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Benchmarking Sustainable Performance in Shareholder Wealth Creation: A Data Envelopment Analysis Approach

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Abstract: The evaluation of companies' sustainability performance in generating shareholder wealth is increasingly reliant on environmental, social, and governance (ESG) ratings. This study introduces a novel approach by applying data envelopment analysis (DEA) as an alternative to conventional linear regression methods. A conceptual framework has been developed to integrate E-, S-, and G-scores into DEA models, enabling a more nuanced interpretation of whether a company's ESG efforts contribute to or undermine wealth creation. This approach also assesses the relative effectiveness of a company's ESG initiatives compared to its peers, taking into account key wealth creation variables. An empirical analysis was conducted on a sample of 80 listed South African companies, calculating the technical efficiency of each company. The findings indicate that linear regression analysis falls short in benchmarking individual companies' ESG efforts in relation to shareholder wealth creation. In contrast, DEA effectively addresses this challenge by offering a robust benchmarking tool. The practical implications of this study are significant, as the concepts of 'fruitless' and 'fruitful' ESG efforts introduced here provide companies with a transferable framework for comparing their sustainability performance against peers. The empirical application underscores the value of DEA in distinguishing between productive and counterproductive ESG strategies, thereby enhancing the precision of sustainability assessments in the context of shareholder wealth.

Keywords: Benchmarking; Data envelopment analysis (DEA); Environment, social and governance (ESG); Shareholders' wealth; Sustainability performance

JEL Classification: C670; M410; M140

1. Introduction

Disclosing non-financial information, such as a company's sustainability performance, is becoming of the utmost importance (Raimo et al., 2021). Investors and other stakeholders widely use ESG ratings to evaluate companies' sustainability performance (Aureli et al., 2020; Brogi & Lagasio, 2018; Repka et al., 2021). Sustainable performance refers to a company's ability to create value over time while considering its operational impact on the individual ESG components (Searcy, 2012). Some companies exploit it to achieve a competitive edge, while others perceive it as a standard operation (Ioannou & Serafeim, 2019).

Value creation refers to generating or increasing wealth for a company (Aydogmus et al., 2022). Any company's primary goal is to create wealth for its stakeholders by enhancing the value of the company (Correia et al., 2019). Therefore, creating value is essential for companies seeking to maintain a competitive edge while contributing positively to the broader economy and society (Henisz et al., 2019). By analysing key performance indicators using a selected approach, such as accounting performance, market performance, and company value, this study seeks to identify the best practices used by companies to enhance their sustainable performance in wealth creation.

Companies must question whether they should only focus on profits or enhance their sustainability performance by investing in sustainable activities that might or might not lead to increased wealth (Scholtens & Zhou, 2008). This implies that it is critical for companies to understand whether their sustainability performance led to wealth creation or if it is only a fruitless expense destroying shareholders' wealth (Dočekalová et al., 2022). Therefore, in the literature, there are two distinctive views regarding the sustainability performance and wealth creation of companies:

- One argument is that a company's superior sustainability performance (ESG rating) signals a positive reflection that attracts more stakeholders and consequently promotes the company's financial performance, which is essential to creating shareholders' wealth (Arvidsson & Dumay, 2021; Clément et al., 2022).
- An opposite argument is that ESG activities come at a cost to the company; inputs are made that reduce profits and consequently destroy shareholders' wealth (Janah & Sassi, 2021; Zumente & Bistrova, 2021).

Researchers attempted to prove which one of the arguments is confirmed by mostly applying linear regression analysis to determine how sustainability performance relates to companies' financial performance. They tested associations between companies' ESG, E-, S-, and G-scores and financial performance, primarily divided into accounting-based measures (e.g., return on equity (ROE), return on assets (ROA), return on capital employed (ROCE), etc.) and Tobin's Q as a market-based measure (Aydogmus et al., 2022; Brogi & Lagasio, 2018; Carnini Pulino et al., 2022; Elmghaamez et al., 2023; Giannopoulos et al., 2022; Hamdi et al., 2022; Hwang et al., 2021; Jha & Rangarajan, 2020; Johnson, 2020; Kalia & Aggarwal, 2023; McWilliams & Siegel, 2000; Rahman et al., 2023; Velte, 2017; Wingard & Vorster, 2001; Yang et al., 2022). Note that the above authors used different combinations of those measures in their studies.

Companies have started identifying ways to incorporate sustainability considerations into their cost-of-capital estimations (Bianchini & Gianfrate, 2018). This links to the backdrop that when a company's weighted average cost of capital (WACC) decreases, the value thereof increases (Hargrave, 2024; Rahman et al., 2023). Consequently, a few studies also added the WACC in their regression models to the above financial performance measure to obtain a broader view of shareholders' wealth creation, as the WACC is helpful in measuring a company's value (Atan et al., 2018; Johnson, 2020; Mans-Kemp & van der Lugt, 2020; Piechocka-Kałużna et al., 2021). By analysing the above studies which applied linear regression analysis, it shows that the debate about the two arguments continues since they yielded mixed results. Evidence from the above, for example, is that some studies (Carnini Pulino et al., 2022; Hamdi et al., 2022; Zhao et al., 2018) found that ESG performance positively impacts accounting-based performance measures, while Jha & Rangarajan (2020) found the opposite. Giannopoulos et al. (2022) found that ESG positively impacts Tobin's Q, while Jha & Rangarajan (2020) and Velte (2017) found the opposite. A meta-analysis study (Hussain et al., 2018) summarizes the mixed results well. The authors concluded that 14 studies found a positive relationship between ESG and financial performance, 11 found a negative relationship, and four were inconclusive.

Linear regression analysis applied in the above studies can examine assumptions regarding the nature and form of relationships between input and output variables. These relationships are used to describe a regression line, which accounts for the direction of causation between two variables (Asteriou & Hall, 2021). Therefore, linear regression analysis can answer the question of whether ESG in total, or which of its components, significantly impacts financial performance or wealth creation, and vice versa. For example, when financial performance is the dependent variable, a positive relationship supports the argument that ESG promotes shareholders' wealth, and a negative relationship supports the argument that ESG inputs come at a cost that destroys shareholders' wealth.

