



Firm Value of Indonesian Energy Companies: The Effect of ESG Disclosure, Digital Transformation, and Capital Structure

Alicia Amanda Wikaning Tyas

Telkom University,
INDONESIA

Muhamad Muslih*

Telkom University,
INDONESIA

Article Info	Abstract
Article history: Received: June 22, 2026 Revised: August 30, 2026 Accepted: September 10, 2026 Keywords: capital structure; digital transformation; energy sector; ESG; firm value.	Indonesia's energy sector faces substantial financing requirements, continued dependence on fossil fuels, and increasing pressure to strengthen sustainability and technological adaptation. This study examines the relationships of Environmental, Social, and Governance (ESG) disclosure, keyword-frequency-based digital transformation disclosure, and capital structure with firm value among energy-sector companies listed on the Indonesia Stock Exchange. A quantitative explanatory design was employed using a balanced panel of 24 companies observed from 2021 to 2024, resulting in 96 firm-year observations. Firm value was measured using winsorized Tobin's Q, ESG disclosure using a GRI Standards 2021-based disclosure index, digital transformation disclosure using the logarithmically transformed frequency of predefined digital-related keywords, and capital structure using the total-liabilities-to-total-assets ratio. Fixed-effects panel regression was estimated using Stata 17. The results show that ESG disclosure was negatively but not significantly associated with firm value ($\beta = -1.3022, p = 0.068$), while digital transformation disclosure showed a positive but non-significant association ($\beta = 0.2125, p = 0.268$). In contrast, capital structure was positively and significantly associated with firm value ($\beta = 3.5883, p < 0.001$). The model was jointly significant, $F(3, 69) = 9.66, p < 0.001$, with a within R^2 of 0.2957. These findings indicate that the overall-leverage measure had clearer statistical relevance to firm value than the two disclosure-based measures within the observed companies and period. The study contributes to the application of signaling theory by showing that different financial and non-financial corporate signals may differ in their statistical relevance to market valuation. The findings also suggest that companies should manage liabilities prudently while improving the credibility, specificity, and outcome orientation of ESG and digital-transformation reporting.
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INTRODUCTION

Indonesia's energy sector plays a central role in supporting industrial, transportation, household, and commercial activities, while at the same time facing substantial sustainability, technological, and financing pressures (Sukanto et al., 2024; MEMR, 2025). The sector remains highly capital intensive because exploration, infrastructure, production, and power-generation activities require large investments and long planning horizons. At the same time, Indonesia's primary energy supply continues to depend heavily on coal, oil, and natural gas, creating challenges for the country's energy-transition agenda and emissions-reduction commitments (BPH Migas, 2024; Wong & Dewayanti, 2024). This fossil-fuel dependence contributes to greenhouse-gas emissions and creates tension with Sustainable Development Goal 13 and Indonesia's energy-transition commitments (IEA,

* **Corresponding author:**

Muhamad Muslih, Telkom University, INDONESIA. ✉ muhamadmuslih@telkomuniversity.ac.id

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2022; UNFCCC, 2022). The energy transition consequently creates simultaneous sustainability, technological, and financing pressures for energy companies. These pressures are particularly relevant in Indonesia because the sector remains closely connected to fossil-based activities, while companies are increasingly expected to reduce environmental impacts and support the transition toward cleaner energy.

Energy projects also require substantial long-term investment in exploration, infrastructure, power generation, and supporting technologies, making the sector highly capital intensive (MEMR, 2025). At the same time, Indonesia's dependence on imported petroleum increases the sector's exposure to fluctuations in global energy prices, which may raise operating costs and create uncertainty in corporate investment decisions (Aprianto et al., 2024). Companies must therefore maintain business performance while managing ESG-related risks, integrating digital technologies into complex operational processes, and obtaining sufficient funding without creating excessive financial risk. Technological readiness is particularly important because the benefits of energy investment may depend on system integration, operational capability, and efficient energy conversion (Ang et al., 2022). From a signaling perspective, corporate disclosures and financing decisions provide information that may help investors assess corporate risks, strategies, and future prospects, although the effectiveness of these signals depends on their credibility and economic relevance (Connelly et al., 2011). External funding may support productive investment and business expansion, but excessive financial obligations can increase repayment pressure and financial risk (Bui et al., 2023). These combined sustainability, technological, and financing characteristics make listed Indonesian energy companies a particularly relevant setting for examining the relationships of ESG disclosure, digital transformation disclosure, and capital structure with firm value.

Indonesia's primary energy composition further illustrates this challenge. In 2024, coal accounted for 40.37% of Indonesia's primary energy supply, followed by oil at 28.82%, natural gas at 16.17%, and renewable energy at 14.65% (MEMR, 2024). Although the renewable-energy share increased from 12.20% in 2021, fossil fuels continued to dominate Indonesia's primary energy supply throughout 2021-2024. Investment in Indonesia's energy and mineral resources sector increased from USD 27.5 billion in 2021 to USD 32.3 billion in 2024, although renewable-energy investment remained below the level required to support national climate targets (MEMR, 2025). The scale and duration of energy projects make financing decisions particularly important. External financing may provide resources for infrastructure, exploration, and productive investment, but greater financial obligations can also increase repayment pressure and financial risk. Capital structure, operationalized in this study as total liabilities divided by total assets, may therefore be associated with firm value because it reflects the extent of the company's obligations relative to its asset base (Bui et al., 2023).

Signaling theory provides the main theoretical foundation for this study because managers possess more information about corporate conditions, strategies, and future prospects than external investors (Connelly et al., 2011). Companies can reduce this information asymmetry by communicating observable financial and non-financial signals through corporate reports and financing decisions. However, the existence of information does not automatically make a signal effective because its relevance depends on its clarity, credibility, and connection to observable corporate outcomes (Liao, 2025).

In this study, ESG disclosure represents a non-financial signal concerning corporate transparency in reporting environmental, social, and governance matters. Keyword-frequency-based digital transformation disclosure represents the intensity with which companies communicate their technological orientation, while capital structure represents a financial signal concerning the company's overall leverage, measured as total liabilities relative to total assets (Bui et al., 2023; Merelyn & Eriandani, 2022; Verhoef et al., 2021). Investors may use these signals to evaluate corporate risks and prospects, and their assessments may subsequently be reflected in firm value (Muslih & Nurlina, 2024).

