Strategic green entrepreneurship for business sustainability of Batik SMEs in Indonesia: the role of knowledge and ambidextrous innovation

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Abstract: Batik SMEs in today's highly competitive landscape encounter numerous obstacles concerning their sustainability. This study employs an approach that integrates green knowledge management (GKM) and ambidextrous green innovation (AGI) as sequential mediating factors to investigate the link between green entrepreneurial orientation (GEO) and sustainable performance (SP). We employed an accidental-purposive sampling method to collect quantitative data, specifically selecting 401 respondents from 253 batik SMEs in Indonesia that are actively engaged in green entrepreneurship and innovation. A second-order PLS-SEM analysis yielded multiple findings. Initially, we found that GEO had an insignificant direct effect on SP. Furthermore, GKM and AGI have been established as sequential mediators in this relationship. Lastly, the dimensional analysis indicated that batik SMEs appear to prioritise exploitative green innovation over exploratory innovation. Future research should examine the relationships among these dimensions for more profound insights and investigate how AI capabilities can enhance the GKM process.

Keywords: sustainability performance; green entrepreneurial orientation; GEO; green knowledge management; GKM; green innovation; green business; Indonesia.

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1 Introduction

Batik, an ancient art from Java, Indonesia, intricately combines spiritual and philosophical concepts within its fabric patterns. Traditional techniques involve repeatedly applying resist and dye to create these elaborate designs (Syed Shaharuddin et al., 2021). The Indonesian textile industry has thrived since UNESCO designated batik as an 'Intangible World Heritage of Humanity' in 2009 (Izzah, 2023). This trend is particularly evident in East Java, which has the second-highest population of batik SMEs in Indonesia, following Central Java (Nouvan, 2025). Despite an uptick in sales during the COVID-19 pandemic in 2022, batik experienced a further decline in 2023 (Al-Fajri, 2024). Even batik SMEs in East Java continued to face challenges until 2025 in the form of rampant imports of counterfeit batik (Nurdifa, 2025).

Additionally, batik production raises significant social and environmental concerns. For instance, river water pollution in Madura (Syafaruddin, 2023) highlights how wastewater from the batik industry contributes to environmental degradation. The chemicals used in this production process have also led to skin irritation among many employees (Hapis et al., 2023). As a result, batik SMEs continue to fall short of expectations in terms of their economic, environmental, and social performances. Batik SMEs in East Java face considerable challenges in maintaining their operations. Therefore, establishing a strategy to enhance the sustainability performance of batik SMEs in East Java is critical. The sustainability of SMEs cannot be ignored, as their failure can extensively impact on economic growth and social welfare (Mansour et al., 2025).

Sustainability performance can be achieved through green entrepreneurship practice (Prasetio et al., 2025). Some researchers have demonstrated that adopting a green entrepreneurial orientation (GEO) can significantly improve sustainable performance (SP) (i.e., Appiah et al., 2023; Coelho et al., 2023; Tze San et al., 2022; Muangmee et al., 2021). However, results from studies by Frare and Beuren (2022), Majali et al. (2022), and Ye et al. (2022), are not adequately represented from an empirical standpoint. Despite some conflicting findings, the research indicated that a GEO may not positively influence SP.

Some research studies indicated that a GEO has a positive and significant impact on green innovation (GI) (e.g., Appiah et al., 2023; Rong et al., 2025). According to Shehzad et al. (2023) and Baquero (2024), GI techniques should be examined from exploratory and exploitative perspectives. This dual approach enables organisations to pursue new sustainable practices while effectively leveraging existing resources. Meanwhile, a contrast study by Majali et al. (2022) suggested that GEO has a favourable but insignificant impact on GI. Additionally, Doeden (2020) noted a lack of evidence in this area, finding that entrepreneurial orientation negatively affects GI, although this effect is insignificant.

GEO significantly affects green knowledge management (GKM) (Shehzad et al., 2023). However, similar studies remain scarce. Wang et al. (2023) found that GEO has a notable and beneficial effect on 'knowledge creation process', an aspect of GKM. Additionally, effective knowledge management (KM) assists optimal GI outcomes (Ngoc Huynh et al., 2024), even in examining the concept of innovation's ambidexterity (Shehzad et al., 2023). Consequently, GKM supports and encourages ambidextrous green innovation (AGI).

The novelty of this study is a second-order strategy framework that connects SP with GEO using AGI and GKM as sequential mediation constructs. The framework is grounded in three key theories: the stakeholder theory, knowledge-based view (KBV), and dynamic capability (DC). This framework was tested on batik SMEs in East Java, Indonesia as a unique approach that perhaps rarely explored before.

This study aims to examine how GEO affects SP and to explore the sequential mediating roles of GKM and AGI in the relationship between these two constructs. Additionally, it seeks to identify the dimensions and indicators that most effectively represent each research variable within the context of batik SMEs in East Java, Indonesia.

