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GREEN INNOVATION AS A MEDIATOR BETWEEN ENVIRONMENTAL MANAGEMENT SYSTEM EFFECTIVENESS AND ENVIRONMENTAL PERFORMANCE: EVIDENCE FROM INDONESIAN MINING COMPANIES

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Abstract

The mining industry faces intense pressure to reduce its ecological footprint, and ISO 14001-based environmental management systems (EMS) are widely adopted in response. Yet certification alone may not translate into better environmental outcomes. Drawing on stakeholder and legitimacy theories, this study examines whether EMS effectiveness improves environmental performance and whether green innovation mediates this relationship. The sample comprises 20 mining companies listed on the Indonesia Stock Exchange that consistently published sustainability reports in 2022–2024 (60 firm-year observations). Because all sample firms were ISO 14001-certified, EMS effectiveness is measured inversely by emissions intensity, that is, greenhouse gas emissions (tCO_2e) per unit of output. Green innovation and environmental performance (GRI 302–306) are measured through content analysis of sustainability reports. Random-effects panel regressions with firm-clustered standard errors and cluster-bootstrapped indirect effects were estimated. Emissions intensity has no significant effect on either environmental performance or green innovation, whereas green innovation is positively associated with environmental performance. The indirect effect is not robustly different from zero; thus, the mediation hypothesis is not supported. The findings suggest that, once certification is universal, superior environmental performance stems from substantive green innovation rather than from the EMS itself.

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1. Introduction

The mining industry is a pillar of economic development in resource-rich emerging economies such as Indonesia, contributing substantially to export earnings, state revenue, and regional infrastructure. However, mining activities also generate some of the most severe and persistent environmental impacts of any industrial sector, including land degradation and deforestation, acid mine drainage, dust and greenhouse gas emissions, biodiversity loss, and disruption of local hydrological systems (Cheng et al., 2025). Unreclaimed mine pits also pose safety and health risks to surrounding communities. These conditions place mining companies under intense scrutiny from regulators, investors, local communities, and civil society, making environmental performance a central dimension of their legitimacy and licence to operate.

A common corporate response to such pressure is the adoption of an environmental management system (EMS), typically certified against the ISO 14001 standard. An EMS provides a structured plan–do–check–act framework for identifying environmental aspects, setting objectives, monitoring impacts, and ensuring regulatory compliance (Din et al., 2024; Melnyk et al., 2003). In Indonesia, the government complements voluntary standards with the Corporate Performance Rating Program in Environmental Management (PROPER), which rates firms from black to gold according to their compliance and beyond-compliance efforts (Digdowiseiso et al., 2022). As a result, ISO 14001 certification has become a near-standard feature of large listed mining companies.

Despite its popularity, the effectiveness of EMS in improving actual environmental outcomes remains contested. Several studies report that ISO 14001 adoption reduces emissions and improves environmental performance (Arimura et al., 2008; Melnyk et al., 2003; Testa et al., 2014), whereas others argue that certification may be adopted ceremonially to signal conformity, with weak links to operational change (Boiral, 2007; King et al., 2005). Valero-Gil et al. (2023) even find that EMS adoption can create organisational rigidities that weaken the contribution of eco-innovation to environmental performance. This debate suggests that what matters is not whether a firm holds a certificate but how effectively the system reduces the firm's environmental burden, such as its greenhouse gas emissions per unit of output, and whether the system is translated into substantive changes in technologies and processes.

Green innovation offers one plausible channel through which an EMS could affect environmental performance. Green innovation refers to new or modified products, processes, and technologies that reduce environmental harm while improving efficiency (Chen et al., 2006). An effective EMS generates information about environmental aspects, sets improvement targets, and allocates resources, all of which may stimulate environmental innovation (Inoue et al., 2013; Wagner, 2008). In turn, green innovation, such as cleaner extraction methods, renewable energy use, water recycling, and the productive reuse of mining waste, directly reduces resource consumption, emissions, and waste (Singh et al., 2020; Tian et al., 2023). Under this logic, green innovation should mediate the relationship between EMS effectiveness and environmental performance.

Empirical evidence on this mediating mechanism, however, is limited in three respects. First, most studies examine manufacturing firms in developed economies or China, while evidence

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from extractive industries in emerging markets is scarce. Second, prior studies largely operationalise EMS as a binary certification dummy. When nearly all firms in an industry are certified, as is the case for Indonesian listed mining companies, such a dummy has no explanatory power, and the relevant question shifts from adoption to effectiveness, which can be observed through outcome-based indicators such as emissions intensity (Testa et al., 2014). Third, studies in the Indonesian mining context have focused mainly on the financial consequences of green innovation or environmental performance (e.g., Yuniarti et al., 2022) rather than on the managerial antecedents of environmental performance itself.