Previous studies report mixed evidence regarding the relationship between ESG and firm value. Aydoğmuş et al. (2022) found that ESG performance was positively associated with firm value, whereas Prabawati and Rahmawati (2022) reported a negative relationship in ASEAN companies. These differences may arise because previous studies use different measures, including commercial ESG scores, ESG performance, and item-based disclosure indexes. The relationship may also depend

on sectoral characteristics, the credibility and readability of ESG information, and whether investors perceive the reported information as financially material (Huang et al., 2025).

Evidence concerning digital transformation is also inconsistent. Ma et al. (2022) and Wang and Xia (2024) found that digital transformation was positively associated with firm value, whereas Handayani et al. (2025) reported a negative relationship. One possible explanation for these differences is the distinction between actual digital implementation and disclosure-based measurement. Keyword frequency captures how intensively companies communicate digital themes, but it does not directly indicate technological investment, system integration, implementation maturity, or realized operational benefits.

Capital structure findings also vary across previous studies. Bui et al. (2023) found that the liabilities-to-assets ratio was positively associated with Tobin's Q. Nguyen (2024) similarly reported a positive relationship between the total-debt ratio and Tobin's Q, although the result differed across debt maturities. Attia et al. (2023), meanwhile, identified a nonlinear relationship that varied according to firm size. A higher liabilities-to-assets ratio may reflect greater reliance on external obligations to support operations and investment. However, high financial obligations may be interpreted negatively when repayment pressure, financing costs, or financial-distress risks exceed the expected benefits.

The literature therefore leaves several specific gaps. Previous studies have commonly examined ESG, digital transformation, and capital structure separately across different models, sectors, and country settings, while limited empirical evidence is available on their simultaneous examination as financial and non-financial corporate signals. Moreover, limited evidence exists on the combined use of a GRI-based ESG disclosure index, keyword-frequency-based digital transformation disclosure, and capital structure measured using the total-liabilities-to-total-assets ratio among listed Indonesian energy companies. Consequently, it remains unclear whether disclosure-based and financing-based signals have comparable statistical relevance to firm value during Indonesia's 2021-2024 energy-transition period.

This study addresses these gaps by integrating GRI-based ESG disclosure, keyword-frequency-based digital transformation disclosure, and capital structure measured using the total-liabilities-to-total-assets ratio in one panel-data model. Specifically, it examines their individual and joint relationships with the firm value of Indonesian energy companies listed on the Indonesia Stock Exchange during 2021-2024. Theoretically, this study extends the application of signaling theory by examining whether financial and non-financial corporate signals have comparable market relevance in a capital-intensive emerging-market sector. Practically, the findings are expected to assist company management and investors in evaluating the relevance of sustainability disclosure, digital orientation, and financing decisions. The study does not directly measure investor preferences; therefore, its contribution is limited to identifying which variables are statistically associated with firm value within the observed model and period.

LITERATURE REVIEW

Theoretical Framework

Signaling theory is used as the main theoretical foundation of this study because the three explanatory variables represent information or corporate decisions that originate from management but can be observed by external parties. Managers generally possess more information about internal conditions, strategies, risks, and future prospects than investors, creating information asymmetry between the two parties (Connelly et al., 2011; Spence, 1973). ESG disclosure and digital transformation disclosure communicate non-financial information concerning sustainability and technological orientation, while capital structure communicates a financial signal concerning the company's overall leverage, financial obligations, and funding risk. Signaling theory therefore provides a coherent basis for examining whether these financial and non-financial signals are associated with firm value (Muslih & Nurlina, 2024). The theory does not imply that every corporate disclosure will automatically be interpreted as a positive signal. Signal effectiveness depends on whether the information is observable, credible, understandable, and relevant to the receiver's decision (Connelly et al., 2011; Liao, 2025). Consequently, extensive disclosure may remain a weak signal when it is generic, difficult to verify, or not connected to observable economic outcomes.

Firm value represents the market's assessment of a company's ability to manage its resources, maintain business continuity, and generate future economic benefits (Sinta et al., 2024; Suastra et al., 2023). A higher firm value generally reflects stronger market confidence in the company's current condition and future prospects (Muslih & Nurlina, 2024; Suastra et al., 2023). Financial characteristics such as leverage and corporate financial performance also provide relevant information concerning the company's financial condition and risk profile (Sari & Mahardika, 2023). Because investors respond to financial and non-financial information through their market decisions, firm value provides an appropriate outcome for evaluating whether corporate signals are reflected in market valuation.

This study measures firm value using Tobin's Q, which compares the market value of equity plus total liabilities with total assets. Tobin's Q was selected because it incorporates market expectations and evaluates the company's overall resource base rather than relying solely on historical accounting earnings (Desmiza, 2023; Saraswati et al., 2024). Accordingly, firm value is positioned as the dependent variable, while ESG disclosure, digital transformation disclosure, and capital structure are positioned as the explanatory variables in the research framework presented in Figure 1.

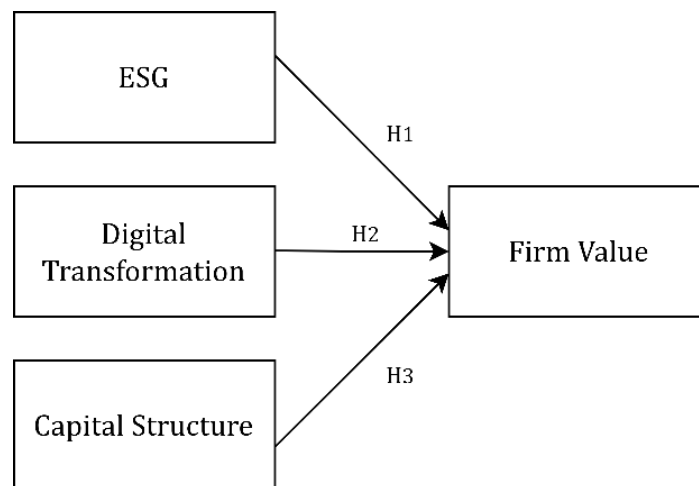


Figure 1. Research Framework

ESG Disclosure

ESG disclosure refers to the extent to which a company reports environmental, social, and governance information through its annual report and sustainability report (GRI, 2021; Hardiningsih et al., 2024). Such disclosure provides external parties with information concerning environmental impacts, relationships with employees and communities, governance structures, policies, and corporate accountability. In this study, ESG represents the breadth of disclosed information rather than the company's actual ESG performance or the quality of its sustainability practices (Ramadhan et al., 2023).

