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Original Article

Technological Innovation and MSME Performance: Mediating Roles of Green Entrepreneurship and Green Marketing

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Abstract: The growing emphasis on sustainable development has encouraged micro, small, and medium enterprises (MSMEs) to integrate environmental considerations into their business strategies. However, empirical evidence is limited on how technological innovation contributes to MSME performance through sustainability-oriented mechanisms. This study aims to examine the direct effect of technological innovation on MSME performance, as well as its indirect effects through green entrepreneurship and green marketing. Using a quantitative research design, primary data were collected from MSME owners and analyzed through Structural Equation Modeling to evaluate both measurement and structural models, including mediation effects. The results indicate that technological innovation positively and significantly influences green entrepreneurship, green marketing, and MSME performance. Green marketing demonstrates a positive and significant effect on MSME performance, whereas green entrepreneurship, although positive, does not show a statistically significant direct effect. Mediation analysis reveals that both green entrepreneurship and green marketing mediate the relationship between technological innovation and MSME performance, with green marketing exhibiting a stronger mediating role. These findings suggest that technological innovation enhances performance not only directly but also by strengthening sustainability-oriented marketing and entrepreneurial practices. The study concludes that innovation capability constitutes a strategic foundation for improving MSME competitiveness, particularly when aligned with effective green marketing strategies. These insights contribute to the sustainability and innovation literature and provide practical guidance for MSME managers and policymakers seeking to promote environmentally responsible business development.

Keywords: Technological Innovation; Green Entrepreneurship; Green Marketing; MSME Performance.

1. Introduction

Green entrepreneurship and green marketing have become strategic imperatives worldwide as firms seek to align economic goals with environmental stewardship (Babu et al., 2026; Yin et al., 2022). By definition, green entrepreneurship (also called eco- or sustainable entrepreneurship) involves

entrepreneurial ventures that integrate environmental protection into product, process, and market innovations (Yin et al., 2022). Green marketing similarly refers to promotional and product strategies that prioritize minimizing environmental impact, thereby enhancing brand image and customer loyalty (Babu et al., 2026). Contemporary research shows that such green strategies yield competitive advantages: organizations adopting green initiatives "often experience improved brand reputation, stronger customer loyalty, and sustained profitability" (Babu et al., 2026). Babu et al. (2026) find that implementing green marketing practices has "a positive and significant influence on business performance," mediated by enhanced competitive advantage and innovation.

These ideas are grounded in well-established theories. Sustainability theory (Triple Bottom Line) holds that long-term success depends on balancing economic, environmental, and social objectives (Tjahjadi et al., 2020). Empirically, Tjahjadi et al. (2020) show that in Indonesian MSMEs a green market orientation significantly improved performance, "supporting the theory of sustainability" and the need to "balance economic, environmental, and social issues". Resource-Based View (RBV) complements this by viewing green capabilities as valuable resources. Babu et al. (2026), note that under RBV, green marketing actions are "valuable, rare, hard to imitate, and non-replaceable" assets that strengthen competitiveness. Stakeholder theory provides a market-driven rationale: firms must satisfy stakeholder demands for environmental responsibility. Anwar et al. (2024) explain, "stakeholder pressure forces businesses to reconsider their planning and consider environmental issues". In summary, firms with proactive green entrepreneurial orientation and marketing can leverage unique internal resources (innovation, brand image) to meet external pressures and achieve sustainable performance.

Empirical studies broadly support positive links between green strategies and MSME performance. A meta-analysis of 23 studies ($N \approx 6666$) found a strong correlation ($r \approx 0.58$) between a firm's green entrepreneurial orientation and its sustainable performance (Öztürk et al., 2024). In China, Yin et al. (2022) report that green utility-model innovations significantly improved SME performance, whereas green invention innovations had no effect. This suggests that even incremental eco-innovations can yield growth. In Pakistan, Samad et al. (2025) show that green entrepreneurial orientation, intellectual capital, and innovation capabilities each had positive associations with SME sustainable performance. Likewise, Babu et al. (2026) in Bangladesh confirm that green marketing initiatives significantly boost firm performance. These authors emphasize that green marketing's effect operates through enhanced competitive advantage and innovation.

