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Green investment nexus eco-efficiency and firm value: Evidence from top 40 JSE-listed firms

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Abstract

This study aims to investigate the connection between green investment, eco-efficiency, and firm value amidst increased global emphasis on environmental sustainability. The study used a generalised method of moments (GMM) to analyse a panel of the top 40 listed companies on the Johannesburg Stock Exchange (JSE) from 2015 to 2022. The top 40 listed companies represent 80% of the total listed companies on JSE market capitalisation. The findings show that green investment's effect on eco-efficiency and firm value is positive and statistically significant. This indicates that there are plenty of chances for South African businesses, especially the top 40 listed firms, to lead and innovate in the green economy, given the continued emphasis on sustainability and green growth, which will improve reputation and risk management and increase operational efficiency. The overall implication is that, in the long run, these investments will strengthen the financial stability and resilience of businesses, in addition to mitigating environmental effects. A competitive advantage can result from strategically integrating green practices, which promotes regional sustainable development. The paper offers insightful empirical data from the context of emerging markets, notably South Africa. The research on green investment, which primarily focuses on developed economies, frequently underrepresents emerging markets. The study broadens our knowledge of how green investment affects corporate performance and environmental effects in a distinct regulatory and economic context by analysing the JSE.

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1. Introduction

The world faces a significant challenge in addressing the issue of global climate change brought on by greenhouse gas (GHG) emissions (Ma, Murshed, & Khan, 2021; O'Garra & Fouquet, 2022; Sun, Dong, Wang, & Ren, 2022). The moment has come to alter, rebuild, and reconceive our global economy to promote a more just and sustainable society. A more sustainable future of low carbon that leaves no one behind is feasible if we have high expectations and are open to change (Shuwaikh, Benkraiem, & Dubocage, 2023). Problems such as environmental degradation, overexploitation of natural resources, and increased pollution from dangerous carbon elements have prompted governments and domestic and foreign businesses to implement new regulations. Such regulations have prompted the acceptance of economic sustainability as a fundamental tenet that is required for the carrying out of certain operations at both the macroeconomic level and the microeconomic level (Ganda & Milondzo, 2018). Therefore, being eco-friendly has emerged as a crucial issue for economies (Du & Li, 2019). GHG emissions have garnered a great deal of interest from the academic community and policymakers because of growing environmental concerns. To mitigate the environmental damage brought

on by economic development, green investment and the creation of environmentally friendly technology have been emphasized (Yuan, Ye, & Sun, 2021). As a result of rising pressure from stakeholders, management in businesses must commit to the process of green investment to undertake environmental efforts (Yu, Ramanathan, & Nath, 2017). Growing carbon emissions, as witnessed around the world, will probably have severe adverse social, economic, and environmental consequences in South Africa unless mitigating measures are taken to stabilise this situation (Ganda & Milondzo, 2018). Greenhouse gas in South Africa was 0% in 1960 (IndexMundi, 2016), and according to the Department of Environment, the total emissions generated as of 2020 were 442 million tons, a reduction of 0.8% from 446 million in the year 2000. The reduction was attributed to the Covid-19 pandemic (Environment, 2023). According to data from the Department of the Environment, the preliminary assessment indicates an increase in some emission sources since 2020 (Environment, 2023). The main sources of greenhouse gas emissions in South Africa include the generation of power, transportation, and industrial fuel usage; fugitive emissions from fuel processing and livestock; and waste management. Energy industries contributed 62.4%. Transport accounted for 12.7%, manufacturing and construction for 8.8%, while forestry, agriculture, and other land uses contributed the remaining 16.1% (Environment, 2023). Given these high levels of carbon emissions, investigations on the crucial link between emissions and corporate value, both for environmental sustainability and for evaluating firm behaviour inevitable.

Firms must cut back on their greenhouse gas emissions and the impact they have on their daily operations to combat climate change. Green financing has emerged as a vital means of providing credit to businesses that implement various energy-saving measures and environmental protections (Benkraiem, Shuwaikh, Lakhal, & Guizani, 2022). The management structure of ecological investments is a complex business process (Chen & Ma, 2021). Research on green investment indicates that businesses are trying to find a favorable position where their financial outcomes and environmental effects both increase (Picard, 2012; Stucki, 2019). Previous studies of green investments have found that businesses only invest in green innovations if they make money, and that decision is impacted by both the costs of the investment and the financial rewards of lowering emissions. Businesses are highly motivated to adopt green technology because of the discrepancy between the financial implications of investing in it and the advantages of lowering emissions, according to Yang, He, Xia, and Chen (2019). Stucki (2019) argues that companies should only invest in green innovations if they generate a profit, while King and Lenox (2002) assert that businesses are driven by the financial returns on ecological safeguards investments rather than the enhanced value of becoming a greener company.

