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# Parallel Pathways from Green Entrepreneurial Orientation to SME Sustainable Performance via Incremental Green Product Innovation and AI Usage Capability

**Indra Muis**

indramuis@binainsani.ac.id

Universitas Bina Insani

**Widiya Dewi Anjaningrum**

Institut Teknologi dan Bisnis Asia Malang

**Yohny Anwar**

Universitas Pembangunan Panca Budi Medan

**Dewi Indriani Jusuf**

International Women University

**Zulfahmi Zulfahmi**

Northern University of Malaysia

**Research Article**

**Keywords:** Green Entrepreneurial Orientation, Sustainable Performance, Incremental Green Product Innovation, AI Usage Capability, SME

**Posted Date:** November 19th, 2026

**DOI:** https://doi.org/10.21203/rs.3.rs-11091192/v1

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**Additional Declarations:** No competing interests reported.

# Parallel Pathways from Green Entrepreneurial Orientation to SME Sustainable Performance via Incremental Green Product Innovation and AI Usage Capability

Indra Muis[1*], Widiya Dewi Anjaningrum[2], Yohny Anwar[3] ,Dewi Indriani Jusuf[4], Zulfahmi Zulfahmi[5]

[1] Bina Insani University, Bekasi, Indonesia
[2] Institut Teknologi dan Bisnis ASIA Malang, Kota Malang, Indonesia
[3] Universitas Pembangunan Panca Budi Medan, Medan, Indonesia
[4] International Women University, Bandung, Indonesia
[5] Universiti Utara Malaysia, Jitra, Malaysia
*Corresponding Author

## Abstract

SMEs face pressure to achieve economic, environmental, and social sustainability while operating under resource and technological constraints. Although GEO is associated with sustainable performance, evidence remains limited on the organizational mechanisms that enable GEO to produce sustainability outcomes, particularly through IGPI and AIUC. Based on DCV, this study examines whether IGPI and AIUC function as parallel mediation mechanisms linking GEO to SSP. This cross-sectional quantitative study involved 154 batik SMEs in Central Java, Indonesia. We analyzed the data using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 4. The results showed that GEO was positively associated with IGPI ($\beta = 0.747$, $p < 0.001$) and AIUC ($\beta = 0.622$, $p < 0.001$). IGPI ($\beta = 0.583$, $p < 0.001$) and AIUC ($\beta = 0.278$, $p < 0.001$) were both positively associated with SSP, whereas GEO's direct association with SSP was positive but not statistically significant ($\beta = 0.080$, $p = 0.164$). Both indirect effects were significant: GEO–IGPI–SSP ($\beta = 0.436$, $p < 0.001$) and GEO–AIUC–SSP ($\beta = 0.173$, $p < 0.001$). The estimated indirect effect through IGPI was larger than through AIUC, although no formal test of the difference between the two indirect effects was conducted. PLS-Predict produced positive $Q^2$_predict values for AIUC (0.377), IGPI (0.551), and SSP (0.466), indicating predictive relevance, while comparison with the linear-model benchmark showed that predictive performance was not uniformly superior. These findings extend DCV by showing that the association between GEO and sustainability performance is transmitted through distinct product-level and digital organizational transformation mechanisms.

Keywords: Green Entrepreneurial Orientation; Sustainable Performance; Incremental Green Product Innovation; AI Usage Capability; SME

## 1. Introduction

Small and medium-sized enterprises (SMEs) play a crucial role in economic development, job creation, and local value creation. However, their efforts to achieve sustainability are often limited by financial, technological, managerial, and knowledge resources. Compared to large corporations, SMEs generally have a smaller organizational scope to undertake costly environmental transformations, develop new technologies, or establish specialized sustainability functions. As a result, achieving economic competitiveness while improving environmental and social outcomes is a great strategic management challenge. SMEs' sustainable performance (SSP) is shaped not only by environmental practices but also by the interaction of organizational resources, managerial attention, innovation, technology, and sustainability-oriented capabilities [1, 2]. With limited resources, the ability to translate sustainability intentions into concrete organizational actions becomes critical [3,4].

One strategic orientation that can facilitate this transformation is the Green Entrepreneurship Orientation (GEO). GEO reflects a company's entrepreneurial attitude towards environmental opportunities and integrates green, proactive, and risk-taking innovation into organizational decision-making [5]. Rather than representing specific environmental practices, GEO shapes how companies identify sustainability-related opportunities, allocate resources, pursue innovation, and respond proactively to environmental pressures. This orientation is particularly relevant for SMEs because it can direct limited organizational resources to opportunities that address environmental challenges while supporting business development.

Coelho et al.[6] demonstrate that GEO drives green product and process innovation and contributes to sustainability performance among industrial SMEs. Ishaq et al.[7] also show that GEO and green innovation contribute to sustainable performance in emerging economies. Evidence from Indonesian SMEs also suggests that GEO can improve sustainable business performance through direct and indirect pathways involving green innovation. [8]. At the aggregate level, Öztürk et al.[9] provide meta-analytical evidence of the positive relationship between GEO and sustainable corporate performance across financial, environmental, social, and overall dimensions.

These findings establish GEO as an important strategic pioneer of sustainable performance.

However, the well-established relationship between GEO and SSP does not fully explain how strategic orientation translates into sustainability outcomes. Strategic orientation provides direction and motivation, but performance consequences depend on organizational mechanisms that transform strategic intentions into concrete actions. Recent studies show that innovation, knowledge creation, resource orchestration, and other organizational capabilities play a critical role in this transformation [10,6]. For example, green product and process innovation is an important pathway through which GEO contributes to sustainability performance. At the same time, exploratory and exploitative green innovation have also been found to mediate the GEO–green performance relationship [6,11]. Thus, the key issue is not only whether GEO improves SSP, but which organizational mechanisms enable SMEs to translate GEO into sustainable performance.

The study first examined gradual green product innovation (IGPI). Green innovation encompasses various forms of innovation, and distinguishing incremental innovation from radical innovation is particularly relevant in resource-constrained SME environments. Radical green innovation generally involves substantial technological or market change and greater uncertainty, while incremental innovation emphasizes the gradual modification, refinement, and improvement of existing products and technologies. [12,13]. Incremental innovation can offer SMEs a viable path to improving environmental performance by building on existing knowledge, technology, production routines, and market relationships, rather than relying solely on large-scale technological transformation. [14,15].

Existing evidence supports IGPI's relevance to SSP. Coelho et al. [6] suggest that IGPI contributes to SSP, while Oduro [16] in a meta-analysis of 99 studies involving 134,841 SMEs, reported a positive association between green product innovation and SMEs' sustainable performance [17]. It also suggests that green innovation can simultaneously improve environmental performance, profitability, product quality, and

job satisfaction. Nevertheless, previous studies have primarily examined green product innovation as a broad construct or combined product and process innovation, rather than explicitly isolating incremental green product innovation as a distinct mechanism. Although exploitative green innovation offers a closely related conceptual pathway [11].

The second mechanism is AI Utilization Capabilities (AIUC). The growing adoption of artificial intelligence (AI) offers SMEs opportunities to improve information processing, decision-making, operational efficiency, resource utilization, innovation, and sustainability management. However, AI adoption alone does not necessarily result in organizational value. Recent research distinguishes technology adoption from the organizational capabilities needed to use and integrate AI effectively into business activities. Peretz-Andersson et al. [18] show that SMEs develop AI capabilities through resource acquisition, learning, governance, process coordination, and employee engagement, while Haefner et al. [19] emphasize experimentation, organizational learning, integration, and organizational transformation as essential conditions for implementing and developing AI. AIUC is also related to economic, environmental, and social performance among SMEs [20], while Kumar et al. [21] show that AIUC can contribute positively to environmental sustainability performance.

Importantly, emerging evidence suggests that entrepreneurial orientation can support AI utilization. Hruby [22] report a positive relationship between entrepreneurial orientation and effective AI integration among SMEs, stating that proactive, experimental, and opportunity-seeking can facilitate the utilization of new technologies. From this perspective, GEO can influence not only green innovation but also an organization's ability to use AI amid environmental and business challenges. However, existing studies primarily examine AI capabilities as a predecessor, moderator, or supporting resource, rather than as a mediating organizational capability that allows GEO to contribute to SSP—for example, Hussain et al. [23] place AI capabilities as a moderator of eco-innovation–performance relationships, while Alwakid and Dahri [24] show that GEO and AIUC together contribute to green creativity and innovation. These studies provide important building blocks, but the role of AIUC as a mediator remains underexplored.

These gaps point to an unresolved mechanism-level question: how does GEO translate into SME sustainable performance when multiple organizational transformation mechanisms operate simultaneously? Existing studies have established separate relationships among GEO, green innovation, AI capability, and sustainability outcomes, but have paid limited attention to the simultaneous role of incremental green product innovation (IGPI) and AI usage capability (AIUC) as parallel mediating mechanisms. These mechanisms represent two distinct but complementary forms of transformation. IGPI captures product-level transformation through gradual environmental improvements to existing products. Rather than representing AI adoption or ownership alone, AIUC captures digital organizational transformation through the ability to integrate and leverage AI for information processing, decision-making, resource orchestration, organizational learning, and adaptation.

The Dynamic Capability View (DCV) provides a theoretical basis for integrating these mechanisms. From this perspective, GEO represents an upstream strategic orientation that directs managerial attention toward sustainability-related opportunities. In contrast, IGPI and AIUC are organizational mechanisms through which strategic intentions translate into concrete actions and sustainability outcomes. GEO can stimulate product-level reconfiguration through IGPI and capability development through AIUC. The sustainability implications of GEO may therefore depend not only on the strategic orientation itself but also on the organizational mechanisms through which that orientation is enacted.

Accordingly, this study asks: How is GEO translated into SSP through IGPI and AIUC? To answer this question, the study develops and empirically tests a parallel mediation model examining the direct association between GEO and SSP and the indirect associations transmitted through IGPI and AIUC among batik SMEs in Central Java, Indonesia.

The study makes three related contributions. First, it advances the GEO–SSP literature by shifting attention from the direct association between strategic orientation and sustainability outcomes to the organizational mechanisms through which that

relationship translates into performance. Second, it refines the green innovation literature by distinguishing IGPI as a product-level transformation mechanism rather than treating green innovation as a broad or undifferentiated construct. Third, it extends the emerging AI and sustainability literature by conceptualizing AIUC as an organizational capability and mediating mechanism rather than merely as technology adoption, a predictor, or a moderator. By examining IGPI and AIUC simultaneously, the study provides an integrated DCV-based explanation of two complementary pathways through which SMEs can translate green entrepreneurial orientation into economic, environmental, and social sustainability outcomes.

