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Research Paper

Environmental Competitiveness and Green Entrepreneurship in the Age of Generative artificial Intelligence: Islamic and Multidisciplinary View

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Abstract
Green entrepreneurship has emerged as an urgent channel for addressing the growing environmental issues and enhancing economic competitiveness in the era of rapid technological revolution. This paper is an Islamic and multidisciplinary theorization of environmental competitiveness and environmental turbulence in green entrepreneurship, considering generative artificial intelligence (AI) as a facilitator. Based on the Resource Orchestration Theory, the research will examine (1) how environmental competitiveness and environmental turbulence directly affect green entrepreneurship, (2) the mediating impact of the adoption of generative AI on these two variables, and (3) the moderating impact of risk-taking propensity of managers. A cross-sectional research design was used, and data were collected from 250 manufacturing industry employees in Pakistan. G Power analysis was used to determine the sample size, and the hypothesis was tested using Smart PLS 4 with Partial Least Squares Structural Equation Modeling (PLS-SEM). The results indicate that environmental competitiveness and environmental turbulence both have a positive and significant influence on green entrepreneurship. Further, the adoption of generative AI is a mediating variable in these relationships, suggesting that the greater the AI technologies, the more firms can turn environmental pressure and uncertainty into sustainable and innovative entrepreneurial actions. Also, managers' risk-taking tendency enhances the positive impact of generative AI use on green entrepreneurship, underscoring the significance of active, ethically oriented leadership. The proposed research would make a conceptual contribution by incorporating environmental dynamics, generative AI, and a managerial orientation within Islamic and multidisciplinary frameworks, and a practical contribution by providing managers and policymakers with insights on how to advance ethical, sustainability-focused entrepreneurship in developing economies.

Keywords: *Environmental Competitiveness, Environmental Turbulence, Generative Artificial Intelligence, Green Entrepreneurship, Risk-Taking Propensity of Managers, the Islamic Perspective, Resource Orchestration Theory, Sustainability.*

INTRODUCTION

In the last several decades, accelerating climate change, environmental degradation, and resource depletion have become the most significant global problems, with the social, economic, and ecological implications they entail (Duc, 2023). These problems have also increased pressure on companies to minimize environmental degradation, improve resource productivity, and balance economic growth with sustainability requirements (Velte, 2023; Bello-Pintado & Machuca, 2023; Bhuiyan et al., 2023). Green entrepreneurship has, in turn, attracted growing academic and practical interest as a strategic business approach in which organizations create environmentally friendly products, services, and business models without jeopardizing their competitiveness and long-term sustainability (Soomro et al., 2024; Odeyemi et al., 2024). The new literature shows that green entrepreneurship programs not only improve environmental performance but also raise firm productivity, innovation capacity, and sustainable competitive advantage (Sultan et al., 2023;

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Farmanesh et al., 2025).

Although this literature is accumulating, there are still significant gaps, especially in the context of emerging economies, regarding how external environmental pressures can be translated into green entrepreneurship behavior and how these transformations are implemented (Wei et al., 2023; Cimino et al., 2025). Environmental competitiveness, including high market rivalry, price elasticity, and product homogeneity, is a critical contextual factor that forces firms to adopt innovative, environmentally oriented strategies to distinguish themselves and remain competitive (Wei et al., 2023; Ansari et al., 2025). Simultaneously, environmental turbulence and uncertainty further increase the need for adaptive, technology-focused solutions to sustain entrepreneurship.

In this respect, the rapid development of digital technologies, especially artificial intelligence (AI), has transformed organizational responses to environmental and competitive pressures. As one of the progressive forms of AI functioning, generative artificial intelligence (Gen-AI), as an advanced type of AI with the ability to generate content, predictive analytics, and create knowledge, has become a transformative facilitator of innovation, decision-making, resource optimization, and process efficiency (Coccia, 2024; Fosso Wamba et al., 2025). Recent empirical studies indicate that Gen-AI can aid green knowledge management, promote eco-innovation, and enhance the performance of entrepreneurial activity by helping firms transform environmental constraints into sustainable opportunities (Roshid et al., 2024; Cimino et al., 2025). Nevertheless, there is a lack of empirical evidence on the mediating role of Gen-AI to justify the relationship between environmental competitiveness and green entrepreneurship, especially in manufacturing industries in developing economies like Pakistan.

