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ENVIRONMENTAL PERFORMANCE, FIRM SIZE, LEVERAGE, AND THE FINANCIAL PERFORMANCE OF MINING COMPANIES LISTED ON THE INDONESIA STOCK EXCHANGE 2018 - 2024

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ABSTRACT

Drawing on legitimacy, stakeholder, agency, and trade-off theories, this study examines whether environmental performance, firm size, and leverage are associated with the financial performance of mining and energy companies listed on the Indonesia Stock Exchange over 2018–2024. The novelty is its focus on within-firm change: 15 of the 17 sample firms shifted PROPER (Company Environmental Performance Rating Program) rating at least once, which the model separates from the commodity cycle common to all firms. This quantitative study uses secondary data from audited financial statements and PROPER decrees of the Ministry of Environment and Forestry; purposive sampling yielded 17 firms and 119 firm-year observations. Environmental performance is proxied by the PROPER score, firm size by the natural logarithm of total assets, leverage by the debt to equity ratio (DER), and financial performance by return on assets (ROA). After Chow and Hausman tests, a firm fixed effect panel regression with year effects was estimated in R with firm-clustered standard errors and wild cluster bootstrap p-values. Each one-unit increase in DER is associated with a 3.223 percentage-point lower ROA ($p < 0.001$). The PROPER coefficient is positive but weak ($p = 0.113$; bootstrap $p = 0.071$), and firm size is not significant ($p = 0.208$); jointly, the three variables are significant ($F = 11.733$; $p < 0.001$). Without year effects, environmental performance and firm size become significant, indicating that the 2021–2022 commodity boom partly drives their apparent association with ROA. Leverage is most stably associated with profitability, whereas the environmental link requires caution.
Keywords: Environmental Performance, Firm Size, Leverage, Financial Performance, PROPER

ABSTRAK

Berlandaskan teori legitimasi, teori pemangku kepentingan, teori keagenan, dan teori trade-off, penelitian ini menganalisis apakah kinerja lingkungan, ukuran perusahaan, dan leverage berhubungan dengan kinerja keuangan perusahaan pertambangan dan energi di Bursa Efek Indonesia periode 2018–2024. Kebaruan penelitian ini terletak pada fokusnya terhadap perubahan di dalam setiap perusahaan: 15 dari 17 perusahaan sampel berpindah peringkat PROPER (Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup) paling sedikit satu kali, dan model memisahkan perpindahan tersebut dari siklus komoditas yang dialami seluruh perusahaan. Penelitian kuantitatif ini menggunakan data sekunder dari laporan keuangan auditan dan keputusan PROPER Kementerian

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Lingkungan Hidup dan Kehutanan; melalui purposive sampling, diperoleh 17 perusahaan dengan 119 observasi perusahaan-tahun. Kinerja lingkungan diproksikan dengan skor PROPER, ukuran perusahaan dengan logaritma natural total aset, leverage dengan debt to equity ratio (DER), dan kinerja keuangan dengan return on assets (ROA). Berdasarkan uji Chow dan uji Hausman, regresi panel fixed effect perusahaan dengan efek tahun diestimasi menggunakan R, dengan standard error cluster per perusahaan dan p-value wild cluster bootstrap. Setiap kenaikan satu satuan DER berkaitan dengan penurunan ROA sebesar 3,223 poin persentase ($p < 0,001$). Koefisien PROPER positif tetapi lemah ($p = 0,113$; p bootstrap = 0,071), dan ukuran perusahaan tidak signifikan ($p = 0,208$); secara simultan, ketiga variabel signifikan ($F = 11,733$; $p < 0,001$). Tanpa efek tahun, kinerja lingkungan dan ukuran perusahaan menjadi signifikan, yang menunjukkan bahwa sebagian keterkaitannya dengan ROA bersumber dari lonjakan komoditas 2021–2022. Leverage memiliki keterkaitan paling stabil dengan profitabilitas, sedangkan keterkaitan kinerja lingkungan perlu ditafsirkan dengan hati-hati.
Kata Kunci: Kinerja Lingkungan, Ukuran Perusahaan, Leverage, Kinerja Keuangan, PROPER

I. INTRODUCTION

The profitability of Indonesian mining companies fluctuates considerably, and individual firms do not follow the same pattern. Table 1 presents the return on assets (ROA) of the 17 listed mining and energy firms examined in this study, computed from their audited financial statements for 2018–2024. Mean ROA fell from 10.51% in 2018 to 3.96% in 2020, when six of the 17 firms recorded losses, rose to 22.79% in 2022, and then moderated to 10.80% in 2024. The differences between firms are just as pronounced: in 2022, ROA ranged from a low of 1.14% to a high of 61.63%. Even firms within the same subsector followed different paths. PT Timah Tbk fell back into a loss in 2023 (ROA −3.50%), whereas PT Vale Indonesia Tbk recorded an ROA of 9.38%, and the ROA of PT Bukit Asam Tbk decreased from 28.17% in 2022 to 11.14% in 2024.