Studies in Indonesia align with these findings. For example, Sari et al. (2023) find that among West Java MSMEs, entrepreneurial marketing and innovation capability both positively influenced firm performance under crisis conditions. Although not explicitly about environmental issues, this highlights the power of proactive marketing strategies. More directly, Ramdan et al. (2023) examine West Java culinary MSMEs and find that green marketing initiatives significantly improve brand awareness. In creative industries, Fawaid et al. (2026) studied Indonesian Batik MSMEs and found that environmentally oriented entrepreneurship (green entrepreneurship) markedly enhanced product innovation and business sustainability. They observe that most batik firms already display environmental awareness and engage in product innovation, leading to stable profits and permanent employment (Fawaid et al., 2026a).

2. Literature Review

2.1. Technological innovation

Technological innovation in MSMEs refers to a firm's ability to adopt, develop, and implement new technologies to improve operational efficiency, product quality, and business sustainability. Technological innovation encompasses product innovation, process innovation, and digital innovation, such as the use of environmentally friendly production technologies, process automation, and digital platforms for marketing and business management. Recent studies indicate that technological innovation plays a crucial role in enhancing MSME performance, particularly when such innovation aligns with environmental sustainability objectives (Yin et al., 2022; Zhang & Walton, 2024). Furthermore, Aboelmaged and Hashem (2023) argue that green technology adoption not only improves resource efficiency but also enhances MSMEs' competitive advantage in increasingly environmentally conscious markets.

2.2. Green Entrepreneurship

Green entrepreneurship (GE) is broadly defined as entrepreneurial activity that explicitly integrates environmental sustainability into business strategy and practices (Öztürk et al., 2024; Review & Korchagina, 2024). Unlike traditional entrepreneurs who focus chiefly on economic gains, green entrepreneurs pursue dual goals of profit and ecology, introducing eco-friendly products, processes or business models to solve environmental problems (Zhang & Meng, 2022). In practice, GE encompasses the creation of business ventures that promote renewable energy, recycling, pollution reduction or conservation (Li et al., 2022;

Silajdiié et al., 2015). It emphasizes long-term ecological goals and corporate social responsibility alongside economic performance.

Theoretical models of green entrepreneurship often extend classic entrepreneurship theories by adding an environmental dimension. For instance, GEO (Green Entrepreneurial Orientation) is conceptualized as a proactive strategic orientation analogous to traditional EO (entrepreneurial orientation) but focused on environmental opportunities (Khan et al., 2023; Öztürk et al., 2024). Some authors highlight dual orientations combining market orientation with ecological orientation, so that enterprises solve "market failures of old practices" by offering sustainable solutions (Review & Korchagina, 2024).

Green entrepreneurship is an entrepreneurial orientation that integrates economic value creation with environmental responsibility by identifying and exploiting environmentally sustainable business opportunities. In recent literature, green entrepreneurship is commonly conceptualized as a multidimensional construct comprising green opportunity recognition, green innovation orientation, environmental commitment, and proactive environmental behavior (Yin, Salmador, & Li, 2022; Hameed et al., 2022; Abbas & Dogan, 2023).

2.3. Green Marketing

Green marketing refers to marketing activities oriented around ecological concerns. Early definitions from the 1990s framed it as efforts to develop and promote environmentally safe products through a green marketing mix (Alnasser & Asem, 2025; Kiyak & Grigoliene, 2023). A widely-used description is that firms undertake "efforts made by companies to design, promote, price, and distribute products in a way that promotes environmental protection" (Kiyak & Grigoliene, 2023). In other words, green marketing is a holistic approach where companies integrate environmental considerations into all marketing decisions: product design (eco-friendly materials), promotion (environmental claims), pricing (accounting for environmental costs), and placement (sustainable distribution) (Alnasser & Asem, 2025; Kiyak & Grigoliene, 2023). More recently, scholars emphasize it as a strategic, firm-wide orientation. Kiyak & Grigoliene (2023) define green marketing as a holistic management process in which organizations market products with minimal environmental impact. Key features include eco-labelling, green branding, and communication of a pro-environmental corporate image.