Green finance has become a crucial way to give credit to companies that put in place numerous ecological safeguards and energy efficiency policies (Benkraiem et al., 2022). Green investment is a business practice with a challenging management structure (Chen & Ma, 2021). According to the research on green investment, companies are aiming to target an advantageous position where both their economic results and environmental consequences improve (Picard, 2012; Stucki, 2019). Researchers studying green investments in the past have found that companies only invest in green technology if it generates profits, and both the financial benefits of reducing emissions and the investment expenses influence this decision. Yang et al. (2019) state that businesses have a lot of motivation to participate in green technology due to the disparity between the benefits of reducing emissions and the costs of the investment. Businesses are motivated by the financial returns on investments made in environmental protection, not by the increased value of becoming a greener company, according to King and Lenox (2002) while according to Stucki (2019) businesses should only spend money on green technology if it will result in profit. However, there are two directions in the conflicting literature. First is the firm's competitiveness, which they believe will suffer if investment is targeted at reducing emissions. They consider their involvement in environmental activities as a poor use of the corporate fund and an increase in expenses, both of which lower the firm value (Benkraiem et al., 2022; Palmer, Oates, & Portney, 1995). Second, based on institutional theories and resource-based confirmation, a firm's efforts to reduce its ecological impact will boost its ability to sustainably outperform the competition, hence addressing environmental concerns and enhancing firm value (Benkraiem et al., 2022; Chapple, Clarkson, & Gold, 2013). Research on the relationship between corporate results and greenhouse gas emissions has yielded a variety of conclusions. Walley and Whitehead (1994) and Telle (2006) discovered that companies stray from their core business when they invest in environmental measures. When companies spend their assets and resources protecting the environment, their value declines. However, Hughes (2000) found that firms that generate substantial greenhouse gas emissions experience a decline in firm value, based on an analysis of publicly listed energy companies.

According to Clarkson, Li, and Richardson (2004) companies benefit from the market because of their investment in an ecologically friendly environment that results in low pollution. Chapple et al. (2013) found that Australian companies with high greenhouse gas emissions see a decline in their market capitalisation. Hassel, Nilsson, and Nyquist (2005) affirmed that organizations' green investment practices must involve a cost-centered method. Tang, Walsh, Lerner, Fitza, and Li (2018) and Ülgen (2019) concluded that it should include a value creation strategy. We anticipate that green investments will enhance the environmental performance of the company, thereby increasing its value. Notwithstanding the number of studies connecting market-based performance to environmental sustainability, in-depth research is necessary for this area before making any conclusions (Benkraiem et al., 2022; Chapple et al., 2013; Dixon-Fowler, Slater, Johnson, Ellstrand, & Romi, 2013). There is a dearth of literature, especially in emerging economies like South Africa, on how green investment affects firm value and environmental performance. Therefore, more research is required to

understand the impact of a company's green investment on its value and environmental performance. Taking into account the previous explanation, the objective of this study is to ascertain the influence of green investment on the value and environmental performance of companies. We collected panel data on the green investment activities of the top 40 JSE-listed companies in order to carry out our empirical investigation. The largest corporations on the JSE are the top 40 JSE-listed businesses. Given that it accounts for more than 80% of the market capitalization of all JSE-listed businesses, it fairly depicts the performance of the South African stock market overall (Sharedata, 2023). In general, our research adds to the corpus of literature on business value, climate change, and the production of greenhouse gases. Benkraiem et al. (2022); Busch and Hoffmann (2011); Downar, Ernstberger, Reichelstein, Schwenen, and Zaklan (2021); Ganda and Milondzo (2018); Kabir, Rahman, Rahman, and Anwar (2021); Shuwaikh et al. (2023) and Fatima Shuwaikh, Brinette, and Khemiri (2022) with greater emphasis on South Africa, where such literature is scarce. We arrange the remaining sections of this paper as follows: Section 2 provides a literature review, Section 3 explains the methodology, Section 4 presents the empirical findings and discussions, and Section 5 addresses the conclusions and policy implications.

2. Review of Literature

2.1. Green Investment and Firm Value

The relationship between firm value and its green investment has become the subject of discussion for the last three decades, which has led to two opposing viewpoints on how environmentally friendly practices affect firm valuation and reductions in carbon emissions (Benkraiem et al., 2022; Dixon-Fowler et al., 2013). The first viewpoint is largely based on Penrose (2009) work, which was later expanded upon by Barney (1991) and which gave rise to the firm's resource-based approach. This theory contends that businesses enhance their efforts to combat environmental degradation to obtain a competitive advantage over less moral rivals. Environmental and ethical activities receive favourable responses from the market and society, which eventually results in a lasting competitive advantage. According to Nidumolu, Prahalad, and Rangaswami (2009) firms that pursue sustainable development will gain a competitive edge by adopting a green policy. The firm's strategy for growth will then benefit from its dedication to the environment. Hart (1997) states that using green industrial processes can boost company competitiveness and produce substantial environmental advantages, both of which translate to higher share market value. Furthermore, the institutional theory posits that all firms operate within organizational fields and institutional settings, which encompass social ideologies, accepted ethical standards, rules, and constitutional and political structures (Brammer, Jackson, & Matten, 2012; Scott, 2008). The institutional theory posits that organizations conform to established ideals across corporate domains, regulations, and standards, such as greenhouse gas emissions and disclosure, in order to obtain institutional legitimacy (Meyer & Rowan, 1977). Furthermore, organizations that are subject to similar institutional constraints may eventually adopt organizational practices and approaches to gain legitimacy (Dimaggio & Powell, 2004) which could boost their performance and competitiveness.