However, regression analysis cannot answer the research question: How can a company benchmark its efficiency, relative to its peers, in converting sustainability performance into wealth creation? The above two arguments can be summarized as either ESG efforts are fruitless and destroy wealth or ESG efforts promote wealth creation. Furthermore, companies would be interested in whether their ESG efforts are adequate relative to their peers, given the output in terms of financial performance/wealth creation. By linking the arguments with the research question, it can be refined as follows:

- How can a company benchmark whether or not its ESG efforts are fruitless, and if they are fruitless, to what extent?
- How can a company benchmark whether its ESG efforts are fruitful in generating wealth?

Another concern is that linear regression analysis typically only involves a single dependent variable, "Y," and one or more independent variables, "X". Therefore, regression analysis may face challenges when dealing with multiple input and output variables simultaneously. Therefore, an accounting-based measure such as ROE, a market-based measure such as Tobin's Q, and a value creation measure such as the WACC cannot be simultaneously accommodated in a single model to determine how the E-, S-, and G-scores impact them. What is needed is a benchmark model. DEA can be helpful in this regard. DEA measures performance against best practices rather than against average performance. Therefore, a DEA approach was utilised to evaluate and benchmark how efficiently the sustainable performance (ESG-scores) of companies is converted to wealth creation. DEA is defined as a non-parametric technique to calculate a relative ratio of weighted multiple outputs to weighted multiple inputs for each individual decision-making unit (DMU) (Ren et al., 2008; Tavana et al., 2023). This ratio is described as the *relative* efficiency score of the DMU (Avkiran, 2011) and is helpful for this study by using a *single aggregated score* to estimate how efficient a company is, relative to its peers, in converting E-, S-, and G-scores into ROE, Tobin's Q, and the WACC.

Mixed-method research was used to reach the objectives, which were as follows: firstly, to qualitatively develop a conceptual framework that contextualises companies' fruitless and fruitful efforts of converting ESG efforts into wealth creation; secondly, to develop two DEA models accommodating the fruitless and fruitful concepts; thirdly, the two DEA models will be quantitatively demonstrated in an empirical study to indicate how a sample of companies are *relatively* efficient in converting their ESG efforts into wealth creation; and fourthly, the benchmarking process for inefficient companies will be demonstrated.

This paper is primarily conceptual in nature, and a sample of companies demonstrates the concepts of "fruitless" and "fruitful". Only a limited number of companies were selected for the sample, as a generalisation of the results is not feasible because the efficiency results are not absolute as they are only measured relative to the selected sample companies. Nevertheless, the selected companies are peers, and each one's efficiency is only relative to that of the remaining companies in the sample.

ESG data was sourced from InvestVerte, an ESG rating provider, and the financial statement data was sourced from IRESS. A sample of 80 South African companies listed on the Johannesburg Stock Exchange (JSE) for 2022 was selected for the demonstration in the empirical study.

The following section is the Materials and Method section, which contains developing a DEA conceptual framework, discussions on sustainability performance, wealth creation, DEA, data for the empirical study, and descriptive statistics of the data. This is followed by the Results section, divided into the model specification, the estimation of technical efficiency, a discussion of the results, and a demonstration of benchmarking an inefficient company. The study is concluded in the final section.

2. Materials and Methods

2.1 Developing a Conceptual Framework

This paper introduces a novel contribution to the field by defining the concepts of fruitless and fruitful in the context of sustainability performance and wealth creation. It then examines how a company's technical efficiency in converting input variables-such as E-, S-, and G-scores-into output variables like ROE, Tobin's Q, and WACC, determines whether the company's conversion efforts are fruitless or fruitful.

The study's first objective is to develop a conceptual framework that contextualises companies' fruitless and fruitful efforts, built on the idea of Oberholzer et al. (2022), who used the term fruitless in a DEA analysis. According to Collins Dictionary (2024), fruitless implies, in the context of this study, input efforts that are unproductive or without successful results, whereas fruitful implies that input efforts produce good results.

The input-to-output ratio measures efficiency. A general benchmarking problem aims for the "less-the-better" for inputs and the "more-the-better" for outputs (Cook et al., 2014). Therefore, a company needs to lower its input and/or increase its output to improve efficiency. By using E-, S-, and G-scores as inputs, the dilemma is that companies strive for "more-the-better" to increase their sustainability performance score. However, this will harm their efficiency! The breakthrough achieved in this study concerns the development of a conceptual framework indicating how to present the E-, S-, and G-scores in two DEA models and interpret the results to determine whether companies' ESG efforts are fruitless and destroy wealth, or whether ESG efforts promote wealth creation, and whether companies' ESG efforts are fruitful relatively to their peers, given their ROE, Tobins' Q, and WACC. Therefore, the framework is presented against a backdrop to minimise inputs and maximise outputs for higher efficiency. In order for companies to improve efficiency, they should strive to lower inputs and/or increase outputs. To explain the concepts of fruitless and fruitful efforts, two models were developed. The ROE percentage (output) and ESG scores (input) used in the two models are random percentages to explain the concept.

2.1.1 Model 1: Fruitless effort

In Model 1, the concept of fruitless ESG efforts is conceptualised. This means that one company can have more or better sustainable performance (inputs) than another but still get the same output as the other company with fewer inputs. This implies that the efforts invested by the company with the higher ESG were fruitless, as more inputs yielded little fruitful impact on the outputs. In Table 1, both companies have an output of ROE = 10%, but Company A has an input of 50 ESG points, and Company B has 60 ESG points.

Table 1. Model 1: Fruitless effort

	Company A	**Company B**
Input (ESG score)	50	60
Output (ROE)	10%	10%
Relative efficiency	10/50 = 20% (efficient)	10/60 = 16.6% (inefficient)

Source: Authors' compilation

In this example, Company A is more efficient than Company B as Company A has a lower ESG score (50) than Company B (60), but still manages to achieve the same output (ROE=10%). This model implies that Company B's additional 10 points (60-50) in the ESG score (effort) were fruitless. In other words, Company B should have obtained the current output of 10% ROE with ten fewer ESG points. This does not imply that Company A's 50 ESG points are better than Company B's 60 ESG points, as we do not want to encourage Company B to lower its sustainability performance from 60 to the benchmark of 50 points. Remember, this is not a production function where the emphasis is all on the efficiency ratio. ESG is not a production function. This study is only concerned with the distance these companies are operating from the efficiency frontier.