## 2. Literature Review

### 2.1 DCV as Grand Theory

DCV provides a theoretical basis for explaining how companies adjust their strategic orientation and available resources to SSP as environmental and technological conditions change. Unlike a resource-based perspective that emphasizes ownership of valuable resources, DCV focuses on an organization's capacity to integrate, build, and reconfigure resources and capabilities in response to environmental changes. [25, 26]. This perspective is particularly relevant for SMEs, which operate under resource constraints and must constantly adapt and combine existing resources and capabilities to meet emerging opportunities and challenges. Teece et al. [27] conceptualize dynamic capabilities as the ability to integrate, build, and reconfigure internal and external competencies, while Teece [25] develops this logic through three interrelated processes: sensing, seizing, and transforming/reconfiguring. Sensing involves identifying emerging opportunities and threats; seizing involves mobilizing resources and making strategic decisions to capitalize on identified opportunities; and transforming or reconfiguring involves updating and rearranging organizational resources, routines, and capabilities as conditions change. Applied to sustainability, these processes let companies recognize environmental and market opportunities, deploy resources to sustainability-oriented initiatives, and adjust organizational products, technologies, and practices accordingly.

DCV is therefore well suited to explain sustainability transformation because SSP depends not only on owning green or digital resources, but also on the ability to turn strategic intentions into organizational actions. Recent evidence of SMEs suggests that strategic orientation and innovation capabilities can strengthen strategic renewal and sustainable performance [28]. GEO can drive green product and process innovation that contributes to economic, environmental, and social performance [6].

### 2.2 GEO as an Upstream Strategic Orientation

GEO represents an upstream strategic orientation that directs SMEs towards environmental opportunities and sustainability-oriented actions. GEO integrates environmental considerations into entrepreneurial decision-making and is generally reflected in green innovation, green proactivity, and green risk-taking [5]. Instead of representing specific environmental practices, GEO reflects the enterprise-level posture that shapes how SMEs identify opportunities, pursue green solutions, and invest resources under uncertainty. From a DCV perspective, GEO enables sensing, seizing, and reconfiguring: green proactivity supports anticipation of environmental and market changes, green innovation encourages the search for environmentally oriented solutions, and green risk-taking reflects a willingness to allocate resources to uncertain sustainability opportunities.

This distinction matters because strategic orientation does not automatically produce SSP; its effect depends on the company's ability to translate strategic intentions into concrete organizational capabilities and activities. Empirical evidence suggests that GEO can stimulate green innovation by creating knowledge and orchestrating resources [10]. While Coelho et al. [6] show that GEO contributes to green product and process innovation among SMEs.

### 2.3 Organizational Mechanisms and SSP

IGPI and AIUC are two organizational mechanisms through which GEO can be translated into sustainability-oriented outcomes. Gradual Green Product Innovation (IGPI) refers to the sustainable modification, refinement, and environmental

improvement of existing products, rather than developing entirely new technology trajectories. This approach is particularly relevant for SMEs because it lets companies build on existing knowledge, technology, routines, and market relationships while introducing environmentally friendly improvements [12,13]. From a DCV perspective, IGPI reflects the transformation and reconfiguration of existing organizational resources in response to environmental opportunities, with GEO providing a strategic impetus to sense and capitalize on those opportunities through innovation. Empirical evidence supports this mechanism: Coelho et al. [6] show that GEO stimulates green product and process innovation among industrial SMEs; Idrees et al. [10] identified knowledge creation and resource orchestration as important mechanisms linking GEO to green innovation performance; and Baquero [11] showed that GEO stimulates exploitative green innovation, which provides a highly correlated conceptual basis for gradual innovation.

AIUC is the second organizational mechanism through which GEO can be translated into SSP. Rather than representing AI adoption or ownership alone, AIUC captures digital organizational transformation through the ability to integrate and leverage AI in information processing, decision-making, resource orchestration, learning, and organizational adaptation. From a DCV perspective, AIUC is a technology-enabled organizational capability that transforms technological and organizational resources into actionable outcomes. [18,19,29].

The SSP represents the multidimensional outcome of these organizational capability mechanisms, referring to the extent to which SMEs simultaneously achieve desired economic, environmental, and social outcomes. Sustainability performance therefore goes beyond financial outcomes to include environmental improvements and positive social consequences. [1,16].

In this study, the economic, environmental, and social dimensions are treated as theoretically distinct manifestations of a broader sustainability outcome rather than as interchangeable indicators of the same performance domain. Economic performance captures the firm's ability to maintain financial viability, efficiency, and market

competitiveness; environmental performance reflects improvements in resource use, waste reduction, and environmental impact; while social performance concerns outcomes for employees, customers, and other relevant stakeholders. Although these dimensions represent different domains of organizational performance, they jointly reflect the broader sustainability objective of balancing economic viability with environmental responsibility and social value creation. Accordingly, SSP is conceptualized as a multidimensional sustainability outcome encompassing these three theoretically distinct but complementary dimensions.

From a DCV perspective, SSP arises from a company's ability to adapt and reconfigure resources and capabilities in response to changing environmental and technological conditions. This perspective is supported by evidence that green innovation contributes to economic, environmental, and social performance among SMEs [6] that green product innovation is positively associated with SSP [16] and that the effective use of AI can contribute to economic, environmental, and social performance outcomes [20].

### 2.4 Integrating DCV into the Proposed Research Model

Previous discussions positioned DCV as a key theoretical lens for explaining how SMEs translate strategic orientation into sustainable performance, with GEO serving as upstream strategic triggers that direct managerial attention and resources to sustainability-related opportunities. This orientation is expected to translate into results through organizational mechanisms that transform resources and capabilities into concrete actions. Two complementary mechanisms are proposed: IGPI is an innovation-based pathway in which SMEs gradually reconfigure existing products and related resources to achieve environmental improvement. At the same time, AIUC represents a digital organizational capability through which firms enact dynamic capability processes. Although both mechanisms share the same strategic orientation, they reflect different forms of organizational transformation, with IGPI primarily concerned with product-level change and AIUC with organizational and digital capability development.

From a process perspective, AIUC in the present framework is not simply a proxy for the availability or adoption of artificial intelligence. Rather, AIUC captures the organizational capability that emerges when a firm's strategic orientation toward environmental opportunities is translated into technological experimentation, resource commitment, organizational learning, and process integration. GEO provides the strategic direction for identifying sustainability-related opportunities. In contrast, AIUC provides the organizational means to process information, support managerial decisions, orchestrate resources, and reconfigure activities in response to those opportunities. Therefore, AIUC occupies an intermediate position in the DCV process: GEO provides the strategic trigger, AIUC represents the capability-development and utilization mechanism, and SSP represents the resulting multidimensional sustainability outcome.

The resulting theoretical framework can be represented in Figure 1 as follows:

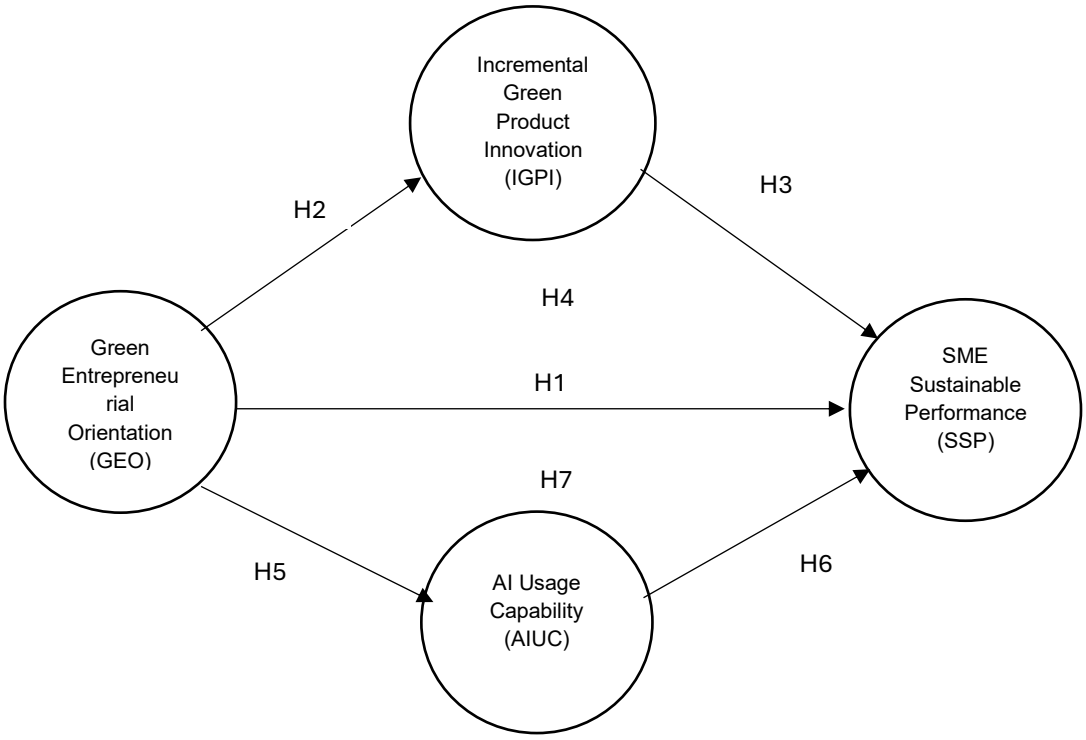



Figure 1: Conceptual Framework

This model proposes that GEO can influence SSP through two parallel pathways—GEO → IGPI → SSP and GEO → AIUC → SSP—while also enabling a direct relationship (GEO → SSP). This configuration allows the study to distinguish the hypothesized direct association of GEO with SSP from the indirect associations transmitted through organizational transformation mechanisms. Coelho et al. [6] established a GEO–innovation–sustainability green path, while recent AI research suggests that AI capabilities can support sustainability through organizational learning, resource orchestration, innovation, and transformation. Alwakid and Dahri [24] provide strong evidence from joint examinations of AIUC and GEO related to SSD, while [29] explicitly link AI adoption in SMEs to a dynamic capability perspective.

Nevertheless, the current framework differs in explicitly placing IGPI and AIUC as parallel mediation mechanisms between GEO and SSP. The uploaded document identifies this dual mechanism configuration as a major unresolved issue in the literature. Existing studies provide evidence for individual building blocks, but rarely integrate these two mechanisms into a single explanatory model.

