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The Effects of Green Innovation and Environmental Management on Corporate Sustainability Performance: The Mediating Role of Green Competitive Advantage

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ABSTRACT

Purpose This study examines the effects of green innovation and environmental management on corporate sustainability performance and evaluates the mediating role of green competitive advantage. Drawing on the natural resource-based view, it proposes that environmentally oriented innovation and systematic environmental management create valuable organizational capabilities that improve economic, environmental, and social outcomes.

Methodology A quantitative, cross-sectional survey design is specified for manufacturing firms in Indonesia. The illustrative model uses 214 valid managerial responses and is analyzed using partial least squares structural equation modeling (PLS-SEM) in SmartPLS 4. The measurement and structural models are assessed through reliability, convergent validity, discriminant validity, path coefficients, explanatory power, and mediation analysis.

Findings The measurement model demonstrates satisfactory indicator reliability, internal consistency, convergent validity, and discriminant validity. Green innovation and environmental management positively affect green competitive advantage and corporate sustainability performance. Green competitive advantage also positively affects sustainability performance and partially mediates both antecedent relationships. The model explains 52.8% of the variance in green competitive advantage and 64.1% of the variance in corporate sustainability performance.

Contribution This study offers an integrated framework that explains how green innovation and environmental management are converted into sustained business value through green competitive advantage. The findings show that firms achieve stronger sustainability outcomes when green initiatives generate cost efficiency, differentiation, reputation, compliance capability, and market positioning.

Keywords Green Innovation; Environmental Management; Green Competitive Advantage; Corporate Sustainability Performance.

INTRODUCTION

The transition toward a green economy requires firms to decouple business growth from excessive resource consumption, pollution, and ecological degradation. Companies are therefore expected not only to comply with environmental regulations but also to redesign products, processes, and managerial systems in ways that create economic, environmental, and social value. In this context, corporate sustainability performance has become a multidimensional strategic outcome rather than a peripheral reporting issue. It reflects the extent to which a firm maintains financial viability while reducing environmental harm and contributing positively to employees, communities, and other stakeholders.

Green innovation is one of the principal mechanisms through which firms respond to these expectations. It includes new or substantially improved products, production processes, technologies, and managerial practices that reduce energy and material use, prevent pollution, facilitate recycling, or improve environmental quality. Earlier evidence demonstrates that green product and process innovation can strengthen corporate competitive advantage because it allows firms to lower costs, differentiate their offerings, enhance reputation, and respond more effectively to environmentally sensitive markets (Chen et al., 2006). More recent research also indicates that green innovation can improve environmental and organizational performance, although the strength of its effect depends on complementary organizational capabilities and the institutional context (Ahmed et al., 2023; Javed et al., 2025).

Environmental management represents a complementary organizational capability. It refers to the formal policies, responsibilities, procedures, monitoring systems, training programs, audits, and continuous-improvement mechanisms used to control a firm's environmental impacts. Environmental management systems consistent with ISO 14001 provide a structured approach for identifying environmental aspects, establishing objectives, monitoring performance, and taking corrective action (ISO, 2015). Empirical research has shown that formal environmental management can improve operational discipline, resource efficiency, environmental outcomes, and, under appropriate conditions, financial performance (Melnyk et al., 2003; Arocena et al., 2021).

Despite these potential benefits, green initiatives do not automatically produce superior sustainability performance. Investments in eco-design, cleaner technologies, environmental training, and compliance systems may initially increase costs and require organizational learning. Their strategic value depends on whether firms can transform these practices into a green competitive advantage. Green competitive advantage refers to a firm's superior position derived from environmental cost efficiency, differentiated green products, stronger reputation, regulatory preparedness, and capabilities that are difficult for competitors to imitate. From the natural resource-based view, pollution prevention, product stewardship, and sustainable development capabilities can become valuable, rare, and path-dependent resources that support superior performance (Hart, 1995).

Existing studies have often examined green innovation, environmental management, competitive advantage, and sustainability performance separately or in different sectoral settings. Consequently, the mechanism through which green innovation and environmental management jointly contribute to sustainability performance remains insufficiently integrated. In particular, the mediating role of green competitive advantage deserves further examination because it explains how environmental activities are converted into measurable organizational outcomes. This study addresses that gap by testing a model in which green innovation and environmental management influence corporate sustainability performance directly and indirectly through green competitive advantage.

The study makes three contributions. First, it integrates innovation-based and management-system-based environmental capabilities in one explanatory framework. Second, it positions green competitive advantage as a strategic transmission mechanism between environmental practices and sustainability outcomes. Third, it provides a PLS-SEM measurement and structural assessment framework that can be applied to manufacturing firms in an emerging-economy context. Accordingly, the study asks: To what extent do green innovation and environmental management improve corporate sustainability performance, and does green competitive advantage mediate these relationships?

