

## Green Accounting and Intellectual Capital Efficiency as Drivers of Firm Value: Evidence from the Indonesian Mining Sector

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### ARTICLE INFORMATION

#### Publication information

#### Research article

#### HOW TO CITE

Ethelind, S., & Setijaningsih, H. T. (2026). Green accounting and intellectual capital efficiency as drivers of firm value: Evidence from the Indonesian mining sector. *International Journal of Accounting and Finance in Asia Pasific*, 9(3), 914-931.

#### DOI:

<https://doi.org/10.32535/ijafap.v9i3.5101>

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Received: 15 August 2026

Accepted: 18 September 2026

Published: 20 October 2026

### ABSTRACT

Post-pandemic economic conditions have increased the relevance of environmental performance and intangible resources in investor assessments, particularly in environmentally intensive industries. This study examines the relationship between PROPER-based environmental performance, intellectual capital efficiency, and firm value among mining companies listed on the Indonesia Stock Exchange (IDX) from 2021 to 2024. Using purposive sampling, the study analyzes 40 observations from 10 companies through panel data regression with the REM in Stata 15. The results indicate that environmental performance is negatively associated with firm value in both models, with and without control variables ( $b = -0.24$ ,  $p = 0.048$ ;  $b = -0.31$ ,  $p = 0.021$ , respectively). Human capital efficiency is positively associated with firm value in the model with control variables ( $b = 0.019$ ,  $p = 0.017$ ). Structural capital efficiency and relational capital efficiency are not statistically significant in either model, while capital employed efficiency is significant only in the model without control variables. Higher PROPER ratings do not guarantee higher market valuations, while human capital efficiency may better attract investors. Companies should communicate environmental performance and develop employee capabilities, while regulators should ensure transparent and consistent environmental reporting.

**Keywords:** Firm Value; Green Accounting; Indonesia Stock Exchange; Intellectual Capital Efficiency; Mining Sector

**JEL Classification:** M41; G32; Q56

## INTRODUCTION

Firm value is an important indicator that reflects market perceptions regarding a company's current condition and future prospects. This is consistent with signaling theory, in which information related to a company's investment decisions serves as a positive signal that the company possesses favorable growth opportunities and prospects, thereby increasing firm value and ultimately enhancing shareholder welfare (Alghifari et al., 2022).

Indonesia is facing a paradoxical phenomenon in which macroeconomic stability is not proportional to firm value responses in the capital market. Indonesia's economic growth data indicate relatively stable performance, reaching 5.02% in 2021, 5.31% in 2022, 5.04% in 2023, and 5.03% in 2024, respectively (Central Agency of Statistics Indonesia [Badan Pusat Statistik Indonesia/BPS Indonesia], 2022; 2023; 2024; 2025). However, the Composite Stock Price Index (CSPI) grew by only 10.08% in 2021, 4.09% in 2022, and 6.16% in 2023, before declining to -2.65% in 2024 (Dwi, 2025). This phenomenon indicates that economic growth is not always aligned with capital market performance, as reflected in the suboptimal growth of the CSPI.

The 2021–2024 period reflects a phase of economic transition. In 2021, economic recovery began following the impact of the COVID-19 pandemic, although the recovery process was uneven across countries, including Indonesia. In 2022, economic conditions gradually adjusted toward a more stable environment compared to 2021 (International Monetary Fund [IMF], 2022). Furthermore, the increase in the Fed's interest rates significantly raised external borrowing costs, which triggered capital outflows from emerging markets (Matschke et al., 2023), including Indonesia. This situation shifted investors' perspectives, where assessments were no longer primarily based on historical performance, but rather on business resilience and corporate readiness in addressing medium- and long-term risks (Anton et al., 2025). Based on these dynamics, investors no longer merely respond to overall economic growth, but increasingly rely on firm-specific signals in evaluating investment potential and risk (Vo et al., 2026). In addition, investors have begun incorporating long-term risks, including environmental, social, and governance (ESG) risks, into stock valuation considerations. Consequently, non-financial factors have increasingly become important determinants of firm value (Suhartini et al., 2024; Sundarasen et al., 2024).

Under these conditions, the implementation of green accounting (GA) has become increasingly important because a company's ability to measure, report, and manage environmental costs may serve as an important signal of operational efficiency and environmental risk mitigation (Astuti & Ahmar, 2025). GA practices have been proven to contribute to improving company performance in the long term through reduced operational costs, efficient use of resources, and better environmental risk management (Saragih et al., 2024). Several studies have found that GA has a significant positive effect on firm value (Lestari & Restuningdiah, 2021; Saputra & Windyastuti, 2024), while other studies have reported no significant effect (Fernando et al., 2024). In addition, recent empirical evidence from Indonesia shows that both GA and intellectual capital have a significant positive effect on sustainability performance, with GA exhibiting a stronger effect (Suryanawa et al., 2025).