### 2.5 Theoretical Contribution of the Framework

This DCV application offers three theoretical extensions. First, it expands the GEO–SSP literature beyond the dominant direct effects perspective. Although the existing evidence suggests that GEO is positively associated with SSP, DCV suggests that the strategic value of GEO should be understood through the organizational capabilities and activities that translate strategic orientation into outcomes. Second, the framework distinguishes two forms of organizational transformation. IGPI represents an exploitative, product-oriented transformation in which SMEs continuously improve their existing green products. AIUC represents a digital and capability-oriented transformation, in which SMEs develop the capacity to leverage AI for sensing, decision-making, resource orchestration, and organizational transformation. Third, the framework extends DCV to new technologies by conceptualizing AIUC as a contemporary dynamic digital capability.

## 2.6 Hypothesis Development

### GEO and SSP

GEO represents a strategic orientation in which companies integrate environmental considerations into entrepreneurial decision-making, opportunity recognition, innovation, and resource commitment. Instead of being an isolated environmental practice, GEO reflects a company-level strategic posture that encourages proactive responses to environmental opportunities and sustainability pressures, which is particularly relevant for SMEs because their sustainability outcomes are highly dependent on how managerial priorities and limited resources are directed to environmental and market opportunities [5]. From a strategic management perspective, companies with stronger GEO are more likely to integrate environmental goals into strategic choices and operational activities, proactively identify green market opportunities, develop environmentally oriented solutions, and allocate resources to uncertain green initiatives, allowing them to pursue economic value creation alongside environmental and social improvements.

Empirical evidence supports this argument. Coelho et al. [6] found that GEO contributes positively to SSP among industrial SMEs, while Musfar et al. [8] also reported the positive effect of GEO on SSP among Indonesian food SMEs. Öztürk et al. [9] further identified a significant positive relationship between GEO and SSP across financial, environmental, social, and overall performance dimensions, suggesting that GEO is a strategic orientation that can support broader organizational sustainability. Nevertheless, the magnitude of this relationship may depend on the company's ability to translate strategic orientation into concrete organizational capabilities and innovation activities.

**H1: GEO has a positive effect on SSP.**

### GEO and IGPI

GEO is expected to encourage IGPI because its entrepreneurial orientation toward environmental issues creates strategic motivation for companies to continue improving

existing products in response to ecological needs and market opportunities. Unlike radical green innovation, which often requires large technological investments and involves greater uncertainty, IGPI emphasizes modifications, refinements, and gradual improvements to existing products and technologies [13,12]. This innovation path is highly compatible with SME resource constraints. From a dynamic capability perspective, strategic orientation does not automatically lead to innovation; rather, it directs how companies identify opportunities, mobilize resources, create knowledge, and transform existing resources into new organizational outcomes. Idrees et al. [10] show that GEO contributes to green innovation performance through knowledge creation, while resource orchestration influences the effectiveness of this transformation. Similarly, Coelho et al. [6] show that GEO drives product and process innovation among SMEs, suggesting that environmental entrepreneurship orientation can translate into tangible product innovation at the product level.

Gradual innovation is particularly relevant in resource-constrained SME environments because gradual green innovation lets companies leverage existing knowledge, technology, production routines, and market relationships while introducing environmentally beneficial modifications. Baquero [11] found that GEO positively stimulates exploitative green innovation, which is conceptually aligned with incremental innovation by emphasizing the refinement and use of existing green solutions. Hossain et al. [30] Also found that GEO contributes positively to ambidextrous green innovation among manufacturing SMEs, while recent evidence suggests that entrepreneurial orientation is related to both radical and incremental green innovation. However, these innovation types require different organizational conditions [31].

**H2: GEO positively affects IGPI.**

**IGPI and SSP**

IGPI is expected to improve SSP because sustainable product-level improvements can generate ecological, economic, and social value simultaneously. By modifying existing products to reduce resource consumption, waste, emissions, or other environmental

impacts, SMEs can improve environmental outcomes while maintaining compatibility with existing production capabilities and markets. The broader eco-innovation literature supports this relationship. Oduro [16] found that eco-friendly product innovation has significant positive effects on SSP, including economic, environmental, and social outcomes. Similarly, Rahmani et al. [32] show that IGPI contributes positively to environmental performance, while Coelho et al. [6] show that IGPI is an important pathway through which GEO contributes to the sustainability of the three benefits. The strategic value of gradual innovation is crucial for SMEs because gradual product upgrades allow companies to reap sustainability benefits without undertaking highly uncertain technological transformations [17]. For example, a study found that eco-innovation among Colombian SMEs contributes to environmental improvement through resource efficiency, emission reduction, and waste management while supporting profitability, product quality, and job satisfaction. Han et al. [33] also show that technology-driven product eco-innovation improves economic and environmental performance.

**H3: IGPI has a positive effect on SSP.**

**The Mediating Role of IGPI**

The relationship between GEO and SSP is not entirely straightforward, as GEO provides strategic direction that must be translated into concrete action, with IGPI as one such mechanism. GEO encourages SMEs to identify environmental opportunities, allocate resources to green initiatives, and pursue environmentally oriented innovations. At the same time, IGPI translates these intentions into sustainable product improvements that can generate economic, environmental, and social benefits. Previous studies support this mediation logic, showing that green product and process innovations, exploratory and exploitative green innovations, and ambidextrous green innovations can mediate the relationship between GEO and sustainability outcomes. [6,11,34]. However, most existing studies treat green innovation as a broad construct or combine product and process innovations, so the role of IGPI-specific mediation

remains underexplored. The study therefore builds on prior research by examining how GEO translates into SSP through gradual product-level environmental improvements.

**H4: IGPI mediates the positive relationship between GEO and SSP.**

**GEO and AIUC**

The relationship between GEO and AIUC reflects a capability-oriented pathway that complements the product-level transformation represented by IGPI. GEO can foster AIUC by shaping managerial attention, experimentation, resource allocation, and organizational learning, thereby encouraging SMEs to explore and integrate new technologies into strategic and operational processes. GEO can foster AIUC by shaping managerial attention, experimentation, resource allocation, and organizational learning, encouraging SMEs to explore and integrate new technologies into strategic and operational processes. Hruby [22] supports this view by showing that entrepreneurial orientation is strongly linked to effective AI integration among SMEs. In the context of GEO, environmental entrepreneurship encourages companies to seek innovative responses to ecological and market challenges, with AI supporting information processing, decision-making, resource optimization, forecasting, and innovation. This argument is further supported by Alshammakhi and Sheikh [35] and Alwakid and Dahri [24], who show that AIUC and entrepreneurial orientation can strengthen knowledge utilization, innovation, creativity, and ultimately SSP.

**H5: GEO has a positive effect on AIUC.**

**AIUC and SSP**

AIUC is expected to improve SSP by improving decision-making, operational efficiency, resource allocation, innovation, and sustainability-oriented management. Its value depends not only on AI adoption but also on companies' ability to effectively use and integrate AI resources into organizational processes to generate knowledge and actionable outcomes. Empirical evidence supports this relationship, suggesting that AI and AIUC contribute to economic, environmental, and social performance and can strengthen green innovation and sustainability. [20,35,21,36,24]. For SMEs, AI can

improve information processing, resource optimization, opportunity identification, operational efficiency, waste reduction, and sustainability-oriented decision-making without requiring proportionate organizational expansion. However, these benefits depend on effective organizational utilization, not just technology adoption.

**H6: AIUC positively affects SSP.**

**The Mediating Role of AIUC**

The mediating role of AIUC can be theoretically explained through DCV, particularly the sequential logic of sensing, seizing, and reconfiguring. From this perspective, GEO is not expected to generate sustainable performance merely by establishing an environmental strategic posture. Rather, GEO shapes how firms recognize environmental opportunities, search for innovative solutions, commit resources, and develop organizational capabilities that translate strategic intentions into concrete actions. AIUC represents one such capability-development mechanism because it enables SMEs to convert AI-related resources and knowledge into actionable organizational processes and sustainability-oriented decisions.

At the sensing stage, GEO directs managerial attention toward environmental problems, emerging green-market opportunities, changing customer expectations, technological developments, and sustainability-related threats. A strong green entrepreneurial orientation is characterized by proactiveness, innovativeness, and willingness to experiment with new solutions. Consequently, firms with stronger GEO have greater strategic motivation to explore emerging technologies, including AI, when such technologies can improve their ability to identify environmental, operational, and market opportunities. This argument aligns with evidence that entrepreneurial orientation is associated with effective AI integration among SMEs and that developing AI capability requires organizational learning, experimentation, and the progressive integration of technological resources into business activities. [22,19].

At the seizing stage, recognizing an opportunity is insufficient; firms must mobilize resources and make organizational decisions to exploit it. In this context, GEO can

encourage SMEs to allocate managerial attention, financial resources, employee effort, and organizational learning to develop and use AI. Importantly, AIUC is not equivalent to simply adopting or possessing AI technology. It reflects the firm's ability to acquire, integrate, learn from, coordinate, and effectively utilize AI-related resources within actual business processes [18]. This shows that manufacturing SMEs develop AI capabilities by acquiring and accumulating resources, then bundling them through learning, governance, process coordination, and employee involvement. Therefore, GEO provides the strategic impetus for technological experimentation and resource commitment, while AIUC represents the organizational capability that emerges when firms effectively integrate these resources.

At the reconfiguring stage, AIUC enables SMEs to translate their developed information and technological resources into organizational action. AI-supported information processing and pattern recognition can strengthen firms' ability to identify opportunities and threats; AI-supported analytics can improve decision-making and strategic responsiveness; and AI-enabled coordination, learning, automation, and resource orchestration can facilitate changes in organizational routines and processes. Thus, AI's sustainability value does not arise from owning the technology itself, but from the firm's ability to embed AI into organizational routines and use it to support continuous adaptation. This interpretation aligns with research showing that AI capability becomes valuable when firms integrate technological, human, and organizational resources and translate them into actionable organizational outcomes. [37,19,38].

The proposed mediation therefore follows a theoretically ordered mechanism: GEO establishes the strategic orientation for responding to environmental opportunities; this orientation stimulates technological search, experimentation, resource commitment, and organizational learning; these processes contribute to the development and utilization of AIUC; and AIUC subsequently enables more effective information processing, decision-making, resource orchestration, innovation, and organizational adaptation, which contribute to economic, environmental, and social performance. In

other words, AIUC explains how GEO can translate into sustainable performance through developing an organizational capability rather than technology adoption alone.

This mechanism is particularly relevant to SMEs because resource constraints make it difficult to achieve sustainability simply by scaling up physical or financial resources. AIUC provides a capability-based pathway to recombine and leverage existing human, informational, technological, and organizational resources more effectively. Recent evidence indicates that AI capabilities can support sustainable entrepreneurship, innovation, and economic, environmental, and social outcomes, while entrepreneurial orientation facilitates the organizational conditions required for effective AI integration [35,20]. Similarly, Cimino et al. [29] connect dynamic capabilities with AI adoption and subsequent sustainability-related outcomes in SMEs.