Addressing these gaps, this study asks two questions: (1) Does EMS effectiveness, reflected in lower emissions intensity, improve the environmental performance of Indonesian mining companies? (2) Does green innovation mediate this relationship? Using panel data on 20 listed mining companies over 2022–2024, this study contributes to the literature in three ways. First, it moves beyond the adoption-based view of EMS by examining an outcome-based measure of EMS effectiveness in a setting where certification is universal. Second, it provides a rigorous test of the mediating role of green innovation using random-effects panel models and cluster-bootstrapped indirect effects, following current recommendations in mediation analysis (Preacher & Hayes, 2008; Zhao et al., 2010). Third, it offers evidence from an environmentally sensitive extractive industry in an emerging economy, informing regulators and managers about where environmental improvements actually originate.

The remainder of this paper is structured as follows. Section 2 reviews the theoretical background and develops the hypotheses. Section 3 describes the research method. Section 4 presents and discusses the results, and Section 5 concludes with implications, limitations, and suggestions for future research.

2. Literature Review

2.1 Stakeholder and Legitimacy Theory

This study draws on stakeholder theory as its main theoretical lens. A stakeholder is any individual or group that can affect or is affected by the achievement of an organisation's objectives (Freeman, 1984). Stakeholder theory posits that firms are accountable not only to shareholders but also to customers, employees, communities, governments, and the natural environment, and that long-term value creation depends on managing these relationships (Donaldson & Preston, 1995). In environmentally sensitive industries, stakeholders exert pressure through regulation, market demand, investor screening, and community activism, encouraging firms to adopt environmental management practices and to disclose their environmental performance.

Legitimacy theory complements this view by explaining how firms respond to such pressure. Organisations seek congruence between their activities and the norms and values of society (Suchman, 1995). Firms may pursue legitimacy substantively, by changing their operations, or symbolically, by adopting visible structures and disclosures that signal conformity without altering core activities (Meyer & Rowan, 1977). Applied to EMS, this distinction implies that certification can either reflect genuine environmental commitment or serve as a "rational myth" decoupled from practice (Boiral, 2007). Similarly, firms with poorer environmental

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records may disclose more environmental information to repair their legitimacy (Cho & Patten, 2007; Patten, 2002). The natural-resource-based view further suggests that environmental capabilities create value only when they are embedded in organisational routines and technologies, such as pollution prevention and product stewardship (Hart, 1995). Together, these perspectives imply that the environmental payoff of an EMS depends on whether it is translated into substantive changes, of which green innovation is a prime example.

2.2 EMS Effectiveness and Environmental Performance

ISO 14001 specifies the requirements for an EMS that enables organisations to identify environmental aspects, comply with legal obligations, set objectives, and continuously improve their environmental performance. Proponents argue that a well-functioning EMS institutionalises environmental responsibility within routines, improves monitoring and control, and reduces legal and financial risks (Melnyk et al., 2003). Empirical studies support this view: Arimura et al. (2008) find that ISO 14001 reduces natural resource use, solid waste, and wastewater in Japanese facilities; Testa et al. (2014) show that ISO 14001 is associated with lower CO_2 emissions; Abid et al. (2021) report that ISO 14001 contributes significantly to green growth; and L. Wang et al. (2023) find that EMS certification improves the environmental, rather than the financial, performance of Chinese enterprises.

Nevertheless, the benefits of EMS vary across firms. J. X. Wang and Zhao (2020) show that the economic effects of ISO 14001 depend on firm size and age, while Boiral (2007) and King et al. (2005) document that certification may be pursued for external signalling with limited operational change. These findings suggest that the effectiveness of implementation, rather than mere certification, determines environmental outcomes. Because the core purpose of an EMS is to reduce the environmental burden of operations, an effective EMS should manifest in lower emissions per unit of output (Testa et al., 2014). From a stakeholder perspective, firms whose EMS effectively lowers emissions intensity demonstrate stronger commitment and are expected to achieve better overall environmental performance. As emissions intensity is an inverse measure of EMS effectiveness, the following hypothesis is proposed:

H1: *Emissions intensity has a negative effect on environmental performance (EMS effectiveness has a positive effect on environmental performance).*