2 Theory and hypotheses development

2.1 Stakeholders theory, KBV, and DC

The internal and external interactions between a firm and its stakeholders are the primary foci of the stakeholder theory which suggests that businesses should not only prioritise their interests; they should also consider the needs of those who are important to them (Aisjah et al., 2023) to achieve a long-term sustainability. At the same time, the KBV asserts that knowledge is a company's most valuable asset regarding long-term strategy (Bergh et al., 2025). Therefore, organisations should cultivate strong green knowledge to enhance economic performance, positively impact community welfare, and ensure ecological sustainability. Meanwhile, DCs emphasise the necessity for businesses to possess the ability to integrate, build, and reconfigure their resources effectively to maintain competitiveness. If organisations develop strong DCs, they can foster green innovation by aligning their strategic management with sustainability and environmental priorities (Borah et al., 2025).

2.2 The relational between GEO and SP

GEO significantly enhances SP (Wang et al., 2025; Ma et al., 2025). Nurturing a GEO can yield long-term advantages, which indicates that an environmentally conscious

entrepreneurial approach is linked to improved long-term financial, ecological, and social outcomes for companies (Muangmee et al., 2021; Tze San et al., 2022; Appiah et al., 2023). This comprehensive perspective highlights the necessity of embedding sustainability into fundamental business strategies. At the same time, the stakeholder theory highlights how organisation interacts with stakeholders (Abdeladim and Yahyaoui, 2024). Since GEO responds to the demands of consumers, governments, and communities for sustainable products and production processes, it serves not only as a resource-based internal strategy but also as an external legitimising tool securing stakeholder support. Thus, the first hypothesis of this research is as follows.

H1 Batik SMEs may greatly enhance their SP by shifting their orientation to green entrepreneurship.

2.3 The relational between GEO, AGI, and SP

GI more likely emerges when entrepreneurs adopt a green perspective (Rong et al., 2025; Ngoc Huynh et al., 2024; Appiah et al., 2023). Businesses that strive to be environmentally friendly are more inclined to develop innovative solutions benefitting the environment and are sustainable over time (Wang et al., 2023; Frare and Beuren, 2022). Companies aiming for success in today's environmentally conscious market may need to cultivate a GEO. Shehzad et al. (2023) and Baquero (2024) viewed GI as ambidextrous, encompassing both exploratory and exploitative forms.

Meanwhile, research by Muangmee et al. (2021), Elzek et al. (2021), Li et al., (2023), and Ahmed et al. (2023) highlighted the critical role of GI in achieving SP. Indicators of economic, environmental, and social performance all suggest a positive correlation between increased GI and SP. As demonstrated by Shehzad et al. (2023), AGI significantly and positively affects SP. Businesses must be willing to explore and implement GI to remain competitive in a dynamic market. With GEO influencing AGI and AGI impacting SP, there exists a strong connection between these three elements.

Based on the stakeholder theory, GEO reflects a company's response to the expectations of its stakeholders. Meanwhile, DC describes an organisation's ability to adapt to the ever-changing environmental demands by integrating, developing, and reconfiguring its internal and external competencies. AGI translates strategic objectives into SP, establishing it as a crucial DC. Therefore, the research hypotheses are as follows:

H2 With an increasing focus on green entrepreneurship, batik SMEs can increase AGI.

H3 Batik SMEs can improve their SP by making a stronger commitment to AGI.

H4 By emphasising green entrepreneurship, batik SMEs can encourage AGI, which in turn leads to SP.

2.4 The link between GEO, AGI, and GKM

Several earlier works have shown that AGI can be generated by high GEO (e.g., Rong et al., 2025; Baquero, 2024; Shehzad et al., 2023). Majali et al. (2022) found a favourable but minor impact of GEO on GI; nevertheless, there is a gap in the empirical data supporting this claim. The results of Doeden (2020) are likewise lacking in empirical support; they showed that entrepreneurial orientation negatively affects GI, albeit

marginally. As a result, while the GI output slightly decreases, the company's orientation toward environmentally friendly entrepreneurship increases.

Given the contradictory findings in studies examining GEO's impact on GI, it is plausible that GEO acts as a mediating variable between the two. Results from the study by Shehzad et al. (2023) showed that GEO significantly improves GKM. Additionally, comparable research remains elusive. Among the dimensions of GKM, the Knowledge Creation Process is shown to be positively and significantly impacted by GEO (Yu et al., 2022).

At the same time, GEO has an outsized beneficial effect on GI (Wang et al., 2022). KM is an external variable that significantly impacts on GI (Shehzad et al., 2022). The results were quite close to what is expected. Moreover, GI is positively and significantly impacted by GKM (Wang et al., 2022; Shehzad et al., 2023). This effect remains even after a more in-depth examination of the innovation's ambidexterity. While GEO affects GKM, GKM also affects AGI. This demonstrates a close relationship between the three variables.

