Original Research Article

Enhancing SMEs' Sustainability through Digital Adoption and Green Orientation: The Mediating Role of Green Product Innovation

Abstract

Small, and Medium Enterprises (SMEs) are increasingly required to integrate sustainability with digital transformation to remain competitive in rapidly evolving markets. However, many SMEs face resource and capability constraints that hinder effective adoption of green strategies. This study investigates how digital technology adoption, green dynamic capabilities, and green market orientation influence sustainable performance, with green product innovation examined as a mediating factor. Drawing on data from 105 SME owners and managers in Indonesia, the study applies Partial Least Squares Structural Equation Modeling (PLS-SEM) to test the proposed model. The results indicate that all three predictors positively and significantly affect green product innovation and sustainable performance, with green dynamic capabilities exerting the strongest influence. Moreover, green product innovation fully mediates the relationship between green market orientation and sustainable performance. These findings extend theoretical insights into sustainable business practices among SMEs by confirming the strategic role of eco-innovation. Practically, the study highlights the importance of capacity-building initiatives that enable MMEs to leverage digital tools, develop adaptive green capabilities, and translate environmental orientation into market-driven, sustainable product innovations.

Keywords: digital technology adoption; green dynamic capability; green market orientation; green product innovation; sustainable performance

1. Introduction

Small and medium-sized enterprises (SMEs) are the backbone of most economies worldwide, representing approximately 90% of all businesses and contributing more than 50% of employment (World Bank Group, 2022). In emerging economies such as Indonesia, SMEs play an even more vital role, contributing over 60% to GDP and employing more than 97% of the national workforce (Kementerian Koperasi dan UKM, 2023). Despite their centrality, SMEs often face structural and strategic limitations, particularly when attempting to integrate sustainability principles into their business models. These constraints include limited access to advanced technologies, insufficient capabilities for green innovation, and underdeveloped market strategies targeting environmentally conscious consumers (Bhuiyan et al., 2024).

As global environmental challenges intensify, businesses are increasingly expected to engage in sustainable practices, not merely as a form of compliance, but as a strategic imperative. Simultaneously, the fourth industrial revolution—characterized by rapid digital transformation—has reshaped the operational landscape for SMEs, providing opportunities for efficiency gains, transparency, and innovation. Digital technology adoption (DTA), when leveraged effectively, can serve as a catalyst for green innovation by enabling data integration, resource optimization, and real-time environmental monitoring (Haq & Huo, 2023). However, empirical findings remain inconsistent: while some studies show that digital adoption improves firm-level sustainability performance (Kraus et al., 2020), others argue that technological tools alone do not lead to better outcomes unless firms possess internal capabilities and coherent strategies to support implementation (Y. Chen et al., 2014).

In this context, the concept of green dynamic capabilities (GDC) emerges as a crucial variable. Drawing from the dynamic capabilities view (DCV), GDC refers to a firm's ability to sense environmental shifts, seize opportunities, and reconfigure internal resources in a sustainable direction (Teece, 2007). These capabilities help SMEs manage environmental complexity and uncertainty while fostering green product innovation (GPI) and long-term competitiveness (Bhuiyan et al., 2024; Mubeen et al., 2023)

GDC have been empirically linked to higher levels of innovation and resilience, particularly in volatile markets where environmental regulations and customer demands evolve rapidly (Borah et al., 2025). However, there is a need for more integrated models that link GDC to digital adoption, market orientation, and sustainable performance, especially within micro and small enterprises that often lack formal structures and slack resources.

Another variable receiving increasing scholarly attention is green market orientation (GMO), which represents the firm's strategic alignment with environmental values in responding to market needs. GMO enables SMEs to proactively identify eco-conscious consumer preferences, incorporate sustainability into product design, and communicate green values effectively (Papadas et al., 2017). Studies suggest that GMO is associated with improved market legitimacy, customer satisfaction, and performance outcomes (Sulaiman, 2025). Nonetheless, the mechanisms by which GMO contributes to firm performance—particularly through green innovation—remain under-explored. Most existing studies treat GMO as a direct predictor of performance, without fully accounting for its interaction with internal capabilities and innovation processes.

Green product innovation (GPI) is likely to serve as the mediating mechanism that links strategic orientations (such as GMO and DTA) to sustainability outcomes. GPI refers to the development or modification of products to reduce environmental impact throughout their lifecycle. It transforms strategic intent into tangible outputs, providing measurable value to both firms and stakeholders (Q. Zhang et al., 2022). Although innovation has long been recognized as a driver of sustainable performance, few studies have tested GPI as a mediator within an integrated framework involving digital adoption, GDC, and market orientation—especially in the SME sector of emerging economies.

