Bangladesh Journal of administration and Management
Volume 38, Issue 1, July-December-2025
DOI: 10.56379/bjam.V38i1.103;ISSN 1811-5195
https://journal.bcsadminacademy.gov.bd/index.php/bjam

Green Innovation and Sustainable Competitive Advantage: Evidence from Manufacturing Firms in Bangladesh

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Abstract

Environmental pressures and evolving buyer requirements are compelling manufacturing firms in emerging economies to integrate sustainability into their competitive strategies. In Bangladesh, however, empirical evidence on how different types of green innovation shape sustainable competitive advantage (SCA) remains limited. This study examines how three dimensions of green innovation, such as green product, process, and technology innovation, affect SCA among Bangladeshi manufacturing firms, drawing on the Natural Resource-Based View (NRBV). A quantitative cross-sectional survey was administered to 180 manufacturing firms, yielding 164 fully completed responses from managers knowledgeable about innovation and sustainability practices. Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) in SmartPLS 4.0, with reliability, convergent and discriminant validity, model fit, and structural paths rigorously assessed. Green product innovation has a positive and statistically significant effect on SCA, whereas green process and green technology innovations exhibit non-significant relationships with SCA. Model fit indices (e.g., SRMR, NFI) indicate an acceptable overall model. The findings suggest that market-visible, eco-friendly product initiatives are currently the most effective route to sustainable competitiveness in Bangladesh's manufacturing sector. Managers should prioritise green product innovation, while policymakers design financial and technical support mechanisms to deepen process and technology capabilities, enabling a gradual shift from compliance-driven to strategically embedded green innovation.

1. Introduction

In recent years, environmental challenges have increasingly shaped how businesses operate, particularly in developing nations striving to balance growth with sustainability (Maziriri & Maramura, 2022). The manufacturing sector of Bangladesh now faces mounting pressure to adopt practices that reduce ecological harm while maintaining profitability (Emon & Khan, 2024). Additionally, rising global awareness of climate change, stringent buyer requirements, and evolving government policies have collectively urged firms to rethink traditional production models (Maziriri & Maramura, 2022). As a result, sustainability has moved from a peripheral concern to a strategic priority (Tu & Wu, 2021). Yet, in this context of change, the question remains: how can Bangladeshi firms remain competitive while aligning with green and sustainable practices?

Green innovation is conceptualised as product, process, and technological advancements designed to minimise environmental impact (Karimi Takalo et al., 2021). It has emerged as a promising pathway to competitiveness (Hayat & Qingyu, 2024). In emerging economies, where resource constraints are acute and markets are cost-sensitive, adopting environmentally responsible innovations can serve multiple purposes (Gao et al., 2021). It not only enhances reputation among international buyers but also improves efficiency and long-term resilience (Umair Anwar et al., 2025). For Bangladesh, which aspires to sustain export-led growth amid tightening environmental standards, green innovation is no longer optional; it is becoming a prerequisite for market access and industrial survival (Emon & Khan, 2024).

Despite growing awareness, empirical research connecting green innovation and sustainable competitive advantage within the Bangladeshi context remains limited. Most existing studies have concentrated on developed economies or treated green innovation as a single, undifferentiated construct (Liu, 2024). Few have explored how the different forms of innovation product, process, and technology uniquely contribute to a firm's sustained competitive advantage. Additionally, developing economies like Bangladesh have significantly different regulatory, cultural and financial contexts (Emon & Khan, 2024). Consequently, the findings of the developed world cannot be readily applied to the firms of emerging economies. This gap leaves both policymakers and managers without clear evidence of which types of innovation truly drive competitiveness in the firms of Bangladesh.

Therefore, the main objective of this study is to examine how green product, process, and technology innovations influence sustainable competitive advantage among manufacturing firms in Bangladesh. The study draws on the Natural Resource-Based View (NRBV) (Hart, 1995). The NRBV theory posits that environmentally oriented capabilities can become valuable and inimitable resources that sustain superior performance over time (Hart, 1995). Guided by this perspective, the research seeks to answer the following question:

How do green product, process, and technology innovations affect sustainable competitive advantage among manufacturing firms in Bangladesh?

