

Unveiling the ESG- firm performance Link in Mining: Examining the role of Climate change and greenhouse gas emission as moderator

¹Sarita Sahoo, ²Pinaki Nandan Pattnaik

¹Research Scholar, School of Economics and Commerce, KIIT Deemed to be University

²Dean, School of Innovation and Entrepreneurial Leadership, KIIT Deemed to be University

Abstract

Environmental, Social, and Governance (ESG) performance is increasingly viewed as a lever for responsible business growth and long-term value creation. This study explores how ESG practices influence firm performance and market value, particularly when aligned with environmental commitments such as greenhouse gas reduction and climate action. Focusing on Indian firms, the research applies a panel data approach and fixed-effects regression to assess both the direct and moderating effects of ESG dimensions on financial outcomes. The findings suggest that ESG engagement when embedded with a genuine environmental intent can enhance organizational accountability and stakeholder trust. Furthermore, the moderating role of climate responsiveness and emission management underscores the importance of integrating sustainability within core corporate strategy. By shifting the lens from ESG as a compliance measure to a performance enabler, this study presents a roadmap for firms to pursue environmental and financial goals in tandem. It highlights the need for contextual, metrics-driven ESG strategies tailored to local and sector-specific challenges.

Keywords: *ESG Score, Firm Performance, ROE Accounting Performance, ROA Accounting Performance, Tobin's Q Market Performance, Mining Sector*

Introduction

In recent years, the mining industry has faced intensifying scrutiny over its environmental and social impacts. The concepts of Environment, Social issues and Governance (ESG) practices have gained prominence as structure of exercising responsibility, resilience, and risk management at the corporate level (Cinciulescu, 2024). In all sectors, there has been a growing recognition that ESG integration fosters long-term value creation, stronger relationships with stakeholders, and a competitive edge. But the mining industry, with its profound environmental impacts and stringent government oversight, provides an interesting and challenging setting for analyzing the real effects of ESG practices on corporate performance (Karen, 2023).

Mining companies frequently operate within ecologically delicate regions and deal with heightened expectations from governments, investors, and local communities to implement sustainable and ethical measures (Fraser, 2021). In this context, ESG performance is no longer an option but rather a critical element in preserving the social license to operate (Verrier et al., 2022). While mining firms have invested considerably in community development, cleaner technologies, and ESG disclosures, the benefits from such investments tend to be mixed and, in some cases, inconclusive (Khemir et al., 2019).

The purpose of this research is to examine the relationship between ESG (Environmental, Social, and Governance) performance and firm performance in the mining sector, with a specific focus on how climate change and greenhouse gas (GHG) emissions moderate this relationship. By

analyzing both accounting-based (ROA, ROE) and market-based (Tobin's Q) performance indicators, the study aims to provide a comprehensive understanding of how ESG practices influence financial outcomes. This research seeks to fill existing gaps in the literature, particularly in the context of emerging economies like Indonesia, and offer insights that can guide corporate strategy, investment decisions, and policy formulation for sustainable development in high-impact industries.

There is an increasing body of literature supporting the positive link between ESG and firm performance, more recent literature has pointed out that this relationship is not linear nor consistent across sectors. Mining is a capital-intensive sector with long project cycles and heavy environmental liabilities, which means it may not benefit from the adoption of ESG measures in the same way that service-based or less resource-intensive sectors do (Khan, 2024). For this reason, it becomes essential to examine some of the moderating factors that might impact this ESG-performance relationship. Climate change alongside greenhouse gas (GHG) emissions serve as two critical factors that have strategic and operational impacts for mining companies (Ulrich, Trench & Hagemann, 2022).

Likewise, greenhouse gas emissions serve as a direct factor for environmental impact, especially in the mining industry which is known for its carbon-intensive operations (Yang, Bai & Zhang, 2021). Firms with high emissions might incur penalties, face reputational harm, and regulatory burdens, which may negate the positive impacts of ESG engagement (Luo & Tang, 2023; Zhang, Wang & Dong, 2022). Conversely, firms that reduce emissions and disclose climate risks proactively may enhance their reputation and gain rewards. Therefore, GHG emissions can either reinforce or weaken the relationship between ESG efforts and firm performance depending on how these emissions are managed.

The purpose of this research is to examine the relationship between ESG (Environmental, Social, and Governance) performance and firm performance in the mining sector, with a specific focus on how climate change and greenhouse gas (GHG) emissions moderate this relationship. By analyzing both accounting-based (ROA, ROE) and market-based (Tobin's Q) performance indicators, the study aims to provide a comprehensive understanding of how ESG practices influence outcomes. This research seeks to fill existing gaps in the literature, particularly in the context of emerging economies like Indonesia, and offer insights that can guide corporate strategy, investment decisions, and policy formulation for sustainable development in high-impact industries.

This study seeks to address the gap in the literature concerning the role of climate change and greenhouse gas emissions in moderating the relationship between ESG performance and firm-level performance in the mining sector. Drawing on stakeholder theory and resource-based theory, the research justifies ESG practices as not only ethical considerations but also as strategic assets that can create certain advantages for the firm in specific contexts. Stakeholder theory suggests firms that achieve alignment with stakeholder's views, through environmental and social governance, are more likely to receive sustained goodwill and long-term performance benefits (Jones, Harrison & Felps, 2018). At the same time, the resource-based view (RBV) stresses the importance of internal ESG management capabilities as a competitive differentiator.

The relevance of this research has both a theoretical and a practical dimension. From a theoretical perspective, it broadens the context of ESG-performance interrelationship by

incorporating climate change and emissions intensity as key contextual parameters. From a practical perspective, it benefits managers, investors, and policymakers in the mining sector by aiding in the alignment of sustainability targets. This study seeks to build a more precise framework for decision-making in high-impact sectors by determining the circumstances under which ESG strategies influence firm performance.

To conclude, the mining industry continues to grapple with the challenge of balancing sustainability mandates alongside profitability. This research seeks to examine the interrelationship between ESG performance and outcomes by looking into the conditional impacts of climate change and GHG emissions. The results of this study will help shed light on whether ESG actions enhance corporate value in the mining sector, or if the results are dependent on firms' strategies around risk management, capital structure, and environmental responsibility.