According to KBV, GEO promotes the creation, storage, and sharing of green knowledge by businesses in the areas of eco-friendly manufacturing practices and innovation. GKM enables businesses to process and utilise this knowledge optimally, establishing the foundation for future innovations. Furthermore, according to DC, GKM enables SMEs to identify green market opportunities, utilise knowledge effectively, and restructure company processes for greater sustainability. As a result of these steps, AGI emerges as a combination of exploratory and exploitative innovation. Therefore, the following research hypotheses are as follows:

H5 Batik SMEs' GKM practices can be improved in proportion to their GEO.

H6 The degree to which SMEs prioritise environmentally conscious KM determines the efficacy of their AGI.

H7 AGI among batik SMEs can be fostered via improved GKM methods brought about by a greater emphasis on green entrepreneurship.

As mentioned previously, GEO impact SP. Additionally, GEO influences GKM, which in turn affects AGI, and AGI subsequently impacts SP. Overall, the relationship between GEO and SP is formed through a sequence mediation of GKM and AGI. This relationship underscores the complexity of these variables, indicating that changes in one can have cascading effects on the other, and consequently, requires careful analysis. Therefore, the final hypothesis of this study is as follows.

H8 Batik SMEs that emphasise green entrepreneurship and are supported by AGI and GKM as sequential mediating factors will achieve better long-term outcomes.

3 Method

This study utilises a quantitative methodology to analyse the complex relationship between GEO and SP, with sequential mediation by GKM and AGI. It focuses on the batik SMEs in East Java, Indonesia, specifically the managerial level. The SMEs were selected through accidental-purposive sampling based on specific criteria:

1 the business must have been operating for a minimum of three years to ensure sustainability

2 it has 5 to 100 employees

3 it has a waste disposal facility

4 it facilitates green innovation.

According to Hair et al. (2020), the minimum sample size should be at least five to ten times the number of indicators or items measuring the variables. This research questionnaire consists of 35 items, resulting in an intended sample size of between 175 and 350 SMEs. After collecting the data of SMEs population from the offices of Department of Industry and Department of Cooperative and SME in all municipalities and regencies in East Java, online questionnaires were distributed 600 SMEs via WhatsApp, Instagram DM, and owner or business e-mail. The questionnaire enables each SME, particularly medium-sized businesses, to have multiple representatives from the company participate in its completion. This method promotes a more thorough understanding of the various perspectives within the organisation. Furthermore, it ensures the collection of all pertinent insights, resulting in a more precise representation of the company's sustainability innovation. A total 401 respondents from 256 SMEs completed questionnaires were returned within four months (June to September 2025), yielding a response rate of 42.67%. Thus, the data collected for analysis met the minimum sample size requirement. The measurements of the latent constructs are shown in Table 1. Simultaneously, the gathered data were subjected to PLS-SEM inferential analysis using SmartPLS software (version 4.1.1.4).

Table 1 Latent construct measurement

Latent constructs	*Dimensions*	*Manifest constructs*
GEO Adapted from Appiah et al. (2023) and Shehzad et al. (2023)	Autonomy (GEO1)	(GEO11) SME often runs green enterprises independently.
		(GEO12) SME often prioritises eco-friendly initiatives.
	Innovativeness (GEO2)	(GEO21) SME prioritises green manufacturing practices.
		(GEO22) SME prioritises eco-friendly products.
	Risk taking (GEO3)	(GEO31) SME takes calculated risks to reduce production waste and safeguard the environment.
		(GEO32) SME takes calculated risks to shield locals from manufacturing waste.
	Proactiveness (GEO4)	(GEO41) SME's eco-friendly products dominate the industry.
		(GEO42) SME is the pioneer in green product innovation.
	Aggressiveness (GEO5)	(GEO51) Offering green products could put the SME in a competitive market.
		(GEO52) SME collaborates with government and/or community, and/or institutions.

Source: Created by the Authors (2025)

Table 1 Latent construct measurement (continued)

