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The Mediating Role of Environmental Sustainable Development Between Corporate Social Responsibility and Green Innovation

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ABSTRACT

Amid the escalating global climate crisis, recycling firms are increasingly expected to integrate social responsibility with environmentally sustainable practices and green innovation. This study examines the mediating role of environmental sustainable development (ESD) in the relationship between corporate social responsibility (CSR) and green innovation (GI) in Indonesia's recycling industry. Using a quantitative survey, data were collected from 129 recycling companies and analyzed through SEM-PLS. The results show that CSR positively affects ESD ($\beta = 0.684$; $p < 0.001$) and GI ($\beta = 0.343$; $p < 0.001$), while ESD also positively affects GI ($\beta = 0.401$; $p < 0.001$). The indirect effect of CSR on GI through ESD is significant ($\beta = 0.271$; $p < 0.001$), indicating partial mediation because the direct CSR–GI path remains significant. These findings suggest that CSR contributes to green innovation more effectively when translated into resource-saving, waste-reducing, and environmentally sustainable development practices. The study extends CSR and green innovation literature and offers practical guidance for recycling firms seeking to align sustainability commitments with competitive, low-carbon innovation strategies.

Keywords: Corporate Social Responsibility; Environmental Sustainable Development; Green Innovation; Sustainable Development; Indonesia

JEL Classification: M14; Q01; Q56; Q58

INTRODUCTION

Firms should innovate in management, finance, competitiveness, or product development, but these should go hand in hand with Environmentally Sustainable Development, or at least, this is increasingly expected (Ali, 2026). Environmental stewardship is now central to debates on business sustainability, resource efficiency, and long-term environmental responsibility (Nogueira et al., 2025; Sarfraz et al., 2023). The Triple Bottom Line model is a framework for sustainable development that considers social, environmental, and financial performance, often referred to as people, planet, and profit. According to this perspective, many manufacturing firms, therefore, have started to meet such demands by acting in a less detrimental manner toward the environment. Moreover, public perceptions and understanding regarding environmental sustainable development (ESD) also play a role in supporting sustainability initiatives (Bekele et al., 2026). Innovation is regarded as a strategic instrument for achieving long-term sustainability via advancements in goods, processes, and management. Furthermore, recycling is a primary strategy for resource conservation and enhancing ESD.

Stakeholder theory sees firms as social institutions with obligations to consumers, employees, communities, and the natural environment (Haldorai, 2025). Corporate social responsibility (CSR) in the recycling industry in Indonesia is an application of a corporate commitment to ESD Sustainability practices, and green innovation (GI) will ultimately improve firm performance (Abdurrohman et al., 2026). However, data from the National Waste Management Information System show that Indonesia is still generating nearly 33 million tons of waste every year, 40.06 percent of which is not managed. This issue is also consistent with recent evidence showing that CSR and green accounting can support sustainable waste management in Indonesia, particularly when organizational awareness and environmental responsibility are strengthened (Moroki & Pesak, 2026).

This study seeks to investigate the impact of CSR on GI and the mediating role of ESD in CSR's impact on GI in Indonesia's recycling industry. Previous research about eco-friendly performance across different industries has been conducted, such as by firms listed in Indonesia, as well as with global competitive firms listed on the Pakistan Stock Exchange. With Indonesian SMEs, many of these studies focused mainly on either economic or environmental aspects (Abdurrohman et al., 2026). Thus, the social dimension was much less observed. This study fills this gap and offers a broader view of sustainability in the recycling industry. Furthermore, as control variables, the Company's Ability and Sustainable Performance are included in the model to eliminate the effects of internal and external factors on the CSR–GI relationship, thereby enabling optimal results and minimizing research bias (Wahyuningrum et al., 2026).

The significance of this study lies in the fact that the global recycling industry is a strategic sector in addressing the global climate crisis. However, the data reveal that the economic viability of businesses cannot be viewed in isolation from their environmental responsibility. The study is novel for testing a partial mediation model in which ESD serves as a strategic pathway from CSR to GI in the Indonesian recycling industry, integrating Natural Resource-Based View (NRBV) and TEM theories. It contributes theoretically to the literature on strategic management, and in practice, it assists managers in designing CSR strategies to enhance green, competitive innovation in a cost-effective manner. Policy-wise, it complements Indonesia's agenda for a circular economy and sustainable development by aligning with the country's and industry codes of compliance and by advancing recycling technology.

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LITERATURE REVIEW

Corporate Social Responsibility (CSR)

CSR is a strategic effort in which a corporation incorporates social and environmental responsibilities into its core business practices. The practice involves maximizing stakeholder value through nine measures of governance, including ethical governance, effective performance of social duties, a safe working environment, governance through legal compliance, employee engagement, adherence to human resource development, non-financial reporting, energy management, and environmental protection (Sidharta et al., 2026).

Green Innovation (GI)

GI is the adoption of new technologies, products, or processes to reduce negative environmental impacts and improve resource efficiency. This concept includes four indicators: sustainable product design, clean production technology, eco-friendly materials, and waste management systems. These indicators help minimize ecological risks while strengthening corporate competitiveness (Sidharta et al., 2026).