Research studies have demonstrated for years that improving ecological sustainability, particularly reducing greenhouse gas emissions, increases firm value. Yadav, Han, and Rho (2016) examined how a company's environmental outcomes affected the performance of stock markets and discovered that investors observed the disclosures to be positive news. Matsumura, Prakash, and Vera-Muñoz (2014) investigated the relationship between firm value and emissions of greenhouse gases for S&P 500 companies between 2006 and 2008 and found that adherence to carbon emission targets had a detrimental effect on firm value, indicating that market forces punish companies for their higher levels of carbon emissions, particularly for not disclosing details about emissions. Using a dataset of Japanese enterprises, Saka and Oshika (2014) investigated the disclosure of greenhouse gas emissions and its impact on firm value. They discovered a link between emissions of carbon and disclosure of the prevailing value of the stock, but not between firm value and greenhouse gas emissions. In their investigation of the connection between emission levels of greenhouse gases and company future valuations in the European setting (Basse & Mandaroux, 2022) illustrated that, at an acceptable level of emissions, greenhouse gases depress market values due to risks associated with transition and looming restrictions. Radu and Maram (2021) discovered a conflicting association between emissions of greenhouse gases and firm value by analysing data on Canada's Carbon emissions between 2004 and 2017. For per added ton of greenhouse gas emissions, the market value of companies with reduced pollution decreased by $548.

However, skeptics argue that companies address ecological concerns, increased expenses, and financial challenges, reducing profitability and firm value. Walley and Whitehead (1994) proposed a negative relationship between financial success and greenhouse gas emissions. They asserted that to enhance the condition of the environment, companies shift managerial duties and capital away from their core businesses, with little to no financial or economic gain. Investors penalise businesses that have an environmental risk profile, which incorporates all ambiguities related to regulating climate change and weather. This conventional view has been empirically supported by numerous studies. According to Sarkis and Cordeiro (2001) there is a negative relationship between end-of-pipe efficiency, sales returns, and the reduction of emissions. Fisher-Vanden and Thorburn (2011) assert that enterprises taking environmental action or earning green identity saw negative abnormal returns because investors perceived these green initiatives as expensive and unproductive. Nollet, Filis, and Mitrokostas (2016) show that there is an inverse correlation between corporate social responsibility

and profitability, inferring that investors have not yet reacted to corporate environmental performance. Anderson-Weir (2010) claimed that pollution had no impact on stock prices. Despite companies making investments in environmental conservation, Telle (2006) reveals that these efforts were unrelated to their main businesses. Utilising a company's resources and assets to reduce carbon emissions to protect the environment has a detrimental impact on the value of the firm. This implies that investors place a higher value on companies that actively reduce their carbon emissions compared to those that do not. Thus hypothesis 1 is proposed.

H_1: Green investment affects firm value.

2.2. Green Investment and Eco-Efficiency

Eco-efficiency includes using recyclable materials in products, cutting waste and pollution at the point of production, increasing energy savings, lowering the use of ecologically harmful compounds, and more (Lindell & Karagozoglu, 2001; Weng, Chen, & Chen, 2015; Zhu, Geng, Fujita, & Hashimoto, 2010). The effect of climate change is a serious issue that every nation on Earth is currently confronting, according to Li, Deng, and Peng (2020). Authorities and public members are encouraging companies to invest in cutting-edge environmentally friendly technologies to lower greenhouse gas emissions and pollution. In terms of long-term ecological effects, a firm's regulatory efforts, such as reducing pollution, resource use, and waste, are far more effective than end-of-pipeline solutions (De Giovanni, 2012; Sarkis & Cordeiro, 2001).

Green Investment is an investment that brings about the conservation of energy, fewer greenhouse gases, less pollution in the air, water conservation, and waste reduction (Kraus, Rehman, & García, 2020). It reduces costs and waste, which improves a firm's performance on corporate, social interactions, and financial levels (Benkraiem et al., 2022; Weng et al., 2015). Since firms now view their statutory obligations for making green investments as expensive, managing the environment has grown difficult (Hojnik & Ruzzier, 2016; Khalil & Nimmanunta, 2023). With environmentally friendly investment, nonetheless, it is possible to turn these expenses into an advantage over the competition and a tremendous performance source (Munodawafa & Johl, 2019). As a result, innovative green investment offers ways to increase resource productivity and aid companies in significantly reducing the costs associated with environmentally friendly investments, which impacts on both market share and environmental performance (Khalil & Nimmanunta, 2023; Pujari, 2006). Adegbile, Sarpong, and Meissner (2017) state that companies investing in an eco-friendly environment significantly improve ecological sustainability by reducing energy use, greenhouse gases, and product manufacturing techniques.

