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THE INFLUENCE OF ENVIRONMENTAL EFFICIENCY ON THE FINANCIAL PERFORMANCE OF JSE-LISTED FOOD AND BEVERAGE PRODUCERS

Анотація. *Компанії виробничого сектору широко визнаються одними з основних джерел забруднення довкілля, що зумовлює зростаюче занепокоєння щодо екологічних наслідків їхніх виробничих процесів. Високий рівень споживання енергії та води, викиди вуглецю та утворення відходів у процесі виробництва суттєво сприяють погіршенню стану навколишнього середовища в цій галузі. Додаткові екологічні виклики, такі як глобальне потепління, забруднення повітря та нестача води, лише посилюють ці ризики. У зв'язку з цим виникає нагальна потреба у пошуку альтернативних стратегій для зменшення негативного впливу промислових операцій на довкілля. Еко-ефективність розглядається як перспективний підхід до реструктуризації виробничих процесів з метою мінімізації їхнього екологічного сліду. Завдяки здатності зменшувати виснаження ресурсів і знижувати рівень забруднення, еко-ефективність визнається важливим інструментом досягнення сталого розвитку. Також поширеною є думка, що залучення компаній до екологічно відповідальної діяльності, зокрема спрямованої на підвищення еко-ефективності, може позитивно впливати на фінансові результати. У цьому дослідженні проаналізовано вплив еко-ефективності на чистий прибуток обраних компаній з виробництва продуктів харчування та напоїв, що котируються на Йоганнесбурзькій фондовій біржі (JSE), у період з 2012 по 2021 рік. Для оцінки взаємозв'язку між показниками еко-ефективності та чистим прибутком було використано модель узагальнених моментів (GMM). Дані отримано з опублікованих щорічних інтегрованих звітів обраних компаній. Результати аналізу засвідчили позитивний, але статистично незначущий зв'язок між енергозбереженням і чистим прибутком. Аналогічно, збереження води та скорочення викидів вуглецю також продемонстрували позитивну, але незначущу кореляцію з прибутком. Водночас скорочення відходів і виручка від продажу (використана як контрольна змінна) виявилися негативно пов'язаними з чистим прибутком. На основі отриманих результатів дослідження рекомендує компаніям активізувати зусилля щодо зниження споживання енергії та води, а також*

скорочення викидів вуглецю з метою підвищення прибутковості. Крім того, майбутні дослідження доцільно зосередити на впливі еко-ефективності на інші показники ефективності компаній, розширити часові межі панелі та охопити інші сектори економіки.

Ключові слова: *еко-ефективність, чистий прибуток, фінансова результативність, енергозбереження, водо-збереження, скорочення викидів вуглецю, скорочення відходів, виручка від продажу.*

JEL Classification: L25, Q5, M41, M21

Abstract. *A feldolgozóipari vállalatokat széles körben a környezetszennyezés fő okozóinak tekintik, ami egyre nagyobb aggodalomra ad okot gyártási folyamataik ökológiai hatásaival kapcsolatban. A gyártás során az energia- és vízfogyasztás, a szén-dioxid-kibocsátás és a hulladéktermelés magas szintje jelentősen hozzájárul az ágazat környezetszennyezéséhez. További környezeti kihívások, mint például a globális felmelegedés, a légszennyezés és a vízhiány tovább súlyosbítják ezeket a kockázatokat. Következésképpen sürgősen szükség van alternatív stratégiák meghatározására az ipari műveletekkel kapcsolatos környezeti hatások mérséklésére. Az ökológiai hatékonyság ígéretes megközelítésként jelent meg az ipari folyamatok átalakítására, hogy azok ökológiai lábnyomát a lehető legkisebbre csökkentsék. Az erőforrások kimerülésének és a szennyezésnek a csökkentése révén az öko-hatékonyságot a fenntartható fejlődés előmozdításának alapvető eszközeként ismerik el. Széles körben elterjedt az a nézet is, hogy a vállalati elkötelezettség a környezettudatos gyakorlatok iránt, beleértve az öko-hatékonyságot fokozó gyakorlatokat is, pozitívan befolyásolhatja a pénzügyi teljesítményt. Ez a tanulmány a 2012-2021 közötti időszakban a Johannesburgi Értéktőzsdén (JSE) jegyzett, kiválasztott élelmiszer- és italgyártó vállalatok esetében vizsgálja az öko-hatékonyság hatását a vállalati nettó nyereségre. Az öko-hatékonysági mutatók és a nettó nyereség közötti kapcsolat értékelésére a GMM-modellt (Generalized Method of Moments) alkalmazták. Az adatokat a kiválasztott vállalatok közzétett éves integrált jelentéseiből gyűjtötték. Az elemzés pozitív, de statisztikailag jelentéktelen kapcsolatot mutatott ki az energiatakarékosság és a nettó nyereség között. Hasonlóképpen, a víztakarékosság és a szén-dioxid-kibocsátás csökkentése is pozitív, de nem szignifikáns kapcsolatban állt a nettó nyereséggel. Ezzel szemben a hulladékcsökkentés és az árbevétel (kontrollváltozóként használt) negatív kapcsolatot mutatott a nettó nyereséggel. Ezen eredmények alapján a tanulmány azt javasolja, hogy a vállalatok fokozzák az energia- és vízfogyasztás csökkentésére és a szén-dioxid-kibocsátás minimalizálására irányuló erőfeszítéseiket a nyereségesség növelése érdekében. Emellett a jövőbeli kutatásoknak fel kell tárniuk az öko-hatékonyság hatását a vállalati teljesítmény más mutatóira, hosszabb időszakokat kell figyelembe venniük, és ki kell terjeszteniük a hatókörüket a gazdaság más ágazataira is.*