Review of Literature

The shift towards more corporate sustainability practices has brought more focus to the scholarly debate on the connection between a firm's performance and Environmental, Social, and Governance (ESG) practices. ESG is no longer just a corporate responsibility symbol; it has become a strategic asset aimed at creating long-term value and minimizing risks (Gary, 2019). Corporations are under scrutiny not only for their financial results but also for their environmental, social, and governance practices. Even though many scholars agree that ESG initiatives positively impact firm performance, especially through reputation, investor confidence, and operational efficiency, there is still limited evidence in highly regulated and environmentally sensitive sectors, such as mining.

The mining sector is particularly difficult for the examination of the ESG-firm performance linkage. Mining operations confront severe challenges in terms of environmental destruction, social disruption, and governance (Hirons, 2020). Consequently, mining companies are under greater scrutiny to prove that they are making tangible efforts towards sustainability (Hussain et al., 2019).. At the same time, the cost burden of adopting such ESG changes in undertakings that demand considerable capital is enormous. On one hand, a strong ESG record may increase the likelihood of obtaining permits, decrease adverse community relations, and improve access to patient capital (Leung & You, 2023). On the other hand, these initiatives entail huge costs without delivering any short-term returns, raising doubts on their impact on performance. This illustrates the rationale for seeking other factors that may condition or moderate the relationship between ESG and firm's performance.

Also important is greenhouse gas (GHG) emissions which serve as a direct reflection of a firm's environmental footprint. Mining firms have been considered some of the largest emitters of carbon. As climate change becomes a more pressing global issue, these companies have begun to receive more attention (D Van Halderen et al., 2016). Carbon emissions have an adverse impact on a mining firm's image and can also lead to regulatory fines and a loss of stakeholder goodwill. On the other hand, well-managed firms that reduce their GHG emissions are seen more favorably and so may enjoy better market valuation and capital costs (Kaiser & Welters, 2019). This means that GHG emissions are an indicator of a firm's environmental risk and, at the same time, of its ability to manage that risk (Xue, Zhang & Li, 2020). The balance between emissions control and performance will likely shape how much ESG practices foster firm-wide success.

Regardless of the importance of these factors, most literature has overlooked climate change alongside emissions as integrated moderators within the ESG-performance matrix (Issa, 2024). Very few research has looked into their combined impact, especially in high-risk industries such as mining. This means there is still a lack of understanding on how ESG frameworks affect internal financial strategies and external environmental impacts and, in turn, firm performance. Filling this gap could help in arriving at more accurate and context-driven assessments concerning the value of ESG strategies.

In light of these factors, this study aims to analyze the moderating roles of climate change and GHG emissions within the ESG performance and firm outcomes relationship in the mining sector. Through this, the study hopes to advance understanding of the contexts in which sustainability efforts result in measurable performance improvements. This study is particularly important in providing actionable insights for mining companies, policymakers, and investors attempting to balance sustainability performance in an intensely regulated and impactful industry. Researchers by and large lean on examples from banks or manufacturers, so we still do not know how ESG scores really move the needle for companies that dig, haul, and process nature's raw materials.

Despite the growing global emphasis on sustainability and responsible business practices, empirical evidence on the relationship between ESG performance and firm outcomes remains mixed and fragmented particularly in the context of environmentally sensitive sectors like mining. While several studies have explored the direct influence of ESG on firm performance, the findings vary significantly across sectors, countries, and performance metrics (Bahadori, Kaymak & Seraj, 2021; Carnini Pulino et al., 2022). Much of the existing research has focused on developed economies with mature sustainability regulations, leaving a knowledge gap in emerging markets like Indonesia, where ESG practices are still evolving and regulatory enforcement is often inconsistent.

Objectives

- **Objective 1:** *To examine the nexus between ESG practices and firm performance in specific mining industry in Indian context.*
- **Objective 2:** *To investigate the role of GHG emission in ESG practices and Firm Performance nexus.*
- **Objective 3:** *To examine the effect of Climate change policy in the relationship between ESG and Firm Performance.*

Environmental Score (E Score)

Environmental Score (E Score) reflects a company's performance in managing its environmental impact, including factors like greenhouse gas emissions, energy use, waste management, and compliance with environmental regulations (Guesser et al., 2015). The Mining business is rough on earth, using a lot of land, water, power and pumping out plenty of greenhouse gases, so the E score really matters there. A strong E score tells investors that the company keeps its environmental risks in check, embraces cleaner tech and spends on long-term green projects (Sun, Zhang & Hazarika, 2023).

For mining companies, a high E Score acts like a multipurpose strategy badge. Greener habits can cut costly fines, build trust with locals, and shrink day-to-day risks in areas with tough rules (Ramadass, Sathyanarayana & Fathima, 2023). At the same time, investors and shoppers now reward strong green records with cheaper capital and higher stock prices. This research focuses at how the E Score-part of the full ESG grade-affects performance, and how leverage levels and past emissions shape that impact.

Social Score (S Score)

Social Score (S Score) reflects how well a company manages its social responsibilities, including employee welfare, community impact, and human rights (Liang & Renneboog, 2017). It tracks how well the firm treats those groups and handles the links that keep the business running. In mining, where pits and trucks can change local towns, native lands, and day-to-day jobs, that score matters a lot for keeping a social license and surviving over the long haul. Safety on the site, fair labor rules, diverse hiring, active dialogue with communities, strong human-rights stand, and customers who feel valued all feed into the S Score (Hemphill & Kelley, 2016).

Miners that keep a solid social score usually polish their public image, lower the odds of clashes with local communities, and build sturdier ties with regulators, NGOs, and other partners (Frederiksen, 2019). Because the industry carries a long legacy of social drama, a high S score reads as early-warning risk control and proof of ethical day-to-day work. This report uses that S score to track how social push- outs affect performance in the sector, zeroing in on bottom-line numbers and how the market judges them. It also checks whether heavy debt and high greenhouse-gas output mute, amplify, or otherwise change the value lift that social deeds can deliver.