Table 1. Return on Assets of Sample Companies, 2018–2024 (%)

Item	2018	2019	2020	2021	2022	2023	2024
Mean (17 firms)	10.51	5.45	3.96	14.97	22.79	11.85	10.80
Median	6.76	4.50	3.58	8.87	14.21	9.38	8.05
Minimum	−3.52	−3.80	−10.76	−15.22	1.14	−3.50	1.07
Maximum	45.56	18.33	21.27	52.02	61.63	39.51	38.98
Firms with a loss	2	2	6	1	0	1	0
PT Aneka Tambang Tbk (ANTM)	2.63	0.64	3.62	5.66	11.36	7.19	8.65
PT Bukit Asam Tbk (PTBA)	21.19	15.48	10.01	22.25	28.17	16.23	11.14
PT Vale Indonesia Tbk (INCO)	2.75	2.58	3.58	6.70	7.54	9.38	1.82
PT Timah Tbk (TINS)	0.87	−3.46	−2.32	8.87	7.96	−3.50	9.27

Source: Audited consolidated financial statements, 2018–2024 (IDX, 2025), processed by the authors (2026). ROA = profit for the year ÷ total assets × 100.

Part of this volatility clearly stems from factors external to the firm. The prices of coal, nickel, gold, and tin rose simultaneously in 2021–2022 and subsequently declined, and such a sector-wide movement cannot be attributed to the characteristics of individual firms. Nevertheless, firms differ substantially within each year, and these differences persist after the cycle reverses. This observation raises the question addressed in this study: once the common movement in commodity prices is taken into account, which characteristics that management can influence remain associated with a firm's profitability? Studies of mining firms point to three such characteristics. Environmental performance matters because mining operations depend on environmental permits and community acceptance; firm size reflects the scale of an asset-intensive business; and leverage reflects how that asset base is financed (Aurelia et al., 2022; Gurusinga et al., 2025; Safira et al., 2025).

Indonesian evidence on these three factors remains inconclusive. Among studies that proxy environmental performance with PROPER, Rani et al. (2024) and Gurusinga et al. (2025) report a significant association with financial performance, whereas Aurelia et al. (2022) and Delima et al.

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(2025) do not. For firm size, Safira et al. (2025) report a positive association, Hasanah and Widiyati (2024) report no association, and Aurelia et al. (2022) report a negative one. Findings on leverage are more consistent and largely negative (Aurelia et al., 2022; Safira et al., 2025; Vidyashani & Manurung, 2024). Most of these studies cover three to five years and employ pooled multiple regression, which compares firms with one another. Such a design cannot reveal whether a firm that improves its own PROPER rating also becomes more profitable, nor can it separate firm-level change from the commodity cycle when most of the sample years fall within a boom or a downturn.

This study therefore examines the individual and joint associations of environmental performance, firm size, and leverage with the financial performance of IDX-listed mining and energy firms over 2018–2024. It makes three contributions. First, it exploits within-firm variation: 15 of the 17 firms changed their PROPER rating at least once during the period, which makes it possible to observe what happens when a firm improves its own rating. Second, it augments the firm fixed effect model with year effects so that common shocks, such as the pandemic and the commodity boom, are not attributed to the three variables. Third, it maintains reliable inference despite the small number of firms by using firm-clustered standard errors and wild cluster bootstrap p-values. The findings are expected to help managers identify which levers move together with profitability, provide investors with a clearer interpretation of environmental ratings and financing decisions, and show researchers how strongly the choice of model shapes the conclusions.

II. LITERATURE REVIEW

Theoretical Background

This study is grounded in four theories. According to legitimacy theory, a company can continue to operate only as long as society approves of it, that is, as long as its conduct is consistent with prevailing norms, values, and expectations (Suchman, 1995). This pressure is greater for mining companies, whose extraction activities can cause pollution and damage ecosystems; a mining company that loses its legitimacy faces the risk of community opposition, legal sanctions, and reputational harm, all of which eventually affect its earnings (Nadila et al., 2025). Stakeholder theory extends the range of parties to whom managers are accountable beyond shareholders to include the government, local communities, employees, and creditors (Freeman, 1984). This theory is relevant to firm size, because larger firms attract greater scrutiny and are expected to disclose more information, and to leverage, because creditors expect to be repaid.

The other two theories concern financing. Agency theory deals with the conflict of interest between owners (principals) and the managers (agents) who act on their behalf, which gives rise to the need for monitoring (Jensen & Meckling, 1976). Trade-off theory regards the capital structure decision as a balance: debt generates a tax saving because interest is tax-deductible, but it also increases the risk of bankruptcy and the costs of financial distress (Myers, 1984). Debt therefore adds value up to an optimal level, beyond which interest expenses begin to erode earnings. Pecking order theory interprets the same correlation differently: highly profitable firms rely on internal funds and therefore require less debt, so low leverage may be a consequence rather than a cause of strong profitability (Fama & French, 2002; Myers, 1984).

Previous Findings and Sources of Inconsistency

Table 2 organizes the Indonesian studies most comparable to this one by sample, period, measures, and method. A comparison of these studies points to four reasons for their conflicting results. The first relates to measurement: some studies use the PROPER rating while others use environmental or ESG disclosure, and the dependent variable ranges from ROA to net profit and firm value; Nurnilamsari et al. (2025), for example, examine firm value rather than profitability. The second relates to the sample: coal-only samples (Sakina & Darmawan, 2024; Vidyashani & Manurung, 2024) are exposed to a single commodity price, whereas broader mining samples combine coal, metals, and oil and gas, each of which has a different price cycle. The third relates to timing: windows of three to five years fall largely within either the 2019–2020 downturn or the 2021–2022 boom, so one study may detect a positive relationship where another detects none. The fourth relates to method: pooled multiple

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regression, which mainly compares firms with one another, predominates, and only a few studies use panel estimators that follow the same firm over time (Delima et al., 2025; Sakina & Darmawan, 2024). Evidence from mining firms in other countries suggests similar sources of variation. Adomako and Tran (2022) show that, in a sample of 194 mining companies, environmental strategy influences financial performance through competitiveness, which develops gradually; Sun et al. (2020) find that the financial performance of Chinese listed mining companies responds to climate risks in ways that vary with the resource extracted; and Paredes Gómez et al. (2016) note that more profitable Latin American mining firms carry less debt, implying that the correlation between leverage and profitability may run in either direction.

