

Green Technology Investment, Environmental Governance, and Environmental Sustainability in IDX Basic Materials Companies

*A,B,C,DSilpia, A,C,EYanti, C,FAde Trisyanto

Universitas Buana Perjuangan Karawang, Indonesia

DOI: [10.46821/equity.v7i1.864](https://doi.org/10.46821/equity.v7i1.864)

Submitted: June 3, 2026 | Accepted: August 11, 2026 | Published: September 2, 2026

A – Research Concept and Design, B – Collection and/or Assembly of Data, C – Data Analysis and Interpretation, D – Writing The Article, E – Critical Revision of The Article, F – Final Approval of Article.

ABSTRACT

This study examines how green technology investment and environmental governance are associated with environmental sustainability among Indonesia Stock Exchange (IDX) basic materials companies during 2020-2024. Using sustainability report data from 20 firms (100 firm year observations), the relationships were estimated with partial least squares structural equation modeling (PLS-SEM). Green technology investment ($\beta = 0.339$, $t = 4.920$, $p < 0.001$) and environmental governance ($\beta = 0.329$, $t = 4.804$, $p < 0.001$) were positively associated with environmental sustainability. Model explanatory power was modest ($R^2 = 0.208$), and both effect sizes were small ($f^2 = 0.145$ and 0.136). Consistent with the Natural Resource Based View (NRBV), the findings suggest that technology investment and environmental governance operate as complementary capabilities, but neither is a dominant explanation of environmental sustainability. The study contributes contextual evidence from an environmentally intensive Indonesian sector while maintaining a noncausal interpretation.

Keywords: Basic Materials, Environmental Governance, Environmental Sustainability, Green Technology Investment, Natural Resource Based View.

INTRODUCTION

Environmental sustainability has become a central accounting and governance concern because listed companies are increasingly expected to identify, manage, and disclose the environmental consequences of their operations. In Indonesia, Financial Services Authority Regulation No. 51/POJK.03/2017 embeds sustainability reporting within the corporate reporting environment for issuers and public companies (Otoritas Jasa Keuangan, 2017). This context is especially salient for IDX Basic Materials firms, whose activities are closely connected with material processing, resource use, waste generation, and environmental risk. Indonesian research likewise shows that environmental innovation, environmental management accounting, and sustainability disclosure increasingly shape corporate assessment and decision making (Asila & Falikhatun, 2023; Rifai et al., 2024; Wasyiah et al., 2025).

How to Cite:

Silpia, Yanti, Trisyanto, A. (2026). Green Technology Investment, Environmental Governance, and Environmental Sustainability in IDX Basic Materials Companies. *Equity: Jurnal Akuntansi*, 7(1), 1-10. <https://doi.org/10.46821/equity.v7i1.864>.

*Corresponding Author:

Email : ak22.silpia@mhs.ubpkarawang.ac.id

Addres : Jalan Ronggo Waluyo Sirnabaya, Jl. HS.Ronggo Waluyo No.184,
Telukjambe Timur, Karawang, Jawa Barat, 41361



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One strategic response is green technology investment, namely the allocation of corporate resources to cleaner technologies and processes intended to reduce environmental burdens and improve resource efficiency (Adi & Wardi, 2022). Firm level evidence links sustainable investment with improved energy and carbon performance (Atif et al., 2023), while Indonesian studies associate green technology and renewable technology adoption with energy efficiency and emissions reduction (Rusmayadi et al., 2023; Tiawon & Miar, 2023). Manufacturing oriented work also positions green engineering and green accounting as complementary mechanisms for embedding environmental considerations in operations (Lumbanbatu & Sriyanto, 2025), while Sari et al. (2025) highlight the strategic relevance of green innovation, CSR, and eco efficiency in Indonesian manufacturing. Nevertheless, environmental outcomes are not automatically large or uniform; Rukh et al. (2025) show that green finance outcomes depend on investment patterns and implementation conditions.

Environmental governance represents a second organizational capability. Governance mechanisms can strengthen environmental oversight, accountability, disclosure quality, and the integration of sustainability considerations into decision making. Hyun & Yu (2024) report a positive association between CSR governance quality and corporate environmental performance, while Soussi et al. (2025) document the relevance of sustainability governance mechanisms. In Indonesia, corporate governance is also associated with sustainability report disclosure (Rumaningsih & Rusmanto, 2024). More broadly, institutional conditions can shape the governance performance relationship in ASEAN (Handoyo & Anas, 2024), and Vitale et al. (2025) show that mandatory sustainability reporting may alter how governance mechanisms relate to ESG outcomes. Environmental governance may therefore function as a substantive organizational capability when oversight, accountability, and environmental decision making are implemented in an integrated manner.