Indonesia, and specifically the province of Yogyakarta, provides an ideal context for examining these relationships. The region is home to thousands of creative-based micro and small enterprises, particularly in crafts, food, fashion, and cultural products. While many of these businesses demonstrate agility and entrepreneurial drive, they also face challenges in digital integration, environmental compliance, and capability development. Existing studies on Indonesian SMEs have largely focused on either technology adoption or green innovation in isolation, with limited effort to integrate multiple constructs into a cohesive sustainability framework (Piot-Lepetit, 2025; Tjahjadi et al., 2020).

To address these gaps, this study develops and empirically tests a conceptual model linking digital technology adoption, green dynamic capabilities, and green market orientation to sustainable performance, with green product innovation as a mediating variable. By focusing on SMEs in Yogyakarta, this research aims to contribute to theory and practice in several ways. First, it expands the understanding of how digital and green strategies interact to shape innovation and sustainability outcomes. Second, it provides empirical evidence on the mediating role of GPI, a topic underrepresented in current literature. Third, it offers insights for policymakers and SME stakeholders on how to foster ecosystem-based approaches to sustainability that leverage both digital infrastructure and internal capabilities.

2. Literature review

Theoretical foundation

In the pursuit of sustainable development goals (SDGs), Small, and Medium Enterprises (SMEs) face increasing pressure to integrate environmental and digital imperatives into their core strategies. While traditionally constrained by limited resources and technological capabilities, SMEs are now expected to adopt sustainable innovations and embrace digital transformation to enhance resilience and competitiveness (Lu et al., 2023). Digital technologies such as IoT, big data analytics, and cloud platforms enable firms to improve environmental performance through real-time monitoring, resource optimisation, and transparency in operations (Li et al., 2020). Simultaneously, green strategic orientation—particularly in the form of green market orientation and dynamic capabilities—has emerged as a critical determinant of innovation and long-term sustainability (Papadas et al., 2017; Teece, 2007). As sustainability becomes a market norm rather than a differentiation strategy, the synergy between digitalisation and environmental responsiveness is increasingly vital.

Moreover, empirical evidence suggests that integrating sustainability principles within organisational processes enhances not only environmental outcomes but also economic and social performance, especially when guided by proactive capabilities and market intelligence (Bhuiyan et al., 2024; Singh et al., 2022). Green product innovation serves as a central mechanism through which SMEs can translate digital adoption and strategic orientation into measurable sustainable performance. However, the pathways linking digital capabilities, green strategies, and sustainability remain underexplored—particularly in developing economies where institutional support and technological infrastructure vary significantly. To address this gap, the present study develops and empirically tests a set of hypotheses that connect digital technology adoption, green dynamic capabilities, and green market orientation with green product innovation and sustainable performance, thereby offering a holistic model for sustainability-driven SMEs.

Hypothesis development

2.1. The Role of Digital Technology Adoption in Driving Green Product Innovation

Digital technology adoption (DTA) enables firms to improve efficiency, integrate sustainability, and foster innovation. Digital tools are seen as key enablers for product development, especially in resource-constrained environments like SMEs. Technologies such as IoT, cloud computing, and design software facilitate real-time data analysis, lifecycle design, and transparent green supply chains.

Several studies have confirmed this link. Haq & Huo (2023) found that digital adoption significantly enhances SMEs' ability to collaborate on green design. Similarly, Mubeen et al. (2023) showed that digitally enabled firms are more agile in integrating sustainability into product innovation. In emerging economies, digital platforms also allow

SMEs to access environmental knowledge, regulatory updates, and eco-conscious markets (Thaher et al., 2022), thus supporting the co-creation of green products.

However, the effectiveness of digital adoption in driving green innovation depends on its integration into core innovation processes (C.-L. Chen et al., 2021). Without strategic alignment, technology may improve operations without promoting eco-innovation. Given the growing empirical support and theoretical rationale, this study put forward the following hypothesis:

H1: Digital technology adoption has an influence on green product innovation.

2.2. Green Dynamic Capabilities as Drivers of Eco-Innovation

Green dynamic capabilities (GDC) refer to an organization's ability to sense, seize, and transform resources in response to environmental challenges and sustainability opportunities (Teece, 2007). In the context of product innovation, GDC empower firms to continuously adapt their processes, supply chains, and technologies to meet green performance standards. Empirical evidence strongly supports the role of GDC in driving green product innovation across various industries and regions.

