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Does Green Innovation Matter? The Role of Green Product and Process Technology Innovation in the CSR–Financial Performance Relationship

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ABSTRACT

This study examines the mediating role of green product and process technology innovation in the relationship between corporate social responsibility (CSR) disclosure and financial performance among mining companies listed on the Indonesia Stock Exchange (IDX) during the 2019–2023 period. Using purposive sampling, 25 companies were selected, yielding 125 firm-year observations analyzed through panel data mediated regression and the Sobel test. The results indicate that CSR disclosure has a positive and significant effect on both green product ($b = 0.726$, $p < 0.001$) and green process innovation ($b = 0.782$, $p < 0.001$), as well as on financial performance measured by Return on Equity ($b = 1.296$, $p = 0.003$). However, neither green product nor green process innovation significantly mediates the CSR–financial performance relationship. Furthermore, green product innovation has a significant negative effect on financial performance ($b = -0.972$, $p = 0.021$), while green process innovation shows no significant effect. These findings suggest that although CSR disclosure encourages green technological innovation, its financial benefits may only be realized in the long term due to substantial upfront investment costs. This study contributes to the discourse on green innovation as a mediating mechanism between CSR and financial performance in resource-intensive industries.

Keywords: Corporate Social Responsibility; Financial Performance; Green Process Innovation; Green Product Innovation; Green Technology Innovation; Mining Industry

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INTRODUCTION

Corporate Social Responsibility (CSR) has become a central element of modern corporate management, offering companies a structured means of contributing to their social and environmental surroundings while enhancing organizational transparency and reputation. Although the relationship between CSR disclosure and financial performance is well documented, the mechanism connecting the two remains contested, with green technology innovation frequently proposed as a mediating channel through which CSR translates into financial value (Li et al., 2023).

Several theoretical perspectives help explain how green technology innovation may connect CSR disclosure with financial outcomes. Agency theory suggests that transparent CSR disclosure reduces information asymmetry between management and shareholders, encouraging investment in sustainability-oriented innovation that aligns managerial and shareholder interests (Jensen & Meckling, 1976). Stakeholder theory holds that firms are morally obligated to satisfy the expectations of a broad range of stakeholders (customers, regulators, and local communities) and that developing environmentally responsible products and processes is one avenue through which this obligation is fulfilled (Freeman & Reed, 1983). The resource-based view (RBV) frames green product and process innovation as internal, difficult-to-imitate resources capable of generating sustained competitive advantage once effectively deployed (Barney, 1991). Signaling theory further proposes that CSR disclosure and green innovation function as positive signals to capital markets regarding a firm's sustainability commitment and long-term value-creation capacity (Spence, 1973).

Despite this theoretical grounding, empirical evidence on the CSR–innovation–performance nexus remains mixed. Li et al. (2023) found that green technology innovation positively mediates the relationship between CSR disclosure and financial performance among firms listed on the Shanghai and Shenzhen stock exchanges, a pattern echoed in studies by Chen and Jin (2023), Duque-Grisales et al. (2020), and Wang et al. (2020). In contrast, López et al. (2007) and Michelon & Parbonetti (2012) reported that CSR disclosure enhances financial performance through channels other than technological innovation, such as market perception and stakeholder relationships. Meanwhile, Brammer and Millington (2008) documented cases in which CSR disclosure was negatively associated with financial performance, attributing this to the high implementation costs of CSR and sustainability initiatives, which can outweigh short-term financial benefits.

These divergent findings are especially salient for the mining industry, a sector characterized by substantial environmental impact, including land degradation, water pollution, and high emissions, alongside considerable potential to develop green technologies such as cleaner extraction methods, waste-processing systems, and land-reclamation techniques. Mining firms therefore face dual pressure: to disclose meaningful CSR activity that satisfies stakeholder and regulatory expectations, and to invest in environmentally oriented innovation that supports long-term operational sustainability. However, empirical evidence on whether green product and process technology innovation genuinely mediate the CSR–financial performance relationship within mining firms in emerging markets, such as Indonesia, remains limited.