The Natural Resource Based View (NRBV) provides the theoretical mechanism connecting these capabilities to environmental sustainability. Hart (1995) argues that competitive capabilities can be built around pollution prevention, product stewardship, and sustainable development. From this perspective, green technology investment represents a resource commitment that can support cleaner processes and more efficient resource use, whereas environmental governance provides the monitoring, coordination, and accountability needed to translate environmental commitments into organizational routines. Evidence on green investment and financing also suggests that resource commitments can support sustainable business performance through complementary organizational pathways (Ye & Dela, 2023). The two constructs are therefore positioned as complementary internal capabilities rather than interchangeable practices.

The literature nevertheless leaves an unresolved question. Green investment studies commonly emphasize financing, technology adoption, energy efficiency, or carbon outcomes, whereas governance studies more often focus on disclosure, board structures, CSR governance, or ESG performance. Evidence is also mixed regarding the conditions under which investment and governance translate into environmental outcomes. This creates an empirical and analytical gap for an integrated test of green technology investment and environmental governance within the same model in the Indonesian Basic Materials setting. The contribution of this study is therefore not merely its 2020-2024 observation window, but the joint positioning of investment and governance

as complementary NRBV capabilities and the assessment of their relative explanatory contribution to a disclosure based environmental sustainability construct.

Based on NRBV and the preceding evidence, two associational hypotheses are proposed. H1: Green technology investment is positively associated with environmental sustainability. H2: Environmental governance is positively associated with environmental sustainability. The study aims to examine these relationships among IDX Basic Materials companies during 2020-2024. Scientifically, it tests an integrated capability perspective within sustainability accounting; managerially, it evaluates whether investment and governance signals in sustainability reports are associated with higher environmental sustainability scores while explicitly considering the magnitude and explanatory limits of the model.

RESEARCH METHOD

Location and Time of Research

The study focuses on IDX listed Basic Materials companies and uses sustainability reports and related corporate disclosures for the 2020-2024 reporting period. The reports were obtained from the IDX and official company websites. Data collection and analysis were conducted during 2025-2026, while the analytical observation window remained 2020-2024.

Research Approach

This study uses a quantitative explanatory and observational design with the firm year as the unit of analysis. The model evaluates associations among disclosure based latent constructs. Because the observations follow the same firms across five reporting years, the coefficients are interpreted as model based associations rather than panel causal effects. Statistical significance is therefore considered together with effect size, explanatory power, and the observational nature of the design.

Data Collection Methods

Data were collected through document analysis of corporate sustainability reports. Purposive sampling was applied to IDX Basic Materials companies with sustainability report information sufficient to construct the study indicators throughout 2020-2024. These criteria produced a balanced analytical sample of 20 firms observed for five consecutive years, yielding 100 firm year observations.

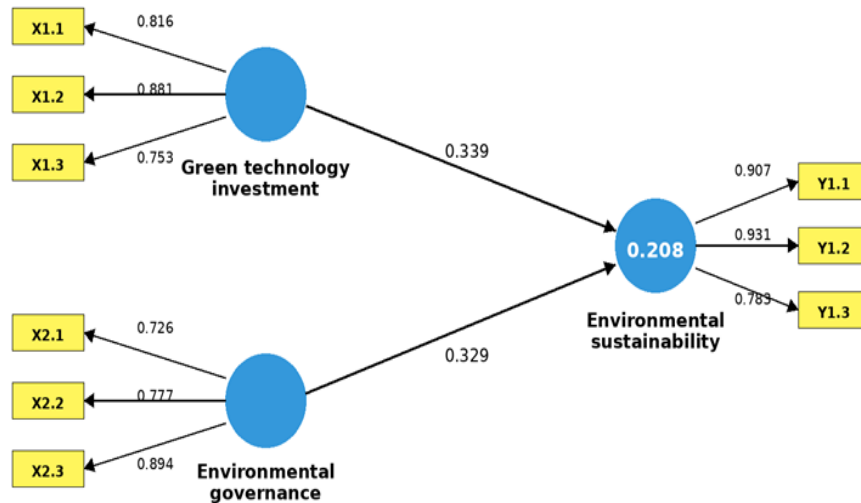
Construct Measurement

Green technology investment (X1), environmental governance (X2), and environmental sustainability (Y) were specified as reflective constructs, each represented by three disclosure based indicators: X1.1-X1.3, X2.1-X2.3, and Y1.1-Y1.3. Indicator scores were derived from sustainability report information; accordingly, the constructs represent reported environmental orientation rather than direct physical measures such as emissions or energy intensity. Interpretation is maintained at the construct level and does not attribute the structural relationships to individual indicator specific mechanisms.