This study contributes to both theory and practice by empirically examining how green innovations drive sustainable competitive advantage in Bangladesh's manufacturing sector. It extends the NRBV theory by illustrating its applicability to an emerging-economy context. Additionally, it offers practical insights for managers to gain a sustainable competitive advantage while investing in green innovations. Further, the study benefits the policy makers in designing policies that truly contribute the business growth while ensuring green innovation for protecting the environment and promoting the sustainability agenda. The study supports the achievement of the United Nations' Sustainable Development Goals (SDGs), particularly SDG 9, SDG 12, and SDG 13, by promoting innovation that advances responsible production and climate action.

To achieve this goal, the paper is structured as follows. The next section reviews the relevant literature and develops the hypotheses. Section three outlines the research methodology. The subsequent section presents the results and interprets key findings. The final section concludes with theoretical and managerial implications, as well as suggestions for future research.

2. Literature Review and Hypothesis Development

2.1 Green Innovation

Green innovation refers to the introduction of new products, processes, or technologies that reduce environmental harm while sustaining business performance (Umair Anwar et al., 2025). Scholars generally view green innovation as an extension of traditional innovation that integrates ecological concerns into corporate strategy (Hayat & Qingyu, 2024). Researchers often distinguish between three key dimensions such as green product innovation, green process innovation, and green technology innovation (Karimi Takalo et al., 2021).

Green product innovation emphasises designing or modifying products to minimise resource consumption and waste generation (Bergfors & Larsson, 2009). Green process innovation involves improving production and operational activities to reduce emissions, water use, and waste, often resulting in cost efficiency and compliance with environmental standards (Khan et al., 2021). Meanwhile, green technology innovation focuses on developing or adopting technologies such as renewable energy systems, emission control devices, and digital monitoring tools that help organisations meet sustainability goals (Schiederig et al., 2012). Collectively, these forms of innovation enable firms to enhance environmental performance while responding to growing regulatory, consumer, and market pressures.

2.2 Sustainable Competitive Advantage

Sustainable Competitive Advantage (SCA) refers to a firm's ability to maintain superior performance over time through the possession of valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). In today's context, competitive advantage extends beyond efficiency or cost leadership (Maziriri & Maramura, 2022). It encompasses reputation, innovation, and environmental stewardship (Hayat & Qingyu, 2024). Firms that integrate sustainability into their operations often gain legitimacy among stakeholders and secure long-term growth (Umair Anwar et al., 2025).

2.3 Theoretical Underpinnings

This study is grounded in the Natural Resource-Based View (NRBV) (Hart, 1995), which extends the classical Resource-Based View (RBV) (Barney, 1991) by emphasising the strategic value of environmental capabilities. NRBV argues that a firm's long-term success increasingly depends on pollution prevention, product stewardship, and sustainable development (Hart, 1995). Within this framework, green innovation represents a key capability that allows firms to transform ecological pressures into strategic opportunities (Lau and Wong, 2024). By integrating environmental considerations into product design, production processes, and technology adoption, firms develop resources that are valuable, difficult to imitate, and aligned with emerging market expectations (Makhloufi et al., 2022).

While RBV highlights the importance of valuable and inimitable resources, it offers limited guidance on how firms respond to environmental challenges. NRBV is therefore more appropriate for this study, particularly in the context of Bangladesh, where manufacturing firms face rising ecological compliance demands from global buyers and local regulators (Rakin, S.R. et al. 2020).

