



The Impact of Carbon Emissions on the Cost of Capital for Johannesburg Stock Exchange Listed Mining Firms

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ABSTRACT

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The increasing integration of Environmental, Social and Governance (ESG) factors into capital allocation decisions has elevated the importance of carbon emissions as a material financial risk. This study explores the theoretical and empirical relationship between carbon emissions and the cost of equity capital (Ke) among Johannesburg Stock Exchange (JSE) listed mining firms, one of the most carbon-intensive sectors in South Africa. Grounded in stakeholder theory, signaling theory and risk-pricing frameworks, the study hypothesizes that firms with higher carbon intensity face elevated Ke due to increased perceived risk and declining investor confidence. While international evidence supports this relationship, the extent to which South African capital markets internalize carbon risk remains unclear. The literature review reveals a critical gap in local empirical research, particularly regarding the quality of carbon disclosures, regulatory enforcement, and investor response in emerging markets. Drawing on panel data from 2018 to 2022, the study proposes a fixed effects regression model using Capital Asset Pricing Model (CAPM)-estimated Ke as the dependent variable and carbon intensity as the key explanatory variable, alongside controls for firm size, financial leverage, market beta, and valuation. The findings are expected to contribute to both academic literature and policy discussions on sustainable finance in South Africa, highlighting whether carbon performance is adequately priced in the equity market. This study also addresses methodological gaps in current research by focusing on actual emissions rather than disclosure proxies alone.

1. INTRODUCTION

In an era of intensifying climate risk and global decarbonization efforts, environmental performance has become a material financial issue for capital markets [1]. Institutional investors, rating agencies, and regulators are increasingly linking carbon-intensive operations with higher financial risk, especially in emerging economies where environmental governance remains fragmented [2, 3]. For listed firms in South Africa's mining sector, a key driver of the national economy and also a major source of carbon emissions, this shift is particularly urgent [4, 5].

As sustainability disclosures become more standardized and investor sentiment grows increasingly Environmental, Social and Governance (ESG)-driven, firms with higher carbon footprints may face a penalty in the form of higher cost of capital (CoC) [2, 6]. However, the precise relationship between carbon emissions and the cost of equity capital (Ke) remains empirically underdeveloped in emerging markets. While international studies offer some guidance, local

dynamics including state regulation, disclosure maturity, and sectoral volatility, create a complex environment in which the financial materiality of emissions must be carefully evaluated [7, 8]. This paper explores the theoretical foundations and empirical findings surrounding carbon emissions and their effect on capital costs, especially in carbon-intensive sectors like mining. While global allocators have increasingly priced in environmental risks, the extent to which these risks are internalized in South Africa's capital markets remains unclear.

The significance of this study lies in its contribution to understanding how environmental performance, particularly carbon emissions, influences financial outcomes in emerging markets. As global investors increasingly integrate ESG considerations into their decision-making, firms in carbon-intensive sectors like mining face growing scrutiny over their environmental impact. By examining the link between carbon emissions and the Ke among Johannesburg Stock Exchange (JSE)-listed mining firms, this research provides valuable insights into how environmental risk is perceived and priced by investors in South Africa. The findings not only bridge an

important gap in local empirical literature but also offer practical implications for firms seeking to enhance competitiveness through sustainable practices. Moreover, the study supports policymakers and regulators in strengthening disclosure frameworks and carbon reporting standards, fostering a more transparent and responsible financial ecosystem aligned with global sustainability goals.

1.1 Objectives of the study

The following are the objectives of the study:

- i. To examine the relationship between carbon emissions intensity (CEI) and the Ke among JSE-listed mining firms.
- ii. To analyze how firm-specific financial factors such as firm size, financial leverage, book-to-market ratio (BM), and market beta affect the cost of equity alongside carbon intensity.
- iii. To evaluate whether environmental risk, in the form of carbon emissions, is incorporated into investor-required returns within South Africa's mining sector.

2. REVIEW OF LITERATURE

2.1 Theoretical framework

Environmental performance, particularly carbon emissions, has transitioned from a reputational consideration to a quantifiable risk factor influencing firm valuation and financing [9]. Several key theories offer insights into how carbon-related risks may affect a firm's Ke [2, 10]. Among these, stakeholder, legitimacy and risk pricing theory provide the strongest conceptual grounding for understanding the relationship between carbon emissions and capital costs in mining firms [11-13].