Kulcsszavak*: ökohatékonyság, nettó nyereség, pénzügyi teljesítmény, energiatakarékosság, víztakarékosság, szén-dioxid-kibocsátás csökkentése, hulladékcsökkentés, árbevétel.*

Abstract*. Companies operating in the manufacturing sector are commonly perceived as the primary contributors to environmental pollution, leading to increasing apprehension regarding the environmental issues arising from their production processes. These companies' consumption of energy and water, carbon emission, and waste generated during the production process contribute significantly to environmental pollution experienced within the industry. Other challenges that present substantial risks to the conservation of the environment include among others, global warming, air pollution, and water scarcity. Hence, it becomes imperative to seek alternative strategies to address the environmental challenges encountered by businesses during the execution of production operations. As a result, eco-efficiency represents a potential approach for restructuring industrial operations and activities with the aim of reducing the adverse environmental effects of businesses. Due to its ability to reduce resource depletion and to decrease pollution, eco-efficiency is regarded as a valuable tool for achieving sustainable development. It is also believed that if industries commit to environmental protection activities such as engagement in activities that promote eco-efficiency, financial performance can be improved. This paper therefore measured the effect of eco-efficiency on corporate net profit for selected*

Johannesburg Stock Exchange listed food and beverage manufacturing companies for the period 2012 to 2021. The Generalised Method of Moment (GMM) statistical model was used to measure the relationship between eco-efficiency and corporate net profit. Data were obtained from published annual integrated reports of the Johannesburg Stock Exchange (JSE) listed food and beverage manufacturing companies. In analysing the effect of energy conservation on corporate net profit, a positive yet insignificant relationship was revealed. Results further revealed that water conservation is positively yet insignificantly related to net profit. In the same vein, carbon reduction was found to be positively and insignificantly related to net profit. On the other hand, waste reduction and sales revenue (control variable) are negatively related to net profit. Therefore, the paper recommends that companies should minimise the consumption of energy and water and reduce carbon emissions to enhance corporate net profit. The paper further recommends future research on the effect of eco-efficiency on other company success indicators. Future research may expand the panel years beyond ten years and focus on other sectors.

***Keywords**: eco-efficiency, net profit, financial performance, energy conservation, water conservation, carbon reduction, waste reduction, sales revenue.*

Problem statement. The manufacturing sector is perceived as the main contributor to environmental pollution, leading to increasing apprehension regarding the environmental issues arising from their production processes. The consumption of energy and water, carbon emission, and waste generated by companies in this sector during the production process contribute significantly to environmental pollution experienced within the industry [1]. Other challenges that present substantial risks to the conservation of the environment include among others, global warming, air pollution, and water scarcity [2]. In view of these growing concerns about emerging environmental problems resulting from industrial activities, eco-efficiency has become a targeted subject among scholars throughout the world [3]. Several countries, including the Republic of South Africa have collaborated in establishing national environmental regulations that govern the environmental practices of manufacturing industries [4; 5; 6]. However, industries persist in contaminating the environment by emitting carbon, indulging in excessive water and energy consumption, and unsustainably depleting natural resources, consequently negatively impacting the planet [7]. Hence, it becomes imperative to seek alternative strategies to address the environmental challenges resulting from businesses' activities during the execution of production operations ([8].