2.4 Hypotheses Development

Drawing on the NRBV, it is proposed that firms pursuing green innovation are better positioned to achieve sustainable competitive advantage. Green product innovation can enhance brand reputation, satisfy environmentally conscious customers, and open new market opportunities (Maziriri & Maramura, 2022). Green process innovation contributes to operational efficiency, waste reduction, and regulatory compliance (Khan et al., 2021). Green technology innovation, meanwhile, allows firms to modernise their production base and build resilience against environmental and resource-related risks (Gao et al., 2021).

Accordingly, the following hypotheses are formulated:

H1: Green innovation positively affects sustainable competitive advantage among manufacturing firms in Bangladesh.

H1a: Green product innovation positively influences sustainable competitive advantage.

H1b: Green process innovation positively influences sustainable competitive advantage.

H1c: Green technology innovation positively influences sustainable competitive advantage.

Based on the discussion and the theoretical underpinnings from the extant scholarship, this study develops the following conceptual framework.

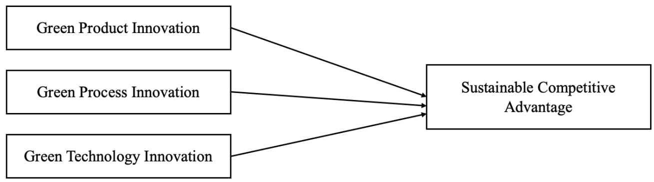

Figure 1. Conceptual Framework

The research framework consists of four main constructs: Green Product Innovation, Green Process Innovation, Green Technology Innovation, and Sustainable Competitive Advantage. Each construct was measured using multi-item reflective indicators adapted from well-established studies (Gao et al., 2021; Khan et al., 2021; Umair Anwar et al., 2025). In the figure-1, green innovation represents the independent variable, and the sustainable competitive advantage represents the dependent variable.

3. Research Methodology

3.1 Research Design

This study employed a quantitative, cross-sectional research design to examine how green innovation influences sustainable competitive advantage among manufacturing firms in Bangladesh. The survey method was chosen because it enables efficient data collection from a larger number of firms and provides a suitable basis for statistical analysis using the Partial Least Squares Structural Equation Modelling (PLS-SEM) approach (J. Hair & Alamer, 2022). The model was analysed using SmartPLS 4.0, which is appropriate for predictive and exploratory research models with multiple latent constructs.

3.2 Population, Sampling, and Data Collection

The target population comprised manufacturing firms operating in Bangladesh, including those from the textile, apparel, food processing, and light engineering sectors. These industries were selected due to their growing exposure to environmental regulations, export market demands, and sustainability pressures.

A purposive sampling technique was applied to ensure that respondents had sufficient knowledge about their firms' innovation practices and sustainability strategies. A total of 180 structured questionnaires were distributed both in person. Out of these, 164 fully completed responses were returned, yielding a response rate of approximately 91. Further, to assess the adequacy of the sample size, the 10-times rule was applied (J. F. Hair et al., 2019).

According to this guideline, the minimum sample should be at least ten times the largest number of structural paths directed toward a latent construct in the model (Priyanath et al., 2020). In this study, the dependent construct (Sustainable Competitive Advantage) received three paths from the independent constructs (Green Product, Process, and Technology Innovation). Therefore, the minimum recommended sample size was 10 × 3 = 30. The obtained sample of 164 responses comfortably exceeds this requirement, confirming that the data are adequate for PLS-SEM analysis and provide sufficient statistical power.

3.3 Measurement of Constructs

All measurement items were adapted from prior validated studies and slightly rephrased to fit the Bangladeshi context. Respondents rated each statement on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

Table 1. Operationalising the constructs.