Table 2. Synthesis of Previous Indonesian Studies

Study	Sample and period	Measures	Main finding
Aurelia et al. (2022)	15 mining firms, 2018–2020	PROPER, environmental cost, DER, size; profitability	PROPER not significant; size and leverage negative (multiple regression)
Rani et al. (2024)	12 mining firms, 2017–2021	PROPER, capital structure; financial performance	Both related to financial performance (multiple regression)
Sakina & Darmawan (2024)	9 coal firms, 2019–2022	ESG disclosure; ROA, ROE, Tobin's Q	Disclosure negatively related to ROA (fixed effect panel)
Hasanah & Widiyati (2024)	Indonesian listed companies	CSR, intellectual capital, size, environmental rating; financial performance	Firm size not significant
Vidyashani & Manurung (2024)	Coal firms, 2021–2023	DER; net profit	DER examined as a determinant of net profit
Gurusinga et al. (2025)	11 mining firms, 2020–2023	PROPER, environmental cost; ROA	PROPER significant (multiple regression)
Safira et al. (2025)	Mining firms, 2020–2022	Firm size, leverage; financial performance	Size positive; leverage negative
Delima et al. (2025)	17 coal, oil and gas firms, 2020–2023	Green accounting, PROPER, DER, size; ROE	PROPER and size not significant; DER negative; model significant overall (random effect panel)
Nurnilamsari et al. (2025)	Mining firms, 2018–2022	Financial and environmental performance; firm value	Environmental performance not significant for firm value

Source: Processed by the authors (2026)

These patterns have two implications for the present study. Because previous studies disagree on the direction of the environmental and size effects, the hypotheses are formulated without a predicted direction and are evaluated using two-tailed tests. Because the disagreement appears to be linked to short samples and cross-firm comparisons, the analysis employs a seven-year panel, estimates within-firm relationships, and removes the year-specific shocks that a short sample would otherwise capture.

Hypothesis Development

Environmental performance refers to how effectively a company manages the environmental impacts of its activities. From the legitimacy perspective, a firm that obtains a better PROPER rating should find it easier to retain its licence to operate, avoid sanctions and shutdowns, and encounter less local opposition, all of which protect revenue and lower operating risk. The stakeholder perspective further suggests that a better rating may facilitate access to financing and improve relations with regulators. Porter and van der Linde (1995) argue that environmental practices can stimulate efficiency and innovation; in the mining context, this argument is supported by Adomako and Tran (2022), who demonstrate that a sustainable environmental strategy enhances mining firms' competitiveness and,

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consequently, their financial performance, and more broadly by evidence linking social and financial performance (Orlitzky et al., 2003; Waddock & Graves, 1997). In contrast, Friedman (1970) views environmental expenditure as a cost that reduces profit, and achieving a better rating generally requires such expenditure. Since neither theory nor evidence establishes the direction of the relationship, H1 is formulated without a sign:

H1: Environmental performance is associated with financial performance.

Firm size reflects the volume of resources a company controls. For mining firms, size is important because of capital intensity: larger firms spread fixed costs over greater output, develop their own infrastructure, and obtain long-term financing on better terms (Rajan & Zingales, 1995). From the stakeholder perspective, larger firms are also subject to closer monitoring, which may discipline managers. However, size may also give rise to agency costs, such as excessive spending and investment in low-return projects (Jensen, 1986), and a substantial portion of a mining firm's assets consists of reserves and equipment whose returns depend on commodity prices. Since previous findings are divided among positive, insignificant, and negative effects, H2 is likewise formulated without a predicted direction:

H2: Firm size is associated with financial performance.

Leverage indicates the extent to which a firm finances its assets with debt. According to trade-off theory, debt increases profitability up to an optimal level, owing to the tax shield (Cao & Whyte, 2023; Modigliani & Miller, 1963) and the discipline that repayment obligations impose on managers (Jensen, 1986), but reduces profitability beyond that level because of interest expenses and the risk of financial distress (Myers, 1984). Pecking order theory predicts a negative correlation for a different reason, namely that profitable firms require less debt (Fama & French, 2002), a pattern also observed among Latin American mining firms (Paredes Gómez et al., 2016). This risk is more acute for mining firms because interest must still be paid even when commodity prices collapse. Indonesian mining studies generally report a negative association (Aurelia et al., 2022; Safira et al., 2025); however, because theory allows for either sign, H3 is also formulated without a predicted direction:

H3: Leverage is associated with financial performance.

