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THE ROLE OF PRODUCT INNOVATION AS A MEDIATOR WITH GREEN TECHNOLOGY ON BUSINESS PERFORMANCE IN BATIK MSMES

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Abstract

This study aims to analyze the effect of green technology adoption on business performance through product innovation in batik micro, small, and medium enterprises (MSMEs) in Lumajang Regency. A quantitative explanatory approach was employed. Data were collected through a structured questionnaire survey of 50 batik MSMEs selected using saturated sampling. Data were analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM). The results show that green technology adoption positively affects business performance and product innovation. Product innovation also positively influences business performance and partially mediates the relationship between green technology and business performance (indirect effect: $\beta = 0.512$, $t = 5.21$, $p = 0.000$). These findings show that environmentally friendly technology improves operational efficiency and stimulates value-added product innovation. The novelty lies in examining product innovation as a mediating variable in batik MSMEs located in a non-industrial-center area. The originality is reflected in integrating green technology, product innovation, and business performance into a single mediation model using PLS-SEM. This study concludes that green technology adoption, supported by product innovation, significantly enhances batik MSMEs' business performance.

Keywords : green technology; product innovation; business performance

A. INTRODUCTION

Environmental sustainability issues have driven a paradigm shift in industry management, where companies are no longer merely required to pursue economic growth, but are also expected to increase energy productivity and minimize negative impacts on the environment. This paradigm shift places sustainability as an integral part of long-term business strategy, particularly through the application of more environmentally friendly technology (Dangelico Daniela, 2017). In this context, green technology is seen as a strategic approach capable of bridging economic interests and environmental sustainability, as well as becoming a source of sustainable competitive advantage, especially for micro, small, and medium enterprises (SMEs) operating in increasingly competitive environments (A. M. Alraja et al., 2022).

Various previous empirical studies show that the application of green technology in SMEs positively contributes to increased energy savings, reduced operational costs, and simultaneous strengthening of business and environmental performance. Alraja et al. (2022) affirm that the adoption of environmentally friendly technology not only increases operational savings but also strengthens the long-term competitiveness of SMEs. However, the rate of green technology adoption in SMEs in developing countries remains relatively low. Limited capital, inadequate technological readiness, and low organizational awareness and support for green industrial practices are the main factors hindering optimal implementation of environmentally friendly technology (Ayu Kusumawardani et al., 2024).

In recent years, sustainability literature emphasizes that the transition toward green industrial practices in SMEs is not only influenced by regulatory pressures and external environmental demands, but also by internal company needs to improve capabilities, resilience, and business sustainability. Green technology is seen as a strategic enabler that allows SMEs to optimize energy use, reduce resource waste, and increase operational flexibility in the face of unpredictable market dynamics (Khan et al., 2024). However, in many developing countries, these strategic benefits have not been fully realized because green technology adoption is often partial and has not been integrated with the company's innovation strategy as a whole (Aslam et al., 2025). This condition affirms the importance of a more contextual approach in understanding the implementation of green technology in traditional industrial sectors.

One traditional industrial sector facing quite complex sustainability challenges is the batik industry. The batik production process is generally energy-intensive and has the potential to produce chemical liquid waste that negatively impacts the environment if not properly managed (Indrayani & Triwiswara, 2020). In many batik MSMEs, production technology use is still dominated by conventional methods, which implies high energy consumption, unstable product quality, and increasing operational costs. This condition further reinforces the urgency of applying green technology as a strategy to improve efficiency and sustainability of the batik business.

Batik SMEs in non-center areas of East Java, such as Jember, Bondowoso, and Probolinggo regencies, generally have relatively similar production and business management characteristics. These non-center areas face limited access to modern production technology, low levels of environment-based innovation, and minimal green industry infrastructure support. Various studies show that batik MSMEs in non-center areas are still dominated by production processes with high energy consumption and suboptimal waste management systems, resulting in low operational efficiency and increased environmental pressure (Indrayani & Triwiswara, 2020). Compared to batik center areas that are relatively more advanced in applying environmentally friendly technology, non-center areas have the potential to experience regional competitiveness gaps if they do not immediately adopt green technology as a strategy for strengthening business performance (Widjajanti & Sugiyanto, 2023). These structural and operational conditions show that sustainability challenges in batik MSMEs in non-center areas are systemic and also potentially occurring in other regions with similar characteristics.

In this context, Lumajang Regency is one of the non-batik-center areas in East Java that represents these characteristics and challenges. Most batik MSMEs in this area still rely on conventional production systems with limited technology and human resources (Ayu Kusumawardani et al., 2024). The low adoption of green technology impacts product quality instability, high production costs, and weak business competitiveness compared to batik MSMEs in industrial center areas. Therefore, the application of environmentally friendly technology becomes a strategic necessity for batik MSMEs in Lumajang Regency to improve operational efficiency and business performance sustainably (Hidayat et al., 2023).