From a signaling perspective, comprehensive and credible ESG disclosure may reduce information asymmetry by helping investors assess sustainability risks, governance quality, and the company's long-term commitments (Liao, 2025). The signal is more likely to be reflected in firm value when the disclosed information is relevant, readable, credible, and connected to future corporate performance (Huang et al., 2025). Previous studies report different findings regarding the relationship between ESG and firm value. Aydoğmuş et al. (2022) and Msomi et al. (2025) found positive relationships, whereas Prabawati and Rahmawati (2022) reported a negative relationship among ASEAN companies. These differences may arise from variations in ESG measurement, sectoral characteristics, reporting credibility, and research context.

Therefore, broader ESG disclosure is expected to strengthen transparency, reduce information asymmetry, and support a more favorable market assessment, particularly when the disclosed information is credible and relevant. Based on signaling theory and the supporting empirical evidence, ESG disclosure is expected to be positively associated with firm value.

H1: ESG disclosure has a positive effect on firm value.

Digital Transformation

Digital transformation refers to organizational change generated through the integration of digital technologies into business processes, strategies, and business models (Verhoef et al., 2021; Vial, 2019). Technologies such as artificial intelligence, big data, cloud computing, blockchain, and other digital applications may support information processing, operational efficiency, innovation, and decision-making. However, the benefits of digital transformation depend on the company's ability to integrate these technologies into its operations and strategy rather than merely adopting individual digital tools (Ma et al., 2022; Zheng & Bu, 2024). Because detailed internal data on digital investment and implementation are generally not publicly available for all sampled companies, this study observes digital transformation through information communicated in annual reports.

The measure is constructed from the frequency of five groups of digital-related keywords: artificial intelligence, blockchain, cloud computing, big data, and digital technology. These categories represent major digital domains identified in previous textual-analysis studies (Li et al., 2023; Zhao et al., 2024). Annual reports constitute formal communication channels through which management communicates corporate strategies, initiatives, and future orientation to external parties (Healy & Palepu, 2001).

Keyword frequency captures the intensity with which companies communicate digital-transformation themes. Unlike a dichotomous presence-or-absence measure, frequency preserves differences between companies that mention digital themes only occasionally and those that discuss them more extensively. Nevertheless, this disclosure-based measure does not directly capture technological investment, implementation maturity, system integration, or the actual operational success of digital transformation. The total frequency is transformed using the natural logarithm after adding one, expressed as $\ln(1 + \text{keyword frequency})$. The addition of one retains observations with no identified keywords, while the logarithmic transformation reduces the disproportionate influence of very high frequencies. The resulting measure therefore represents the intensity of digital-transformation disclosure rather than actual digital implementation.

Under signaling theory, more extensive and credible digital-transformation disclosure may communicate technological adaptability, innovation orientation, and preparedness for future business changes. When investors perceive the information as credible and connected to observable operational benefits, the disclosure may support a more favorable market assessment (Zhang & Song, 2025; Zheng & Bu, 2024). Empirically, Ma et al. (2022) found that digital transformation increased enterprise value directly and indirectly through technological and business-model innovation. Wang and Xia (2024) also reported a positive relationship between digital transformation and firm value. These findings suggest that digital orientation may be positively valued when it is followed by innovation and observable economic benefits.

Accordingly, companies that communicate stronger digital orientation are expected to provide a positive signal concerning their adaptability and future capabilities. Digital transformation disclosure is therefore expected to be positively associated with firm value.

H2: Digital transformation disclosure has a positive effect on firm value.

Capital Structure

Capital structure generally refers to the combination of debt and equity used by a company to finance its operations and long-term growth (Arhinful et al., 2025). Capital-structure decisions affect the company's cost of capital, risk profile, funding capacity, and overall financial condition (Arhinful et al., 2025; Priyan et al., 2024). External financing may provide resources for operations and investment; however, excessive financial obligations may increase repayment pressure and financial risk.

In this study, capital structure is operationalized as overall leverage using the liabilities-to-assets ratio, calculated by dividing total liabilities by total assets. A higher ratio indicates that the company has a larger amount of total liabilities relative to its asset base. Bui et al. (2023) employed the liabilities-to-assets ratio and distinguished it from short-term- and long-term-debt ratios. Accordingly, the measure used in this study includes total reported liabilities rather than only

interest-bearing borrowings or debt classified by maturity. The ratio was selected because it provides an asset-based measure of the company's overall leverage.

Empirically, [Bui et al. \(2023\)](#) found that the liabilities-to-assets ratio was positively associated with Tobin's Q. [Nguyen \(2024\)](#) similarly reported that the total-debt ratio and short-term-debt ratio were positively associated with Tobin's Q, whereas the long-term-debt ratio was not statistically significant. Evidence from Indonesia also indicates that capital structure is relevant in explaining variations in firm value, although its relationship may operate together with other company characteristics such as profitability and institutional ownership ([Wardoyo & Fauziah, 2024](#)). These findings indicate that leverage may be relevant to market-based firm value, although its relationship may differ according to the proxy and maturity structure used.

From a signaling perspective, financing decisions, particularly debt commitments, may communicate information about the company's condition and future prospects because managers possess information that may not be fully available to external investors ([Ross, 1977](#)). Debt commitments may be interpreted as a positive signal when they reflect management's confidence in the company's future cash-flow capacity and ability to meet contractual obligations. However, this interpretation is conditional because excessive or poorly managed leverage may increase financial risk and weaken the expected benefits of external financing ([Arhinful et al., 2025](#); [Bui et al., 2023](#)). In the present study, the liabilities-to-assets ratio captures overall leverage and should not be interpreted as representing only interest-bearing debt.