Green marketing refers to marketing strategies that emphasize the development and communication of environmentally friendly products and services, aiming to create value for consumers while minimizing negative environmental impacts. The dimensions of green marketing include green product, green pricing, green promotion, and green distribution, which are reflected in the use of eco-friendly materials, credible green marketing claims, and efficient, sustainable distribution systems. Research over the past five years demonstrates that green marketing practices significantly contribute to improved brand image, consumer trust, and MSME performance (Tjahjadi et al., 2020; Hameed et al., 2022; Abbas & Dogan, 2023). Additionally, green marketing has been identified as a key mechanism through which green entrepreneurial orientation is translated into tangible business performance outcomes (Khan et al., 2024).

2.4. Performance of MSMEs

In the context of business performance and sustainability research, the term determinants refer to underlying factors or drivers that systematically influence a firm's strategic orientation, operational behavior, and resultant outcomes, particularly in relation to environmental and economic performance. Determinants are conceptualized as antecedent variables that explain variance in organizational performance, often grounded in theoretical paradigms such as the Resource-Based View (RBV) and dynamic capabilities frameworks, which posit that internal capabilities and external orientations coalesce to shape sustainable competitive advantage (Fumey et al., 2025). In sustainability studies, determinants extend beyond traditional financial indicators to encompass environmental orientation, innovation capability, leadership commitment, and market responses to ecological imperatives, reflecting a multi-dimensional understanding of performance that integrates economic, environmental, and social metrics (Ernawati, 2025).

MSME performance, from a sustainability perspective, should not be measured solely by financial outcomes but should also incorporate market and environmental performance. Financial performance includes sales growth and profitability; market performance is reflected in increased market share and customer satisfaction; and environmental performance relates to resource efficiency and waste reduction. Recent studies suggest that MSMEs that integrate technological innovation, green entrepreneurship, and green marketing tend to achieve superior and more sustainable business performance (Yin et al., 2022; Abbas & Dogan, 2023; Zhang & Walton, 2024). Therefore, a multidimensional approach to measuring MSME performance is essential to comprehensively capture the impact of green strategies.

2.5. Micro, Small, and Medium Enterprises (MSMEs)

Micro, Small, and Medium Enterprises (MSMEs) are a heterogeneous category of economic actors defined by a combination of criteria such as number of employees, asset size, and annual turnover, with specific thresholds varying across countries and institutional frameworks. Internationally, institutions such as the World Bank and OECD recognize MSMEs as encompassing businesses that are not large in scale but play disproportionate roles in employment, innovation, and economic diversification (World Bank, 2026). Microenterprises typically include entities with up to ten employees and limited financial resources, whereas small and medium firms operate with progressively higher thresholds of staff and turnover, although exact definitions differ by jurisdiction (turn1search9). This classification serves analytical and policy purposes by enabling targeted support, benchmarking, and comparative analysis of enterprise performance across regions and sectors.

2.6. Hypothesis Development

2.6.1. Technological innovation and green entrepreneurship.

Technological innovation positively and significantly influences green entrepreneurship, as the adoption of new environmentally friendly technologies enables entrepreneurs to develop sustainable products, processes, and business models that reduce environmental impact while creating economic value. Yin et al., (2022) find that green technological innovation significantly improves entrepreneurial outcomes and firm performance in SMEs, indicating that innovation is a key driver of green entrepreneurship. (Samad et al., 2025) show that green innovation capability positively influences green entrepreneurial orientation and sustainable SME performance. (Fawaid et al., 2026b) demonstrate that environmentally oriented entrepreneurship in MSMEs is strengthened by technological and digital innovation, which enhances sustainable business practices.
H_1: Technological innovation positively and significantly influences green entrepreneurship.

2.6.2. Technological innovation and green marketing

Empirical evidence consistently shows a positive, significant relationship between technological innovation and green marketing. Tjahjadi et al. (2020) demonstrate that green innovation acts as a key mechanism through which green market orientation translates into superior business performance, indicating that innovation strengthens the implementation of green marketing strategies. Similarly, Yin, Salmador, and Li (2022) find that green technological innovation significantly enhances SMEs' ability to commercialize environmentally friendly products, thereby reinforcing green-oriented marketing activities and improving firm performance. Their findings suggest that innovation-driven green marketing enables SMEs to differentiate themselves in environmentally sensitive markets.
H_2: Technological innovation positively and significantly influences green marketing.