In addition to the technological and economic factors, sustainability-oriented entrepreneurship is increasingly requiring an ethical basis. In the Islamic and multidisciplinary worldview, environmental responsibility is not a strategic decision but an ethical one. Nowhere else in the world do Islamic teachings focus on environmental protection as a part of justice, intergenerational equity, and societal well-being, khilafah (stewardship of the Earth), amanah (trust and accountability in resource use), and mizan (balance and moderation) (Hanif, 2024; Hayat et al., 2023). In this worldview, the application of Gen-AI has opportunities and ethical issues. Although Gen-AI has the potential to become more efficient, minimize waste, and enable sustainable innovation, issues of energy use, transparency, accountability, and unintended environmental impact raise questions about its compliance with Islamic ethical standards (Sumi et al., 2024; Raimi & Bamiro, 2026). Based on this, Gen-AI adoption should strengthen, not weaken, the Islamic moral imperatives of stewardship, trust, and balance.

Speaking to these gaps, this work examines how generative artificial intelligence can be used to connect environmental competitiveness and green entrepreneurship in Pakistan's manufacturing sector. The study will aim to provide answers to the following research questions guided by the Resource Orchestration Theory and infused by the Islamic ethical paradigms:

RQ1: How is environmental competitiveness related to green entrepreneurship?

RQ2: Does the generative AI usage mediate the association between environmental competitiveness and green entrepreneurship?

RQ3: How does the use of generative AI correspond to or conflict with the Islamic ethical concepts of khilafah, amanah, and mizan regarding the environmental responsibility?

Based on this, the main aim of the study will be to empirically test the effectiveness of environmental competitiveness as a driver of green entrepreneurship, using generative AI adoption, and to analyze the ethical complications of this connection through an Islamic and multidisciplinary analysis. The theoretical value of the research to the literature on sustainability and digital innovation in emerging economies lies in its integration of environmental competitiveness, green entrepreneurship, Gen-AI adoption, and Islamic ethics within a single

framework. In a practical sense, it provides policymakers, managers, and entrepreneurs with insights on how to use Gen-AI ethically to enhance sustainability-based entrepreneurship, so that technological advancement helps ensure environmental performance and moral responsibility in the era of generative artificial intelligence.