Latent constructs	*Dimensions*	*Manifest constructs*
GKM Adapted from Sahoo et al. (2023) and Yu et al. (2022)	Acquisition (GKM1)	(GKM11) SME provides webinars, computers, laptops, and the internet to educate staff on eco-friendly methods.
		(GKM12) SME allows staff obtain external eco-friendly practice knowledge offline.
	Sharing (GKM2)	(GKM21) Staff can inform their managers and colleagues about eco-friendly techniques.
		(GKM22) Managers and staff can quickly learn about environmentally friendly procedures elsewhere.
	Storage (GKM3)	(GKM31) Staff can store data retrieved from internal corporate sources on company's devices.
		(GKM32) Staff can store data acquired from external sources on company's devices.
	Application (GKM4)	(GKM41) Assisting staff in using internal green knowledge.
		(GKM42) Assisting staff in using external green knowledge.
	Creation (GKM5)	(GKM51) A program allowing personnel explore greener business methods.
		(GKM52) SME appreciates staff's eco-friendly recommendations.
AGI Adapted from Shehzad et al. (2023) and Baquero (2024)	Exploitative (AGI1)	(AGI11) SME actively develops existing products using easily recyclable, reusable, and biodegradable materials.
		(AGI12) SME actively develops existing products using packaging that is easily recycled, reused, and biodegradable.
		(AGI13) SME meticulously develops batik production processes to conserve energy.
	Exploratory (AGI2)	(AGI21) SME relentlessly pursues innovative product designs that use readily recyclable, reusable, and biodegradable materials.
		(AGI22): SME readily adopts recyclable, reusable, and biodegradable packaging.
		(AGI23): SME produce batik with efficient energy and newest technology.
SP Adapted from Cheah et al. (2024) and Chen et al. (2024)	Economic (SP1)	(SP11) Market share has risen.
		(SP12) Market offerings have increased.
		(SP13) The net profit of the company has increased.
	Environmental (SP2)	(SP21) There has been a reduction in manufacturing waste.
		(SP22) Energy consumption has decreased.
		(SP23) Chemical usage has decreased.

Source: Created by the Authors (2025)

Table 1 Latent construct measurement (continued)

Latent constructs	*Dimensions*	*Manifest constructs*
SP Adapted from Cheah et al. (2024) and Chen et al. (2024)	Social (SP3)	(SP31) The provision of social aid for impoverished communities has improved. (SP32) The company's reaction to customer allegations has been consistently positive. (SP33) There has been a steady improvement in workplace safety and health assurance.

Source: Created by the Authors (2025)

4 Results

4.1 Respondent's demographics

Table 2 presents the demographics of the survey respondents, revealing that most female respondents are primarily aged 40 to 59 and typically hold a bachelor's degree, despite many others possessing only a high school diploma. This unique aspect of the batik industry reflects a shift toward commercial development, historically associated with women passing down traditional skills, led by a new, more formally-educated generation. Many batik businesses are managed by individuals with experience and stability, either through inheritance or by establishing their enterprises, as evidenced by the presence of older age groups in the data. Due to limited resources and the need for complete oversight of operations, most respondents serve as both owners and managers, a common practice in SMEs. The sector's resilience is evident, as most of these businesses have been in operation for over a decade. These enterprises are predominantly small-scale, employing between five and 19 people. It suggests that batik is likely to be a sustainable and steadily growing business rooted in tradition.

Table 2 Respondent's demographics

Categorical		*Frequency*	*%*
Gender	Male	166	41.4%
	Female	235	58.6%
Age	20–39 years old	89	22.2%
	40–59 years old	244	60.8%
	> 59 years old	68	17.0%
Education	Senior high school	155	38.7%
	Diploma	19	4.7%
	Bachelor's degree	183	45.6%
	Master's degree	44	11.0%
Position	Owner	195	48.6%
	Manager	163	40.6%
	Others	43	10.7%

Source: Primary Data Processes by the Authors (2025)

Table 2 Respondent's demographics (continued)

Categorical		*Frequency*	*%*
Business experience	3–10 years	90	22.4%
	> 10 years	311	77.6%
Business size	Small (5–19 employees)	346	86.3%
	Medium (20–99 employees)	55	13.7%

Source: Primary Data Processes by the Authors (2025)

4.2 PLS-SEM external model evaluation

This study employed factor loading and average variance extracted (AVE) metrics to evaluate the external model. A factor loading value exceeding 0.7 at the manifest construct level is deemed valid. Conversely, the AVE must be greater than 0.5 (Anjaningrum et al., 2024). Figure 1 illustrates the validity of each item across the dimensions of each latent construct, as shown by the values on the line connecting the dimension to the manifest construct – specifically, that are not in parentheses and exceed 0.7. This finding confirms that all items are valid and effectively measure the latent construct.