Given the substantial financing requirements of energy companies, greater reliance on external obligations may support corporate operations and investment when those obligations are managed within the company's financial capacity. From a signaling perspective, manageable leverage may also communicate confidence in the company's ability to maintain operations and meet its obligations. Based on signaling theory and the supporting empirical evidence, capital structure measured using the liabilities-to-assets ratio is therefore expected to be positively associated with firm value ([Bui et al., 2023](#); [Ross, 1977](#)).

H3: Capital structure has a positive effect on firm value.

METHOD

This study employed a quantitative explanatory design to estimate the statistical relationships between ESG disclosure, keyword-frequency-based digital transformation disclosure, capital structure, and firm value ([Creswell & Creswell, 2022](#)). Because the study did not employ an experimental or quasi-experimental identification strategy, the estimated coefficients are interpreted as panel associations after accounting for time-invariant firm-specific effects rather than as definitive causal effects. The research procedure is summarized in Figure 2.

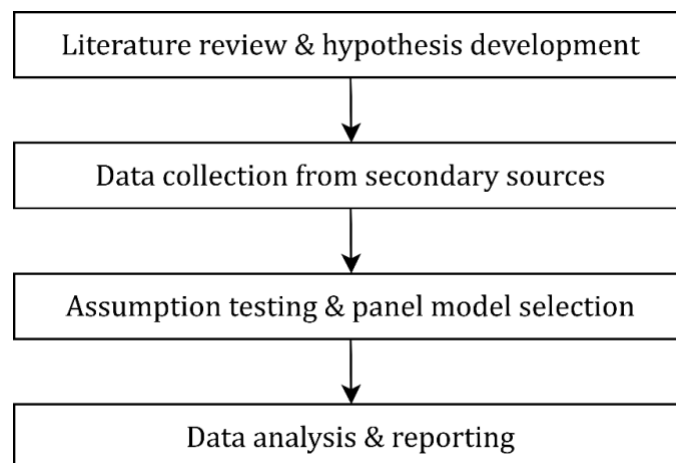


Figure 2. Research Stages Flowchart

Source: Adapted from [Creswell & Creswell \(2022\)](#)

As summarized in Figure 2, the research procedure consisted of four stages. First, signaling theory and relevant empirical studies were reviewed to develop the conceptual framework and

hypotheses. Second, secondary data were collected from annual reports, financial statements, and sustainability reports, followed by sample screening and variable measurement. Third, diagnostic tests and panel-model selection procedures were conducted. Fourth, the selected panel regression model was estimated using Stata 17, and the findings were interpreted in relation to signaling theory and the energy-sector context.

The population comprised 89 energy-sector companies listed on the Indonesia Stock Exchange as of 2024. Purposive sampling was applied at the screening stage using predefined criteria concerning listing continuity and the availability of the reports required to measure the research variables. The sample was determined through sequential screening, as presented in Table 1.

Table 1. Sample Selection Process

No.	Sample-selection criteria	Number of companies
1	Energy-sector companies listed on the Indonesia Stock Exchange as of 2024	89
2	Companies not continuously listed during 2021–2024	(6)
3	Companies that did not consistently publish the required annual reports and financial statements during 2021–2024	(45)
4	Companies whose annual and/or sustainability reports did not provide the information required to construct the GRI Standards 2021-based ESG disclosure index consistently during 2021–2024	(14)
Final research sample		24
Observation period, 2021–2024		4 years
Total firm-year observations: 24 companies × 4 years		96

As shown in Table 1, the sequential screening process resulted in 24 eligible companies. These companies represented all firms that satisfied the predefined inclusion criteria, and no further subsampling was conducted. Observing the 24 companies over four consecutive years produced a balanced panel of 96 firm-year observations.

The balanced panel of 96 firm-year observations was operationally adequate for estimating the specified parsimonious fixed-effects model because each of the 24 companies was observed in all four years and the model contained three focal explanatory variables. The final fixed-effects specification retained 69 residual degrees of freedom. However, no formal statistical-power analysis was conducted. Because the dataset covers only 24 eligible companies and four reporting years, the findings are limited to the observed sample and should be generalized beyond the sampled companies with caution.

The 2021–2024 period was selected to provide four consecutive and comparable reporting years during a period of increasing attention to ESG disclosure, corporate digital adaptation, and Indonesia's energy-transition agenda. This period also covers Indonesia's strengthened emissions-reduction commitment under the Enhanced Nationally Determined Contribution, while 2024 was the latest complete reporting year available when the data were collected (MEMR, 2024; UNFCCC, 2022).

Firm value was measured using Tobin's Q, calculated as the sum of the market value of equity and total liabilities divided by total assets (Bui et al., 2023; Saraswati et al., 2024):

$$TQ_{it} = \frac{MVE_{it}Equity + TL_{it}}{TA_{it}}$$

where TQ_{it} represents Tobin's Q for company i in year t , MVE_{it} represents the market value of equity, TL_{it} represents total liabilities, and TA_{it} represents total assets. Tobin's Q was winsorized at the 5th and 95th percentiles before the descriptive and regression analyses (Abuzaid & Alkrunz, 2024). Values below the 5th percentile were replaced with the 5th-percentile value, while values above the 95th percentile were replaced with the 95th-percentile value. These cut-off points were selected to limit the influence of observations located in the two extreme tails of the distribution while retaining all 96 firm-year observations in the analysis. Thus, winsorization did not remove any company or observation from the sample.

ESG disclosure was measured through manual content analysis using a standardized checklist adapted from the GRI Standards 2021. The final checklist comprised 100 unique disclosure items: 31 environmental items, 39 social items, and 30 governance and related general-disclosure items derived from GRI 2: General Disclosures. GRI 307-1 and GRI 419-1 were not scored separately to avoid duplicate scoring of compliance-related information included in GRI 2-27 under the 2021 Standards (GRI, 2021). The classification of the GRI 2 items as governance and related general disclosures represents an operational adaptation of this study and does not imply that GRI officially classifies every GRI 2 disclosure as a governance indicator.