Furthermore, intellectual capital also creates value because it enhances investor confidence in a company's future prospects and its ability to adapt to changes in the business environment (Ni et al., 2020). The empirical evidence indicates that intellectual capital disclosure significantly affects firm value, as companies increasingly recognize its role in creating sustainable competitive advantage (Rosharlianti et al., 2022). To

address this measurement challenge, intellectual capital efficiency was developed through the Modified Value-Added Intellectual Coefficient (MVAIC) model, which consists of four main components: Human Capital Efficiency (HCE), Structural Capital Efficiency (SCE), Relational Capital Efficiency (RCE), and Capital Employed Efficiency (CEE) (Rana & Hossain, 2023). Each component exhibits unique characteristics where HCE relates to human capital, SCE to structural systems, RCE to external relationships, and CEE to physical assets. Previous studies examining the effects of these MVAIC components have produced inconsistent and mixed findings (Rehman et al., 2022; Xu & Liu, 2020; Zhang et al., 2021), thereby creating a research gap that warrants further investigation.

The mining sector was selected because its activities generate substantial environmental impacts, including land degradation, air and water pollution, as well as significant deforestation (Sonter et al., 2020). Furthermore, the mining industry in Indonesia is considered the sector with the highest ESG exposure, resulting in strict scrutiny from regulators and the public. Therefore, this study provides an ideal setting to examine whether GA and intellectual capital efficiency can serve as stronger determinants of firm value within the mining sector, particularly by considering the 2021–2024 period as a natural experiment characterized by economic turbulence.

The research questions addressed in this study are as follows: (1) Does GA have a significant positive effect on firm value; (2) Does HCE have a significant positive effect on firm value; (3) Does SCE have a significant positive effect on firm value; (4) Does RCE have a significant positive effect on firm value; and (5) Does CEE have a significant positive effect on firm value. The findings of this study are expected to provide new insights and references for future research, assist companies in formulating sustainability and resource efficiency strategies, and support regulators in evaluating policies related to sustainability reporting standards in Indonesia.

## **LITERATURE REVIEW**

### **Theoretical Review**

According to signaling theory, companies need to convey important information through financial statements so that external parties, such as investors and creditors, can make appropriate decisions. Financial statements must be of high quality to reduce information asymmetry between management and external stakeholders, thereby minimizing distrust and supporting long-term business sustainability. In the context of GA, reporting environmental activities is important because it serves as a corporate signal to the market and helps alleviate investor concerns regarding environmental risks and future regulatory burdens (Saputra & Windyastuti, 2024). Furthermore, the disclosure of intellectual capital can provide critical information to investors, such as the quality of human resources, organizational structure, and innovation capacity. This indicates that intellectual capital sends a positive signal to the market, which in turn may reduce the cost of equity and enhance firm value (Abdallah et al., 2025).

According to legitimacy theory, companies are expected to operate in accordance with societal norms, values, and laws. Consequently, companies voluntarily disclose environmental and social information to meet stakeholder expectations and, ultimately, achieve organizational objectives while ensuring business continuity (Fernando et al., 2024). In the mining sector, which is characterized by high environmental exposure, legitimacy becomes crucial because corporate activities directly affect the environment and surrounding communities. Therefore, environmental disclosure through GA is undertaken to respond to stakeholder pressures and to strengthen corporate legitimacy (Sundarasan et al., 2024).

According to resource-based theory, companies can achieve competitive advantage by utilizing internal resources that are valuable, rare, difficult to imitate, and irreplaceable (Odat & Bsoul, 2022). Companies capable of leveraging internal resources in the form of intellectual capital, including technology, systems, human resources, and relationships, are more likely to achieve stronger financial performance and establish a direct foundation for enhancing firm value in the long term (Ahmed et al., 2022).

### **Hypotheses Development**

#### ***Green Accounting (GA) and Firm Value***

GA is an emerging field of accounting that enables companies to identify, measure, and report the environmental impacts of their operational and production activities, thereby promoting greater environmental responsibility and providing more comprehensive information to stakeholders (Dwianika et al., 2024). Based on the study conducted by Saputra and Windyastuti (2024), GA, as proxied by the Corporate Performance Rating Program in Environmental Management (PROPER) ratings, has a significant positive effect on firm value because it enhances corporate image, strengthens stakeholder trust, and improves corporate legitimacy, which ultimately increases firm value. Companies implementing GA are perceived as being more environmentally responsible, thereby improving transparency and reducing information asymmetry, which is consistent with signaling theory (Lestari & Restuningdiah, 2021). Consequently, stakeholder trust increases and contributes to higher firm value.

H1: GA has a significant positive effect on firm value.

#### ***Intellectual Capital Efficiency and Firm Value***

##### ***Human Capital Efficiency (HCE)***

HCE is the first element that emphasizes the knowledge, skills, capabilities, and experience possessed by company employees (Rana & Hossain, 2023). This concept refers to how effectively an organization can manage, develop, and utilize its human resources to generate economic value added (Xu & Liu, 2020). Studies conducted by Mustafa et al. (2024) and Zhang et al. (2021) support this perspective by demonstrating that HCE has a positive and significant relationship with firm value. This indicates that human capital is a vital resource in creating firm value. Employee expertise and innovation enable companies to adapt to dynamic business changes. Therefore, investors tend to assign higher valuations to companies that are capable of effectively managing the potential of their human resources.

H2: HCE has a significant positive effect on firm value.