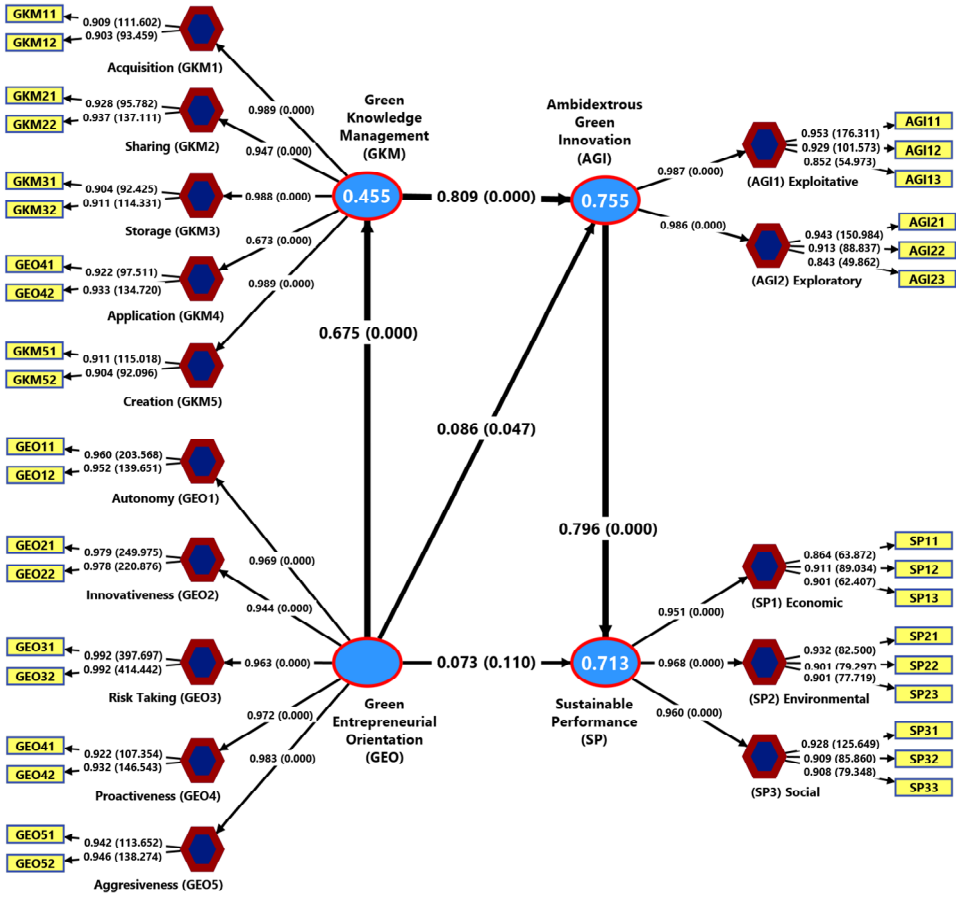
The AVE values for each dimensional and latent construct, exceeding 0.5 (see Table 3), indicate that this research tool demonstrates convergent validity. Furthermore, the study instrument showed reliability, evidenced by CA values reaching higher than 0.6 and CR values reaching 0.8 (refer to Table 3), underscoring its consistency across various assessments.

4.3 PLS-SEM internal model evaluation

The determination test (R^2) indicates the percentage contribution of the exogenous latent construct to the endogenous latent construct. A minimum R^2 value of 0.67 suggests a significant influence of the exogenous latent construct on the endogenous latent construct (Hair et al., 2014). Figure 1 presents a clear representation of these values through blue circles. The GKM R^2 value of 0.455 indicates that GEO accounts for approximately 45.5% of GKM, reflecting a moderate level of influence. In contrast, the AGI R^2 value of 0.755 indicates that GEO and GKM together account for approximately 75.5% of AGI, demonstrating a big impact. Finally, the SP R^2 value of 0.713 suggests that GEO and AGI combined account for roughly 71.3% of SP, also indicating a significant effect.

Table 4 presents the results of the effect size test (f^2). The criteria for interpreting effect size are defined: an f^2 value of 0.02 indicates a weak impact; an f^2 value of 0.15 signifies a moderate impact; and an f^2 value of 0.35 represents a strong impact (Hair et al., 2014). The data in Table 4 reveals that the exogenous latent constructs exert a strong impact, particularly AGI on SP, GEO on GKM, and GKM on AGI. In contrast, the exogenous latent construct with the weak impact is GEO on SP and GEO on AGI. The findings emphasise the crucial role of AGI in enhancing GEO's influence on SP. Currently, GEO's impact on SP is just sufficient, and its impact on AGI is weak. Therefore, the presence of GKM is essential, as it significantly strengthens the relationships between GEO and GKM, GKM and AGI, and ultimately, AGI and SP.

Figure 1 PLS-SEM graphical output (see online version for colours)



Source: SmartPLS's 4.1.1.4 Output (2025)

Table 3 Validity and reliability evaluation

	AVE	*CA*	*CR (rho_a)*	*CR (rho_c)*
Latent construct				
GEO	0.859	0.982	0.982	0.984
GKM	0.789	0.970	0.971	0.974
AGI	0.800	0.950	0.952	0.960
SP	0.756	0.960	0.960	0.965
Dimension construct				
GEO1	0.913	0.905	0.910	0.955
GEO2	0.957	0.955	0.956	0.978
GEO3	0.984	0.984	0.984	0.992
GEO4	0.860	0.838	0.840	0.925
GEO5	0.891	0.878	0.879	0.942

Source: SmartPLS's 4.1.1.4 Output (2025)

Table 3 Validity and reliability evaluation (continued)