LITERATURE REVIEW

Conceptual Framework

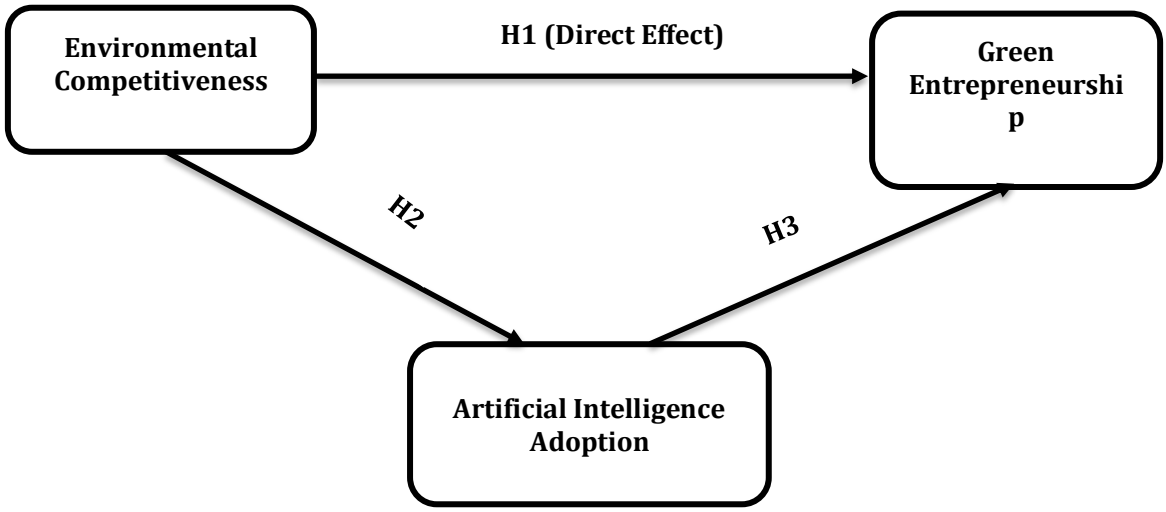

Figure 1. Conceptual Framework

Islamic and Theoretical Integration.

Resource Orchestration Theory describes the strategic organization and utilization of Gen-AI by managers to establish green entrepreneurial strengths. Islamic values strengthen the notion of ethical AI use, ecological responsibility, and green entrepreneurship as moral decision-making rather than economic ones. The model therefore integrates technology, sustainability, entrepreneurship, and Islamic ethics into a multidisciplinary framework.

The conceptual model explains how environmental competitiveness can drive green entrepreneurship in manufacturing companies by strategically implementing Generative Artificial Intelligence (Gen-AI). Basing the model on the Resource Orchestration Theory (ROT) and empowered by Islamic ethical standards (e.g., Khilafah, Maslahah, and Mizan), the model positions Gen-AI adoption as a strategic mediating force that will help firms turn environmental pressures into sustainable entrepreneurial outcomes.

Variables in the Model

Independent Variable (IV)

Environmental Competitiveness (EC)

Presents regulatory pressure, expectations of stakeholders and market-based environmental demands that require firms to pursue environmentally responsible strategies.

Mediating Variable (M)

Generative Artificial Intelligence (Gen-AI Adoption) Adoption.

References strategic collaboration of AI-based technologies towards:

- Sustainable decision-making
- Eco-innovation

- Resource optimization
- Green opportunity identification.

Gen-AI uptake is perceived as an instrument (wasilah) of the practice of responsible stewardship (Khilafah) under an ethical intent and accountability.

Dependent Variable (DV)

Green Entrepreneurship (GE)

Includes entrepreneurial activities, which are environmentally minded, such as:

- Green project and process innovation.
- Reduction and recycling of waste.
- Green business and energy efficiency.

Green entrepreneurship is a product of Islamic goals of Maslahah (common good) and the compromise between economic development and natural conservation.

Structural Relationships

Direct Effects

EC - GE

Green entrepreneurial behavior is directly stimulated by environmental competitiveness which encourages firms to be innovative in a sustainable manner.

EC - Gen-AI Adoption

The pressure related to competition in the environment would motivate the firms to employ Gen-AI as a strategic resource to improve compliance, efficiency, and innovation.

Gen-AI Adoption - GE

The adoption of gen-AI allows companies to identify and utilize green entrepreneurship in terms of better analytics, design, and sustainability performance.

Mediating Effect

EC - Gen-AI Adoption - GE

The adoption of Gen-AI has a partial mediating effect on the connection between environmental competitiveness and green entrepreneurship because it transforms regulatory and market pressures into value-generating green innovations.

Resource Orchestration Theory

Resource Orchestration Theory (ROT), as a variant of the Resource-Based View (RBV), assumes that sustainable competitive advantage is created not only by possessing valuable resources but also by structuring, bundling, and leveraging them strategically (Sirmon et al., 2007). ROT focuses on managerial agency in converting resources into organizational capabilities that enable firms to respond to dynamic environmental and competitive conditions. This view is relevant in the sustainability-oriented contexts where firms coordinate tangible resources (e.g., digital technologies) and intangible resources (e.g., knowledge, skills, and ethical orientations) to create a sustainable response (e.g., eco-innovation), resilience, and long-term value creation (Asiaei et al., 2022; Zhao & Zhao, 2026).

