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The Impact of Green Innovation on Corporate Sustainability Performance: A Case Study of Micro, Small, and Medium-Sized Enterprises (MSMEs) in Malang City, Indonesia

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Abstract: This research assesses the impact of green innovation on the sustainable performance of micro, small, and medium-sized enterprises (MSMEs) in Malang City using a systematic and empirical approach. Employing Structural Equation Modeling-Partial Least Squares (SEM-PLS), the study analyzes several antecedent variables and their effects on green innovation, emphasizing employee conduct and government pressure as significant drivers. Data collection was conducted through Likert-scale questionnaires and Focus Group Discussions (FGDs) involving MSME practitioners and local government officials. A quantitative explanatory approach employed Structural Equation Modeling-Partial Least Squares (SEM-PLS) to analyze data from 216 purposively sampled MSME respondents via Likert-scale questionnaires, supplemented by Focus Group Discussions (FGDs) with practitioners and local officials. The model assessed outer and inner validity, reliability, path coefficients, R-square values (0.647 for green innovation, 0.718 for sustainable performance), and bootstrapping for hypothesis testing. Employee conduct (path coefficient = 0.344, p=0.000) and government pressure (path coefficient = 0.317, p=0.000) significantly drive green innovation, which strongly enhances sustainable performance (path coefficient = 0.650, p=0.000). Environmental dynamics positively affect sustainable performance (path coefficient = 0.195, p=0.002) but negatively moderate the green innovation–sustainable performance link (path coefficient = -0.094, p=0.009), indicating instability weakens benefits amid regulatory and environmental changes. These findings highlight internal behaviors and policy enforcement as key levers over technological or competitive factors in resource-constrained MSMEs. Prioritizing employee pro-environmental engagement and government regulatory support fosters green innovation for improved MSME sustainability, while building adaptive strategies helps counter environmental dynamism; these insights guide policymakers and owners toward integrated environmental–economic strategies.

Keywords: Environmental dynamics; Green innovation; MSME's; SEM-PLS; Sustainable performance

Introduction

Micro, Small, and Medium-sized Enterprises (MSME's) serve as the main pillars driving national economic growth and contribute significantly to employment absorption and Indonesia's Gross Domestic Product (GDP), accounting for 60.3% or IDR 8,573.89 trillion in 2024 (Indonesia's Central Bureau of Statistics,

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2025). In Malang City, the number of MSME's in 2024 reached 24,765 units, a sharp increase from the previous year, driven by various training programs and regional government policies (Department of Cooperatives, Industry, and Trade of Malang City, 2025).

However, the rapid growth of MSME's also brings negative impacts, particularly on the environment, due to the high volume of plastic waste and water pollution generated by local economic activities (National Waste Management Information System, 2025). The Brantas River pollution index in Malang City in 2025 reached 8.31, categorized as moderately polluted (Environmental and Forestry Station of Malang City, 2025). The predominant use of plastic packaging and suboptimal waste management among MSME's remain significant challenges for achieving economic and environmental sustainability.

To address these challenges, green innovation is increasingly recognized as a critical strategic approach to achieve both business and environmental sustainability in contemporary contexts (Amstrong et al., 2008; Sáez Martínez et al., 2016; Tariq et al., 2017). Green innovation encompasses product and process innovations aimed at reducing energy consumption, minimizing pollution, and enhancing waste recycling (Chen et al., 2008; Fitriani, 2015). In Indonesia, the application of green innovation is regulated by Law No. 32 of 2009 on Environmental Protection and Management and Law No. 3 of 2014 on Industry, which mandate sustainable use of technology, product management, and waste handling across all industrial sectors, including MSME's (Republic of Indonesia Law, 2014).

Green innovation is recognized as one of the key variables in measuring a company's sustainable performance, including MSME's, encompassing economic, social, and environmental dimensions—the triple bottom line (Schrank & Kijkasiwat, 2024). Research by Firdausyi et al. (2023) in Kediri demonstrated that green innovation positively influences MSME's' sustainable performance, with technological capability and Corporate Social Responsibility (CSR) as antecedent variables. Other studies have also found that competitor pressure, government regulation, and employee behavior encourage green innovation practices, positively enhancing both organizational and environmental performance (Wang et al., 2021).