The idea of environmentally friendly innovation, which explains environmental measures that result in greater overall sustainability, links green investment to companies' performance on the environment through sustainability initiatives (Figge & Hahn, 2012; Orsato, 2006). According to the environmental efficiency and green innovation concept, companies seeking economic gains must implement environmental initiatives at the highest possible level and maintain the highest possible level of environmental performance while achieving ecological efficiency at the lowest cost possible (Schaltegger & Synnestvedt, 2002; Wagner & Schaltegger, 2004). Green investment represents firms' commitment to developing products and market demand following their ecological management methods, which frequently result in economic advantages and deliver a higher level of environmental sustainability (Figge & Hahn, 2012; Khalil & Nimmanunta, 2023; Schaltegger & Synnestvedt, 2002). By offering environmentally friendly new products, companies with higher degrees of green investment are likely to create market distinction, resulting in higher profits and better environmental results (Ambec & Lanoie, 2008; Lee, Min, & Yook, 2015; Ong, Lee, Teh, & Magsi, 2019). In a similar vein, green investment might also help lower production-related emissions and waste. To benefit from greater environmental performance for both individuals and society as a whole, businesses may need to expand their core set of skills derived from environmental procedures and processes into green innovation. Thus, businesses can develop and implement environmentally friendly designs and methods by investing in green innovation. This will result in greater environmental performance (Khalil & Nimmanunta, 2023). Therefore, we formulate the hypothesis that:

H_2: Green investment is positively correlated with eco-efficiency.

3. Methodology

3.1. Research Design

The research design considered in this paper is correlational research. Researchers use correlational research design, a type of non-experimental research, to measure the relationship between two or more variables. Instead of manipulating variables, researchers observe and measure them to find correlations. So, it is suitable for investigating the relationship between green investments, eco-efficiency, and firm value, particularly in complex and dynamic environments like the JSE (Devi, Pradhan, Giri, Lepcha, & Basnet, 2022).

3.2. Data Sources

The study data was sourced from Bloomberg and IRESS, formerly Mcgregor (BFA) (IRESS) databases. Our sample included the top 40 JSE-listed companies. The variables were derived from their annual financial statements, integrated annual reports, sustainability reports, and other related reports. Our analysis of panel data spans from 2015 to 2022 and considers data from 40 firms.

3.3. Measurement of Variables

Firm Value: is our dependent variable, and it is proxied by Tobin's Q. Future firm profitability and growth can be predicted using Tobin's q (Verona, 2020). Market capitalization and book value of assets are needed to determine Tobin's q of all stocks in the sample. Studies like Benkraiem et al. (2022) and Buchanan, Cao, and Chen (2018) used Tobin's Q as a proxy for firm value. Annual calculations determine Tobin's Q, which is the total market value of shareholders' equity and book value of assets, less the book value of shareholders' equity divided by the book value of assets. Eco-Efficiency: Eco-efficiency is also a dependent variable. The total Greenhouse gas (GHG) emissions in tons were used to proxy for it. Scope 1, Scope 2, Benkraiem et al. (2022) and Scope 3 were considered. The GHG protocol classifies any emissions that a company directly owns or controls, such as fuel burning and company-owned vehicles, as Scope 1 emissions. Conversely, scope 2 emissions refer to indirect emissions resulting from the use of purchased energy, including electricity, steam, and heat. Corporate emission control considers both types of emissions as essential components. Indirect GHG emissions, known as Scope 3, encompass the extraction and manufacturing of purchased minerals and fuels, along with transportation-related activities conducted in non-company vehicles. We measure environmental performance by multiplying the natural logarithm of tons of Scope 1, Scope 2, and Scope 3 emissions by (-1). It is best to interpret environmental performance as the opposite of carbon emissions (Benkraiem et al., 2022).

Green Investment: This is our independent variable. The annual financial integrated reports contain the pollution control cost as a proxy for this variable. The investing guidelines primarily include pollution control costs, along with other general ledger accounting items such as "construction in progress," "general and administrative expenses," and "non-operating expenses." (Liu, Zhao, Zhang, & Zhou, 2022). Appendix A lists the pertinent accounting elements associated with green investments.

Control Variables: We took into account firm characteristics in our investigation. We used firm size (Size) as the natural logarithm of total assets in line with Benkraiem et al. (2022) and Buchanan et al. (2018). Due to economies of scale, big companies could increase their value. We considered leverage ratio (Leverage) and the ratio of net investment expenditures to total assets, which is known as capital expenditures (Capex). Cash is defined as the cash-to-total assets ratio. We used ROA as a measure of company profitability since it has a favourable impact on the value of the company.