	AVE	*CA*	*CR (rho_a)*	*CR (rho_c)*
Dimension construct				
GKM1	0.821	0.783	0.783	0.902
GKM2	0.870	0.850	0.853	0.930
GKM3	0.823	0.785	0.786	0.903
GKM4	0.860	0.838	0.841	0.925
GKM5	0.823	0.785	0.786	0.903
AGI1	0.832	0.898	0.904	0.937
AGI2	0.811	0.883	0.887	0.928
SP1	0.797	0.872	0.873	0.922
SP2	0.831	0.898	0.898	0.936
SP3	0.837	0.903	0.904	0.939

Source: SmartPLS's 4.1.1.4 Output (2025)

Table 4 Effect size (f^2) value

	f^2	*Meaning*
GEO -> SP	0.011	Weak impact
GEO -> AGI	0.016	Weak impact
AGI -> SP	1.329	Strong impact
GEO -> GKM	0.836	Strong impact
GKM -> AGI	1.457	Strong impact

Source: SmartPLS's 4.1.1.4 Output (2025)

4.4 Hypotheses evaluation

The t-test is utilised for hypothesis testing. A t-statistic exceeding 1.96 at a 5% significance level, or a p-value lower than 0.05, indicates statistical significance. The path coefficient value (path. coef.) indicates the direction of the impact, whether positive or negative. The findings of the t-test are presented in Table 5.

The statistical analysis using PLS-SEM indicates that the direct impact of GEO on SP is positive but insignificant with the path coef. of 0.073, a t-statistic of 1.597 (<1.96), and a p-value of 0.110 (>0.05). As a result, the initial research hypothesis (H1) is rejected. The direct impact of GEO on AGI is positive and significant, with a path coef. of 0.086, a t-statistic of 1.984 (>1.96), and a p-value of 0.047 (<0.05). Therefore, the second research hypothesis (H2) is supported, although statistically it is almost insignificant (this result is consistent with the f^2 test which shows a weak impact of GEO on AGI)

The direct impact of AGI on SP is positive and significant, with a path coef. of 0.796, a t-statistic of 19.377 (>1.96), and a p-value of 0.000 (<0.05). Consequently, the third research hypothesis (H3) is supported. The direct impact of GEO on GKM is positive and significant, with a path coef. of 0.675, a t-statistic of 13.054 (>1.96), and a p-value of 0.000 (<0.05). Therefore, the fifth research hypothesis (H5) is supported. The direct impact of GKM on AGI is positive and significant, with a path coef. of 0.809, a t-statistic

of 20.873 (>1.96), and a p-value of 0.000 (<0.05). Thus, the sixth research hypothesis (H6) is supported.

Table 5 T-test results

	Path-coef.	*T-statistic*	*P-value*	*Inference*
Direct impact of latent constructs				
GEO -> SP	0.073	1.597	0.110	(+) Insignificant; H1 Rejected
GEO -> AGI	0.086	1.984	0.047	(+) Significant; H2 Supported
AGI -> SP	0.796	19.377	0.000	(+) Significant; H3 Supported
GEO -> GKM	0.675	13.054	0.000	(+) Significant; H5 Supported
GKM -> AGI	0.809	20.873	0.000	(+) Significant; H6 Supported
Specific indirect impact of latent constructs				
GEO -> AGI -> SP	0.068	2.090	0.037	(+) Significant; H4 Supported AGI is a complete mediation
GEO -> GKM -> AGI	0.546	15.257	0.000	(+) Significant; H7 Supported GKM is a partial mediation
GEO -> GKM -> AGI -> SP	0.435	12.879	0.000	(+) Significant; H8 Supported GKM and AGI are sequential mediation
Second order or dimension level				
GEO -> Autonomy (GEO1)	0.969	326.811	0.000	'Aggressiveness' is the strongest dimension
GEO -> Innovativeness (GEO2)	0.944	135.518	0.000	
GEO -> Risk Taking (GEO3)	0.963	217.202	0.000	
GEO -> Proactiveness (GEO4)	0.972	283.465	0.000	
GEO -> Aggressiveness (GEO5)	0.983	450.901	0.000	
AGI -> Exploitative (AGI1)	0.987	231.874	0.000	'Exploitative' is the strongest dimension
AGI -> Exploratory (AGI2)	0.986	207.763	0.000	
GKM -> Acquisition (GKM1)	0.989	692.071	0.000	'Creation' is the strongest dimension
GKM -> Sharing (GKM2)	0.947	172.063	0.000	
GKM -> Storage (GKM3)	0.988	674.888	0.000	
GKM -> Application (GKM4)	0.673	13.002	0.000	
GKM -> Creation (GKM5)	0.989	779.981	0.000	
SP -> Economic (SP1)	0.951	157.762	0.000	'Environmental' is the strongest dimension
SP -> Environmental (SP2)	0.968	265.984	0.000	
SP -> Social (SP3)	0.960	152.517	0.000	