2.1.2 Model 2: Fruitful

In this model, the efficiency will again be calculated by dividing the inputs by the outputs (Inputs/Outputs). The goal is to encourage companies to be fruitful and simultaneously increase their sustainability performance and wealth creation. In other words, they increase their ESG scores and ROE. The information is the same as in Model 1. However, as shown in Table 2, this model uses inverse inputs (1/input) to calculate efficiency. This means one (1) would be divided by the input to calculate an efficiency percentage.

In Table 2, Company A now has an input (ESG score) of 2%, whereas Company B has an input (ESG score) of 1.67%. This model illustrates that Company B's inverse input of 1.67% is better than Company A's inverse input of 2% because Company B used a lower percentage of inputs to achieve the same output as Company A. In other words, Company B's ESG score of 60 points is better than Company A's score of 50 points. This approach implies that Company A should move from using 2% input to 1.67% input to be efficient, as Company B only used 1.67% input and still achieved the same output of 10% ROE as Company A, who used 2% input. Thus, Company A should move from 50 ESG points to 60 ESG points when converted. The goal is to encourage companies to increase their ESG score to improve their sustainability performance. Therefore, when we look at Model 2, which uses inverse inputs, it is clear that companies should increase their ESG scores in order to be more efficient in wealth creation.

Table 2. Model 2: Fruitful effort

	Company A	**Company B**
Input (ESG score)	1/50 = 2%	1/60 = 1.67%
Output (ROE)	10%	10%
Relative efficiency	10/2 = 5 (inefficient)	10/1.67 = 5.99 (efficient)

Source: Authors' compilation

2.1.3 Interpretation of the models

What is learnt from Model 1 is, relative to Company A, that the inefficient Company B's 10 more ESG points (1) do not signal a positive reflection that attracts more stakeholders who can help to increase financial performance/shareholders' wealth, and (2) come as a cost and destroy shareholders' wealth. However, in Model 2, Company B is awarded for its higher ESG performance. What is learnt from Model 2 is, relative to Company B, the inefficient Company A's 10 less ESG points is not at the same sustainability performance level than its peer, given the ROE output of 10%.

2.2 Sustainability Performance

There are many definitions of sustainability or sustainable development. However, the report of Brundtland (2023) *Our Common Future*, which remains contemporary, states that "sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It measures a company's environmental, social, and economic impact. It is increasingly important as companies and governments recognise the need to address the challenges of climate change, resource depletion, and social inequality (Rajesh & Goswami, 2023). Recently, companies and investors have treated social and environmental risks as critical when making decisions about financing and investments. Businesses have become more responsible for addressing the environmental and social issues that their operations cause (Eccles & Klimenko, 2019). There are several methods for measuring sustainability performance, including ESG ratings. The fact that ESG can be broken down into its components allows for a more detailed analysis of a company's sustainability practices and their impact on the environment, society, and the economy (Li et al., 2021).

Eight of the top ten global risks in 2023 are related to ESG (World Economic Forum, 2023). These risks pertain to various sustainability challenges, such as natural disasters, climate change, cost-of-living crises, extreme weather events, natural resource crises, and geoeconomic confrontations. Overall, the evidence suggests that paying attention to ESG factors is essential for investors and companies, as it can lead to better financial performance, and sustainable and responsible business practices (Aggarwal, 2013). When considered collectively, ESG factors provide a holistic view of a company's sustainability and overall performance. The components of

ESG are described as follows:

• The "E" component pertains to environmental issues, which include factors such as, amongst other aspects, biodiversity, climate change, pollution, carbon emissions, water usage and water security, and utilisation of natural resources. An environmental score (E-score) is, therefore, a *quantification of a company's environmental impact* (Amel-Zadeh & Serafeim, 2018; Bissoondoyal-Bheenick et al., 2023; Horvathova, 2010).

• The "S" component encompasses social issues, which relate to factors such as, amongst other aspects, labour standards, human rights and community, health and safety, and customer responsibility. A social score (S-score) *quantifies a company's involvement with stakeholders* such as employees, communities, suppliers, and customers (Amel-Zadeh & Serafeim, 2018; Bissoondoyal-Bheenick et al., 2023; Henisz et al., 2019).

• The "G" component concerns governance issues, which connect to factors such as, amongst other aspects, risk management, anti-corruption, tax transparency, leadership, the board of directors, and corporate governance. Strong governance practices are associated with better financial performance, a lower risk of fraud and corruption, and increased transparency and accountability. Governance factors refer to *how a company is managed and governed* (Amel-Zadeh & Serafeim, 2018; Bissoondoyal-Bheenick et al., 2023; Rhodes, 2007).

Other studies were found that also applied DEA in their sustainability-economic performance research (Iazzolino et al., 2023; Janicka & Sajnóg, 2023; Tampakoudis et al., 2023). However, to the best of our knowledge, no other studies test companies' efficiency in converting all three ESG components' scores into wealth creation in the context of fruitless and fruitful wealth creation. For example, Iazzolino et al. (2023) investigated how ESG impacts European companies operating in different sectors. They tested the efficiency of how the inputs, total assets and total equity, are converted into earnings before interest/tax/depreciation/amortisation, revenues, and ESG scores. A related study tested the efficiency of how environmental performance, such as waste production, water and energy consumption, and CO_2 emissions, is converted into economic performance (Janicka & Sajnóg, 2023). Tampakoudis et al. (2023) used DEA to determine the efficiency of mutual funds during COVID-19. They then determined how those efficiency scores relate to ESG scores by using an analysis of variance (ANOVA).

2.3 Wealth Creation

Creating wealth sustainably is essential for companies seeking a competitive edge while contributing positively to the broader economy and society (Henisz et al., 2019). By analysing key performance indicators using an alternative selected approach, such as accounting performance, market performance, and WACC, this study seeks to identify the best practices in value creation that companies can adopt to enhance their sustainable performance.