As a result, eco-efficiency represents a potential approach for restructuring industrial operations and activities with the aim of reducing the adverse environmental effects of businesses [9; 10]. Because of its ability to reduce resource depletion and decrease pollution, eco-efficiency is regarded as a valuable tool for achieving sustainable development [11]. Furthermore, the Paris Agreement was ratified during the United Nations Climate Change Conference with the objectives of mitigating global warming through the reduction of greenhouse gas emissions and establishing net zero emission benchmarks for industrial operations [12]. Failure to tackle the matter of industrial environmental sustainability through the adoption of eco-efficient practices will result in Sustainable Development Goal 12 (SDG 12) objectives merely serving as rhetoric.

Several researchers have examined the correlation between individual eco-efficiency variables and financial performance variables, revealing different results. For instance, [13] discovered that the reuse of water has the potential to improve water conservation practices in manufacturing enterprises. On the other hand, [14] affirm that manufacturing companies can enhance their financial performance by engaging in the production of goods and services that promote environmental protection, thus boosting eco-efficiency. [15;16] have also looked at the financial implications of individual variables of eco-efficiency. Despite the existing research on the link between individual eco-efficiency variables and financial performance, there is a need to combine the four major eco-efficiency variables, which are, energy conservation, water conservation, carbon reduction and waste reduction, to establish their relationship with financial performance. Based on the researcher's review, little previous research exists on the effect of combined eco-efficiency variables on financial performance. However, the researcher could not find evidence of a similar previous research, which has used a combination of four eco-efficiency variables (energy, water, carbon, and waste) within the JSE listed food and beverage manufacturing companies, to assess their financial implication, hence, a gap exists in the literature. This paper therefore analyses the effect of eco-efficiency (energy conservation, water conservation, carbon reduction, and waste reduction) on corporate net profit (NP) for selected food and beverage manufacturing companies listed on the Johannesburg Stock Exchange (JSE).

Literature review. This section presents the literature as follows: energy conservation and NP, water conservation and NP, carbon reduction and NP, and waste reduction and NP.

Energy conservation and NP. The modern manufacturing industry's excessive energy consumption is a major contributor to harmful emissions and environmental degradation [17]. To effectively combat climate change, an urgent action needs to be taken to significantly reduce these emission levels and reverse the damaging effects. Immediate and decisive steps are required to address this critical issue and safeguard the planet's future. Some researchers suggest energy efficiency models or approaches, whereas other studies reveal that manufacturing firms utilizing production methods that require less energy attain strong financial outcomes [18;19]. For example, the study of [20] found green investment to have a positive and significant relationship with financial performance, with NP as one of the variables. In contrast, the study of [21] found no significant relationship between energy saving and NP. In spite of the differences in findings from the aforementioned studies, publicly listed manufacturing companies should invest in energy efficiency initiatives to improve operational efficiency in addition to compliance.

Water conservation and NP. The initial measure in achieving environmental sustainability involves ensuring that the resources utilized, such as water and various materials, are sourced from origins that do not inflict harm on the environment [22]. Nevertheless, various manufacturing firms persist in their excessive consumption of water and other resources in a manner that is not sustainable, consequently having detrimental effects on the planet [7]. Some researchers suggest that manufacturing firms have the potential to conserve water while simultaneously reaping significant

advantages, including enhanced financial performance. For instance, [23] argues that reducing water consumption is essential for achieving a balance between sustainability and profitability and that companies that implement water-saving strategies and practices are likely to experience increased profits. Researcher such as [24] has found water use efficiency to have an insignificant effect on net profit margin. On the other hand, [25] postulate that financial performance can be enhanced by making sure water management plans and activities are properly disclosed. Manufacturing companies should also empower their employees to adopt more sustainable practices in order to minimize wasteful water usage.