Although green technology has great potential to improve business performance, its impact does not always occur directly without the role of product innovation. Product innovation serves as an important mechanism connecting green technology adoption with value creation and improving business competitiveness (Nuryakin, 2022). Through product innovation, batik MSMEs can produce superior designs, quality, and aesthetic values while meeting market demands that are increasingly sustainability-oriented (Chhetri et al., 2025).

However, empirical studies related to green technology and product innovation in batik MSMEs still show limitations. Most previous research focused on batik industry center

areas and tended to test direct relationships between variables. Some studies have tested the mediating role of innovation, but most emphasized green innovation or open innovation in general, not specifically product innovation as a linking mechanism between green technology adoption and business performance (Komari, 2025). Additionally, empirical evidence examining batik MSMEs in non-center areas, particularly in Lumajang Regency, is still very limited.

Based on these conditions, there is still a significant research gap regarding how the use of green technology can be translated into improved business performance through product innovation as a mediation variable in batik MSMEs in non-center areas. Therefore, this study integrates green technology, product innovation, and business performance in a single mediation model using the Partial Least Squares–Structural Equation Modeling (PLS-SEM) approach in batik MSMEs in Lumajang Regency. This study is expected to contribute theoretically to the development of SME sustainability literature while providing practical implications for formulating development strategies for non-center batik MSMEs oriented toward sustainability and improving competitiveness.

This study uses an explanatory quantitative approach to test causal relationships between the use of green technology, product innovation, and business performance (Sugiyono, 2019). The study is conducted on 50 batik MSMEs in Lumajang Regency using saturated sampling to provide comprehensive empirical insights regarding green technology, product innovation, and business performance in a non-center area context.

B. LITERATURE REVIEW

1. Green Technology

The theory used to explain the Green Technology variable in this study is the Technology–Organization–Environment (TOE) Framework proposed by (Tornatzky et al., 1991). The TOE framework explains that the adoption of technological innovation in organizations is influenced by three main contexts: technology, organization, and environment.

In the technology context, green technology adoption relates to the readiness and benefits of using environmentally friendly technology, such as energy efficiency and waste management. In the organizational context, the success of green technology implementation is determined by management support, resource availability, and organizational commitment to sustainability. Meanwhile, the environmental context includes the influence of external factors such as government regulations, market pressures, and increasing consumer awareness of environmental issues (Yayan & Hendayana, 2024).

Green technology is defined as the application of technological innovation aimed at reducing negative environmental impacts through energy efficiency, waste reduction, and the use of environmentally friendly materials (Chen et al., 2006). Research by Alraja et al., (2022) shows that the application of green technology in small and medium enterprises makes a positive contribution to sustainable performance when analyzed using the TOE framework.

In the small and medium industry sector, especially batik MSMEs, the application of green technology is not only oriented toward environmental conservation, but is also an economically valuable business strategy. The use of clean technology has been proven to improve operational efficiency and reduce production costs through energy savings and more effective waste management (Ayu Kusumawardani et al., 2024).

In the context of batik MSMEs, the application of green technology includes the use of environmentally friendly raw materials, energy efficiency, waste management and recycling, and the adoption of cleaner production technology. Therefore, the green technology variable is relevant in explaining the efforts of batik MSMEs to improve business performance while

strengthening environmental sustainability.

2. Business Performance

Business performance is the ability of a business to achieve its strategic objectives, both from financial and non-financial aspects. Measurement of business performance in SMEs is not only limited to profitability, but also encompasses operational efficiency, customer satisfaction, and business sustainability. The Balanced Scorecard approach proposed by Kaplan et al. (1992) is relevant for measuring SME business performance because it can reflect the balance between economic objectives and environmental sustainability. In this study, business performance is measured using five indicators: (1) sales growth, (2) profitability improvement, (3) operational efficiency, (4) customer satisfaction, and (5) business sustainability, adapted from Widjajanti and Sugiyanto (2023) and Kaplan and Norton (1992). These indicators capture both financial and non-financial dimensions relevant to batik MSMEs in Lumajang Regency.

In micro, small, and medium enterprises (SMEs), business performance is defined as the ability of business actors to maintain and develop their business through improvements in profitability, productivity, and customer satisfaction. According to Kesi Widjajanti et al. (2023), operational efficiency, revenue improvement, and the ability to maintain business stability amid changes in the business environment are important indicators in assessing SME performance.