2.6.3. Technological innovation and SMEs performance

Technological innovation is widely recognized as a key determinant of MSME performance, particularly in dynamic and highly competitive markets. Through technological innovation, MSMEs can improve product quality, enhance production efficiency, and develop marketing strategies that better respond to changing customer needs. These improvements enable MSMEs to strengthen their market position, increase sales growth, and achieve superior overall performance. Empirical studies provide strong evidence of a positive and significant relationship between technological innovation and MSME performance. Yin, Salmador, and Li (2022) find that green technological innovation significantly improves MSME performance by enhancing their ability to commercialize innovative, environmentally friendly products. Similarly, Dahri et al. (2025) demonstrate that innovation capability positively influences sustainable performance in SMEs, suggesting that firms with stronger technological innovation are better equipped to achieve long-term economic and environmental outcomes. In the Indonesian context, Fawaid et al. (2026) report that technological and digital innovation significantly enhance business sustainability and performance among MSMEs, particularly through improved innovation and market responsiveness.
H_3: Technological innovation positively and significantly influences MSMEs' performance.

2.6.4. Technological innovation and MSME performance through green entrepreneurship

Technological innovation contributes significantly to MSME performance not only through direct efficiency gains but also indirectly by fostering green entrepreneurship. Technological innovation enables MSMEs to adopt environmentally friendly production processes, develop green products, and implement sustainable business models. These capabilities encourage entrepreneurs to identify and exploit green business opportunities, which form the core of green entrepreneurship. As a result, technological innovation

enhances MSME performance by stimulating environmentally oriented entrepreneurial activities. Technological innovation represents a strategic resource that strengthens green entrepreneurial orientation by enabling firms to transform environmental challenges into market opportunities. Green entrepreneurship, in turn, enables MSMEs to leverage these innovations to create value through sustainable products and services, thereby improving business performance (Yin, Salmador, & Li, 2022). This aligns with sustainability theory, which emphasizes that firms that achieve long-term performance successfully integrate economic objectives with environmental responsibility.
H_4: technological innovation and MSME performance through green entrepreneurship

2.6.5. Technological innovation and MSME performance through green marketing

Empirical studies consistently demonstrate the mediating role of green marketing in the innovation–performance relationship. Babu et al. (2026) find that green marketing practices significantly improve business performance, and that innovation capability enhances their effectiveness. Their findings suggest that firms with higher technological innovation are better able to implement green marketing initiatives that enhance competitive advantage and financial performance. Similarly, Tjahjadi et al. (2020) report that green innovation mediates the relationship between green market orientation and business performance, indicating that innovation-driven green marketing is a key mechanism through which sustainability-oriented strategies translate into performance outcomes. Evidence from SMEs further supports this relationship. Yin, Salmador, and Li (2022) show that green technological innovation enhances SMEs' ability to commercialize environmentally friendly products, thereby strengthening green-oriented marketing efforts and improving firm performance. In addition, Dahri et al. (2025) demonstrate that green innovation capability positively influences sustainable firm performance by enabling SMEs to adopt proactive green marketing strategies. In the Indonesian MSME context, Ramdan et al. (2023) find that green marketing initiatives significantly enhance brand awareness, which is an important non-financial dimension of MSME performance.

3. Materials and Methods

This study employs a quantitative research design, using an explanatory survey method and a random sampling approach, to examine the structural relationships among technological innovation, green marketing, green entrepreneurship, and MSME performance. Quantitative designs are widely used in recent sustainability and marketing management studies because they enable objective measurement, hypothesis testing, and generalization of findings to a defined population (Hair et al., 2022). Based on the research objectives, this study adopts a combination of descriptive and explanatory research designs. The integration of these two approaches enables a comprehensive understanding of the research phenomenon by both describing the current conditions and explaining the causal relationships among the studied variables.

Descriptive research is employed to systematically, factually, and accurately describe the characteristics of the research object, namely, culinary Micro, Small, and Medium Enterprises (MSMEs) in Bogor City, Indonesia. This approach aims to provide an empirical overview of current levels of technological innovation adoption, green marketing practices, green entrepreneurial orientation, and MSME performance. Descriptive research is particularly useful for portraying existing conditions, identifying patterns, and capturing the general tendencies of sustainability-oriented marketing and innovation practices within MSMEs at a specific point in time.