Carbon reduction and NP. Carbon emissions result from multiple sources during the consumption of energy and the combustion process [26]. These emissions pose a serious threat to the planet such as global warming. The research conducted by [27] indicates that manufacturing firms have the potential to mitigate global warming by significantly lowering carbon dioxide emissions associated with excessive energy consumption. Additionally, the aforementioned researchers highlight the importance of avoiding technologies that contribute to climate change and global warming. On the other hand, [28; 29; 30] propose that manufacturing firms aiming to enhance their competitive edge and achieve positive financial outcomes should consider leveraging carbon performance as a foundational strategy. Conversely, [31] firms with high carbon emission face challenges of increased costs that negatively and insignificantly affect profitability. Nevertheless, an inverse relationship appears to exist between carbon reduction efforts and overall financial performance.

Waste reduction and NP. The manufacturing processes that transform raw materials into finished goods produce waste, which considerably exacerbates environmental pollution and presents substantial risks to both the ecosystem and its inhabitants [1]. The research conducted by [32] and [33], posits that manufacturing enterprises can implement strategies encompassing reduction, reuse, recycling, reclamation, recovery, and restoration within their production processes to effectively manage the waste generated. [34] and [35], assert that the effective implementation of the strategies discussed will significantly reduce both raw material usage and waste. Consequently, this reduction will lead to a decrease in all production-related costs, ultimately enhancing overall financial performance. Many studies have been conducted to investigate the effect of waste reduction on financial performance and found different results. For example, [36] found that waste management practices exert an insignificant impact on the net profit of the firms being examined. In contrast, [37] identified a significant positive correlation between waste management and net profit margin. Despite the diverse dynamics of relationships identified and the associated costs linked to the development and implementation of waste reduction strategies, manufacturing firms should not be deterred. Rather, they ought to enhance their investments in waste reduction initiatives to mitigate waste generation, thereby striving to prevent pollution.

Research aims and objectives. This paper is built on the premise that industries are polluting the environment through high energy and water usage, huge amounts of carbon emitted, and waste generated. Therefore, the paper sought to measure the relationship between eco-efficiency and net profit.

Methodology. This section investigates the potential link between eco-efficiency metrics and net profit (NP) for 14 food and beverage manufacturing companies listed on the Johannesburg Stock Exchange (JSE), considering their manufacturing operations as a source of environmental pollution. The data utilized in this study was acquired from the published annual integrated reports of a selection of companies spanning the years 2012 to 2021[38]. The selected timeframe was chosen based on the belief that any modifications to laws and regulations concerning eco-efficiency might have been implemented. The panel multiple linear regression analysis was employed to ascertain and evaluate the correlation between eco-efficiency variables and net profit. For analysis, the paper uses the model regressions below:

$$NP_{it} = \alpha_i + \beta_1\ \mathrm{ENRCON}_{it} + \beta_2\ \mathrm{WATCON}_{it} + \beta_3\ \mathrm{CAREMM}_{it} + \beta_4\ \mathrm{WASGEN}_{it} + \beta_5\ \mathrm{SALREV}_{it} + \varepsilon_{it},$$

ε = error term

α = constant

β = Beta is representing coefficients explaining the partial elasticities of explanatory variable

it = the i represents company and the t represents the year

Description of variables is presented in Table 1.

Table 1- Description of variables*

Acronym/Abbreviation	Name of the acronym	Measurement of data	Source of data
NP	Net profit	In Rand amounts per year	Annual integrated reports
ENRCON	Energy consumption	In kilowatts of energy per year	Annual integrated reports
WATCON	Water consumption	In kiloliters 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

**Source: Authors' own construct*

It is therefore worth noting that it is the concepts of energy conservation, water conservation, carbon reduction and waste reduction that will be used in the analysis, discussion, and conclusions to align with the aim of this study. The aim of this study was to examine the effect that the four eco-efficiency variables have on NP.

Results and discussions.

Descriptive analysis. There 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 for NP as a dependent variable was 12.425, whereas the mean for independent variables: energy conservation, water conservation, carbon reduction and

waste reduction were 17.968; 13.358; 12.755 and 14.730, respectively. Moreover, the mean for control variable, sales revenue was 18.298.