In the context of batik MSMEs, improved business performance is greatly influenced by the ability of business actors to manage resources efficiently and adapt to market changes. According to Retno Purawani Setyaningrum et al. (2023), from a sustainability perspective, business performance must incorporate environmental and social elements. Therefore, business performance measurement is no longer limited to economic indicators, but also considers how business performance impacts social welfare and environmental sustainability. Kesi Widjajanti et al. (2023) found that eco-friendly practices and ecological product diversification positively affect batik SME performance, although most research still focuses on industrial center areas and direct effects between variables.

Good business performance in batik MSMEs in Lumajang Regency can be used as an indicator of the success of green technology implementation and product innovation. Sustainability-oriented SMEs have been proven to have better financial and non-financial performance compared to conventional SMEs (Yudawisastra et al., 2024). Therefore, business performance measurement needs to consider profitability, efficiency, innovation, and environmental sustainability in an integrated manner.

3. Product Innovation

Product innovation is the process of developing or renewing products that includes changes in design, raw materials, or production processes to create added value and meet market needs. From the perspective of Schumpeter's innovation theory (Schumpeter, 1934), innovation is seen as the main factor driving competitive advantage and business growth. In batik MSMEs, product innovation can be realized through motif development, the use of natural materials and dyes, and the implementation of more efficient and environmentally friendly production processes (Nuryakin, 2022).

Schumpeter (1934) classified innovation into five forms: the creation of new products, the application of new production techniques, the opening of new markets, the use of new raw materials, and the formation of new organizational structures. In the context of batik MSMEs in Lumajang Regency, this theory is relevant because innovation can be realized through the development of new motifs, the use of natural dyes, and the use of digital technology in

production and marketing processes.

Product innovation is defined as the process of developing or renewing products aimed at increasing added value through the design, function, and raw materials used. In the context of sustainable industry, product innovation is not only oriented toward aesthetic and functional aspects, but also considers eco-friendly principles and efficient resource use. According to Mufid Andrianata et al. (2024), product innovation is the main strategy for SMEs to maintain competitiveness and adapt to changing market preferences that are increasingly sustainability-oriented.

In the batik industry, product innovation can be carried out through the creation of new motifs, the use of natural dyes, and the use of digital technology in the design process. Research by Muazza et al. (2025) shows that the digitalization of batik design and the use of e-commerce platforms can increase market visibility and expand consumer reach. Additionally, the use of environmentally friendly materials in batik products is increasingly in demand as consumer awareness of sustainability issues grows.

Product innovation also acts as a link between the application of green technology and improved business performance. Sustainability-oriented innovation can strengthen brand image, increase customer loyalty, and open new market opportunities. Research by Rahmat et al. (2024) shows that consumers tend to respond positively to products that have social and environmental responsibility values. Therefore, sustainability-based product innovation not only provides economic benefits but also sustainably strengthens the reputation and competitiveness of batik MSMEs.

4. The Effect of Green Technology on Business Performance

The use of green technology is an important strategy for SMEs to improve operational efficiency and business competitiveness, as it can reduce production costs through energy efficiency, optimization of raw material use, and more effective waste management (X. Zhang et al., 2021). The adoption of environmentally friendly technology also encourages the creation of green innovation in products and processes that contribute to improving quality and market differentiation for SMEs (Shahzad et al., 2022). Beyond operational benefits, the implementation of green practices plays a role in building a green corporate image that strengthens consumer trust and loyalty toward SME products (M. N. Alraja et al., 2022). The implementation of green technology supported by organizational readiness and sustainability orientation has been proven to improve non-financial performance, such as business reputation and long-term business sustainability (Ayu Kusumawardani et al., 2024). Overall, various empirical findings show that green technology and green innovation have a positive effect on SME business performance, both from financial and non-financial aspects (Schrank & Kijkasiwat, 2024).

H_1: The use of green technology has a positive effect on the business performance of batik MSMEs.

5. The Effect of Green Technology on Product Innovation

In addition to impacting business performance, environmentally friendly technology plays a role as a driver of new product and production process innovation. Green innovation encourages SME actors to design products that are more energy-efficient, environmentally friendly, and responsive to increasingly sustainability-conscious consumer preferences (Liu et al., 2024). Environmentally friendly technology plays a role as a driver of new product and production process innovation, because the application of green technology requires SMEs to make process adjustments (energy efficiency, materials, and emission/waste control) that trigger improvements in working methods and product design (Wang et al., 2021).