Governance Score (G Score)

Governance Score (G Score) is defined as a measure of how effectively a company is governed, focusing on board structure, transparency, ethical conduct, and compliance with regulations (Manning, Braam & Reimsbach, 2019). It tells investors whether leaders act in good faith, disclose openly, and treat all parties with respect. In mining, firms often work in shaky political zones or face thick layers of rules, so sturdy governance protects jobs, profits, and local trust (Meutia, Lumowa & Sakakibara, 2022). To build the score, analysts check board independence, pay links to performance, shareholders say, audit strength, anti-bribery steps, and plain-spoken reporting.

ESG Score

ESG Score is a combined measure of a company's performance in environmental, social, and governance aspects, reflecting its overall sustainability and ethical impact (Rajesh & Rajendran, 2020). ESG number gives investors, customers, and employees a quick peek at how seriously the business takes sustainability, ethics, transparency, and accountability. Mines routinely get grilled over pollution, displaced communities, rough labor setups, and whether they play by the rules. A high score tells the world that the firm steers its waste, treats workers fairly, follows the law, and thinks long-term about the planet and profit (Verhezen, 2015).

ROA Accounting Performance

Return on Assets (ROA) serves as an important accounting benchmark that indicates how effectively a firm taps its entire asset pool to create profit (Panigrahi, 2017). Analysts obtain the ratio by dividing net income by the value of total assets. In heavy industries such as mining, ROA provides clear insight into operational discipline by revealing how well costly investments—equipment, land, tunnels, and processing plants—yield revenue. An elevated ROA signals superior asset stewardship, pointing to tighter control, lower waste, and ultimately stronger profit margins (Musa, 2024).

ROE Accounting Performance

Return on Equity (ROE) on the other hand, measures the return generated on shareholders' equity (Ichsani & Suhardi, 2015). ROE illustrates management's ability to turn owners' capital into earnings, a vital sign in any arena but especially in resource extraction, where budgets can be enormous and regulations unpredictable. For mining firms, a robust ROE assures investors that their stake is working hard amid commodity volatility and permit hurdles (Goh, Saville & Scheepers, 2016). ROA and ROE collectively furnish a rounded picture of internal efficiency, enabling observers to judge how new environmental, social, and governance initiatives translate into bottom-line performance.

Tobin's Q Market Performance

Tobin's Q defines a market-based measure of firm performance, expressed as the ratio of a company's market value to the replacement cost of its assets. Tobin's Q is a well-known market signal investors use to judge how a company is performing (Bartlett & Partnoy, 2020). The ratio simply compares what the market thinks all a firm's assets are worth with what it would cost to replace those same assets. When the Q sits above 1, investors clearly believe the brand has extra future profits, while a reading under 1 means many see the firm as overpriced or slow-growing. Because mining is a rough and risk-laden business, that same ratio lets traders spot strengths and weaknesses hid from usual balance-sheet figures.

Greenhouse Gas (GHG) Emission

Greenhouse gas emissions, which include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), are the by-products of many human activities that trap outgoing heat and warm the planet. In mining, these gases become a pressing issue because the industry burns large amounts of fossil fuel, consumes prodigious energy, and disturbs vast swathes of land (Deb et al., 2017). Heavy emissions harm local ecosystems and expose companies to tougher regulations, public backlash, and mounting costs. Therefore, tracking and curbing these releases is crucial for miners' keen on boosting their environmental standing and meeting ever-stricter global sustainability goals.

Climate Change

Climate change is the modification of worldwide or local climate systems over an extended period of time, mostly caused by the fossil fuel industry and combustion systems, deforestation, and other form of industrial activities. These activities emit greenhouse gases, which capture CO₂, CO, CH₄, and N₂O, taking a toll on the earth's delicate equilibrium. The results of climate change encompass global temperature inflation, the melting of glaciers, the rise of the sea-level, more frequent 'droughts and floods', shift in ecosystems along with biodiversity, and in extreme

cases shift of ecosystems. The earth is left ravaged and vulnerable, and the damage is not restricted only to the ecosystem, it also has dire consequences for the world economy, public health as well the for, water, and health; the problem is urgent and a holistic approach is vital.

Relationship between ESG Score and ROE Accounting Performance

The connection between ESG (Environmental, Social, and Governance) Score and Return on Equity (ROE) illustrates the extent to which a company earns profit on equity investments relative to its equity profit and responsibly manages its business operations. Effective risk management, stakeholder engagement, and operational efficiency usually translate to solid net returns, and these factors are often signaled by a higher ESG score (Lee et al., 2023; Strine, Smith & Steel, 2020). Increased investor confidence, lower capital costs, and better talent retention attained because of strong ESG performance further improves ROE. Nevertheless, sector variations and industry-specific ESG norms and reporting standards are likely to influence this relationship. Thus, hypothesis 1a is given as:

H_{1a}: There is a significant impact of ESG Score on ROE Accounting Performance.

Association between ESG Score and ROA Accounting Performance

As a measure of a firm's capacity to derive earnings from its assets, Return on Assets (ROA) is critical to a firm's performance. Strong operational governance and risk management resources are critical to a firm's long-term enduring productivity, as ESG-aligned firms often demonstrate. This suggests a positive association between a firm's ESG score and its ROA. Firms aligned to ESG standards strive toward efficiency and innovation, thus, providing better asset and profit utilization. Hence, ESG performance is likely to reflect a firm's operational wellness. So, hypothesis 1b is formulated as:

H_{1b}: There is a significant impact of ESG Score on ROA Accounting Performance.

Effect of ESG Score on Tobin's Q Market Performance

Tobin's Q, which reflects the market value of a firm against its replacement value, is often utilized to measure perception and value, especially the intangible aspects of a firm. A firm's ESG score can enhance its Tobin's Q, as investors tend to favor well-governed and sustainably managed firms for their ability to deliver stable, long-term returns (Baniami, 2021). Market participants may view ESG leadership as demonstrating lower regulatory risk, a stronger reputation, and greater resilience to external shocks, which justifies a higher market valuation. This is critical in regions where ESG-focused investment strategies are gaining traction. Therefore, hypothesis 1c is articulated as:

H_{1c}: There is a significant effect of ESG Score on Tobin's Q Market Performance.