Importantly, conceptualizing AIUC as a mediator rather than a moderator changes the study's theoretical question. A moderating perspective would ask whether AI capability changes the strength of an existing GEO–SSP relationship. Instead, the present study asks whether GEO contributes to SSP by stimulating the development and effective use of AI-related organizational capabilities. AIUC therefore represents an endogenous organizational mechanism through which strategic environmental orientation is translated into sustainability-related outcomes. This mechanism complements the IGPI pathway: whereas IGPI captures what SMEs transform through gradual improvement of existing products, AIUC captures how SMEs strengthen their organizational capacity to sense, decide, coordinate resources, learn, and adapt through AI-enabled processes.

**H7: AIUC mediates the positive relationship between GEO and SSP.**

## 3. Research Methodology

### 3.1 Research Design and Research Context

This study used a quantitative cross-sectional survey design to examine how GEO contributes to SSP through two parallel organizational mechanisms: IGPI and AIUC. The empirical context was batik SMEs in Central Java, Indonesia.

The batik sector offers a relevant context for examining sustainability-oriented strategic transformation because batik SMEs operate in a resource-constrained environment while facing environmental, economic, social, and technological challenges. In particular, the sector involves resource-intensive production that generates waste, while firms must remain competitive and adapt to changing market and technological conditions. These characteristics make incremental green product innovation and AIUC development potentially relevant mechanisms through which a green entrepreneurial orientation can translate into sustainable performance.

The cross-sectional design was employed to assess the hypothesized relationships among GEO, IGPI, AIUC, and SSP based on respondents' assessments collected during a single period. The research model was grounded in the DCV, which provides a basis for examining how strategic orientation translates into organizational capabilities and innovation activities that contribute to sustainability outcomes.

The Research Ethics Committee of Bina Insani University granted ethical approval for this study (Approval No. 2472/BiU/7.9/X/2026), and all participants provided informed consent.

### 3.2 Population and Sampling

The reference population comprised 254 batik industry units in Central Java, Indonesia, as reported by the Center for Crafts and Batik, Ministry of Industry of the Republic of Indonesia, as of July 2024. We assessed the minimum sample size based on the maximum number of structural paths pointing to an endogenous construct and the number of indicators in the measurement model, following Hail et al. [39] The minimum sample requirement based on the 7-times heuristic was 133 observations (19 indicators × 7). The final sample of 154 valid responses therefore exceeded this minimum requirement. The final sample of 154 valid observations therefore exceeded the heuristic minimum requirement.

The study used purposive sampling because it required respondents with relevant experience in managing and operating batik SMEs. Inclusion criteria required that the

SME had operated for more than five years and had undertaken green entrepreneurship practices. One knowledgeable respondent was selected from each participating SME. Respondents were required to be sufficiently familiar with their firm's use of digital or AI-enabled tools to provide informed assessments of AIUC. A total of 154 valid observations were obtained and analyzed**.** All participants provided freely-given informed consent prior to their participation in the study.

### 3.3 Data Collection and Common Method Bias

Data were collected using a structured questionnaire administered to eligible batik SMEs in Central Java, Indonesia. One knowledgeable respondent was selected from each participating SME to provide organizational-level assessments of GEO, IGPI, AIUC, and SSP. To reduce potential common method bias, several procedural remedies were applied during data collection. The questionnaire used clear, concise wording; we told respondents there were no right or wrong answers; and we emphasized confidentiality to reduce evaluation apprehension and encourage accurate responses. We administered the questionnaire consistently to all participating SMEs and retained only responses from respondents who met the predefined eligibility criteria for analysis.

Because the study used a cross-sectional, single-source questionnaire design, we cannot completely rule out common method bias. Therefore, interpret the findings with this methodological consideration in mind. Collinearity diagnostics were also examined as part of the structural model assessment, with the results reported in Section 4.2.

### 3.4 Measurement of Variables

The research model comprised four latent constructs: GEO, IGPI, AIUC, and SSP. The measurement items were adapted from established literature and contextualized to the batik SME setting.

In this study, GEO was defined by 5 items capturing green innovativeness, proactiveness, and risk-taking, adapted from established sustainability-oriented entrepreneurship scales. [40,41]. IGPI was measured through 4 items recording

ongoing environmental upgrades in existing products, with a tendency toward SMEs' eco-innovation approaches [42,43]. AIUC was measured through 4 items adapted from [44,45]. We operationalized SSP as a sustainability-oriented performance construct encompassing environmental, economic, and social outcomes, using six indicators adapted from Khan et al. [46] were employed.

We conceptualized SSP as a multidimensional sustainability performance construct encompassing three theoretically distinct but complementary domains: economic, environmental, and social performance. These three domains were operationalized through six indicators adapted from Khan et al. [46]. Two indicators represent each domain. This conceptualization allows the three domains to retain their substantive distinctiveness while jointly representing the broader organizational-level sustainability outcome.

### 3.5 PLS-SEM Analysis

The hypotheses were tested using Partial Least Squares Structural Equation Modeling (PLS-SEM) implemented in SmartPLS 4 [47]. We used PLS-SEM because the proposed model includes multiple latent constructs and simultaneously estimates direct relationships and two parallel mediation pathways. The analysis examines how GEO translates into SSP through two theoretically distinct mechanisms: IGPI and AIUC.

The analysis was conducted in two stages. First, we assessed the measurement model by examining indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. We evaluated indicator reliability using outer loadings and assessed internal consistency reliability using Cronbach's alpha, rho_A, and composite reliability. Convergent validity was assessed using average variance extracted (AVE). Discriminant validity was evaluated primarily using the heterotrait-monotrait ratio (HTMT), supported by the Fornell-Larcker criterion and cross-loadings [48].

Second, we evaluated the structural model using the inner variance inflation factor (VIF), coefficient of determination ($R^2$), effect size ($f^2$), and out-of-sample predictive assessment. We tested hypotheses using bootstrapping in SmartPLS 4, with path coefficients, t-values, and p-values to evaluate the proposed relationships. [49]. Out-of-sample predictive performance was assessed using the PLS-Predict procedure with repeated 10-fold cross-validation (10 repetitions). We used $Q^2$_predict to assess predictive relevance and examined RMSE and MAE as prediction-error measures. We also compared PLS-SEM prediction errors with those from the linear-model (LM) benchmark, following the prediction-oriented assessment logic recommended for PLS-SEM. [50].

Model fit statistics, including SRMR and NFI, were reported as supplementary diagnostics. Given PLS-SEM's prediction-oriented nature, these statistics were not used as the sole basis for evaluating model adequacy.

## 4. Results

### 4.1 Respondents' Profile

154 respondents from 254 batik SMEs in Central Java Province, Indonesia, completed the survey. As shown in Table 1, the respondents were predominantly female and aged 36–50 years, with most occupying managerial positions. More than half had completed senior high school, while the remainder held undergraduate or postgraduate qualifications. Although managers made up the majority of respondents, owners, who often held managerial positions or served only in managerial roles, also completed the questionnaire. The predominance of owners and managers among respondents supports their suitability as knowledgeable informants for assessing organizational-level constructs.

**Table 1. Respondent's Demographics**

| Categorical | | Freq. | % |
|---|---|---|---|
| **Gender** | Male | 78 | 50,65% |
| | Female | 76 | 49,35% |
| **Age** | 21 – 35 years old | 46 | 29,87% |
| | 36 – 50 years old | 72 | 46,75% |

| | | | |
|---|---|---|---|
| | 51 – 65 years old | 32 | 20,78% |
| | > 65 years old | 4 | 2,60% |
| **Education** | Senior High School | 81 | 52,60% |
| | Undergraduate Program | 57 | 37,01% |
| | Postgraduate Program | 16 | 10,39% |
| **Position** | Owner | 34 | 22,08% |
| | Manager | 120 | 77,92% |

### 4.2 Outer Model Measurement

The measurement was first evaluated to establish the reliability and validity of the constructs before testing the structural relationships. The assessment included outer loadings, internal consistency reliability, convergent validity, and discriminant validity.

### Indicator Reliability

As shown in Table 2, the outer loadings ranged from 0.762 to 0.974. The loadings for AIUC ranged from 0.840 to 0.922; for GEO, from 0.762 to 0.915; for IGPI, from 0.899 to 0.932; and for SSP, from 0.961 to 0.974. All indicators exceeded the 0.70 threshold, indicating satisfactory indicator reliability (See Table 2).

**Table 2. Reliability and Convergent Validity**

| Construct | Cronbach's α | rho_A | Composite Reliability | AVE |
|---|---|---|---|---|
| **AIUC** | 0.900 | 0.907 | 0.930 | 0.770 |
| **GEO** | 0.911 | 0.914 | 0.934 | 0.739 |
| **IGPI** | 0.937 | 0.937 | 0.955 | 0.841 |
| **SSP** | 0.985 | 0.986 | 0.988 | 0.932 |

The results indicate satisfactory internal consistency reliability for all constructs. Cronbach's alpha values ranged from 0.900 to 0.985, rho_A values ranged from 0.907 to 0.986, and composite reliability values ranged from 0.930 to 0.988. All values exceeded the 0.70 criterion.

Convergent validity was also established. AVE values ranged from 0.739 to 0.932, exceeding the minimum criterion of 0.50 for all constructs. These results indicate that

the constructs explain a substantial proportion of the variance in their respective indicators.

### Discriminant Validity

Discriminant validity was assessed using HTMT, with the Fornell-Larcker criterion and cross-loadings providing supplementary evidence. The HTMT values ranged from 0.680 to 0.869. The highest value occurred between IGPI and SSP (HTMT = 0.869), while all other construct pairs produced HTMT values below 0.85. The highest value remained below the more liberal 0.90 criterion, providing adequate evidence of discriminant validity (See Table 3).

**Table 3. HTMT Results**

| Construct Pair | HTMT |
|---|---|
| **AIUC – GEO** | 0.680 |
| **AIUC – IGPI** | 0.753 |
| **GEO – IGPI** | 0.807 |
| **AIUC – SSP** | 0.773 |
| **GEO – SSP** | 0.727 |
| **IGPI – SSP** | 0.869 |

The Fornell-Larcker results provided consistent evidence. The square roots of AVE were 0.877 for AIUC, 0.860 for GEO, 0.917 for IGPI, and 0.965 for SSP, and each exceeded its correlations with the other constructs, as shown in Table 3.

The cross-loading assessment also showed that each indicator loaded highest on its assigned construct. Although SSP exhibited particularly high indicator loadings, the six indicators represent substantively distinct aspects of sustainability performance. SSP1 and SSP2 address environmental outcomes, SSP3 and SSP4 address economic outcomes, and SSP5 and SSP6 address social outcomes. Therefore, the high loadings

were not sufficient grounds to remove individual indicators because doing so could reduce the SSP construct's content coverage.