Antecedent variables are constructs that emerge before other factors and possess the potential to influence them causally within a relational framework. These variables are also referred to as driving factors and are typically characterized as independent, exogenous, or unrestrained (Firdausyi et al., 2022). A study conducted by Hanaysha et al. (2025) identified three antecedent variables (green entrepreneurial orientation, technological capability, and Corporate Social Responsibility (CSR)) to examine their influence on green innovation and its subsequent impact on the sustainable performance of micro, small, and medium-sized enterprises (MSME's). The findings demonstrated that the antecedent variables, technological capability and CSR, had positive and significant relationships with green innovation. Thus, higher levels of technological capability and more effective CSR initiatives among MSME's are associated with greater improvements in green innovation practices within these enterprises.

Synthesizing insights from Tariq et al. (2017), antecedent drivers of green innovation span market dynamics, stakeholder pressures, technology, collaborative networks, organizational levels, and sociocultural factors, with technological and social elements playing predominant roles. Further analyses by Wang et al. (2021) confirm the positive and statistically significant impacts of competitor pressure, governmental pressure, and employee behavior on green innovation adoption, underscoring the multifaceted and systemic determinants that shape sustainability transitions in MSME's.

Moderating variables are also recognized as crucial, such as environmental dynamics that can strengthen or weaken the relationship between green innovation and sustainable performance (Chan et al., 2016). The study by Firdausyi et al. (2022) also used environmental dynamics as a moderating variable to examine the effect of green innovation on sustainable performance. Environmental dynamics negatively moderated (weakened) the relationship between green innovation and sustainable performance. The higher the level of environmental dynamics, the lower the company's sustainable performance.

Empirical studies on green innovation within the MSME's context, remain limited and tend to focus on large corporations (Schrank & Kijkasiwat, 2024; Riani et al, 2022; Rustiarini et al., 2022). Additionally, antecedent and moderating variables among MSME's are often examined separately, whereas an integrative approach is more relevant for addressing local environmental and economic challenges (German et al., 2023). Therefore, this study focuses on analyzing the influence of antecedent and moderating factors on green innovation practices among MSME's to improve sustainable performance in Malang City. Technological capability, social responsibility, competitor pressure, government pressure, and employee behavior are comprehensively tested as primary variables. At the same time, environmental dynamics are employed as a moderating factor that may strengthen or weaken the effect of green innovation practices on firms' sustainable performance (Wang et al., 2021; Hanaysha et al., 2025; Chan et al., 2016).

Method

This study employs a quantitative explanatory approach, utilizing Structural Equation Modeling–Partial Least Squares (SEM-PLS) as the primary analytical method to investigate the causal relationships among the study variables. SEM-PLS was selected for its ability to analyze complex interconnections among latent constructs without assuming multivariate normality and for its suitability for relatively small sample sizes. Moreover, the SEM-PLS approach enables adaptive predictive assessment in multidimensional contexts, such as examining the nexus between green innovation and the sustainable performance of MSME's, with environmental dynamics serving as a moderating variable.

A total of 216 respondents were selected using purposive sampling based on criteria of participation in training, business incubation, and activities related to product innovation and waste management. They represent various business sectors, ranging from food and crafts to service industries, with the largest proportion coming from Kedungkandang District, followed by Sukun, Klojen, Blimbing, and Lowokwaru. The diverse educational backgrounds and business durations of the respondents provide a comprehensive overview of the MSME population in Malang City, the research object, ensuring that the analysis results are well represented in the field reality. In addition to questionnaire data, Focus Group Discussions (FGDs) were conducted with MSME's practitioners and officials from the Department of Cooperatives, Industry, and Trade of Malang City to identify implementation strategies and validate the empirical outcomes.

The research model examines the causal relationships and effects among five antecedent variables (technological capability, Corporate Social Responsibility (CSR), competitor pressure, government pressure, and employee behavior) on green innovation practices. It further investigates the relationship and impact of green innovation on the sustainable performance of MSME's in Malang City, as well as the moderating effect of environmental dynamism, which potentially alters the direction and strength of the relationship between green innovation and sustainable performance.