2.3 EMS Effectiveness and Green Innovation

An EMS may also stimulate green innovation. The systematic identification of environmental aspects reveals inefficiencies and pollution sources, while improvement targets create pressure to search for new solutions. Porter and van der Linde (1995) argue that well-designed environmental management triggers innovation that can offset compliance costs. Wagner (2008) finds that EMS implementation is associated with environmental process innovation among European firms, and Inoue et al. (2013) show that the maturity of ISO 14001 increases environmental R&D expenditure in Japanese facilities. In contrast, Valero-Gil et al. (2023) caution that standardised procedures may create rigidities that hinder exploratory innovation. On balance, firms with an effective EMS, reflected in low emissions

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intensity, possess the information, resources, and managerial attention that support green innovation. Accordingly, the following hypothesis is proposed:

H2: *Emissions intensity has a negative effect on green innovation (EMS effectiveness has a positive effect on green innovation).*

2.4 Green Innovation and Environmental Performance

Green innovation encompasses the development and implementation of environmentally friendly technologies, processes, and products, including energy efficiency, emission reduction, renewable materials, and waste recycling (Chen et al., 2006; Tian et al., 2023). Because green innovation changes the physical processes that generate environmental impacts, it is expected to improve environmental performance directly. Prior studies consistently support this relationship. Singh et al. (2020) find that green innovation improves environmental performance in manufacturing SMEs; Ahmed et al. (2023) report that green innovation significantly affects environmental and organisational performance; Cheng et al. (2025) show that innovation oriented towards pollution prevention improves environmental performance; and Din et al. (2024) find that green innovation is a significant driver of environmental performance in manufacturing. At the macro level, Nguyen et al. (2024) find that green innovation contributes positively to environmental performance in the long run. Accordingly:

H3: *Green innovation has a positive effect on environmental performance.*

2.5 The Mediating Role of Green Innovation

Combining the arguments above, green innovation may act as the mechanism that converts EMS effectiveness into environmental outcomes. Several studies show that green innovation transmits the effects of organisational practices on environmental performance: it mediates the relationship between corporate social responsibility and environmental performance (Bhat et al., 2024), between green human resource management and environmental performance (Ogiemwonyi et al., 2023), between fintech adoption, green transformational leadership, and environmental performance (Tian et al., 2023), and between environmental CSR and social performance (Fosu et al., 2024). Under stakeholder and legitimacy theories, an effective EMS should stimulate green innovation, which, in turn, delivers tangible improvements in environmental performance. Accordingly:

H4: *Green innovation mediates the relationship between EMS effectiveness (emissions intensity) and environmental performance.*

The research framework is presented in Figure 1.

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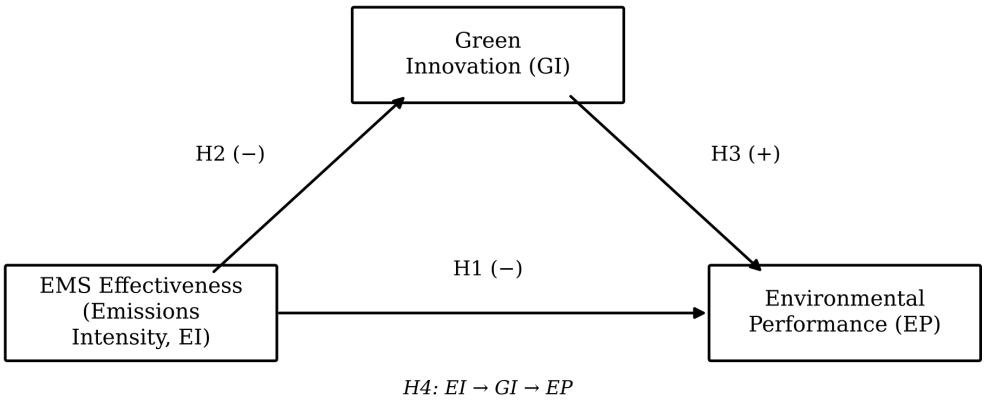


Figure 1. Research Framework
Source: Developed by the authors (2026).

3. Research Methods

3.1 Population, Sample, and Data

This study employs a quantitative approach using secondary panel data. The population comprises mining companies listed on the Indonesia Stock Exchange (IDX). The sample was selected by purposive sampling using the following criteria: (1) the company was listed on the IDX during 2022–2024; (2) the company published sustainability reports consistently over the period; and (3) the reports contained the information needed to measure all research variables. Twenty companies met these criteria, yielding a balanced panel of 60 firm-year observations. The observation period starts in 2022 because, by then, sustainability reporting under Financial Services Authority (OJK) Regulation No. 51/POJK.03/2017 was mandatory and comparable across listed firms. Data were hand-collected from sustainability reports and annual reports.