2.1.1 Stakeholder and legitimacy theories

Stakeholder theory suggests that corporations exist within a web of relationships with multiple stakeholders: investors, employees, regulators and society, and must balance their diverse expectations to ensure long-term survival and success [11, 14]. From this perspective, environmental performance directly influences financial outcomes because stakeholders reward or punish firms based on their perceived responsibility [2]. Investors, for example, may penalise firms with poor carbon performance by demanding higher required returns, thereby raising their Ke [15].

Legitimacy theory complements this by asserting that firms seek social legitimacy and use environmental disclosures to align with societal values, norms and expectations [12, 16]. In this view, carbon emissions are not just operational outputs but social signals of environmental responsibility or negligence [12]. Firms with high carbon intensity face legitimacy deficits that manifest as reputational risks, heightened regulatory scrutiny, and ultimately higher financing costs [17].

In carbon-intensive sectors such as mining, legitimacy theory is particularly relevant [12]. High-emitting firms must demonstrate that they are actively managing their environmental impact as failure to do so can lead to investor divestment, regulatory penalties, and ultimately, higher costs of equity capital [18]. These industries are also exposed to activist campaigns, shareholder resolutions, and reputational pressures that increase the financial materiality of carbon

emissions [19]. For example, investors in emerging markets such as South Africa are increasingly influenced by ESG-driven mandates from global capital allocators, making legitimacy a key determinant of access to finance [19].

Moreover, legitimacy challenges are particularly acute in contexts with weak or inconsistent regulatory enforcement, such as South Africa, where environmental governance has been criticised for fragmented oversight and inconsistent penalties [20]. In such settings, firms may rely heavily on voluntary disclosure to maintain legitimacy, but the effectiveness of this strategy depends on the credibility of carbon data [14]. When disclosures are perceived as incomplete or unreliable, investors discount them, maintaining higher return expectations and thus higher Ke [21].

Empirical research supports these theoretical claims. Studies have shown that firms with better ESG or carbon disclosures attract long-term investors and enjoy reduced costs of capital [2, 15]. Conversely, firms that underperform on carbon measures or issue low-quality disclosures face legitimacy concerns that raise investor scepticism and increase financing costs [6]. In the mining sector, where emissions are often high and unavoidable, legitimacy depends on absolute emission levels but on demonstrated commitment to emissions reduction and transparent communication [22].

Thus, stakeholder and legitimacy theories suggest that carbon emissions materially influence a firm's CoC by shaping investor perceptions of social responsibility, credibility and long-term viability [23]. These frameworks imply that mining firms with stronger environmental performance and transparent disclosures can lower their Ke, while poor performers risk reputational penalties that elevate capital costs [2, 15].

2.1.2 Risk pricing theory

While the stakeholder and legitimacy theories emphasize the social and institutional dimensions of carbon emissions, risk pricing theory provides a financial market-oriented explanation [10, 13]. Rooted in asset pricing models, risk pricing theory asserts that investors adjust their required returns based on exposure to firm-specific and systemic risks [24]. Carbon emissions are increasingly recognised as such a risk factor, influencing both systematic market risk (through climate change impacts) and firm-specific risks (through regulatory costs, litigation, and reputational damage) [9, 10, 25].

This theory assumes that higher carbon emissions increase the likelihood of future costs, such as carbon taxes, emissions trading liabilities, regulatory sanctions, or environmental litigation [9, 10]. These anticipated costs are capitalised into investor expectations, leading to higher Ke for carbon-intensive firms [10]. Empirical studies confirm this logic. For instance, Bolton and Kacperczyk [10] demonstrate that carbon-intensive firms face significantly higher financing costs because markets price carbon risk into equity returns. Similarly, Trinks et al. [3] showed that mining and energy firms with greater carbon exposure face higher CoC as capital markets anticipate risks related to energy transition policies.

The tightening of climate-related regulation further strengthens the explanatory power of risk pricing theory [13]. As climate policies mature, investors increasingly view carbon intensity as a proxy for exposure to future liabilities [10]. The implementation of South Africa's carbon tax, though initially modest, signals an evolving regulatory landscape where emissions will translate more directly into financial costs.

Even if carbon prices are relatively low today, risk pricing theory suggests that forward-looking investors will discount future regulatory tightening by demanding higher returns from carbon-intensive firms [10].