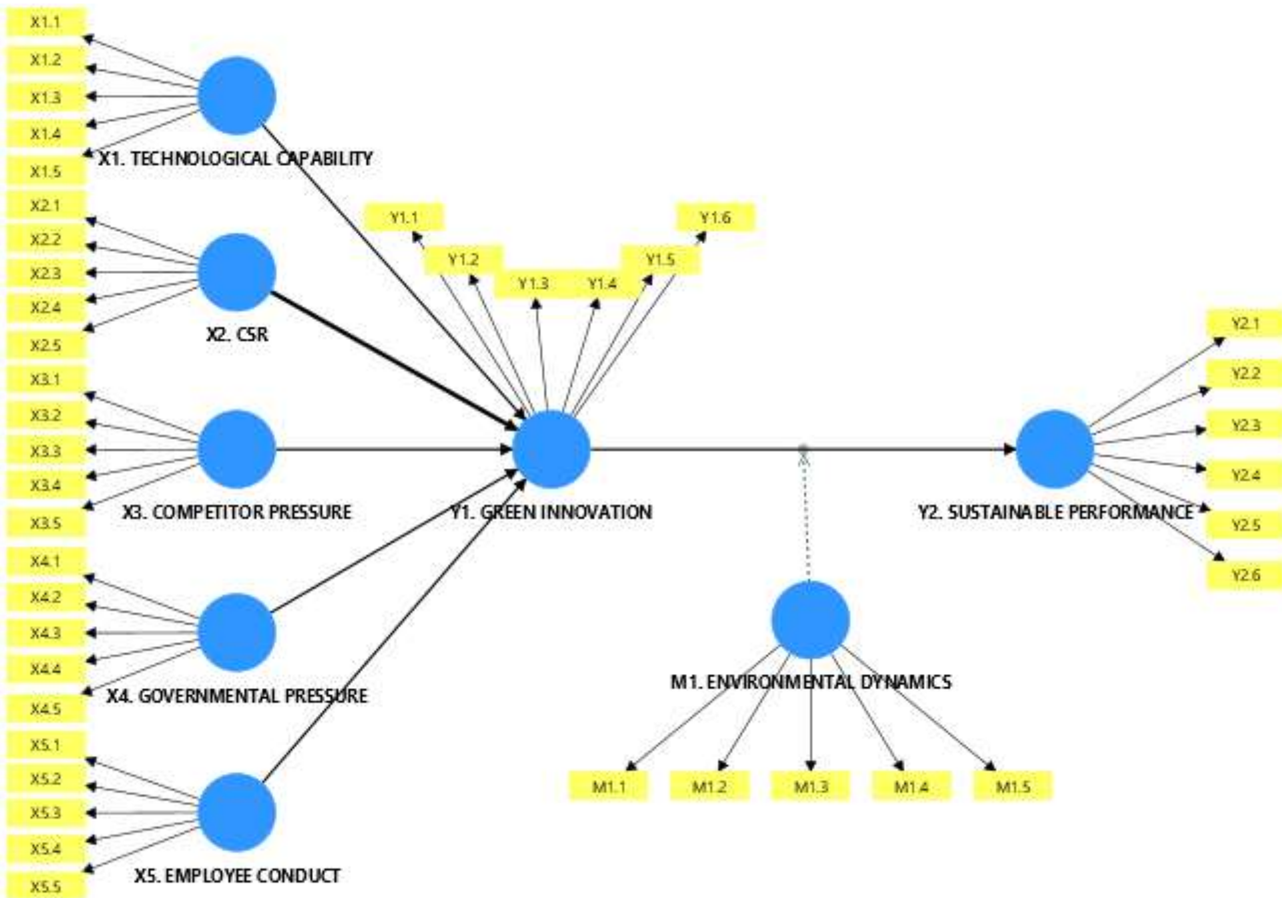

Figure 1. Conceptual framework

The analytical process in this study was conducted systematically in two fundamental phases: the evaluation of the measurement model (outer model), and the assessment of the structural model (inner model). Within the outer model stage, validity and reliability were assessed through indicators such as factor loadings (>0.7), Cronbach's alpha (>0.6), composite reliability (>0.7), and average variance extracted (AVE >0.5). These metrics ensured that the observed indicators consistently and accurately reflected their corresponding latent constructs. Discriminant validity was examined using cross-loading analysis to verify that each indicator had a stronger association with its designated construct than with others (Hair et al, 2006).

The inner model was utilized to examine the causal relationships among latent variables in accordance with the proposed hypotheses. This stage evaluated the structural relationships through path coefficients, coefficient of determination (R^2), effect size (F^2), predictive relevance (Q^2), t-statistics (>1.96), and p-values (<0.05). These statistical parameters were used to determine the strength, direction, and significance of intervariable relationships, as well as the explanatory power of exogenous variables in accounting for the variance of endogenous ones (Hair et al, 2019). Furthermore, path analysis incorporated an assessment of the moderating influence of environmental dynamics on the link between green innovation and sustainable performance using Smart-PLS's moderation analysis feature. Table 1 presents the hypotheses used in this research model.