3.2 Variable Measurement

Environmental performance (EP) is measured using a disclosure index based on GRI 302 (Energy), GRI 303 (Water and Effluents), GRI 304 (Biodiversity), GRI 305 (Emissions), and GRI 306 (Waste). Each indicator is scored 1 if disclosed and 0 otherwise, and the index equals the number of disclosed items divided by the total number of applicable items, so that EP ranges from 0 to 1. Green innovation (GI) is measured using a content-analysis index of green product, process, and technology innovation items disclosed in the sustainability report, scored dichotomously and divided by the total number of items.

EMS effectiveness is measured inversely by emissions intensity (EI). Because every sample firm held ISO 14001 certification throughout 2022–2024 (an EMS adoption dummy equals 1 for all 60 observations), certification status has no variance and cannot be used as an explanatory variable. Following the argument that an effective EMS should reduce the environmental burden of operations (Testa et al., 2014), this study uses an outcome-based

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indicator, namely the firm's total greenhouse gas emissions divided by its unit of output, as reported in the sustainability report:

$$EI_{it} = \text{Total GHG emissions}_{it}\ (tCO_2e) \,/\, \text{Unit of output}_{it}$$

A lower EI indicates a more effective EMS, whereas a higher EI indicates a less effective EMS. Consequently, H1 and H2 predict negative coefficients for EI. The operationalisation of the variables is summarised in Table 1.

Table 1. Operational Definition of Variables

Variable	Definition	Measurement
Environmental performance (EP)	Extent of the firm's environmental performance reporting on energy, water, biodiversity, emissions, and waste	Number of GRI 302–306 items disclosed ÷ total applicable items
Green innovation (GI)	Development and implementation of environmentally friendly products, processes, and technologies	Number of green innovation items disclosed ÷ total items
Emissions intensity (EI), inverse proxy of EMS effectiveness	Greenhouse gas emissions generated per unit of output; lower values indicate a more effective EMS	Total GHG emissions (tCO_2e) ÷ unit of output

Note: All sample firms were ISO 14001-certified during 2022–2024.
Source: Compiled by the authors (2026).

3.3 Model Specification and Analysis Strategy

Mediation is tested using the causal-steps framework (Baron & Kenny, 1986) combined with a direct test of the indirect effect, as recommended by Zhao et al. (2010) and Preacher and Hayes (2008). Three panel equations are estimated:

$$EP_{it} = \alpha_0 + c \cdot EI_{it} + \varepsilon_{it} \quad (1)$$

$$GI_{it} = \beta_0 + a \cdot EI_{it} + u_{it} \quad (2)$$

$$EP_{it} = \gamma_0 + c' \cdot EI_{it} + b \cdot GI_{it} + e_{it} \quad (3)$$

where i denotes the firm and t the year. Equation (1) estimates the total effect (H1), Equation (2) estimates path a (H2), and Equation (3) estimates path b (H3) and the direct effect c'. The indirect effect equals $a \times b$ (H4). Under the hypotheses, a and c are expected to be negative and b positive, implying a negative indirect effect of EI (i.e., a positive indirect effect of EMS effectiveness). The significance of the indirect effect is evaluated using a firm-level cluster bootstrap with 2,000 resamples, which preserves the within-firm correlation structure of the panel (Cameron et al., 2008). Percentile confidence intervals are used as the primary criterion because bias-corrected intervals may have inflated Type I error rates (Fritz et al., 2012); bias-corrected intervals and the Sobel test are reported for completeness.

The appropriate panel estimator (common, fixed, or random effects) is selected for each equation using the Chow test, the Hausman (1978) test, and the Breusch–Pagan Lagrange multiplier (LM) test. Diagnostic tests include the variance inflation factor (VIF) for multicollinearity, the Breusch–Pagan test for heteroskedasticity, the Jarque–Bera test for

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residual normality, and the Wooldridge test for serial correlation in panel data (Wooldridge, 2010). Statistical significance is evaluated at the 1%, 5%, and 10% levels.