Source: SmartPLS's 4.1.1.4 Output (2025)

The analysis of the indirect impact of GEO on SP through AGI is positive and significant with a path coef. of 0.068, a t-statistic of 2,090 (>1.96), and a p-value of 0.037 (<0.05). Consequently, AGI contributes as a partial mediation factor in the relationship between GEO and SP. Hence, the fourth research hypothesis (H4) is supported. Meanwhile, the indirect impact of GEO on AGI through GKM is notable, with a path coef. of 0.546, a t-statistic of 15.257 (>1.96), and a p-value of 0.000 (<0.05). It suggests that GKM serves as a partial mediating factor in the relationship between GEO and AGI. Thus, the seventh research hypothesis (H7) is supported.

Additionally, the indirect impact of GEO on SP through GKM and AGI is positive and significant, with a path coef. of 0.435, a t-statistic of 12.879 (>1.96), and a p-value of 0.000 (<0.05). It indicates that GKM and AGI act as sequential mediating factors in the relationship between GEO and SP. Thereby, the eighth research hypothesis (H8) is supported.

Further analysis of the t-test findings may be conducted by reviewing the strength at the second-order or dimension level. However, this method does not test the hypothesis. According to the GEO model, aggressiveness is the most GEO-reflective attribute. Meanwhile, AGI found that SMEs perform better in exploitative green innovation than exploratory green innovation. Additionally, knowledge creation is identified as the most GKM-reflective factor in the GKM process. Finally, when evaluating SP from a metric perspective, environmental performance is the most indicative of it, followed by economic and social success.

5 Discussion

The research findings indicate a complex relationship between GEO, HKM, AGI, and SP. The adoption of a GEO positively influences the SP of batik SMEs in East Java. The implementation of green environmental orientation (GEO) positively affects SP, albeit to a relatively modest extent. The study indicates that simply adopting a strategic orientation is insufficient for batik SMEs that lack the necessary capabilities for effective implementation. A sustainability mindset, on its own, does not guarantee measurable improvements in performance. These findings suggest that green-orientated strategic intentions must be translated into action through AGI, which focuses on exploitative green innovation in the short term while prioritising exploratory green innovation in the long term. Nonetheless, merely aspiring to achieve AGI is unlikely to succeed without effective GKM. GKM is essential for facilitating the sharing and integration of sustainable practices within SMEs. By promoting knowledge sharing and embracing diverse perspectives, SMEs can more effectively adapt their strategies to address emerging sustainability challenges and opportunities. These findings underscore the crucial role of GKM in implementing GEO to achieve AGI, which subsequently influences SP.

The findings align with previous studies (e.g., Frare and Beuren, 2022; Majali et al., 2022; Ye et al., 2022), that stated that GEO does not always lead to SP directly, particularly regarding economic outcomes. However, these results contrast with some earlier findings (e.g., Wang et al., 2025; Ma et al., 2025; Appiah et al., 2023; Coelho et al., 2023) which suggested the importance of GEO in directly driving sustainability. However, it remains crucial for batik SMEs to align themselves with green entrepreneurship. By implementing environmentally friendly practices and utilising

sustainable materials, these businesses can reduce their environmental impacts while attracting an increasingly conscious consumer base. This shift promotes economic growth, supports cultural heritage, and preserves the intricate traditions of batik craftsmanship. Managers' conduct is crucial to green business operations (Kharuddin et al., 2022).

It is essential for SMEs to adopt a proactive and forward-thinking approach when implementing GEO (Abdulsamad et al., 2025). SMEs should maintain a high degree of autonomy (Kusi et al., 2024), ensure independence, and strive for self-sufficiency. Furthermore, by demonstrating a willingness to take risks, face the barriers (Iqbal et al., 2025), and focus on environmentally sustainable innovation, SMEs can successfully achieve sustainability. This commitment not only enhances their competitive edge but also contributes positively to the overall ecosystem (Du et al., 2025). In this case, the DCs and innovation enable quick fashion trend adaption, providing a defensible market position (Sujarwo and Indriani, 2025). So that, strategic green values and innovation in sustainability are vital (Prabawati et al., 2025).

The research also found that GKM and AGI mediate the relationship between GEO and SP in a sequential manner. Batik SMEs with an entrepreneurial spirit prioritising environmental concerns are more likely to pursue green options, such as using natural dyes or recycling waste materials. Furthermore, Batik SMEs with a sustainability-focused entrepreneurial mindset are more inclined to experiment with greener production methods and discover innovative ways to integrate environmental values into their operations. Integrating sustainable practices into production processes for environmental and resource management is essential for enhancing the performance of SMEs (Zhidebekkyzy et al., 2025). Additionally, innovation is necessary for transforming GEO into sustainable outcomes (Musfar et al., 2025). A solid understanding of entrepreneurial orientation will empower SMEs to enhance their innovation capabilities and thrive in a competitive business landscape (Manalu et al., 2025).