Table 1. The Hypothesis to be Tested

Hypothesis	Description
H_1	Technological capability (X1) has a positive and significant effect on green innovation of SMEs' (Y1)
H_2	Corporate Social Responsibility (X2) has a positive and significant effect on green innovation of SME's (Y1)
H_3	Competitors' pressure (X3) has a positive and significant effect on green innovation of SME's (Y1)
H_4	Governmental pressure (X4) has a positive and significant effect on green innovation of SME's (Y1)
H_5	Employee conduct (X5) has a positive and significant effect on green innovation of SME's (Y1)
H_6	Green innovation (Y1) has a positive and significant effect on the sustainable performance of SME's (Y2)
H_7	Environmental dynamics (M1) has a positive and significant effect on the sustainable performance of SME's (Y2)
H_8	Environmental dynamics (M1) significantly moderate the relationship between green innovation (Y1) and sustainable performance (Y2)

Following the acquisition of the SEM-PLS output, hypothesis testing was conducted to assess the significance of the path analysis results. Subsequently, the findings were explored through Focus Group Discussions (FGDs) to formulate managerial strategies for MSME owners/managers and local government authorities to implement green innovation and achieve sustainable performance. The strategic analysis emphasized the strength of inter-variable relationships, the consideration of practical priorities, and compliance with relevant regulatory frameworks.

Result and Discussion

Outer Model

The results of the loading factor analysis demonstrate that all indicators employed to measure the research constructs are valid and satisfy the convergent validity criteria. This analysis was conducted to assess the extent to which each indicator accurately represents its corresponding latent variable using Partial Least Squares Structural Equation Modeling (PLS-SEM). Based on the computed values, all loading factors exceed the minimum threshold of 0.7, with the highest recorded value at 0.928 and the lowest at 0.744. These findings suggest that each indicator makes a significant contribution to explaining its associated construct. Therefore, no indicators were eliminated from the model (Hair et al., 2019).

Table 2. Construct Reliability and Validity

Variable	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	AVE
M1	0.921	0.921	0.941	0.761
X1	0.900	0.905	0.926	0.716
X2	0.894	0.896	0.922	0.704
X3	0.927	0.932	0.945	0.775
X4	0.879	0.882	0.912	0.675
X5	0.917	0.919	0.938	0.751
Y1	0.869	0.872	0.901	0.603

The reliability and validity tests indicate that all of the variables in this study can be measured accurately and consistently using the selected indicators, thereby enabling the results to be trusted. The Cronbach's alpha coefficients for all constructs surpass 0.86, with the highest values recorded for Competitor Pressure (X3) at 0.927 and Environmental Dynamics (M1) at 0.921. These figures demonstrate strong internal consistency among the indicators within each construct. Composite

Reliability (both rho_a and rho_c) values are all greater than 0.8, while specific constructs such as X3 and M1 exceed 0.94, confirming exceptional instrument reliability. Moreover, convergent validity, assessed via Average Variance Extracted (AVE), is robust across all constructs, exceeding the 0.6 threshold. The highest AVE is observed in X3 (Competitor Pressure) at 0.775, and the lowest in Y1 (Green Innovation) at 0.603. Overall, these results confirm that all latent variables in the SEM-PLS model are both reliable and valid for further analytical procedures (Hair et al., 2019; Umrani et al., 2018).

Further analysis was conducted to test discriminant validity. The cross-loadings further confirm the discriminant validity of the constructs, as each indicator's loading is higher on its associated latent variable than on any other construct in the model. This ensures that the indicators distinctly measure the intended variables without substantial overlap across constructs. Consequently, the variables under investigation (technological capability, corporate social responsibility, competitor pressure, government pressure, employee behavior, environmental dynamics, green innovation, and sustainable performance) demonstrate apparent discriminant validity, reinforcing the robustness of the measurement model.

Inner Model

The analysis of the structural model, or inner model, constitutes a fundamental phase in assessing causal relationships among latent variables in this study. This stage evaluates the magnitude and significance of the direct effects of antecedent variables on Green Innovation (Y1) and subsequently the impact of Green Innovation (Y1) on Sustainable Performance (Y2) of MSME's in Malang City, incorporating the moderating role of Environmental Dynamism (M1). Model evaluation criteria include path coefficients, R-Square values, t-statistics, and p-values, which collectively determine the significance of relationships between variables. Additionally, the Predictive Relevance (Q^2) metric is analyzed to gauge the model's predictive capacity for endogenous variables.