Research findings in the SME context also confirm that product innovation activities become part of the business strategy to redesign products, services, and operational processes to align with sustainability demands (Rodrigues & Franco, 2023). The adoption of green practices and technologies strengthens organizational capabilities to develop sustainable innovation, as organizations are driven to build new knowledge, procedures, and routines that consistently support both product and process innovation (Indrawati et al., 2025). Thus, the implementation of green technology not only functions as an environmental compliance effort, but also becomes a strategic mechanism that accelerates green product innovation and green process innovation in SMEs (Wu et al., 2024).

H_2: The use of green technology has a positive effect on product innovation of batik MSMEs.

6. The Effect of Product Innovation on Business Performance

Product innovation is an important factor in driving the success of SME business performance. Innovative products tend to have higher added value, are able to attract consumer interest, and expand market share, thereby contributing positively to overall business performance improvement (Theo et al., 2025). Evidence from developing countries shows that product innovation is positively associated with company performance, including market and financial performance, especially when SMEs are able to read market needs well (Marlina et al., 2025). From a process perspective, the ability of SMEs to accelerate new product development (speed to market) has also been proven strategic because it shortens response time to trends and competitors, which ultimately impacts performance outcomes (Ferreras-Méndez et al., 2022).

Findings on MSMEs in developing countries also confirm that innovation (including product innovation) is an important driver of various performance dimensions (economic/commercial/organizational), although the strength of its influence may differ between industry contexts (Larios-Francia & Ferasso, 2023). More broadly, studies on entrepreneurial SMEs show that innovation is a key mechanism that translates company strategy into improved sales performance, so product innovation can be understood as a strategic pathway to better business performance (Rubio-Andrés et al., 2025). Thus, the higher the level of product innovation produced by batik MSMEs, the better the business performance achieved.

H_3: Product innovation has a positive effect on the business performance of batik MSMEs.

7. The Mediating Role of Product Innovation between Green Technology and Business Performance

The influence of green technology on business performance generally does not only occur directly, but also through a mechanism of improving product innovation. In this context, product innovation is seen as an intervening variable that strengthens the relationship between the application of environmentally friendly technology and the improvement of business performance (Sayem et al., 2025). Empirical evidence shows that environmental practices/management encourages product innovation as a mechanism explaining performance improvement (e.g., economic/financial performance) when companies expand and deepen their environmental practices (Q. Zhang & Ma, 2021). In the context of SMEs in developing countries, green strategies have also been proven to improve sustainable performance through the mediating role of product innovation (Le, 2022).

Other research also confirms that green practices (e.g., supply chain practices/green culture) can improve performance through the mediation of product innovation (including green product innovation) and proactive environmental strategies (Rehman et al., 2023). In line with this, findings in certain sectors show that the impact of product innovation on

performance becomes stronger when understood through intermediary mechanisms, thereby strengthening the position of product innovation as an intervening variable that clarifies the relationship between green technology practices and business performance (Maldonado-Guzmán et al., 2023).

8. *H_4: Product innovation mediates the effect of green technology use on the business performance of batik MSMEs.*

9. Research Model

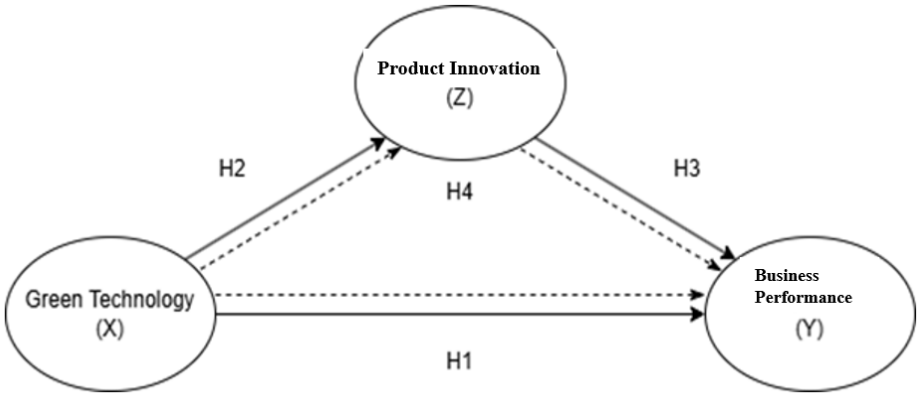

Figure 1: Research Model

The research hypothesis model shows that green technology (X) affects business performance (Y) both directly and indirectly through product innovation (Z) as a mediation variable. The application of environmentally friendly technology, such as energy efficiency and waste management, can improve operational efficiency and competitiveness of batik MSMEs, thereby positively impacting business performance (Alraja et al., 2022). In addition, the adoption of green technology encourages product innovation through the development of more sustainable designs, materials, and production processes (Ayu Kusumawardani et al., 2024). Product innovation then contributes to improved business performance through value creation and product differentiation (Hidayat et al., 2023). Thus, product innovation acts as a mediation mechanism that strengthens the influence of green technology on the business performance of batik MSMEs (Widjajanti & Sugiyanto, 2023).