Furthermore, climate-related financial disclosure frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD) enhance the salience of carbon risk by standardizing how firms report exposure to climate risks [26]. As disclosures improve comparability, investors are better able to differentiate high and low-carbon performers, sharpening the risk pricing mechanism [15, 26]. Firms with high carbon intensity and poor disclosure are thus doubly penalised, once for emissions exposure and again for information asymmetry [2, 3].

Risk pricing theory also has particular resonance in emerging markets such as South Africa, where financial systems are increasingly integrated into global capital flows [27]. International institutional investors, many of whom are signatories to climate-focused coalitions such as the Principles for Responsible Investment (PRI), incorporate carbon metrics into valuation and portfolio allocation decisions [9]. For JSE-listed mining firms seeking global capital, carbon intensity therefore represents a material financial risk factor that directly influences K_e [3, 10].

Empirical findings illustrate this dynamic. Trinks et al. [3] show that firms in jurisdictions with more stringent climate policies face higher CoC when carbon emissions are high, confirming the risk-pricing mechanism. While most evidence comes from developed markets, studies of emerging economies also suggest that investors are increasingly sensitive to carbon risks, albeit with weaker enforcement of pricing mechanisms [27]. This suggests that South African firms are not immune to global trends in carbon risk pricing, even if local enforcement lags [4, 5, 9].

Thus, risk pricing theory underscores the financial materiality of carbon emissions by linking them directly to investor return expectations [10]. For mining firms, this implies that higher carbon intensity leads to higher K_e , not because of social legitimacy concerns alone but because investors anticipate direct financial consequences [3].

2.1.3 Integrating theories in practice

While the stakeholder and legitimacy theories highlight the social and reputational channels through which carbon emissions affect CoC, the risk pricing theory emphasizes the direct financial channel [10, 13]. Together, these frameworks suggest that the impact of carbon emissions on K_e is multidimensional, encompassing both institutional legitimacy and forward-looking risk assessments [2, 10, 18].

In practice, this means that mining firms are judged not only on whether they align with societal values but also on how their emissions position them with respect to future financial risks [12, 13]. For instance, a mining firm with high carbon intensity may face both legitimacy challenges (stakeholder disapproval and reputational damage) and risk pricing penalties (higher expected regulatory or tax costs) [10, 18]. Conversely, firms that proactively reduce emissions and transparently disclose their performance may benefit from both enhanced legitimacy and lower risk premiums [2, 15].

In South Africa, the integration of these theories is particularly salient [19, 27]. Weak regulatory enforcement reduces the reliability of legitimacy-driven disclosure mechanisms, but global investor integration strengthens risk pricing pressures [5, 9]. As a result, JSE-listed mining firms

operate in a hybrid environment where both legitimacy and financial risk channels matter [3, 4]. This dual framework underscores the importance of examining carbon emissions not only as an environmental issue but also as a determinant of firm financing and valuation [2, 10].

2.2 Empirical literature

2.2.1 Global empirical evidence

Globally, researchers have increasingly explored how carbon performance affects the CoC. El Ghoul et al. [2] conducted a pioneering study and found that firms with superior environmental performance, including lower emissions, enjoyed a lower K_e . The authors argued that markets reward environmentally responsible behaviour with better access to capital and reduced risk premiums. Similarly, Chava [6] found that firms in polluting industries faced significantly higher loan spreads and equity costs, even when controlling for firm fundamentals. The study suggested that investors penalize carbon-intensive firms, especially when climate-related risks are not disclosed transparently.

Dhaliwal et al. [15] contributed by demonstrating that firms disclosing corporate social responsibility (CSR) metrics, including emissions, experienced a lower CoC and more accurate analyst forecasts. Their results supported the idea that disclosure quality reduces information asymmetry and strengthens investor confidence. Trinks et al. [3] provided further evidence that the cost of equity is positively correlated with carbon emissions, particularly in countries with robust ESG investing cultures. He noted that the strength of this relationship is moderated by institutional quality, regulatory enforcement, and investor sophistication. Trinks et al. [3] also confirmed that carbon intensity increases both the cost of debt and equity, especially in sectors where transition risk is high. Their multi-country panel study emphasized that climate-related risk pricing is becoming normalized across capital markets.

2.2.2 Emerging market evidence

In contrast to developed economies, evidence from emerging markets is mixed. Belkhir et al. [8] found that while investors in emerging markets are beginning to factor in ESG risks, their responses are weaker due to lower transparency and weaker institutional frameworks. In particular, the effects of carbon emissions on capital costs are less pronounced in jurisdictions where carbon pricing policies are weak or non-existent [21]. Eccles and Krzus [28] highlighted that in many emerging economies, ESG disclosures are inconsistent, limiting the ability of investors to compare firms on environmental performance. As a result, even if high-emitting firms are riskier, the market may fail to penalize them without standardized emissions data.