The R-Square value for Green Innovation is 0.647, indicating that 64.7% of its variance is explained by the independent variables, which is classified as moderate to high explanatory power. For Sustainable Performance, the R-Square is 0.718, suggesting that 71.8% of its variance is accounted for by Green Innovation, close to a robust model classification. Adjusted R-Square values of 0.642 for Green Innovation and 0.715 for Sustainable Performance further corroborate the model's robustness. These statistical outcomes underpin hypothesis testing and formulation of targeted managerial strategies to bolster the implementation of Green Innovation and enhance Sustainable Performance in MSME's across Malang City.

Table 3. R-Square & Adjusted R-square

Variable	R-square	Adjusted R-square
Y1. Green Innovation	0.647	0.642
Y2. Sustainable Performance	0.718	0.715

The evaluation of the inner model was extended by assessing F-Square (F2) values, which quantify the effect size of each exogenous latent construct on the corresponding endogenous latent constructs within the SEM-PLS approach. According to Hair et al. (2019), the F-Square statistic reflects the incremental change in the R-Square of an endogenous variable when a given exogenous predictor is excluded from the model, thereby delineating the relative contribution of each predictor construct.

Table 4. F-Square

Variable	Y1. Green Innovation	Y2. Sustainable Performance
M1. Environmental Dynamics		0.074
X1. Technological Capability	0.000	
X2. CSR	0.022	
X3. Competitor Pressure	0.007	
X4. Governmental Pressure	0.089	
X5. Employee Conduct	0.128	
Y1. Green Innovation		0.784
Y2. Sustainable Performance		
M1. Environmental Dynamics X Y1. Green Innovation		0.045

The F-Square (F2) matrix revealed that Employee Behavior (X5) had the most pronounced effect on Green Innovation (Y1), with an F2 value of 0.128, denoting a small to moderate effect. Both Corporate Social Responsibility (CSR, X2) and Government Pressure (X4) showed minor effects (F2 values of 0.022 and 0.089, respectively), while Technology Capability (X1) and Competitor Pressure (X3) exerted negligible in influence. Green Innovation (Y1) itself exhibited a substantial effect (F2=0.784) as a predictor of Sustainable Performance (Y2). Environmental Dynamism (M1) showed a small effect (F2=0.074) on Sustainable Performance, and its interaction with Green Innovation (Y1) accounted for a minimal effect (F2=0.045). Collectively, these findings highlight Employee Behavior as a pivotal antecedent for fostering Green Innovation and further establish Green Innovation as a significant determinant of Sustainable Performance within the model.

In continuation, the analysis incorporated the Predictive Relevance (Q^2) score to assess the structural model's out-of-sample predictive capability. The Q^2 predict values of 0.611 for Green Innovation (Y1) and 0.648 for Sustainable Performance (Y2) signify that the model demonstrates substantial predictive relevance for these endogenous constructs. Conventionally, Q^2 values above 0.35 are interpreted as indicative of strong predictive power. Thus, these empirical results provide robust evidence of the model's ability to accurately forecast variance in Green Innovation and Sustainable Performance among MSME's in Malang City. The strong performance of the Q^2 metric further substantiates the model's reliability, not only in explicating the relational dynamics among variables but also in supporting empirically grounded, evidence-based strategic decision making for the MSME sector.

Hypothesis Testing

Hypothesis testing in SEM-PLS is rigorously conducted by evaluating path coefficients, p-values, and t-statistics derived from the structural model. The path coefficient provides a standardized measure of the direction and magnitude of influence between latent constructs, signifying both strength and the nature of hypothesized relationships. Statistical significance of these relationships is determined through bootstrapping, which produces robust estimates of standard errors. The t-statistic is computed as the ratio of the path coefficient to its standard error, and the p-value quantifies the probability that the observed effect might have occurred by chance. A hypothesis is supported when the t-statistic exceeds the conventional threshold (generally 1.96 for a 5% significance level) and the p-value is below 0.05, indicating that the relationship is both substantial and statistically significant.