##### ***Structural Capital Efficiency (SCE)***

SCE is the second element that reflects a company's ability to manage and utilize information systems, procedures, databases, and organizational structures to support human resource productivity and improve corporate performance (Al-Khoury et al., 2022). Studies conducted by Ali et al. (2022) and Rehman et al. (2022) demonstrate that SCE has a positive and significant relationship with bank market value. SCE provides the infrastructure required to enhance employee productivity, operational efficiency, and effective business processes. This condition ultimately improves profitability and creates greater market value for banks.

H3: SCE has a significant positive effect on firm value.

### **Relational Capital Efficiency (RCE)**

RCE is the third element that reflects a company's ability to establish and manage strategically valuable external relationships, particularly with customers, suppliers, and other stakeholders (Xu & Liu, 2020). Through these relationships, companies can enhance business success because strong external relationships are capable of creating sustainable competitive advantages (Rana & Hossain, 2023). Studies conducted by Rana & Hossain (2023) and Rehman et al. (2022) indicate that RCE has a positive and significant effect on market value. When companies are able to establish strong relationships with customers, market trust in the company's credibility and reputation increases. Consequently, companies tend to receive higher market valuations due to the positive corporate image that has been established.

H4: RCE has a significant positive effect on firm value.

### **Capital Employed Efficiency (CEE)**

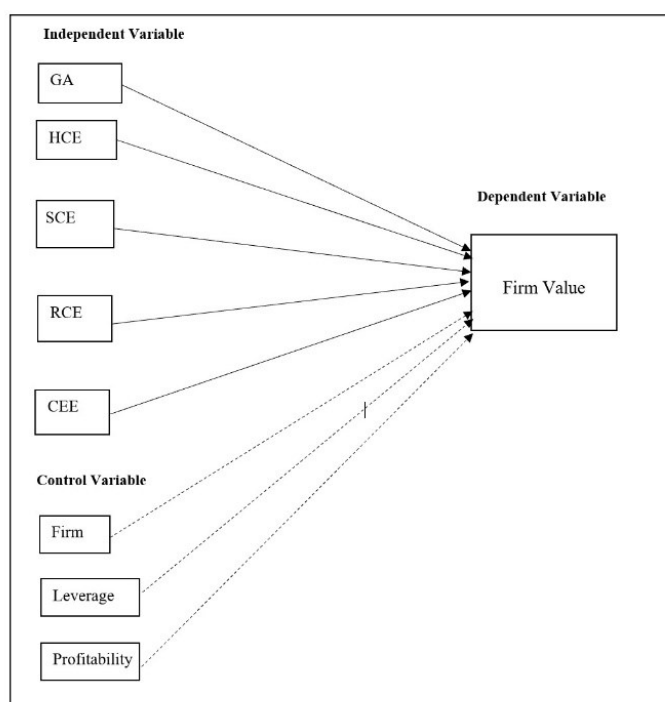
CEE is the fourth element that reflects a company's ability to utilize physical and financial resources to create added value for shareholders. In other words, CEE reflects the level of efficiency in utilizing invested capital to generate net income and enhance economic value (Rana & Hossain, 2023). Research conducted by Odat and Bsoul (2022) demonstrates that CEE has a positive and significant effect on firm value. This finding is consistent with the study of Zhang et al. (2021), which indicates that companies still require investment in physical capital to support production activities and achieve higher market valuations.

H5: CEE has a significant positive effect on firm value.

### **Conceptual Framework**

The conceptual framework of this study is developed through a theoretical review and hypothesis development in Figure 1.

**Figure 1.** Research Framework



## RESEARCH METHOD

### Research Design

This study is a quantitative research employing panel data analysis to examine the effect of GA and intellectual capital efficiency on firm value. The panel data combine cross-sectional observations of mining sector companies with time-series observations during the 2021–2024 period.

### Population and Sampling

The population of this study comprises companies in the energy and basic materials sectors listed on the Indonesia Stock Exchange (IDX) during the 2021–2024 period. Purposive sampling was applied based on predetermined criteria to obtain companies that met the requirements for the analysis. The initial population consisted of 204 companies. Furthermore, the researchers applied a purposive sampling technique by selecting companies that exclusively engaged in mining activities, resulting in an initial sample of 103 companies. Subsequently, several criteria were established by the researchers, which ultimately resulted in a final sample of 10 companies over a four-year observation period, generating a total of 40 observations (see [Table 1](#)).

**Table 1.** Sample Selection

| No                                   | Sample Selection Criteria                                                                                        | Total |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------|-------|
| 1                                    | Energy and basic materials sector companies listed on the IDX                                                    | 204   |
| 2                                    | Non-mining companies in the energy and basic materials sectors                                                   | 101   |
| 3                                    | Companies that did not publish complete annual reports and/or sustainability reports during the 2021–2024 period | 16    |
| 4                                    | Companies that did not generate net income during the 2021–2024 period                                           | 32    |
| 5                                    | Companies that did not have positive SCE during the 2021–2024 period                                             | 1     |
| 6                                    | Companies that were not registered in the PROPER program                                                         | 44    |
| Total companies meeting the criteria |                                                                                                                  | 10    |
| Observation period                   |                                                                                                                  | 4     |
| Total observations                   |                                                                                                                  | 40    |

### Data Collection

The study used secondary data obtained through documentation of annual reports and/or sustainability reports of the sampled companies for the 2021–2024 period. The required financial, environmental, and company-level information was extracted from these reports according to the operational definitions of the study variables. Information related to environmental performance was obtained based on the companies' PROPER ratings.