2.2.3 South African evidence

South Africa, despite being a pioneer of integrated reporting, has limited research directly examining the relationship between carbon emissions and capital costs [19]. Johnson [4] found that environmental disclosures on the JSE, especially for mining firms, improved investor confidence and reduced cost of equity over time. However, the study focused more on disclosure presence than actual emissions intensity. Ganda and Milondzo [27] found a weak relationship between sustainability and reporting CoC, suggesting that mere reporting is insufficient unless it is coupled with genuine

performance improvement and investor engagement. Ngcobo [5] further argued that many JSE-listed mining firms have inconsistent or non-comparable emissions disclosures, weakening the potential signaling value of carbon data.

These studies suggest that while environmental disclosures may influence investor behaviour, the direct relationship between actual carbon emissions and K_e remains empirically unexplored in South Africa's mining sector.

2.3 Conceptual synthesis and research gaps

Across theoretical and empirical literature, the argument that carbon emissions impact the CoC is increasingly well-founded. The mechanisms include stakeholder pressures, legitimacy maintenance, investor risk perceptions, and agency cost mitigation [14]. Empirically, several global studies have established a statistically significant positive relationship carbon intensity and K_e [3].

However, key gaps remain, particularly in the South African context:

- Most local studies (e.g., Ganda and Milondzo [27] and Johnson [4]) examined the presence or absence of ESG disclosures, rather than measuring actual carbon emissions. This distinction is critical, as high disclosure does not always reflect low carbon emissions.
- Few studies examine how carbon risk interacts with financial fundamentals like financial leverage, market beta, and valuation ergo leaving multidimensionality of risk under-theorized and under-tested [28].
- Although mining is among the highest-emitting sectors in South Africa, very few studies focus exclusively on this sector. Given its prominence on the JSE and its environment impact, a mining-specific investigation is long overdue [5, 20].
- With South Africa's carbon tax regime maturing, the cost implications of emissions are becoming more tangible, which may affect investor behavior [8]. Yet, the literature has not kept pace with these developments [29].

Thus, the present study seeks to empirically test the relationship between carbon emissions and the CoC for JSE-listed mining firms over the period 2018–2022, addressing a notable research gap in ESG-finance integration in emerging markets.

3. METHODOLOGY

This section presents the research design, regression model, variable definitions, and estimation techniques employed in this study. The study uses a panel data approach to assess whether carbon emissions are priced into the CoC by investors on the JSE, with a focus on listed mining firms between 2018 and 2022. This study adopts a quantitative research design using panel data analysis to investigate the relationship between carbon emissions and the K_e among JSE-listed mining firms. The methodology integrates econometric modeling with established financial theories, ensuring both statistical rigor and theoretical coherence.

The sample consists of 32 JSE-listed mining firms observed over a five-year period from 2018 to 2022. After removing firms with incomplete data, missing values, and outliers (relating to CEI, cost of equity, and controls), the final balanced panel comprises 15 firms and 75 firm-year observations taken into consideration. Data were sourced from

company annual reports, sustainability disclosures, and financial databases such as McGregor BFA and IRESS, ensuring reliability and consistency across firms and years. To reduce potential endogeneity between CEI and the cost of equity (K_e), we use lagged CEI (the previous year's value) as the main explanatory variable.

The given short time span ($T = 5$), panel unit-root tests add little additional insight, and the Capital Asset Pricing Model (CAPM)-based cost of equity (K_e) is naturally closely linked to beta. To address this, incorporated year fixed effects, used firm-level clustered and Driscoll–Kraay standard errors, and performed robustness checks using winsorized variables to reduce the impact of outliers. These measures reassure us that the main results, especially the positive and significant effect of CEI on the cost of equity, are robust and reliable [30].