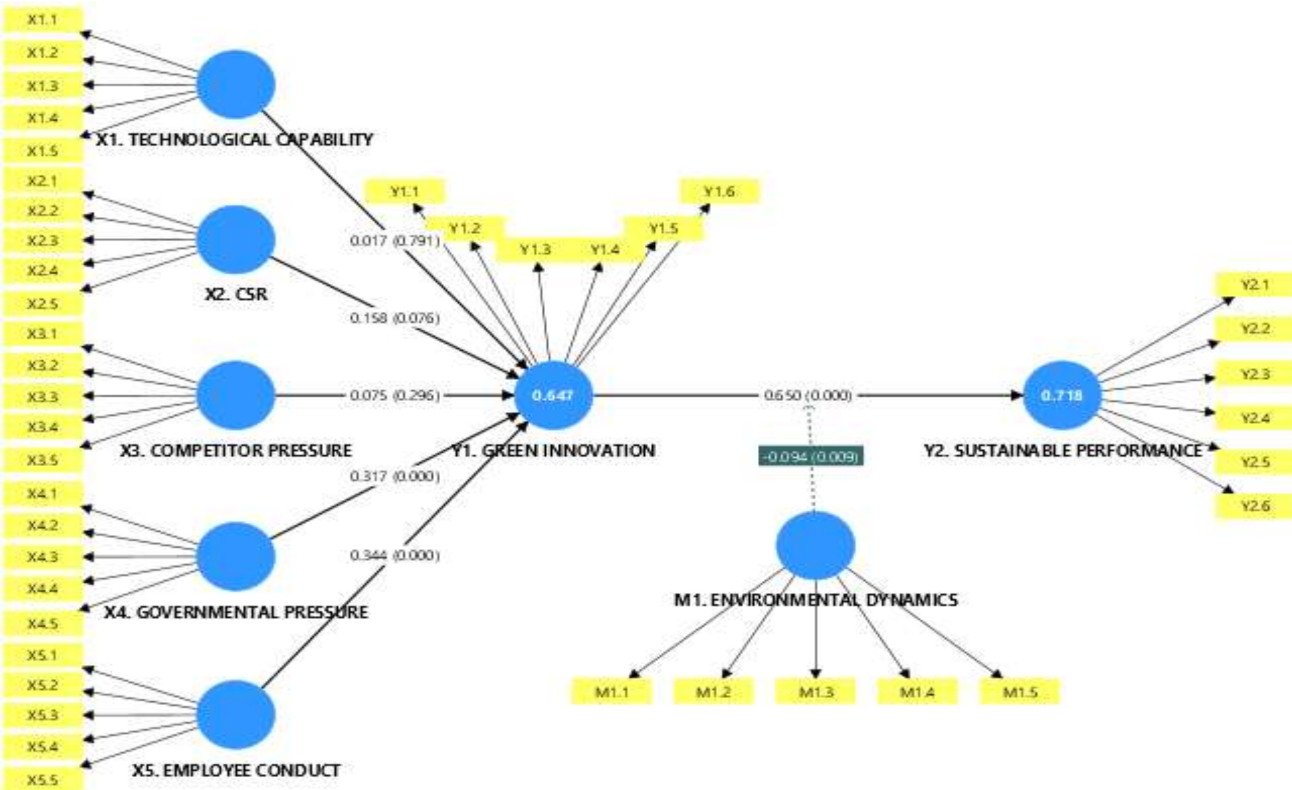

Figure 2. Bootstrapping Result

Table 5. Bootstrapping Result

Interaction between variables	Path Coefficient (O)	Sample mean (M)	Standard deviation (STDEV)	T-statistics (|O/STDEV|)	P- values
X1. Technological Capability -> Y1. Green Innovation	0.017	0.017	0.064	0.265	0.791
X2. CSR -> Y1. Green Innovation	0.158	0.163	0.089	1.774	0.076
X3. Competitor Pressure -> Y1. Green Innovation	0.075	0.075	0.072	1.045	0.296
X4. Governmental Pressure -> Y1. Green Innovation	0.317	0.325	0.086	3.690	0.000
X5. Employee Conduct -> Y1. Green Innovation	0.344	0.336	0.089	3.875	0.000
Y1. Green Innovation -> Y2. Sustainable Performance	0.650	0.661	0.067	9.691	0.000
M1. Environmental Dynamics -> Y2. Sustainable Performance	0.195	0.192	0.063	3.074	0.002
M1. Environmental Dynamics X Y1. Green Innovation -> Y2. Sustainable Performance	-0.094	-0.088	0.036	2.620	0.009

The first hypothesis examined the effect of Technological Capability on Green Innovation. The path coefficient was 0.017 with a p-value of 0.791 and a t-statistic of 0.265. Since the P-value is greater than 0.05 and the T-statistic is less than 1.96, the relationship is statistically insignificant. Therefore, the hypothesis (H1) is rejected, indicating that technological capability does not have a significant impact on improving green innovation among MSME's. This suggests that technological readiness alone does not directly determine the adoption of green innovation practices. These findings differ from those of Firdausyi et al. (2022), who demonstrated that higher technological capability enhances firms' green innovation performance through improved resource integration and process efficiency.