Environmental Sustainable Development (ESD)

ESD offers a high-level framework that guides firms to maximize the use of natural resources while ensuring ecological systems remain sustainable and do not collapse under economic activity. Operationally, ESD is quantified by three indicators: (1) pressure, (2) state, and (3) response. They assist organizations in evaluating the success of sustainability strategies, delivering on ecological commitments, and enhancing long-term social accountability (Sidharta et al., 2026).

Sustainable Performance (SP)

SP is the extent of organizational success that is a multi-dimensional construct composed of the interrelation of economic, social, and environmental dimensions. This idea proposes that performance is measured not only by profit but also by the organization's ability to create sustainable value for its stakeholders. SP is conceptualized in this study using 10 indicators to gain deep insights into sustainability performance (Sidharta et al., 2026).

Company Ability (CA)

CA is a firm's strategic capability that provides a competitive advantage through its unique resources and characteristics. Under the Resource-Based View framework, CA has been defined using six indicators: cost efficiency, product differentiation, quality of customer service, market share, flexibility to market changes, and brand equity. Sustainable competitive advantage is supported through these indicators (Sidharta et al., 2026).

Theoretical Background

The Triple Bottom Line approach was popularized by Elkington in Cannibals with Forks, which frames business performance through three interrelated dimensions: people, planet, and profit. It provides a unique view of business through an expanded lens beyond the accounting focus, which has mostly focused on financial matters. TBL emphasizes that firm performance evaluation should be based not only on financial performance but also on social and environmental performance. This approach includes three major aspects: people, planet, and profit (Nogueira et al., 2025). People refers to the impact of business activity on people, including community engagement and ethical business conduct. In line with this perspective, corporate environmental disclosure can strengthen accountability by communicating environmental responsibility to stakeholders

and enabling public monitoring of corporate activities (Fitriasari, 2023). Planet refers to the environmental impact, covering resource consumption, pollution, and efforts to combat climate change. Profit refers only to a firm's revenue and costs (Alhemimah et al., 2025).

This study is also part of a NRBV, an extension of the Resource-Based View, suggesting that by achieving competencies in three related imperatives, a firm could build competitive advantage through internal resources that are valuable, rare, inimitable, and non-substitutable (Boota et al., 2025). The NRBV suggests that competitive advantage arises from resources and capabilities developed through environmental management. This framework inspires firms to embed green capabilities as an integral component of modern management strategy (Urbanek, 2022). Environmental performance, green innovation, and sustainable development are key mechanisms for achieving environmental protection, alleviating ecological burdens, and enhancing enterprise reputation and competitiveness. Cost efficiency, differentiation, and market focus may further strengthen competitive advantage when supported by environmental capabilities and innovation-oriented resources (Alhemimah et al., 2025; Boota et al., 2025).

Hypotheses Development

Corporate Social Responsibility and Environmental Sustainable Development

Corporate social responsibility is related to Environmental Sustainable Development since both highlight the firm's obligation for long-term sustainability (Mazur-Wierzbicka & Swiatkiewicz, 2023). CSR is also perceived as a firm-oriented commitment to engage in commerce that is sensitive to its social and environmental effects on stakeholders. In this respect, ESD can be considered one of the primary expressions of CSR because it already addresses the environment through a responsible environmental strategy, including environmental protection, resource efficiency, and waste and pollution prevention (Mazur-Wierzbicka & Swiatkiewicz, 2023).

CSR provides firms with an ethical and strategic framework for planning programs that support ESD. Corporate legitimacy and public reputation could be strengthened through investments in waste management, energy efficiency, and eco-friendly innovation. On the other hand, ESD helps firms turn CSR into specific, output-based actions that can be measured at the operational level, making social responsibility more than a normative policy (Albitar et al., 2024). Integrating CSR and ESD enhances stakeholder trust from a stakeholder theory perspective and mitigates the risk of future social and environmental consequences. They represent a beneficial combination of the cornerstones of sustainable business (Mahajan et al., 2023). From this premise, therefore base a study on the following hypothesis:

H1: CSR has a positive effect on ESD.

Environmental Sustainable Development and Green Innovation

Environmental sustainable development and green innovation are interconnected, as they both aim for long-term sustainable development (Siregar et al., 2024). ESD focuses on responsible natural resource management, emissions mitigation, energy conservation, and environmental protection as key platforms for sustainable development (Akinsemolu & Onyeaka, 2025). In this context, GI is one of the tools through which ESD targets can be achieved through environmentally friendly innovations in products, processes, technologies, and management systems (Din et al., 2024).

ESD and GI complement each other. Similarly, recent literature suggests that environmental innovation can strengthen sustainable business performance when it is

supported by resource-based capabilities and innovation-oriented strategies (Ng & Cheah, 2025). Partnering with various stakeholders lends legitimacy to green innovation initiatives and provides a business case for firms to engage in green innovation to build greener, more efficient operations (Novitasari & Agustia, 2023). On the contrary, green innovation enables firms to turn ESD pledges into concrete practices by conserving energy, recycling waste, using green materials, and adopting sustainable product design (Gloria, 2025). Thus, green innovation is not just a reaction to regulatory and market pressures; it is an enduring source of competitive advantage. Named stakeholders are seen to increase organizational legitimacy, which enhances the legitimacy of the social network between corporations and their stocks in a firm; thus, the corporate reputation and competitiveness (Augustin-Behravesh et al., 2025). From this premise, therefore base a study on the following hypothesis:

H2: ESD has a positive effect on GI.