Borah et al. (2025) found that GDC—through green operations, green transactions, and green technology development—significantly increase firms' capacity to develop eco-innovative products. These capabilities enable firms to optimize production efficiency, collaborate with sustainable partners, and adopt or develop green technologies, thereby generating products with superior environmental value. This aligns with Zhu et al. (2023), who emphasized that GDC enhance firms' ability to identify and exploit green innovation opportunities, particularly when supported by robust technological infrastructure. Taken together, these findings indicate that firms with strong green dynamic capabilities are better positioned to integrate environmental considerations across all stages of product development. Hence, the following hypothesis is proposed:

H2: Green dynamic capability has a positive influence on green product innovation.

2.3. Green Market Orientation as a Driver of Sustainable Product Innovation

Green Market Orientation (GMO) refers to a firm's strategic focus on identifying, understanding, and responding to environmental concerns and preferences within its target markets. Rooted in the broader concept of market orientation, GMO extends this logic by embedding sustainability values into market intelligence, customer engagement, and value delivery (Papadas et al., 2017). In the context of green product innovation, GMO acts as a catalyst that channels consumer-driven environmental demands into tangible product features and sustainable design.

Sulaiman (2025) emphasized that firms practicing GMO are more adept at collecting and responding to environmental market information, engaging with eco-conscious consumers, and adapting product attributes to align with sustainability preferences. Such practices enhance not only environmental legitimacy but also product differentiation in green-conscious segments. Tjahjadi et al. (2020) further demonstrated that GMO fosters innovation by guiding firms toward greener product strategies, which subsequently improve performance outcomes and competitive positioning.

Empirical findings from Prakoso et al. (2025), focusing on SMEs in West Java's food sector, show that active green segmentation and sustainability-driven marketing communication stimulate investment in green product development. SMEs that implement reciprocal feedback loops with green consumers have introduced products with advanced sustainability attributes—such as biodegradable packaging and certified eco-friendly materials – highlighting the direct translation of market signals into innovation. Based on this synthesis of theoretical and empirical insights, the following hypothesis is proposed:

H3: Green market orientation has a positive influence on green product innovation.

2.4. The Role of Digital Technology Adoption in Enhancing Sustainable Performance

The adoption of digital technologies is increasingly recognized as a strategic enabler of sustainable performance, particularly within the dimensions of environmental, social, and economic outcomes. Digitalization empowers organizations to integrate sustainability principles across operational, managerial, and reporting systems by leveraging tools such as the Internet of Things (IoT), big data analytics, and automation.

Dal Bello et al. (2022) demonstrated that the deployment of IoT-driven environmental management systems and digital analytics platforms facilitated real-time tracking of energy consumption and emissions. These systems enabled firms to identify inefficiencies, optimise resource use, and foster cross-functional collaboration—all of which contribute to improved sustainability performance across the triple bottom line. Importantly, these tools allowed for responsive interventions that minimize environmental impact while maintaining economic efficiency.

In a complementary study, Q. Wang et al. (2025) found that firms with higher levels of digital maturity produced more comprehensive and reliable sustainability reports. The integration of digital tools enhanced the consistency and transparency of environmental, social, and governance (ESG) disclosures, strengthening stakeholder trust and accountability. Such reporting practices are increasingly viewed as indicators of organizational sustainability orientation. Given consistent evidence from recent literature, it is hypothesized that digital technology adoption significantly contributes to enhanced sustainable performance.

H4: Digital technology adoption has a positive influence on sustainable performance.

2.5. The Contribution of Green Dynamic Capabilities to Sustainable Performance in SMEs

Green dynamic capabilities (GDC) are firms' abilities to integrate, build, and reconfigure internal and external competencies to address environmental challenges and sustainability-driven opportunities (Teece, 2007). In the context of SMEs, GDC are particularly vital as they enable smaller firms to overcome resource constraints through agility, innovation, and responsiveness to stakeholder pressures.

Mishra & Kiran (2025) highlight that GDC enhance organisational creativity and responsiveness, enabling the development of green innovations that align with both environmental regulations and market expectations. This alignment supports improvements across all pillars of sustainable performance—economic, environmental, and social. GDC facilitate superior resource utilisation, reduce waste, and strengthen environmental governance structures, leading to measurable gains in sustainability metrics such as energy efficiency and emissions compliance.