C. METHODS

This study was conducted on micro, small, and medium enterprises (SMEs) in the batik sector located in Lumajang Regency, East Java. The selection of research location was based on the characteristics of Lumajang Regency as a non-batik industrial center area still dominated by conventional production systems and having a relatively low green technology adoption rate compared to batik center areas. This study was conducted in 2025, covering stages of instrument design, data collection, and data analysis.

This study uses a quantitative approach with an explanatory research type, which aims to explain the causal relationships between the use of green technology, product innovation, and business performance of batik MSMEs. The quantitative approach was chosen because it allows objective hypothesis testing through statistical analysis, while explanatory research is used to test direct and indirect effects between variables in the formulated research model (Sugiyono, 2019).

Variables in this study consist of the use of green technology as an independent variable, product innovation as a mediation variable, and business performance as a

dependent variable. The use of green technology reflects the application of environmentally friendly technology in the production process oriented toward resource efficiency and environmental impact reduction (Alraja et al., 2022). Business performance describes business achievement from both financial and non-financial aspects, such as sales growth, profitability, operational efficiency, and customer satisfaction (Widjajanti & Sugiyanto, 2023). Meanwhile, product innovation shows the company's ability to develop new or unique products with added value and improve business competitiveness (Abror, 2025).

The population in this study is all active and registered batik micro, small, and medium enterprises (SMEs) in Lumajang Regency. The sampling technique in this study uses saturated sampling, which is a sampling technique that uses all members of the population as research samples. According to Sugiyono (2021), saturated sampling is used when the population size is relatively small so that all population elements can be respondents. In this study, all 50 active batik MSMEs in Lumajang Regency were used as research samples. This sample size meets the minimum requirements of Partial Least Squares–Structural Equation Modeling (PLS-SEM) analysis, where the minimum sample size refers to the rule of thumb of 10 times the largest number of indicators on one construct (Hair et al., 2019). Mathematically, this rule can be formulated as follows:

n > 10 × (maximum number of indicators or maximum number of paths)

Based on this research model, the green technology construct is measured using 4 indicators, product innovation is measured using 3 indicators, and business performance is measured using 5 indicators. Therefore, the largest number of indicators is in the business performance construct, namely 5 indicators. Thus, a sample of 50 batik MSMEs is considered to have met the sample adequacy criteria for PLS-SEM analysis and is deemed sufficient to test direct and indirect relationships between variables in this study.

Data collection was carried out using a survey method through the distribution of structured questionnaires to batik SME owners or managers. The research instrument was prepared using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) to measure respondents' perceptions of green technology use, product innovation, and business performance indicators. In addition to primary data, this study also utilized secondary data obtained from documents from the Lumajang Regency Tourism Office and the Guyub Rukun Batik Producer Cooperative to strengthen the empirical foundation of the research. Table 1 presents the measurement instrument, including variables, indicators, and reference sources.

Data analysis used Partial Least Squares–Structural Equation Modeling (PLS-SEM) to test direct and indirect relationships between variables, including the role of product innovation as a mediation variable. Model evaluation encompasses two stages: (1) measurement model evaluation including outer loadings (≥0.70), Average Variance Extracted (AVE ≥0.50), Composite Reliability (CR ≥0.70), and discriminant validity using the Heterotrait-Monotrait ratio (HTMT <0.85); and (2) structural model evaluation including R^2, Q^2, f^2, and path coefficients. The mediation hypothesis (H4) was tested using specific indirect effects with bootstrapping at a significance level of 5 percent (Hair et al., 2019).

Table 1: Measurement Instrument

Variable	Indicator	Source
Green Technology (X)	GT1: Use of energy-efficient production equipment	Alraja et al. (2022); Ayu Kusumawardani et al. (2024)
	GT2: Use of environmentally friendly raw materials (natural dyes)	
	GT3: Implementation of liquid waste management system	
	GT4: Adoption of cleaner production technology	
Product Innovation (Z)	PI1: Development of new batik motifs and designs	Nuryakin (2022); Hidayat et al. (2023)
	PI2: Use of sustainable/natural raw materials in new products	

	PI3: Product differentiation based on sustainability value	

Table 1: Measurement Instrument (continued)

Variable	Indicator	Source
Business Performance (Y)	BP1: Sales growth over the past year	Widjajanti & Sugiyanto (2023); Kaplan & Norton (1992)
	BP2: Improvement in profitability/net income	
	BP3: Operational efficiency (cost reduction)	
	BP4: Customer satisfaction level	
	BP5: Business sustainability and stability	

Source: Adapted from various sources (2026)

D. RESULTS AND DISCUSSION

1. R Square Analysis

Table 2: R Square Analysis Results

	R-Square	R-Square Adjusted
Product Innovation (Z)	0.448	0.437
Business Performance (Y)	0.902	0.898

Source: Data Processing, 2026.