Corporate Social Responsibility and Green Innovation

CSR and GI are interrelated concepts, as both are sustainability-oriented and focus on value co-creation between firms and their stakeholders (Dungtripop et al., 2025). CSR involves conducting business in an economically, socially, and environmentally sustainable manner that is not only profitable but also responsible. As such, CSR serves as a strategic platform, pushing firms to innovate in green technologies to meet sustainability demands and stakeholder expectations (Sarfraz et al., 2023).

CSR fosters GI by strengthening firms' ethical commitment, stakeholder responsiveness, and environmental innovation capacity (Sarfraz et al., 2023; Simmou et al., 2023). Through investment in clean technologies, energy efficiency, waste management, and eco-friendly products, organizations can enhance legitimacy and stakeholder trust (Gurler, 2026). From a stakeholder theory perspective, CSR helps firms balance the needs of customers, employees, communities, and the environment (Neumann et al., 2025). Therefore, CSR is not only a moral obligation but also a source of competitive advantage that supports long-term sustainability and a dynamic business model (Zahid et al., 2024). From this premise, therefore base a study on the following hypothesis:

H3: CSR has a positive effect on GI.

Mediating Environment Sustainable Development

Environmental sustainable development serves as a mediating mechanism that connects corporate social responsibility and green innovation (Sarfraz et al., 2023). CSR provides the working dimension of the concept that works from the perspective of economic, social, and environmental responsibilities, while ESD encodes practice in tangible and quantifiable forms of sustainability practice. Here, CSR is considered not only as a compliance in the normative sense but also as a strategic significance for the build-up of environmental capabilities for green innovation (Al-Ali & O'Mahony, 2025).

Environmental sustainable development is about resource optimization, waste reduction, energy efficiency, and pollution prevention, and helps firms to avoid harmful business conduct (Monir et al., 2022). This leads to an organizational culture that stimulates green innovation, which focuses on greener products, processes, and management systems. ESD addresses this demand by serving as the strategic means of translating the social dimension of CSR into sustainable innovation outcomes (Marietza & Nadia, 2021). Viewed through the lens of stakeholder theory, firms are expected to adapt to stakeholder interests over time. Thus, ESD is a crucial factor in enhancing a firm's

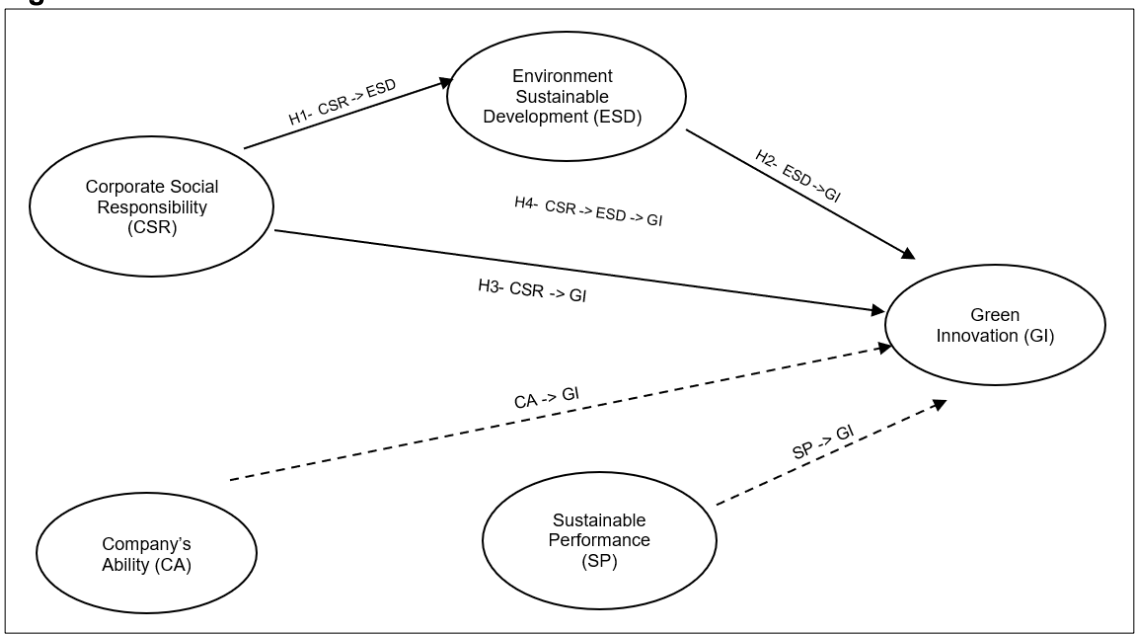
capacity to sustain green innovation (Sarfraz et al., 2023; Simmou et al., 2023). Based on this premise, the study formulates the following hypothesis:

H4: ESD mediates the relationship between CSR and Green Innovation.

Conceptual Framework

Figure 1 presents a conceptual framework illustrating the relationships among the study's key constructs, derived from both the theoretical review and the empirical findings. It illustrates how the researcher has placed the independent and dependent variables with their relevant mediating or moderating variable(s). Each construct relationship is based on existing concepts and evidence from prior research. This model allows for structural, systematic, and hypothesis-driven research analysis.