The documentary unit of analysis consisted of the annual report and sustainability report available for each company-year observation. When the same disclosure item appeared in both documents, the item was counted only once for that firm-year observation. Each item received a score of 1 when information corresponding to the disclosure requirement was identified in the reports and a score of 0 when the information was not identified. An item was scored only once for each firm-year observation, regardless of how frequently the information appeared. The same checklist, coding definitions, and decision rules were applied consistently across all companies and reporting years (Ramadhan et al., 2023).

$$ESG_{it} = \frac{\sum_{j=1}^{100} X_{ijt}}{100}$$

where $X_{ijt} = 1$ if company i disclosed item j in year t , and $X_{ijt} = 0$ otherwise. index ranges from 0 to 1, with a higher value indicating broader ESG disclosure. All disclosure items were assigned equal weights. The unweighted approach was selected because the study measures disclosure breadth rather than the relative materiality, quality, or performance of individual ESG items. Equal weighting also avoids introducing subjective researcher-assigned importance scores and is consistent with the dichotomous disclosure-index approach used by Ramadhan et al. (2023). Therefore, a higher index indicates broader disclosure but does not necessarily indicate superior ESG performance or reporting quality.

Digital transformation disclosure was measured using textual analysis of annual reports. The measurement was based on five digital-technology categories identified in previous textual-analysis studies: artificial intelligence, blockchain, cloud computing, big data, and digital technology applications (Li et al., 2023; Zhao et al., 2024). The terms counted in this study were “artificial intelligence”; “blockchain”; “cloud computing” and “cloud server”; “big data”; and “digital technology,” “digitalization,” and “digital transformation.” These categories represent major digital domains used in prior corporate digital-transformation measures and are not intended to capture every possible form of digital technology.

For each firm-year observation, every occurrence of the predefined terms was counted, and the frequencies across the five categories were summed. A frequency-based measure was used instead of a dichotomous presence-or-absence score because it preserves variation between companies that mention digital themes only occasionally and companies that discuss them repeatedly. Accordingly, the measure captures the intensity of digital-transformation communication in annual reports rather than merely the existence of a digital-related term. The total keyword frequency was transformed using the natural logarithm after adding one:

$$DT = \ln(1 + \sum_{k=1}^5 FREQ_{kit})$$

where $FREQ_{kit}$ represents the total frequency of terms belonging to digital-technology category k for company i in year t . The logarithmic transformation reduces right-skewness, limits the disproportionate influence of exceptionally high keyword counts, and improves comparability across firms (Zhao et al., 2024; Zheng & Bu, 2024). The resulting variable reflects disclosure intensity and does not directly measure digital investment, technological maturity, system integration, or implementation success.

Capital structure was measured using the total-liabilities-to-total-assets ratio, calculated by dividing total liabilities by total assets. This ratio captures the company's overall leverage because it includes both current and non-current liabilities rather than only interest-bearing borrowings. A

higher value indicates a larger amount of total liabilities relative to the company's asset base. The operationalization follows Bui et al. (2023), who distinguish the liabilities-to-assets ratio from short-term- and long-term-debt ratios:

$$CS_{it} = \frac{TL_{it}}{TA_{it}}$$

where TL_{it} represents total liabilities and TA_{it} represents total assets of company i in year t .

$$TQ_{w,it} = \alpha + \beta_1 ESG_{it} + \beta_2 DT_{it} + \beta_3 CS_{it} + \mu_i + \varepsilon_{it}$$

where $TQ_{w,it}$ represents the winsorized Tobin's Q of company i in year t ; ESG_{it} represents the ESG disclosure index; DT_{it} represents keyword-frequency-based digital transformation disclosure; and CS_{it} represents capital structure measured using the total-liabilities-to-total-assets ratio. Furthermore, α denotes the intercept; β_1 , β_2 , and β_3 denote the regression coefficients; μ_i represents unobserved firm-specific effects that remain constant over time; and ε_{it} represents the idiosyncratic error term. In this study, i refers to the 24 sampled companies, while t refers to the observation years from 2021 to 2024.

The model was specified to test the three focal associations established in the conceptual framework rather than to maximize predictive fit. Firm fixed effects account for unobserved company-specific characteristics that remain constant over time. However, the model does not control for omitted time-varying factors, including annual changes in profitability, firm size, liquidity, or sales growth. Therefore, residual omitted-variable bias remains possible, and the estimated coefficients are interpreted as conditional associations rather than definitive causal effects. The exclusion of time-varying control variables is acknowledged as a study limitation.

Multicollinearity among the explanatory variables was assessed using the Variance Inflation Factor (VIF), with values below 10 interpreted as indicating no serious multicollinearity. Heteroskedasticity was assessed using the Breusch-Pagan/Cook-Weisberg test. A probability value above 0.05 indicated that the null hypothesis of constant variance was not rejected. All diagnostic tests and panel estimations were conducted using Stata 17.

Panel-model selection was conducted before estimating the regression. The Chow test compared the Common Effect Model and the Fixed Effect Model, while the Hausman test compared the Fixed Effect Model and the Random Effect Model (Basuki, 2021). A probability value below 0.05 in the Chow test was interpreted as supporting the Fixed Effect Model over the Common Effect Model, whereas a probability value below 0.05 in the Hausman test supported the Fixed Effect Model over the Random Effect Model. The Lagrange Multiplier test compares the Random Effect Model with the Common Effect Model and does not directly select the Fixed Effect Model. Because the Chow and Hausman tests were decisive for the final model selection, the Lagrange Multiplier test was treated only as a supplementary comparison. The numerical results are presented in the Results section. The selected Fixed Effect Model estimates the coefficients from within-company variation over time while absorbing unobserved firm characteristics that remain constant during the observation period.

RESULTS AND DISCUSSION

Descriptive Statistics

Before the descriptive analysis, Tobin's Q was winsorized at the 5th and 95th percentiles to limit the disproportionate influence of extreme values while retaining all companies and firm-year observations in the sample (Abuzaid & Alkrunz, 2024). The unusually high observations were identified for PT Bayan Resources Tbk (BYAN) in 2022–2024 and PT Batulicin Nusantara Maritim Tbk (BESS) in 2021. These observations were retained but capped at the specified percentile thresholds. Table 2 presents the descriptive statistics for the resulting 96 firm-year observations.