### Variable Measurement

This study uses Firm Value (TOBINSQ) as the dependent variable, which represents the ratio of market value to the replacement value of the company's assets ([Alaika & Firmansyah, 2024](#); [Fernando et al., 2024](#)). Environmental performance, referred to as GA in the initial conceptual framework, is proxied by the PROPER rating ([Lestari & Restuningdiah, 2021](#)). The rating reflects a company's environmental management performance, with higher scores indicating better performance. Accordingly, the estimated coefficient should be interpreted as the association between PROPER-based environmental performance and firm value, rather than as a direct estimate of the effect of green accounting practices or environmental cost accounting.

In addition, the other independent variable is Intellectual Capital, which is measured using four main efficiency components. These components consist of HCE, which reflects a company's ability to create value through the utilization of human resources; SCE, which reflects a company's ability to create value through the effectiveness of its internal systems and processes; RCE, which reflects a company's ability to create value through establishing relationships with external parties and stakeholders; and CEE, which reflects a company's ability to create value through the efficient utilization of physical capital (Rana & Hossain, 2023).

Meanwhile, the control variables consist of firm size (SIZE), measured using the natural logarithm of total company assets (Fernando et al., 2024); leverage (DER) (Rana & Hossain, 2023), measured by dividing total liabilities by total equity; and profitability (ROA), measured by the company's ability to utilize its total assets to generate net income (Saputra & Windyastuti, 2024). The operational definitions and measurement formulas for all variables are presented in Table 2.

**Table 2.** Variable Measurement

| Variable                            | Formula                                                                                                                                                | Reference                                                    |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| Dependent Variable                  |                                                                                                                                                        |                                                              |
| Firm Value (TOBINSQ)                | Tobin's Q = (Equity Market Value + Debt) / (Equity Book Value + Debt)                                                                                  | Fernando et al. (2024); Rana & Hossain (2023)                |
| Independent Variables               |                                                                                                                                                        |                                                              |
| Green Accounting (GA)               | PROPER Rating (5= certificate under Gold, 4= certificate under Green, 3= certificate under Blue, 2= certificate under Red, 1= certificate under Black) | Lestari & Restuningdiah (2021); Saputra & Windyastuti (2024) |
| Human Capital Efficiency (HCE)      | Value Added (VA) /Human Capital (HC)                                                                                                                   | Rana & Hossain (2023)                                        |
| Structural Capital Efficiency (SCE) | Structural Capital (SC)/Value added (VA)<br>SC =VA-HC                                                                                                  | Rana & Hossain (2023)                                        |
| Relational Capital Efficiency (RCE) | Relational Capital (RC)/Value added (VA)                                                                                                               | Rana & Hossain (2023); Zhang et al. (2021)                   |
| Capital Employed Efficiency (CEE)   | Value added/Capital Employed                                                                                                                           | Odat & Bsoul (2022); Rana & Hossain (2023)                   |
| Control Variables                   |                                                                                                                                                        |                                                              |
| Firm Size (SIZE)                    | Ln (Total Assets)                                                                                                                                      | Fernando et al. (2024)                                       |
| Leverage (DER)                      | Debt Capital/Equity Capital                                                                                                                            | Rana & Hossain (2023)                                        |
| Profitability (ROA)                 | Net Income/Total Assets                                                                                                                                | Fernando et al. (2024); Saputra & Windyastuti (2024)         |

### Data Analysis

The panel data regression model was selected because the analyzed data consist of both cross-sectional and time-series dimensions. Two regression models were estimated to examine the relationships between the independent variables and firm value, namely a model without control variables and a model with control variables.

#### Model 1 (Without Control Variables)

$$TOBINSQ_{it} = \beta_0 + \beta_1GA_{it} + \beta_2HCE_{it} + \beta_3SCE_{it} + \beta_4RCE_{it} + \beta_5CEE_{it} + \varepsilon_{it}$$

### Model 2 (With Control Variables)

$$TOBINSQ_{it} = \beta_0 + \beta_1GA_{it} + \beta_2HCE_{it} + \beta_3SCE_{it} + \beta_4RCE_{it} + \beta_5CEE_{it} + \beta_6SIZE_{it} + \beta_7DER_{it} + \beta_8ROA_{it} + \varepsilon_{it}$$

Where :

TOBINSQ<sub>it</sub> = Firm value (Tobin's Q)

GA<sub>it</sub> = Green Accounting (GA)

HCE<sub>it</sub> = Human Capital Efficiency (HCE)

SCE<sub>it</sub> = Structural Capital Efficiency (SCE)

RCE<sub>it</sub> = Relational Capital Efficiency (RCE)

CEE<sub>it</sub> = Capital Employed Efficiency (CEE)

SIZE<sub>it</sub> = Firm Size

DER<sub>it</sub> = Leverage

ROA<sub>it</sub> = Profitability

β<sub>0</sub> = Constant term

β<sub>1</sub>, β<sub>2</sub>, β<sub>3</sub>, β<sub>4</sub>, β<sub>5</sub>, β<sub>6</sub>, β<sub>7</sub>, β<sub>8</sub>= Estimated coefficients

ε<sub>it</sub> = Error term

i = Firm (1, 2, 3, ..., n)

t = Year ( 2021, 2022, 2023, 2024)

The appropriate panel-data model was determined using the Chow test, Hausman test, and Lagrange Multiplier (LM) test. These tests were used to determine the suitability of the pooled/common effect, fixed effect, or random effect specification for the panel data. Classical assumption tests were also conducted to assess whether the regression model met the required statistical assumptions before hypothesis testing.