Figure 1. Research Framework



RESEARCH METHOD

This study empirically examines the mediating effect of ESD in the relationship between CSR and GI using a quantitative approach. Company Ability (CA) and Sustainable Performance (SP) are included as control variables to strengthen model robustness and isolate the main CSR–ESD–GI relationships.

Research Design and Measurement of Variables/Operationalization

This research design is a quantitative, causal-associative approach that aims to analyze the role of ESD as a mediating variable between CSR and GI. These data were obtained using structured questionnaires administered to purposively selected recycling firms, and then the significance of the mediation was assessed using SEM-PLS. This design is intended to produce objective and replicable findings regarding the relationships among CSR, ESD, and GI.

The sampling criteria included recycling firms that were actively operating in Indonesia, had identifiable business activities related to material recovery or waste processing, and were represented by owners or managers who understood the firm's sustainability and innovation practices. Respondent eligibility was limited to decision makers or operational representatives with sufficient knowledge of CSR activities, environmental programs,

and green innovation initiatives. This clarification is important because the constructs were measured through organizational perceptions rather than individual consumer attitudes.

Population and Samples

This industry in Indonesia mainly processes waste materials such as plastic, paper, textiles, and wood into value-added products, including furniture, organic fertilizer, and handicrafts. It is chosen because it has not been intensively studied, though it plays a key role in sustainability and serves as an alternative to address environmental concerns.

Procedures and Data Collection

The data for this study were acquired using a structured electronic questionnaire survey conducted online using Google Forms. Company representatives were contacted using the information available on their websites and social media platforms. All variables were assessed utilizing a five-point Likert scale to investigate the links among specified constructs. This is research with four types of variables: independent, dependent, mediating, and control.

Data Analysis Technique

The analysis uses descriptive categories. Research Paper 2864 profiles respondents and the features of recycling companies to test the model in this study. The data analysis method is an SEM-PLS model. The PLS path modeling technique was used to estimate and assess the mediating effect of ESD on the CSR-GI in an era of global climate change, using SmartPLS software.

RESULTS

Respondents' Demographic Profile

This study used 241 questionnaires sent to recycling companies in Indonesia, yielding 129 valid responses (53.5% response rate). They analyzed the data by type of use, company characteristics, regional representation, and respondent demographics. These results show participants with different professional backgrounds. The demographic and operational details of the respondents are presented in the table below to reinforce the study's robustness.

Table 1. Respondent Characteristics

Information	Category	Obs (n=129)	Percentage (%)
Gender	Male	81	63
	Female	48	37
Educational level	Junior high school	3	2
	Senior high school	30	23
	Bachelor	78	61
	Master	18	14
Position	Owner	63	49
	Manager	66	51
Recycling type	Plastic	60	47
	Paper	12	9
	Textile	9	7
	Glass	3	2
	Domestic Waste	18	14
	Used cooking oil	9	7
	Organic	12	9
	Electronic	3	2

Business experience [year]	Less than 3	57	44
	3-6	33	26
	7-9	30	23
	More than 10	9	7
Province	Yogyakarta	29	23
	Jakarta	21	16
	Central Java	20	15
	East Java	11	9
	West Java	20	16
	Bali	7	5
	Riau	2	2
	Banten	9	7
	South Kalimantan	3	2
	East Nusa Tenggara	3	2
	Central Kalimantan	2	2
	Riau Island	1	1
	Lampung	1	1

Table 1 shows that 81 respondents (63%) were male and 48 respondents (37%) were female. The majority had completed a bachelor's degree (78 respondents, 61%), followed by senior high school (30 respondents, 23%), earned a master's degree (18 respondents, 14%), and junior high school (3 respondents, 2%). The national sample included managers (66 respondents, 51%) and business owners (63 respondents, 49%). Plastic recycling was the most popular recycling business, with 60 respondents (47%). Between 1 and 4 October 2025, a total of 129 respondents answered this survey, whose backgrounds varied by province across Indonesia, including Yogyakarta, Jakarta, Central Java, and West Java.

Statistics Descriptive

It is applied in the context of this study because SmartPLS is suitable for models containing mediating variables, relatively small sample sizes, and multiple-item constructs. Moreover, SmartPLS supports the assessment of convergent validity, discriminant validity, and reliability (Laily et al., 2025). The descriptive statistics are shown in Table 2. The distribution of the data was considered acceptable because the skewness and kurtosis values in the statistical output were within the commonly used ±2 threshold.

Table 2. Descriptive Statistics

Variable	Mean	SD	Min	Max
Company Ability	0.000	1.000	-2.183	1.235
Corporate Social Responsibility	0.000	1.000	-2.689	0.738
Environmental Sustainable Development	0.000	1.000	-3.203	0.725
Green Innovation	0.000	1.000	-2.819	0.834
Sustainable Performance	0.000	1.000	-2.903	1.417

According to Table 2, the mean value of all variables is 0.000 and the standard deviation is 1.000, indicating that the data were standardized before further analysis. ESD has the widest range, from -3.203 to 0.725, with a kurtosis value of 1.898, suggesting a platykurtic distribution. All variables show negative skewness, indicating a left-skewed distribution. Overall, these results indicate sufficient variability in the data to support further analysis.