4. Results and Discussion

4.1 Descriptive Statistics

Table 2 presents the descriptive statistics. EP ranges from 0.120 to 1.000, with a mean of 0.813 and a median of 0.960, indicating that most firms report extensively on GRI 302–306; 43.3% of the observations attain the maximum score of 1.000. GI ranges from 0.133 to 0.733, with a mean of 0.427, implying that the average firm discloses fewer than half of the green innovation items. EI ranges from 0.003 to 0.090 tCO_2e per unit of output, with a mean of 0.027 and a relatively large standard deviation (0.021). The maximum is more than 30 times the minimum, indicating that EMS effectiveness differs substantially across firms even though all of them hold ISO 14001 certification. Over time, mean EP increased from 0.742 in 2022 to 0.826 in 2023 and 0.872 in 2024, and mean GI rose from 0.413 to 0.450, while mean EI remained stable at about 0.026–0.027.

Table 2. Descriptive Statistics

Variable	N	Min	Max	Mean	Median	Std. Dev.
EP	60	0.120	1.000	0.813	0.960	0.252
GI	60	0.133	0.733	0.427	0.400	0.175
EI	60	0.003	0.090	0.027	0.023	0.021

Source: Data processed (2026).

Table 3 presents the Pearson correlation matrix. GI is positively and significantly correlated with EP ($r = 0.476$, $p < 0.01$). Contrary to expectations, EI is positively correlated with GI ($r = 0.266$, $p < 0.05$) and with EP ($r = 0.220$, $p = 0.092$), suggesting that firms with higher emissions intensity tend to disclose more green innovation and environmental information. None of the correlations is high enough to indicate multicollinearity.

Table 3. Pearson Correlation Matrix

Variable	EP	EI	GI
EP	1.000		
EI	0.220*	1.000	
GI	0.476***	0.266**	1.000

*Note: ***, **, and * denote significance at 1%, 5%, and 10%, respectively.*
Source: Data processed (2026).

4.2 Panel Model Selection and Diagnostic Tests

Table 4 reports the model-selection tests. For all three equations, the Chow test rejects the common-effects model in favour of the fixed-effects model ($p < 0.01$), the Hausman test does not reject the random-effects model ($p > 0.28$), and the LM test rejects the common-effects

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model in favour of the random-effects model ($p < 0.01$). Therefore, the random-effects model (REM) is selected for all equations. This result is consistent with the panel structure: with only three years per firm, most of the variation in the variables is between rather than within firms, which the REM uses efficiently.

Table 4. Panel Model Selection Tests

Equation	Chow (F)	Hausman (χ^2)	LM (χ^2)	Selected
(1) EI → EP	7.535 (0.000)	0.853 (0.356)	26.972 (0.000)	REM
(2) EI → GI	15.240 (0.000)	0.048 (0.827)	40.504 (0.000)	REM
(3) EI, GI → EP	5.549 (0.000)	2.484 (0.289)	19.412 (0.000)	REM

Note: p-*values in parentheses.*
Source: Data processed (2026).

Table 5 reports the diagnostic tests. The VIF of 1.076 indicates no multicollinearity, and the Jarque–Bera test does not reject residual normality ($p = 0.139$). However, the Breusch–Pagan test indicates heteroskedasticity ($p < 0.001$), and the Wooldridge test indicates first-order serial correlation ($p < 0.001$). To obtain valid inference under these conditions, all models are estimated with standard errors clustered at the firm level, which are robust to both heteroskedasticity and within-firm serial correlation.

Table 5. Diagnostic Tests

Test	Statistic (*p*-value)	Conclusion
Multicollinearity (VIF)	1.076	No multicollinearity
Normality (Jarque–Bera)	3.948 (0.139)	Residuals normal
Heteroskedasticity (Breusch–Pagan)	21.018 (0.000)	Heteroskedastic
Serial correlation (Wooldridge)	109.151 (0.000)	Serially correlated

Note: Heteroskedasticity and serial correlation are addressed using firm-clustered robust standard errors.
Source: Data processed (2026).

4.3 Hypothesis Testing

Table 6 presents the random-effects estimates. In Equation (1), EI has a positive and insignificant effect on EP ($c = 1.764$, $t = 1.640$, $p = 0.106$). The coefficient is neither significant nor in the hypothesised negative direction; therefore, H1 is not supported. In Equation (2), EI also has a positive and insignificant effect on GI ($a = 2.037$, $t = 1.449$, $p = 0.153$); thus, H2 is not supported. In Equation (3), GI has a positive effect on EP that is significant at the 10% level ($b = 0.470$, $t = 1.857$, $p = 0.068$), whereas the direct effect of EI remains insignificant ($c' = 0.966$, $p = 0.485$). H3 is therefore supported. In the pooled estimates, a one-standard-deviation increase in GI is associated with an increase of about 0.45 standard deviations in EP, compared with only 0.10 for EI. Adding GI raises the overall R^2 from 0.043 in Equation (1) to 0.219 in Equation (3), indicating that green innovation explains a considerably larger share of the variation in environmental performance than emissions intensity does.