Construct	Example Measurement Items	Sources
Green Product Innovation (GIN)	Our products are designed to minimise environmental impact . We use recyclable or biodegradable materials. Our packaging reduces waste.	Liu, L. 2024
Green Process Innovation (GPr)	Our production processes reduce emissions and waste. We use energy-efficient technologies. Our firm complies with environmental standards.	Gao, Y., Sun, Y. et al. 2021
Green Technology Innovation (GT)	We have adopted renewable energy systems. We use pollution -control and waste -recycling technologies. We invest in digital tools for environmental monitoring.	Hayat, K., & Qingyu, Z. 2024
Sustainable Competitive Advantage (SCA)	Our sustainability efforts enhance brand reputation. Our operations achieve long-term cost efficiency. We maintain superior performance compared to competitors.	Liu, L. 2024; Hayat, K., & Qingyu, Z. 2024

3.4 Reliability and Validity Tests

The measurement model was evaluated to ensure the reliability and validity of the constructs (J. Hair & Alamer, 2022). Internal consistency was examined using Cronbach's Alpha (α) and Composite Reliability (CR), with both metrics compared against the recommended threshold of 0.70 (J. F. Hair et al., 2019). Additionally, convergent validity was assessed through the Average Variance Extracted (AVE), where values greater than 0.50 were considered acceptable (Priyanath et al., 2020). Furthermore, discriminant validity was tested using the Fornell–Larcker criterion, Heterotrait–Monotrait (HTMT) ratio, and cross-loadings (Ab Hamid et al., 2017).

The Fornell–Larcker criterion compared the square root of AVE with the correlations among constructs, while the HTMT ratio evaluated inter-construct correlations with a cut-off value of 0.85 (Fornell & Larcker, 1981). Moreover, cross-loadings were examined to confirm that each indicator's loading on its associated construct exceeded its loadings on other constructs (Harlow, 2023). These assessments followed established guidelines for evaluating measurement quality in PLS-SEM (J. F. Hair et al., 2019).

3.5 Model Evaluation and Hypothesis Testing

The relationships among the study constructs were examined through the structural model analysis in SmartPLS. Path coefficients were estimated and evaluated using a bootstrapping procedure with 5,000 resamples, which provided robust estimates of standard errors and significance levels (J. Hair & Alamer, 2022). For each hypothesised path, the Original Sample (O), Sample Mean (M), Standard Deviation (STDEV), T-statistics (|O/STDEV|), and P-values were used to assess the direction, magnitude, and statistical significance of the hypothesised relationships (J. F. Hair et al., 2020). A p-value less than 0.05 was considered statistically significant, indicating support for the corresponding hypothesis (Christopher Westland, 2010).

The overall fit of the structural model was assessed using several model fit indices generated by SmartPLS, including the Standardised Root Mean Square Residual (SRMR), d_ULS, d_G, Chi-square, and the Normed Fit Index (NFI) (J. Hair & Alamer, 2022). The Saturated Model and Measurement Model were both examined to evaluate the consistency between the observed and predicted covariance matrices (J. F. Hair et al., 2019). The SRMR was used as a primary indicator of model fit, while d_ULS and d_G provided additional measures of discrepancy (Harlow, 2023). The Chi-square and NFI values were also reviewed to assess the degree to which the proposed model reproduced the empirical data structure (Priyanath et al., 2020).

3.6 Ethical Considerations

Ethical integrity was maintained throughout every stage of the research process to ensure transparency, confidentiality, and voluntary participation. Before data collection, all respondents were informed about the purpose of the study, the confidential nature of their responses, and their right to withdraw at any point without justifying. Participation was entirely voluntary, and no incentives were offered to influence responses.

Respondents were assured that the information provided would be used solely for academic and research purposes. Personal and company details of the respondents will be kept secret. The study followed the ethical guidelines of social science research, aligning with the standards of the Declaration of Helsinki and institutional ethical norms. All data were securely stored, accessible only to the researcher, and handled in a way that ensured data integrity, privacy, and respect for participants' professional confidentiality.

4. Results and Discussion

4.1 Measurement Model Evaluation

Before examining the hypothesised relationships among the constructs, a comprehensive evaluation of the measurement model was conducted to ensure the reliability, validity, and overall robustness of the instruments used in the study. Assessing the measurement model is an essential preliminary step in Partial Least Squares Structural Equation Modelling (PLS-SEM) (J. F. Hair et al., 2020). The measurement model determines whether the observed variables adequately represent the latent constructs before proceeding to test the structural relationships (Priyanath et al., 2020).