Accounting performance provides insight into the financial health of companies. It involves measuring and evaluating an organisation's financial and operational performance using various accounting tools and techniques. The most common proxies used to measure the accounting performance of companies include financial ratios, such as profitability ratios (e.g., ROE, ROA, ROCE), efficiency ratios (e.g., asset turnover, inventory turnover), and liquidity ratios (e.g., current ratio, quick ratio) (Correia et al., 2019). Following similar studies also focusing on the association between sustainability performance and wealth creation (Brogi & Lagasio, 2018; Elmghaamez et al., 2023; Hussain et al., 2018; Jha & Rangarajan, 2020; Johnson, 2020; Kalia & Aggarwal, 2023; Wingard & Vorster, 2001), ROE was selected to represent the accounting-based measure since it is an overall indicator of a company's success in maximising wealth (Correia et al., 2019).

Market performance is a comprehensive evaluation of a company's activities, including its financial performance, customer satisfaction, and market share. The market performance of a company can be used to determine its ability to create value for its stakeholders, including investors, customers, employees, and society at large (Sarkar et al., 2001). Market performance can be measured using various metrics, including the price/earnings ratio, dividend yield, and earnings per share, but two commonly used methods are Tobin's Q and the market-to-book value ratio (Rahman et al., 2023; Robbetze et al., 2017). Following similar studies also focusing on the association between sustainability performance and wealth creation (Aydogmus et al., 2022; Brogi & Lagasio, 2018; Elmghaamez et al., 2023; Giannopoulos et al., 2022; Hussain et al., 2018; Jha & Rangarajan, 2020; Johnson, 2020; Rahman et al., 2023; Velte, 2017), we selected Tobin's Q in the study as it is a ratio of a company's market value to its replacement cost, representing all its physical assets. A value of 1 suggests that the market fairly values a company's assets (CFI Team, 2023). Therefore, a value of more than 1 suggests that a company's market value is higher than its replacement cost, indicating a positive market performance. In contrast, a value of less than 1 suggests a negative market performance.

Company valuation is a crucial aspect of finance that involves the estimation of a company's worth or value (Mukhtaruddin et al., 2019). In order to determine company value, various methods can be employed, including the WACC, which is a component in determining the value that was selected for this study. The WACC is a critical financial metric that companies and investors use to evaluate investment opportunities and assess the cost of financing (Damodaran, 2016). The WACC is calculated by considering the cost of equity, debt, and other sources of capital. It has been found that as a company's WACC increases, so does its level of risk, while the valuation of the company will decrease (Hargrave, 2024). Furthermore, it has been found that companies with a strong ESG performance were more likely to have lower costs of capital, higher valuations, and a more robust financial performance (Rahman et al., 2023). The capital funding of companies is made up of two main components, namely, the cost of debt and equity. Therefore, these financing sources are two of the WACC's most important components (Namany & Kissani, 2017). Following related studies (Atan et al., 2018; Johnson, 2020; Mans-Kemp & van der Lugt, 2020; Piechocka-Kałużna et al., 2021), we also selected WACC as a company value estimate.

2.4 DEA

2.4.1 Defining DEA

DEA is a non-parametric linear programming (extreme point) tool that assesses the comparative effectiveness of multiple outputs to multiple inputs ratios for a certain DMU (Wu et al., 2023). This helps to estimate the technical efficiency, which is the efficiency of converting multiple inputs into multiple outputs aggregated into a single score (Oberholzer, 2013; Tavana et al., 2023). Non-parametric is a field of statistics that focuses on analysing data that can only be measured on a nominal or ordinal scale, where calculations cannot be used (Kohl et al., 2019). Consequently, DEA uses a single model to estimate a company's efficiency by comparing how it transforms multiple inputs into multiple outputs relative to the peer companies that compete with each other in the same sample (Halkos & Salamouris, 2004; Liu & Wang, 2009). The underlying principle of DEA is that, if a particular company can produce units of output with a certain number of inputs, other companies should also be able to do the same if they are operating their business efficiently. It, therefore, identifies efficient companies that could be used as benchmarks for inefficient companies and potential areas for improvement (Avkiran, 1999).

An advantage of DEA is that it does not require assuming a functional relationship between inputs and outputs (Trick, 1998). Therefore, the selection of input and output variables is at the discretion of the analyst. However, this flexibility, combined with the linear programming extreme point distinction, may introduce noise, including symmetrical noise with a zero mean, which can lead to measurement errors (Trick, 1998).

DEA has mostly been used in terms of production theory in economics, but DEA can also be used as a benchmarking tool in operations management, where a specific set of measures is used to benchmark the performance of service and manufacturing operations (Zhu, 2015). In this article, DEA helps estimate technical efficiency (TE), which provides information on how well inputs, the components of ESG, are converted into outputs, the components of wealth creation (Avkiran, 1999; Coelli et al., 2005). Furthermore, the primary goal of DEA modeling is to identify the most efficient virtual company for each actual inefficient company and, subsequently, compare the inefficient company with its best virtual counterpart to determine its efficiency level. All the efficient companies generate an efficiency frontier, which serves as a benchmark line, where the virtual companies are also mapped. Companies not operating on this frontier are considered inefficient, and to achieve full efficiency, they must move towards this benchmark frontier (Oberholzer, 2014).

DEA can be used to measure input-oriented efficiency or output-oriented technical efficiency. input-oriented DEA measures how much a company can reduce its inputs while still maintaining the same level of output, which is recommended when a DMU can control its inputs better than it can control outputs; and output-oriented DEA, on the other hand, measures how much a company can increase its outputs while using the same level of inputs, which is recommended when outputs are more accessible to control than inputs (Coelli et al., 2005; Zubir et al., 2023). The following basic formulation of the DEA input-oriented model explains its principle, namely, that the efficiency of a DMU can only be estimated when a linear programming problem is created for each DMU (Zhu, 2007; Zhu, 2015):

$$\begin{aligned} &\theta^* = \min\theta \\ &\text{Subject to} \\ &\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{i0} \qquad i = 1, 2, \dots, m; \\ &\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0} \qquad r = 1, 2, \dots, s; \\ &\sum_{j=1}^{n} \lambda_j = 1 \\ &\lambda_j \geq 0 \qquad j = 1, 2, \dots, n. \end{aligned} \tag{1}$$

where, θ represents the input-oriented efficiency score of DMU_0. If θ=1, DMU_0 lies on the (best practice) frontier. If θ<1, DMU_0 does not lie on the frontier and should decrease its input levels. DMU_0 represents one of the n DMUs under review; x_{i0} and y_{r0} are respectively the ith input and rth output for DMU_0. Each observation, DMU_j (j = 1,...n), uses m inputs x_{ij} (i = 1,2,...,m) to produce s outputs y_{rj} (r = 1,2,...,s). These n observations will determine the efficiency frontier. The reference set indicates the extent to which inputs can be reduced, and outputs increased to make the DMU under evaluation efficient. The reference set provides coefficients (λ_j) that form a hypothetical efficient DMU. The non-zero most favourable λ_j represents the benchmarks for the specific DMU under evaluation. The output-oriented approach is similar; however, the functions of the inputs and the outputs are contradictory (Zhu, 2007; Zhu, 2015).