### 4.3 Structural Model Assessment

Following the assessment of the measurement model, the structural model was evaluated to examine the hypothesized relationships among GEO, IGPI, AIUC, and SSP. The structural model assessment included collinearity diagnostics, explained variance ($R^2$), effect sizes ($f^2$), predictive relevance ($Q^2$_predict), and hypothesis testing. Figure 2 presents the estimated PLS-SEM model, including the standardized path coefficients, coefficients of determination for the endogenous constructs, and outer loadings of the measurement indicators.

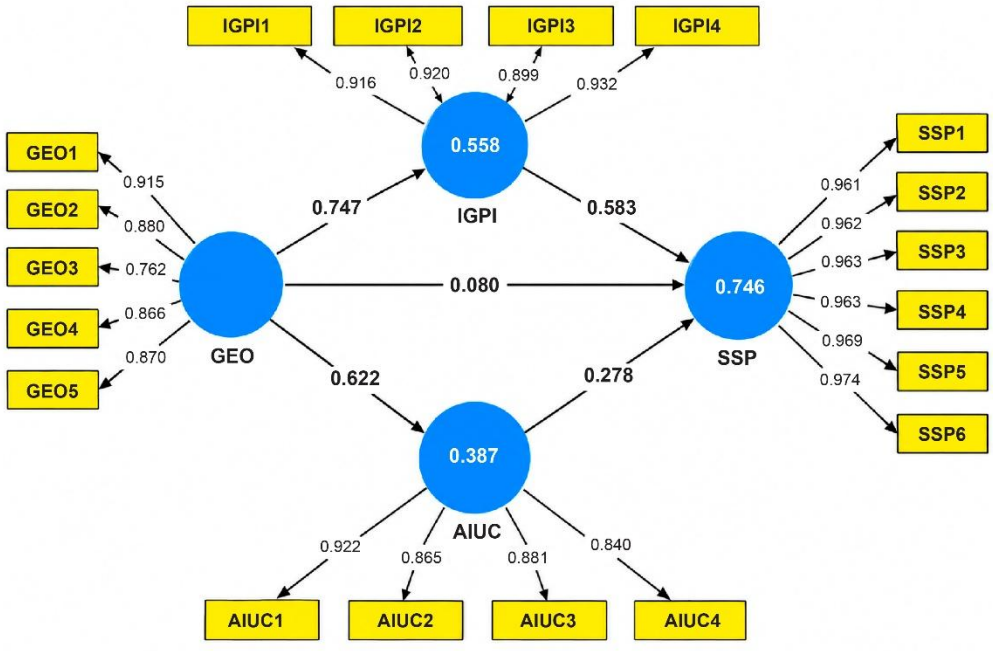



Figure 2. Estimated PLS-SEM model showing indicator loadings, structural path coefficients, and $R^2$ values

As shown in Figure 2, GEO is positively related to both mediating constructs. The path coefficient from GEO to IGPI is 0.747, while the path coefficient from GEO to AIUC is 0.622. Both IGPI and AIUC are positively associated with SSP, with path coefficients

of 0.583 and 0.278, respectively. In contrast, the direct path from GEO to SSP is relatively small (β = 0.080). These coefficients provide an initial overview of the structural relationships, while the subsequent hypothesis-testing section assesses their statistical significance through bootstrapping.

The coefficient of determination ($R^2$) assesses the structural model's explanatory power. As shown in Figure 2, GEO explains 38.7% of the variance in AIUC ($R^2 = 0.387$) and 55.8% of the variance in IGPI ($R^2 = 0.558$). In turn, GEO, IGPI, and AIUC jointly explain 74.6% of the variance in SSP ($R^2 = 0.746$). These results indicate that the proposed model accounts for a substantial proportion of the variance in the endogenous constructs, particularly SME sustainable performance.

**Collinearity Assessment**

Before testing the hypotheses, collinearity among the predictor constructs was assessed using inner VIF values. The VIF values ranged from 1.000 to 2.796. The highest VIF was observed for the IGPI → SSP relationship (VIF = 2.796), followed by GEO → SSP (VIF = 2.376) and AIUC → SSP (VIF = 2.017). The remaining paths involving GEO as the predictor of AIUC and IGPI had VIF values of 1.000. All values were below 5.0, indicating no critical multicollinearity in the structural model.

**Effect Size**

The effect-size analysis further indicates that GEO has a large effect on IGPI ($f^2 = 1.262$) and AIUC ($f^2 = 0.632$). IGPI has a large effect on SSP ($f^2 = 0.480$), whereas AIUC has a smaller but meaningful effect ($f^2 = 0.151$). In contrast, GEO's direct effect on SSP has a negligible effect size ($f^2 = 0.011$). These findings suggest that the two proposed organizational mechanisms explain GEO's contribution to SSP more than a substantial direct effect (See Table 4).

**Table 4. Effect Sizes ($f^2$)**

| Structural Relationship | $f^2$ | Interpretation |
|---|---|---|
| **GEO → IGPI** | 1.262 | Large |
| **GEO → AIUC** | 0.632 | Large |

| | | |
|---|---|---|
| **IGPI → SSP** | 0.480 | Large |
| **AIUC → SSP** | 0.151 | Medium |
| **GEO → SSP** | 0.011 | Negligible |

### Explanatory Power

The structural model explained 38.7% of the variance in AIUC ($R^2$ = 0.387; adjusted $R^2$ = 0.383) and 55.8% of the variance in IGPI ($R^2$ = 0.558; adjusted $R^2$ = 0.555). For SSP, GEO, IGPI, and AIUC, they jointly explained 74.6% of the variance ($R^2$ = 0.746; adjusted $R^2$ = 0.741) (See Table 5).

The results indicate substantial explanatory power for SSP, suggesting that GEO, IGPI, and AIUC together explain a considerable proportion of variation in sustainable performance among the sampled batik SMEs.

**Table 5. Coefficient of Determination**

| Endogenous Construct | $R^2$ | Adjusted $R^2$ |
|---|---|---|
| **AIUC** | 0.387 | 0.383 |
| **IGPI** | 0.558 | 0.555 |
| **SSP** | 0.746 | 0.741 |

### Predictive Relevance

Predictive relevance and out-of-sample predictive performance were assessed using PLS-Predict. The $Q^2$_predict values were positive for all endogenous constructs: 0.377 for AIUC, 0.551 for IGPI, and 0.466 for SSP. These results indicate that the model has out-of-sample predictive relevance for all three endogenous constructs. At the construct level, the corresponding PLS-SEM RMSE values were 0.800, 0.679, and 0.740, while the MAE values were 0.622, 0.519, and 0.559 for AIUC, IGPI, and SSP, respectively (See Table 6).

Comparison with the linear-model (LM) benchmark showed that predictive performance was not uniformly superior to the benchmark. At the indicator level, PLS-

SEM RMSE was lower than LM RMSE for 5 of 14 indicators, while PLS-SEM MAE was lower for 4 of 14 indicators. The latent-variable comparison further showed higher PLS-SEM loss than LM loss for AIUC (0.383 vs. 0.352, $p = 0.007$) and IGPI (0.290 vs. 0.266, $p < 0.001$). In contrast, the difference for SSP was not statistically significant (0.273 vs. 0.276, $p = 0.651$). Overall, PLS-SEM loss was higher than LM loss (0.310 vs. 0.295, $p = 0.002$). Thus, the results support predictive relevance but provide limited evidence that the proposed PLS-SEM model predicts better than a simple linear benchmark; predictive performance varies across constructs and indicators.

**Table 6. Out-of-sample predictive assessment using PLS-Predict and the linear-model benchmark.**

| Construct | $Q^2$_predict | PLS-SEM RMSE | PLS-SEM MAE | PLS loss | LM loss (p) |
|---|---|---|---|---|---|
| **AIUC** | 0.377 | 0.800 | 0.622 | 0.383 | 0.352 ($p = 0.007$) |
| **IGPI** | 0.551 | 0.679 | 0.519 | 0.290 | 0.266 ($p < 0.001$) |
| **SSP** | 0.466 | 0.740 | 0.559 | 0.273 | 0.276 ($p = 0.651$) |
| **Overall** | — | — | — | 0.310 | 0.295 ($p = 0.002$) |

*$Q^2$_predict > 0 indicates predictive relevance.

a. Lower RMSE, MAE, and loss values indicate lower prediction error.

b. LM loss comparisons are based on the latent-variable PLS-SEM versus linear-model benchmark output.

**Model Fit**

As supplementary model diagnostics, the SRMR was 0.062 for the saturated model and 0.094 for the estimated model. The corresponding NFI values were 0.771 and 0.747.

These statistics served as supplementary diagnostics, while the primary evaluation of the PLS-SEM model focused on measurement quality, structural relationships, explanatory power, effect sizes, and predictive relevance.

### 4.4 Direct Effects and Hypothesis Testing

The structural model results indicate that GEO significantly predicted both IGPI and AIUC. GEO had a strong positive effect on IGPI (β = 0.747, t = 18.067, p < 0.001), supporting H2. GEO also had a positive and statistically significant effect on AIUC (β = 0.622, t = 11.458, p < 0.001), supporting H5 (See Table 7).

Both mediating mechanisms were positively associated with SSP. IGPI had a positive and statistically significant effect on SSP (β = 0.583, t = 7.421, p < 0.001), supporting H3. AIUC also had a positive and statistically significant effect on SSP (β = 0.278, t = 4.510, p < 0.001), supporting H6.

In contrast, GEO had no statistically significant direct effect on SSP (β = 0.080, t = 0.979, p = 0.164); therefore, H1 was not supported.

The results are notable because GEO strongly predicts both proposed mediating mechanisms, whereas its direct association with SSP becomes statistically insignificant once IGPI and AIUC are included in the model.

**Table 7. Direct Effects and Hypothesis Testing**

| Hypothesis | Relationship | β | t | p | Decision |
|---|---|---|---|---|---|
| **H1** | GEO → SSP | 0.080 | 0.979 | 0.164 | Not supported |
| **H2** | GEO → IGPI | 0.747 | 18.067 | <0.001 | Supported |
| **H3** | IGPI → SSP | 0.583 | 7.421 | <0.001 | Supported |
| **H5** | GEO → AIUC | 0.622 | 11.458 | <0.001 | Supported |
| **H6** | AIUC → SSP | 0.278 | 4.510 | <0.001 | Supported |

### 4.5 Parallel Mediation Analysis

The parallel mediation analysis revealed that both IGPI and AIUC significantly transmitted the relationship between GEO and SSP. The specific indirect effect of GEO on SSP through IGPI was positive and statistically significant (β = 0.436, t = 6.855, p < 0.001), supporting H4. Similarly, the indirect effect through AIUC was positive and statistically significant (β = 0.173, t = 4.175, p < 0.001), supporting H7 (See Table 8).