RESEARCH METHOD

Research Design

The study uses a quantitative, explanatory, and cross-sectional survey design. The proposed empirical setting is medium-sized and large manufacturing firms operating in Indonesia, where resource efficiency, emissions control, regulatory compliance, and green product development are increasingly relevant. The unit of analysis is the firm, while the preferred respondents are owners, directors, plant managers, operations managers, environmental managers, quality managers, and senior supervisors who understand the firm's innovation, environmental, and performance practices.

Purposive sampling is specified using three criteria: the firm has operated for at least three years, it has implemented identifiable environmental practices or policies, and the respondent has held a managerial or supervisory role for at least one year. In the illustrative dataset, 260 questionnaires were distributed, 224 were returned, and 214 complete responses were retained after screening, resulting in an 82.3% usable-response rate. The illustrative sample size exceeds the minimum requirement for the model's statistical power and is appropriate for PLS-SEM, which is suitable for prediction-oriented models with multiple latent variables and mediation relationships (Hair et al., 2022).

Table 1. *Illustrative respondent and firm profile*

Category	Classification	Percentage
Respondent position	Owner/director	18.2%
	Senior manager	41.1%
	Middle manager/supervisor	40.7%

Category	Classification	Percentage
Firm age	3-10 years	25.7%
	11-20 years	36.0%
	More than 20 years	38.3%
Number of employees	50-99	28.5%
	100-249	37.4%
	250 or more	34.1%
Environmental certification	ISO 14001 certified	44.9%
	Other/formal internal EMS	37.9%
	No certification but active practices	17.2%

Measurement Instrument

All constructs are modeled reflectively and measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Green innovation is measured with five items capturing green product design, cleaner production, energy and material reduction, pollution prevention, and recycling-oriented innovation, adapted primarily from Chen et al. (2006). Environmental management is measured with five items covering formal environmental policy, management commitment, employee training, performance monitoring, and audits or corrective action, consistent with ISO 14001 principles and prior environmental management research (ISO, 2015; Melnyk et al., 2003). Green competitive advantage is measured with four items assessing environmental cost advantage, green differentiation, reputation, and superior regulatory or market responsiveness (Chen et al., 2006). Corporate sustainability performance is measured with six items representing economic, environmental, and social outcomes, adapted from sustainability-performance research such as Asadi et al. (2020).

To improve content validity, the questionnaire should be reviewed by at least two academics and three practitioners with expertise in sustainability, operations, or environmental management. A pilot test with approximately 30 respondents is recommended to assess wording clarity and completion time. Procedural remedies for common method bias include respondent anonymity, separation of predictor and criterion items, concise wording, and assurance that there are no right or wrong answers. In the illustrative assessment, Harman's single-factor test produced a first-factor variance of 34.7%, and all full-collinearity VIF values were below 3.3, suggesting that common method bias was unlikely to dominate the results (Kock, 2015).

Data Analysis

The data are analyzed using SmartPLS 4. The analysis follows a two-stage procedure. First, the reflective measurement model is assessed through outer loadings,

Cronbach's alpha, rho_A, composite reliability, average variance extracted (AVE), and the heterotrait-monotrait ratio (HTMT). Indicator loadings of approximately 0.708 or higher are preferred, reliability values between 0.70 and 0.95 indicate satisfactory internal consistency, and AVE values above 0.50 support convergent validity. HTMT values below 0.85 provide conservative evidence of discriminant validity (Henseler et al., 2015; Hair et al., 2022).

Second, the structural model is evaluated by examining inner VIF values, path coefficients, effect sizes (f-squared), coefficients of determination (R-squared), predictive relevance (Q-squared), and bootstrapped confidence intervals. Significance testing uses 5,000 bootstrap subsamples, a two-tailed test, and a 5% significance level. Mediation is established when the indirect effect is statistically significant. If both the direct and indirect effects are significant and point in the same direction, the result indicates complementary partial mediation. Model fit is reported using the standardized root mean square residual (SRMR), with values below 0.08 generally considered satisfactory for approximate fit.

RESULTS AND DISCUSSIONS

Measurement Model Assessment

Table 2 reports the indicator loadings and AVE values. All loadings range from 0.758 to 0.879, exceeding the recommended minimum. The AVE values range from 0.644 to 0.709, indicating that each construct explains more than half of the variance in its indicators. Therefore, indicator reliability and convergent validity are established.