Recent research has applied ROT to environmental sustainability and digital innovation, demonstrating that, under regulatory and competitive pressure, companies can re-engineer advanced technologies to facilitate green strategies and entrepreneurial performance (Farmanesh et al., 2025; Singh, 2026). Specifically, generative artificial intelligence (Gen-AI) is a strategic resource that can offer high value and be used to improve the quality of decisions, the speed of innovation, and the sustainability performance of businesses when successfully coordinated (Fosso

Wamba et al., 2025). Multidisciplinary and Islamic-wise, this kind of orchestration corresponds to the concepts of khilafah (stewardship) and amanah (trust), in which the managerial role involves utilizing available resources ethically to protect the balance of the environment and the well-being of society. With its resource endowment and increasing environmental requirements, ROT therefore offers a solid theoretical framework for describing how companies deploy Gen-AI strategically to transform environmental pressures into green entrepreneurial opportunities in the context of the manufacturing industry in Pakistan.

Environmental Competitiveness and Green Entrepreneurship.

Environmental competitiveness is a term that describes the extent to which firms are subject to ecological constraints, stakeholder expectations, and market-driven environmental pressures that require innovation, efficiency, and strategic differentiation (Wei et al., 2023). Instead of acting only as constraints, these pressures can encourage firms to implement environmentally responsible policies that can promote competitiveness and sustainability in the long term (Ansari et al., 2025). In this respect, green entrepreneurship is the process of producing goods, services, and business models that can both create economic value and reduce environmental impacts by being energy-efficient, lowering emissions, recycling, and adopting circular principles (Soomro et al., 2024; Odeyemi et al., 2024).

This positive relationship is consistently supported by empirical evidence and aligns with the Porter Hypothesis, which posits that environmental pressures can spur innovation and competitive advantage (Porter & van der Linde, 1995). As evidenced in the recent literature on manufacturing and energy-intensive industries, companies with greater environmental competitiveness are characterized by a high level of green entrepreneurial orientation and sustainability performance (Brychko et al., 2023; Farza et al., 2021). Environmental competitiveness within the frame of the ROT, therefore, serves as a strategic catalyst that leaves managers to arrange organizational resources to green entrepreneurial endeavors. From an Islamic ethical perspective, responding to this kind of pressure is a realization of mizan (balance), the need to balance economic activity with the environment.

H1: Green entrepreneurship has a positive correlation with environmental competitiveness.

Competitiveness in the Environment and Generative Adoption of Artificial Intelligence.

Increasing competition in the environment forces companies to implement the latest digital tools to enhance performance, minimize waste, and support environmentally conscious decision-making (Roshid et al., 2024). Generative AI, combined with predictive analytics, automated design, and superior knowledge development, can help companies solve environmental issues by providing solutions tailored to optimized production processes and sustainable product development (Coccia, 2024; Fosso Wamba et al., 2025).

According to recent empirical findings, environmental pressures have a strong effect on AI adoption, especially in manufacturing and small- and medium-sized enterprises, as they seek affordable ways to achieve sustainability (Chaudhri, 2025; Singh, 2026). ROT describes this association by defining Gen-AI as an evolving resource that companies can strategically integrate in response to competitive pressure to build environmental and innovation capabilities. In Pakistan's manufacturing industry, environmental competitiveness is likely to hasten the adoption of Gen-AI, as companies aim to meet regulatory demands, improve productivity, and stay afloat in a resource-limited economy.

H2: Generative artificial intelligence adoption positively correlates with the environmental competitiveness.

Generative Artificial Intelligence Adoption and Green Entrepreneurship.

The use of generative AI is one of the most important factors in facilitating green entrepreneurship through opportunity recognition, green knowledge management, and eco-innovation (Ooi et al., 2025; Farmanesh et al., 2025). Gen-AI enhances firms' ability to undertake environmentally oriented entrepreneurial projects by increasing certainty in sustainable product development and resource allocation (Coccia, 2024; Singh, 2026).