This study addresses this gap by examining the role of green product and process technology innovation in mediating the effect of CSR disclosure on the financial performance of mining companies listed on the Indonesia Stock Exchange (IDX) during the 2019–2023 period. Specifically, this study investigates: (1) the effect of CSR disclosure on green product technology innovation; (2) the effect of CSR disclosure on

financial performance; (3) the mediating role of green product technology innovation in the CSR–financial performance relationship; (4) the effect of CSR disclosure on green process innovation; (5) the mediating role of green process innovation in the CSR–financial performance relationship; (6) the effect of green product technology innovation on financial performance; and (7) the effect of green process innovation on financial performance. By focusing on an environmentally intensive, financially material sector in an emerging-market context, this study contributes new empirical evidence on whether green technology innovation genuinely bridges CSR commitment and financial value creation.

LITERATURE REVIEW

Corporate Social Responsibility

CSR refers to a firm's sustained commitment to act ethically and contribute to economic development while improving the quality of life of its workforce, local communities, and society at large (Carroll, as cited in Li et al., 2023). Carroll's classic framework categorizes CSR into four types of responsibility (economic, legal, ethical, and philanthropic), implying that CSR extends well beyond mere legal compliance. Stakeholder theory (Freeman, 1994) posits that firms hold a moral responsibility toward all parties affected by their operations, rather than shareholders alone, and that meeting these expectations through CSR strengthens long-term firm value.

Legitimacy theory (Deegan, 2002) offers a complementary explanation, arguing that organizations must continuously demonstrate that they operate within the norms and expectations of society to sustain their societal license to operate; CSR disclosure functions as one of the primary tools through which firms manage this legitimacy. Agency theory (Jensen & Meckling, 1976) adds a governance-oriented perspective, explaining that transparent CSR disclosure can mitigate conflicts of interest between managers and shareholders by increasing accountability and reducing information asymmetry. In this study, CSR is measured through a content-analysis index based on the Global Reporting Initiative (GRI) standard, encompassing six dimensions: economic, environmental, labor practices, human rights, society, and product responsibility (Li et al., 2023; Michelon & Parbonetti, 2012).

Green Technology Innovation

Green technology innovation refers to the development of new methods and technologies, whether embedded in products or production processes, that reduce negative environmental impact while improving resource efficiency (Duque-Grisales et al., 2020). Duque-Grisales et al. (2020) distinguish between two dimensions of green technology innovation: green product innovation, which concerns the development of environmentally friendly products, and green process innovation, which concerns the adoption of environmentally efficient production processes. The resource-based view (Barney, 1991; Wernerfelt, 1984) frames both dimensions as internal, valuable, and difficult-to-imitate resources capable of generating sustained competitive advantage. The natural resource-based view extends this logic specifically to environmental strategy, proposing that firms pursuing pollution prevention, product stewardship, and sustainable development can achieve superior long-term performance (Hart & Dowell, 2011).

In this study, green product innovation is measured using a seven-item index covering eco-design, environmentally friendly product features, use of recyclable raw materials, minimization of product impact, product life-cycle considerations, and development of renewable-energy products, while green process innovation is measured using a five-item index covering the adoption of environmentally friendly production technology,

reduction of hazardous materials, energy-efficiency improvement, emission and waste reduction, and adoption of standardized environmental management systems such as ISO 14001.

Financial Performance

Financial performance reflects a firm's ability to generate profit and create value for shareholders through the effective management of financial resources (Richard et al., 2009). This study measures financial performance using Return on Equity (ROE), calculated as net profit divided by total equity (Brigham & Houston, 2018; Li et al., 2023). Shareholder value theory maintains that the primary objective of corporate management is to maximize shareholder value through investment, financing, and dividend decisions that generate returns exceeding the cost of capital. Signaling theory (Spence, 1973) complements this view by suggesting that firms' disclosure of CSR activities and green technology innovation functions as a positive market signal, reducing perceived risk and enhancing investor confidence, which in turn can translate into more favorable financial outcomes.

Hypotheses Development

Building on stakeholder theory and the resource-based view, firms with more extensive CSR disclosure are expected to be more likely to develop environmentally oriented products, since meeting stakeholder expectations for sustainability often requires innovation in product design and features (H1). Guided by agency theory and signaling theory, effective CSR implementation is also theorized to enhance financial performance by strengthening firm reputation, stakeholder trust, and investor confidence (H2). Because green product innovation has been proposed in prior studies as a channel through which CSR translates into improved financial outcomes (e.g., Duque-Grisales et al., 2020; Li et al., 2023), this study further tests whether green product innovation mediates the relationship between CSR disclosure and financial performance (H3).