The moderating effect of GHG Emission on the relationship between ESG Score and ROE Accounting Performance

Greenhouse gas (GHG) emissions can serve as a moderating variable in the relationship between ESG scores and ROE, demonstrating how the ESG's effectiveness impacts the environment. Firms with higher ESG scores but inferior GHG performance may be penalized financially

because of heightened environmental risk and regulatory scrutiny (Rajesh & Rajendran, 2020). On the other hand, firms that has a strong ESG performance and maintain low greenhouse emissions can improve profitability through cost savings and enhanced reputational impacts as well as better access to green financing. This indicates that the financial benefits derived from ESG strategies are dependent on the firm's actual environmental performance. Thus, hypothesis 2a is given as:

H_{2a}: GHG Emission acts as a moderator between ESG Score and ROE Accounting Performance.

The moderating effect of GHG Emission on the relationship between ESG Score and ROA Accounting Performance

Sustainability initiatives are critical to a firm's operational returns. This suggests that GHG emissions might have a pronounced impact on the ESG-ROA relationship (Saputra, 2022). Environmental, social, and governance (ESG) initiatives with high scores and low emission strategies are predicted to strengthen asset productivity, while high emissions would lead to efficiencies that reduces productivity (Suardana, Astawa & Martini, 2018). Therefore, extreme ESG score would lead to reputational damage, environmental penalties, and deteriorating productivity. This would, indeed, strengthen the predicted favorable impact of ESG on a firm's operational performance. So, hypothesis 2b is formulated as:

H_{2b}: GHG Emission acts as a moderator between ESG Score and ROA Accounting Performance.

The moderating effect of GHG Emission on the relationship between ESG Score and Tobin's Q Market Performance

Stringent measures to ensure environmental compliance and manage GHG emissions are fundamental requirements of the ESG framework. Access to capital has a pronounced association with ESG metrics, emissions, and corporate governance (Asiri, 2015). ESG compliance serves as a benchmark that is expected to, propel an organization's long-term valuation and strengthen investor relations. Investor perception of corporate sustainability frameworks as ESG-Score serves as a constraint on a firm's valuation and affects Tobin's Q (Mysaka & Derun, 2021). Conversely, strong ESG performance and low emissions enhance market valuation, substantiating the former. Therefore, hypothesis 2c is given as:

H_{2c}: The moderating effect of GHG Emission on the relationship between ESG score and Tobin's Q Market Performance.

The moderating effect of Climate Change on the relationship between ESG Score and ROE Accounting Performance

Consideration of climate change issues concerns the possible external risks that could affect corporate profitability, which might change the ESG-ROE relationship. There might be a struggle to earn profits as a result of climate disruption for firms that have high ESG scores but little climate resilience. On the other hand, firms that practice proactive climate change adaptations and sustainable practices stand to protect their profitability and the trust of investors. This implies that climate change serves as a contextual factor that either enhances the returns from ESG investments or limits the returns on ESG investments.

Thus, the hypothesis 3a is given as:

H_{3a}: The moderating effect of Climate Change on the relationship between ESG score and ROE Accounting Performance.

The moderating effect of Climate Change on the relationship between ESG Score and ROA Accounting Performance

Climate change can likely have a moderating impact on the ESG-ROA relationship by affecting the ways in which sustainability impacts operations productivity. Some companies experiencing climate change impacts supply chain disruptions, resource scarcities, or infrastructure damage which may begin facing lower returns on ESG spend. On the upside, companies that proactively assess climate risks within their ESG frameworks tend to have better climate change exposure for asset protection, performance consistency, and climate value preservation, which emphasizes the need for ESG implementation to be climate context-responsive for optimal value and asset-driven returns. So, the hypothesis 3b is:

H_{3b}: The moderating effect of Climate Change on the relationship between ESG score and ROA Accounting Performance.

The moderating effect of Climate Change on the relationship between ESG Score and Tobin's Q Market Performance

Investors can perceive a firm's climate change preparedness as a strong determinant of how ESG spend translates to market capitalization. High ESG scores which lack climate vulnerability assessment may be deemed as insufficient, giving rise to skepticism and resultant market undervaluation. In contrast, firms that aim at climate mitigation and adaptation within their ESG frameworks become more marketable as they are perceived to be a lower long-term risk and more strategically sound. This makes climate change a central moderator in determining ESG's firm value impact. Thus, the hypothesis 3c is formulated as:

H_{3c}: The moderating effect of Climate Change on the relationship between ESG score and Tobin's Q Market Performance.

Based on the above hypothesis, the research model is as follows:

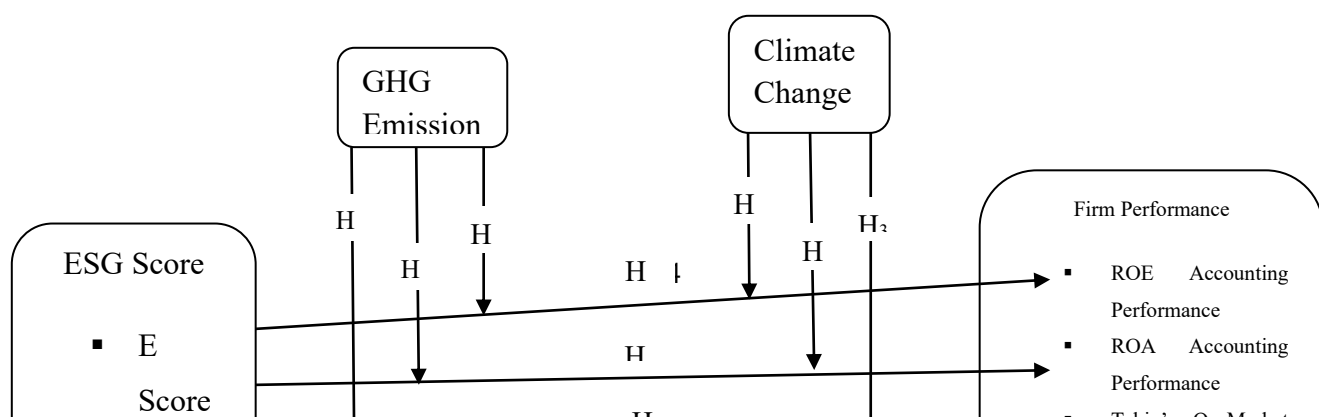


Figure 1. Hypothesized Research Model

Research Methodology

Data

The sample for this research comprises 10 mining companies operating in India. The data has been collected from the annual reports of these companies over a five-year period, covering the financial years from 2020 to 2024. To ensure data accuracy and robustness, extreme outlier values were smoothed by replacing them with values closer to the central data range. The selection of companies was based on data availability and industry relevance to ensure consistency and reliability in the analysis.