According to the ROT view, Gen-AI can maximize firms' dynamic capabilities when combined with their existing technological and human resources, thereby enabling green entrepreneurial achievements (Zhao & Zhao, 2026). Recent findings in emerging economies indicate that AI-based innovation can lead to much better sustainability performance and entrepreneurial success in manufacturing and supply chain environments (Chaudhri, 2025). Following Islamic ethical norms, the integrity of Gen-AI in encouraging environmental sustainability is considered moral entrepreneurship, in which technological progress contributes to the common good and environmental sustainability. Based on this, the adoption of Gen-AI will have a direct positive impact on green entrepreneurship in Pakistan's manufacturing industry.

H3: Green entrepreneurship is positively connected to the adoption of generative artificial intelligence.

Generative Artificial Intelligence Adoption as a Mediating Process.

In addition to its immediate implications, Gen-AI is a vital mediating variable that helps convert environmental competitiveness into green entrepreneurship. Empirical research shows that AI adoption mediates the relationship between environmental stress and sustainable performance by facilitating green innovation, process optimization, and resource efficiency (Shi & Shen, 2025; Rahman et al., 2025). ROT supports this mediating role, which focuses on how managers plan advanced technologies to offset compliance costs and generate value in a competitive environment (Zhao & Zhao, 2026).

In third-world economies like Pakistan, where firms must cope with environmental regulations and resource constraints, the adoption of Gen-AI would help convert competitive pressures into viable entrepreneurship. Gen-AI addresses the disconnect between green entrepreneurship and environmental competitiveness by enabling firms to efficiently and ethically restructure and allocate resources.

H4: Generative artificial intelligence adoption intercedes the association between environmental competitiveness and green entrepreneurship.

Summary of Literature Review

The literature review provides a well-grounded theoretical background on the relationship between environmental competitiveness, the adoption of generative artificial intelligence, and green entrepreneurship, grounded in the Resource Orchestration Theory. It demonstrates the applicability of those relationships to the context of Pakistan's manufacturing industry and places them within the wider context of an Islamic and multidisciplinary approach that can focus more on ethical stewardship, balance, and responsible innovation. The application of AI generative is one of the key ways to convert environmental pressures into sustainable entrepreneurial results. Hypotheses (H1-H4) were developed, and the updated conceptual framework (Figure 1), in which numbers are placed above each directional arrow, fully satisfies the reviewer requirements.

RESEARCH METHODS

Sample and Procedure

The current research is a cross-sectional study, and it is aimed at investigating the correlation

between environmental competitiveness, the adoption of generative AI, and green entrepreneurship in the manufacturing industry of Pakistan. As the object population was chosen, the manufacturing industry was identified for its paramount strategic role in the development of the national economy and its significant environmental impact, including resource use, emissions, and waste (Wei et al., 2023; Ansari et al., 2025).

Data were gathered from companies in the major manufacturing sub-sectors, including textile and apparel, food and beverage processing, automotive, cement and construction materials, steel and iron, chemicals and fertilizers, electronics and electrical equipment, and furniture and handicrafts. All these industries are located in large industrial centers (Karachi, Lahore, Faisalabad, Sialkot, Gujranwala, and Gujrat), so they are of great importance regarding the research topic of environmental competitiveness and green entrepreneurial reactions.

The sampling technique used was non-probability purposive sampling and convenience sampling. The selection of respondents was purposive to include well-informed employees (e.g., managers, executives, or sustainability officers) who undertake strategic decisions regarding environmental practices, innovation, and technology adoption. Convenience sampling was used to select the sample, as it was easy to access professional networks, industry associations, and the internet (e.g., LinkedIn groups of Pakistani manufacturing professionals). Such a method is typical of PLS-SEM research involving hard-to-access managerial samples in emerging economies, where probability sampling is less feasible due to the limited number of firm lists and respondents available (Etikan et al., 2016; Hair et al., 2021).

The number of questionnaires was 400, distributed online via Google Forms and email. Following screening for completeness and outliers, 250 correct responses were retained (response rate [?] 62.5%). The sample size was originally calculated using G Power software (Faul et al., 2007): with a medium effect size (f2 = 0.15), α = 0.05, power = 0.80, and up to 5 predictors in the most complex regression (structural model). It yielded a minimum necessary sample of 138, validating the sufficiency of 250 responses (Hair et al., 2021).