The total indirect effect of GEO on SSP was 0.609, whereas the total effect was 0.689. In comparison, the direct effect of GEO on SSP was only 0.080 and was not statistically significant.

The findings therefore indicate that the association between GEO and SSP is transmitted predominantly through the proposed organizational mechanisms. The estimated indirect effect through IGPI (β = 0.436) was approximately 2.52 times the estimated indirect effect through AIUC (β = 0.173). This indicates that IGPI made the larger estimated indirect contribution within the parallel mediation model. However, interpret the ratio as a difference in effect magnitude rather than evidence of a statistically significant difference between the two indirect effects, because a formal difference test was not reported.

**Table 8. Indirect and Total Effects**

| Effect | β | t | p | 95% CI LL | 95% CI UL | Decision |
|---|---|---|---|---|---|---|
| **Indirect: GEO → IGPI → SSP** | 0.436 | 6.855 | <0.001 | Actual | Actual | Significant |
| **Indirect: GEO → AIUC → SSP** | 0.173 | 4.175 | <0.001 | Actual | Actual | Significant |
| **Total indirect effect** | 0.609 | — | — | | | — |
| **Total effect: GEO → SSP** | 0.689 | — | — | | | — |

## 5. Discussion

This study examines how GEO contributes to SSP through two organizational mechanisms, namely IGPI and AIUC. Drawing on DCV, this study proposes that GEO represents upstream strategic orientation, while IGPI and AIUC represent distinct mechanisms through which entrepreneurial intentions translate into sustainability outcomes. Empirical findings strongly support this mechanism-based explanation. In particular, GEO significantly influences IGPI and AIUC, and both significantly improve SSP. However, GEO has no statistically significant direct effect on SSP. Both indirect effects are positive and significant, with the IGPI pathway being larger than the AIUC

pathway. These findings provide important theoretical and managerial implications for understanding sustainability transformation among resource-constrained SMEs.

The non-significant direct effect of GEO on SSP has important theoretical implications. It suggests that a green entrepreneurial orientation should not be interpreted as a performance outcome in itself. Rather, its sustainability value appears to depend on the firm's ability to translate strategic environmental intent into concrete organizational transformation. This finding advances a mechanism-oriented interpretation of the Dynamic Capability View, in which strategic orientation requires capability development and innovation activities before generating sustainability outcomes.

### 5.1 GEO and SSP

In contrast to H1, GEO has a positive but statistically insignificant direct effect on SSP ($\beta = 0.080$, $t = 0.979$, $p = 0.164$), suggesting that GEO alone does not automatically lead to superior sustainable performance among batik SMEs. Rather than indicating that GEO is irrelevant to sustainability, the non-significant direct association suggests that its relationship with SSP may be contingent on intervening organizational mechanisms.

Although these findings differ from previous studies that reported on a positive GEO–SSP relationship [9],[6],[8]. They suggest that the GEO effect depends on organizational mechanisms that translate strategic orientation into concrete actions. From a DCV perspective, GEO represents strategic direction, not capability itself; companies must mobilize and reconfigure resources through innovation and technological capabilities to produce measurable results. Thus, GEO can be interpreted as an upstream strategic trigger, while IGPI and AIUC determine whether this orientation translates into SSP, as reflected in the insignificant but indirect effects of the two mechanisms.

### 5.2 GEO and IGPI

H2 is strongly supported, as GEO has a positive and significant effect on IGPI ($\beta = 0.747$, $t = 18.067$, pp. $< 0.001$), one of the model's strongest structural relationships,

suggesting that stronger GEO encourages batik SMEs to upgrade their products gradually, in accordance with Coelho et al. [6]Al-Swidi et al. [51]Idrees et al. [10]Shehzad et al. [31], and Baquero [11]. GEO encourages companies to identify environmental opportunities, experiment with solutions, mobilize resources, and develop green products. This strong relationship matters for batik SMEs because IGPI can be achieved through gradual changes to existing products, materials, designs, production techniques, packaging, and resource use, without requiring radical technological transformations or large investments. From a DCV perspective, GEO provides strategic motivation for such improvements, while existing knowledge, production routines, and market relationships support resource reconfiguration and gradual green innovation.

### 5.3 IGPI and SSP

H3 is strongly supported: IGPI has a positive, significant effect on SSP ($\beta = 0.583$, $t = 7.421$, $p < 0.001$), suggesting that gradual environmental improvements in products are associated with better economic, environmental, and social performance among batik SMEs. Consistent with Coelho et al. [6], and Oduro [16]the findings suggest that gradual product innovation can offer a viable sustainability pathway for resource-constrained SMEs by improving materials, production methods, resource efficiency, durability, inputs, and product design. From a DCV perspective, IGPI represents an exploitative transformation mechanism in which SMEs refine and recombine existing resources and routines rather than undertaking costly radical transformations. This allows traditional SMEs to generate sustainability value while leveraging accumulated skills, local knowledge, established production routines, and customer relationships.

### 5.4 The Mediating Role of IGPI

H4 is strongly supported, as the indirect effects of GEO on the SSP via IGPI are positive and significant ($\beta = 0.436$, $t = 6.855$, $p < 0.001$) and substantially stronger than the pathway through AIUC ($\beta = 0.173$), indicating that the estimated indirect effect through IGPI was larger than the corresponding indirect effect through AIUC among the SMEs studied. Although previous research has linked GEO, green innovation, and

sustainability, this study expands the literature by identifying product-oriented incremental innovation as a key mediation mechanism. [6],[11]. In the context of batik SMEs, where product characteristics strongly shape market competitiveness, customer preferences, cultural identity, and production practices, GEO can motivate companies to identify green opportunities. At the same time, IGPI translates this orientation into concrete product improvements that improve the SSP. Thus, the insignificant direct relationship between GEO and SSP does not diminish GEO's importance; rather, IGPI transmits its influence, serving as an operational mechanism that turns green strategic intentions into sustainable performance.

### 5.5 GEO and AIUC

H5 is strongly supported, as GEO has a positive and significant effect on AIUC ($\beta$ = 0.622, t = 11.458, pp<0.001), suggesting that SMEs with a stronger green entrepreneurial orientation are more likely to develop AI utilization capabilities. These findings expand the conventional view of GEO beyond environmental innovation and green practices by suggesting that green-oriented companies are also encouraged to explore digital technologies to address environmental, operational, and market challenges. According to Hruby [22] and Peretz-Andersson et al. [18] DCV can explain this relationship, where environmental strategic sensitivity encourages companies to acquire, learn, integrate, and use digital resources. Importantly, AIUC reflects organizational capabilities, not just AI adoption, and requires employee competencies, process integration, organizational learning, and incorporating AI-generated information into managerial decisions. Thus, GEO can drive green product transformation and develop digital organizational capability.

### 5.6 AIUC and SSP

H6 is supported, as AIUC has a positive and significant effect on SSP ($\beta$ = 0.278, t = 4.510, $p < 0.001$), confirming that effective AI use contributes to sustainable performance among batik SMEs. However, the effect is smaller than IGPI's. Latest evidence shows that AIUC can generate economic, environmental, and social benefits when organizations effectively integrate technological and human resources through

organizational learning, experimentation, resource acquisition, governance, and process coordination. [37],[19],[18],[20]. AIUC supports sustainability by improving information processing, decision-making, resource optimization, operational efficiency, and product development. The estimated coefficient for AIUC was smaller than that for IGPI, indicating a weaker estimated direct association with SSP in the current structural model. Interpret this difference descriptively rather than as evidence that AIUC is intrinsically less important than IGPI. AIUC nevertheless represents a complementary organizational capability through which SMEs can strengthen information processing, decision-making, resource utilization, learning, and adaptation.

### 5.7 The Mediating Role of AIUC

H7 is supported, as the indirect effect of GEO on SSP through AIUC is positive and statistically significant ($\beta = 0.173$, $t = 4.175$, $p < 0.001$). This finding aligns with the theoretically specified mechanism in which AIUC translates GEO into SSP. In DCV terms, the finding suggests that the sustainability value of green entrepreneurial orientation is partly realized when it is converted into an organizational capability to use AI.

The parallel mediation analysis showed that both pathways were positive and statistically significant: GEO → IGPI → SSP ($\beta = 0.436$, $p < 0.001$) and GEO → AIUC → SSP ($\beta = 0.173$, $p < 0.001$). The estimated indirect effect through IGPI was larger than that through AIUC. However, the authors reported no formal statistical test comparing the two indirect effects, so this difference should be interpreted descriptively. The two pathways are conceptually complementary rather than interchangeable: IGPI captures product-level transformation, whereas AIUC captures digital organizational capability development. The larger estimated IGPI indirect effect may reflect the immediate relevance of product-level environmental improvements to batik SMEs' operational and market context. However, the cross-sectional design does not allow us to establish the underlying reason for this difference empirically. The significant AIUC pathway nevertheless indicates that digital capability development is also part of the mechanism through which GEO is associated with SSP. Together, these

findings extend prior research by integrating product-level green innovation and AI-enabled organizational transformation within a single parallel mediation framework.

### 5.8 The Dual Mediation Mechanism: IGPI versus AIUC

These findings provide three key theoretical contributions. First, they extend the DCV by showing that the GEO–SSP relationship is better understood as a capability-mediated process in which strategic orientation translates into organizational capabilities and actions, as reflected in the non-significant direct association between GEO and SSP and the significant indirect associations through IGPI and AIUC. Second, the study contributes to the green innovation literature by identifying IGPI as a distinct product-level mechanism through which SMEs can translate GEO into SSP. Third, the study extends DCV to the AI context by conceptualizing AIUC as an organizational transformation mechanism rather than mere technology adoption. In addition, the PLS-Predict results provide a useful boundary condition for interpreting the model. Although all endogenous constructs showed positive $Q^2$_predict values, the model did not consistently outperform the linear benchmark. Thus, the model provides evidence of predictive relevance without implying uniformly superior predictive accuracy.

### 5.9 Theoretical Implications

These findings provide three key theoretical contributions. First, they extend the DCV by showing that the GEO–SSP relationship is better understood as a capability-mediated process in which strategic orientation is transformed into organizational capabilities and actions, as reflected in the insignificant direct effects of GEO and significant indirect effects through IGPI and AIUC. Second, the study contributes to the green innovation literature by identifying IGPI as a distinct and important mechanism, suggesting that gradual environmental improvements at the product level can provide an effective pathway for SMEs to translate GEO into SSP. Third, the study extends DCV to the AI context by conceptualizing AIUC as an organizational transformation mechanism, suggesting that AI-related value arises not only from technology adoption

but also from an organization's ability to use AI effectively through resource orchestration, learning, integration, and organizational adaptation.