The hypothesis testing results for the CSR variable on Green Innovation indicate a Path Coefficient of 0.158, a P-Value of 0.076, and a T-statistic value of 1.774. These results imply that the CSR variable has a very weak, statistically insignificant positive relationship with Green Innovation (P-Value > 0.05 and T-statistic < 1.96). Therefore, H_0 is accepted and H_2 is rejected, suggesting that there is no significant relationship between the CSR variable and Green Innovation. This result contrasts with Hanaysha et al. (2024) and Putra et al. (2025), who found that a strong CSR orientation positively influences environmental innovation. The discrepancy may be attributed to the fact that CSR initiatives among local MSME's in this study are still more philanthropic than strategic, resulting in a limited impact on innovation practices.

The third hypothesis assessed the impact of Competitor Pressure on Green Innovation. The results showed a path coefficient of 0.075, a P-value of 0.296, and a T-statistic of 1.045. This means that competitor pressure exerts no significant influence on green innovation. Hence, H_3 is rejected, confirming that competitive dynamics alone do not compel MSME's to adopt green innovation practices without supportive policy or incentive mechanisms. This finding diverges from the results of El Kassar et al. (2019), Wang et al. (2021), and German et al. (2023), who found that higher competitive intensity positively influences firms' environmental innovation strategies. The divergence can be explained by contextual factors among SMEs in Malang. These enterprises often operate under resource constraints, limited market differentiation, and weaker environmental regulations, reducing the perceived need to innovate in response to competition.

The fourth hypothesis analyzed the effect of Government Pressure on Green Innovation. With a path coefficient of 0.317, a P-value of 0.000, and a T-statistic of 3.690, the results demonstrate a strong and significant positive relationship. The null hypothesis is rejected, while the alternative hypothesis (H4) is accepted. This finding confirms that regulatory pressure and government policies serve as primary external drivers that effectively encourage SMEs to implement green innovation measures. This supports Fernando et al. (2017), Soewarno et al. (2019), Rustiarini et al. (2022) and Wang et al. (2021), who found that governmental policies are major determinants of green-oriented practices in small business sectors.

The fifth hypothesis tested the relationship between Employee Conduct and Green Innovation. The path coefficient was 0.344 with a P-value of 0.000 and a T-statistic of 3.875. These results show a statistically significant and positive relationship. Thus, the null hypothesis is rejected, while the alternative hypothesis (H5) is accepted. Employee pro-environmental behavior significantly fosters the adoption of green innovation, underscoring the crucial role that internal staff culture plays in sustainable transformation. This result is consistent with Wang et al. (2021), who found that employee green behavior plays a crucial role in driving innovation performance and environmental competitiveness.

The sixth hypothesis investigated the influence of Green Innovation on Sustainable Performance. The path coefficient of 0.650, the P-value of 0.000, and the T-statistics of 9.691 indicate a strong and significant effect. Therefore, the alternative hypothesis (H6) is accepted. This demonstrates that increased implementation of green innovation substantially enhances MSME's' sustainable performance through improved efficiency, waste reduction, and environmental impact mitigation. This finding aligns with Riani et al. (2022), Firdausyi et al. (2024), Wang et al. (2021), and Dahri et al. (2025), which demonstrate that corporate green innovation practices are positively correlated with and exert a highly significant influence on the company's sustainable performance.

The seventh hypothesis examined the impact of Environmental Dynamism on Sustainable Performance. The path coefficient of 0.195 with a P-value of 0.002 and a T-statistic of 3.074 indicates that environmental dynamism significantly and positively influences sustainability. The alternative hypothesis (H7) is accepted, showing that environmental changes and challenges can stimulate adaptive strategic responses toward sustainable operations.

Finally, the eighth hypothesis analyzed the moderating role of Environmental Dynamism in the relationship between Green Innovation and Sustainable Performance. The path coefficient was -0.094, the P-value was 0.009, and the T-statistic was 2.620. The negative coefficient indicates that high environmental dynamism weakens the relationship between green innovation and sustainable performance, although this moderating effect remains statistically significant. Thus, H_8 is accepted, suggesting that while green innovation generally promotes sustainability, unstable environmental conditions may reduce its overall impact. This is consistent with Firdausyi et al. (2023), who found that market instability and environmental uncertainty can hinder the stability of green innovation adoption.