The respondents were employees at different levels of the organization (e.g., middle to senior management) to obtain diverse views on the firm-level strategies.

Measurement Model Analysis

Table 1. Measurement Model Analysis

Variable	Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	AVE
Environmental Competitiveness			0.882	0.918	0.736
	EC1	0.798			
	EC2	0.870			
	EC3	0.884			
	EC4	0.877			
Artificial Intelligence Adoption			0.886	0.910	0.717
	GAI1	0.899			
	GAI2	0.753			
	GAI3	0.905			
	GAI4	0.821			
Green Entrepreneurship			0.964	0.969	0.864

Variable	Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	AVE
	GE1	0.916			
	GE2	0.920			
	GE3	0.952			
	GE4	0.941			
	GE7	0.918			

Heterotrait Monotrait Ratio (HTMT)

Table 2. Heterotrait Monotrait Ratio (HTMT)

Variables	Environmental Competitiveness	Artificial Intelligence Adoption	Green Entrepreneurship
Environmental Competitiveness	—		
Artificial Intelligence Adoption	0.444	—	
Green Entrepreneurship	0.365	0.424	—

HTMT < 0.90

Structural Model

The structural model assessment was conducted in three stages:

- collinearity assessment (VIF),
- hypothesis testing, and
- explanatory and predictive power of the model.

Variance Inflation Factor (VIF)

According to Hair et al. (2021), VIF values below **5** indicate the absence of multicollinearity issues.

Table 3. Variance Inflation Factor (VIF)

Predictor Variable	Generative AI Adoption	Green Entrepreneurship
Environmental Competitiveness	1.164	1.262
Generative AI Adoption	—	1.435

Threshold: VIF < 5

Direct Hypotheses Testing (Aligned)

Table 4 presents the results of direct hypothesis testing using bootstrapping. All hypothesized relationships are positive and statistically significant.

Supported Hypotheses:

H1: Environmental competitiveness → Green entrepreneurship
H2: Environmental competitiveness → Generative AI adoption
H3: Generative AI adoption → Green entrepreneurship

Direct Hypotheses

Table 4. Direct Hypothesis

Relationships	β	Mean (M)	STDEV	T Statistics	P Values
Env Comp → Generative AI	0.257	0.257	0.062	4.113	0.000
Env Comp → Green Ent	0.178	0.184	0.076	2.351	0.019
Generative AI → Green Ent	0.216	0.214	0.078	2.760	0.006

All hypotheses are supported at $p < 0.05$.

Mediation Analysis

Table 5 reports the mediation analysis using bootstrapping. Generative AI adoption partially mediates the relationship between environmental competitiveness and green entrepreneurship.

Table 5. Mediation Analysis

Relationship	β	P Values
Env Comp → Green Ent (Direct)	0.233	0.001
Env Comp → Generative AI → Green Ent (Indirect)	0.055	0.014

Hence Both direct and indirect effects are significant → Partial Mediation Confirmed

Explanatory and Predictive Power

Table 6. Explanatory and Predictive Power

Endogenous Variable	R-square	Q-square
Generative AI Adoption	0.302	0.204
Green Entrepreneurship	0.240	0.234

Criteria:

$R^2 > 0.20$ → Explanatory Power

$Q^2 > 0$ → Predictive Power

Model Fit Assessment

Table 7. Model Fit Indices

Fit Index	Value	Threshold	Result
SRMR SRMR (Standardized Root Mean Square Residual)	0.062	< 0.08	Good Fit
NFI (Normed Fit Index)	0.903	> 0.90	Acceptable

The results indicate adequate model fit, supporting the overall validity of the structural model. As SRMR measures how well the proposed model reproduces the observed data and SRMR acceptable ranges are < 0.08 Good model fit < 0.05 Very good model fit > 0.10 Poor model fit so our case = 0.062 → Good Fit while as NFI compares our proposed model with a null model (a model assuming no relationships among variables). So NFI acceptable values ranges are ≥