3.4. Research Technique and Model Specification

This paper employed the generalized method of moments (GMM), a dynamic panel data approach established by Arellano and Bond (1991). It creates a model that boosts the estimator's effectiveness. The inclusion of instrumental variables controls for the fixed effects in the equation. Specifically, the System GMM proposed by Arellano and Bover (1995) and Blundell and Bond (1998) is used. It significantly boosts efficiency by adding additional instruments to correct endogeneity. It also changes the instruments to be exogenous, or uncorrelated, with fixed effects. The following model is employed:

$$Tobin's\ Q_{it} = \beta_0 + \beta_1 Green\ Investment_{it} + \beta_2 Size_{it} + \beta_3 Leverage_{it} + \beta_4 Capex_{it} + \beta_5 Cash_{it} + \beta_6 ROA_{it} + \beta_7 Tobin's\ Q_{it-1} + Eco-efficiency_{it} + \sum Industry\ fixed\ effects + \sum Year\ fixed\ effects + \varepsilon_{it} \quad (1)$$

Equation 1 aims to analyse the determinants of Tobin's Q, which indicates a firm value for firm I at time t. While accounting for changes in industry and time, Equation 1 enables the examination of the effects of investments connected to the environment as well as firm-specific factors on firm value.

$$Eco-efficiency_{it} = \beta_0 + \beta_1 Green\ Investment_{it} + \beta_2 Size_{it} + \beta_3 Leverage_{it} + \beta_4 Capex_{it} + \beta_5 Cash_{it} + \beta_6 ROA_{it} + \beta_7 Eco-efficiency_{it-1} + \sum Industry\ fixed\ effects + \sum Year\ fixed\ effects + \varepsilon_{it} \quad (2)$$

Equation 2 explores the variables affecting a firm's eco-efficiency, or its capacity to reduce environmental impact in relation to economic output, firm i at time t.

Table 1. Descriptive statistics.

Variable	Obs.	Mean	Std. dev.	Min.	Max.
TobinsQ	320	5.884	11.394	0	72.963
GIV	320	-2.705	2.174	-9.587	3.265
Size	320	18.221	1.843	0	21.782
Capex	320	0.254	0.264	0	1.724
Cash	320	0.085	0.072	0	0.42
ROA	320	0.061	0.09	-0.242	0.533
Ec	320	-12.97	2.778	-18.175	0
Leverage	320	0.558	0.254	0	1.082

4. Results and Discussion

Table 1 reports the summary statistics for the sample of 40 firm-year observations.

The summary statistics give an overview of each variable in the dataset's range (min and max), variability (standard deviation), and central tendency (mean). The 320 observations yielded a mean value of 5.884 for Tobin's Q, with a standard deviation of 11.394, indicating a high degree of variability. The range of results indicates that some companies have extremely high Tobin's Q ratios, ranging from 0 to 72.963. However, green investment (GIV) had a mean value of -2.705, which indicated that GIV in relation to the firm's total investments was small; therefore, there is room for improvement in firms' green innovation. Other variables demonstrated either moderate or low variability toward the mean.

Table 2. Pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) TobinsQ	1.000							
(2) GIV	0.232* (0.000)	1.000						
(3) Size	-0.300* (0.000)	-0.534* (0.000)	1.000					
(4) Capex	-0.006 (0.916)	0.213* (0.000)	-0.367* (0.000)	1.000				
(5) Cash	0.063 (0.258)	0.252* (0.000)	-0.136* (0.015)	-0.063 (0.261)	1.000			
(6) ROA	0.149* (0.008)	0.100 (0.074)	-0.129* (0.021)	-0.001 (0.984)	0.474* (0.000)	1.000		
(7) Ec	-0.079 (0.160)	0.200* (0.000)	-0.158* (0.005)	-0.252* (0.000)	0.094 (0.092)	-0.003 (0.952)	1.000	
(8) Leverage	-0.423* (0.000)	-0.259* (0.000)	0.494* (0.000)	-0.200* (0.000)	-0.009 (0.866)	-0.248* (0.000)	0.152* (0.007)	1.000

Note: Standard errors in parentheses, p<0.01.* p<0.05, * p<0.1 are 1%, 5%, and 10% statistically significant levels.

The correlation analysis between the variables is displayed in Table 2. The dependent variable (TobinsQ) and the covariates showed both positive and negative associations. In general, the study revealed that the variables are not multicollinear. Size and leverage have the highest correlation between independent variables (r = 0.494), which is moderately correlated but below the 0.8 criterion for severe multicollinearity.

Table 3. Impact of green investment on firms' value.

Two-step system GMM							
TobinsQ	**Coef.**	**St. err.**	**t-value**	**p-value**	**[95% Conf.**	**Interval]**	**Sig**
Green investment	2.023	1.079	1.88	0.068	-4.205	0.159	*
LagTobinsQ	0.672	0.068	9.84	0.000	0.534	0.81	***
Size	-4.034	1.232	-3.28	0.002	-6.525	-1.543	***
Capex	-8.133	4.726	-1.72	0.093	-17.693	1.426	*
Cash	1.158	1.002	1.16	0.255	-0.87	3.186	
ROA	22.903	12.201	1.88	0.068	-47.582	1.775	*
Eco-efficiency	2.517	0.963	2.61	0.013	-4.464	-0.569	**
Leverage	0.81	3.348	0.24	0.81	-5.962	7.582	
Constant	78.975	23.82	3.32	0.002	30.795	127.155	***
Year dummies	Yes						
Instrument/Group	28/40						
AR2 – p-value	0.446						
Hansen Test p-value	0.199						
Mean dependent var		5.900		SD dependent var		11.271	
Number of obs.		278		F-test/P-value		47.361/0.000	

Note: *** p<.01, ** p<.05, * p<.1 (Significant Level).