Table 2 - Summary Statistics*

	NP	ENRCON	WATCON	CAREMM	WASGEN	SALREV
Mean	12,425	17.968	13.358	12.755	14.730	18.298
Standard Error	2.249	0.222	0.444	0.159	0.254	0.233
Median	0,121	18.084	13.894	12.701	14.314	17.149
Std Dev	26.610	2.629	5.252	1.876	3.011	2.751
Kurtosis	4.341	-0.064	5.910	2.907	1.086	-0.907
Skewness	1.584	-0.025	-2.310	0.270	0.560	0.603
Range	197.559	11.991	25.824	11.330	15.130	9.173
Minimum	-82.344	12.210	-5.032	6.995	7.837	14.436
Maximum	115.216	24.201	20.792	18.325	22.968	23.609
Count	140	140	140	140	140	140

**Source: STATA software*

Results further showed standard deviation for the dependent variable NP as 26.610. In addition, the standard deviation for energy conservation, water conservation, carbon reduction and waste reduction were 2.629; 5.252; 1.876 and 3.011, respectively.

For the control variable, sales revenue, the standard deviation was 2.751. When a standard deviation exceeds the mean, it is considered widely dispersed. The standard deviation for NP of 26.610 is greater than its mean of 12.425.

This implies that NP is widely dispersed. However, the standard deviation for energy conservation, water conservation, carbon reduction and waste reduction are less than their mean. This is an indication that the abovementioned independent variables are not widely dispersed. In the same vein, the standard deviation for control variable, sales revenue, is less than the mean. This implies that sales revenue is also not widely dispersed.

Correlation Matrix. This section displays the correlation matrix, which reveals the degree of association between a given independent variable and its respective data points, as well as the interdependencies among multiple independent variables.

The correlation between energy conservation and NP is negative and extremely weak shown in Table 3 as -0.029. On the other hand, water conservation is positively correlated with NP shown as 0.110, although the correlation is weak. As with water conservation, the correlation between carbon reduction and NP is also positive but weak shown as 0.144. Results further revealed an extremely weak correlation between waste reduction and NP shown as -0.011. Lastly, sales revenue showed a negative yet moderate correlation with -0.429.

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reduction and NP shown as -0.011. Lastly, sales revenue showed a negative yet moderate correlation with -0.429.

Table 3 - Pearson Correlation*

	NP	ENRCON	WATCON	CAREMM	WASGEN	SALREV
NP	1					
ENRCON	-0.029	1				
WATCON	0.110	-0.148	1			
CAREMM	0.144	0.181	-0.075	1		
WASGEN	-0.011	0.251	-0.120	0.235	1	
SALREV	-0.429	0.039	0.173	-0.044	0.004	1

**Source: STATA software*

Unit root test. The analysis employs the Levin-Lin-Chu unit-root test to assess the stationarity of the panels utilized in the research. The findings are detailed in Table 4. Under the null hypothesis, the panels are classified as non-stationary, whereas the alternative hypothesis posits that they are stationary. A significance level of 0.05 (5%) is established; any p-value falling below this threshold is considered significant, thereby supporting the acceptance of the alternative hypothesis and the rejection of the null hypothesis.

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

**Source: Author's computation*

The results in Table 4 indicate that, with the exception of water conservation, the p-values for all panels fall below the 5% significance threshold.

This substantial evidence in favour of the alternative hypothesis, which posits the stationarity of the panels, warrants the rejection of the null hypothesis. The presence of stationarity implies the absence of a unit root, which is desirable, as datasets with a unit root are prone to producing disingenuous interpretations [39].

Cointegration tests. The Pedroni panel cointegration test utilizes eleven statistics to assess the alternative hypothesis of cointegration among the variables within the estimated model, contrasted against the null hypothesis of no cointegration [40]. Among these statistics, seven are categorized as standard statistics, while four are designated as weighted statistics. Table 5 presents a summary of the cointegration results, detailing the outcomes for all eleven statistics.

The critical value is established at 5%, whereby the alternative hypothesis indicates the presence of cointegration, in contrast to the null hypothesis, which posits its absence. Acceptance of the alternative hypothesis occurs when the p-value falls below 0.05. As indicated in Table 5, six out of the eleven statistics yield values less than 0.05, thereby rendering the rejection of the null hypothesis of non-cointegration. Consequently, it is concluded that a long-term relationship exists, as the alternative hypothesis endorsing cointegration is supported.