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Table 6. Random-Effects Regression Results

Variable	(1) EP	(2) GI	(3) EP
Constant	0.766*** (16.465)	0.372*** (8.870)	0.587*** (4.659)
EI	1.764 (1.640)	2.037 (1.449)	0.966 (0.703)
GI	–	–	0.470* (1.857)
Overall R^2	0.043	0.070	0.219
F-statistic (*p*)	0.626 (0.432)	1.960 (0.167)	2.918 (0.062)
Observations	60	60	60

Note: t-*statistics based on firm-clustered standard errors in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.*
Source: Data processed (2026).

Table 7 reports the test of the indirect effect. The point estimate of the indirect effect is 0.957 (bootstrap SE = 1.190), which is positive rather than negative as hypothesised. The 95% percentile bootstrap confidence interval [−0.108; 4.173] includes zero, and the Sobel test is not significant ($z = 0.973$, $p = 0.331$). The bias-corrected interval [0.005; 5.665] marginally excludes zero, but this method is known to be liberal (Fritz et al., 2012), and the corresponding bias-corrected interval based on pooled OLS estimates [−0.102; 9.756] includes zero. Because path *a* is also insignificant and has the opposite sign to that hypothesised, there is no evidence that green innovation transmits the effect of EMS effectiveness to environmental performance. Therefore, H4 is not supported. Figure 2 summarises the path estimates.

Table 7. Indirect Effect Test (EI → GI → EP)

Statistic	Value
Indirect effect ($a \times b$)	0.957
Bootstrap standard error	1.190
95% percentile bootstrap CI	[−0.108; 4.173]
95% bias-corrected bootstrap CI	[0.005; 5.665]
Sobel test *z* (*p*)	0.973 (0.331)
Conclusion	No robust mediation

Note: Firm-level cluster bootstrap with 2,000 resamples based on random-effects estimates.
Source: Data processed (2026).

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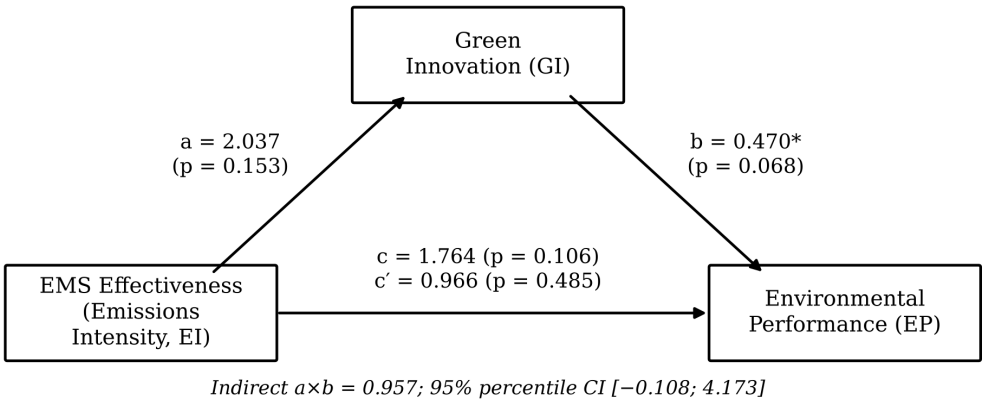


Figure 2. Path Estimates of the Mediation Model
*Note: * significant at 10%. Random-effects estimates with firm-clustered standard errors. Signs predicted by the hypotheses: a (−), b (+), c (−).*
Source: Data processed (2026).

4.4 Robustness Checks

Several robustness checks were conducted (Table 8). First, the models were re-estimated using pooled OLS with firm-clustered standard errors. Second, year dummies were added to control for common time trends, such as the general increase in reporting quality. Third, EI was log-transformed to reduce the influence of its skewed distribution. Fourth, EI was winsorised at the 5th and 95th percentiles. Fifth, because EP is bounded between 0 and 1 and many observations lie at the upper bound, Equation (3) was re-estimated using a fractional logit model (Papke & Wooldridge, 1996). Across all specifications, the effect of GI on EP remains positive and significant (p between 0.017 and 0.064), the direct effect of EI remains insignificant, no coefficient of EI is negative and significant, and every 95% confidence interval for the indirect effect includes zero. The only notable sensitivity concerns the total effect of EI on EP, which is positive and significant at 5% in the pooled OLS ($p = 0.048$) and at 10% with year dummies ($p = 0.057$) and winsorisation ($p = 0.099$), but not in the preferred REM or in the log specification. This pattern indicates that the weak positive association between EI and EP arises mainly from differences between firms and runs opposite to H1.