Table 1. Construct Measurement Framework

Construct	Indicator Codes	Specification	Data Source
Green technology investment	X1.1, X1.2, X1.3	Reflective	Sustainability reports
Environmental governance	X2.1, X2.2, X2.3	Reflective	Sustainability reports
Environmental sustainability	Y1.1, Y1.2, Y1.3	Reflective	Sustainability reports

Source: Data Processed, 2026



Source: Data Processed, 2026

Figure 1. PLS-SEM Model Estimates

Data Analysis

The study uses partial least squares structural equation modeling (PLS-SEM) in SmartPLS. Following standard PLS-SEM reporting practice, the reflective measurement model was evaluated using outer loadings, Cronbach's alpha, composite reliability (ρ_a and ρ_c), average variance extracted (AVE), and cross loadings (Hair et al., 2019). Loadings of approximately 0.70 or higher, reliability values above 0.70, and AVE values above 0.50 were used as measurement model benchmarks. Discriminant separation was evaluated using the cross loading criterion. The structural model was assessed through R^2 , adjusted R^2 , f^2 , path coefficients, t statistics, and p values. Statistical significance was evaluated at the 5% level; software output reported as $p = 0.000$ is presented as $p < 0.001$. Because the design is observational and contains repeated firm year observations, inference emphasizes direction, magnitude, effect size, and explanatory power rather than causal interpretation.

RESULTS AND DISCUSSION

Measurement Model

All outer loadings exceeded 0.70, ranging from 0.726 to 0.931. AVE values were 0.670 for green technology investment, 0.643 for environmental governance, and 0.767 for environmental sustainability. Cronbach's alpha values were 0.754, 0.743, and 0.849, respectively, while composite reliability (ρ_c) ranged from 0.843 to 0.908. These values support adequate convergent validity and internal consistency for the reflective measurement model.

Table 2. Outer Loadings

Indicator	Outer Loading
X1.1	0.816
X1.2	0.881
X1.3	0.753
X2.1	0.726
X2.2	0.777
X2.3	0.894
Y1.1	0.907
Y1.2	0.931
Y1.3	0.783

Source: Data Processed, 2026

Table 3. Reliability and Convergent Validity

Construct	Cronbach's α	rho_a	rho_c	AVE
Green technology investment	0.754	0.763	0.858	0.670
Environmental governance	0.743	0.886	0.843	0.643
Environmental sustainability	0.849	0.901	0.908	0.767

Source: Data Processed, 2026

Table 4. Cross Loading Matrix

Indicator	X1	X2	Y
X1.1	0.816	-0.191	0.302
X1.2	0.881	-0.064	0.212
X1.3	0.753	0.116	0.242
X2.1	-0.043	0.726	0.182
X2.2	-0.105	0.777	0.151
X2.3	-0.004	0.894	0.334
Y1.1	0.189	0.348	0.907
Y1.2	0.311	0.344	0.931
Y1.3	0.350	0.046	0.783

Source: Data Processed, 2026

Discriminant Validity

Each indicator loaded more strongly on its assigned construct than on the other two constructs in the cross loading matrix. This pattern supports discriminant separation under the criterion applied in the study. Because HTMT provides a more sensitive complementary assessment of discriminant validity (Henseler et al., 2015), the cross loading evidence is interpreted as supportive rather than exhaustive and is considered together with convergent validity and reliability results.

Structural Model

The structural model explained 20.8% of the variance in environmental sustainability ($R^2 = 0.208$; adjusted $R^2 = 0.192$). The model therefore has limited explanatory power and leaves substantial variation outside the two specified relationships. Effect sizes were small for both green technology investment ($f^2 = 0.145$) and environmental governance ($f^2 = 0.136$). The combination of statistically

significant paths with modest effect sizes indicates that both constructs are relevant correlates of environmental sustainability, but neither provides a comprehensive explanation on its own.

Hypothesis Testing

Green technology investment had a positive path coefficient with environmental sustainability ($\beta = 0.339$, $SE = 0.069$, $t = 4.920$, $p < 0.001$), supporting H1. Environmental governance also had a positive coefficient ($\beta = 0.329$, $SE = 0.069$, $t = 4.804$, $p < 0.001$), supporting H2. Both paths are statistically significant within the specified PLS-SEM model. Given the observational firm year design, the coefficients are interpreted as associations among the modeled constructs rather than definitive causal estimates.