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Factor Loading, Validity, and Reliability R^2, f^2, and Q^2 Evaluation

Initially, this study followed an algorithmic route to significance of loadings, validity, and reliability checks using SmartPLS, represented in Figure 2. Moreover, Table 3 shows the result of loadings; all the items of the sample are showing up as expected (with a. 70 or greater), and no significant cross-load between any two antecedents, i.e. For all constructs, the value of discriminant validity and convergent validity is above 0.70 and 0.50, respectively, which fulfil the basic requirements (Laily et al., 2025). In addition, since all constructs have a composite reliability of more than 0.70, all constructs meet the reliability criteria set by Laily et al. (2025). Results for the validity and reliability of the constructs constructed are shown in Table 3.

Figure 2. Algorithm for Structural Model 1

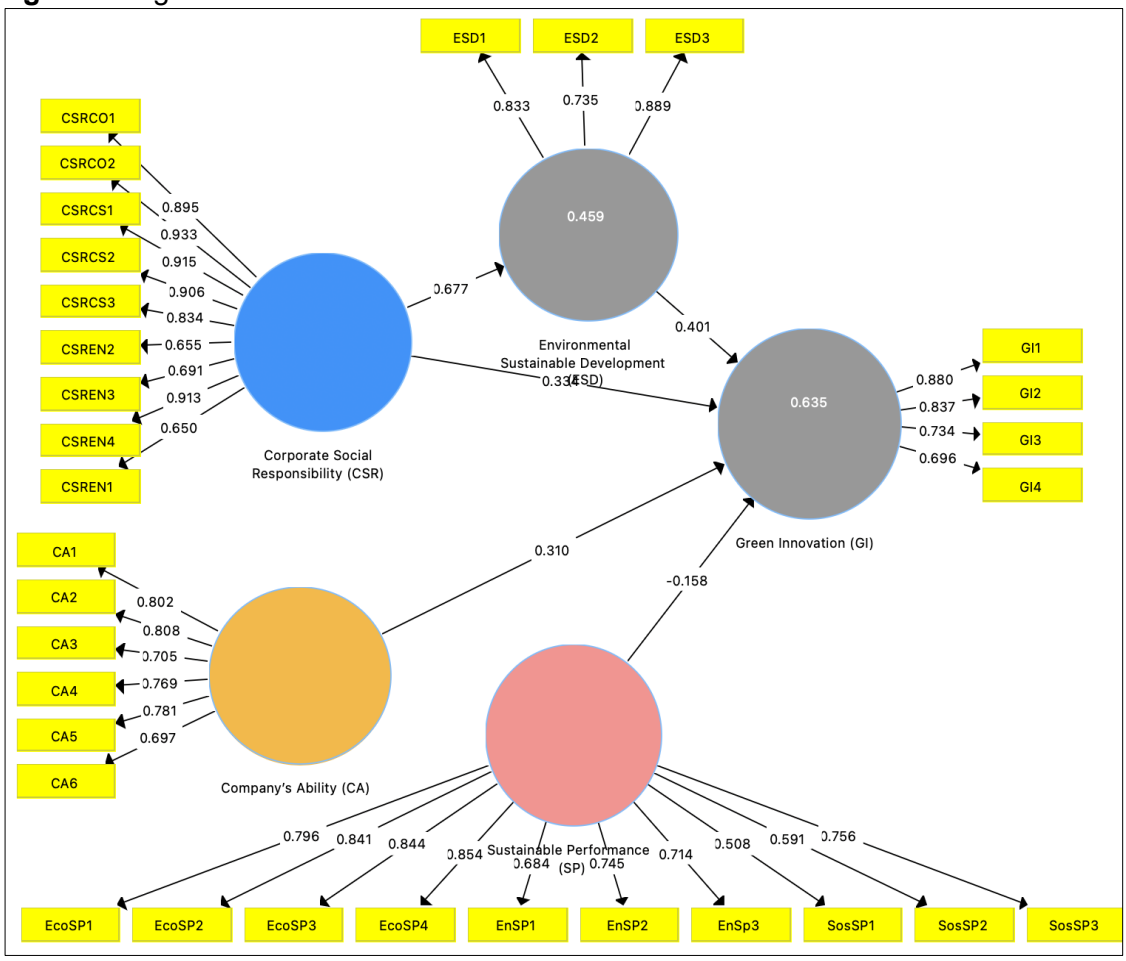

Table 3. Validity and Reliability

Variable	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Company Ability	0.851	0.883	0.882	0.590
Corporate Social Responsibility	0.952	0.969	0.961	0.677
Environmental Sustainable Development	0.776	0.826	0.861	0.665
Green Innovation	0.787	0.827	0.859	0.635
Sustainable Performance	0.907	0.924	0.933	0.549

Based on Table 3, all variables have Cronbach's Alpha, rho_A, and Composite Reliability values greater than 0.70, indicating that the research instrument is reliable. Moreover, the AVE values for the respective variables are above 0.50, indicating that the

convergent validity of each investigated construct can be sufficiently established. Thus, the indicators for CA, CSR, ESD, GI, and SP are consistent with the measurement requirements and are therefore eligible for further analysis of the research model.