Table 5 - Summary of Pedroni panel cointegration tests*

	Probability	
Panel	Statistics	Weighted statistics
"Panel v-Statistics"	0.9804	0.9567
"Panel rho-statistics"	1.0000	0.9999
"Panel PP-statistics"	0.0000	0.0000
"Panel ADF statistics"	0.0207	0.0006
Group		
"Group rho-Statistics"	1.0000	-
"Group-PP-Statistics"	0.0000	-
"Group ADF Statistics"	0.0000	-

**Source: Author's computation*

Diagnostic tests. Diagnostic tests are crucial in panel data analysis as inaccuracies in model results can be revealed, particularly when researchers overlook the implications of violating regression assumptions. In line with previous studies such as that of [41], the researcher conducted diagnostic tests on panel data to detect existing abnormalities and misspecifications that could compromise the reliability and accuracy of estimators. Specifically, the researcher employed the VAR residual test to identify heteroscedasticity, the Wooldridge test to detect autocorrelation, and the Jarque-Bera test in conjunction with the Kurtosis for normality testing.

VAR residual heteroscedasticity tests. The research employed VAR residual heteroscedasticity tests to determine whether the data was influenced by heteroscedasticity. These tests operate under the null hypothesis of heteroscedasticity, which stands in contrast to the alternative hypothesis of homoscedasticity. It is important to highlight that the preferred situation is homoscedasticity within the evaluated model, which is realized when the computed probability value exceeds 0.05. However, as indicated by the results presented in Table 6, the null hypothesis of heteroscedasticity is accepted since the computed probability value falls below 0.05.

Table 6 - Abridged Results of Heteroscedasticity*

TEST NAME	**Probability value**	**Decision**
Heteroscedasticity with Cross Terms NP	0.0011	Accept Null

**Source: E-views Outcomes*

Autocorrelation tests. If the p-value is greater than 0.05, the null hypothesis is accepted. In contrast, when the p-value is less than 0.05, the null hypothesis is usually rejected. The null hypothesis asserts the nonexistence of first-order autocorrelation, while the alternative hypothesis argues for its presence. The obtained results indicate a p-value of 0.0639, which exceeds the 0.05 threshold. Therefore, the null hypothesis is accepted, implying that first-order autocorrelation is absent.

Table 7 - Wooldridge test results*

F (1,13)		4.103
Prob > F		0.0639

**Source: STATA software*

Normality tests. Figure 1 presents normality tests results.

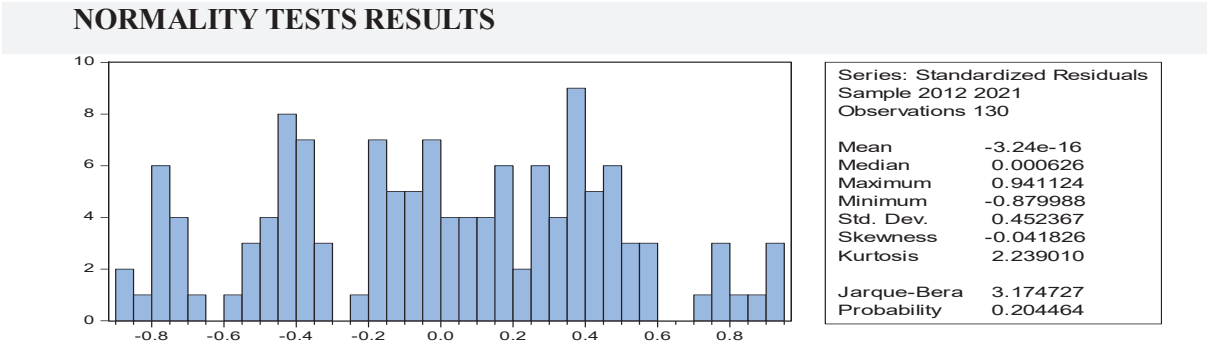

Fig. 1. Normality test results
**Source: E-Views 9.0 output*

For a dataset to be considered normally distributed, the Jarque-Bera probability value must be non-significant, and the Kurtosis should approximate a value of 3. An examination of Figure 1 reveals that the residuals exhibit a normal distribution, as indicated by the Jarque-Bera probability value exceeding the threshold of 0.05.

Hausman tests. Hausman distinguishes between FE model and RE models in panel data. Table 8 illustrates the findings of the Hausman test.