Moreover, Huang & Xiao (2023) emphasized that GDC mediate the relationship between stakeholder pressure and green innovation outcomes. Firms with high levels of GDC are better equipped to translate external environmental expectations into coherent, organization-wide sustainability strategies. This internal alignment fosters cross-functional collaboration and accelerates the implementation of sustainability initiatives. Based on consistent theoretical and empirical findings, the following hypothesis is proposed:

H5: Green dynamic capability has a positive influence on the sustainable performance of SMEs

2.6. The Impact of Green Market Orientation on Sustainable Performance in SMEs

Green Market Orientation (GMO) refers to an organization's strategic focus on understanding and addressing environmentally conscious consumer needs, collecting market intelligence related to sustainability, and responding proactively to environmental trends and feedback (Papadas et al., 2017). In the context of SMEs, GMO functions as a critical driver for embedding sustainability into marketing, product development, and operational strategies.

Sulaiman (2025) demonstrated that SMEs practicing strong GMO—through proactive engagement with green consumers and continuous monitoring of sustainability-related market signals—experience improvements in operational efficiency, resource conservation, and brand legitimacy. Further supporting this, Tjahjadi et al. (2020) found that GMO stimulates both product and process-based green innovations, which serve as mediating mechanisms linking market orientation to improved firm performance and sustainability outcomes. Engagement with environmentally conscious customers accelerates the identification of market-relevant eco-innovation opportunities and shortens development cycles, leading to improved environmental reputation and economic returns. Given the theoretical grounding and empirical consistency across multiple studies, the following hypothesis is proposed:

H6: Green market orientation has a positive influence on the sustainable performance of SMEs.

2.7. The Impact of Green Product Innovation on SMEs' Sustainable Performance

Green product innovation (GPI) refers to the development of products with environmentally friendly features, sustainable resource usage, and recyclable or biodegradable designs. For SMEs, GPI represents not only a response to regulatory and market pressures but also a strategic tool to improve their sustainable performance across environmental, social, and economic dimensions.

Sulaiman (2025) found that SMEs engaging in GPI—through the use of renewable materials, reduced packaging waste, and eco-label certifications—experienced measurable gains in resource efficiency, brand image, and consumer trust. These improvements collectively contribute to better sustainability outcomes and market differentiation. Similarly, Rehman et al. (2023) demonstrated that GPI significantly enhances sustainability performance and plays a mediating role in the relationship between organizational values and ESG outcomes.

In a sectoral perspective, Qing et al. (2025) examined SMEs in the beauty industry and concluded that firms implementing green innovation and sustainable production technologies achieved greater energy efficiency, waste reduction, and competitive resilience.

These findings emphasize that GPI serves as both an operational and strategic lever for improving long-term sustainability. Based on this theoretical and empirical foundation, the following hypothesis is proposed:

H7: Green product innovation has a positive influence on the sustainable performance of SMEs.

2.8. The Mediating Role of Green Product Innovation

GMO reflects a firm's strategic commitment to understanding and fulfilling environmentally conscious consumer preferences, while GPI represents the operationalization of this orientation through the development of eco-friendly product features, sustainable inputs, and circular design principles (Papadas et al., 2017). Sulaiman (2025) highlighted that a strong green market orientation facilitates the formulation of innovative product attributes—such as biodegradable materials and low-impact packaging—that align with consumer expectations and regulatory demands. These innovations contribute significantly to economic performance through increased customer loyalty, environmental performance via reduced ecological footprints, and social performance through improved corporate legitimacy.

Supporting this, Tjahjadi et al. (2020) found that green innovation serves as a critical mediator linking GMO to firm performance. Their study demonstrates that proactive engagement with green consumers enables firms to identify opportunities for differentiation through sustainability-driven product innovation, leading to superior competitiveness and long-term performance benefits. Based on this integrated theoretical and empirical foundation, the following hypothesis is proposed:

H8: Green product innovation mediates the influence of green market orientation on SMEs' sustainable performance

Based on the theoretical basis, previous research, and hypothesis formulation that have been described, this research framework describes the relationship between variables in the context of SMEs.