The three variables may be associated with ROA jointly as well as individually, because each represents a distinct channel through which a mining firm's circumstances change: its relationship with regulators and communities (environmental performance), the scale of its operations (firm size), and its financial risk (leverage). The joint test therefore examines whether these firm characteristics, taken together, explain changes in ROA beyond those common to all firms in a given year. Using a random effect panel of 17 coal, oil, and gas firms over 2020–2023, Delima et al. (2025) found a significant overall model even though only capital structure was individually significant. Accordingly:

H4: Environmental performance, firm size, and leverage are jointly associated with financial performance.

Figure 1 illustrates the research framework. Each arrow represents one hypothesis and rests on a distinct theoretical argument: H1 on legitimacy and stakeholder theories, with the Porter hypothesis and the cost view as competing predictions; H2 on economies of scale and access to financing, weighed against agency costs; and H3 on trade-off theory, with pecking order theory as an alternative explanation. H4 combines the three channels. In addition to the hypothesized relationships, the model controls for two other sources of variation: persistent differences between firms, such as subsector and geology, and shocks that affect all firms in the same year, such as commodity prices and the pandemic.

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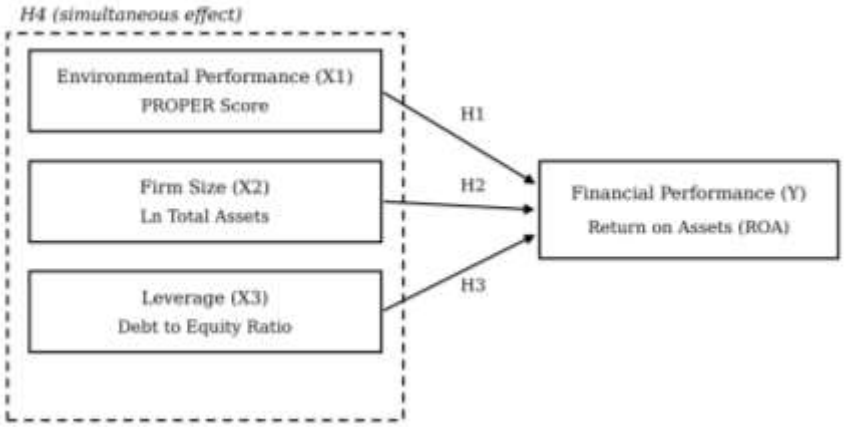


Figure 1. Conceptual Framework
Source: Processed by the authors (2026)

III. RESEARCH METHOD

This study employs a quantitative approach with an associative-causal design, in which statistical tests are used to determine whether the independent variables are associated with the dependent variable. It relies solely on secondary data collected through documentation. Audited consolidated financial statements for 2018–2024 were retrieved from the IDX website (IDX, 2025), and PROPER ratings were retrieved from the annual PROPER decrees issued by the Ministry of Environment and Forestry (KLHK, 2025).

The population comprises all mining and energy companies listed on the IDX during 2018–2024, and the sample was determined by purposive sampling (Sugiyono, 2022). A company was included if it (1) remained listed throughout 2018 – 2024, (2) received a PROPER rating in every year of that period, (3) published complete annual financial statements, and (4) operates in mining or energy rather than resource processing. Table 3 presents each stage of the selection process, and Table 4 lists the 17 companies together with their subsectors and observations.

The second criterion requires justification because it may introduce selection bias. It is necessary because the analysis follows each firm's own rating over time, and a firm that enters or exits PROPER has no comparable rating for the years in which it does not participate. However, the criterion favours mature producers whose sites are continuously supervised by KLHK. The excluded firms are mostly newly listed companies, holding companies whose operations are rated under the names of their subsidiaries, or firms that were rated in only some years. If these firms differ systematically in their environmental practices or profitability, the estimates apply to established PROPER participants rather than to the sector as a whole (Heckman, 1979). The range of PROPER scores is also narrower than in the full population, which tends to bias the estimated relationship toward zero. Since no data were collected on the excluded firms, this issue is acknowledged as a limitation rather than tested.

Table 3. Sample Selection Process

Stage	Description	Number
1	Initial population: mining and energy sector companies listed on the IDX, 2018–2024	113
2	Companies that did not take part in PROPER throughout 2018–2024	(75)
3	Companies that took part in PROPER throughout 2018–2024 (KLHK data)	38
4	Companies that did not publish complete financial statements for 2018–2024	(14)
5	Companies with complete PROPER and financial data	24
6	Companies in resource-processing industries rather than mining or energy (cement, pulp and paper, petrochemicals, chemical distribution)	(7)
7	Final sample	17
8	Number of observations (17 companies × 7 years)	119

Source: IDX (2025) and KLHK (2025), processed by the authors (2026)

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Table 4. Sample Companies

No	Code	Company	Subsector	Reporting currency	PROPER score range
1	ADRO	PT Adaro Energy Indonesia Tbk (now AlamTri Resources Indonesia)	Coal	USD	4–5
2	BYAN	PT Bayan Resources Tbk	Coal	USD	3–4
3	GEMS	PT Golden Energy Mines Tbk	Coal	USD	3–4
4	HRUM	PT Harum Energy Tbk	Coal	USD	3–4
5	ITMG	PT Indo Tambangraya Megah Tbk	Coal	USD	3–4
6	MBAP	PT Mitrabara Adiperdana Tbk	Coal	USD	4
7	PTBA	PT Bukit Asam Tbk	Coal	IDR	3–5
8	TOBA	PT TBS Energi Utama Tbk	Coal	USD	3–4
9	ANTM	PT Aneka Tambang Tbk	Metals and minerals	IDR	3–5
10	DKFT	PT Central Omega Resources Tbk	Metals and minerals	IDR	2–3
11	INCO	PT Vale Indonesia Tbk	Metals and minerals	USD	4–5
12	TINS	PT Timah Tbk	Metals and minerals	IDR	3–5
13	MEDC	PT Medco Energi Internasional Tbk	Oil and gas	USD	3–5
14	PGAS	PT Perusahaan Gas Negara Tbk	Oil and gas	USD	3–5
15	ABMM	PT ABM Investama Tbk	Mining services and energy investment	USD	3–4
16	INDY	PT Indika Energy Tbk	Mining services and energy investment	USD	3–4
17	PTRO	PT Petrosea Tbk	Mining services and energy investment	USD	3