In Table 2, all constructs demonstrated Cronbach's alpha (α) and Composite Reliability (CR) values well above the recommended threshold of 0.70, thereby confirming the internal consistency of the scales (J. F. Hair et al., 2019).

Table 2. Construct Reliability and Validity of the Measurement Model

	Cronbach's alpha	**Composite reliability (rho_a)**	**Composite reliability (rho_c)**	**Average variance extracted (AVE)**
GIN	0.847	0.882	0.895	0.682
GPr	0.891	0.962	0.932	0.821
GT	0.799	0.906	0.875	0.702
SCA	0.934	0.948	0.953	0.834

The Cronbach's alpha values ranged between 0.799 and 0.934, while the composite reliability (CR) values ranged from 0.882 to 0.962, indicating that the indicators within each construct are highly interrelated and measure the same underlying concept (Harlow, 2023). Furthermore, the Average Variance Extracted (AVE) values for all constructs were above 0.50, with the lowest being 0.682 and the highest reaching 0.834. This demonstrates that more than 50 per cent of the variance in each construct is explained by its respective indicators, thereby establishing convergent validity (Priyanath et al., 2020). These results collectively indicate that the measurement items possess adequate reliability and that each construct captures a substantial proportion of variance from its indicators.

In addition to assessing reliability and convergent validity, the discriminant validity of the constructs was examined to ensure that they are empirically distinct, and measure separate theoretical concepts. Discriminant validity was assessed using both the Fornell–Larcker criterion (Table 3) and the Heterotrait–Monotrait (HTMT) ratio of correlations (Table 4), which are widely recognised in the PLS-SEM literature for evaluating construct distinctiveness (Fornell & Larcker, 1981).

Table 3. Discriminant Validity – Fornell–Larcker Criterion

	GIN	**GPr**	**GT**	**SCA**
GIN	0.826			
GPr	-0.215	0.906		
GT	0.408	-0.177	0.838	
SCA	0.331	-0.083	0.170	0.913

According to Table 3, the square roots of AVE values (displayed along the diagonal) are greater than the inter-construct correlations, fulfilling the Fornell–Larcker criterion (Fornell & Larcker, 1981). This confirms that each construct shares more variance with its indicators than with other constructs in the model. This outcome provides strong evidence that the constructs are theoretically unique and empirically distinguishable from one another.

The HTMT ratios, presented in Table 4, further support this finding. All HTMT values are below the conservative threshold of 0.85, indicating that the constructs do not exhibit multicollinearity or conceptual overlap (Priyanath et al., 2020).

Table 4. Discriminant Validity – Heterotrait–Monotrait (HTMT) Matrix

	GIN	**GPr**	**GT**	**SCA**
GIN				
GPr	0.240			
GT	0.488	0.229		
SCA	0.352	0.095	0.176	

Values below this cut-off point confirm that respondents were able to differentiate among the various dimensions of green innovation—namely product, process, and technology innovation—as well as sustainable competitive advantage. This reinforces the notion that each construct captures a distinct aspect of firms' environmental innovation behaviour and competitiveness.

To further validate the discriminant integrity of the model, the cross-loadings of individual indicators were examined. As shown in Table 5, each indicator loaded more strongly on its corresponding construct than on any other construct, satisfying the requirement of indicator-level discriminant validity (Ab Hamid et al., 2017).