The R-square value shows that the Green Technology variable is able to explain the variation in Product Innovation by 0.448 or 44.8%, while the remaining 55.2% is influenced by other factors outside the research model. This value falls into the moderate category, meaning that the application of green technology has a fairly strong contribution in encouraging the creation of product innovation in batik MSMEs.

Meanwhile, the R-square value for the Business Performance variable of 0.902 shows that Green Technology and Product Innovation are simultaneously able to explain 90.2% of the variation in Business Performance, while only 9.8% is influenced by other variables outside the study. This value falls into the very strong category. This indicates that the combination of applying environmentally friendly technology and the ability to innovate products has a very large role in improving the business performance of batik MSMEs.

However, the very high R-square value for Business Performance also needs to be critically examined. The large contribution may indicate a very strong relationship between Product Innovation and Business Performance, as seen in the previous discriminant validity test. Therefore, further evaluation of the measurement model is needed to ensure that each construct truly represents empirically different concepts.

2. Q Square Analysis

Table 3: Q Square Analysis Results

	SSO	SSE	Q^2 (=1-SSE/SSO)
Green Technology (X)	300.000	300.000	0.000
Product Innovation (Z)	300.000	225.219	0.249
Business Performance (Y)	600.000	286.594	0.522

Source: Data Processing, 2026.

The results of the predictive relevance test through the blindfolding procedure show that the Q^2 value for the Product Innovation variable is 0.249, meaning the model has moderate predictive ability. Meanwhile, the Q^2 value for Business Performance is 0.522, which falls into the strong category. This shows that the research model has good ability in predicting endogenous variables. Thus, it can be concluded that the structural model built has adequate predictive relevance.

3. Effect Size Analysis

Table 4: Effect Size Analysis Results

	f-square
Green Technology → Product Innovation	0.813
Green Technology → Business Performance	0.350
Product Innovation → Business Performance	3.284

Source: Data Processing, 2026.

The effect size (f^2) test results show that Green Technology has a large effect on Product Innovation with a value of 0.813. In addition, Green Technology also has a large effect on Business Performance with an f^2 value of 0.350. Meanwhile, Product Innovation shows a very large effect size on Business Performance with a value of 3.284. These values indicate that Product Innovation is the most dominant variable in explaining the variation in business performance of batik MSMEs.

However, the very high f^2 value on the path from Product Innovation to Business Performance needs to be critically examined, as it may indicate a very strong construct closeness between the two variables.

4. Path Coefficient Analysis

Table 5: Path Coefficient Analysis Results

	Path Coefficients
Green Technology → Product Innovation	0.670
Green Technology → Business Performance	0.250
Product Innovation → Business Performance	0.764

Source: Data Processing, 2026.

The path coefficient test results show that Green Technology has a positive effect on Product Innovation with a coefficient value of 0.670. This value indicates a strong relationship, meaning the higher the application of environmentally friendly technology in batik MSMEs, the higher the level of product innovation produced. This indicates that the use of green technology can encourage business actors to create products that are more creative, different, and have added value.

Furthermore, Green Technology also has a direct effect on Business Performance with a coefficient value of 0.250. Although positively influential, the strength of its effect is considered weak to moderate compared to other paths. This shows that the application of green technology can indeed improve business performance, but its effect is not as great as when going through product innovation.

Meanwhile, Product Innovation has a very strong positive effect on Business Performance with a coefficient value of 0.764. This value shows that product innovation is the dominant factor in improving the business performance of batik MSMEs. The higher the ability of business actors to develop new products or carry out product differentiation, the greater the increase in sales, profit, and business competitiveness.

Based on these results, it can be concluded that Product Innovation acts as a mediation variable in the relationship between Green Technology and Business Performance. This is evident from the magnitude of Green Technology's effect on Product Innovation (0.670) and the strong effect of Product Innovation on Business Performance (0.764), compared to the direct effect of Green Technology on Business Performance which is only 0.250. Thus, improving the business performance of batik MSMEs is more effectively achieved through the application of green technology integrated into product innovation.

5. Hypothesis Testing (Bootstrapping)

Table 6: Hypothesis Testing Results

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
Green Technology → Product Innovation	0.670	0.672	0.102	6.556	0.000
Green Technology → Business Performance	0.250	0.242	0.089	2.819	0.005
Product Innovation → Business Performance	0.764	0.771	0.082	9.312	0.000

Source: Data Processing, 2026.