Model Predictive Accuracy

The model predictive accuracy was evaluated with R^2 (Coefficient of Determination), Q^2 (Predictive Relevance), and f^2. These assess the model's ability to explain endogenous variance and predict out-of-sample, as described in the accompanying table. This assessment follows that of conventional PLS-SEM guidelines for evaluating explanatory power and predictive utility (Sarstedt et al., 2021).

Table 4. R^2, Adjusted R^2, and Q^2 Predict

Variable	R^2	Adjusted R^2	Q^2
Environmental Sustainable Development	0.459	0.455	0.281
Green Innovation	0.635	0.623	0.378

In Table 4, the model explains 45.9% of the variance in ESD (R^2 = 0.459, adjusted R^2 = 0.455), as shown in the above table. Q£Q^2 = 0.281: Due to the value of Q^2 being larger than 0.2, the predictive relevance is adequate. Contrarily, Green Innovation also holds the R2 of 0.635 and an adjusted R2 of 0.623, which indicates the model explains 63.5% of the variance in the construct. The Q^2 value is 0.378, high enough to show good predictive relevance. This means that the research model has both explanatory and predictive power.

Table 5. Effect Size (f^2) Assessment

Variable	ESD	GI
Company Ability		0.070
Corporate Social Responsibility		0.072
Green Innovation	0.078	0.066
Sustainable Performance		0.063

Table 5 presents the f^2 effect size values used to assess the substantive contribution of each predictor to the endogenous constructs. Overall, the reported f^2 values range from 0.063 to 0.078, indicating small effect sizes based on common PLS-SEM guidelines. CA and CSR show small contributions to GI, with f^2 values of 0.070 and 0.072, respectively, while SP also shows a small contribution to GI with an f^2 value of 0.063. Therefore, the model indicates that the predictors contribute to the endogenous constructs at a small but still meaningful level.

Discriminant Validity Results

The GI and ESD are strongly correlated, as shown in Table 6. The findings support their interconnectedness by demonstrating a positive correlation between GI and ESD. Additionally, the discriminant validity of these constructs is superior to that of other components, ensuring the robustness of the measurement model.

Table 6. Heterotrait-Monotrait Ratio, Discriminant Validity, and Correlation

Variable	CA	CSR	ESD	GI	SP
Fornell-Larcker criterion.					
Company Ability	0.752				
Corporate Social Responsibility	0.720	0.839			
Environmental Sustainable Development	0.623	0.667	0.821		
Green Innovation	0.660	0.720	0.707	0.791	
Sustainable Performance	0.738	0.719	0.674	0.587	0.741

Heterotrait-Monotrait Ratio					
Company Ability					
Corporate Social Responsibility	0.765				
Environmental Sustainable Development	0.671	0.754			
Green Innovation	0.734	0.772	0.849		
Sustainable Performance	0.834	0.751	0.746	0.633	

As shown in Table 6, the square root AVEs are higher than the correlations among the other constructs, indicating adequate discriminant validity based on the Fornell-Larcker criterion. Furthermore, every Heterotrait-Monotrait Ratio (HTMT) value is below the 0.90 threshold, further demonstrating adequate conceptual distinctiveness. Consequently, the constructs of CA, CSR, ESD, GI, and SP fulfill the discriminant validity criteria for measurement model analysis.

Direct Testing of Bootstrapping Structural Models

The structural model was evaluated through path analysis using bootstrapping procedures and assessment of the measurement properties, as presented in Table 7 (Hair et al., 2020; Sarstedt et al., 2021). In line with recent guidelines for inference in variance-based SEM, bootstrapping is a nonparametric way to evaluate the statistical significance of path coefficients and other PLS-SEM estimates. These, then, are consistent with recent trends related to reporting standards for PLS-SEM and follow more traditional logic of establishing hypothesized relationships first, followed by measurement invariance and model fit.

Table 7. Direct Effects and Indirect Effects [Bootstrapping]

Path		Original Sample	T Statistics	P Values	Result
Effects Direct	H1_ CSR -> ESD	0.684	11.317	0.000***	Support
	H2_ ESD -> GI	0.401	6.084	0.000***	Support
	H3_ CSR -> GI	0.343	4.074	0.000***	Support
Variable Control	CA -> GI	0.310	2.600	0.010**	Support
	SP -> GI	-0.164	1.444	0.149	Not Supported
Effects Indirect	H4_CSR -> ESD -> GI	0.271	5.684	0.000***	Support

Note: ***p < 0.01; **p < 0.05; *p < 0.10.

Bootstrapping (2,000 samples) was used to test the anticipated relationships. The results indicate that CSR has a positive impact on ESD (T = 11,308; p = 0,000), thus supporting H1. The positive impact of ESD on GI (T = 6.075; p = 0.000) also provides strong support for H2. Furthermore, CSR has a positive and significant impact on GI (T = 4.069; p = 0.000), thus verifying H3. The effect of CA on GI (β = 0.310; p = 0.010) is positive and significant, while that of SP on GI(β = -0.158; p = 0.149) is negative but not significant. CSR not only has a direct effect on GI but also an indirect effect through ESD (β = 0.271; p < 0.001), which was also significant; therefore, CSR was fully mediated by ESD between CSR and GI (Table 7). Using bootstrapping to analyze the dataset more accurately produced the bootstrapping results table as detailed earlier in the paper. Figure 3 visualizes the results of bootstrapping, making it easy to read the data distribution and the variability of the measured parameters. This visualization also helps compare the computed estimates with the actual data, providing a better overview of the model's reliability for this research.