Table 5. Cross-Loadings of Measurement Items

	GIN	**GPr**	**GT**	**SCA**
GIN1	0.739	-0.144	0.346	0.167
GIN2	0.887	-0.187	0.326	0.313
GIN3	0.825	-0.171	0.371	0.247
GIN4	0.845	-0.197	0.330	0.322
GPr1	-0.185	0.827	-0.246	-0.059
GPr2	-0.223	0.956	-0.145	-0.094
GPr3	-0.167	0.931	-0.111	-0.065
GT1	0.305	-0.147	0.763	0.083
GT2	0.283	-0.214	0.841	0.127
GT3	0.412	-0.111	0.903	0.186
SCA1	0.242	0.012	0.092	0.863
SCA2	0.338	-0.097	0.174	0.926
SCA3	0.309	-0.130	0.159	0.929
SCA4	0.307	-0.067	0.182	0.933

Items under Green Product Innovation (GIN1–GIN4) loaded substantially higher on their intended construct than on other latent variables. This indicates that each item is conceptually aligned and statistically appropriate. Similarly, all items measuring Green Process Innovation (GPr1–GPr3), Green Technology Innovation (GT1–GT3), and Sustainable Competitive Advantage (SCA1–SCA4) exhibited strong and clean loadings, demonstrating that none of the indicators displayed problematic cross-loadings.

Collectively, the results from these tests internal consistency reliability, convergent validity, and discriminant validity confirm that the measurement model exhibits satisfactory psychometric properties. The reliability indices confirm the stability and consistency of the indicators. Additionally, the validity assessments verify both the internal coherence and distinctiveness of the constructs. These findings provide confidence that the measurement model is statistically sound and conceptually valid, establishing a solid foundation for evaluating the hypothesised structural relationships in the subsequent analysis.

4.2 Structural Model Evaluation and Hypothesis Testing

After confirming measurement adequacy, the structural model was analysed to examine the causal relationships between the three dimensions of green innovation and sustainable competitive advantage. The results, summarised in Table 6 and visualised in Figure 2, reveal that only one of the hypothesised relationships was statistically significant.

Table 6. Structural Model Results and Hypotheses Testing

	Original sample (O)	**Sample mean (M)**	**(STDEV)**	**T statistics (|O/STDEV|)**	**P values**
GIN -> SCA	0.313	0.310	0.074	4.202	0.000
GPr -> SCA	-0.009	-0.018	0.098	0.092	0.926
GT -> SCA	0.041	0.062	0.070	0.590	0.555

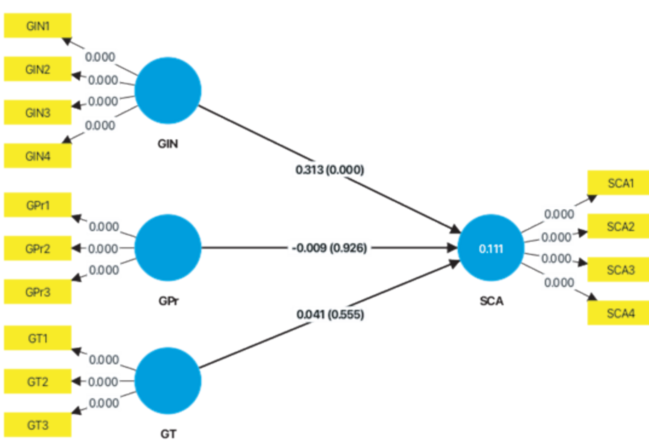

Figure 2. Structural Model

Specifically, Green Product Innovation → Sustainable Competitive Advantage ($\beta = 0.310$, $t = 4.202$, $p < 0.001$) showed a strong and positive relationship, thus supporting H1a. This finding indicates that firms introducing environmentally friendly products such as recyclable packaging, energy-efficient materials, or biodegradable product designs gain tangible competitive benefits. Green product innovation not only enhances firms’ reputation and compliance with environmental standards but also helps attract environmentally conscious consumers and export buyers (Karimi Takalo et al., 2021). The finding aligns with previous studies (Umair Anwar et al., 2025), which argue that eco-innovation at the product level contributes directly to brand differentiation and long-term profitability.