Table 2. Descriptive statistics of research variables

No	Variable	Obs	Mean	Std. Dev.	Min	Max
1	Firm Value	96	1.4505	1.2433	0.6041	5.8101
2	ESG Disclosure Index	96	0.6432	0.2297	0.1200	0.9700

3	Digital Transformation	96	1.0651	0.7398	0.0000	2.9957
4	Capital Structure	96	0.4659	0.1988	0.0480	0.8781

Table 2 presents the descriptive statistics for the 96 firm-year observations. All firm-value statistics are based on Tobin's Q after winsorization at the 5th and 95th percentiles. Winsorized Tobin's Q had a mean of 1.4505 and a standard deviation of 1.2433, with values ranging from 0.6041 to 5.8101. The mean Tobin's Q above one indicates that, on average, the combined market value of equity and total liabilities exceeded the recorded value of the sampled companies' assets. However, the relatively large standard deviation indicates substantial variation in firm value across firm-year observations.

The ESG disclosure index had a mean of 0.6432 and a standard deviation of 0.2297, indicating that the sampled companies disclosed approximately 64.32% of the 100-item checklist on average. The index ranged from 0.1200 to 0.9700, showing considerable variation in disclosure breadth across the firm-year observations.

Digital transformation disclosure had a mean of 1.0651 and a standard deviation of 0.7398, with values ranging from 0 to 2.9957. The minimum value indicates that no predefined digital-transformation terms were identified in some firm-year annual reports, whereas the maximum indicates substantially greater disclosure intensity in other observations. This measure reflects the frequency of digital-transformation communication rather than the depth or success of technological implementation.

Capital structure, measured using the total-liabilities-to-total-assets ratio, had a mean of 0.4659. Thus, the sampled companies' total liabilities were equivalent to approximately 46.59% of total assets on average. The ratio ranged from 0.0480 to 0.8781, showing considerable variation in overall leverage across the firm-year observations. To provide direct evidence of changes in the research variables during the observation period, Table 3 presents their annual mean values from 2021 to 2024. Table 3 presents the multicollinearity test results for all independent variables used in the regression model.

Table 3. Annual Mean Values of Research Variables

Year	Firm Value	ESG	Digital Transformation	Capital Structure
2021	1.7216	0.5483	0.8730	0.5151
2022	1.4524	0.6308	0.9134	0.4722
2023	1.2674	0.6888	1.2090	0.4515
2024	1.3605	0.7050	1.2650	0.4248

Source: Research Data 2026

As shown in Table 3, the mean firm value declined from 1.7216 in 2021 to 1.2674 in 2023, before increasing slightly to 1.3605 in 2024. Thus, firm value did not follow a consistent upward or downward pattern throughout the observation period.

The mean ESG disclosure index increased consistently from 0.5483 in 2021 to 0.7050 in 2024. These values are equivalent to an increase in average disclosure breadth from approximately 54.83% to 70.50% of the 100-item checklist. This pattern indicates that the sampled energy companies disclosed a broader range of ESG information over the observation period. However, the increase describes disclosure breadth and does not necessarily indicate an equivalent improvement in ESG performance or reporting quality.

Digital transformation disclosure also increased overall, from 0.8730 in 2021 to 1.2650 in 2024. The largest increase occurred between 2022 and 2023, when the mean rose from 0.9134 to 1.2090. This pattern indicates that digital-transformation terminology appeared more frequently in the companies' annual reports over time. Nevertheless, because the variable is based on keyword frequency, the increase reflects greater disclosure intensity rather than confirmed technological implementation or operational success.

In contrast, the mean total-liabilities-to-total-assets ratio declined consistently from 0.5151 in 2021 to 0.4248 in 2024. This pattern indicates that the sampled companies' total liabilities relative to their asset base decreased on average during the observation period. These annual movements are descriptive and do not by themselves establish causal relationships between the variables. Table

4 presents the multicollinearity test results for the explanatory variables included in the regression model.

Table 4. Multicollinearity test results

Variable	VIF	Result
ESG Disclosure Index	1.34	No multicollinearity
Digital Transformation	1.32	No multicollinearity
Capital Structure	1.05	No multicollinearity
Mean VIF	1.24	

Multicollinearity was assessed using the Variance Inflation Factor. As presented in Table 4, the VIF values were 1.34 for ESG disclosure, 1.32 for digital transformation disclosure, and 1.05 for capital structure, with a mean VIF of 1.24. All values were substantially below the threshold of 10; therefore, no serious multicollinearity was identified among the explanatory variables (Indartini & Mutmainah, 2024).

The Breusch–Pagan/Cook–Weisberg test produced $\chi^2(1)=0.62$ with a probability value of 0.4297. Because the probability value exceeded 0.05, the null hypothesis of constant variance was not rejected. Accordingly, the test did not provide evidence of heteroskedasticity under the tested specification.

Panel Data Model Selection

Table 5 presents the results of the Chow, Hausman, and Lagrange Multiplier tests used to select the appropriate panel-data estimation model.

Table 5. Panel Data Model Selection Results

Test	Test statistic	p-value	Decision
Chow test	$F(23,69)=12.32$	0.0000	FEM preferred
Hausman test	$\chi^2(3)=17.43$	0.0006	FEM preferred
Lagrange Multiplier test	$\text{Chibar}^2(01)=56.47$	0.0000	REM preferred to CEM

Source: Research Data 2026

As shown in Table 5, the Chow test produced $F(23, 69) = 12.31$ with $p < 0.001$, indicating that the Fixed Effect Model was preferable to the Common Effect Model. The Hausman test produced $\chi^2(3) = 17.43$ with $p = 0.0006$, supporting the Fixed Effect Model over the Random Effect Model.

The Lagrange Multiplier test produced $\text{chibar}^2(01) = 56.47$ with $p < 0.001$, indicating that the Random Effect Model was preferable to the Common Effect Model. However, the LM test does not compare the Random Effect Model directly with the Fixed Effect Model. Therefore, the Chow and Hausman tests were decisive in selecting the Fixed Effect Model as the final estimation specification (Basuki, 2021).

Based on the panel-model selection results, the Fixed Effect Model was used to estimate the associations of ESG disclosure, digital transformation disclosure, and capital structure with firm value. The estimation results are presented in Table 6.