Parallel reasoning applies to the process dimension of green technology: CSR disclosure is expected to encourage firms to adopt more environmentally efficient production processes (H4), drawing on evidence that green core competencies foster green process innovation and improve firm performance (Ozbey et al., 2024); the mediating role of green process innovation in the CSR–financial performance relationship is therefore also tested (H5). Finally, because both green product and process innovation constitute strategic resources under the RBV, each is hypothesized to directly affect financial performance (H6 and H7). Accordingly, the following seven hypotheses are proposed.

H1: CSR disclosure has a positive effect on green product technology innovation.
H2: CSR disclosure has a positive effect on financial performance.
H3: Green product technology innovation mediates the effect of CSR disclosure on financial performance.
H4: CSR disclosure has a positive effect on green process innovation.
H5: Green process innovation mediates the effect of CSR disclosure on financial performance.
H6: Green product technology innovation affects financial performance.
H7: Green process innovation affects financial performance.

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RESEARCH METHOD

This study employs a quantitative approach using secondary panel data obtained from the annual reports of mining companies listed on the IDX during the 2019–2023 period, accessed through the official IDX website (https://www.idx.co.id) and each sample company's official website.

The population comprises all mining companies listed on the IDX between 2019 and 2023, totaling 329 firm-year observations. Using purposive sampling, the sample was selected based on three criteria: (1) continuous listing on the IDX throughout 2019–2023; (2) continuous publication of annual reports during the period; and (3) continuously positive net profit throughout the period. These criteria yielded 25 companies and 125 firm-year observations.

CSR disclosure is measured through a content-analysis index based on the GRI standard, covering 91 items across six dimensions (economic, environmental, labor, human rights, society, and product responsibility). Green product innovation is measured using a seven-item index covering eco-design, environmentally friendly product features, use of recyclable materials, and renewable-energy product development. Green process innovation is measured using a five-item index covering adoption of environmentally friendly production technology, reduction of hazardous materials, energy efficiency, emission and waste reduction, and ISO 14001 certification. Financial performance is measured using ROE, calculated as net profit divided by total equity.

Data were analyzed using panel data path analysis, decomposed into three regression sub-structures: (1) CSR on green product innovation, (2) CSR on green process innovation, and (3) CSR, green product innovation, and green process innovation on ROE. Each sub-structure was estimated using both the Fixed Effect Model (FEM) and Random Effect Model (REM) in EViews 12, with the Hausman test used to select the appropriate model. Classical assumption tests—normality (Jarque–Bera), multicollinearity (correlation matrix), heteroskedasticity, and autocorrelation (Durbin–Watson)—were conducted to ensure the validity of the regression estimates. The significance of direct effects was assessed using t-tests and F-tests, while the mediating roles of green product and process innovation were tested using the Sobel test, comparing the calculated t-statistic against the critical value of 1.98 at the 5% significance level.

RESULTS

Table 1. Descriptive Statistics of the Study Variables for 25 Sampled Mining Companies (2019–2023)

Variable	Min.	Max.	Mean
CSR Disclosure Index	0.119	0.657	0.375
Green Product Innovation Index	0.229	1.000	0.747
Green Process Innovation Index	0.200	0.800	0.454
Return on Equity (ROE, %)	-84.01	83.63	13.22

Note. M = mean based on five-year company averages (N = 25 companies; 125 firm-year observations).

Table 1 presents the descriptive statistics of the research variables across the 25 sampled mining companies during 2019–2023. On average, the sampled firms disclosed approximately 37.5% of the 91 GRI-based CSR items, with more extensive reporting on economic aspects (e.g., economic value generated and distributed, infrastructure investment) and environmental aspects (energy, water, waste, and emissions), while

items such as human-rights risk assessments, indigenous community protection, and consumer data protection were rarely disclosed. Green product innovation was more widely adopted (mean index of 0.747) than green process innovation (mean index of 0.454), suggesting that sample firms have progressed further in developing environmentally friendly product features than in transforming their internal production processes. ROE varied considerably across firms and years, ranging from an average of −84.01% (PT Ancora Indonesia Resources Tbk.) to 83.63% (PT Baramulti Suksessarana Tbk.), reflecting substantial heterogeneity in profitability within the mining sector during the observation period.