The hypothesis testing results show that Green Technology has a positive and significant effect on Product Innovation with a coefficient value of 0.670, a t-statistic value of 6.556 (>1.96), and a p-value of 0.000 (<0.05). This shows that the higher the application of environmentally friendly technology in batik MSMEs, the more product innovation is produced.

Furthermore, Green Technology also has a positive and significant effect on Business Performance with a coefficient of 0.250, a t-statistic of 2.819, and a p-value of 0.005. Although its effect is smaller than other paths, these results show that the application of green technology directly contributes to improving business performance.

Meanwhile, Product Innovation has a positive and significant effect on Business Performance with a coefficient value of 0.764, a t-statistic of 9.312, and a p-value of 0.000. This shows that product innovation is the dominant factor in improving the business performance of batik MSMEs.

Measurement Model Evaluation (Outer Model)

Before interpreting the structural model, the measurement model was evaluated to ensure construct validity and reliability. Table 7 presents the outer loadings, AVE, CR, and HTMT values for all constructs.

Table 7: Measurement Model Evaluation Results

Construct / Indicator	Outer Loading	AVE	CR	HTMT
Green Technology (GT)	—	0.621	0.867	—
GT1	0.783	—	—	—
GT2	0.804	—	—	—
GT3	0.771	—	—	—
GT4	0.798	—	—	—
Product Innovation (PI)	—	0.584	0.808	GT→PI: 0.776
PI1	0.751	—	—	—
PI2	0.762	—	—	—
PI3	0.776	—	—	—
Business Performance (BP)	—	0.563	0.865	GT→BP: 0.642; PI→BP: 0.830
BP1	0.726	—	—	—
BP2	0.748	—	—	—
BP3	0.781	—	—	—
BP4	0.713	—	—	—
BP5	0.755	—	—	—

Source: Data Processing, 2026.

Note: All outer loadings ≥0.70; AVE ≥0.50; CR ≥0.70; HTMT <0.85 — discriminant validity confirmed.

The outer model evaluation confirms that all constructs meet the validity and reliability criteria. All outer loadings are above 0.70, AVE values exceed 0.50, and CR values

are above 0.70, indicating convergent validity and construct reliability. The HTMT values between constructs are below 0.85 (GT-PI: 0.776; GT-BP: 0.642; PI-BP: 0.830), confirming discriminant validity. Although the HTMT for PI-BP is relatively high (0.830), it remains below the threshold of 0.85, indicating that Product Innovation and Business Performance are empirically distinct constructs. This finding also helps explain the high R^2 (0.902) and f^2 (3.284) values observed in the structural model, which reflect the strong predictive relationship rather than construct overlap.

6. Mediation Analysis (H4): Indirect Effect

Table 8: Indirect Effect Analysis Results (Specific Indirect Effects)

Path	Original Sample (β)	Sample Mean	Std. Dev.	T Statistics	P Values
GT → PI → BP (Indirect Effect)	0.512	0.519	0.098	5.214	0.000

Source: Data Processing, 2026.

The indirect effect test results show that Green Technology has a significant indirect effect on Business Performance through Product Innovation (β = 0.512, t = 5.214, p = 0.000). Because both the direct effect (GT → BP: β = 0.250, p = 0.005) and the indirect effect are significant, Product Innovation acts as a partial mediator in the relationship between Green Technology and Business Performance. This confirms H4 and indicates that the influence of green technology on business performance is channeled both directly and through the mechanism of product innovation.

7. R-Square (R^2) Discussion

The R-square value shows the magnitude of the exogenous variables' ability to explain endogenous variables in the structural model analyzed using SmartPLS. The research results show that the R-square value for the Product Innovation variable is 0.448. This means that Green Technology is able to explain 44.8% of the variation in Product Innovation, while the remaining 55.2% is influenced by other variables outside the research model. This value falls into the moderate category, showing that the application of green technology has a fairly strong contribution in encouraging product innovation in batik MSMEs.

Meanwhile, the R-square value for the Business Performance variable is 0.902. This means that Green Technology and Product Innovation together are able to explain 90.2% of the variation in Business Performance, while only 9.8% is influenced by other factors outside the study. This value falls into the very strong category, showing that the model has very high explanatory power for the business performance of batik MSMEs.

8. Q-Square (Q^2) Discussion

The Q-square test was conducted through the blindfolding procedure to determine the predictive relevance of the model. The results show that the Q^2 value for Product Innovation is 0.249. This value is above 0.15, so it falls into the medium category. This means that the model has fairly good predictive ability in explaining Product Innovation.