### 5.10 Managerial Implications

The study examines how GEO contributes to SSP through two parallel organizational transformation mechanisms, IGPI and AIUC, based on DCV. Using data from 154 batik SMEs in Central Java, Indonesia, the findings support this mechanism-based perspective. The measurement assessment showed satisfactory reliability and validity, while the structural model demonstrated substantial explanatory power and strong out-of-sample predictive relevance. GEO had a positive but statistically insignificant direct association with SSP ($\beta = 0.080$, $p = 0.164$), while its indirect associations through IGPI ($\beta = 0.436$, $p < 0.001$) and AIUC ($\beta = 0.173$, $p < 0.001$) were positive and significant. GEO was also positively associated with IGPI and AIUC, and both mediators were positively associated with SSP, suggesting that GEO's sustainability value is realized especially when strategic intentions translate into concrete innovation and organizational capabilities. PLS-Predict produced positive $Q^2_predict$ values for AIUC (0.377), IGPI (0.551), and SSP (0.466), but the LM comparison indicated that predictive performance was not uniformly superior to the linear benchmark.

The estimated indirect effect through IGPI was larger than that through AIUC in the present sample, although no formal statistical difference test was conducted. AIUC nevertheless provides a complementary digital pathway. In theory, these findings extend DCV by showing that strategic orientation alone does not directly guarantee SSP; its value depends on the firm's ability to translate strategic intentions into innovation and capability development. IGPI and AIUC represent distinct yet complementary mechanisms: IGPI emphasizes product transformation, while AIUC emphasizes AI-based information processing, decision-making, resource utilization, and organizational adaptation. Managerially, SMEs should move beyond articulating green entrepreneurial intentions by integrating gradual green product improvement with AI capability development, while recognizing that the current model shows

predictive relevance rather than uniformly superior predictive accuracy over a linear benchmark.

The study examines how GEO contributes to SSP through two parallel organizational transformation mechanisms, IGPI and AIUC, based on DCV. Using data from 154 batik SMEs in Central Java, Indonesia, the findings support this mechanism-based perspective. The measurement assessment demonstrated satisfactory reliability and validity, while the structural model showed substantial explanatory power and predictive relevance. GEO exerts a positive but insignificant direct effect on SSP ($\beta = 0.080$, $p = 0.164$), while its indirect effects through IGPI ($\beta = 0.436$, $p < 0.001$) and AIUC ($\beta = 0.173$, $p < 0.001$) are positive and significant. GEO also significantly strengthens IGPI and AIUC, and both mediators contribute positively to SSP, suggesting that GEO's sustainability value is realized especially when strategic intentions translate into concrete innovations and organizational capabilities.

These limitations also provide opportunities for future research. First, the cross-sectional design and focus on batik SMEs in Central Java, Indonesia, limit the generalization of findings to other industries, regions, and national contexts; longitudinal and cross-contextual studies may provide stronger evidence of how GEO, IGPI, and AIUC develop and interact over time. Second, the study relies on questionnaire-based, single-source organizational assessments, which may introduce common method bias. Although the authors applied procedural remedies during data collection, they cannot completely rule out this possibility. Future research could therefore combine perceptual measures with objective economic, environmental, and social performance indicators and, where feasible, obtain data from multiple respondents within each SME. Although the sample exceeded the PLS-SEM heuristic minimum, future studies could employ a priori power analysis to establish sample adequacy independently of heuristic rules. Third, the model examines only IGPI and AIUC as transformation mechanisms; future studies may investigate additional organizational and contextual factors, including government support, digital infrastructure, resource constraints, organizational learning, green knowledge, and environmental dynamics, to better explain differences in GEO effectiveness in SMEs.

Finally, the PLS-Predict assessment indicated positive predictive relevance but did not show uniformly superior predictive performance relative to the linear benchmark. Future studies could therefore compare alternative, theoretically grounded models using larger, longitudinal datasets and employ additional predictive model-comparison procedures to examine whether predictive accuracy changes across SME digital maturity and sustainability contexts.

### 6.1 Limitations and Future Research

These limitations also provide opportunities for future research. First, the cross-sectional design and focus on batik SMEs in Central Java, Indonesia, limit the generalization of findings to other industries, regions, and national contexts; longitudinal and cross-contextual studies may provide stronger evidence of how GEO, IGPI, and AIUC develop and interact over time. Second, the study relies on questionnaire-based, single-source organizational assessments, which may introduce common method bias. Although the authors applied procedural remedies during data collection, they cannot completely rule out this possibility. Future research could therefore combine perceptual measures with objective economic, environmental, and social performance indicators and, where feasible, obtain data from multiple respondents within each SME. Although the sample exceeded the PLS-SEM heuristic minimum, future studies could employ a priori power analysis to establish sample adequacy independently of heuristic rules. Third, this model only examines IGPI and AIUC as transformation mechanisms; future studies may investigate additional organizational and contextual factors, including government support, digital infrastructure, resource constraints, organizational learning, green knowledge, and environmental dynamics, to better explain differences in GEO effectiveness in SMEs.

Future research may also examine whether the relative importance of IGPI and AIUC changes as SMEs increase their digital maturity and sustainability capabilities. Longitudinal and comparative studies can determine whether AIUC evolves from a complementary capability to a more central mechanism as SMEs develop greater

technological knowledge, data resources, and organizational readiness. Overall, the findings suggest that GEO creates sustainable value not only through strategic intentions but also through organizational mechanisms that translate those intentions into action. IGPI represents a stronger pathway in the current context. At the same time, AIUC offers an additional digital pathway to sustainable performance, providing a more precise, mechanism-based explanation of how SMEs can translate green entrepreneurship orientation into economic, environmental, and social value.

Overall, the findings support a mechanism-based explanation in which organizational transformation mechanisms primarily transmit the association between GEO and sustainability performance.

**Ethical Approval and accordance**

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The research protocol, including the research instrument (questionnaire), was reviewed and approved by the Research Ethics Committee of Bina Insani University, Bekasi, Indonesia, under approval number 2472/BiU/7.9/X/2026, dated 28 October 2026. The protocol was approved in accordance with the ethical guidelines and research governance standards implemented at Bina Insani University. The committee concluded that the study met the required ethical standards, including social value, scientific integrity, minimal risk to participants, and voluntary participation. Informed consent was obtained from all participants prior to their involvement. Participation was fully voluntary and anonymous, and all responses were used solely for academic research purposes.

**Consent to Participate declaration**: Verbal informed consent was obtained from all individual participants included in the study prior to their participation. Each respondent was informed of the purpose of the study, the voluntary nature of participation, the anonymity of their responses, and their right to withdraw at any time without any consequence. Consent was obtained freely and without coercion before the questionnaire was administered.

**Consent to Publish declaration**: Not applicable. No personally identifiable information was collected, and the data are reported only in aggregate form.

**Data availability:** The datasets generated and analysed during the current study are not publicly available because participants were assured that their responses would be reported only in aggregate form and would be used solely for academic research purposes. The data are available from the corresponding author upon reasonable request.

**Funding Declaration**: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**Competing interests:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Authors' contributions:** I.M. conducted the literature review, processed data with SmartPLS, wrote the manuscript, and financed the publication.

W.D.A. did library research, formulated questionnaires, collected data, and financed the research publication.

Y.A. did library research, collected data, wrote the manuscript, and financed the research publication.

D.I.J. did library research, collected data, wrote the manuscript, and financed the research publication.

Z. finalized the manuscript, proofread it, and financed the research publication.

All authors reviewed the manuscript.

**Reference**

[1] R. Salvador, P. Veng, S. Michael, L. Schmidt-Kalles, and S. Brüning, “Explaining sustainability performance and maturity in SMEs – Learnings from a 100-participant sustainability innovation project,” vol. 419, no. February, 2023.

[2] N. Kannan, S., & Gambetta, “Technology-driven sustainability in small and medium-sized enterprises: a systematic literature review,” *J. Small Bus. Strateg.*, vol. 35, no. 1, pp. 129–157, 2025.

[3] J. Abid, N., Ceci, F., & Aftab, “Attaining sustainable business performance under resource constraints: Insights from an emerging economy,” *Sustain—dev.*, 2023, doi: https://doi.org/10.1002/sd.2763.

[4] M. K. AlAjmi, “The impact of digital leadership on teachers’ technology integration during the COVID-19 pandemic in Kuwait,” *Int. J. Educ. Res.*, vol. 112, p. 101928, 2022.

[5] E. Tuncer, B., & Korchagina, “A systematic literature review and conceptual framework on green entrepreneurial orientation,” *Adm. Sci.*, vol. 14, no. 6, 2024.

[6] C. Coelho, A., Ferreira, J., & Proença, “The impact of green entrepreneurial orientation on sustainability performance through green innovation: Moderating role of ambidexterity,” *Bus. Strateg. Environ.*, vol. 33, no. 4, pp. 3184–3202, 2023.

[7] A. Ishaq, M. I., Sarwar, H., Aftab, J., Franzoni, S., & Raza, “Accomplishing sustainable performance through leaders’ competencies, green entrepreneurial orientation, and innovation in an emerging economy: Moderating role of institutional support,” *Bus. Strateg. Environ.*, 2023, doi: https://doi.org/10.1002/bse.3557.

[8] G. Musfar, T. F., Zulkarnain, Alwie, A. F., & Wijayanto, “Enhancing sustainable business performance through green entrepreneurial orientation in circular economy food SMEs,” *Environ. Econ.*, vol. 16, no. 4, p. 2025.02, 2025, doi: https://doi.org/10.21511/ee.

[9] Z. Öztürk, R., Öztürk, M., & Kızılkan, “Meta-analysis of the relationship between green entrepreneurial orientation and sustainable firm performance,” *Sustainability*, vol. 16, no. 24, 2024.

[10] N. A. Idrees, H., Xu, J., & Andrianarivo Andriandafiarisoa Ralison, “Green entrepreneurial orientation and knowledge creation process as enablers of green innovation performance: the moderating role of resource orchestration capability,” *Eur. J. Innov. Manag.*, vol. 28, no. 3, pp. 754–782, 2023.

[11] A. Baquero, “Linking green entrepreneurial orientation and ambidextrous green innovation to stimulate green performance : a moderated mediation approach,” vol. 30, no. 8, pp. 71–98, 2026, doi: 10.1108/BPMJ-09-2023-0703.