Table 6. Fixed Effect Model Estimation Results

Variable	Coefficient	Std. Error	t-stat	P> t	95% Conf. Interval
ESG (X1)	-1.3022	0.7019	-1.86	0.068	[-2.7023, 0.0980]
Digital Transformation (X2)	0.2125	0.1903	1.12	0.268	[-0.1670, 0.5921]
Capital Structure (X3)	3.5883	0.8303	4.32	0.000	[1.9320, 5.2446]
Constant	0.3900	0.6750	0.58	0.565	[-0.9566, 1.7366]
Within R ²	0.2957	$F(3,69)$	9.66	Prob > F	0.0000
Number of observations	96	Number of companies	24	ρ (rho)	0.8127

Source: Research Data 2026

Table 6 presents the Fixed Effect Model estimates based on 96 firm-year observations from 24 energy-sector companies. The model was statistically significant as a whole, with $F(3, 69) = 9.66$ and $p < 0.001$. The within R² of 0.2957 indicates that changes in ESG disclosure, digital transformation

disclosure, and capital structure explained 29.57% of the variation in winsorized Tobin's Q within the same companies over time. The remaining 70.43% represents within-company variation not explained by the variables included in the model.

The rho value of 0.8127 indicates that a substantial proportion of the composite error variance was attributable to unobserved firm-specific effects. However, rho was not used as the basis for selecting the Fixed Effect Model; the final specification was determined through the Chow and Hausman tests. The constant was statistically insignificant ($p = 0.565$) and was therefore not interpreted substantively.

At the individual-variable level, ESG disclosure had a negative but statistically insignificant coefficient ($\beta = -1.3022$ $p = 0.068$). Digital transformation disclosure had a positive but statistically insignificant coefficient ($\beta = 0.2125$ $p = 0.268$). Capital structure, measured using the total-liabilities-to-total-assets ratio, had a positive and statistically significant coefficient ($\beta = 3.5883$ $p < 0.001$). The hypothesis-testing decisions are summarized in Table 7.

Table 7. Hypothesis-Testing Summary

Hypothesis	Variable	Coefficient	P> t	Decision
H1	ESG effect to firm value	-1.3022	0.068	Not supported
H2	Digital transformation effect to firm value	0.2125	0.268	Not supported
H3	Capital structure effect to firm value	3.5883	<0.001	Supported

Source: Research Data 2026

The effect of ESG disclosure on firm value (H_1)

The Fixed Effect Model produced an ESG disclosure coefficient of -1.3022 with a probability value of 0.068. Because the probability value exceeded the predetermined significance level of 0.05 and the 95% confidence interval included zero, H1 was not supported. Although the estimated coefficient was negative, the result does not provide sufficient statistical evidence that broader ESG disclosure reduces firm value.

One possible explanation concerns the measurement approach used in this study. The GRI-based index captures the breadth of information disclosed, but it does not directly measure reporting quality, credibility, materiality, external assurance, or actual ESG performance. Consequently, companies with similar disclosure-index values may differ substantially in the specificity and economic relevance of the information they communicate. The effectiveness of a signal depends not only on the quantity of information disclosed but also on its observability, credibility, clarity, and relevance to the receiver's decision (Connelly et al., 2011; Liao, 2025). The readability and presentation of ESG information may also influence whether the disclosure is reflected in market valuation (Huang et al., 2025).

The annual descriptive results reinforce this distinction. The mean ESG disclosure index increased from 0.5483 in 2021 to 0.7050 in 2024, but this increase in disclosure breadth was not accompanied by a statistically significant association with firm value. Thus, a broader quantity of reported ESG items may not be sufficient to form a valuation-relevant signal when the information is not clearly connected to observable risk reduction, operational performance, or future economic outcomes. This explanation remains interpretive because the study did not directly measure reporting quality or investor perceptions.

The result differs from Aydoğmuş et al. (2022) and Msomi et al. (2025), who reported positive relationships between ESG and firm value. The difference may arise from variations in ESG measurement, country setting, sectoral characteristics, and observation period. The present study uses an equally weighted disclosure-breadth index, whereas other studies may use ESG performance indicators or commercial ESG scores. Therefore, the result indicates that broader ESG disclosure was not significantly associated with firm value in the observed Indonesian energy companies; it does not demonstrate that ESG practices are economically unimportant.

The effect of digital transformation on firm value (H_2)

Digital transformation disclosure produced a positive coefficient of 0.2125 with a probability value of 0.268. Because the probability value exceeded 0.05 and the 95% confidence interval included zero, H2 was not supported. The positive direction was consistent with the proposed hypothesis, but the statistical evidence was insufficient to establish a significant association with firm value.

The insignificant result may be related to the disclosure-based measurement approach. The variable records how frequently predefined digital-transformation terms appear in annual reports, but it does not directly measure technological expenditure, implementation maturity, system integration, employee capability, or realized operational benefits. Therefore, repeated references to artificial intelligence, big data, cloud computing, blockchain, or digitalization do not necessarily indicate that these technologies have been integrated into core operations or generated measurable economic outcomes.

This distinction is important from a signaling perspective. Digital-transformation disclosure may communicate technological orientation and organizational adaptability, but the existence of such communication does not automatically make it an effective signal. Its relevance to firm value depends on whether the information is credible and connected to observable innovation, efficiency, or future performance (Connelly et al., 2011; Zheng & Bu, 2024).

The mean digital transformation disclosure measure increased from 0.8730 in 2021 to 1.2650 in 2024. Nevertheless, the FEM result indicates that the increase in disclosure intensity was not significantly associated with firm value. This pattern supports the distinction between greater communication of digital themes and successful digital implementation.

The finding differs from Ma et al. (2022) and Wang and Xia (2024), who reported positive relationships between digital transformation and enterprise or firm value. Their findings indicate that digital transformation may create value when it supports technological innovation, business-model development, or observable performance improvements. In the present study, keyword frequency may not provide sufficient information about whether these benefits were actually realized. A delayed relationship is also possible, but lagged effects were not directly tested in this study.

The effect of capital structure on firm value (H₃)

Capital structure measured using the total-liabilities-to-total-assets ratio produced a coefficient of 3.5883 with a probability value below 0.001. Its 95% confidence interval was entirely positive; therefore, H₃ was supported. In within-company terms, an increase of 0.01 in the total-liabilities-to-total-assets ratio was associated with an increase of approximately 0.0359 in winsorized Tobin's Q, holding ESG disclosure, digital transformation disclosure, and time-invariant firm-specific characteristics constant.