Data analysis is conducted using Structural Equation Modeling (SEM) with LISREL software, a covariance-based SEM technique suitable for theory testing and confirmation. LISREL is chosen because it allows rigorous evaluation of both the measurement and structural models, ensuring high methodological validity. The sample size for this study was determined based on the recommendations of Hair et al. (2010), who suggest that an adequate and representative sample size for multivariate analysis using Structural Equation Modeling (SEM) ranges from 100 to 200 respondents, or at least 5–10 times the number of estimated parameters. The sample in this study consists of 330 respondents. This sample size meets the minimum requirements for conducting multivariate analysis using Structural Equation Modeling (SEM) and ensures robust and reliable statistical results.

4. Results

Table 1 presents the Goodness-of-Fit (GOF) indices for the measurement models of four latent constructs: Technological Innovation, Green Entrepreneurship, Green Marketing, and MSME Performance. The GOF evaluation aims to determine whether the proposed measurement models adequately represent the observed data. The findings indicate that all constructs satisfy the recommended fit criteria, as demonstrated by both absolute and incremental fit indices. Regarding the absolute fit measures, the Goodness-of-Fit Index (GFI) values for all constructs range from 0.93 to 0.96, exceeding the recommended threshold of 0.90, indicating a good overall model fit.

Table 1. Result of Goodness of Fit (GoF)

Indicator	Expected Value	Technological Innovation	Green Entrepreneurship	Green Marketing	Performance of MSMEs	Conclusion
GFI	> 0.90	0.94	0.93	0.94	0.96	Good Fit
RMSEA	< 0.08	0.6	0.08	0.06	0.06	Good Fit
NFI	> 0.90	0.99	0.98	0.99	0.99	Good Fit
IFI	> 0.90	0.98	0.98	0.98	0.99	Good Fit
AGFI	> 0.90	0.91	0.9	0.91	0.93	Good Fit
RFI	> 0.90	0.98	0.97	0.98	0.98	Good Fit
CFI	> 0.90	0.99	0.99	0.99	0.99	Good Fit

Furthermore, the Root Mean Square Error of Approximation (RMSEA) values range between 0.06 and 0.08, remaining within the acceptable limit of 0.08. This result confirms an acceptable level of approximation error and supports the adequacy of the measurement models. In terms of incremental fit indices, the results reveal that the NNFI, NFI, AGFI, RFI, IFI, and CFI values for all constructs consistently exceed 0.90, with most indices approaching 0.99. These findings suggest that the proposed measurement models provide a substantially better fit than a null or independence model. The GOF results confirm that the measurement models for Technological Innovation, Green Entrepreneurship, Green Marketing, and MSME Performance exhibit satisfactory fit with the empirical data. Consequently, the models are considered statistically valid and reliable, thereby justifying further analysis through structural model evaluation and hypothesis testing using Structural Equation Modeling (SEM).

Table 2. Result of Hypothesis Testing

Hypothesis	Relationship	Coefficient (β)	t-value	t-table	Result	Conclusion
H1	Technological Innovation → Green Entrepreneurship	0.66	13.71	1.96	13.71 > 1.96	Supported (Positive, Significant)
H2	Technological Innovation → Green Marketing	0.77	18.47	1.96	18.47 > 1.96	Supported (Positive, Significant)
H3	Technological Innovation → MSME Performance	0.57	10.8	1.96	10.80 > 1.96	Supported (Positive, Significant)
H4	Green Entrepreneurship → MSME Performance	0.14	1.8	1.96	1.80 < 1.96	Not Supported (Positive, Not Significant)
H5	Green Marketing → MSME Performance	0.56	7.37	1.96	7.37 > 1.96	Supported (Positive, Significant)
H6	Technological Innovation → MSME Performance (Mediated by Green Entrepreneurship)	Direct: 0.0121 (1.21%) Indirect: 0.0143 (1.43%)			Indirect > Direct	Partial Mediation (Green Entrepreneurship)
H7	Technological Innovation → MSME Performance	Direct: 0.0121 (1.21%) Indirect: 0.0539 (5.39%)			Indirect > Direct	Partial Mediation (Green Marketing)

Hypothesis	Relationship	Coefficient (β)	t-value	t-table	Result	Conclusion
	(Mediated by Green Marketing)					