To mitigate the presence of outliers in the study, the winsorizing technique was applied at the 5th and 95th percentiles. Data processing and analysis were conducted using Stata version 15.

## RESULTS

### Descriptive Statistics

All data were analyzed using descriptive statistical tests to provide a general overview of the variables during the research period, including the standard deviation, minimum value, maximum value, and mean value of all variables.

**Table 3.** Descriptive Statistics Results

| Variable | Obs | Mean   | Min    | Max   | SD     |
|----------|-----|--------|--------|-------|--------|
| TOBINSQ  | 40  | 1.146  | 0.681  | 1.931 | 0.349  |
| GA       | 40  | 4.1    | 3      | 5     | 0.744  |
| HCE      | 40  | 7.322  | 2.513  | 22.23 | 5.005  |
| SCE      | 40  | 0.704  | 0.264  | 0.908 | 0.174  |
| RCE      | 40  | 0.108  | 0.001  | 0.486 | 0.132  |
| CEE      | 40  | 0.231  | 0.035  | 0.646 | 0.155  |
| SIZE     | 40  | 31.253 | 28.954 | 32.6  | 1.094  |
| DER      | 40  | 0.899  | 0.1443 | 3.295 | 0.844  |
| ROA      | 40  | 0.104  | 0.0144 | 0.336 | 0.0831 |

Table 3 shows that the firm value variable (TOBINSQ) has an overall mean value of 1.146, with a minimum of 0.681 and a maximum of 1.931. The mean value above 1 indicates that, on average, the market value of the sampled companies exceeded the book-based value of their assets during the observation period. Meanwhile, the GA

variable has an overall mean value of 4.1, with a minimum of 3 and a maximum of 5. This indicates that the sampled companies generally had PROPER ratings between the Blue and Gold categories, with an average rating above the Green category.

Furthermore, the HCE variable has an overall mean value of 7.322, with a standard deviation of 5.005, indicating considerable variation in HCE across the sampled companies. The SCE variable has an overall mean value of 0.704, while the RCE and CEE variables have mean values of 0.108 and 0.231, respectively. The variation in these intellectual capital efficiency measures is reflected in their respective minimum and maximum values.

For the control variables, firm size (SIZE) has an overall mean value of 31.253, with a minimum of 28.954 and a maximum of 32.6. The relatively narrow range indicates limited variation in firm size among the sampled companies. Furthermore, the leverage variable (DER) has an overall mean value of 0.899, with a minimum of 0.1443 and a maximum of 3.295. Meanwhile, the profitability variable (ROA) has an overall mean value of 0.104, with a minimum of 0.0144 and a maximum of 0.336. These statistics indicate variation in the financial characteristics of the sampled companies during the observation period.

### Panel Model Selection

The selection of the most appropriate model for this study is determined through the Chow, Hausman, and LM tests.

**Table 4.** Panel Model Selection

| Type of Test   | Description    | Model 1 (Without Control Variables) | Model 2 (With Control Variables) |
|----------------|----------------|-------------------------------------|----------------------------------|
| Chow Test      | Prob > F       | 0.0006                              | 0.0027                           |
| Result         |                | FEM                                 |                                  |
| Hausman Test   | Prob > chi2    | 0.3406                              | 0.985                            |
| Result         |                | REM                                 |                                  |
| LM Test        | Prob > chibar2 | 0.0037                              | 0.0165                           |
| Result         |                | REM                                 |                                  |
| Selected Model |                | REM                                 |                                  |

Table 4 shows the model specification test results. While the Chow test points to the FEM for both models, the Hausman and LM tests indicate that the REM is more appropriate for both Model 1 and Model 2.

### Classical Assumption Test

Classical assumption tests must be conducted prior to hypothesis testing to ensure that the results are valid and unbiased.

**Table 5.** Multicollinearity Test

| Variable | VIF                                 |                                  | Result<br>(Model 1 and 2)            |
|----------|-------------------------------------|----------------------------------|--------------------------------------|
|          | Model 1 (Without Control Variables) | Model 2 (With Control Variables) |                                      |
| GA       | 1.27                                | 3.49                             | Free from multicollinearity problems |
| HCE      | 2.38                                | 2.79                             | Free from multicollinearity problems |
| SCE      | 6.64                                | 6.84                             | Free from multicollinearity problems |

|      |      |      |                                      |
|------|------|------|--------------------------------------|
| RCE  | 5.28 | 6.74 | Free from multicollinearity problems |
| CEE  | 1.46 | 5.78 | Free from multicollinearity problems |
| SIZE | -    | 5.54 | Free from multicollinearity problems |
| DER  | -    | 1.74 | Free from multicollinearity problems |
| ROA  | -    | 4.77 | Free from multicollinearity problems |
| Mean | 3.41 | 4.71 | Free from multicollinearity problems |

Table 5 shows that the variance inflation factor (VIF) values for all independent and control variables are below 10. The highest VIF values are observed for SCE and RCE, but they remain below the threshold of 10. Thus, the regression models do not indicate a multicollinearity problem.