DISCUSSION

Green Technology Investment and Environmental Sustainability

The positive association between green technology investment and environmental sustainability is consistent with the NRBV proposition that environmental resource commitments can become organizational capabilities when they support pollution prevention and cleaner production (Hart, 1995). It also aligns with Atif et al. (2023) and Rusmayadi et al. (2023), who link sustainable or green technology investment with favorable energy, carbon, and environmental outcomes. In the basic materials setting, this relationship is economically plausible because cleaner technologies can improve resource productivity and strengthen a firm's capacity to integrate environmental considerations into operating and reporting decisions. Because the construct is derived from sustainability report information, the result indicates that firms with stronger green technology investment profiles also tend to exhibit stronger reported environmental sustainability profiles.

The magnitude of the relationship provides an important boundary to that interpretation. The f^2 value of 0.145 is small and the full model explains 20.8% of environmental sustainability variance, indicating that green technology investment is one component of a broader environmental performance architecture rather than a sufficient condition for sustainability. Implementation quality, asset intensity, energy mix, regulatory exposure, and complementary organizational capabilities may shape the environmental value ultimately realized from investment. This interpretation is consistent with Rukh et al. (2025), who emphasize the importance of investment patterns and implementation conditions. For managers, the implication is not simply to increase green expenditure, but to connect technology investment with operating processes, monitoring systems, and measurable environmental objectives.

Table 5. Structural Model Explanatory and Effect Size Statistics

Statistic	Value
R^2	0.208
Adjusted R^2	0.192
f^2 : Green technology investment $\rightarrow$ Environmental sustainability	0.145
f^2 : Environmental governance $\rightarrow$ Environmental sustainability	0.136

Source: Data Processed, 2026

Table 6. Structural Paths and Hypothesis Tests

Hyp.	Path	β	SE	t	p	Decision
H1	X1 $\rightarrow$ Y	0.339	0.069	4.920	< 0.001	Supported
H2	X2 $\rightarrow$ Y	0.329	0.069	4.804	< 0.001	Supported

X1 = Green Technology Investment; X2 = Environmental Governance; Y = Environmental Sustainability.

Source: Data Processed, 2026

Environmental Governance and Environmental Sustainability

Environmental governance also showed a positive association with environmental sustainability. This finding is consistent with Hyun & Yu (2024) and Soussi et al. (2025), who identify governance and sustainability governance mechanisms as relevant to environmental performance. Within NRBV, governance functions as an enabling capability because it provides oversight, accountability, and coordination so that environmental resources are integrated into strategic and operating decisions. The positive path therefore suggests that environmental resource commitments are more meaningful when accompanied by organizational arrangements that formalize responsibility, monitoring, and accountability.

The small f^2 value for environmental governance (0.136) indicates that governance is an enabling rather than dominant explanation of environmental sustainability. Its contribution is likely to depend on whether governance mechanisms operate substantively instead of merely satisfying formal reporting requirements. This boundary condition is consistent with Handoyo & Anas (2024) and Vitale et al. (2025), who emphasize the role of institutional and reporting contexts in shaping governance outcomes. At the construct level, the model does not attribute the association to a single governance practice; it supports environmental governance as a composite organizational capability. Managerially, the result favors integrating environmental oversight, investment decisions, accountability, and performance monitoring.

Overall Contribution and Implications

Taken together, the two positive paths support the study's integrated NRBV positioning. Green technology investment ($\beta = 0.339$) and environmental governance ($\beta = 0.329$) have similar standardized coefficients, suggesting that neither capability clearly dominates the other within the specified model. The study contributes contextual evidence that resource commitment and governance can be analyzed jointly as complementary capabilities in sustainability accounting for IDX Basic Materials firms. The R^2 of 0.208 and small f^2 values are equally informative: investment and governance should be read as partial signals rather than comprehensive explanations of environmental sustainability. From an accounting perspective, sustainability report information about environmental resource commitments is more informative when interpreted together with governance quality and the magnitude of the underlying statistical relationships, rather than as stand alone evidence of physical environmental performance. For managers, investors, and report users, this distinction supports a more disciplined reading of sustainability disclosures and highlights the need to connect reported commitments with operational environmental metrics.

CONCLUSION

This study finds that green technology investment and environmental governance are positively associated with environmental sustainability among 20 IDX Basic Materials companies observed during 2020-2024. The PLS-SEM coefficients are 0.339 and 0.329, respectively, with $p < 0.001$ for both paths. However, both effect sizes are small ($f^2 = 0.145$ and 0.136), and the model explains 20.8% of environmental sustainability variance ($R^2 = 0.208$). Within the NRBV framework, the findings support an interpretation of investment and governance as complementary environmental capabilities rather than stand-alone determinants. For practice, firms should coordinate green technology investment with substantive environmental governance, monitoring, and accountability. Because the constructs are disclosure based and the design is observational, the evidence is best understood as sustainability alignment rather than direct causal proof of changes in emissions, energy efficiency, or regulatory compliance.

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