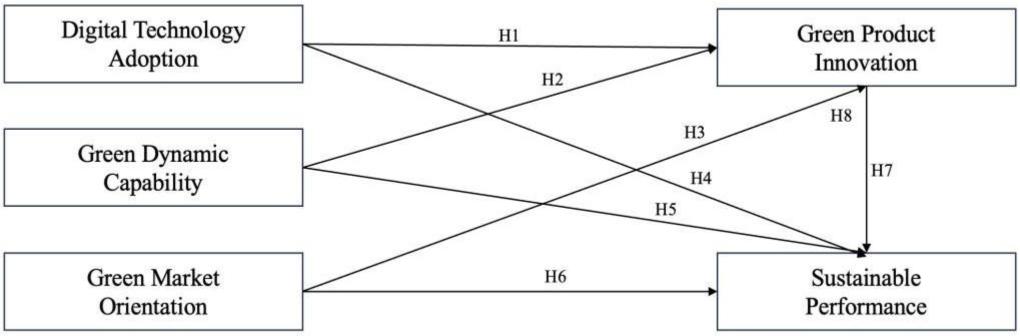

Figure 1 Research Framework

3. Methods

This study employed a quantitative research methodology using a cross-sectional survey design to examine relationships between digital technology adoption, green dynamic capability, green market orientation, green product innovation, and sustainable performance among SMEs in Yogyakarta. A quantitative approach was selected as it allows systematic measurement of variables and statistical hypothesis testing through structured questionnaires (Creswell, 2009).

The study was conducted in Yogyakarta, Indonesia, selected as a creative economy center with significant MSME contribution to the regional economy and a hub for education, culture, and creativity supporting sustainable MSME development. The population consisted of 347,391 SMEs in Yogyakarta Badan Perencanaan Pembangunan, Riset, dan Inovasi Daerah (2025) including business owners and managers. Using purposive sampling technique (Sekaran & Bougie, 2016) and the Slovin formula with 10% margin of error, the minimum required sample was approximately 100 respondents. A total of 105 valid responses were collected from MSME owners or managers, representing fashion and textiles (46.7%), food and beverages (36.2%), manufacturing or small industry (10.5%), and furniture (6.7%).

All variables were measured using validated instruments adapted from previous research, modified for the Indonesian MSME context, with items measured on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Digital technology adoption was measured using 9 indicators adapted from Sudirman et al. (2025) and J. Wang et al. (2025), covering internet connectivity accessibility, digital device availability, digital technology utilization in business transactions and internal processes, continuous digital investment, and digital tools for data analysis (Sudirman et al., 2025; J. Wang et al., 2025). Green dynamic capability was measured using 10 indicators from Borah et al. (2025), assessing abilities to monitor green technology market demand, evaluate development impacts, review green production activities, develop environmental knowledge, absorb and apply green knowledge, integrate knowledge into processes, strategically place green expertise employees, and allocate resources for green innovation (Borah et al., 2025). Green market orientation used 10 indicators from Sulaiman (2025) and Papadas et al. (2017), evaluating customer satisfaction driving environmentally friendly business, commitment to serving green customers, provision of eco-friendly product information, competitive advantage based on understanding green customer needs, measurement of customer satisfaction with green attributes, customer service operations, investment in eco-friendly products, and dissemination of customer satisfaction data (Papadas et al., 2017; Sulaiman, 2025). Green product innovation employed 9 indicators from Sulaiman (2025) and Tjahjadi et al. (2020), covering use of environmentally friendly and energy-efficient raw materials, optimization of material usage, innovation to reduce material consumption, design for reusability and recyclability, effective reduction of hazardous emissions and waste, recycling of waste and emissions, reduction of resource consumption, and development of environmentally friendly packaging (Sulaiman, 2025; Tjahjadi et al., 2020). Sustainable performance used 11 indicators from Sulaiman (2025) and Tjahjadi et al. (2020) based on the Triple Bottom Line framework, assessing social performance (workforce welfare, community development, long-term partnerships), economic performance (economic benefits to community, sustainable business network, profitability, competitiveness, market share), and environmental performance (non-harmful products, responsible material and energy policies, use of environmentally friendly technologies) (Sulaiman, 2025; Tjahjadi et al., 2020).

Data were collected through online questionnaires distributed via Instagram, WhatsApp, and TikTok using Google Forms platform. A pilot test with 30 respondents ensured questionnaire clarity and reliability, with minor adjustments made based on feedback. Data collection occurred from September to October 2024, with respondents informed about research purpose, confidentiality assurance, and voluntary participation. Screening questions ensured respondents met inclusion criteria (SME owners or managers in Yogyakarta). The mandatory response feature in Google Forms eliminated missing data.