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Table 8. Robustness Checks

Specification	*a* (EI→GI)	*b* (GI→EP)	*c′* (EI→EP)	*c* (total)	95% CI indirect
Pooled OLS	2.259 (0.280)	0.648** (0.035)	1.227 (0.498)	2.691** (0.048)	[−0.408; 8.139]
Year dummies	2.238 (0.294)	0.631** (0.043)	1.206 (0.521)	2.617* (0.057)	[−0.468; 7.853]
ln(EI)	0.058 (0.138)	0.695** (0.035)	−0.005 (0.920)	0.035 (0.384)	[−0.014; 0.134]
Winsorised EI	3.952* (0.074)	0.656* (0.064)	0.855 (0.781)	3.447* (0.099)	[−0.355; 8.087]
Fractional logit (EP)	–	5.178** (0.017)	9.779 (0.462)	20.957 (0.172)	–

Note: p-*values based on firm-clustered standard errors in parentheses. ** and * denote significance at 5% and 10%, respectively.*
Source: Data processed (2026).

4.5 Discussion

4.5.1 EMS Effectiveness and Environmental Performance

Contrary to H1, emissions intensity, the inverse proxy of EMS effectiveness, does not have a significant negative effect on environmental performance. If anything, the association is positive, although insignificant in the preferred model. This finding differs from studies reporting that effective ISO 14001 implementation improves environmental outcomes (Abid et al., 2021; Arimura et al., 2008; Testa et al., 2014; L. Wang et al., 2023), but it is consistent with research questioning the substantive effect of EMS (Boiral, 2007; King et al., 2005; Valero-Gil et al., 2023).

The positive direction offers an important insight when interpreted through legitimacy theory. Because EP is measured as the extent of environmental reporting under GRI 302–306, firms with higher emissions intensity, which face greater exposure to stakeholder scrutiny, may disclose more environmental information to defend their legitimacy. This pattern mirrors the evidence of Patten (2002) and Cho and Patten (2007), who find that poorer environmental performers tend to provide more extensive environmental disclosures, and contrasts with the voluntary disclosure view that better performers disclose more (Clarkson et al., 2008). In the Indonesian mining context, where all firms are ISO 14001-certified and subject to PROPER assessment, certification no longer differentiates firms in the eyes of stakeholders; instead, high-emitting firms appear to use comprehensive reporting as a legitimation strategy (Meyer & Rowan, 1977; Suchman, 1995).

A further explanation relates to the nature of emissions in mining. Emissions intensity is determined largely by commodity type, geology, mining methods, and energy sources, which are difficult to change in the short term through management procedures alone. Moreover, the strong rise in EP across 2022–2024, combined with stable EI, suggests that improvements in environmental reporting were driven by other factors, such as tightening reporting requirements and PROPER assessment, rather than by changes in EMS effectiveness. Finally, the weak positive association in the pooled estimates disappears when unobserved firm characteristics are accounted for, indicating that larger and more emission-intensive operations both report more extensively and emit more per unit of output, rather than emissions intensity causing better reporting.

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4.5.2 EMS Effectiveness and Green Innovation

Contrary to H2, emissions intensity has no significant negative effect on green innovation; the coefficient is positive but insignificant. This finding is consistent with Valero-Gil et al. (2023), who argue that standardised EMS procedures may create routines and rigidities that discourage exploratory environmental innovation, and with Wagner (2008), who finds that EMS is associated mainly with incremental process improvements rather than broad environmental innovation. The positive direction is also consistent with a pressure-driven view of innovation: firms with higher emissions intensity face stronger regulatory and stakeholder pressure, which may push them to undertake and disclose more green innovation initiatives (Porter & van der Linde, 1995). In the Indonesian mining context, EMS implementation tends to emphasise compliance with environmental permits, monitoring, and reporting obligations. These activities are necessary but are oriented towards controlling existing impacts rather than developing new technologies. The finding therefore supports the view that an EMS does not automatically become a platform for innovation unless firms deliberately link environmental management with innovation management (Inoue et al., 2013).