In contrast, the relationships between Green Process Innovation ($\beta = -0.018$, $t = 0.092$, $p = 0.926$) and Green Technology Innovation ($\beta = 0.062$, $t = 0.590$, $p = 0.555$) with Sustainable Competitive Advantage were not statistically significant, leading to the rejection of H1b and H1c.

The slight negative but non-significant coefficient for green process innovation suggests that process-level improvements such as cleaner production methods, waste minimisation, and energy-efficient machinery may not yet translate into competitive gains (Liu, 2024). In Bangladesh, many firms pursue process innovations primarily for compliance rather than strategic differentiation (Khan et al., 2021). The high installation and operating costs of effluent treatment plants (ETPs), unreliable electricity infrastructure, and limited technical expertise often make process innovations burdensome rather than value-enhancing (Liu, 2024). These structural constraints may reduce the immediate performance benefits of process innovations, which helps explain the marginal negative coefficient observed.

4.3 Model Fit and Predictive Relevance

The overall quality of the structural model was evaluated through several model fit indices presented in Table 7.

Table 7. Model Fit Indices of the Structural Model

Indicator	Saturated Model	Estimated Model	Interpretation
SRMR	0.059	0.059	Acceptable (< 0.08)
d_ULS	0.36	0.36	Acceptable
d_G	0.221	0.221	Acceptable
Chi-square	226.196	226.196	Acceptable
NFI	0.848	0.848	Marginal but acceptable

The Standardised Root Mean Square Residual (SRMR) value of 0.059 is well below the threshold of 0.08, confirming an acceptable fit between the model and the observed data (J. F. Hair et al., 2020). The Normed Fit Index (NFI) of 0.848, although slightly below the ideal benchmark of 0.90, is considered satisfactory for exploratory studies using PLS-SEM. Both the d_ULS (0.360) and d_G (0.221) values indicate minimal discrepancies between the saturated and estimated models, suggesting consistency in model specification. The Chi-square value (226.196) further supports the adequacy of the model's fit to the empirical data.

4.4 Discussion

The overall findings provide valuable insight into the emerging pattern of green innovation and competitiveness in a developing-country context. The significant impact of green product innovation underscores that firms in Bangladesh's manufacturing sector are increasingly aware of global environmental expectations and are leveraging product-related initiatives to improve market access, particularly in export-oriented industries such as textiles and ready-made garments (Emon & Khan, 2024). These firms appear to focus on "market-visible" sustainability efforts that appeal directly to international buyers and environmentally conscious consumers (Lau & Wong, 2024).

The non-significance of green process and technology innovations points to a critical developmental gap. Process-level innovation requires investment in cleaner production technologies, waste minimisation, and energy efficiency (Bergfors & Larsson, 2009). However, many Bangladeshi firms still face financial and technical barriers (Rakin et al., 2020). Similarly, the slow adoption of green technologies can be attributed to limited access to advanced equipment, insufficient institutional incentives, and a lack of collaboration between industry and research organisations (Schiederig et al., 2012). This suggests that while awareness of sustainability is growing, the capability maturity necessary for deeper environmental transformation remains limited.

In practical terms, the findings imply that Bangladeshi firms tend to prioritise environmental strategies that are visible, low-cost, and externally driven rather than those requiring long-term systemic change. Policymakers and industry associations can play a crucial role by creating enabling environments through fiscal incentives, technical training, and green financing. These initiatives encourage firms to move beyond surface-level greening toward integrated sustainability strategies.

The results also align with previous NRBV-based research emphasising that environmental initiatives become strategic only when embedded within firm capabilities and managerial culture (Hart, 1995). In this sense, green product innovation can be viewed as an entry point for sustainability-driven competitiveness, while process and technology innovation may represent the next stage of evolution toward deeper ecological integration. Future research could further explore mediating or moderating factors—such as firm size, managerial commitment, or regulatory stringency that condition the relationship between green innovation and sustainable performance.