Data analysis involved descriptive statistics (frequency, mean, standard deviation) for respondent profiles and variables (Sekaran & Bougie, 2016), followed by inferential analysis using Partial Least Squares-Structural Equation Modeling (PLS-SEM) with SmartPLS 4 software. PLS-SEM was selected for its suitability in testing complex theoretical models with non-normally distributed data (Hair & Alamer, 2022). The measurement model evaluation included convergent validity assessment through outer loadings (>0.70) and Average Variance Extracted (AVE >0.50), discriminant validity evaluation using cross-loadings and Fornell-Larcker criterion, and internal consistency reliability assessment using Cronbach's alpha and composite reliability (>0.70) (Hair & Alamer, 2022). The structural model evaluation examined Variance Inflation Factor (VIF <5) for multicollinearity, R^2 values for variance explanation, path coefficients using bootstrapping with 5,000 resamples (t-statistics >1.96, p-values <0.05), and Stone-Geisser Q^2 values (>0) for predictive relevance (Hair & Alamer, 2022).

3. Results

3.1. Descriptive Analysis

A total of 105 MSME respondents participated in this study. Based on business type, most respondents operated in the fashion and textile sector (46.7%), followed by food and beverage (36.2%), manufacturing or small industry (10.5%), and furniture (6.7%). In terms of business age, the majority of firms had been operating for 1–5 years (29.5%), followed by 5–10 years (25.7%), more than 10 years (24.8%), and less than one year (20%), indicating a relatively mature distribution of business experience. Regarding annual revenue, most respondents (81%) reported earnings of ≤300 million rupiah, while 16.2% earned between 300 million and 2.5 billion rupiah, and only 2.9% reported revenues above 2.5 billion rupiah. Based on firm size, 61.9% of businesses employed 1–5 workers, 28.6% employed 5–20 workers, while only 9.5% employed more than 20 workers, confirming the dominance of micro and small enterprises in the sample.

3.2 Descriptive Variable Analysis

The descriptive analysis indicates generally high levels of agreement across all variables. Digital Technology Adoption recorded a mean score of 4.18, suggesting that respondents had broadly adopted digital technologies for operational efficiency, decision-making, and information dissemination. Green Dynamic Capability obtained an average score of 3.97, indicating that firms moderately to strongly possess capabilities to sense environmental opportunities, integrate green knowledge, and allocate resources toward sustainable innovation. Green Market Orientation achieved the highest mean score (4.29), reflecting a strong customer- and environment-oriented market focus, particularly in serving environmentally conscious customers and providing eco-related information. Green Product Innovation recorded a mean score of 4.20, demonstrating that respondents actively innovate through the use of eco-friendly materials, waste reduction, energy efficiency, and recyclable packaging. Finally, Sustainable Performance showed a mean score of 4.08, indicating that respondents generally perceived their businesses as performing sustainably across economic, social, and environmental dimensions.

3.3. Measurement Model Evaluation

Convergent validity was assessed using indicator loadings and Average Variance Extracted (AVE). As recommended in PLS-SEM literature, indicator loadings exceeding 0.70 and AVE values above 0.50 indicate satisfactory convergent validity. The results show that all measurement items loaded strongly on their respective constructs, with outer loadings exceeding the recommended threshold of 0.70. In addition, all constructs demonstrated AVE values above 0.50, indicating that a substantial proportion of indicator variance is explained by the latent variables. These results confirm that the measurement model meets the criteria for convergent validity.

Discriminant validity was evaluated using the Heterotrait–Monotrait ratio of correlations (HTMT), which is considered a more rigorous and reliable criterion than cross-loadings in variance-based SEM. Following established guidelines, HTMT values below 0.90 indicate adequate discriminant validity between constructs. The results show that all HTMT values were below the recommended threshold, confirming that each construct is empirically distinct and captures a unique theoretical concept. Therefore, the measurement model demonstrates satisfactory discriminant validity.

Construct reliability was examined using Cronbach's Alpha and Composite Reliability (CR). The results indicate that all constructs achieved reliability values above the recommended minimum threshold of 0.70, demonstrating strong internal consistency among the measurement items. These findings confirm that the measurement instruments used in this study are reliable and suitable for subsequent structural model analysis.

Overall, the evaluation of convergent validity, discriminant validity, and reliability confirms that the measurement model satisfies all recommended criteria. The indicators reliably represent their respective latent constructs, and the constructs are empirically distinct from one another. Consequently, the measurement model is deemed adequate, allowing for further analysis of the structural relationships among variables.

3.4. Reliability Test

This study assessed construct reliability using Cronbach's alpha, which is widely applied to evaluate internal consistency and is considered a valid reliability indicator. A Cronbach's alpha value exceeding 0.70 indicates that a construct meets the minimum reliability requirement. The results demonstrate that all constructs in this study achieved Cronbach's alpha values well above the recommended threshold, thereby confirming satisfactory internal consistency for each variable. A detailed summary of the reliability test results is presented in Table 1.