2.4.2 Variable return to scale (VRS) and constant return to scale (CRS)

Farrell (1957) was the first to propose a method for measuring productive efficiency considering all inputs. In response to Farrell's challenge to estimate the production function using either parametric or non-parametric linear technology, Charnes et al. (1978) developed the CCR DEA model in 1978 where multiple inputs are minimised while multiple outputs are maximised. This model measures the CRS model, assuming outputs linearly change with a change in inputs (Coelli et al., 2005). CRS is a significant assumption because it only works for a specific range of production levels since outputs increase in the same proportion as the inputs increase (Anderson, 2016).

Subsequently, Banker et al. (1984) developed the BCC DEA model, measuring the VRS, assuming that the economy's scale shifts if a DMU changes in size (Fancello et al., 2020; Zubir et al., 2023). VRS means that when inputs increase, outputs do not increase proportionally. In other words, if an organisation grows, its efficiency will change, either increasing or decreasing (Avkiran, 1999). VRS automatically assumes that every DMU is fully scale efficient (Coelli et al., 2005). Therefore, the difference between VRS and CRS efficiency is scale efficiency [Scale efficiency falls outside the scope of this study]. In the above Eq. (1), the constraint on $\sum_{j=1}^{n} \lambda_j$ determines the return to scale efficiency type. Eq. (1) demonstrates the more relaxed VRS approach. To obtain the CRS efficiency estimate then $\sum_{j=1}^{n} \lambda_j = 1$ needs to be removed and should be replaced by (Zhu, 2007):

$$\sum_{j=1}^{n} \lambda_j \leq 1 \tag{2}$$

2.5 Data for Empirical Study

This study applied the quantitative method to the empirical study. An exploratory study was conducted using cross-sectional data from secondary sources. ESG data was broken up into three components and obtained from an ESG rating provider, InvestVerte. Financial statement data, the ROE, Tobin's Q, and the WACC of each company were retrieved from the IRESS database.

For the demonstration, companies that operate in the industrial (36), consumer cyclical (27), and consumer defensive (17) sectors for the 2022 financial year were used. We assume they are peers for our demonstration purposes because these sectors are relatively comparable, making it easier to compare different companies' sustainability and financial performance. Eighty companies formed the convenient sample, as the researchers were initially dependent on the companies' data received from InvestVerte. Some of the companies' data in the IRESS database was incomplete, so those data were sourced directly from the companies' websites.

The major problem with the ESG scoring of ESG data retrieved from InvestVerte is that there is no universal scoring system (InvestVerte, 2023). InvestVerte statistically merged the information received from different ESG providers and sources of attributes that could explain the movement in ESG ratings. Their primary objective is to develop and maintain an internal and transparent scorecard, identifying the most pertinent ESG rating attributes for businesses operating in a specific sector. A final integrated joint model combines the quantitative (companies' financial ratios) and qualitative (ESG scores) data. A logistic regression analysis combines the quantitative and qualitative scores. The scores are then rescaled between 0, the weakest, and 100, the strongest.

2.5.1 Descriptive statistics

Descriptive statistics are a set of statistical tools used to summarise and describe the main features of a dataset. It provides information about the mean, median, standard deviation, and variability, i.e., the minimum and maximum of the data (Table 3).

From the ESG statistics, Table 3 indicates that the mean of the S-score is the highest (70.81%), followed by the G-score mean (66.32%) and the respectably lower E-score (48.19%). The table shows the minimum and maximum scores for the E-, S-, and G-components. The minimum and maximum S- and G-scores are relatively close to each other. A significant figure in the table is, for example, the minimum score for E is 24.61. This indicates that one of the companies is not sustainable at all in terms of its environmental impact. The relatively low standard deviation of the ESG components shows that the data are not widely spread around the mean. Therefore, the mean is a reliable representation of the data.

Regarding the wealth creation statistics, Table 3 indicates that ROE ranges from -75.67% to 461.24%, with an average of 17.94%. The table further shows that Tobin's Q ranges from 0.08 to 3.84, with an average of 1.03, which indicates that the market values the companies' assets as slightly higher than their replacement costs on average. The WACC ranges from a deficient 2.22% to 21.14%, with an average of 9.16%. The range between the minimum and maximum values for ROE, Tobin's Q, and WACC is relatively wide. This is confirmed by somewhat high standard deviations, which also implies that there may be outliers in the data. However, the outliers are not a problem, as DEA is a non-parametric method that works with rankings. However, an issue is that DEA software cannot accommodate negative values. Therefore, negative values (which exist in the ROE data) can be eliminated by adding 75.67% to each of the other companies' ROEs, but it may not accurately reflect the situation (Tampakoudis et al., 2023). In an effort not to distort the data, we adopted the approach of ranking the ROE data in order of profitability. Therefore, the minimum ROE% of -75.67% is ranked the lowest, the 1st place, and the maximum ROE% of 461% is ranked the highest, the 80th place.