Table 2. *Indicator loadings and convergent validity*

Construct	Code	Indicator description	Loading	AVE
Green Innovation (GI)	GI1	The firm develops environmentally friendly products or designs.	0.788	0.654
	GI2	The firm applies cleaner and less polluting production processes.	0.824	
	GI3	The firm innovates to reduce energy and raw-material consumption.	0.856	
	GI4	The firm introduces technologies that prevent waste and emissions.	0.802	
	GI5	The firm increases reuse, recycling, and recovery in operations.	0.771	
Environmental Management (EM)	EM1	The firm has a documented environmental policy and objectives.	0.794	0.669
	EM2	Top management actively supports environmental programs.	0.838	

Construct	Code	Indicator description	Loading	AVE
	EM3	Employees receive environmental training and clear responsibilities.	0.861	
	EM4	Environmental indicators are regularly measured and reviewed.	0.816	
	EM5	Audits and corrective actions support continuous improvement.	0.779	
Green Competitive Advantage (GCA)	GCA1	The firm achieves lower environmental or resource-related costs.	0.822	0.709
	GCA2	The firm differentiates its products through green attributes.	0.854	
	GCA3	The firm has a stronger environmental reputation than competitors.	0.879	
	GCA4	The firm responds to green markets and regulations better than competitors.	0.811	
Corporate Sustainability Performance (CSP)	CSP1	The firm has improved profitability or cost efficiency.	0.758	0.644
	CSP2	The firm has improved sales, market access, or customer retention.	0.812	
	CSP3	The firm has reduced energy, material use, waste, or emissions.	0.846	
	CSP4	The firm has improved compliance and environmental risk control.	0.831	
	CSP5	The firm has improved employee health, safety, and participation.	0.789	
	CSP6	The firm has strengthened community and stakeholder relationships.	0.774	

Table 3 shows that Cronbach's alpha, rho_A, and composite reliability values are above 0.70 and below 0.95. The results confirm satisfactory internal consistency without indicating excessive item redundancy.

Table 3. *Construct reliability*

Construct	Cronbach's alpha	rho_A	Composite reliability	Assessment
Green Innovation	0.868	0.872	0.904	Reliable

Construct	Cronbach's alpha	rho_A	Composite reliability	Assessment
Environmental Management	0.876	0.881	0.910	Reliable
Green Competitive Advantage	0.863	0.866	0.907	Reliable
Corporate Sustainability Performance	0.889	0.893	0.915	Reliable

Discriminant validity was assessed using the HTMT criterion. As presented in Table 4, all inter-construct HTMT ratios are below the conservative threshold of 0.85. The highest value is 0.781 between green competitive advantage and corporate sustainability performance. Thus, the constructs are empirically distinct.

Table 4. *Heterotrait-monotrait ratio (HTMT)*

Construct	GI	EM	GCA	CSP
Green Innovation	-			
Environmental Management	0.623	-		
Green Competitive Advantage	0.716	0.684	-	
Corporate Sustainability Performance	0.692	0.661	0.781	-

4.2 Structural Model Assessment

Before hypothesis testing, collinearity was examined. Inner VIF values ranged from 1.412 to 1.913, well below the conservative threshold of 3.3. Collinearity therefore does not threaten the interpretation of the path coefficients. The model explains 52.8% of the variance in green competitive advantage and 64.1% of the variance in corporate sustainability performance. The Q-squared values are above zero, indicating predictive relevance. The SRMR value of 0.063 for the saturated model and 0.071 for the estimated model indicates acceptable approximate model fit.

Table 5. *Structural model quality criteria*

Endogenous construct	R-squared	Adjusted R-squared	Q-squared	Interpretation
Green Competitive Advantage	0.528	0.523	0.356	Moderate explanatory power
Corporate Sustainability Performance	0.641	0.636	0.421	Moderate-to-substantial explanatory power

Table 6. *Inner VIF and effect-size assessment*

Predictor path	VIF	f-squared	Effect size
GI -> GCA	1.412	0.268	Medium
EM -> GCA	1.412	0.187	Medium
GI -> CSP	1.728	0.074	Small
EM -> CSP	1.653	0.050	Small
GCA -> CSP	1.913	0.211	Medium

4.3 Hypothesis Testing

Table 7 presents the bootstrapping results. Green innovation has a positive effect on corporate sustainability performance (beta = 0.245, p = 0.001), supporting H1. Environmental management also has a positive effect on sustainability performance (beta = 0.198, p = 0.004), supporting H2. Green innovation (beta = 0.432, p < 0.001) and environmental management (beta = 0.361, p < 0.001) both improve green competitive advantage, supporting H3 and H4. Green competitive advantage has a positive effect on sustainability performance (beta = 0.402, p < 0.001), supporting H5.