Table 1. Cronbach's Alpha

Variable	Cronbach's Alpha
Digital Technology Adoption	0.941
Green Dynamic Capability	0.942
Green Market Orientation	0.941
Green Product Innovation	0.952
Sustainable Performance	0.946

3.5. Structural Model Test (Inner Model)

The structural (inner) model analysis was conducted to examine the causal relationships among the latent variables in the research model. This stage aims to evaluate the model's explanatory and predictive power by assessing collinearity, the coefficient of determination (R-square), hypothesis testing through path coefficients, and predictive relevance (Q-square).

Collinearity was assessed by examining the Variance Inflation Factor (VIF) values to ensure that multicollinearity did not bias the estimation of the structural model. A VIF value below 5 indicates the absence of critical collinearity issues among constructs. The results show that all VIF values are below the recommended threshold, confirming that collinearity does not pose a concern in this study. The detailed VIF results are reported in Table 2.

Table 2. Detailed VIF resutls

	DTA	GDC	GMO	GPI	SP
DTA				1.553	1.698
GDC				1.456	1.603
GMO				1.334	1.626

GPI					2.097

The coefficient of determination (R-square) measures the proportion of variance in endogenous variables explained by their respective exogenous variables. This metric reflects the explanatory power and predictive accuracy of the structural model. As shown in Table 15, the R-square value for Green Product Innovation is 0.523, indicating a moderate level of explanatory power. Meanwhile, Sustainable Performance exhibits a high R-square value of 0.784, suggesting that the model explains a substantial proportion of variance in sustainable performance outcomes.

Table 3. R-Square

Variable	R Square	Adjusted R Square
Green Product Innovation	0.523	0.509
Sustainable Performance	0.784	0.776
Variable	R Square	Adjusted R Square

3.6. Hypothesis Testing

Hypothesis testing was conducted using path coefficients to evaluate the direction and strength of relationships among constructs. Path coefficient values range from −1 to 1, where positive values indicate a positive relationship and negative values indicate a negative relationship. The significance of the hypotheses was assessed using the bootstrapping procedure in SmartPLS 4. Following Hair & Alamer (2022), a hypothesis is considered supported when the p-value is less than 0.05 and the t-statistic exceeds 1.96 (Hair & Alamer, 2022).

The results indicate that all proposed hypotheses are statistically significant and supported. Table 4 presents a comprehensive summary of the path coefficients, t-statistics, p-values, and hypothesis conclusions.

Table 4. Results of the Path Coefficients Test

Path	Original Sample	T-Statistics	P-Values	Conclusion
DTA → GPI	0.263	2.261	0.024	H1 Confirmed
GDC → GPI	0.264	2.712	0.007	H2 Confirmed
GMO → GPI	0.373	3.35	0.001	H3 Confirmed
DTA → SP	0.211	2.391	0.017	H4 Confirmed
GDC → SP	0.431	6.889	0	H5 Confirmed

GMO → SP	0.121	2.238	0.025	H6 Confirmed
GPI → SP	0.318	3.95	0	H7 Confirmed
GMO → GPI → SP	0.119	2.462	0.014	H8 Confirmed

3.5.4. Predictive Relevance (Q-Square)

Predictive relevance was assessed using the Q-square (Q^2) value obtained through the blindfolding procedure. A Q-square value greater than zero indicates that the model has predictive relevance for a particular endogenous construct. As shown in Table 5, both Green Product Innovation and Sustainable Performance exhibit Q-square values well above zero, demonstrating that the model has strong predictive capability and effectively explains variations in the endogenous variables.

Table 5. Q-Square

Variable	Q^2 (= 1 − SSE/SSO)
Green Product Innovation	0.474
Sustainable Performance	0.703

4. Discussion

This study confirms that digital technology adoption, green dynamic capabilities (GDC), and green market orientation significantly contribute to green product innovation and sustainable performance among SMEs in Yogyakarta, Indonesia. These findings are consistent with existing literature that emphasizes the strategic importance of integrating digital technologies and environmental orientation to enhance the competitiveness of SMEs, particularly in emerging economies.

First, the role of digital adoption is critical in driving both operational efficiency and green innovation. Digital platforms facilitate real-time environmental monitoring and sustainable product development. Piot-Lepetit (2025) adds that digitalization enhances supply chain transparency and traceability, especially in agri-food sectors, enabling firms to better align with environmental compliance. Similarly, M. Zhang et al. (2021) showed that digital-based organizational control reinforces green innovation, contributing to improved triple bottom line outcomes.