### Hypothesis Test

Hypothesis testing was conducted to examine whether each independent variable individually has a significant effect on the dependent variable.

**Table 6.** Hypothesis Test Result

| Variable | Model 1 (Without Control Variables) |         |                      |             |
|----------|-------------------------------------|---------|----------------------|-------------|
|          | Coef.                               | P-Value | Result               | Conclusion  |
| GA       | -0.24                               | 0,048   | Significant Negative | H1 Rejected |
| HCE      | 0.01                                | 0.264   | Insignificant        | H2 Rejected |
| SCE      | -0.89                               | 0.144   | Insignificant        | H3 Rejected |
| RCE      | -0.67                               | 0.402   | Insignificant        | H4 Rejected |
| CEE      | 0.936                               | 0.018   | Significant Positive | H5 Accepted |
| SIZE     | -                                   | -       | -                    | -           |
| DER      | -                                   | -       | -                    | -           |
| ROA      | -                                   | -       | -                    | -           |
| Variable | Model 2 (With Control Variables)    |         |                      |             |
|          | Coef.                               | P-Value | Result               | Conclusion  |
| GA       | -0.31                               | 0.021   | Significant Negative | H1 Rejected |
| HCE      | 0.019                               | 0.017   | Significant Positive | H2 Accepted |
| SCE      | -0.8                                | 0.088   | Insignificant        | H3 Rejected |
| RCE      | -0.45                               | 0.544   | Insignificant        | H4 Rejected |
| CEE      | 0.476                               | 0.413   | Insignificant        | H5 Rejected |
| SIZE     | 0.015                               | 0.909   | Insignificant        | -           |
| DER      | -0.09                               | 0.05    | Significant Negative | -           |
| ROA      | 0.324                               | 0.479   | Insignificant        | -           |

Table 6 presents the regression results for the models without and with control variables. In Model 1, the PROPER-based environmental performance measure has a negative and statistically significant coefficient ( $\beta = -0.24$ ,  $p = 0.048$ ), while HCE, SCE, and RCE are not statistically significant. CEE has a positive and statistically significant coefficient ( $\beta = 0.936$ ,  $p = 0.018$ ). In Model 2, environmental performance remains negatively and significantly associated with firm value ( $\beta = -0.31$ ,  $p = 0.021$ ), and HCE has a positive and statistically significant coefficient ( $\beta = 0.019$ ,  $p = 0.017$ ). SCE, RCE, and CEE are not statistically significant in this model. Among the control variables, leverage has a negative coefficient with a reported p-value of 0.050, while firm size and profitability are

not statistically significant. These results indicate that the statistical significance of HCE and CEE differs across model specifications. Hence, H1 is rejected.

For HCE, Model 1 produces a positive but insignificant coefficient (0.01;  $p = 0.264$ ), whereas Model 2 produces a positive and significant coefficient (0.019;  $p = 0.017$ ). Accordingly, H2 is rejected in Model 1 but accepted in Model 2. SCE has a negative and insignificant coefficient in both models (-0.89;  $p = 0.144$  in Model 1 and -0.80;  $p = 0.088$  in Model 2). Therefore, H3 is rejected. Similarly, RCE has a negative and insignificant coefficient in both Model 1 (-0.67;  $p = 0.402$ ) and Model 2 (-0.45;  $p = 0.544$ ), resulting in the rejection of H4. CEE has a positive and significant coefficient in Model 1 (0.936;  $p = 0.018$ ), resulting in the acceptance of H5. However, its effect becomes positive but insignificant in Model 2 (0.476;  $p = 0.413$ ), resulting in the rejection of H5 in the model with control variables. Among the control variables in Model 2, SIZE and ROA are statistically insignificant, while DER has a negative and significant coefficient (-0.09;  $p = 0.05$ ).

### Robustness Test

In this study, the robustness check was performed by replacing the dependent variable with Price-to-Book Value (PBV) as an alternative proxy for firm value. Furthermore, the robustness check was also conducted by modifying the estimation model, specifically by replacing the Random Effect Model (REM) with the Fixed Effect Model (FEM).

**Table 7.** Robustness Check (PBV)

| Variable | Robustness Check (PBV) |         |                      | Conclusion          |
|----------|------------------------|---------|----------------------|---------------------|
|          | Coeff                  | P-Value | Result               |                     |
| GA       | -0.45                  | 0.015   | Significant Negative | Robustly consistent |
| HCE      | 0.03                   | 0.001   | Significant Positive | Robustly consistent |
| SCE      | -1.41                  | 0.022   | Significant Negative | Inconsistent        |
| RCE      | -0.83                  | 0.476   | Insignificant        | Robustly consistent |
| CEE      | 0.48                   | 0.53    | Insignificant        | Robustly consistent |
| SIZE     | 0.07                   | 0.735   | Insignificant        | Robustly consistent |
| DER      | -0.24                  | 0       | Significant Negative | Robustly consistent |
| ROA      | 0.64                   | 0.272   | Insignificant        | Robustly consistent |

Based on Table 7, the results reveal that the independent variable GA remains significantly negative, while HCE remains significantly positive. Meanwhile, the independent variable SCE becomes significantly negative. This finding may occur because the PBV proxy is solely equity-based. In the mining sector, which is characterized by high levels of debt, the independent variable SCE on firm value may be more apparent when debt is not excluded from the calculation.