Table 3. Descriptive statistics for sustainability performance and wealth creation measures

	ESG			Wealth creation		
	E-score (%)	**S-score (%)**	**G-score (%)**	**ROE (%)**	**Tobin's Q**	**WACC %**
Mean	48.19	70.81	66.32	17.94	1.03	9.16
Median	49.19	70.80	66.44	11.84	0.80	9.32
S. dev.	6.22	2.63	0.97	52.79	0.71	2.75
Minimum	24.61	64.40	64.08	-75.67	0.08	2.22
Maximum	57.99	75.80	68.62	461.24	3.84	21.14

Source: Calculated from data from InvestVerte and IRESS

3. Results and Discussion

3.1 Model Specification

The study's second objective was to develop two DEA models accommodating the fruitless and fruitful concepts. In Table 4, the inputs that were used in the DEA model represent the components of sustainability performance and are shown by X_1, X_2, and X_3. The three inputs shown in Table 4 are E, S, and G, which are the sustainability measures of each company. The outputs that are used in the DEA model, which represents the measures for value creation, are also shown in Table 4; this is represented by Y_1, Y_2, and Y_3, which represent ROE, Tobin's Q, and the WACC. Note that 1/WACC was used, as the lower the WACC of a company, the better the value creation performance. Therefore, we want the lowest possible WACC.

Both Model 1 and Model 2 aim to produce a single aggregated estimate of the technical efficiency of companies in converting the input variables into the output variables. Model 1 reveals how much of the ESG component's performance was fruitless in creating value. Using the inputs' *inverse* values, Model 2 reveals how fruitful a company is at creating wealth from its ESG performance.

In this article, we also focused on the input-oriented approach, as it may be easier for companies to control their ESG activities than it is to control the output components of value creation. Both the CRS and VRS approaches were applied according to Eqs. (1) and (2).

Table 4. DEA Model 1 and Model 2

	Model 1: Fruitless	**Model 2: Fruitful**
Inputs: Sustainability measures	X_1: E	X_1: 1/E
	X_2: S	X_2: 1/S
	X_3: G	X_3: 1/G
Outputs: Value Creation measures	Y_1: ROE	Y_1: ROE
	Y_2: Tobin's Q	Y_2: Tobin's Q
	Y_3: 1/WACC	Y_3: 1/WACC

Source: Authors' compilation

3.2 Estimating Technical Efficiency

The third objective of the study was to demonstrate the two DEA models in an empirical study. Therefore, the results for the sample of 80 JSE-listed companies are presented in Table 5. These results were obtained after DEA was applied to the data using the software of Zhu (2007).

Table 5 reveals the technical efficiency of both the VRS and CRS approaches, which are presented separately for Model 1 and Model 2. A total of 15 companies are fully efficient under Model 1 TE VRS, and 65 companies are inefficient. Under Model 1 TE CRS, six companies are fully efficient, and 74 are inefficient. For Model 2 under TE VRS, 19 companies are fully efficient, and 61 are inefficient. For TE CRS, only five companies are fully efficient, and 75 are inefficient. The results clearly show how the CRS approach, which assumes a company's inputs and outputs stay in the same ratio when the size changes, discriminates much more than the more relaxed VRS approach (Avkiran, 1999; Coelli et al., 2005).

Table 5. Input-orientated technical efficiency (n = 80)

Company	Model 1: Fruitless		Model 2: Fruitful		Company	Model 1: Fruitless		Model 2: Fruitful	
Number	**TE VRS**	**TE CRS**	**TE VRS**	**TE CRS**	**Number**	**TE VRS**	**TE CRS**	**TE VRS**	**TE CRS**
1	0.973	0.396	0.963	0.396	43	0.968	0.335	0.987	0.359
2	0.990	0.682	0.977	0.693	44	0.966	0.453	0.996	0.476
3	0.966	0.594	0.983	0.596	45	0.980	0.405	1.000	0.438
4	0.988	0.842	0.972	0.830	46	0.979	0.298	0.997	0.336
5	0.968	0.274	0.982	0.278	47	0.962	0.506	0.983	0.520
6	0.985	0.955	1.000	0.988	48	0.967	0.544	0.988	0.566
7	0.992	0.488	0.942	0.465	49	1.000	0.346	*0.934*	0.325
8	0.970	0.433	0.964	0.427	50	0.980	0.577	1.000	0.582
9	0.967	0.642	1.000	0.685	51	0.996	0.958	1.000	0.994
10	0.992	0.647	0.987	0.560	52	0.957	0.332	0.977	0.337
11	0.986	0.576	0.971	0.441	53	0.975	0.388	0.962	0.387
12	1.000	1.000	0.994	0.985	54	0.949	0.871	1.000	0.940
13	0.983	0.782	0.969	0.778	55	0.983	0.262	0.968	0.267
14	0.954	0.469	0.992	0.465	56	0.967	0.542	0.985	0.556
15	0.979	0.474	0.991	0.467	57	0.957	0.435	0.977	0.436
16	1.000	1.000	0.987	0.961	58	0.967	0.495	0.971	0.499
17	1.000	0.551	0.954	0.395	59	0.957	0.515	0.979	0.519
18	0.982	0.305	0.969	0.309	60	1.000	0.863	0.945	0.773
19	0.964	0.399	0.988	0.429	61	0.987	0.858	1.000	0.888
20	0.984	0.629	0.966	0.616	62	1.000	1.000	1.000	1.000
21	0.983	0.478	0.970	0.480	63	0.987	0.723	0.989	0.727
22	1.000	1.000	1.000	1.000	64	1.000	0.843	1.000	0.858
23	1.000	0.746	0.957	0.731	65	1.000	1.000	1.000	1.000
24	1.000	0.451	0.965	0.358	66	0.961	0.696	1.000	0.706
25	1.000	0.405	0.936	0.356	67	0.993	0.862	0.969	0.864
26	0.946	0.493	0.996	0.497	68	1.000	0.613	0.946	0.556
27	0.969	0.570	0.989	0.603	69	0.977	0.738	0.996	0.796
28	0.963	0.752	1.000	0.804	70	0.958	0.669	0.998	0.673
29	0.969	0.684	0.999	0.727	71	0.969	0.875	1.000	0.936
30	0.960	0.776	1.000	0.830	72	0.968	0.730	0.983	0.735
31	0.992	0.897	0.980	0.896	73	0.966	0.744	0.991	0.781
32	0.983	0.335	0.969	0.258	74	1.000	1.000	0.970	0.573
33	0.982	0.635	0.974	0.623	75	0.974	0.394	0.969	0.366
34	0.965	0.605	0.987	0.619	76	0.989	0.986	1.000	1.000
35	*0.945*	0.450	0.993	0.449	77	1.000	0.992	1.000	0.990
36	0.953	0.511	0.998	0.541	78	0.972	0.278	0.987	0.303
37	0.969	0.559	0.991	0.580	79	0.990	0.936	1.000	0.981
38	0.993	0.452	0.966	0.470	80	0.976	0.596	0.964	0.594
39	0.992	0.885	1.000	1.000					
40	0.970	0.856	0.979	0.849	**Min.**	**0.945**	**0.262**	**0.934**	**0.258**
41	0.963	0.655	0.989	0.688	**Max.**	**1.000**	**1.000**	**1.000**	**1.000**
42	0.987	0.897	0.999	0.915	**Mean**	**0.979**	**0.636**	**0.983**	**0.633**