Second, green dynamic capabilities emerge as the strongest predictor of sustainable performance. GDC enable firms to sense environmental changes, learn, and transform internal processes to align with sustainability objectives. This finding aligns with Teece (2007) dynamic capabilities theory and is empirically supported by Borah et al. (2025), Bhuiyan et al. (2024), and Mubeen et al. (2023), who found that GDC positively affect value co-creation, innovation, and long-term adaptability in SMEs.

Third, green market orientation plays a dual role: directly influencing green product innovation and indirectly contributing to sustainability through innovation mediation. This reinforces Sulaiman (2025) claim that customers' environmental values are key motivators for green-oriented SMEs. In line with Papadas et al. (2017), green marketing orientation requires not only external alignment but also internal strategic integration to produce tangible innovation outcomes.

The mediating role of green product innovation reveals that market orientation alone is insufficient without the ability to transform market signals into innovative products. This supports Tjahjadi et al. (2020), who suggested that green innovation serves as a vital mechanism linking strategic orientation with environmental and economic performance.

Moreover, the unique adaptability of Yogyakarta's SMEs—most of which are micro and small-sized—demonstrates how structural flexibility enables rapid adoption of digital and green innovation strategies. SMEs in developing countries often possess agility advantages that allow them to respond quickly to external pressures. These findings underscore the importance of cross-sector collaboration, as advocated by (Piot-Lepetit, 2025). Integrating digital training, green policy incentives, and market awareness campaigns can reinforce a systemic shift toward sustainable innovation ecosystems, thereby accelerating the green transition of SMEs in Indonesia and beyond.

5. Conclusions

This study examined how digital technology adoption, green dynamic capability, green market orientation, and green product innovation jointly shape sustainable performance among SMEs using a PLS-SEM approach. The findings indicate that digital technology adoption, green dynamic capability, and green market orientation play significant and complementary roles in enhancing both green product innovation and sustainable performance. In particular, green dynamic capability emerges as a central mechanism through which SMEs integrate environmental considerations into their strategic and operational practices, while green market orientation serves as a key driver of environmentally oriented innovation by aligning market intelligence with sustainability objectives. Digital technology adoption further strengthens these relationships by improving organizational responsiveness, information processing, and the effective reconfiguration of resources in support of sustainability goals.

The analysis also demonstrates that green product innovation functions as an important mediating mechanism linking green market orientation to sustainable performance. This finding underscores that awareness of environmentally oriented customer needs and market trends must be translated into tangible green product outcomes to generate meaningful sustainability benefits. Accordingly, the results suggest that market orientation alone is insufficient; rather, it must be supported by robust innovation capabilities that enable SMEs to convert environmental insights into value-creating and environmentally responsible products. Collectively, these relationships highlight the synergistic interaction between digital transformation, dynamic capabilities, market orientation, and green innovation in driving sustainable performance within resource-constrained MSME contexts.

From a theoretical perspective, this study contributes to the sustainable business and management literature by integrating digital transformation, dynamic capability theory, market orientation, and green innovation into a unified empirical framework. The findings extend existing theories by demonstrating how these perspectives interact to explain sustainable performance outcomes in SMEs, thereby enriching understanding of sustainability-driven competitiveness in emerging economy contexts.

From a practical standpoint, the results suggest that MSME owners and managers should prioritize the development of green dynamic capabilities as a strategic foundation for sustainable competitiveness, supported by targeted investments in digital technologies that enable environmentally informed decision-making and transparent stakeholder engagement. SMEs are encouraged to embed sustainability considerations throughout their market intelligence processes, foster cross-functional collaboration between market research and green product development, and treat environmental innovation as a long-term strategic investment rather than a short-term cost. For policymakers and business support institutions, the findings highlight the importance of integrated support initiatives that promote digital adoption for sustainability, strengthen green capabilities through mentoring and peer-learning mechanisms, enhance access to sustainability-oriented market information, and provide technical assistance for green product development.

Future research is encouraged to adopt longitudinal designs to capture the dynamic evolution of digital and green capabilities over time, expand the geographical scope to enhance generalizability across diverse SMEs settings, and incorporate additional explanatory mechanisms such as green process innovation and organizational learning. Further studies may also explore contextual moderators, including entrepreneurial orientation, policy support, and industry characteristics, to deepen understanding of the conditions under which digital and green strategies most effectively contribute to sustainable performance.

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