Methodology

The sample for this study includes 10 Indian mining companies, with data spanning five years (2020–2024). The financial and ESG data were extracted from the annual reports, while the information regarding GHG emissions and Climate Change risks was gathered from company sustainability reports. GHG emissions and Climate Change levels are categorized into three groups: 1 = Low Risk, 2 = Moderate Risk, 3 = High Risk.

To standardize the data and allow for comparison across scales, all continuous variables were transformed into ordinal categorical variables using quantile-based binning (`pd.qcut`) in Python. Each variable was divided into three categories based on tertiles.

This transformation was applied to the following variables using the code:

```
import pandas as pd

# Load data
df = pd.read_csv("Company Values 10.csv")

# Select columns you want to categorize
cols_to_categorize = ['ESG_Score', 'ROA', 'ROE', 'Tobin_Q']

# Categorize each column into 3 quantile-based bins
for col in cols_to_categorize:
    df[col + '_Category'] = pd.qcut(df[col], q=3, labels=[1, 2, 3]).astype(int)

# Preview result
print(df[[col for col in df.columns if 'Category' in col]])
```

Measurement of Variables

In order to understand the relationship between the impact of ESG Score on the firm's economic performance and its market value, three panel data regressions were carried out with ROA, ROE and Tobin's Q as the dependent variables. The scope of this study is limited to 10 Indian mining companies with data sourced from their annual reports for the period 2020 to 2024. The first set of models employing panel regression were used to study the impact of ESG Score on firm level performance. Using Python's linearmodels.PanelOLS, this study applies panel data regression to evaluate the impact of ESG Score on a firm's accounting performance measured through two indicators - Return on Equity (ROE) and Return on Assets (ROA), and on the firm's market performance indicator, Tobin's Q.

Each relationship is modeled as:

$$Y_{it} = \beta_0 + \beta_1 ESG_{it} + \epsilon_{it}$$

where Y_{it} is the performance metric (ROA, ROE, Tobin's Q), i is the firm, and t is the time/year.

This moderation analysis was operationalized in Python by creating interaction variables and fitting panel regressions separately for each moderator across the three dependent variables. To examine moderating effects of GHG Emissions, and Climate Change, interaction terms were introduced into the panel regression model:

$$Y_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 Moderator_{it} + \beta_3 (ESG \times Moderator)_{it} + \epsilon_{it}$$

Data Analysis and Interpretations

The summary statistics for the selected dependent, independent, and moderating variables are shown in the table 1. In the context of the study, the summary statistics of the key variables including firm performance indicators (ROA, ROE, Tobin Q), ESG Score, and the moderating variables (Climate Change and GHG Emission) are presented in table 1. The table provides useful details regarding the number of observations (N), mean, median, minimum and maximum values for each of the variables.

As for the 10 Indian mining companies, the average ROA is 13.6 with a median of 10.1 which reflects positive asset profitability. Return on Equity also improves with mean of 20.5 and median of 13.9 though performance in some firm was highly variable (range from -9.6 to 91.0) indicating strong return on equity in some firms. As for market valuation, Tobin Q, which is a proxy for market valuation, has mean of 2.3 and median of 1.5. This indicates that the market value, in most cases, exceeds the replacement cost of the firm's assets. The ESG Score indicates that the mining firms have a mean of 46.5 and median of 52.0 showcasing the performance on the sustainability metrics was moderate.

The moderation variables, Climate Change and GHG Emission, are categorical variables with a range of 1 to 3 as their values. The variables exhibit a mean of 2.1 and a median of 2.0, suggesting that the majority of companies are placed at the mid-level category for their climate-related concerns and GHG emissions as per the scoring or coding system employed. The descriptive statistics indicate that the sampled companies are profitable and exhibit some degree

of engagement with ESG, although there appears to be a divergence in financial and environmental performance among the sample.

Table 1. Summary Statistics for All Variables

Variable	N	Mean	Median	Min	Max
ROA	50	13.6	10.1	-6.2	65.6
ROE	50	20.5	13.9	-9.6	91.0
Tobin Q	50	2.3	1.5	0.0	15.4
ESG Score	50	46.5	52.0	3.6	85.0
Climate Change	50	2.1	2.0	1.0	3.0
GHG Emission	50	2.1	2.0	1.0	3.0

Table 2 presents the correlation matrix for the key variables used in the study. The findings show an extraordinarily strong correlation between ROA and ROE of 0.98. This indicates that firms that yield higher returns on assets also tend to yield higher returns on equity. Better ESG performance is generally associated with better financial performance, as moderate positive correlations were identified with ESG Score and both ROA (0.53) and ROE (0.47).

Market valuation, represented by Tobin's Q, displays weaker correlations with ESG Score (0.08), Climate Change (0.04), and GHG Emissions (0.06) indicating that less emphasis may be placed on these non-financial metrics by investors. Moreover, as expected, Climate Change and GHG Emissions show strong correlation (0.90), given their environmental interrelatedness. These two environmental aspects also demonstrate moderate positive correlations with ROA and ROE, possibly reflecting sectoral characteristics or the size of the operations among higher performing companies.