3.1 Regression model

The following panel regression model is specified to test the relationship between carbon emissions and the CoC:

$$Ke_{it} = C + \beta_1 CEI_{it} + \beta_2 ROE_{it} + \beta_3 Size_{it} + \beta_4 Lev_{it} + \beta_5 BM_{it} + \beta_6 BETA_{it} + \epsilon_i$$

where,

- Ke_{it} = Cost of equity capital for firm i in year t
- CEI_{it} = Firm-level carbon emissions intensity
- ROE_{it} = Return on equity
- $Size_{it}$ = Log of total assets
- Lev_{it} = Debt-to-equity ratio
- BM_{it} = Book-to-market ratio
- $BETA_{it}$ = Market beta
- ϵ_i = Idiosyncratic error term

This model allows for firm-level heterogeneity and captures how changes in emissions performance relate to changes in the K_e over time. The focus is on the coefficient β_1 , which quantifies the impact of carbon emissions on K_e .

3.2 Variable measurement

3.2.1 Dependent variable: Cost of equity capital

K_e is estimated using the CAPM:

$$KE = R_f + \beta (R_m - R_f)$$

where,

R_f is the risk-free rate (South African 10-year government bond yield).

β is the firm's market beta.

R_m is the expected return on the JSE market portfolio.

CAPM remains one of the most widely used methods for estimating K_e , particularly in emerging markets like South Africa [31].

3.2.2 Independent variable: Carbon intensity

CEI is measured using a standard environmental finance formulation as the natural logarithm of total operational emissions ($Scope 1 + Scope 2$) scaled by firm revenue:

$$Carbon\ intensity = \ln \frac{Scope\ 1 + Scope\ 2\ emissions}{Total\ revenue} \times (-1)$$

This metric captures the firm's emissions efficiency relative

to its output and reflects operational environmental risk [3]. The multiplication by negative log, i.e., (-1), reverses the scale of the natural logarithm, which improves interpretability in regression analysis by ensuring a positive coefficient indicates higher emissions intensity leads to higher cost of equity.

3.2.3 Control variables

To isolate the impact of carbon emissions, several control variables are included:

- a. *Firm size*: Natural logarithm of total assets, as larger firms may have better access to capital and diversified risk [32].
- b. *Financial leverage*: Total debt-to-equity, reflecting the financial structure and bankruptcy risk [33].
- c. *BM*: Captures value/growth characteristics that influence investor expectations [30].
- d. *BETA*: Sourced from McGregor (IRESS), representing systematic risk [34, 35].

3.3 Estimation technique

The panel structure of the data, across 32 JSE-listed mining firms over five years, requires appropriate econometric handling. The study applies fixed effects estimation, which controls for time-invariant, unobserved firm-specific effects. A Hausman test is used to choose between fixed and random effects. The test supports fixed effects, indicating that firm-level heterogeneity is correlated with the regressors [36].

Robustness and Diagnostic Test: To ensure the validity of the model, several diagnostic tests were conducted.

Stationarity was examined using the Levin-Lin-Chu unit root test, which confirmed that all variables are stable over time [37]. Multicollinearity was assessed through the Variance Inflation Factor (VIF) scores, all of which were below 10, indicating no significant multicollinearity [38]. Additionally, Pearson correlation matrices were employed to preliminarily evaluate relationships among variables and avoid redundant predictors [39]. This robust methodological framework ensures that the observed relationship between carbon emissions and the CoC is both statistically reliable and economically meaningful [40].

4. DATA ANALYSIS AND RESULTS

This section presents the empirical findings of the study, beginning with descriptive statistics and diagnostic tests, followed by the results of the panel regression model used to assess the relationship between carbon emissions and the Ke.

4.1 Descriptive statistics

Descriptive statistics provide insight into the distribution and central tendencies of the study variables. The original sample comprised 32 JSE-listed mining firms, generating 160 firm-year observations between 2018 and 2022. Following the exclusion of firms with incomplete data, the final sample included 15 firms with 75 firm-year observations. The key statistics are summarized in Table 1 below:

Table 1. Descriptive statistics of the variables

Variables	Mean	Median	Maximum	Minimum	Standard Deviation
CEI	1.892410	1.781540	4.512830	-0.803120	1.487293
ROE	14.10280	15.88460	76.91230	-76.98210	22.19352
Size	16.69482	17.30411	19.05487	12.56341	1.793428
Lev	0.572941	0.442800	1.873200	0.080540	0.397512
BM	1.742384	1.372400	5.683100	0.415800	1.087596
BETA	1.154922	1.247100	2.184900	-1.273400	0.681912
Ke	15.04172	15.64380	21.18470	0.492600	4.087312

Source: Author's calculations

Note: CEI: carbon emissions intensity; ROE: return on equity; LEV: financial leverage; BM: book-to-market ratio; BETA: market beta; KE: cost of equity capital.