The Hausman test indicated that the Random Effect Model (REM) was the appropriate estimator for all three regression sub-structures (Prob. = 0.629, 0.985, and 0.804, respectively; all > 0.05). The models satisfied the classical assumption tests: residuals were normally distributed (Jarque–Bera probabilities of 0.860, 0.268, and 0.065, all > 0.05); no multicollinearity was detected (correlation coefficients below 1.00); no heteroskedasticity was found (probability values above 0.05 for all independent variables); and no autocorrelation was present (Durbin–Watson statistics of 1.481, 1.227, and 1.662, all within the acceptable range).

Based on the selected REM estimates, the three regression sub-structures were formulated as follows:

$$GPI = 0.455 + 0.726\ CSR + \varepsilon \quad (\text{Adjusted } R^2 = 0.522;\ F = 109.05,\ p = 0.000)$$
$$GPrI = -0.051 + 0.782\ CSR + \varepsilon \quad (\text{Adjusted } R^2 = 0.422;\ F = 73.35,\ p = 0.000)$$
$$ROE = -1.460 + 1.296\ CSR - 0.972\ GPI - 0.102\ GPrI + \varepsilon \quad (\text{Adjusted } R^2 = 0.067;\ F = 3.34,\ p = 0.023)$$

The low adjusted R^2 of the third sub-structure (6.7%) indicates that CSR, green product innovation, and green process innovation jointly explain only a small proportion of the variance in ROE, implying that most of the variation in financial performance among sample firms is driven by factors outside this model, such as commodity prices, firm size, and capital structure. Table 2 summarizes the results of the hypothesis testing, including the t-test results for direct effects and the Sobel test results for the two mediation hypotheses.

Table 2. Hypothesis Testing Results

Hypothesis & Path		Coefficient	Prob. / t (Sobel)	Decision
H1	CSR → GPI	0.726	0.000	Supported
H2	CSR → ROE	1.296	0.003	Supported
H3	CSR → GPI → ROE	—	t = −0.391	Not supported
H4	CSR → GPrI	0.782	0.000	Supported
H5	CSR → GPrI → ROE	—	t = −0.345	Not supported
H6	GPI → ROE	−0.972	0.021	Supported (negative)
H7	GPrI → ROE	−0.102	0.722	Not supported

Note. Sobel test critical value at α = 0.05 is 1.98. GPI = green product innovation; GPrI = green process innovation.

As shown in Table 2, CSR disclosure significantly and positively affects both green product innovation (H1) and green process innovation (H4), as well as financial performance (H2). However, the Sobel test statistics for both green product innovation (t = −0.391) and green process innovation (t = −0.345) fall below the critical value of 1.98, indicating that neither variable significantly mediates the CSR–financial performance relationship (H3 and H5 rejected). Green product innovation is found to have a significant negative effect on financial performance (H6 supported, though in the opposite direction

to the hypothesized sign), while green process innovation shows no significant effect on financial performance (H7 rejected).

DISCUSSION

CSR Disclosure and Green Product/Process Innovation

Consistent with stakeholder theory (Freeman & Reed, 1983) and the resource-based view (Barney, 1991), CSR disclosure positively drives both green product and green process innovation among sampled mining firms. Firms that disclose CSR activities more extensively appear more likely to develop environmentally friendly products and adopt cleaner production processes, likely because CSR practices build stakeholder trust and reputational capital that firms subsequently leverage into environmentally oriented innovation. This finding aligns with Chen & Jin (2023), Li et al. (2023), and Ozbey et al. (2024), who similarly found that green competencies and CSR-related disclosure foster green innovation.

CSR Disclosure and Financial Performance

CSR disclosure is also found to positively and significantly influence ROE, consistent with agency theory (Jensen & Meckling, 1976) and signaling theory (Spence, 1973): transparent CSR disclosure reduces information asymmetry, enhances investor confidence, and signals long-term sustainability commitment, translating into improved profitability. This result corroborates Li et al. (2023) and is broadly consistent with Avinda et al. (2025), who found that ESG disclosure significantly influences firm value among Indonesian coal-sector companies, underscoring the financial relevance of sustainability disclosure in the mining and energy sectors.