Managerial Strategy

The formulation of managerial strategies for Micro, Small, and Medium Enterprises (MSME's) in Malang City is prioritized based on the strength of inter-variable relationships identified through the Structural Equation Model–Partial Least Squares (SEM-PLS) analysis. These strategies aim to strengthen green innovation practices that enhance sustainable performance (SP) across economic, social, and environmental dimensions.

Strengthening Green Innovation Practices to Enhance Sustainable Performance (Path Coefficient = 0.650)

This strategy represents the strongest causal relationship in the model, signifying that the implementation of green innovation significantly increases the sustainable performance of MSME's. The strategy involves accelerating the adoption of environmentally friendly production processes and product innovations. It includes the use of recyclable and biodegradable raw materials, technological upgrading toward energy-efficient processes, and waste minimization initiatives. The government can facilitate this through training programs, research collaboration, and financial support mechanisms such as green financing schemes. By promoting eco-innovation, MSME's can improve resource efficiency, reduce operational costs, and enhance competitiveness while aligning with sustainability principles.

Optimizing Employee Behavior to Improve Green Innovation Practices (Path Coefficient = 0.344)

Employee behavior serves as a crucial endogenous driver that fosters organizational readiness for implementing green initiatives. The managerial strategy focuses on human resource development through sustainability-oriented training, participatory involvement, and performance-based incentives. Capacity-building programs should integrate theoretical and hands-on modules on eco-friendly technologies, waste management, and sustainable production practices. Recognition and reward systems, such as the "Green Employee Award" motivate proactive environmental engagement among staff. Institutionalizing environmental culture within the workplace ensures that sustainability becomes a shared value, contributing to consistent green innovation performance.

Enhancing Government Pressure to Encourage Green Innovation (Path Coefficient = 0.317)

Governmental influence functions as a structural enabler that encourages MSM'Es to adopt sustainable practices through regulatory guidance and economic incentives. The proposed strategy involves strengthening policy frameworks, including strict enforcement of city-level environmental laws (e.g., Malang City Regulation No. 7 of 2021 on Waste Management) and offering policy incentives for environmentally compliant enterprises. The government should improve its supervisory mechanisms by establishing a joint environmental and industrial monitoring task force to ensure compliance, while simultaneously offering rewards such as reduced business licensing fees, tax rebates, or preferential procurement for compliant MSME's. Hence, regulatory pressure becomes a catalyst for innovation rather than merely an administrative requirement.

Managing Environmental Dynamism in the Relationship between Green Innovation and Sustainable Performance (Path Coefficient = –0.094)

Although environmental dynamism moderates the green innovation–sustainability link negatively, managing it effectively can mitigate uncertainty and maintain performance stability. The recommended strategy is enhancing adaptive capacity through technology-enhanced training and diversification initiatives. Policymakers and business associations should organize continuous professional development programs focusing on renewable technologies, digital marketing, and agile business management to help MSME's respond to fluctuating environmental conditions. Financial resilience programs, such as subsidized loans and risk-sharing instruments, can further buffer the effects of external shocks. By adopting flexibility-oriented management and responsive innovation mechanisms, MSME's can sustain competitive advantage and environmental responsibility even under volatile conditions.

Conclusion

The SEM-PLS analysis confirms that employee conduct (path coefficient = 0.344 and P-value < 0.05) and government pressure (path coefficient = 0.317, and P-value < 0.005) emerge as the primary drivers of green innovation among MSMEs in Malang City, while technological capability, CSR, and competitor pressure show insignificant effects. Green innovation strongly predicts sustainable performance (path coefficient = 0.650 and P-value < 0.05), though environmental dynamics exerts a positive direct influence (path coefficient = 0.195 and P-value < 0.05) yet negatively moderates this relationship (path coefficient = -0.094 and P-value < 0.05), underscoring the vulnerability of sustainability gains amid regulatory and environmental instability. These findings advocate for targeted interventions prioritizing pro-environmental employee training, robust policy enforcement, and adaptive strategies to bolster green innovation's efficacy in resource-limited MSME's, thereby fostering integrated economic-environmental resilience in urban contexts.

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Author Contributions
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Conflicts of Interest
Regarding this research study, there is no conflict of interest.

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