The descriptive statistics show substantial variation across all variables, indicating differences in emissions, profitability, size, leverage, valuation, and risk among mining firms. This heterogeneity justifies the use of a fixed-effects panel model to capture firm-specific characteristics. The mean cost of equity is approximately 14.1%, with a variability that reflects differences in firm risk profiles. Carbon intensity varies widely, indicating significant differences in emissions performance among mining firms.

4.2 Correlation

A Pearson correlation matrix was constructed to assess the initial relationships between the variables. The results indicate that carbon intensity is strongly correlated with the Ke ($r \approx 0.61$), suggesting that more carbon-intensive firms tend to have higher Ke. Firm size and market beta also show moderate positive correlations with Ke, while the BM ratio and financial leverage exhibit relatively weak associations. None of the variables is correlated above 0.7, thereby reducing concerns about multicollinearity.

4.3 Unit root and multicollinearity tests

To ensure the validity of the regression analysis, several diagnostic tests were conducted. The Levin-Lin-Chu unit root test confirmed that all variables are stationary at level with $p < 0.05$ [37]. Additionally, the VIF values for all independent variables were below 3, indicating low multicollinearity [39]. These results collectively validate the suitability of the dataset for panel regression analysis.

4.4 Regression findings

According to the regression results presented in Table 2, the model explains approximately 81% (0.812) of the within-firm variation in the cost of equity (adjusted $R^2 = 0.701$), suggesting strong explanatory power for a financial panel model [41]. The results reveal that CEI has a positive and statistically significant effect on the Ke ($\beta = 0.8421, p = 0.004$).

This indicates that more carbon-intensive firms face a higher cost of equity. Market beta and financial leverage (LEV) are also positively associated with Ke, aligning with

expectations under the CAPM and financial risk theory. In contrast, firm size and the BM ratio are not statistically significant at the 5% level. Overall, these findings confirm that environmental risk, in the form of carbon emissions, is reflected in investor-required returns on equity within the South African mining context [4].

Table 2. Regression results

Variable	Coefficient	Std. Error	P-Value
Constant	-1.984	12.4178	0.8621
CEI	0.8421	0.2914	0.004
ROE	-0.0098	0.0071	0.178
LEV	0.6142	0.2819	0.034
Size	0.6894	0.8012	0.3812
BM	-0.3617	0.1879	0.0623
BETA	5.5628	0.2714	0.0000
Effects Specification			
Cross-section fixed			
R-squared		0.812548	
Adjusted R-squared		0.7018261	
Total panel (balanced) observations		75	

Source: Author's calculations

5. DISCUSSION

The study sets out to investigate the relationship between carbon emissions and the CoC for JSE-listed mining firms. The regression analysis confirms that carbon intensity is positively and significantly associated with Ke. These findings have important implications for both theory and practice, especially within the context of emerging markets and environmentally intensive industries.

5.1 Interpretation of findings

The statistically significant positive relationship between carbon intensity (carbon emissions) and the Ke supports the hypothesis that environmental risk is a financially material factor in capital markets [10, 13]. Specifically, the results suggest that firms with higher carbon emissions are perceived by investors as riskier, prompting them to demand higher returns to compensate for future regulatory, reputational and operational risks [9].

This aligns with risk pricing theory, which posits that investors adjust required returns in response to perceived risks [10, 13]. In this context, carbon-intensive firms are exposed to increasing costs from carbon taxes, emission caps, and global climate financial disclosures such as TCFD. The evidence that investors penalize these firms by raising their CoC is consistent with recent global studies [3].

Additionally, these findings are consistent with signaling theory [2]. Poor carbon performance, especially when paired with weak disclosure practices, may signal to investors that a firm is unprepared for the low-carbon transition and this perception elevates investor risk expectations and, by extension, Ke [2, 42].

5.2 Comparison with prior literature

The study's results echo findings from developed market literature, such as El Ghouli et al. [2] and Chava [6], who found that firms with strong environmental performance tend to attract cheaper equity financing. However, this study

contributes a novel perspective by focusing on South Africa's mining sector, where evidence has historically been scarce and mixed.

While Ganda and Milondzo [27] found only weak links between ESG disclosure and CoC on the JSE, this study highlights that actual emissions performance (not just disclosure) is financially material. This distinction underscores the need for investors and regulators to move beyond checkbox disclosure assessments and instead focus on emissions metrics tied to firm operations [43].