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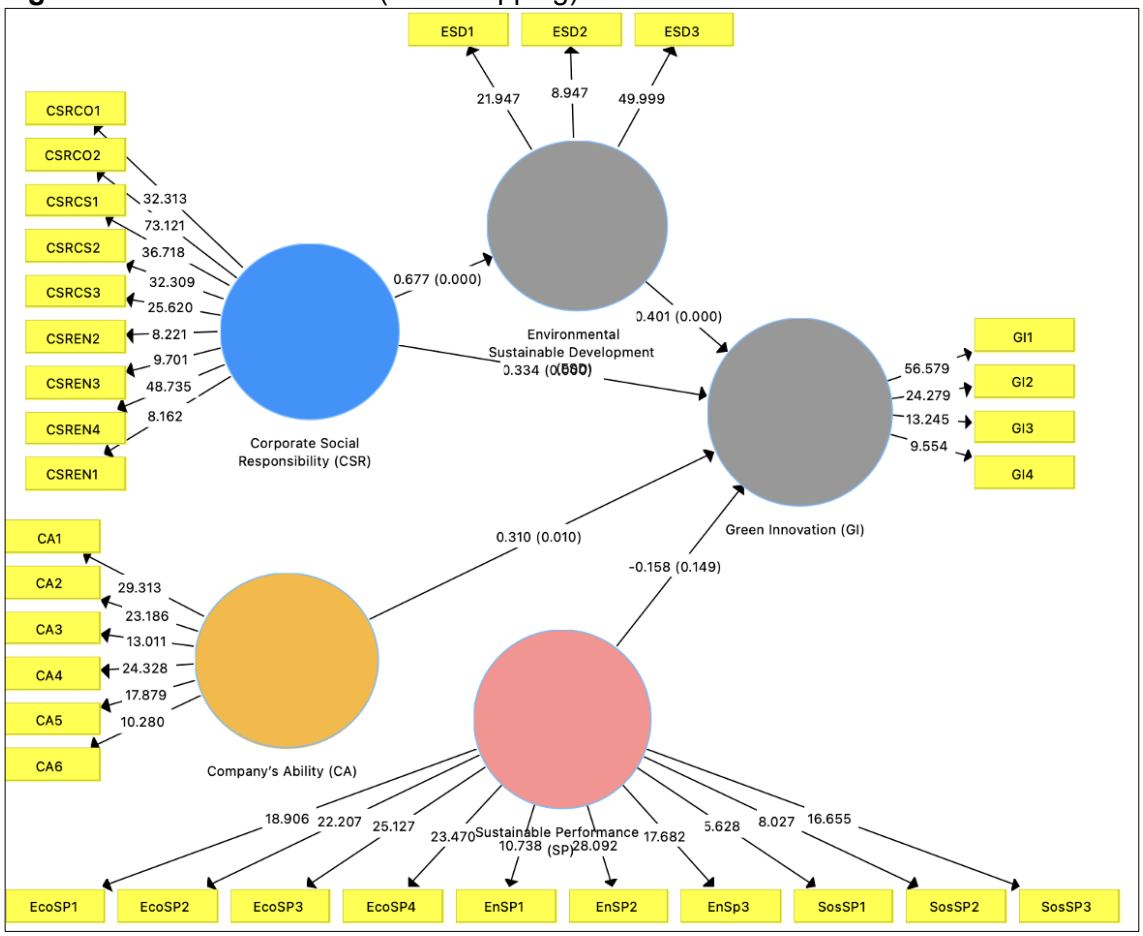
Figure 3. Structural Model 2 (Bootstrapping)



DISCUSSION

H1: Corporate Social Responsibility and Environmental Sustainable Development
The bootstrapping results show that CSR has a positive and significant effect on ESD (β = 0.684; t = 11.317; p < 0.001). Therefore, H1 is supported. This finding indicates that recycling firms with stronger CSR commitments are more likely to institutionalize environmentally sustainable development through responsible resource use, waste management, and environmental protection practices. CSR is therefore considered both an ethical obligation and an organizational strategy that promotes measurable and sustainable environmental outcomes (Mansour et al., 2022; Rosilawati & Rahmawati, 2023).

These results are in line with the notion that CSR implementation can improve awareness of environmental sustainability through the adoption of more responsible operational policies, efficient resource use, and enhanced stakeholder relations (Shang, 2026). CSR in the recycling industry is particularly significant due to the sector's direct association with waste management, material recovery, and the reduction of ecological burdens. Thus, CSR can build a stronger strategic foundation for effective ESD. It is also implied that businesses having a history of demonstrated CSR are more willing to embed sustainability into business processes, thereby promoting greater and more sustainable environmental performance (Kraus et al., 2020).