Table 2 shows the results of the hypothesis test. The first hypothesis posits that technological innovation positively and significantly influences green entrepreneurship. The results show that the calculated t-value (13.71) exceeds the critical value of 1.96, indicating a positive and statistically significant effect. The standardized regression coefficient is 0.66, suggesting that higher levels of technological innovation are associated with a substantial increase in green entrepreneurship. Thus, H1 is supported. The second hypothesis proposes that technological innovation positively and significantly influences green marketing. The findings reveal that the calculated t-value (18.47) exceeds 1.96, confirming a positive, significant relationship. The regression coefficient of 0.77 indicates a strong positive effect, suggesting that technological innovation improvements lead to enhanced green marketing practices. Therefore, H2 is supported. The third hypothesis states that technological innovation positively and significantly influences MSME performance. The calculated t-value of 10.80 exceeds the 1.96 threshold, indicating statistical significance. The regression coefficient of 0.57 indicates that technological innovation positively contributes to MSME performance. Accordingly, H3 is supported. The fourth hypothesis examines the effect of green entrepreneurship on MSME performance. Although the relationship is positive (β = 0.14), the calculated t-value (1.80) is below the critical value of 1.96, indicating that the effect is not statistically significant. Therefore, H4 is not supported.

The fifth hypothesis suggests that green marketing positively and significantly influences MSME performance. The results show that the calculated t-value (7.37) exceeds 1.96, confirming statistical significance. The regression coefficient of 0.56 indicates a strong positive relationship between green marketing and MSME performance. Thus, H5 is supported. The sixth hypothesis tests the mediating role of green entrepreneurship in the relationship between technological innovation and MSME performance. The direct effect of technological innovation on MSME performance is 0.0121 (1.21%), while the indirect effect through green entrepreneurship is 0.0143 (1.43%). Since the indirect effect is slightly greater than the direct effect, the findings suggest that technological innovation enhances MSME performance both directly and indirectly through green entrepreneurship. This indicates a partial mediating effect, supporting H6. The seventh hypothesis examines the mediating role of green marketing in the relationship between technological innovation and MSME performance. The direct effect of technological innovation on MSME performance remains 0.0121 (1.21%), whereas the indirect effect through green marketing is 0.0539 (5.39%). The substantially larger indirect effect indicates that green marketing plays a more dominant mediating role. These results confirm that green marketing partially mediates the relationship between technological innovation and MSME performance. Therefore, H7 is supported.

5. Discussion

This study found that technological innovation positively and significantly influences green entrepreneurship. The findings confirm that H1 is supported. The results indicate that stronger technological innovation in developing environmentally friendly products enhances MSME owners' green entrepreneurial capabilities. In other words, improved technological innovation facilitates the adoption of environmentally oriented business initiatives. This finding is consistent with prior studies by Redondo-Rodríguez et al. (2023), Firmanna and Nasito (2023), and Hidayat et al. (2024), which emphasize the critical role of innovation in fostering sustainable entrepreneurial practices. The results demonstrate a positive and significant relationship, thereby supporting H2. Higher levels of technological innovation strengthen green marketing practices within organizations, as evidenced by the significant t-value and positive regression coefficient. This finding aligns with previous research by Babu, Rouf, and Islam (2026), Hameed et al. (2022), Ruiz et al. (2024), and Zhang and Walton (2024), which highlights innovation as a key driver of environmentally oriented marketing strategies.

Also, the results show a positive and significant effect, supporting H3. This indicates that enhanced technological innovation capabilities contribute to improved MSME performance, both financially and non-financially. The finding is consistent with studies by Yin, Salmador, and Li (2022), Aboelmaged and Hashem (2023), and Abbas and Dogan (2023), which underscore the strategic importance of innovation in improving organizational outcomes. Although the relationship was positive, it was not statistically significant at the 95 percent confidence level, leading to the rejection of H4. This suggests that while green entrepreneurship tends to positively affect performance, its direct effect may not yet be strong enough to yield measurable outcomes. This result may be attributed to the early adoption stage of green entrepreneurship among MSMEs or to the presence of other mediating variables that play a more dominant role. Similar findings

have been reported by Tjahjadi et al. (2020), particularly in the context of small businesses in developing economies.