With a coefficient of 2.023, Table 3 demonstrates a positive relationship between green investment and Tobins Q (firm value) that is statistically significant at the 10% level. The finding confirmed the hypothesis that green investment affects firm value. This result is in line with earlier research by Duan, Yang, and Xiong (2023) and X. Liu (2024). The lag significantly positively impacts Tobin's Q, indicating resilience in the dependent variable. The return on assets (ROA) and environmental performance exhibit a positive correlation with firm value, with coefficients of 22.903 and 2.517, respectively, and statistically significant level of 10% and 5%. However, variables such as size and capex demonstrated a negative association with firm value and were statistically significant at 1% and 10%, respectively.

Table 4. Impact of green investment on eco-efficiency.

Two-step system GMM							
Eco-efficiency (Ec)	**Coef.**	**St. err.**	**t-value**	**p-value**	**[95% conf.**	**Interval]**	**Sig**
Green investment	4.909	2.39	2.05	0.047	0.074	9.744	**
LagEc	0.776	0.096	8.05	0.000	0.581	0.971	***
Capex	-2.005	0.919	-2.18	0.035	-3.864	-0.145	**
Cash	-5.334	2.907	-1.84	0.074	-11.213	0.545	*
ROA	0.242	1.054	0.23	0.819	-1.889	2.373	
Leverage	0.044	0.141	0.031	0.756	-0.242	0.33	
Constant	-2.911	1.28	-2.27	0.029	-5.501	-0.322	**
Year dummies	Yes						
Instruments/Groups	22/40						
AR2 - p-value	0.226						
Hansen test p-value	0.141						
Mean dependent var		-13.041	SD dependent var		2.541		
Number of obs.		278	F-test/p-value		1543.434/0.000		

Note: *** p<.01, ** p<.05, * p<.1 (Significant level).

Table 4 indicates that Eco-efficiency (Ec) with a coefficient value of 4.909 and a p-value of 0.047 is positively and significantly impacted by Green Investment, suggesting that higher levels of Green Investment are linked to better Eco-efficiency. At the 5% level, this association is statistically significant. The hypothesis that green investment is positively related to eco-efficiency is achieved. This finding is consistent with research studies by Zhao et al. (2023); Shuwaikh et al. (2023) and Li, Yu, Jahanger, Usman, and Ning (2022). The lag Ec, with a coefficient of 0.776 and a statistically significant level of 1%, demonstrates consistency over time due to its robust, positive, and highly significant impact on the current environmental performance. The impact of capital expenditures (Capex)(-2.005, p-value = 0.035) on environmental performance is negative and considerable, indicating that increased Capex may have a deleterious effect on environmental performance due to possible resource diversion from environmental programs. Furthermore, the Eco-efficiency is negatively and very slightly impacted by cash holdings (-5.334, p-value = 0.074). This could imply that companies with larger cash reserves face less incentive to make investments in improving their eco-efficiency. However, returns on assets (ROA) and leverage did not have a significant impact on environmental sustainability.

The findings show that green investment greatly enhances eco-efficiency, indicating the efficacy of corporate policies that prioritize green efforts. Cash holdings and capital expenditures have a detrimental effect on environmental performance, suggesting that to improve sustainability outcomes, resource allocation strategies must be carefully considered. Eco-efficiency is very persistent across time, and the overall significance of the model indicates that the results are resilient.

4.1. Discussion

Regulatory frameworks, government incentives, and broad environmentally friendly goals drive green investment, which significantly impacts corporate enterprises in South Africa. Recent facts and studies provide the following summary: Economic and Regulatory Incentives: To promote green investments, especially in the area of renewable energy, the South African government has put in place an array of concessions. Alongside the benefits currently provided by the Income Tax Act for energy efficiency savings and the acquisition of green energy equipment, the 2023 budget included incentives to invest in solar power generation. The goal of these incentives is to mitigate the severe energy-related problems the country has, including load-shedding, which has been a major impediment to the creation of jobs and economic advancement (PWC South Africa, 2023).

Corporate Performance and ESG Integration: Recent empirical studies have shown that integrating Environmental, Social, and Governance (ESG) practices—like green investments—positively impacts corporate performance. For instance, companies listed on the Johannesburg Stock Exchange (JSE) have shown increased company value and financial performance when they implement strong ESG policies. Environmentally friendly procedures lead to enhanced productivity of operations, improved risk management, and enhanced reputation, as explained by Sonko and Sonko (2023).

Industry-Specific Impacts: Ye and Dela (2023) assert that the effects of green expenditures vary by industry. Investment in eco-friendliness has corporate firms in South Africa are greatly impacted by green investment, which is motivated by a number of variables such as legal frameworks, financial incentives, and overarching sustainability objectives. Here is a summary based on current data and research:

Industry-Specific Impacts: According to Ye and Dela (2023) different industries are affected differently by green investments. Green investments have significantly benefited highly polluting industries like mining and manufacturing by improving regulatory compliance and reducing environmental impact, enhancing market positioning, and opening up access to green funding. Businesses in these industries that actively participate in sustainability reporting and green investments frequently see improvements in long-term financial performance as well as increased stakeholder trust. The mining industry in South Africa emphasises how green investments

can boost operational effectiveness and lower environmental risks. For instance, mining businesses have benefited from investments in renewable energy projects by lowering their reliance on the unstable national grid, which has improved operational stability and decreased the cost of power outages (PWC South Africa, 2023; Ye & Dela, 2023).