Table 2. Correlation Matrix for all variables

Variable	Roa	Roe	Tobin_Q	ESG Score	Climate Change	GHG Emission
ROA	1.00	0.98	0.55	0.53	0.41	0.36
ROE	0.98	1.00	0.54	0.47	0.44	0.39

Tobin_Q	0.55	0.54	1.00	0.08	0.04	0.06
ESG Score	0.53	0.47	0.08	1.00	0.32	0.35
Climate Change	0.41	0.44	0.04	0.32	1.00	0.90
GHG Emission	0.36	0.39	0.06	0.35	0.90	1.00

The table 3 shows the coefficient values and their statistical significance which were derived using a fixed-effects panel data regression, considering Indian mining companies from 2020 to 2024. The association between ESG Score and ROA shows a positive coefficient of 0.2500. However, the associated p-value of 0.2478 implies that the association is not statistically significant. While the positive association suggests that better ESG performance may improve operational efficiency (reflected in ROA), the non-significant p-value means that we cannot conclude that this relationship holds for all firms in the sample.

The relationship exhibiting the most convincing ESG correlation is with ROE, as ESG Score has a coefficient of 0.3333 with a p-value of 0.0029, significant at the 1% level denoted by (***). This demonstrates a strong statistically significant relationship. This suggests that firms that perform better on ESG criteria tend to have higher returns on equity, likely because of greater trust from investors, a lower cost of capital, or better risk management.

Concerning Tobin's Q, the coefficient of 0.1458 suggests a weak, positive relationship with ESG Score. However, the large p-value of 0.3913 in this case shows that the relationship is not statistically significant. Therefore, in this case, ESG performance does not consistently affect market-based valuation which may be attributed to a lack of ESG consideration in investor pricing models in emerging markets, such as India.

In summary, while ESG Score has a significant and positive effect on ROE, its relationships with ROA and Tobin's Q are positive but not statistically significant. This implies that ESG efforts are more likely to translate into shareholder value than immediate operational or market performance, underscoring the strategic importance of ESG investment for equity-driven growth.

Table 3. Direct Effects of ESG Score on Performance Variables

Relationship	Coefficient	P-Value	Significance
ESG Score → ROA	0.2500	0.2478	-
ESG Score → ROE	0.3333	0.0029	***
ESG Score → Tobin Q	0.1458	0.3913	-

Table 4 illustrates the moderating impacts of GHG Emission and Climate Change on the association of ESG performance with the firm performance metrics of ROE, ROA, and Tobin's Q. The findings indicate that GHG Emission moderates the ESG → ROE linkage with significant impact, evidenced by an interaction coefficient of 0.1929 and a p-value of 0.0342, which affirms

significance at the 5% level. This indicates that firms with better ESG performance and higher transparency around GHG emissions reap enhanced impacts on their return on equity.

On the other hand, GHG Emission does not significantly affect the ESG → ROA and ESG → Tobin Q relationships, given the p-values of 0.9593 and 0.3940. These values are not only above the conventional significance levels, but are also quite far from them. This suggests that the GHG Emission's moderating impact is predominantly relevant to equity performance, and not to the efficiency of assets or their market value.

For Climate Change, a notable moderating effect appears only for Tobin's Q, where a negative coefficient of -0.2773 with a p-value of 0.0660 was recorded, which is significant only at the 10% mark. As interpreted, this means that the greater the focus on climate change issues, the lesser the positive effect that ESG would have on market-based valuation (Tobin's Q). On the other hand, the moderation effects of Climate Change on ROE and ROA are both statistically non-significant (p-values of 0.2848 and 0.9520, respectively). This suggests that climate change disclosures do not have a statistically significant effect on the relationship between ESG factors and accounting-based performance.

Overall, these findings underscore the fact that at the firm level, the emissions disclosures and other environmental components of ESG are critical and influential in transforming ESG activities into performance, especially in enhancing the returns on shares.

Table 4. Moderating Effect of GHG Emission and Climate Change

Relationship	Interaction Term	Coefficient	P-Value	Significance
GHG Emission moderating ESG → ROE	X_GHG	0.1929	0.0342	***
GHG Emission moderating ESG → ROA	X_GHG	-0.0096	0.9593	-
GHG Emission moderating ESG → Tobin_Q	X_GHG	-0.1277	0.3940	-
Climate Change moderating ESG → ROE	X_CC	0.1025	0.2848	-
Climate Change moderating ESG → ROA	X_CC	0.0117	0.9520	-
Climate Change moderating ESG → Tobin_Q	X_CC	-0.2773	0.0660	***

In conclusion, the two GHG emissions and climate change objectives of ESG have different moderating effects on the ESG–firm performance relationship. GHG Emission has a positive moderation effect on ROE, indicating that companies with better ESG performance and transparent GHG emissions accounting tend to have greater shareholder value in return while Climate Change seemingly moderately weakens the ESG → Tobin's Q relationship. This suggests that greater climate concern may reduce the market's valuation reaction to ESG initiatives. These two findings, in conclusion, demonstrate that while companies may focus on all three aspects of ESG, the emphasis upon disclosure and realistic accounting may yield greater shareholder value on GHG emissions accounting.

Discussion

This research investigates the intricate relationship between ESG (Environmental, Social, and Governance) strategies and the financial performance of firms, making important contributions to scholarly discourse and real-world applications. The results suggest that specific ESG initiatives, especially those pertaining to greenhouse gas emissions and climate change, can have diverse, and at times, contradictory impacts on organizational performance. It is observed that ESG initiatives seem to correlate more strongly with equity-based performance metrics, indicating that both equity holders and other stakeholders are inclined to support firms which exhibit sound governance and sustainability.

This study further stresses the need to analyze environmental considerations as more than just stand-alone metrics but as critical moderators that influence the success of ESG frameworks. The existence of substantial moderating impacts proves that environmental disclosures and performance have the potential to strengthen or weaken the association between ESG efforts and organizational performance. This illuminates the need for, and significance of, environmental corporate transparency and climate change responsiveness.

Practically, the study serves the users of the corporate financial report, corporate executives, regulators, and shareholders. This study makes it clear that, especially the environmental aspects, ESG integration into the backbone of corporate strategy is critical for sustainable long-term value and business resilience. Moreover, companies that manage their environmental responsibilities are likely to improve their competitive advantage as well as the confidence of their investors.

The research also addresses a critical gap in ESG literature by incorporating moderation analysis, an area often overlooked in existing studies. It contributes to a deeper understanding of how ESG impacts are not uniform but vary depending on specific contextual and operational factors. This approach adds nuance to ESG-performance discussions and lays the groundwork for more sophisticated models in future research.