Note: TE = technical efficiency; VRS = variable return to scale; CRS = constant return to scale
Source: Data from InvestVerte and IRESS analysed by the software of Zhu (2007)

The TE VRS mean value for Model 1 of 0.979 implies that the companies, on average, must reduce their inputs (ESG components' score) by 2.10% (1-0.979) to become fully efficient and operate on the efficiency frontier. As previously explained, we do not expect the companies to lower their ESG performance. The DEA conceptual framework we developed helps to interpret the results; we only indicate that 2.10% indicates fruitless ESG efforts; that is, it indicates the degree to which the ESG performance (efforts) is not converted into value creation.

Company 35, with the lowest TE VRS score of 0.945, indicates that 5.5% of their ESG efforts did not create wealth.

The stricter approach of CRS indicates a TE mean value for Model 1 of 63.6%, which implies that companies need to reduce, on average, their inputs by 36.4% (1-0.636) in order to become fully efficient. In the context of the conceptual framework, 36.4% represents the fruitless efforts where ESG performance did not create value for the companies.

For Model 2, the TE VRS mean value implies that inefficient companies must reduce their inputs by 1.7% (1-0.983) to operate on the efficiency frontier. As Model 2's ESG inputs are inverse values, it implies that the companies, on average, must increase their ESG performance by 1.7%. Therefore, based on our conceptual framework, we encourage companies to be fruitful by increasing their sustainability performance.

The TE CRS mean value for Model 2 of 0.633 implies that inefficient companies must reduce their inputs by 36.70% (1-0.633) to reach the efficiency frontier. According to our conceptual framework, this result encourages companies, on average, to increase their ESG performances by 36.7% to become fully efficient.

In the introduction, we argued that linear regression analysis applied in previous related studies examined assumptions regarding the nature and form of relationships between sustainability performance as the input (e.g., E-, S-, and G-scores) and wealth creation measures as output variables (e.g., ROE, Tobin's Q, and the WACC). Therefore, linear regression analysis can answer the question of whether ESG in total, or which of its components, significantly impacts wealth creation, and vice versa. Similar to several studies (Carnini Pulino et al., 2022; Giannopoulos et al., 2022; Hamdi et al., 2022; Jha & Rangarajan, 2020; Kalia & Aggarwal, 2023; Velte, 2017), we could have copied their approach by applying linear regression analysis to the study's data. Then, this study could have yielded results that indicate that the relationship between the dependent variable, alternatively ROE, Tobin's Q, or the WACC, is either significantly positive, significantly negative, or insignificant to the individual independent variables, namely the E-, S-, and G-scores. The study could then have concluded whether the E-, S-, and G-scores individually impact (or do not) each alternative dependent variable. As linear regression models can only accommodate a single independent variable, three separate analyses would have been needed.

However, linear regression cannot calculate the technical efficiency score for each of the companies relative to the remaining 79 companies in the sample. Nor could it indicate the degree to which a company's inputs should change to enable it to operate on the benchmark (efficiency) frontier. Furthermore, the DEA models allow for the inclusion of various sustainability inputs and multiple wealth creation outputs. Technical efficiency measures how effectively a company converts its E-, S-, and G-scores into ROE, Tobin's Q, and WACC. Consequently, a company can benchmark its performance against the top industry competitors. The practical benefit is that an inefficient company can precisely identify how far it is from the efficiency frontier. However, the analysis in Table 5 can tell how well a company is doing compared to the other 79 peer companies, but it cannot tell how it compares relatively to the "theoretical mean" (Trick, 1998).

By using the two models, fruitless (Model 1) and fruitful (Model 2), two different perspectives arise. Model 1 indicates that inefficient companies' superior ESG efforts are fruitless relative to their peers operating on the best practice (efficiency) frontier. The first reason is that their superior ESG efforts do not signal a positive reflection that attracts more stakeholders, which may help to increase financial performance, which consequently leads to shareholders' wealth. Secondly, the superior ESG efforts come at a cost to the company, destroying shareholders' wealth. Model 1 reveals that inefficient companies' ESG (1) signaling should be improved and (2) spending (cost) should be lowered on the following:

- Environmental, e.g., biodiversity, climate change, pollution, carbon emissions, water usage and water security, and utilisation of natural resources.
- Social, e.g., labour costs, human rights and community, health and safety, and customer responsibility.
- Governance, e.g., risk management, anti-corruption, tax transparency, leadership, the board of directors, and corporate governance.

Model 2 indicates that inefficient companies', relative to their peers operating on the best practice (efficiency) frontier, ESG efforts are not adequate, given the output variables. It reveals that inefficient companies' ESG efforts of the above-mentioned examples should be improved, to become fruitful by operating on the efficiency frontier. The following section outlines the simplest route to reach the efficiency frontier.

3.3 Demonstration of Benchmarking an Inefficient Company

The fourth objective was to demonstrate the benchmarking process for an inefficient company. Again, this demonstration only uses the input-oriented approach and only the VRS approach in Model 1 and Model 2, as the VRS approach is more flexible than the CRS approach because it does not assume that the DMUs are operating at constant returns to scale. This demonstration is an example of companies determining how much they must change inputs to become fully efficient. This demonstration is done in steps:

- Step 1: Obtain the company's current input and output values.
- Step 2: Obtain the target input and output values after applying DEA.
- Step 3: Determine the percentage that each input needs to change in order for the company to be efficient.
- Step 4: Identify the benchmark companies to determine how and with how much the company needs to change to operate on the efficiency frontier with the benchmark companies.