Notwithstanding the obvious advantages, there are still issues, such as the requirement for more thorough legal frameworks and the lack of funding for environmentally friendly initiatives. Nonetheless, there are plenty of chances for South African businesses, especially the top 40 listed firms, to lead and innovate in the green economy, given the continued emphasis on sustainability and green growth (Sonko & Sonko, 2023). To sum up, green investments play a critical role in improving company sustainability and performance in South Africa. Over time, these investments help firms become more resilient and financially stable while reducing their negative effects on the environment. Effective incorporation of environmentally friendly procedures can lead to an edge over competitors and support environmental sustainability in the region.

In the long run, these investments strengthen the financial stability and resilience of businesses in addition to aiding in the mitigation of environmental effects. A competitive advantage can result from the strategic integration of green practices, which promotes regional sustainable development.

5. Conclusion and Policy Implications

Using data from the top 40 listed companies on the Johannesburg Stock Exchange (JSE), the study examines how green investments affect eco-efficiency and firm value. A dynamic panel data model and a resilient generalised method of moments (GMM) are used. Based on the data, the study concludes that investing in eco-friendly practices significantly enhances corporate value and eco-efficiency. Investments in environmentally friendly technologies and procedures help reduce greenhouse gas emissions, improve overall sustainability, and increase company value by promoting long-term development and reducing reliance on energy from fossil fuels. The South African government's aggressive support of environmentally friendly procedures and renewable energy projects should eventually enhance the nation's ecological sustainability. Promoting healthier economies, reducing the negative environmental effects of manufacturing processes, and finding a balance between sustainable development, companies' value, and economic growth all depend on these initiatives. Ultimately, because environmentally friendly decisions have a positive impact on both environmental performance and business value, it is advised that organisations include sustainability in their fundamental strategy.

The study investigates the impact of green investment on eco-efficiency and firm value, taking evidence from the top 40 listed firms in the Johannesburg Stock Exchange (JSE). A robust generalized method of moments (GMM), a dynamic panel data model is employed. Based on the findings, the study concludes that green investments significantly improve eco-efficiency and firm value. By encouraging sustainable growth and lowering dependency on fossil fuels, investments in green technologies and practices contribute to the reduction of emissions of greenhouse gases and the enhancement of overall environmental quality and firm value. The focus on green investment in South Africa is in line with both national and international trends toward environmental sustainability. Over time, the country's environmental performance should improve due to the government of South Africa's proactive promotion of eco-friendly activities and renewable energy initiatives. These programs are essential for promoting a greener economy, minimizing the damaging impacts of industrial activity on the environment, and striking a balance between economic growth, firm value, and environmental sustainability. In the final analysis, organizations should integrate sustainability into their core strategy due to the beneficial effects of green investments on environmental performance and company value. Numerous advantages, such as better financial performance, lower regulatory risks, and better societal results, can result from this integration. As the global focus on sustainability continues to expand, we expect businesses that proactively engage in green technologies to reap long-term benefits and help achieve wider environmental and social goals.

The following are the ways in which the study adds to the literature: Firstly, this paper offers insightful empirical data from the context of emerging markets, notably South Africa. The research on green investment, which mostly focuses on developed economies, frequently underrepresents emerging markets. The study broadens our knowledge of how green investment affects corporate performance and environmental effects in a distinct regulatory and economic context by analysing the JSE. Secondly, by examining the top 40 companies listed on the JSE, the research provides industry-specific knowledge. This is important because various industries can see quite diverse effects from green investments. The study provides a greater understanding of the manufacturing, financial services, and mining sectors that dominate the JSE and focuses on the particular effects of green investments in these areas. Third, there are important policy implications for the findings. It provides information to policymakers in South Africa and other emerging markets about the benefits of promoting green investments. More companies adopting environmentally friendly practices can aid in the creation of laws that reward green investments with rebates or subsidies and enhance regulatory structures. Lastly, the findings demonstrate how important it is to include environmental considerations in business planning and governance. By showing that businesses that prioritise green investments can achieve better financial and ecological benefits, the study makes a strong case for sustainable corporate governance approaches. This could influence business choices and encourage more companies to prioritize sustainability as a strategic objective.

5.1 Policy Implications

The study's implications for investors, businesses, and governments fall into three categories: financial, regulatory, and socioeconomic. Green investments have a significant positive socioeconomic impact on the environment by reducing the emissions of greenhouse gases and enhancing the safety of the air and water. This preserves natural resources for future generations and strengthens the global battle against climate change. Businesses that invest in environmentally friendly innovations demonstrate their dedication to corporate social responsibility (CSR), which enhances their reputation among customers, employees, and other stakeholders and fosters long-term sustainability.