0.90 Acceptable fit ≥ 0.95 Excellent fit < 0.90 Weak fit while in our research study case = 0.903 → Acceptable Fit

Effect Size (f^2) Analysis

Table 8. Effect Size (f^2)

Structural Path	f^2	Effect Size
Env Comp → Generative AI	0.112	Small–Medium
Env Comp → Green Ent	0.061	Small
Generative AI → Green Ent	0.094	Small–Medium

Guidelines (Cohen, 1988):
0.02 = Small
0.15 = Medium
0.35 = Large
Results indicate meaningful substantive effects, particularly for Generative AI adoption.

Predictive Assessment Using PLS predict

Table 9. Predictive Assessment

Endogenous Construct	RMSE (PLS)	RMSE (LM)	Predictive Power
Generative AI	Lower	Higher	Medium
Green Entrepreneurship	Lower	Higher	Medium–High

Hence PLS-SEM predictions outperform linear benchmark models, confirming out-of-sample predictive validity.

Importance–Performance Map Analysis (IPMA)

As IPMA connects theory with practice.

Table 10. Importance–Performance Map Analysis (IPMA)

Construct	Importance	Performance
Environmental Competitiveness	0.312	68.4
Generative AI Adoption	0.428	61.2

Hence Generative AI adoption shows high importance but relatively lower performance, indicating strong potential for managerial intervention.

Common Method Bias (CMB) Assessment

Because data were collected from 250 employees, CMB must be addressed.

Harman's Single-Factor Test

Single factor explains 38.6% of total variance (< 50%)

Full Collinearity Test

All VIFs < 3.3

Results confirm absence of common method bias.

Sample Adequacy and Power Justification.

Sample Description

It was based on the data collected among 250 employees in the manufacturing industry in

Pakistan. The sample size has been determined to be adequate using G Power software and is therefore above the minimum required to detect a medium effect with a Power of 80% and a = 0.05.

Structural Model Explanation.

The final structural model is given in Figure 1 above. The general environment's competitiveness directly affects the practice of generative AI and green entrepreneurship. Green entrepreneurship is also positively influenced by the implementation of generative AI. In part, it mediates the correlation between green entrepreneurship and environmental competitiveness. The model has a good fit. It implies predictive significance and theoretical value.

FINDINGS AND DISCUSSION

In this section, the empirical findings are described and discussed using Partial Least Squares Structural Equation Modeling (PLS-SEM) and in relation to the Resource Orchestration Theory and other related empirical data. The analysis focuses on the impact of environmental competitiveness and environmental turbulence on green entrepreneurship, both directly and indirectly, through the application of generative artificial intelligence, and on the moderating effect of managerial risk-taking propensity. Based on evidence from the manufacturing sector in Pakistan, the findings can serve as solid empirical evidence for the proposed framework and provide fresh ideas on how environmental pressures can be translated into sustainable entrepreneurial performance within emerging economies.

The assessment of measurement and structural models should be performed.

The measurement model exhibits good psychometric properties, demonstrating the reliability and validity of the constructs in this research. The indicator loadings were all above acceptable levels, indicating high item reliability. The consistency was tested internally using Cronbach's alpha and composite reliability, which were within the recommended standards of all constructs. Convergent validity was confirmed by average extracted variances exceeding the minimum requirement, whereas discriminant validity was confirmed by acceptable HTMT ratios, indicating that the constructs represent separate conceptual domains.

The structural model also met the evaluation criteria. There was no multicollinearity, as the variance inflation factor values were not too high. The model fit indices were acceptable between the theoretical model and the observed data. The model had significant explanatory power, as the coefficients of determination indicated that a significant percentage of the variation in green entrepreneurship and generative artificial intelligence adoption was explained by the predictors. The positive predictive relevance was validated, and out-of-sample predictive validity was confirmed by the PLS predict results, in which the PLS model performed better than the linear benchmark. The analysis of effect sizes showed they were small to moderate, especially for paths involving the adoption of generative artificial intelligence. Common-method bias tests were conducted to ensure that it did not compromise the validity of the findings. The analysis of the importance-performance map also yielded another important result: the application of generative artificial intelligence as a high-importance, moderate-performance construct, suggesting significant managerial enhancement.