However, a GKM approach is essential for organising all ideas (Boota et al., 2025). SMEs can engage in AGI when they maintain a well-managed green knowledge base (Baquero, 2024; Shehzad et al., 2023). This type of innovation emphasises the enhancement of existing products and processes, while exploratory green innovation is centred on creating new batik items, potentially utilising modern technology. Given that batik SMEs in East Java often operate with limited personnel and financial resources, they tend to concentrate more on exploitation than exploration. Nevertheless, with effective KM, SMEs can achieve a balance between the two. Green innovation, which harmonises incremental improvements with entirely new concepts, enhances sustainability performance (Bello et al., 2022).

This research reveals that the most effective demonstration of GKM occurs during the knowledge creation phase. It suggests that knowledge creation can serve as an innovation engine for batik SMEs, enabling them to adapt to the global green market while preserving their traditional heritage and fostering new ideas. SMEs need to conduct GKM effectively to identify the best concepts for AGI (Shehzad et al., 2023). This task ensures that existing knowledge can be utilised efficiently by company personnel. Having a good knowledge of IT is also crucial for embracing new ideas (Alenezi and Isa, 2024).

6 Theoretical contribution

This sequential mediation model clarifies the stakeholder theory, DC, and KBV by connecting GKM and AGI in GEO and SP. The initial evidence suggests green entrepreneurship helps stakeholders produce value. GKM turns stakeholder feedback into green concepts. Beyond morality, the stakeholder theory shows how knowledge and innovation help the economy, society, and environment. Companies may integrate green practices using AGI. GKM encouraging information flows increases DC sensing, seizing, and reconfiguring. Thus, GKM defines AGI as a flexible capability necessary for corporate plan execution and sustainability. DC theory should stress knowledge-based methods for acquiring and utilising adaptive abilities, particularly in GI. This research reveals how knowledge-based GEO affects innovation and performance. GKM creates, acquires, distributes, and uses green knowledge to balance exploitation and exploratory innovation. It describes knowledge-based approaches. Moreover, while GEO provides stakeholder-driven strategy, AGI reorganises resources for transfers. This paradigm prioritises strategic planning, knowledge development, and capacity building above a single sustainability theory.

7 Practical implication

This study suggests that batik SMEs integrate GEO with methodical GKM. This integration fosters AGI and SP. For environmentally friendly possibilities, business owners, managers, and employees should be aggressive, autonomous, proactive, risk-taking, and innovative. Batik SMEs should manufacture eco-friendly products and work with stakeholders. Moreover, SMEs require green efforts and autonomy. They should develop eco-friendly batik products and methods to decrease industrial waste and benefit the environment and green enterprise requires a robust GKM. They can monitor waste processing and natural dye consumption, integrate it into their IT infrastructure, train employees, and share best practices in batik communities. Utilising renewable energy offers a promising opportunity to enhance economic formalisation while also fostering social responsibility (Lyeonov et al., 2025). Organisations may use green concepts to spread new and innovative ideas and create AGI. Exploitative green innovation improves natural colour persistence and fades resistance while developing green products. If feasible, plant-fibre batik with natural colours can be an alternative. These techniques may help SMEs adapt to the ever-changing market while preserving their heritage, protecting the environment, and safeguarding their workers, customers, and communities.

8 Conclusions

This study investigates the complex relationship between GEO and sustainability performance, emphasising the sequential mediating effects of GKM and AGI within a second-order model. The findings lead to several conclusions:

1 environmental performance emerges as the primary metric for evaluating sustainability improvements in green business models, surpassing economic or social performance

2 the relationship between GEO and sustainability performance is sequentially influenced by the dual strategies of GKM and AGI

3 batik SMEs generally find it more feasible to implement exploitative green innovation than explorative one

4 knowledge creation is identified as the most crucial component of GKM, underscoring its vital role within the framework, which is further reinforced by additional dimensions.

9 Limitations and direction for future research

A limitation of this study is its dependence on a second-order model, which restricts the findings. Differentiating the impact of various aspects of the latent construct presents challenges, especially when assessing the partial influence of exploitative and explorative innovation on economic, environmental, and social performance. Due to the constraints regarding financial and human resources, SMEs often struggle to engage in exploratory innovation. Should SMEs prioritise exploratory innovation, they may encounter potential losses, despite its positive effects on environmental performance.

Therefore, further research should expand the scope of the study and explore the relationships between other dimensions of the latent construct to yield more comprehensive insights. Additionally, as the world transitions toward Society 5.0, integrating diverse artificial intelligence (AI) technologies that enhance knowledge and foster innovation is essential for future conceptual models, as AI can serve as a significant moderating factor. Moreover, a robust connection between stakeholders is crucial to achieve sustainability.

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Declarations

All authors declare that they have no conflicts of interest.

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