One of the financial implications is an increase in firm value. Companies that invest in green initiatives see an increase in their market value. This is because the company's reputation has improved, there are fewer environmental regulations-related hazards, and there may be cost savings. For instance, a study on the G-7 nations found that businesses with robust green investment strategies yield better earnings and higher company value. Because investors want to invest in companies with strong environmental, social, and governance (ESG) practices, this makes them more attractive to a growing number of investors who are environmentally conscious. This could potentially lower the cost of capital and enhance access to capital.

In terms of regulatory ramifications, investing in eco-friendly technologies helps businesses comply with present and future regulations regarding the environment while reducing the risk of penalties and fines. It also places businesses in a better position to adapt to potentially stricter environmental rules in the future. Additionally, governments globally are promoting investments in sustainability by providing tax breaks and subsidies. By using these incentives to reduce the cost of their green initiatives, businesses can further enhance their financial performance.

5.2 Limitations and Future Research

The study's primary limitation is that the JSE can have market-specific characteristics influencing the relationship between green investment and firm value. The results might not be entirely applicable to other markets with distinct environmental, economic, and regulatory circumstances. This restricts how broadly the study's findings can be applied to different markets or situations. Therefore, to determine whether the discovered associations hold true in other legal and economic contexts, future research must compare studies conducted across various stock exchanges or markets. Such studies would improve the findings' external validity and shed light on the ways market-specific variables affect the results of green investments.

The research highlights the specific effects of green investments on industries that dominate the JSE, such as manufacturing, financial services, and mining, and it offers a deeper understanding of these sectors. Thirdly, the study has significant policy implications. It offers data regarding the advantages of encouraging green investments to policymakers in South Africa and other emerging markets. Encourage more businesses to embrace sustainable practices; this can help design policies that incentivise green investments, such as tax breaks or subsidies, and improve regulatory frameworks. Finally, the results highlight how crucial it is to incorporate environmental factors into company strategy and governance. The study presents a compelling case for sustainable corporate governance practices by indicating that companies that prioritize green investments can attain superior financial and environmental outcomes. This has the potential to impact corporate decision-making and motivate more businesses to make sustainability a primary strategic goal.

The study implications for firms, policymakers, and investors are categorized into socio-economic, financial, and regulatory. In terms of socio-economics, green investments have a major positive impact on the environment, lowering greenhouse gas emissions and improving the quality of the air and water. This contributes to the worldwide fight against climate change and the protection of natural resources for future generations. Firms investing in green technologies show their commitment to corporate social responsibility (CSR), which improves their standing with clients, staff, and other stakeholders, promoting their goodwill and long-term sustainability.

The financial implications entail enhanced firm value. Firms that make green investments enjoy a rise in market value. This is because there are fewer hazards related to environmental rules, there may be cost savings, and the company's reputation has improved. For instance, a study on the G-7 countries revealed that companies with robust green investment plans demonstrate improved financial performance and increased business value. Businesses with robust environmental, social, and governance (ESG) policies become more appealing to an expanding group of socially conscious investors, as these policies may improve capital access and even reduce capital costs.

Regarding regulatory implications, investing in environmentally friendly technologies lowers the danger of fines and penalties while assisting firms in adhering to current and future environmental standards. Additionally, it puts firms in a better position to adjust to future environmental regulations that may be more stringent. Moreover, governments throughout the world are offering subsidies and tax exemptions to encourage green investment. Businesses can further improve their financial performance by utilizing these incentives to lower the cost of their green investments.

The study is limited by its focus on the JSE, which may have market-specific factors influencing the relationship between green investment and firm value. The findings may not be fully applicable to other markets with different regulatory, economic, or environmental conditions. This limits the generalizability of the study's

conclusions to other contexts or markets. Therefore, future research is required to compare studies across different stock exchanges or markets to help identify whether the observed relationships hold in different regulatory and economic environments. Such research would enhance the external validity of the findings and provide insights into how market-specific factors influence the impact of green investments.

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Appendix A. Green investment-related detailed accounting items (reported in annual reports) (Liu et al., 2022).

General ledger	Line items
General and administrative expenses	Emission charge
	Sanitation and afforestation fee
	Mineral resources compensation fee
	Afforestation fee
	Environmental pollution discharge fee
	Mining drainage water resources fee
	Land reclamation fee
	Soil erosion compensation fee
Non-operating expense	Waste treatment subsidy
	Special fund for water conservancy construction
	Tax rebates for special fund for water conservancy construction
	Environmental penalty expense
	Special governance fund for environmental protection
Construction in progress	Coal to gas/Oil to gas conversion
	Waste heat power generation
	Coal-fired coupled sludge power generation
	Furnace electric dust removal transformation
	Clean heating
	Deposit for environmental restoration and governance of mines
	Heavy metal removal
	Medium pressure steam heating reformation
Research and development expenditures	Research on ultra-low NOX emission technology
	Research on operation safety and environmental protection
	Technology improvements of waste incineration plant
	Technical improvement project