Overall, the study is significant in emphasizing the strategic role of ESG practices in shaping firm outcomes, advocating for a more integrated, environmentally conscious approach to corporate governance and performance measurement.

Conclusion

In conclusion, this study provides empirical evidence on the influence of ESG performance on firm financial outcomes, emphasizing both direct and moderated relationships. The analysis demonstrates that ESG efforts, particularly when aligned with corporate responsibility in managing GHG emissions and climate change, can have meaningful implications for firm performance. The significant moderating effect of these environmental variables on the ESG-financial performance linkage reinforces the argument that environmental sustainability is not just a compliance issue but a strategic lever for value creation.

The findings hold substantial implications for corporate leaders, investors, and policymakers. For firms, integrating ESG into their core strategies especially with an environmental focus that can enhance financial sustainability and long-term growth. Investors may use ESG and environmental metrics to assess firm resilience and risk exposure. Meanwhile, policymakers should support ESG disclosures and incentivize sustainable business practices. Overall, this research advances ESG literature by highlighting the contextual complexities in ESG-performance relationships and sets the stage for further in-depth exploration of sectoral, regional, and temporal dynamics.

References

- Asiri, B. K. (2015). How investors perceive financial ratios at different growth opportunities and financial leverages. *Journal of Business Studies Quarterly*, 6(3), 1.
- Bahadori, N., Kaymak, T., & Seraj, M. (2021). Environmental, social, and governance factors in emerging markets: The impact on firm performance. *Business Strategy & Development*, 4(4), 411-422.
- Baniamin, H. M. (2021). Linking trust, performance, and governance quality: What can explain the incongruity?. *Commonwealth & Comparative Politics*, 59(2), 128-148.
- Bartlett, R., & Partnoy, F. (2020). The Misuse of Tobin's q. *Vand. L. Rev.*, 73, 353.
- Bolino, M. C., & Grant, A. M. (2016). The bright side of being prosocial at work, and the dark side, too: A review and agenda for research on other-oriented motives, behavior, and impact in organizations. *Academy of Management Annals*, 10(1), 599-670.
- Carnini Pulino, S., Ciaburri, M., Magnanelli, B. S., & Nasta, L. (2022). Does ESG disclosure influence firm performance?. *Sustainability*, 14(13), 7595.
- Cinciulescu, D. (2024). Developments and perspectives on corporate environmental risk management. A comprehensive analysis of ESG integrations. *Revista de Stiinte Politice*, (81), 83-91.
- D Van Halderen, M., Bhatt, M., Berens, G. A., J. Brown, T., & BM Van Riel, C. (2016). Managing impressions in the face of rising stakeholder pressures: Examining oil companies' shifting stances in the climate change debate. *Journal of Business Ethics*, 133, 567-582.
- Deb, M., Sarkar, S. C., Deb, M., & Sarkar, S. C. (2017). Issues of Sustainable Development in the Mines and Minerals Sector in India. *Minerals and Allied Natural Resources and Their*

Sustainable Development: Principles, Perspectives with Emphasis on the Indian Scenario, 519-551.

- Fraser, J. (2021). Mining companies and communities: Collaborative approaches to reduce social risk and advance sustainable development. *Resources Policy*, 74, 101144.
- Frederiksen, T. (2019). Political settlements, the mining industry and corporate social responsibility in developing countries. *The Extractive Industries and Society*, 6(1), 162-170.
- Gabr, D. H., & ElBannan, M. A. (2025). Is it worth it to go green? ESG disclosure, carbon emissions and firm financial performance in emerging markets. *Review of Accounting and Finance*, 24(2), 193-217.
- Gary, S. N. (2019). Best interests in the long term: Fiduciary duties and ESG integration. *U. Colo. L. Rev.*, 90, 731.
- Gathara, Z. M., Kilika, J. M., & Maingi, J. N. (2019). Effect of leverage on financial performance of selected companies listed in the Nairobi Securities Exchange, Kenya. *International Journal of Innovative Finance and Economics Research*, 7(1), 10-33.
- Goh, J. C. L., Saville, A., & Scheepers, C. (2016). Preserving the delicate balance to manage a thriving business in South Africa—the adventure of OneLogix. *Emerald Emerging Markets Case Studies*, 6(2), 1-48.
- Guesser, T., Hein, N., Pfitscher, E. D., & Lunkes, R. J. (2015). Environmental impact management of Brazilian companies: Analyzing factors that influence disclosure of waste, emissions, effluents, and other impacts. *Journal of Cleaner Production*, 96, 148-160.
- Hemphill, T. A., & Kelley, K. J. (2016). Socially responsible global supply chains: The human rights promise of shared responsibility and ISO 45001. *Journal of Global Responsibility*, 7(2), 163-180.
- Hussain, H. I., Grabara, J., Razimi, M. S. A., & Sharif, S. P. (2019). Sustainability of leverage levels in response to shocks in equity prices: Islamic finance as a socially responsible investment. *Sustainability*, 11(12), 3260.
- Ibrahim, H., & Lau, T. C. (2019). The determinants of financial leverage for surviving listed companies in Malaysia. *International Journal of Business and Society*, 20(1), 75-94.
- Ichsani, S., & Suhardi, A. R. (2015). The effect of return on equity (ROE) and return on investment (ROI) on trading volume. *Procedia-Social and Behavioral Sciences*, 211, 896-902.
- Issa, A. (2024). Do emissions reduction initiatives improve financial performance? Empirical analysis of moderating factors. *International Journal of Accounting & Information Management*, 32(2), 228-257.

