manufacturing industries to engage in eco-efficiency practices and to improve existing environmental investments and practices. Additionally, the results will assist with instilling thoughts of engaging in eco-efficiency practices in companies that engage in unsustainable business practices so that they contribute towards the achievement of SDG 12. Moreover, the study results provide insight for food and beverage manufacturing companies managers who pursue eco-efficiency practices while attaining greater financial performance. Commitment to eco-efficiency is viewed positively by companies' stakeholders such as green-minded consumers and investors that will likely associate with the green company, leading to great financial yields. The results further confirmed the stakeholder theory and the institutional theory. The stakeholder theory encourages companies to address the needs and interests of different stakeholders and eco-efficiency

is one of the ways of catering for such interests, whereas the institutional theory influences firms to adopt green practices. Given that at least two eco-efficiency variables out of the four used in this study revealed a positive effect on financial performance in the 10 years covered in this study, it is therefore believed that if manufacturing companies continue to minimise the use of energy and water and reduce carbon emission and waste generation, financial performance might be positively and significantly affected.

This study focused on examining the effect of eco-efficiency variables on ROA of JSE-listed food and beverage manufacturing companies and therefore results were limited to these companies only. The period of study was from 2012 to 2021; as such, the study was limited to 10 years. In addition, this study was limited to four eco-efficiency variables and only one financial performance variable, ROA. The study used only GMM to analyse secondary data from published annual integrated reports of food and beverage manufacturing companies.

The paper recommends future research on the effect of eco-efficiency variables used in this paper on other corporate performance metrics. Future research may also extent the time frame as the 10 years used in this paper might have been the companies' period of investment in eco-efficiency, which might have led to the negative effect of some eco-efficiency variables on ROA. In addition, future researchers may use methods such as Ordinary Least Square (OLS) or Auto Regressive Distributed Lag (ARDL) among others, to confirm the results obtained by this study. Future researchers can extend their focus to other countries as the study focused on companies listed in the Johannesburg Stock Exchange in South Africa.

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