H2: Environmental Sustainable Development and Green Innovation
The results indicate that ESD has a positive and significant effect on GI (β = 0.401; t = 6.084; p < 0.001). Therefore, H2 is supported. This suggests that environmentally sustainable development provides an operational foundation for recycling firms to adopt cleaner processes, eco-friendly materials, and waste-reducing technologies. In Indonesia's recycling sector, ESD can strengthen green innovation by improving resource management, supporting cleaner waste-processing systems, and enhancing firm competitiveness (Agustiani et al., 2025; Handoyo, 2024).

One suggestion is that ESD and business development strategies facilitate the harmonization of green innovation to deliver greater environmental benefits for recycling firms (Mishra, 2025). Well-structured, this model helps consolidate an eco-efficient approach at the corporate level and aligns with the ideas of ecological modernization theory, which holds that environmental degradation and industrial development can be reconciled through appropriate innovation. This also strengthens corporate social responsibility and environmental performance among SMEs (Sidharta et al., 2026).

H3: Corporate Social Responsibility and Green Innovation
The findings show that CSR has a positive and significant effect on GI (β = 0.343; t = 4.074; p < 0.001). Therefore, H3 is supported. This finding indicates that CSR may encourage green innovation by strengthening firms' ethical commitment, stakeholder responsiveness, and investment in environmentally responsible technologies. In recycling firms, CSR can motivate cleaner production, improved waste management, and eco-friendly product or process innovation (Sarfraz et al., 2023; Simmou et al., 2023).

To ensure that firms in the recycling sector of developing economies focus on sustainability initiatives rather than short-term costs and complexities, a long-term commitment is needed (Sidharta et al., 2025). Corporate social responsibility, environmental strategy, and green innovation are instrumental in reducing emissions and material use, thereby improving environmental performance when integrated. The relationship between external CSR and environmental performance is also partially mediated by green innovation (Simmou et al., 2023).

H4: The Mediating Role of Environmental Sustainable Development
The indirect effect of CSR on GI through ESD is positive and significant (β = 0.271; t = 5.684; p < 0.001). Therefore, H4 is supported. However, because the direct effect of CSR on GI remains significant, ESD should be interpreted as a partial mediator rather than a full mediator. This means that CSR can directly promote GI, while also strengthening GI indirectly through environmentally sustainable development practices.

By implementing environmentally responsible policies, processes, and practices, CSR increases firms' likelihood of engaging in green innovation (Gurler, 2026). Resource efficiency, waste management, and reducing ecological harm are core interests in the recycling sector. Thus, organizations must implement CSR and ESD synergistically to achieve green innovation while balancing short-term costs with ongoing operational enhancement and long-term commitment (Sidharta et al., 2025).

CSR programs can be a strategic driver of environmental performance through eco-innovation, particularly when aligned with organizational sustainability goals (Sarfraz et al., 2023). By fusing CSR and innovation strategies, firms can leverage green technologies, environmentally friendly products, and process innovations to achieve operational efficiency and market advantage. It also drives new levels of sustainable

action, lowers environmental footprints, and improves profitability. Such a strategy is needed in developing countries to eliminate or at least reduce the forces that threaten long-term business performance and sustainable development (Dzage et al., 2024).

These findings imply that CSR does not automatically become green innovation unless it is operationalized through environmental sustainable development. In recycling firms, CSR initiatives are likely to create stronger innovation outcomes when they are translated into specific practices such as resource efficiency, pollution prevention, safer material handling, and improved waste-processing systems. This interpretation is consistent with the logic of the NRBV because environmental capabilities can become strategic resources that support innovation and competitiveness. Therefore, ESD should be positioned as a managerial pathway that converts social and environmental commitments into practical innovation routines.

CONCLUSION

This study investigates the mediating effect of ESD on the relationship between CSR and Green Innovation among recycling companies in Indonesia. The empirical results demonstrate that CSR has a positive impact on ESD, indicating that CSR commitment drives responsible natural resource use. Moreover, ESD has a significant impact on Green Innovation, thereby strengthening eco-innovation. CSR also positively influences green innovation. These results further support ESD as a mediator between CSR and Green Innovation, and sustainability integration remains a crucial driver of green innovation.

The theoretical implications of this study for the corporate sustainability literature are to bridge the link between CSR and Green Innovation with ESD. These results serve to substantiate that corporate social responsibility is not just a reputation or compliance tool, but also a strategic driver of environmentally responsible conduct. ESD plays a mediating role, implying that the sustainability of green innovation depends on it. On a practical level, the Indonesian Recycling Business Unit shall make CSR a central strategy rather than an additional distinction to be pursued compatibly with energy- and effort-intensive standards: energy efficiency, waste minimization, material regeneration, and clean production systems. It raises points firms must also consider: enhancing sustainability reporting, scaling up investment in green technologies, and ramping up collaboration with governments, communities, and research institutions to facilitate the scaling up of low-carbon business models.

LIMITATION

This study has several limitations. First, the research object is restricted to recycling enterprises in Indonesia, so the results cannot be generalized to other industries, but they can be applied to different regions. Second, because the data were collected through questionnaires, respondent-perception bias may have occurred. Third, the study design is cross-sectional, meaning it cannot indicate how relationships change over time. Fourth, although CSR, ESD, and Green Innovation were examined in this study, other potential determinants of these relationships are not comprehensively analyzed.

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DECLARATION OF CONFLICTING INTERESTS

The authors have disclosed no potential conflicts of interest related to the investigation, authorship, or publishing of this article.

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