The positive association is relevant to the capital-intensive characteristics of energy companies, whose exploration, production facilities, infrastructure, equipment, and long-term projects require substantial funding (Arhinful et al., 2025; Zandi et al., 2023). External obligations may support operations and investment when they are managed within the company's financial capacity. However, the measure used in this study captures total liabilities and should not be interpreted as representing only interest-bearing debt.

From a signaling perspective, debt creates contractual obligations that require companies to generate sufficient cash flows to meet financial commitments. The willingness to assume these obligations may communicate management's confidence regarding future performance (Ross, 1977). The result is consistent with Bui et al. (2023), who found that the liabilities-to-assets ratio was positively associated with Tobin's Q. Nguyen (2024) also reported a positive relationship between the total-debt ratio and Tobin's Q, although the findings differed across debt maturities.

However, this finding does not mean that continuously increasing total liabilities will always improve firm value. Excessive or poorly managed leverage may increase financing costs, repayment pressure, liquidity risk, and the probability of financial distress (Arhinful et al., 2025). The coefficient should therefore be interpreted as a positive conditional association within the sampled companies and observation period, not as a recommendation to maximize corporate liabilities.

The model also excludes time-varying controls such as profitability and firm size. Consequently, the estimated capital-structure coefficient may partly reflect other changing company conditions correlated with both overall leverage and firm value. This limitation reinforces the need to avoid interpreting the coefficient as definitive causal evidence.

The model-level F test produced $F(3, 69) = 9.66$ with $p < 0.001$. Therefore, the joint null hypothesis that the slope coefficients of ESG disclosure, digital transformation disclosure, and capital structure were simultaneously equal to zero was rejected. This result indicates that the three-

variable regression specification was statistically significant as a whole. However, the significant F test does not imply that every explanatory variable was individually significant. The partial tests showed that capital structure was the only individually significant explanatory variable at the 5% level, whereas ESG disclosure and digital transformation disclosure were not statistically significant.

The findings contribute to signaling theory by indicating that different corporate signals may have different levels of statistical relevance to market valuation. In the observed Indonesian energy companies, capital structure, represented by an observable overall-leverage measure, was significantly associated with firm value. In contrast, ESG disclosure and digital transformation disclosure, both measured from corporate reporting, were not individually significant. This pattern is consistent with the signaling-theory proposition that the presence of information alone is insufficient to create an effective signal. Signal effectiveness also depends on observability, credibility, relevance, and the receiver's ability to connect the information with expected economic consequences (Connelly et al., 2011; Liao, 2025).

The results do not establish that financial signals are universally superior to non-financial signals. Rather, they indicate that, within the sampled companies and period, the overall-leverage signal measured using the total-liabilities-to-total-assets ratio had a clearer statistical association with firm value than the disclosure breadth and keyword frequency captured by the ESG and digital-transformation variables. The insignificant ESG and digital-transformation coefficients do not demonstrate that sustainability and digitalization are irrelevant. Instead, they may indicate that disclosure breadth and keyword frequency do not fully capture the credibility, implementation quality, and observable outcomes required for these non-financial signals to be reflected in firm value.

LIMITATION

The findings should be interpreted in light of several limitations. First, the sample includes only 24 listed energy companies observed over four years. Companies without complete reports or sufficient GRI-based information were excluded, which may cause the sample to underrepresent firms with weaker reporting capacity and limits the generalizability of the findings.

Second, the unweighted ESG index measures disclosure breadth but does not assess reporting quality, materiality, external assurance, or actual ESG performance. Similarly, the digital-transformation measure captures keyword frequency rather than investment, implementation maturity, system integration, or realized operational benefits. These measurement limitations may weaken the estimated relationships when disclosure quantity is only loosely connected to substantive corporate practices.

Third, the model does not include time-varying control variables such as profitability, firm size, liquidity, sales growth, or commodity-price exposure. Although firm fixed effects account for characteristics that remain constant over time, residual omitted-variable bias remains possible. Therefore, the coefficients should be interpreted as conditional associations rather than definitive causal effects. Future studies should use longer panels, implementation-based measures, lagged specifications, year effects, and theoretically justified control variables.

CONCLUSION

The findings indicate that ESG disclosure and keyword-frequency-based digital transformation disclosure were not significantly associated with firm value among Indonesian energy-sector companies during 2021-2024. In contrast, capital structure measured using the total-liabilities-to-total-assets ratio was positively and significantly associated with firm value. Therefore, H1 and H2 were not supported, and H3 was supported. Although the regression model was statistically significant as a whole, this result does not mean that every explanatory variable was individually significant.

The findings refine the application of signaling theory by showing that different corporate signals may have different levels of relevance to market valuation. In the observed companies, the overall-leverage signal represented by the total-liabilities-to-total-assets ratio had clearer statistical relevance than the disclosure breadth captured by the ESG index and the disclosure intensity

captured by digital-transformation keyword frequency. This result does not establish that financial signals are universally superior to non-financial signals. It should also not be interpreted as evidence that continuously increasing the liabilities-to-assets ratio will always improve firm value. Companies should manage their overall liabilities prudently and maintain them within their cash-flow capacity and acceptable level of financial risk.

The insignificant results for ESG disclosure and digital transformation disclosure do not indicate that sustainability practices and digitalization are unimportant. Rather, disclosure breadth and keyword frequency may not fully capture reporting credibility, implementation quality, or observable economic outcomes. Energy companies should therefore improve the specificity, consistency, credibility, and outcome orientation of their ESG and digital reporting. Future studies should extend the observation period, include theoretically relevant time-varying controls such as profitability and firm size, and use measures that more clearly distinguish corporate disclosure from substantive ESG and digital implementation. Lagged specifications, year effects, and comparisons across sectors may also provide more robust evidence.

AUTHOR CONTRIBUTIONS

AW contributed to the conceptualization of the study, formulation of the research questions and hypotheses, development of the research framework, data collection and coding, and preparation of the original manuscript. MM contributed to the development and validation of the research methodology, panel-data analysis using Stata 17, model specification and statistical interpretation, and critical review of the manuscript. Both authors contributed to the interpretation and discussion of the findings concerning ESG disclosure, digital transformation disclosure, capital structure, and firm value. Both authors reviewed and revised the manuscript critically, approved the final version, and agreed to be accountable for all aspects of the work.

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