Note: Each company contributes 7 observations (2018–2024). Source: IDX (2025) and KLHK (2025), processed by the authors (2026)

Table 5 presents the operational definitions of the variables. All financial figures are taken from the consolidated financial statements as of 31 December. Debt in the DER refers to total liabilities, comprising both current and non-current liabilities, and equity includes non-controlling interests. For firms reporting in US dollars, total assets are converted into rupiah using Bank Indonesia's middle exchange rate on 31 December of each year, so that firm size is measured in a single currency across all firms; ROA and DER are ratios and therefore do not require conversion.

Table 5. Operational Definitions of the Variables

Variable	Definition	Formula and measurement	Unit	Data source
Financial performance (Y)	Profit earned from the assets a company controls (Gurusinga et al., 2025)	ROA = Profit for the year ÷ Total assets × 100	Percent	Audited consolidated financial statements (IDX)
Environmental performance (X_1)	Rating of the company's environmental management by the government (Istiningrum, 2023)	PROPER score: Gold = 5, Green = 4, Blue = 3, Red = 2, Black = 1, for the company or its main operating subsidiary in the PROPER decree for year t	Ordinal score	KLHK PROPER decrees
Firm size (X_2)	Scale of the company as reflected by its assets	SIZE = Ln (Total assets in rupiah); USD totals × Bank Indonesia middle rate at 31 December	Natural log	Financial statements; Bank Indonesia
Leverage (X_3)	Use of debt relative to equity in the funding structure (Vidyashani & Manurung, 2024)	DER = Total liabilities (current + non-current) ÷ Total equity (incl. non-controlling interests)	Times	Audited consolidated financial statements (IDX)

Source: Processed by the authors (2026)

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The analysis was carried out in four stages: descriptive statistics, selection of the panel regression model, diagnostic testing, and hypothesis testing. All estimates and tests, including the cluster-robust standard errors and the wild cluster bootstrap, were computed in R version 4.6.1 (R Core Team, 2026). Because 12 observations have a negative ROA, a logarithmic transformation cannot be applied, and the model is therefore specified in levels. The main model incorporates both firm and year fixed effects:

$$ROA_{it} = \beta_1 PROPER_{it} + \beta_2 SIZE_{it} + \beta_3 DER_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

In this equation, α_i captures persistent differences between firms, such as subsector, geology, and reporting currency, while λ_t captures shocks common to all firms in year t, such as commodity prices and the pandemic (Baltagi, 2021). Each coefficient thus indicates how a change in a firm's own variable is associated with a change in its own ROA, relative to other firms in the same year. Since ROA is measured in percent, β_1 represents the percentage-point change in ROA when the PROPER rating improves by one grade, β_2 the change associated with a one-unit increase in the logarithm of total assets, and β_3 the change associated with a one-unit increase in DER. The choice among the common, fixed, and random effect estimators was based on the Chow test (Chow, 1960), the Hausman test (Hausman, 1978), and the Breusch-Pagan LM test (Breusch & Pagan, 1980), and the year effects were tested jointly. The diagnostic tests for the selected model comprise the Jarque-Bera test for normality (Jarque & Bera, 1987), tolerance and VIF for multicollinearity (Ghozali, 2018), the Glejser and modified Wald tests for heteroscedasticity (Greene, 2012), and the Wooldridge test for serial correlation (Wooldridge, 2010).

Standard errors are clustered by firm (Arellano, 1987), which ensures that they remain valid when the errors are heteroscedastic and serially correlated within a firm. Because there are only 17 clusters, conventional cluster-robust tests may reject the null hypothesis too often; therefore, t-statistics are evaluated against a t distribution with 16 degrees of freedom and verified using wild cluster restricted bootstrap p-values based on 9,999 replications with Webb weights (Cameron & Miller, 2015; Roodman et al., 2019; Webb, 2023). H1 to H3 are tested using two-tailed t-tests. H4 is tested using a cluster-robust Wald F-test, F(3, 16), of the null hypothesis that all three coefficients are equal to zero, which is the appropriate joint test when standard errors are clustered. A hypothesis is accepted when its p-value is below 0.05.

IV. RESULTS AND DISCUSSION

Description of Research Object

The final sample consists of 17 firms observed over seven years, yielding 119 observations (Table 4). Coal producers constitute the largest group (ADRO, BYAN, GEMS, HRUM, ITMG, MBAP, PTBA, and TOBA), followed by metal and mineral producers (ANTM, DKFT, INCO, and TINS), oil and gas companies (MEDC and PGAS), and mining services and energy investment companies (ABMM, INDY, and PTRO). Thirteen firms present their financial statements in US dollars and four in rupiah.