4.5.3 Green Innovation and Environmental Performance

Consistent with H3, green innovation is positively associated with environmental performance, and this result is robust across all specifications. The finding supports the natural-resource-based view, which emphasises that environmental advantages derive from capabilities embedded in technologies and processes, such as pollution prevention (Hart, 1995). It is also consistent with Singh et al. (2020), Ahmed et al. (2023), Din et al. (2024), and Cheng et al. (2025), all of whom find that green innovation improves environmental performance. In mining, green innovation includes energy-efficient equipment, renewable energy use, water treatment and recycling, progressive reclamation, and the reuse of overburden and tailings. Such innovations directly reduce energy and water consumption, emissions, and waste, which are precisely the dimensions captured by GRI 302–306. From a stakeholder perspective, green innovation constitutes a substantive response to stakeholder pressure that produces visible and verifiable environmental results.

4.5.4 The Mediating Role of Green Innovation

Contrary to H4, green innovation does not mediate the relationship between EMS effectiveness and environmental performance. Although path *b* is significant, path *a* is not, and the 95% percentile confidence interval for the indirect effect includes zero. Following the typology of Zhao et al. (2010), the pattern corresponds to “no-effect non-mediation”: neither the indirect nor the direct effect of EI is significant. This result differs from studies in which green innovation mediates the effects of CSR, green HRM, or leadership on environmental performance (Bhat et al., 2024; Ogiemwonyi et al., 2023; Tian et al., 2023). The difference suggests that the outcome of a formal management standard is a weaker trigger of innovation than strategic orientations such as CSR or green leadership. In other words, green innovation appears to be an independent driver of environmental performance rather than a channel through which the EMS operates. The finding sheds light on the debate on symbolic versus substantive environmental management: among certified mining firms,

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what distinguishes high environmental performers is not their EMS but whether they innovate.

5. Conclusion and Suggestion

This study examined whether EMS effectiveness, measured inversely by emissions intensity, improves the environmental performance of Indonesian mining companies and whether green innovation mediates this relationship. Using random-effects panel regressions and cluster-bootstrapped indirect effects for 20 listed mining companies over 2022–2024, the study finds that emissions intensity has no significant negative effect on either environmental performance or green innovation, whereas green innovation is positively associated with environmental performance. The mediating role of green innovation is not supported. These findings indicate that, in an industry where ISO 14001 certification is universal, environmental performance is driven by substantive green innovation rather than by the EMS itself.

Theoretically, the study extends stakeholder and legitimacy theories by showing that once a legitimising practice such as ISO 14001 becomes an industry norm, its contribution to environmental outcomes is limited, and substantive actions such as green innovation become the main source of differentiation. The positive, albeit insignificant, association between emissions intensity and environmental reporting also suggests that high-emitting firms may use disclosure as a legitimation tool. Methodologically, the study refines the EMS literature by shifting the focus from certification to an outcome-based measure of EMS effectiveness.

Practically, mining company managers should not treat ISO 14001 certification as an end in itself but should explicitly link their EMS to emission-reduction targets and innovation programmes, such as investments in clean technology, energy efficiency, and waste valorisation. For regulators, including the Ministry of Environment and the OJK, the findings suggest that PROPER assessments and sustainability reporting guidelines could place greater weight on verifiable outcomes, such as emissions intensity and green innovation, than on the existence of management systems or the extent of disclosure. For investors, green innovation disclosures appear to be a more informative signal of environmental performance than EMS-related information.

This study has several limitations. First, the sample is small (20 firms, 60 observations) and covers only three years, which limits statistical power and within-firm variation; non-significant results should therefore be interpreted as an absence of evidence rather than as evidence of absence. Future studies could extend the period and include other environmentally sensitive sectors, such as energy, chemicals, and pulp and paper, to improve generalisability. Second, EP and GI are measured using disclosure indices, which capture reporting quality and may not fully reflect actual environmental outcomes; moreover, 43.3% of the EP observations are at the maximum score, indicating a ceiling effect. Third, emissions intensity is an indirect, outcome-based proxy of EMS effectiveness that is also influenced by commodity type and production technology, and the unit of output used as the denominator follows each company's own reporting, which may limit comparability across firms. Future research could use standardised denominators (e.g., revenue or tonnes produced), direct

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measures of EMS implementation, or PROPER ratings. Fourth, because all firms are ISO 14001-certified, the effect of EMS adoption itself cannot be tested; comparing certified and non-certified firms would provide complementary evidence. Fifth, owing to data constraints, the models do not include control variables such as firm size, profitability, leverage, and ownership, and endogeneity cannot be fully ruled out. Future research could incorporate these controls and apply instrumental variable or dynamic panel approaches.

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