Table 8 - Hausman Tests*

	Coefficients		(b-B)	Standard Error
	(b) FE	(B) RE	Difference	
ENRCON	.6424584	.705593	-.0631346	.1589367
WATCON	-.5729104	.2618159	-.8347263	1.0657754
CAREMM	-.50349	.1546737	-.2050226	.4550981
WASGEN	.0176068	-.1694665	.1870733	.3494892
SALREV	.6192986	-1.962006	2.581304	1.580629

**Source: STATA software*

b = consistency with the Ho and Ha
B = inconsistency with the Ha. and efficient within Ho
Test: Ho: the differences in the coefficients are not systematic
chi2(3) = (b-B).'[(V_b-V_B). ^(-1)] (b-B) = 4.23
Prob>chi2 = 0.5169

A p-value below 0.05 indicates that the null hypothesis should be rejected, whereas a p-value above 0.05 suggests that the null hypothesis should be retained. Although the FE model is favoured according to the alternative hypothesis, the RE model is deemed

preferable when adhering to the null hypothesis. The Hausman test results indicate a p-value of 0.5169, thereby confirming that the RE model is the suitable choice for this analysis.

Random effect results. Table 9 reveals that energy conservation is positively and insignificantly related to the dependent variable (NP). Water conservation is also positively and insignificantly related to NP. The results further show carbon reduction to be positively yet insignificantly associated with NP. However, the relationship between waste reduction and NP is negative and insignificant. Lastly, the relationship between sales revenue and NP is negative and insignificant.

Table 9 - Random effect results*

	NP
ENRCON	0.706 (0.659)
WATCON	0.262 (0.887)
CAREMM	0.155 (1.247)
WASGEN	-0.169 (0.750)
SALREV	-1.962 (1.590)
_cons	32.675 (36.082)
Number of obs	140
Number of groups	14
R-sq	0.3102
Prob>chi2	0.7618
Prob>F	0.7241
Prob>chibar2	0.0000

**Source: STATA software*

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

Although the random effects model was favoured, it presented challenges related to heteroscedasticity within the panel data, issues that are not addressed by the random effects model. Consequently, the analysis was expanded to incorporate Generalized Method of Moments (GMM) in order to enhance the robustness of the findings and to adequately address the concerns of heteroscedasticity.

Extended analysis using Generalised Methods of Moments. GMM is well-established for removing all aspects of indigeneity from the panel model, while considering unobserved, time-invariant country-specific effects [42]. Although RE is generally favoured over FE according to Hausman tests, it possesses certain drawbacks. One major assumption of RE is that it relies on the normal distribution of its errors, which is not universally applicable. In this research, the analysis of VAR tests for heteroscedasticity presented in Table 6 indicates the presence of heteroscedasticity, which is less than ideal. To address the issues of heteroscedasticity, present in panel

data, this study utilizes GMM, which is advantageous in managing serial correlation, heteroscedasticity, and non-normal distribution challenges [43]. Additionally, this estimator is recognized for its capability to minimize standard errors and display greater robustness against heteroscedasticity in panel data [44]. GMM offers a clear methodology for assessing model specifications, thereby enhancing the overall reliability of the analysis.

Generalized method of moments results. Results from Table 10 show that energy conservation is positively and insignificantly related to the dependent variable (NP). Water conservation is also positively and insignificantly related to NP. The results further show carbon reduction to be positively yet insignificantly associated with NP. The correlation between waste reduction and NP is insignificant and negative. Ultimately, the correlation between sales revenue and NP is also negative and insignificant.

Table 10 - GMM results*

	NP
Dependent (constant)	0.205** (0.094)
ENRCON	0.967 (0.597)
WATCON	0.566 (1.594)
CAREMM	1.203 (2.105)
WASGEN	-0.609 (0.381)
SALREV	-0.373 (1.217)
_cons	-14.235 (39.214)
Number of obs	140
Number of groups	14
R-sq	0.0025
Prob>chi2	0.0001
Prob>F	0.0501
Prob>chibar2	0.0328

**Source: STATA software*

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

Discussion of findings. The results show that energy conservation is positively and insignificantly related to NP. These results are in line with those of [18] which found energy savings to have an insignificant relationship with profitability. In addition, a positive relationship between energy conservation and NP indicates an alignment with the stakeholder theory which postulates that a company ought to be managed in the interests of its entire stakeholders [45]. Moreover, this positive relationship between the aforementioned variables is in line with the institutional theory which explicate ways in

which manufacturing companies use natural resources to avoid depletion and pollution and improve eco-efficient practices to gain competitive advantage and financial performance. However, the results contradict which those of [20], which revealed a positive relationship when examining how green investments measured by energy conservation and emission reduction affect financial performance measured by NP and Tobins Q among others. The relationship was statistically significant.