Model 1 (VRS approach): The software of Zhu (2007) used for DEA automatically generates the target values for inputs and outputs and the benchmark companies with their relevant percentages. Company 35, which is the most inefficient, was selected to demonstrate the benchmark process in this demonstration. Company 35's TE is 0.945, according to Model 1.

As presented in Table 6, this company's E-, S-, and G-scores need to decrease by 2.61, 3.87, and 3.75 points, respectively, to justify its current outputs. This implies that the higher current scores (Step 1) than the targets (Step 2) indicate that this company's extent of E, S, and G efforts were fruitless. Step 4: According to the software, the peer benchmark companies for Company 35 are 15.3% of Company 17, 22.5% of Company 23, 55.1% of Company 25, and 7.1% of Company 60.

Model 2 (VRS approach): Company 49 has the lowest TE VRS efficiency score of 0.934 and has been chosen to demonstrate the benchmark process in Model 2. According to the data in Table 6, this company needs to reduce its E-, S-, and G-scores by 0.002, 0.002, and 0.001, respectively. This company will be fruitful when converting the inverse values to the actual score if its E-, S-, and G-scores increase by 4.48, 5.57, and 4.45 to 51.53, 73.87, and 68.62 points, respectively. The software indicates that its peer benchmark company is 100% of Company 54.

Table 6. VRS Input-orientated approach: Model 1 and Model 2

	Model 1			**Model 2**		
	Company 35 (TE VRS = 0.945)			**Company 49 (TE VRS = 0.934)**		
	E-Score	**S-Score**	**G-Score**	**E-Score**	**S-Score**	**G-Score**
Step 1: Current values	47.53	70.33	68.17	1/47.05 = 0.021	1/68.14 = 0.015	1/64.08 = 0.016
Step 2: Target values	44.92	66.46	64.42	0.019	0.013	0.015
Step 3: Change (current value - target value)	(2.61)	(3.87)	(3.75)	(0.002)	(0.002)	(0.001)

4. Conclusions

This study has provided significant insights into how companies can benchmark their efficiency in transforming sustainability performance into wealth creation. A mixed-method research approach was employed, wherein a conceptual framework was qualitatively developed and subsequently tested through the quantitative application of DEA models. The innovative aspect of this study lies in the development of a novel conceptual framework supported by two distinct models: (1) a model to determine the extent to which a company's ESG efforts may be fruitless, and (2) a model to evaluate whether a company's ESG efforts are fruitful, by using appropriate ESG inputs while still generating wealth.

The study set four objectives, including an empirical demonstration wherein the technical efficiency of 80 South African listed companies was calculated. Furthermore, two companies identified as inefficient were selected to illustrate potential improvements in their ESG efforts. It has been concluded that the linear regression analysis commonly applied in previous studies was insufficient to address the research question of benchmarking a company's ESG efforts in creating shareholder wealth. Conversely, the DEA models employed in this study successfully resolved this issue. The practical value of this research lies in its provision of a transferable framework, enabling companies to assess the effectiveness of their ESG efforts—categorized as either 'fruitless' or 'fruitful'—against their peers, as demonstrated in the empirical study.

It is crucial to acknowledge that ESG efforts should not be perceived solely as a tool for financial gain; however, it is essential for companies to understand whether their ESG initiatives are yielding positive outcomes. The value of this study is rooted in its potential to be replicated by companies wishing to apply the 'fruitless' and 'fruitful' DEA models, using their own set of peer companies for benchmarking purposes.

A relatively low technical efficiency score (TE < 1) indicates that a company's ESG efforts are not effectively contributing to wealth creation. Moreover, the benchmarking tool presented in this study offers the capability to set specific targets, assisting companies in identifying the extent to which their E-, S-, or G-scores may be failing to create wealth. Conversely, a relatively high technical efficiency score (TE < 1) reveals the degree to which ESG scores should be increased to achieve a position on the efficiency frontier, representing companies that follow best practices.

The practical implication of this research is that inefficient companies can benchmark against peers to determine which aspects of their efforts to reduce environmental impact, enhance stakeholder relations, and improve governance practices may be detracting from shareholder wealth. Companies can prioritize their environmental, social, and governance initiatives to address any identified inefficiencies. As highlighted in this study, companies identified as inefficient should consider that, relative to their peers, their ESG efforts may either fail to attract stakeholders positively or represent an excessive expenditure on ESG activities. Alternatively, companies can benchmark whether their ESG scores are adequate in comparison to their peers, considering the output in terms of financial performance.

A potential limitation of this study is the use of a convenience sample of 80 JSE-listed companies to demonstrate the VRS and CRS DEA methods, with a focus on an input-oriented approach. This sample was used solely for demonstration purposes, and in practice, a company wishing to benchmark itself would select its own peers as the relevant population. As such, generalisation of the findings is not intended, as the technical efficiency results are relative only to the selected companies. Therefore, a company's efficiency can be measured only in relation to its preselected peers. Additionally, the output-oriented approach was not utilised in this study, which could have provided insights into the necessary improvements in wealth creation performance variables, given the sustainability performance variables as inputs. Nonetheless, the primary focus remains on the transferability of the process employed, allowing companies to apply the fundamentals of this study to their own investigations and peer comparisons. It is essential to note that the selection of variables for DEA models remains the prerogative of the analyst. However, a similar process can be followed to benchmark any company, provided that care is taken to select sample companies from the same industry or those with comparable operations. Future studies may also explore fundamental factors that could enhance the management of sustainability performance in wealth creation.

Author Contributions

Conceptualization, M.O (Merwe Oberholzer); Methodology, M.O., M.M. (Monique Meyer); Software, M.O.; Validation, M.M. and M.O.; Formal analysis, M.M.; Investigation, M.M.; Resources, M.M. and M.O.; Writing - original draft preparation, M.O. and M.M.; Writing - review and editing, M.O. and M.M. Both authors have read and agreed to the published version of the manuscript.

Data Availability

The data used to support the research findings are included within the article and is also available from the corresponding author upon request.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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