Data Analysis Results

Table 6 presents the descriptive statistics. ROA varies considerably and is right-skewed: its values range from −15.22% to 61.63%, the median (7.19%) is markedly lower than the mean (11.48%), and the middle half of the observations falls between 2.60% and 15.88%. The 12 loss-making observations are concentrated in 2019–2021 and in DKFT, TINS, MEDC, INDY, PGAS, and ABMM. A large part of the dispersion occurs between firms: the within-firm standard deviation of ROA is 9.18 percentage points, compared with 14.24 for the full sample. Leverage is also right-skewed (median 0.98; maximum 5.25), with the highest values in mining services, oil and gas, and DKFT. Firm size varies mainly between firms and changes little within each firm over the seven years (within-firm standard deviation 0.31)

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Table 6. Descriptive Statistics

Variable	N	Minimum	Q1	Median	Q3	Maximum	Mean (SD)	Within-firm SD
ROA (%)	119	−15.22	2.60	7.19	15.88	61.63	11.48 (14.24)	9.18
PROPER score	119	2	3	4	4	5	3.80 (0.78)	0.55
Firm size (Ln total assets, Rp)	119	28.44	30.10	30.82	31.52	32.77	30.75 (1.11)	0.31
Leverage (DER, times)	119	0.09	0.41	0.98	1.64	5.25	1.26 (1.12)	0.56

Note: Q1 and Q3 are the first and third quartiles; the within-firm SD is the standard deviation after removing each firm's mean. Source: Data analysis output (R 4.6.1), processed by the authors (2026)

Because PROPER is an ordinal rating, its distribution is more informative than its mean. Table 7 reports the ratings by year. Green is the most frequent rating (52 observations, 43.7%), followed by Blue (41; 34.5%), Gold (23; 19.3%), and Red (3; 2.5%); no Black ratings are recorded. Ratings also change over time: there are 34 year-to-year changes, and 15 of the 17 firms changed their rating at least once. Only MBAP (Green in every year) and PTRO (Blue in every year) retained a single rating throughout. It is precisely this within-firm variation that the fixed effect model uses to estimate the association between environmental performance and ROA.

Table 7. Distribution of PROPER Ratings by Year (number of firms)

Rating	2018	2019	2020	2021	2022	2023	2024
Gold (5)	3	2	4	2	6	3	3
Green (4)	7	8	4	10	7	9	7
Blue (3)	7	6	8	4	4	5	7
Red (2)	0	1	1	1	0	0	0

Source: PROPER decrees (KLHK, 2025), processed by the authors (2026)

Table 8 reports the model selection and diagnostic tests. The common effect model is rejected by the Chow test ($F = 9.677$; $p < 0.001$) and, in favour of the random effect model, by the Breusch-Pagan LM test ($LM = 72.469$; $p < 0.001$), while the random effect model is rejected by the Hausman test ($\chi^2 = 13.414$; $p = 0.004$); accordingly, the fixed effect model is adopted. The year effects are included because they are jointly significant (cluster-robust $F = 3.842$; $p = 0.014$); relative to 2018, ROA was 4.34 and 5.39 percentage points lower in 2019 and 2020, and 4.09 and 9.39 percentage points higher in 2021 and 2022, consistent with the commodity cycle. The normality of the residuals is not rejected (Jarque-Bera $p = 0.362$), and there is no multicollinearity (VIF ranging from 1.138 to 1.452). The Glejser test shows that the magnitude of the residuals is related to firm size, the modified Wald test shows that the residual variance differs across firms, and the Wooldridge test indicates the presence of serial correlation. Since conventional standard errors would therefore overstate precision, inference relies on firm-clustered standard errors and the wild cluster bootstrap.

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Table 8. Model Selection and Assumption Tests

Test	Statistic	Prob.	Conclusion
Chow (CEM vs FEM)	F = 9.677 (16; 99)	< 0.001	Fixed effect
Breusch-Pagan LM (CEM vs REM)	LM = 72.469 (1)	< 0.001	Random effect over common effect
Hausman (REM vs FEM)	χ^2 = 13.414 (3)	0.004	Fixed effect
Year effects (cluster-robust Wald)	F = 3.842 (6; 16)	0.014	Include year effects
Jarque-Bera (normality)	2.032	0.362	Residuals approximately normal
Tolerance / VIF (multicollinearity)	0.689–0.879 / 1.138–1.452	–	No multicollinearity
Glejser (heteroscedasticity)	Absolute residual on PROPER, SIZE, DER	0.794; 0.002; 0.125	Related to firm size
Modified Wald (heteroscedasticity)	χ^2 = 967.015 (17)	< 0.001	Groupwise heteroscedasticity
Wooldridge (serial correlation)	F = 48.619 (1; 16)	< 0.001	Serial correlation present

Source: Data analysis output (R 4.6.1), processed by the authors (2026)

Table 9 reports the estimation results. Column (3), which includes both firm and year effects, is the main model; columns (1), (2), and (4) are provided for comparison, with column (2) representing the firm fixed effect model without year effects. The estimated main equation is ROA = −154.776 + 2.948PROPER + 5.174SIZE − 3.223DER + firm effect + year effect, where the constant equals the mean of the firm-specific intercepts. The within R^2 of 0.128 indicates that, after persistent firm differences and common year shocks are removed, changes in the three variables account for 12.8% of the remaining within-firm variation in ROA over time. This statistic measures goodness of fit for that variation only and does not represent the proportion of financial performance caused by the three variables. Most of the variation in ROA is absorbed by the firm and year effects.