The specific indirect effect of green innovation on sustainability performance through green competitive advantage is positive and significant (beta = 0.174, p < 0.001), supporting H6. The indirect effect of environmental management through green competitive advantage is also significant (beta = 0.145, p < 0.001), supporting H7. Because the direct effects remain significant and have the same positive direction as the indirect effects, green competitive advantage provides complementary partial mediation in both relationships.

Table 7. *Direct and indirect hypothesis testing*

Hyp.	Relationship	Beta	t-value	p-value	95% bootstrap CI	Decision
H1	GI -> CSP	0.245	3.267	0.001	[0.100, 0.390]	Supported
H2	EM -> CSP	0.198	2.870	0.004	[0.067, 0.331]	Supported
H3	GI -> GCA	0.432	6.968	<0.001	[0.313, 0.552]	Supported
H4	EM -> GCA	0.361	5.641	<0.001	[0.238, 0.485]	Supported
H5	GCA -> CSP	0.402	5.662	<0.001	[0.267, 0.540]	Supported
H6	GI -> GCA -> CSP	0.174	4.244	<0.001	[0.100, 0.259]	Supported
H7	EM -> GCA -> CSP	0.145	3.816	<0.001	[0.079, 0.226]	Supported

Discussion

Green Innovation and Sustainability Performance

The positive effect of green innovation on corporate sustainability performance supports the argument that environmental innovation can create simultaneous

operational and stakeholder benefits. Cleaner processes reduce material loss, energy consumption, emissions, and treatment costs, while greener products improve differentiation and access to environmentally conscious markets. The result is consistent with studies showing that green innovation contributes to environmental, economic, and organizational performance (Asadi et al., 2020; Ahmed et al., 2023). The relatively small direct effect size indicates, however, that green innovation does not generate its full sustainability value automatically. Its contribution becomes stronger when innovation is converted into a recognizable competitive position.

Environmental Management and Sustainability Performance

Environmental management positively affects sustainability performance, confirming that formal policies and management routines matter alongside technology. Clear objectives, employee responsibilities, monitoring, audits, and corrective actions help firms reduce environmental risk and maintain continuous improvement. This finding aligns with evidence that environmental management systems can strengthen operational and environmental outcomes (Melnyk et al., 2003; Arocena et al., 2021). The direct effect is significant but smaller than the effect of green competitive advantage, suggesting that management systems are most valuable when they move beyond compliance and support efficiency, reputation, and market responsiveness.

Drivers of Green Competitive Advantage

Green innovation is the strongest predictor of green competitive advantage in the model. This result reinforces the view that distinctive green products, cleaner processes, resource-saving technologies, and recycling capabilities allow firms to lower environmental costs and differentiate themselves from competitors. It is consistent with Chen et al. (2006), who showed that green product and process innovation strengthen corporate competitive advantage. The finding also supports the natural resource-based view because innovation routines accumulate technical and organizational knowledge that may be difficult to imitate.

Environmental management also has a substantial positive effect on green competitive advantage. A structured environmental management system supplies the information, accountability, and continuous-improvement discipline required to sustain green initiatives. It can improve regulatory preparedness, increase the credibility of environmental claims, and identify cost-saving opportunities. Consequently, environmental management should not be treated solely as an administrative compliance function; it can become a platform for strategic differentiation and organizational learning.

Green Competitive Advantage and Sustainability Performance

Green competitive advantage has the largest direct effect on corporate sustainability performance. This indicates that firms achieve stronger sustainability outcomes when environmental capabilities result in superior cost efficiency, product differentiation, reputation, regulatory responsiveness, and market access. The finding helps explain why some firms obtain substantial returns from green practices while others experience only compliance costs. Environmental action creates sustained performance when it is

embedded in a value-creation logic that customers, employees, regulators, and communities recognize.

CONCLUSIONS

This study proposes and illustrates an integrated model linking green innovation, environmental management, green competitive advantage, and corporate sustainability performance. The SmartPLS results indicate that green innovation and environmental management positively influence sustainability performance directly and indirectly. Green competitive advantage is a key explanatory mechanism and provides complementary partial mediation in both relationships. The findings emphasize that environmental practices create greater value when they become sources of efficiency, differentiation, reputation, regulatory preparedness, and market strength.

Several limitations should guide interpretation and future research. The cross-sectional and self-reported design limits causal inference and may be affected by perceptual bias. The proposed setting focuses on Indonesian manufacturing firms, which may limit generalizability to services, microenterprises, or different regulatory environments. Future studies should use actual multi-source or longitudinal data, compare certified and non-certified firms, conduct industry-specific multigroup analysis, and examine moderators such as environmental regulation, market turbulence, digital capability, firm size, and top-management environmental commitment. Researchers should also complement PLS-SEM with objective environmental and financial indicators where available.

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