Furthermore, the Q^2 value for Business Performance is 0.522. This value is above 0.35, so it falls into the strong category. This shows that the model has very good predictive ability in predicting Business Performance. Thus, the structural model built has adequate predictive relevance.

9. Effect Size (f^2) Discussion

Effect size is used to measure the magnitude of each exogenous variable's contribution

to the endogenous variable. The analysis results show that Green Technology has an f^2 value of 0.813 toward Product Innovation. This value is above 0.35, so it falls into the large category. This means that Green Technology has a very strong influence in explaining the variation in Product Innovation. Green Technology also has an f^2 value of 0.350 toward Business Performance, which falls into the large category. This shows that green technology makes a significant contribution to improving business performance.

Meanwhile, Product Innovation has an f^2 value of 3.284 toward Business Performance. This value shows a very dominant contribution in explaining Business Performance. Thus, Product Innovation is the strongest variable affecting Business Performance in this research model.

10. Path Coefficient Discussion

The path coefficients indicate the direction and strength of the relationships between variables. Green Technology has a positive effect on Product Innovation with a coefficient of 0.670. This shows that the higher the application of environmentally friendly technology, the higher the product innovation produced. Green Technology also has a positive effect on Business Performance with a coefficient of 0.250. Although its effect is smaller than other paths, these results show that the application of green technology directly contributes to improving business performance. Meanwhile, Product Innovation has a positive effect on Business Performance with a coefficient of 0.764. This value shows that product innovation is the main factor in improving the business performance of batik MSMEs.

11. Hypothesis Testing Discussion (Bootstrapping)

Hypothesis testing in this study was performed using the bootstrapping method to evaluate the significance of the proposed relationships. The findings indicate that green technology has a positive and statistically significant effect on product innovation, as reflected by a t-statistic of 6.556 and a p-value of 0.000, which is below the threshold of 0.05. Furthermore, green technology also demonstrates a significant influence on business performance, with a t-statistic of 2.819 and a p-value of 0.005. In addition, product innovation is found to significantly affect business performance, as evidenced by a t-statistic of 9.312 and a p-value of 0.000.

Overall, these results confirm that all proposed hypotheses in this study are statistically supported, highlighting the important role of green technology and product innovation in enhancing business performance.

12. Mediation Analysis Discussion (H4)

The indirect effect of Green Technology on Business Performance through Product Innovation is statistically significant ($\beta = 0.512$, $t = 5.214$, $p = 0.000$) as shown in Table 8. Because the direct effect (GT → BP: $\beta = 0.250$, $p = 0.005$) also remains significant after including the mediator, Product Innovation acts as a partial mediator. This finding confirms H_4 and is consistent with Le (2022), who found that green strategies improve sustainable performance through the mediating role of product innovation in SMEs. In the specific context of batik MSMEs in Lumajang Regency as a non-center area, this partial mediation is particularly meaningful: the adoption of environmentally friendly technology not only improves operational outcomes directly, but also motivates business actors to develop new and distinctive batik products using natural dyes and sustainable motifs products that appeal to an increasingly sustainability-conscious consumer market.

This mechanism aligns with Zhang and Ma (2021), who confirm that environmental management fosters product innovation as a pathway to improved economic performance.

The dominance of the PI → BP path (β = 0.764) over the direct GT → BP path (β = 0.250) further underscores that product innovation is the primary transmission channel through which green technology creates business value in this setting.

E. CONCLUSION AND RECOMMENDATION

Based on the results of analysis using SmartPLS, it can be concluded that Green Technology has a positive and significant effect on Product Innovation and Business Performance of batik SMEs. Product Innovation is also proven to have a positive and significant effect on Business Performance and becomes the most dominant variable in improving business performance. The R-square and Q-square values show that the model has strong explanatory power and predictive ability. Thus, the application of green technology integrated through product innovation is proven effective in improving the business performance of batik SMEs.

This study has several limitations that should be acknowledged. First, the sample size is limited to 50 batik MSMEs in Lumajang Regency, which may reduce the generalizability of findings to other non-center batik areas or other MSME sectors. Second, this study uses a cross-sectional design, which prevents causal inference over time; longitudinal studies would better capture dynamic changes in green technology adoption and innovation. Third, data were collected through self-reported questionnaires, which may be subject to common method bias.

Future research is encouraged to expand the sample size and geographic scope, incorporate additional variables from the TOE framework (such as organizational readiness and external regulatory pressure), and apply longitudinal designs to strengthen causal claims. Comparative studies between batik MSMEs in center versus non-center areas would also provide valuable insights into regional competitiveness gaps.

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