This study found that green marketing positively and significantly influences MSME performance. The results confirm that H5 is supported. The significant t-value indicates that green marketing practices meaningfully improve MSME performance. This implies that organizations that actively implement environmentally responsible marketing strategies are more likely to achieve better business outcomes. This finding aligns with research by Hidayat, Kasnowo, and Dwihandoko (2024) and Putri and Riyanto (2023). This study also examined the mediating role of green entrepreneurship in the relationship between technological innovation and MSME performance. The findings support H6. Technological innovation affects MSME performance both directly and indirectly through green entrepreneurship. Although both effects are positive, the indirect effect is slightly stronger, indicating that green entrepreneurship enhances the impact of technological innovation on performance. This suggests that innovation yields greater performance benefits when it is translated into sustainable entrepreneurial practices. This result is consistent with prior studies by Yin, Salmador, and Li (2022), Dahri, Saraih, and Namisango (2025), Khan, Yang, and Waheed (2024), and Hameed, Nisar, and Wu (2022).

This study assessed the mediating role of green marketing in the relationship between technological innovation and MSME performance. The results confirm that H7 is supported. The indirect effect of technological innovation on performance through green marketing is substantially greater than the direct effect, indicating that green marketing significantly strengthens the influence of technological innovation on MSME performance. This finding suggests that innovation generates stronger performance outcomes when supported by effective environmentally oriented marketing strategies. The result is consistent with studies by Putri and Riyanto (2023), Babu, Rouf, and Islam (2026), Tjahjadi et al. (2020), and Hameed et al. (2022).

6. Conclusions

This study examined the role of technological innovation in enhancing MSME performance, both directly and indirectly, through green entrepreneurship and green marketing. The findings demonstrate that technological innovation serves as a fundamental driver of sustainability-oriented business transformation among MSMEs. Specifically, technological innovation positively and significantly influences green entrepreneurship, green marketing, and MSME performance. These results confirm that innovation capability is a critical strategic resource for strengthening competitiveness and sustainability in the MSME sector. Although green entrepreneurship is positively associated with MSME performance, the effect is not statistically significant. This suggests that green entrepreneurial orientation alone may not be sufficient to generate immediate performance improvements, particularly in contexts where sustainability practices are still at an early stage of adoption. In contrast, green marketing has a strong, significant positive influence on MSME performance, suggesting that market-oriented sustainability strategies play a more direct role in enhancing business outcomes. Furthermore, the mediation analysis reveals that both green entrepreneurship and green marketing mediate the relationship between technological innovation and MSME performance. However, green marketing demonstrates a stronger mediating effect, implying that technological innovation yields greater performance benefits when effectively translated into environmentally oriented marketing practices. Overall, the findings highlight the importance of integrating innovation capability with sustainability-driven strategies to achieve superior organizational performance.

Despite its contributions, this study has several limitations. First, the research relies on cross-sectional data, which limits the ability to establish causal relationships over time. Future studies may employ longitudinal designs to capture dynamic changes in innovation and sustainability practices. Second, the sample is confined to MSMEs within a specific regional context, which may restrict the generalizability of the findings to other regions or countries. Third, the study focuses primarily on internal strategic factors, omitting external variables such as regulatory pressure, market turbulence, and institutional support, which may also influence MSME performance. Future research is encouraged to integrate these contextual factors and explore potential moderating effects.

From a theoretical perspective, this study contributes to the literature on innovation and sustainability by demonstrating the mediating roles of green entrepreneurship and green marketing in linking technological innovation to firm performance. The findings enrich the resource-based view and sustainability-oriented innovation frameworks by emphasizing that innovation alone is insufficient; it must be strategically embedded within entrepreneurial and marketing practices to produce optimal outcomes. From a practical standpoint, the results suggest that MSME owners and managers should prioritize technological innovation as a strategic investment to enhance sustainable competitiveness. However, innovation efforts should be complemented by effective green marketing strategies to ensure that sustainability initiatives translate into tangible performance gains. Policymakers should design supportive programs that facilitate access to green technology, provide sustainability training, and encourage environmentally responsible marketing practices among MSMEs. Government agencies and financial

institutions may also develop targeted incentives, such as green financing schemes or innovation grants, to accelerate the adoption of sustainable business models.

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