[12] V. Chistov, J. Carrillo-Hermosilla, and N. Aramburu, “Open eco-innovation. Aligning cooperation and external knowledge with the levels of eco-innovation radicalness,” *J. Open Innov. Technol. Mark. Complex.*, vol. 9, no. 2, p. 100049, 2023, doi: 10.1016/j.joitmc.2023.100049.

[13] M. Ali, Z., Qin, Z., Raza-Ullah, T., Ali, A., & Sherwani, “Leading the way to greening: Aligning leadership styles and market learning for radical and incremental green innovation. Business Strategy and the Environment,” *Bus. Strateg. Environ.*, vol. 34, no. 7, pp. 8571–8589, 2025, doi: https://doi.org/10.1002/bse.70039.

[14] Sarkar, S., & Mateus, “Resource-constrained product innovation—An evidence-based review and research agenda,” *Int. J. Innov. Manag.*, 2024.

[15] A. Appiah-Kubi, E., Koranteng, F. O., Dura, C. C., Mihăilă, A. A., Drigă, I., & Preda, “Green financing and sustainability reporting among SMEs: The role of pro-environmental behavior and digitization,” *J. Clean. Prod.*, vol. 478, p. 143939, 2024.

[16] S. Oduro, “Eco-innovation and SMEs ’ sustainable performance : a meta-analysis,” no. September, 2026, doi: 10.1108/EJIM-11-2023-0961.

[17] T.Tegethoff, R. Santa, J. M. Bucheli, B. Cabrera, and A. Scavarda, “Sustainable development through eco- innovation : A focus on small and medium enterprises in Colombia,” no. 2019, pp. 1–20, 2025, doi: 10.1371/journal.pone.0316620.

[18] E. Peretz-Andersson, S. Tabares, P. Mikalef, and V. Parida, “International Journal of Information Management Artificial intelligence implementation in manufacturing SMEs : A resource orchestration approach,” *Int. J. Inf. Manage.*, vol. 77, no. June 2023, p. 102781, 2024, doi: 10.1016/j.ijinfomgt.2024.102781.

[19] N. Haefner, V. Parida, O. Gassmann, and J. Wincent, “Technological Forecasting & Social Change Implementing and scaling artificial intelligence : A review, framework, and research agenda,” *Technol. Forecast. Soc. Chang*, vol. 197, no. June 2022, p. 122878, 2023, doi: 10.1016/j.techfore.2023.122878.

[20] R. B. Soomro, W. M. Al-rahmi, N. A. Dahri, L. Almuqren, A. S. Al-mogren, and A. Aldaijy, “OPEN A SEM – ANN analysis to examine impact of artificial intelligence technologies on sustainable performance of SMEs,” pp. 1–24, 2025.

[21] D. Kumar, S., Kumar, V., Chaudhuri, R., Chatterjee, S., & Vrontis, “AI capability and environmental sustainability performance: Moderating role of green knowledge management,” *Technol. Soc.*, 2025.

[22] V. Hruby, “Entrepreneurial Orientation in the Age of Artificial Intelligence : A Study of SMEs in the Visegrad Chemical Sector,” vol. 30, no. 3, 2025.

[23] T. Hussain, S., Ahmad, N. H., & Syed, “Green and smart: Sustainable performance of Pakistani SME hotels: The mediating effect of eco-innovation and the moderating role of artificial intelligence capability,” *Multidiscip. Sci. J.*, 2024, doi: https://doi.org/10.31893/multiscience.2025283.

[24] N. A. Alwakid, W. N., & Dahri, “Harnessing AI capabilities and green

entrepreneurial orientation for sustainable SME performance using SEM analysis approach," *Technol. Soc.*, vol. 83, p. 103007, 2025.

[25] D. J. Teece, "Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance," *Strateg. Manag. J.*, vol. 28, no. 13, pp. 1319–1350, 2007.

[26] D. J. Teece, "The evolution of the dynamic capabilities framework," *Artif. Sustain. Entrep.*, vol. 113, p. 238, 2023.

[27] A. Teece, D. J., Pisano, G., & Shuen, "Dynamic capabilities and strategic management. Strategic," *Manag. J.*, vol. 18, no. 7, pp. 509–533, 1997, doi: https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z.

[28] C. Larabi, "Linking innovation capability, strategic orientation, and strategic renewal to sustainable performance: A dynamic capabilities perspective in Saudi small and medium enterprises," *Bus. Strateg. Environ.*, 2025, doi: https://doi.org/10.1002/bse.70229.

[29] A. Cimino, V. Corvello, and C. Troise, "Artificial Intelligence Adoption for Sustainable Growth in SMEs : An Extended Dynamic Capability Framework," pp. 6120–6138, 2025, doi: 10.1002/csr.70019.

[30] A. Hossain, M. I., Ong, T. S., Jamadar, Y., Teh, B. H., & Islam, "Nexus among green entrepreneurship orientation, green ambidexterity innovation, green technological turbulence and green performance: Moderated-mediation evidence from Malaysian manufacturing SMEs," *Eur. J. Innov. Manag.*, 2024, doi: https://doi.org/10.1108/EJIM-04-2024-0495.

[31] A. H. Shehzad, M. U., Zhang, J., Latif, K. F., Jamil, K., & Waseel, "Do green entrepreneurial orientation and green knowledge management matter in the pursuit of ambidextrous green innovation: A moderated mediation model," *J. Clean. Prod.*, 2023.

[32] H. Rahmani, A., Bonyadi Naeini, A., Mashayekh, J., Aboojafari, R., Daim, T. U., & Yalcin, "Green innovation for a greener future: A meta-analysis of the impact on environmental performance," *J. Clean. Prod.*, 2024.

[33] Q. Han, M. S., Ma, S., Wang, Y., & Tian, "Impact of technology-enabled product eco-innovation: Empirical evidence from the Chinese manufacturing industry," *Technovation*, vol. 125, p. 102853, 2023, doi: https://doi.org/10.1016/j.technovation.2023.102853.

[34] J. Mu, R., Workneh, B. A., & Zhang, "The interplay of green entrepreneurial orientation, ambidextrous green innovation and environmental performance," *J. Intellect. Cap.*, 2026, doi: https://doi.org/10.1108/JIC-07-2025-0287.

[35] R. A. Alshammakhi, Q., & Sheikh, "Driving sustainable entrepreneurship through AI and knowledge management: Evidence from SMEs in emerging

economies," *Sustainability*, vol. 17, no. 24, p. 10928, 2025, doi: https://doi.org/10.3390/su172410928.

[36] A. S. Al Halbusi, H., Al-Sulaiti, K. I., Alalwan, A. A., & Al-Busaidi, "AI capability and green innovation impact on sustainable performance: Moderating role of big data and knowledge management," *Technol. Forecast. Soc. Change*, vol. 210, p. 123897, 2025.

[37] I. O. Fosso Wamba, S., Queiroz, M.M., Pappas, "Artificial Intelligence Capability and Firm Performance: A Sustainable Development Perspective by the Mediating Role of Data-Driven Culture," *Inf Syst Front*, vol. 26, pp. 2189–2203, 2026.

[38] P. Madanaguli, A., Sjödin, D., Parida, V., & Mikalef, "Artificial intelligence capabilities for circular business models: Research synthesis and future agenda," *Technol. Forecast. Soc—change*, vol. 200, p. 123189, 2024, doi: https://doi.org/10.1016/j.techfore.2023.123189.

[39] C. M. Hair, J. F., Astrachan, C. B., Moisescu, O. I., Radomir, L., Sarstedt, M., Vaithilingam, S., & Ringle, "Executing and interpreting applications of PLS-SEM: Updates for family business researchers. Journal of Family Business Strategy," *J. Fam. Bus. Strateg.*, vol. 12, no. 3, p. 100392, 2021.

[40] B. Muangmee, C., Dacko-Pikiewicz, Z., Meekaewkunchorn, N., Kassakorn, N., & Khalid, "Green entrepreneurial orientation and green innovation in small and medium-sized enterprises (SMEs)," *Soc. Sci.*, vol. 10, no. 4, p. Article 136, 2021.

[41] Y. Li, W., Sun, Y., & Gao, "Relationship between green entrepreneurship orientation, integration of opportunity and resource capacities and sustainable competitive advantage," *Front. Psychol.*, vol. 13, p. 1068734, 2022.

[42] H. Du, Y., & Wang, "Green innovation sustainability: how green market orientation and absorptive capacity matter?," *Sustainability*, vol. 14, no. 13, p. 8192, 2022.

[43] M. A. B. A. Sulaiman, "Green Product Innovation as a Mediator Between Green Market Orientation and Sustainable Performance of SMEs," *Sustainability*, vol. 17, no. 4, p. 1628, 2025.

[44] N. Mikalef, P., Islam, N., Parida, V., Singh, H., & Altwaijry, "Artificial intelligence (AI) competencies for organizational performance: A B2B marketing capabilities perspective," *J. Bus. Res.*, vol. 164, p. 113998, 2023.

[45] Y. A. Badghish, S., & Soomro, "Artificial intelligence adoption by SMEs to achieve sustainable business performance: application of technology–organization–environment framework," *Sustainability*, vol. 16, no. 5, p. 1864, 2024.

[46] A. Khan, S. A. R., Yu, Z., Golpîra, H., Sharif, A., & Mardani, "A state-of-the-art

review and meta-analysis on sustainable supply chain management," *J. Clean. Prod.*, vol. 278, p. 123357, 2021.

[47] J. F. Hair, M. Sarstedt, C. M. Ringle, and S. P. Gudergan, *Advanced issues in partial least squares structural equation modeling*. SAGE Publications, 2022.

[48] P. A. Henseler, J., Hubona, G., & Ray, "Using PLS path modeling in new technology research: Updated guidelines," *Ind. Manag. Data Syst.*, vol. 121, no. 1, pp. 2–20, 2021.

[49] C. M. Sarstedt, M., Hair, J. F., Pick, M., Liengaard, B. D., Radomir, L., & Ringle, "Progress in partial least squares structural equation modeling use in marketing research," *J. Acad. Mark. Sci.*, vol. 48, no. 6, pp. 1–22, 2020.

[50] C. M. Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J.-H., Ting, H., Vaithilingam, S., & Ringle, "Predictive model assessment in PLS-SEM: Guidelines for using PLSpredict," *Eur. J. Mark.*, vol. 53, no. 11, pp. 2322–2347, 2019, doi: https://doi.org/10.1108/EJM-02-2019-0189.

[51] I. S. Al-Swidi, A. K., Al-Hakimi, M. A., Al-Sarraf, J., & Al Koliby, "Innovate or perish: can green entrepreneurial orientation foster green innovation by leveraging green manufacturing practices under different levels of green technology turbulence?," *J. Manuf. Technol. Manag.*, vol. 35, no. 1, pp. 74-94, 2024.