Non-Significant Mediation of Green Innovation

Despite CSR's positive influence on both green product and process innovation, neither dimension significantly mediates the CSR–financial performance relationship. This result diverges from Duque-Grisales et al. (2020) and Li et al. (2023), who identified green innovation as a significant mediating mechanism, but is consistent with López et al. (2007) and Michelon & Parbonetti (2012), who argue that CSR's financial benefits may flow through channels other than technological innovation. In the mining context, this may reflect the high upfront capital requirements and long payback periods typical of green technology investment, meaning that any financial benefit from innovation may only materialize beyond the study's five-year observation window.

Effect of Green Product and Process Innovation on Financial Performance

The significant negative relationship between green product innovation and ROE suggests that, in the short run, the costs associated with developing environmentally friendly products, research and development, technology acquisition, and production adjustment may outweigh immediate financial returns. This finding is consistent with Brammer and Millington's (2008) observation that environmentally driven cost structures can compress profitability in the short term, and supports Barney's (1991) contention that resources become genuine competitive advantages only once they are efficiently managed and monetized. Green process innovation, while positively driven by CSR, does not significantly affect ROE, suggesting that investments in cleaner production processes, such as adopting environmentally friendly technology or pursuing ISO 14001 certification, have yet to translate into measurable short-term profitability gains in the mining sector, a pattern also noted by Apriono et al. (2023) in their study of environmental sensitivity and financial performance among Indonesian agroindustrial firms.

Broader Implications for Stakeholders

These results carry practical implications beyond the mining firms themselves. For investors, the findings suggest that CSR disclosure remains a financially meaningful signal even when the underlying green innovation has not yet produced measurable profitability gains, implying that CSR-related information can usefully complement traditional financial indicators in investment analysis. For regulators and policymakers, the evidence that green product and process innovation currently impose short-term financial costs points to a possible role for transitional incentives, such as tax relief, green financing schemes, or accelerated depreciation on environmental technology, to help mining firms bridge the gap between environmental investment and financial payoff. For corporate managers, the results caution against expecting immediate financial returns from green innovation and instead call for embedding such investments within a longer-term strategic and financial planning horizon.

CONCLUSION

This study examined the mediating role of green product and process technology innovation in the relationship between CSR disclosure and financial performance among Indonesian mining companies listed on the IDX during 2019–2023. The findings show that CSR disclosure significantly and positively influences both green product innovation and green process innovation, as well as financial performance measured by ROE. However, neither green product innovation nor green process innovation significantly mediates the CSR–financial performance relationship. Furthermore, green product innovation exerts a significant negative effect on financial performance, while green process innovation shows no significant effect.

These findings suggest that, within the mining sector, CSR functions as a driver of green technological innovation, but the financial payoff of that innovation is not yet realized in the short term, most likely due to the substantial upfront investment required and the longer time horizon needed for green technologies to generate measurable financial returns. Practically, mining companies are encouraged to treat CSR disclosure not merely as a compliance obligation but as a long-term strategic investment, while pursuing green innovation initiatives supported by realistic cost-efficiency planning to ensure that environmental commitments eventually translate into financial value. Theoretically, this study reinforces the relevance of stakeholder, resource-based, and signaling perspectives in explaining the CSR–financial performance relationship, while highlighting that green technology innovation's mediating role may depend on contextual factors such as industry cost structure, investment maturity, and observation period length. Future research is encouraged to extend the observation period, incorporate additional financial performance indicators such as Return on Assets, and consider combining green product and process innovation into a single construct to better capture their joint mediating effect.

LIMITATION

This study is subject to several limitations. First, financial performance is measured using a single indicator, ROE, which does not capture other dimensions such as liquidity, solvency, or operational efficiency. Second, CSR and green innovation variables are measured through content analysis of annual reports, which reflects disclosed information rather than the actual extent of implementation. Third, the panel regression approach applied here assumes linear relationships and may not fully capture the long-term or non-linear dynamics between CSR, green innovation, and financial performance. Finally, the five-year observation period may be too short to detect the financial returns of green technology investments, which typically materialize over a longer time horizon.

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DECLARATION OF CONFLICTING INTERESTS
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