**Table 8.** Robustness Check (FEM)

| Variable | Robustness Check (FEM) |         |                        | Conclusion          |
|----------|------------------------|---------|------------------------|---------------------|
|          | Coeff                  | P-Value | Result                 |                     |
| GA       | -0.33                  | 0.048   | Significant Negative   | Robustly consistent |
| HCE      | 0.027                  | 0.003   | Significant Positive   | Robustly consistent |
| SCE      | -0.64                  | 0.143   | Insignificant          | Robustly consistent |
| RCE      | -0.12                  | 0.914   | Insignificant          | Robustly consistent |
| CEE      | 0.019                  | 0.959   | Insignificant          | Robustly consistent |
| SIZE     | -0.16                  | 0.582   | Insignificant          | Robustly consistent |
| DER      | -0.1                   | 0.068   | Insignificant Negative | Inconsistent        |
| ROA      | 0.74                   | 0.338   | Insignificant          | Robustly consistent |

Based on Table 8, the robustness checks provide consistent evidence for the negative association between the PROPER-based environmental performance measure and firm value, as well as the positive association between HCE and firm value, across the alternative PBV measure and FEM specification. However, the results for SCE and DER vary across specifications. Therefore, the robustness checks support the consistency of the findings for environmental performance and HCE, but not for all explanatory and control variables.

## DISCUSSION

### Environmental Performance and Firm Value

In Model 1, the PROPER-based environmental performance measure has a negative and statistically significant coefficient ( $\beta = -0.24$ ,  $p = 0.048$ ). This finding differs from Saputra and Windyastuti (2024) but is consistent with the findings reported by Alaika & Firmansyah (2024) and Surifah et al. (2026). The negative association indicates that higher PROPER ratings were associated with lower firm value in the sampled companies during the observation period. One possible explanation is that improvements in environmental management performance may not translate immediately into higher market valuations, particularly when investors place greater emphasis on short-term financial outcomes. However, the present analysis does not directly measure environmental management costs or investors' perceptions; therefore, the negative coefficient should not be interpreted as evidence that investors consider green accounting a financial burden. The finding instead suggests that better environmental performance, as measured by PROPER ratings, did not automatically correspond to higher firm value in the sampled Indonesian mining companies.

### HCE and Firm Value

In Model 1, HCE has a significance value of 0.264 and a positive coefficient value of 0.01; therefore, H2 is rejected. However, Model 2 shows a significance value of 0.017 and a positive regression coefficient value of 0.019, indicating that HCE has a positive and significant effect on firm value. HCE is proven to be an important determinant of firm value because the market is able to assess the quality of human resources more objectively, particularly in the mining sector. Investors tend to assign higher valuations to companies that not only rely on natural resources but also possess intellectual advantages through their human resources. Therefore, H2 is accepted, and these findings are consistent with the studies of Mustafa et al. (2024) and Zhang et al. (2021), which found that investors appreciate employee capabilities as drivers of innovation that are capable of maintaining corporate resilience during periods of crisis.

### SCE and Firm Value

In Model 1, SCE has a significance value of 0.144 and a negative regression coefficient value of -0.89. Meanwhile, Model 2 shows a significance value of 0.088 and a negative regression coefficient value of -0.8. Both models indicate that the effect of SCE on firm value is insignificant; therefore, H3 is rejected. Accordingly, the findings of this study are inconsistent with the results reported by Ali et al. (2022) and Rehman et al. (2022). This finding indicates that the value generated by SCE may not be effectively communicated to the market, or that the implementation of SCE has become standardized within the mining sector, thereby limiting its ability to provide additional market value. The results of this study are consistent with Rana and Hossain (2023), who stated that companies have not optimally utilized SCE (such as technology, processes, databases, and intellectual properties) to create market value, while the costs associated with SCE tend to reduce corporate profits. These findings are further supported by Xu and Liu (2020), who argued that investors tend to focus on short-term performance.

### **RCE and Firm Value**

In Model 1, RCE has a significance value of 0.402 and a negative regression coefficient value of -0.67. Meanwhile, Model 2 shows a significance value of 0.544 and a negative regression coefficient value of -0.45. Both models indicate that the effect of RCE on firm value is insignificant; therefore, H4 is rejected. Consequently, the findings of this study are inconsistent with the studies conducted by [Rana & Hossain \(2023\)](#) and [Rehman et al. \(2022\)](#). However, these findings are consistent with [Truong et al. \(2026\)](#), who demonstrated that in developing countries such as Vietnam, investments in RCE (including advertising, promotion, and donations) do not generate proportional increases in revenue. Furthermore, relational costs do not create long-term loyalty reflected in market valuation. Studies have demonstrated that investments in relational capital (such as marketing expenses, promotional activities, and public relations) require a longer period to affect profitability, while the market tends to respond negatively or show no response to increases in RCE.