Results further show a positive but insignificant relationship between water conservation and NP. These results agree with those of [24] which found an insignificant relationship between water conservation and NP. However, the study contrast with that of [25] which found a positive significant relationship between corporate water disclosure and financial performance (EPS, ROA, and net profit margin) of companies listed on JSE. The results further show carbon reduction to be positively yet insignificantly associated with NP. These results support those of [28; 29; 30] which propose that manufacturing firms aiming to enhance their competitive edge and achieve positive financial outcomes should consider leveraging carbon performance as a foundational strategy. Conversely, [31] found an insignificant negative effect of carbon emission on profitability.

The relationship between waste reduction and NP is negative and insignificant. As postulated by the stakeholder theory, some firms create value for their stakeholders by meeting their expectations and that enhances financial performance [46]. These results are in support of those of [36] which found that waste management practices exert an insignificant impact on the net profit margin. The results contradict those of [37] which identified a significant positive relationship between waste management and net profit margin.

Conclusions and prospects for further research. This paper aimed to analyse the effect of eco-efficiency (represented by energy conservation, water conservation, carbon reduction and waste reduction) on corporate net profit (NP) of food and beverage manufacturing companies listed on the Johannesburg Stock Exchange. These companies are seen as the greatest polluters of the environment. Findings from the regression outputs show that three independent variables namely energy conservation, water conservation and carbon reduction have a positive (although insignificant) effect on corporate NP. On the other hand, waste generation and the control variable, sales revenue, showed an insignificant and negative effect on corporate NP.

At the theoretical level, this study contributes to the gap in literature in analysing the effect of eco-efficiency variables on corporate net profit and other financial indicators for the food and beverage manufacturing sector. At the practical level, managers are encouraged to reduce energy and water consumption, as well as carbon emissions, to enhance the net profit for food and beverage manufacturers, which corroborates extant studies' findings on the catalytic effect of eco-efficiency on financial indicators [47]. As such, the paper urges companies to prioritize eco-efficiency measures to boost their profitability. Stakeholders, including environmentally conscious consumers and investors, tend to view a commitment to eco-efficiency in a positive light, potentially resulting in strong financial returns for the company. The results are further in support with the stakeholder theory and the institutional theory. The

stakeholder theory promotes companies to consider the needs and interests of various stakeholders, with eco-efficiency being one method of meeting these interests, while the institutional theory pushes firms to implement environmentally friendly practices. It is believed that if manufacturing companies continue to minimise energy and water use, as well as reduce carbon emissions and waste generation, financial performance may be positively and significantly impacted. This is because the majority of eco-efficiency variables used in this study showed a positive effect on financial performance during the 10 years covered in this study.

The results of this study were limited to food and beverage manufacturing companies because the main objective was to investigate how eco-efficiency variables affected the net profit (NP) of JSE listed food and beverage manufacturing companies. The study was restricted to a 10-year timeframe (2012 to 2021). Furthermore, this study used one financial performance variable, and four eco-efficiency variables. Thus, these four eco-efficiency variables were the only ones included in the results. To analyse secondary data from published annual integrated reports of food and beverage manufacturing companies listed on the Johannesburg stock exchange, the study exclusively used GMM. To validate the findings of this study, future researchers might employ techniques like Auto Regressive Distributed Lag (ARDL) and Ordinary Least Square (OLS), among others.

Future studies on the impact of eco-efficiency factors on other corporate performance indicators are suggested in the paper. In addition, future studies may extend the time period because the companies' eco-efficiency investments during the 10 years used in this paper may have had a negative impact on NP from some eco-efficiency variables. Since the study focused on food and beverage manufacturing companies listed on the Johannesburg Stock Exchange in South Africa, future researchers can broaden their focus to other sectors and other countries.

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