Table 9. Panel Regression Results (dependent variable: ROA, %)

Variable	(1) Common effect	(2) Firm FE	(3) Firm and year FE (main)	(4) Random effect
PROPER score	3.119 (2.001)	5.030** (2.011)	2.948 (1.757)	4.337** (1.963)
	p = 0.139	p = 0.024	p = 0.113; boot p = 0.071	p = 0.042
Firm size	−1.420 (1.381)	9.554** (3.576)	5.174 (3.942)	2.903* (1.503)
	p = 0.319	p = 0.017	p = 0.208; boot p = 0.200	p = 0.071
Leverage (DER)	−4.575*** (1.125)	−2.474*** (0.843)	−3.223*** (0.620)	−3.097*** (1.016)
	p = 0.001	p = 0.010	p < 0.001; boot p = 0.009	p = 0.008
Firm effects	No	Yes	Yes	Random
Year effects	No	No	Yes	No
R^2 (within for FE)	0.187	0.236	0.128	–
Joint test of the three coefficients, F(3; 16)	8.845 (p = 0.001)	14.496 (p < 0.001)	11.733 (p < 0.001)	7.594 (p = 0.002)
Observations / firms	119 / 17	119 / 17	119 / 17	119 / 17

Note: Coefficients with firm-clustered standard errors in parentheses; p-values from the t distribution with 16 degrees of freedom; boot p = wild cluster restricted bootstrap p-value (9,999 replications, Webb weights). *, **, *** = significant at 10%, 5%, 1%. Source: Data analysis output (R 4.6.1), processed by the authors (2026)

The central finding emerges from a comparison of columns (2) and (3). Without year effects, all three variables are significant, as in the earlier version of this analysis. Once year effects are added, the PROPER and size coefficients decline by approximately 41% and 46%, respectively, and are no

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longer significant at the 5% level, whereas the leverage coefficient becomes larger and more precisely estimated. The data explain why: ratings improved and assets grew in the very years in which commodity prices and ROA rose for nearly all firms (Tables 1 and 7), so omitting year effects attributes part of the boom to environmental performance and firm size.

Table 10 summarizes the results of the hypothesis tests for the main model. H1 and H2 are rejected at the 5% significance level, whereas H3 and H4 are accepted. The joint result for H4 is driven mainly by leverage

Table 10. Summary of Hypothesis Testing (main model)

Hypothesis	Relationship	t / F	p (boot p)	Direction	Decision
H1	Environmental performance – financial performance	t = 1.678	0.113 (0.071)	Positive	Not supported
H2	Firm size – financial performance	t = 1.313	0.208 (0.200)	Positive	Not supported
H3	Leverage – financial performance	t = −5.202	< 0.001 (0.009)	Negative	Supported
H4	All three variables jointly – financial performance	F (3; 16) = 11.733	< 0.001	–	Supported

Source: Data analysis output (R 4.6.1), processed by the authors (2026)

Table 11 assesses whether the conclusions depend on specific modelling choices. Replacing the PROPER score with category dummies removes the assumption that the distances between ratings are equal; relative to a Blue or Red rating, a Green rating is associated with an ROA that is 6.421 percentage points higher (p = 0.068), and a Gold rating with an ROA that is 3.742 percentage points higher (p = 0.207). Excluding ADRO in 2024, the year in which its coal business was spun off, excluding the four firms that are not primary producers, and excluding loss observations do not change the conclusions: leverage remains negative and significant in every specification, PROPER remains positive and is significant at the 10% level at best, and firm size never reaches significance at the 5% level.

Table 11. Robustness Checks (firm and year fixed effects)

Variable	(a) PROPER dummies	(b) Excluding ADRO 2024	(c) Primary producers only	(d) Profitable observations only
PROPER score	–	2.875 (p = 0.123)	3.774* (p = 0.095)	3.476 (p = 0.104)
Green rating (vs Blue/Red)	6.421* (p = 0.068)	–	–	–
Gold rating (vs Blue/Red)	3.742 (p = 0.207)	–	–	–
Firm size	4.370 (p = 0.279)	5.842 (p = 0.174)	5.430 (p = 0.354)	7.463 (p = 0.107)
Leverage (DER)	−2.871*** (p < 0.001)	−3.243*** (p < 0.001)	−3.705** (p = 0.010)	−6.624*** (p < 0.001)
Observations / firms	119 / 17	118 / 17	91 / 13	107 / 17

Note: Firm-clustered standard errors; *, **, *** = significant at 10%, 5%, 1%. Primary producers exclude PGAS, ABMM, INDY, and PTRO. Source: Data analysis output (R 4.6.1), processed by the authors (2026)

DISCUSSION

Environmental performance and financial performance (H1). A one-grade improvement in a firm's PROPER rating is associated with an ROA approximately 2.9 percentage points higher in the same year, but the estimate is imprecise (p = 0.113; bootstrap p = 0.071); therefore, H1 is rejected at the 5% level. The positive sign is consistent with legitimacy theory, stakeholder theory, and the Porter hypothesis, and the Green rating dummy points in the same direction. These theories propose mechanisms such as easier permitting, fewer sanctions, and lower financing costs, which were not

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measured in this study; the result is consistent with these mechanisms but does not prove that they are at work. The comparison between the models with and without year effects helps explain the disagreement among earlier studies. Gurusinga et al. (2025) and Rani et al. (2024) estimated pooled regressions over short periods, which cannot separate a firm's own rating changes from movements shared by all firms; once these common shocks are controlled for, the association becomes weaker. Two further factors may also attenuate the estimate: all sample firms participate in PROPER and most ratings fall between Blue and Gold, and, in line with Friedman (1970), the cost of improving environmental management may partly offset its short-term benefits. Adomako and Tran (2022) argue that environmental strategy generates returns through competitiveness, which builds up over time, so a model based on same-year data may underestimate a lagged effect.