Overall, the empirical evidence from the PLS-SEM analysis supports only one of the three specific hypotheses. The study finds that green product innovation significantly enhances sustainable competitive advantage, while green process and green technology innovations do not show significant effects. The model demonstrates acceptable fit indices and moderate explanatory power, confirming that green innovation, particularly at the product level, is an emerging strategic pathway for competitiveness in Bangladesh's manufacturing sector. These findings contribute to the growing literature on sustainability in emerging economies by emphasizing that the strategic payoffs of environmental innovation depend on contextual readiness, visibility, and capability maturity.

5. Conclusion

The primary objective of this study was to examine the effect of green innovation on sustainable competitive advantage (SCA) within the Bangladeshi manufacturing sector. Drawing on the NRBV, the research aimed to identify which types of environmentally oriented innovations truly contribute to long-term competitiveness in an emerging-economy context.

Using data from 164 valid responses collected from manufacturing firms and analysed through Partial Least Squares Structural Equation Modelling (PLS-SEM), the study confirmed that green product innovation significantly enhances sustainable competitive advantage, while green process and green technology innovations exert statistically insignificant effects. These findings suggest that visible, market-driven eco-product strategies are more effective in generating competitive value than internal process or technology innovations. Overall, the results demonstrate that the relationship between environmental practices and competitiveness is contingent upon the type and maturity of innovation capabilities within firms.

The study makes several meaningful contributions to the literature on sustainability and strategic management. First, it refines the NRBV by demonstrating that environmental resources and capabilities do not exert uniform effects on sustainable advantage. The findings show that only customer-facing, product-level green innovations translate into measurable competitive performance, while internal process and technology innovations do not yet yield similar benefits. This offers a more differentiated interpretation of NRBV, emphasising that the strategic value of environmental capabilities depends on their visibility, maturity, and alignment with market expectations in resource-constrained contexts.

Second, the study provides context-specific evidence from Bangladesh, an emerging manufacturing hub where environmental awareness is rising but organisational capabilities remain uneven. By empirically examining the multidimensional nature of green innovation, the research deepens understanding of how sustainability transitions unfold in developing economies, where firms often prioritise market-visible initiatives over capability-intensive technological or process improvements.

Finally, the study offers a modest methodological contribution by demonstrating that widely used green innovation and competitive advantage scales remain reliable and valid when applied to a resource-constrained emerging-economy context. By confirming the robustness of these measures using PLS-SEM, the study provides a useful reference point for researchers examining sustainability constructs in similar industrial settings.

From a managerial perspective, the findings indicate that green product innovation should be prioritised as an immediate strategic pathway to sustainable competitiveness. Firms can benefit by designing environmentally friendly products, investing in recyclable packaging, and promoting eco-labels that appeal to global buyers and environmentally conscious consumers. These efforts not only enhance brand image but also satisfy growing export compliance requirements, particularly in the textile and apparel sectors. Policymakers, on the other hand, can accelerate this transition by providing fiscal incentives, low-interest green loans, and technical assistance programs. Such policies will encourage firms to go beyond compliance and build systemic innovation capacity.

While the study offers valuable insights, several limitations must be acknowledged. First, the data were collected from manufacturing firms in

Bangladesh, which may limit the generalizability of results to other industries or national contexts. Future studies could extend this model to service sectors or to cross-country comparisons within South Asia to examine contextual variations. Second, the study used cross-sectional data, which captures relationships at a single point in time. Longitudinal studies would be useful to observe how the impact of green innovation evolves as firms mature in their sustainability practices. Finally, the study focused only on the direct effects of green innovation dimensions. Future research could explore mediating or moderating variables such as organisational culture, leadership commitment, stakeholder pressure, or environmental regulation intensity to uncover deeper causal mechanisms.

Overall, this study highlights that the path toward sustainable competitiveness in emerging economies begins with market-visible environmental innovation—particularly at the product level—but long-term resilience will depend on firms' ability to integrate green process and technology capabilities into their strategic core.

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