- Jones, T. M., Harrison, J. S., & Felps, W. (2018). How applying instrumental stakeholder theory can provide sustainable competitive advantage. *Academy of Management Review*, 43(3), 371-391.
- Kaiser, L., & Welters, J. (2019). Risk-mitigating effect of ESG on momentum portfolios. *The Journal of Risk Finance*, 20(5), 542-555.
- Karen, A. (2023). Compliance with Environmental, Social, and Governance Requirement in the Mining Industry. *Multidisciplinary Journal of Science and Technology*, 3(1), 93-100.
- Khan, S. (2024). Designing a Circular Risk Scorecard (CRIS) to bridge circular economy transitions and financial risk profiles: a theoretical study of 6 Finnish enterprises.
- Khemir, S., Baccouche, C., & Ayadi, S. D. (2019). The influence of ESG information on investment allocation decisions: An experimental study in an emerging country. *Journal of Applied Accounting Research*, 20(4), 458-480.
- Lee, M. T., Raschke, R. L., & Krishen, A. S. (2023). Understanding ESG scores and firm performance: are high-performing firms E, S, and G-balanced?. *Technological Forecasting and Social Change*, 195, 122779.
- Leung, T. C. H., & You, C. S. X. (2023). ESG application in sustainable development of the healthcare industry. In *Environmental, Social and Governance and Sustainable Development in Healthcare* (pp. 47-64). Singapore: Springer Nature Singapore.
- Liang, H., & Renneboog, L. (2017). On the foundations of corporate social responsibility. *The Journal of Finance*, 72(2), 853-910.
- Loi, T. H. (2016). Stakeholder management: a case of its related capability and performance. *Management Decision*, 54(1), 148-173.
- Luo, L., & Tang, Q. (2023). The real effects of ESG reporting and GRI standards on carbon mitigation: International evidence. *Business Strategy and the Environment*, 32(6), 2985-3000.
- Manning, B., Braam, G., & Reimsbach, D. (2019). Corporate governance and sustainable business conduct—Effects of board monitoring effectiveness and stakeholder engagement on corporate sustainability performance and disclosure choices. *Corporate Social Responsibility and Environmental Management*, 26(2), 351-366.
- Meutia, A. A., Lumowa, R., & Sakakibara, M. (2022). Indonesian artisanal and small-scale gold mining—a narrative literature review. *International Journal of Environmental Research and Public Health*, 19(7), 3955.
- Musa, A. (2024). Impact of Ownership Structures on Financial Performance and Distress in Businesses. *Journal of Policy Options*, 7(3), 30-38.
- Mysaka, H., & Derun, I. (2021). Corporate financial performance and Tobin's Q in dividend and growth investing. *Contemporary Economics*, 276-288.

- Panigrahi, S. (2017). Economic Value Added and traditional accounting measures for shareholder's wealth creation. *Panigrahi, SK (2017). Economic Value Added and Traditional Accounting Measures for Shareholder's Wealth Creation. Asian Journal of Accounting and Governance*, 8, 125-136.
- Rajesh, R., & Rajendran, C. (2020). Relating environmental, social, and governance scores and sustainability performances of firms: An empirical analysis. *Business Strategy and the Environment*, 29(3), 1247-1267.
- Ramadass, R., Sathyanarayana, N., & Fathima, Y. (2023). Improving citizen lifestyle in green smart city. In *Green Blockchain Technology for Sustainable Smart Cities* (pp. 29-63). Elsevier.
- Raza, R. S., Mustafa, M. P., & Zoltan, S. A. (2023). Leverage, Debt Maturity and Corporate Financial Performance: Evidence from Non-Financial Firms Listed at Pakistan Stock Exchange. *Journal of Finance and Accounting*, 7(9), 1-11.
- Saputra, F. (2022). Analysis effect return on assets (ROA), return on equity (ROE) and price earning ratio (PER) on stock prices of coal companies in the Indonesia Stock Exchange (IDX) period 2018-2021. *Dinasti International Journal of Economics, Finance and Accounting*, 3(1), 82-94.
- Shi, L., Wang, Y., Zhang, P., Xu, Y., & Zhang, H. (2023). Sustainable Development of the Energy Sector: Application and Impact of ESG Practices in Coal Mine Safety. *International Core Journal of Engineering*, 9(9), 196-201.
- Spinardi, G. (2019). Performance-based design, expertise asymmetry, and professionalism: Fire safety regulation in the neoliberal era. *Regulation & Governance*, 13(4), 520-539.
- Strine Jr, L. E., Smith, K. M., & Steel, R. S. (2020). Caremark and ESG, Perfect Together: A Practical Approach to Implementing an Integrated, Efficient, and Effective Caremark and EESG Strategy. *Iowa L. Rev.*, 106, 1885.
- Suardana, I. B. R., Astawa, I. N. D., & Martini, L. K. B. (2018). Influential factors towards return on assets and profit change. *International journal of social sciences and humanities*, 2(1), 105-116.
- Sun, W., Zhang, X., & Hazarika, N. (2023). Dilemmas of R&D investment risks and sustainability in the clean-tech economy: Evidence from Nasdaq clean edge index components. *International Journal of Green Energy*, 20(2), 139-152.
- Ulrich, S., Trench, A., & Hagemann, S. (2022). Gold mining greenhouse gas emissions, abatement measures, and the impact of a carbon price. *Journal of Cleaner Production*, 340, 130851.
- Verhezen, P. (2015). Concluding Remarks: The Vulnerability of Corporate Reputation. In *The Vulnerability of Corporate Reputation: Leadership for Sustainable Long-Term Value* (pp. 109-124). London: Palgrave Macmillan UK.

- Verrier, B., Smith, C., Yahyaei, M., Ziemski, M., Forbes, G., Witt, K., & Azadi, M. (2022). Beyond the social license to operate: Whole system approaches for a socially responsible mining industry. *Energy Research & Social Science*, 83, 102343.
- Xue, B., Zhang, Z., & Li, P. (2020). Corporate environmental performance, environmental management and firm risk. *Business Strategy and the Environment*, 29(3), 1074-1096.
- Yang, B., Bai, Z., & Zhang, J. (2021). Environmental impact of mining-associated carbon emissions and analysis of cleaner production strategies in China. *Environmental Science and Pollution Research*, 28, 13649-13659.
- Zhang, D., Wang, C., & Dong, Y. (2022). How does firm ESG performance impact financial constraints? An experimental exploration of the COVID-19 pandemic. *The European journal of development research*, 35(1), 219.
- Zhou, M., Huang, Z., & Jiang, K. (2024). Environmental, social, and governance performance and corporate debt maturity in China. *International Review of Financial Analysis*, 95, 103349.