Firm size and financial performance (H2). The size coefficient is positive but not significant ($\beta = 5.174$; $p = 0.208$); hence, H2 is rejected. Size is expected to matter in mining because the industry is capital-intensive: larger firms spread infrastructure and equipment costs over greater output and find it easier to obtain long-term financing for reserve development (Rajan & Zingales, 1995). However, these advantages are largely permanent characteristics of each firm and are therefore captured by the firm effects, whereas within-firm changes in total assets over the seven years are small (within-firm SD 0.31) and coincide with the boom, during which firms accumulated cash and receivables. This finding therefore differs from that of Safira et al. (2025), whose pooled design compares large and small firms, and is consistent with Hasanah and Widiyati (2024), who find no significant effect.

Leverage and financial performance (H3). Leverage produces the strongest result: a one-unit increase in DER is associated with an ROA approximately 3.2 percentage points lower ($p < 0.001$; bootstrap $p = 0.009$), and this result holds across all specifications and robustness checks; therefore, H3 is accepted. This finding is in line with Aurelia et al. (2022), Safira et al. (2025), Vidyashani and Manurung (2024), and Fama and French (2002). The data cannot distinguish among the possible explanations. Trade-off theory emphasizes interest costs and financial distress, which weigh more heavily on mining firms because interest must still be paid when prices fall. Pecking order theory emphasizes the reverse direction of causality, since firms with high earnings during the boom years repay debt and borrow less, as Paredes Gómez et al. (2016) found among Latin American mining firms. Operational factors may also play a role: mining firms often borrow to fund mine development or acquisitions that generate returns only years later, and services and holding companies combine higher leverage with lower margins, although the negative association persists when these firms are excluded. The year effects rule out an explanation based solely on the common commodity cycle, but firm-specific price exposure and investment timing are not controlled for and may contribute to the result.

Simultaneous effect (H4). Jointly, the three variables are significantly associated with ROA ($F(3; 16) = 11.733$; $p < 0.001$); therefore, H4 is accepted, although the joint result depends largely on leverage. The within R^2 of 0.128 indicates that these three firm characteristics explain only a limited portion of the year-to-year variation in ROA within firms once common shocks are removed. The remaining variation probably reflects factors outside the model, such as each firm's commodity mix and realized prices, output, operating costs, and investment timing; Sun et al. (2020), for instance, show that mining firms extracting different resources respond differently to the same external risks. This finding is consistent with the significant overall model reported by Delima et al. (2025); however, it suggests that environmental, scale, and financing characteristics explain less of the variation in mining profitability than pooled models imply.

V. CONCLUSION

This study examined the associations of environmental performance, firm size, and leverage with the financial performance of IDX-listed mining and energy firms over 2018–2024. After controlling for persistent firm differences and common year shocks, higher leverage is consistently associated with lower ROA, better environmental performance is only weakly associated with higher ROA, firm size shows no significant association, and the three variables are jointly significant. Had year effects been

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omitted, environmental performance and firm size would have appeared to be significantly positive, which shows that the commodity cycle can generate spurious relationships in short or pooled samples.

In theoretical terms, the leverage findings are consistent with both the trade-off and pecking order explanations, whereas legitimacy and stakeholder theories receive only weak short-term support; the mechanisms proposed by these theories were not directly observed. In practical terms, managers of mining firms have stronger reasons to keep leverage under control than to expect an immediate increase in profit from a higher PROPER rating, although sound environmental management remains necessary to maintain the licence to operate. Investors and analysts should assess PROPER ratings and financing structure in conjunction with commodity exposure, and researchers investigating mining profitability should incorporate year effects and estimate within-firm relationships.

This study has several limitations. First, the requirement of continuous PROPER participation favours established producers and may introduce selection bias; since no data were collected on the excluded firms, the findings apply to PROPER participants rather than to the entire sector. Second, the 17 firms come from subsectors with different commodity cycles; the year effects capture common shocks but not each firm's own price exposure, and relevant time-varying factors such as realized prices, production volume, and operating costs are not included. Third, with only 17 clusters, the wild cluster bootstrap reduces, but does not eliminate, the risk of imprecise standard errors, and the modest within R^2 limits the predictive value of the model. Fourth, PROPER is an ordinal measure of compliance that does not capture every aspect of sustainability, and ROA reflects only accounting profitability; hence, the findings should not be generalized to all dimensions of sustainability or financial performance. Fifth, ADRO spun off its coal business at the end of 2024, which reduces the comparability of that observation, although excluding it leaves the results unchanged. Future research could expand the sample in terms of firms and years, incorporate firm-level commodity price and production data, employ alternative measures such as ROE or Tobin's Q, and examine whether environmental ratings affect profitability with a lag.

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