### **CEE and Firm Value**

In Model 1, CEE has a significance value of 0.018 and a positive regression coefficient value of 0.936; therefore, H5 is accepted because the effect is positive and significant. However, Model 2 shows a significance value of 0.413 and a positive regression coefficient value of 0.476, indicating that H5 is rejected because the effect is insignificant on firm value. These findings are inconsistent with the studies conducted by [Odat & Bsoul \(2022\)](#), [Rana & Hossain \(2023\)](#), and [Zhang et al. \(2021\)](#), which found that high CEE is capable of increasing net income, thereby providing a positive signal to the market and ultimately increasing stock prices. First, there has been a shift in investor preferences toward greater appreciation of intangible assets, such as HCE ([Mustafa et al., 2024](#)), whereas high CEE is considered common in the mining sector because it has become part of standard operational practices. Second, strict environmental regulations and the high capital intensity of the mining sector lead investors to place greater concern on default risk arising from high debt levels (as reflected in the significant leverage results) and environmental policies (as reflected in the significant GA results), rather than solely focusing on the efficiency of asset utilization.

### **Robustness Checks and Overall Interpretation**

The robustness tests provide stronger support for the consistency of the main findings concerning GA and HCE. Both variables retain their respective negative and positive significant associations under the alternative PBV measure and FEM specification. In contrast, the results for SCE and DER vary across specifications, while RCE, CEE, SIZE, and ROA generally remain statistically insignificant.

Overall, the findings provide differentiated support for the theoretical perspectives underlying the study. The GA results suggest that environmental performance did not automatically translate into higher market valuation, while the HCE results indicate that HCE was more consistently associated with firm value. The findings for SCE, RCE, and CEE further suggest that not all components of intellectual capital efficiency have the same relationship with market valuation.

## **CONCLUSION**

This study examines the association between PROPER-based environmental performance, intellectual capital efficiency, and firm value among mining companies listed on the IDX during 2021–2024. The results show that environmental performance is negatively and significantly associated with firm value in both the model without control variables ( $\beta = -0.24$ ,  $p = 0.048$ ) and the model with control variables ( $\beta = -0.31$ ,  $p = 0.021$ ). Thus, H1 is not supported. This finding indicates that higher PROPER ratings did not correspond to higher firm value among the sampled companies during the observation period. However, the results do not establish that environmental management costs reduced corporate net income or that investors perceived environmental management as a financial burden. Human capital efficiency is positively and significantly associated with firm value in the model with control variables ( $\beta = 0.019$ ,  $p = 0.017$ ), although its association is not statistically significant in the model without control variables. Therefore, the evidence for H2 depends on the model specification. Structural capital efficiency and relational capital efficiency are not statistically significant in either main model, so H3 and H4 are not supported. Capital employed efficiency is positively and significantly associated with firm value in the model without control variables ( $\beta = 0.936$ ,  $p = 0.018$ ), but its association is not statistically significant in the model with control variables ( $\beta = 0.476$ ,  $p = 0.413$ ). Accordingly, the evidence for H5 also depends on the model specification.

These findings suggest that environmental performance and intellectual capital components do not have uniform associations with firm value in the sampled Indonesian mining companies. The negative association between PROPER ratings and firm value indicates that stronger environmental management performance did not automatically correspond to higher market valuation during the period examined. Meanwhile, the positive association between human capital efficiency and firm value in the model with control variables suggests that employee-related capabilities may be relevant to how the market values mining companies. Nevertheless, the differences between model specifications warrant caution when interpreting the results. For company management, the findings support continued attention to environmental performance alongside the development and effective utilization of human capital. Companies should communicate their environmental performance transparently and demonstrate how their environmental and human-resource initiatives relate to their broader business strategies. For regulators, consistent environmental reporting and clear assessment frameworks may help stakeholders interpret companies' environmental performance more meaningfully.

## **LIMITATION**

The control variables, firm size and profitability, have insignificant effects on firm value. Meanwhile, the control variable leverage has a negative and significant effect on firm value. This finding indicates that high debt levels are perceived as an increase in financial risk. As a result, the market responds negatively due to uncertainty regarding the company's ability to repay its debt and interest obligations, thereby reducing stock prices and ultimately decreasing firm value.

Based on the limitations above, several suggestions can be proposed. Future researchers are encouraged to expand the research objects to other sectors and extend the observation period in order to examine the long-term impact of GA and intellectual capital investments. For companies, it is important to convince investors that the implementation of GA should be viewed as a strategic investment for long-term risk mitigation. In addition, companies should consistently develop human resource competencies, while management should exercise greater caution in debt financing decisions to avoid increasing default risk, which is highly concerning to the market. For

investors, greater caution is required in distinguishing companies that genuinely implement GA from those engaging in greenwashing through comprehensive analysis of annual reports. Investors should also remain objective by not overlooking HCE as an indicator of the company's future resilience and should carefully evaluate corporate debt levels. Lastly, regulators are expected to establish standardized and uniform accounting standards for environmental costs as practical guidelines, considering that the current implementation of GA remains voluntary and subjective. Furthermore, regulators should strengthen supervision to ensure that all companies disclose ESG information transparently, thereby enhancing investor confidence.

## **ACKNOWLEDGMENT**

The authors express gratitude to those who have had the pleasure of cooperating during this study or research.

## **DECLARATION OF CONFLICTING INTERESTS**

The authors have declared no potential conflicts of interest concerning the study, authorship, and/or publication of this article.

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