The results also partially challenge findings from Ngcobo [5], who reported a weak investor response to integrated reporting in the South African mining sector. The present study suggests that even within the context of voluntary or inconsistent disclosure, carbon emissions are still priced in, suggesting increasing investor awareness of environmental risks.

5.3 Implications for firms, investors and policymakers

For mining firms, these findings underscore the financial benefits of improving carbon efficiency and investing in emissions reduction strategies. Reducing carbon emissions not only strengthens environmental credentials but also lowers the Ke, improving access to capital and overall firm valuation.

For investors, the results validate a growing ESG integration trend, confirming that carbon risk affects fundamental valuation metrics. Institutional investors may consider adjusting portfolio allocations to minimize exposure to high-carbon assets [9, 26].

For regulators and policymakers, the study highlights the need to strengthen carbon reporting standards in South Africa. Without consistent, mandatory emissions disclosure frameworks, investors face barriers in pricing risk accurately [19]. Enhancing carbon transparency could lower information asymmetry and support more efficient capital allocation in line with South Africa's climate objectives [5, 19].

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study set out to examine the relationship between carbon emissions and the CoC for JSE listed mining firms between 2018 and 2022. Drawing on risk pricing theory, signaling theory and agency theory, the study hypothesized that higher carbon intensity increases perceived firm risk, thereby elevating the CoC [13, 44, 45].

The panel regression analysis shows a statistically significant positive relationship between CEI and Ke, controlling for firm size, financial leverage, BM, and market beta. These findings provide robust evidence that carbon emissions are not only an environmental concern but also a financially relevant factor that investors price into their return expectations [2, 10].

The results also reinforce the notion that capital markets in emerging economies, despite regulatory gaps and disclosure inconsistencies, are increasingly responsive to environmental risk signals [19]. Even in the absence of uniform emissions reporting mandates, carbon performance affects investor behaviour, particularly in carbon-intensive sectors like mining [19, 43].

6.2 Recommendations

Mining Firms: Firms should prioritize emissions reduction strategies and enhance operational energy efficiency, as these factors directly influence capital costs and investor perceptions [3]. Beyond regulatory compliance, companies are encouraged to adopt transparent and credible emissions reporting practices, following globally recognized standards such as the Global Reporting Initiative (GRI) and the TCFD [28]. Furthermore, boards of directors and Chief Financial Officers should integrate carbon strategy into financial planning and capital budgeting processes, recognizing its direct implications for firm valuation and risk management [26].

Investors: Institutional investors and asset managers should incorporate carbon performance metrics into their risk-adjusted valuation models and portfolio allocation decisions [9]. Moreover, investors are encouraged to demand not only comprehensive ESG disclosures but also auditable and consistent carbon emissions data, particularly from firms operating in high-risk sectors [14].

Policymakers and Regulators: There is a strong case for enforcing mandatory carbon reporting through mechanisms such as the JSE Listings Requirements or frameworks led by the National Treasury [19]. Strengthening the South African carbon tax regime and aligning it with disclosure mechanisms would enhance risk pricing and promote sustainable finance [19]. Additionally, regulators should support capacity-building initiatives to help firms improve the quality, transparency, and comparability of their carbon reporting practices, and the digital solutions, when tailored to local contexts, which can accelerate decarbonization and improve sustainability.

Directions for Future Research: Future research could build on current work by exploring how the link between CEI and the cost of equity differs across specific mining commodities. Coal, gold, and PGM operations each have distinct emission profiles, production technologies, and market conditions, which may influence how investors price environmental risks. Although our current dataset does not include large enough sub-samples to meaningfully test these differences, expanding the scope of the data in future studies would allow researchers to conduct more detailed, commodity-level analyses.

In conclusion, this study provides credible evidence that carbon emissions have a significant and positive impact on the Ke for Johannesburg Stock Exchange-listed mining firms. The findings demonstrate that investors in South Africa increasingly recognize carbon intensity as a financial risk, demanding higher returns from firms with poor environmental performance. This confirms that carbon-related risks are becoming embedded in market valuation and investment decisions, even within emerging economies. By highlighting the financial implications of environmental responsibility, the study reinforces the importance of integrating carbon management into corporate strategy, financial planning, and investor relations. Ultimately, the research underscores that reducing emissions is not only an ethical and regulatory necessity but also a strategic pathway to improving capital efficiency and long-term firm value in the transition toward sustainable finance.

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