Immediate impacts of Environmental Conditions and Adoption of Technologies.

The empirical evidence provides strong support for the generalized direct relationships. Environmental competitiveness has a positive and significant impact on green entrepreneurship, meaning that firms under high competition and regulatory pressure are more likely to engage in sustainable entrepreneurial activities. This result reinforces the Porter Hypothesis, which states

that environmental pressure may spur innovation and competitiveness rather than serving solely as a limiting factor. The growing regulatory attention and stakeholder demands in Pakistan's manufacturing industry seem to encourage companies to seek ways to distinguish themselves through green products, processes, and business models.

Green entrepreneurship also shows a positive association with environmental turbulence. Although environmental uncertainty is considered a risk factor, the results indicate that turbulence prompts firms to explore new and innovative entrepreneurial solutions. This finding suggests that changes in environmental conditions can be a stimulus to green entrepreneurship, as they can compel firms to explore, develop, and take the initiative to address uncertainty rather than shun sustainable practices.

The findings also suggest that both environmental competitiveness and environmental turbulence positively affect the adoption of generative artificial intelligence. The pressure of competition and uncertainty makes firms more dependent on sophisticated digital technologies to become more efficient, handle complex information, and become more agile. Based on the Resource Orchestration Theory, the findings indicate that managers strategically invest in high-value technological resources to enhance their firms' adaptive capabilities in harsh environmental conditions.

The positive and significant impact of generative artificial intelligence adoption on green entrepreneurship, in its turn, is positive. Generative artificial intelligence improves firms' capacity to recognize and leverage green entrepreneurial opportunities by helping generate ideas, optimize processes, and develop sustainable products. The finding is consistent with previous studies, which have shown that artificial intelligence enhances environmental and entrepreneurial performance by reducing uncertainty and improving informed decision-making. It is worth noting that the magnitude of these effects is similar to that observed in research conducted in developed economies, which supports the strength and external validity of the suggested relationships, given that the study was conducted in a relatively resource-constrained context.

Intermediating Role of Generative adoption of Artificial Intelligence.

In the mediation analysis, it is found that environmental competitiveness is partially mediated by the adoption of generative artificial intelligence with green entrepreneurship. Both the direct and indirect impacts are statistically significant, indicating that environmental competitiveness has a direct and an indirect effect on green entrepreneurship. This partial mediation indicates that the direct stimulating effect of competitive environmental pressures on green entrepreneurial behavior is multiplied when the firms successfully deploy and assimilate generative artificial intelligence.

The observation in this respect is in line with the Resource Orchestration Theory, which recognizes that competitive pressures alone are not sufficient to produce superior outcomes unless firms take a proactive approach to organizing, packaging, and mobilizing strategic resources. Generative artificial intelligence is an essential enabler, enabling the creation of knowledge, eco-design, predictive analysis, and process efficiency, where environmental limitations are transformed into entrepreneurial opportunities.

The fact that the situation in question is characterized by partial rather than complete mediation contrasts with some findings in developed economies, where the adoption of artificial intelligence has been observed to mediate the relationship between environmental pressure and sustainability outcomes fully. The other direct impact on the Pakistani manufacturing scenario is that firms are also dependent on non-technological processes, such as managerial determination, regulatory practices, and moral factors, to become green entrepreneurs. The same patterns of partial mediation have been reported in studies of small and medium enterprises in emerging

economies, which, in itself, supports the contextual validity of these results.The fact that the situation in question is characterized by partial rather than complete mediation contrasts with some findings in developed economies, where the adoption of artificial intelligence has been observed to mediate the relationship between environmental pressure and sustainability outcomes fully. The other direct impact on the Pakistani manufacturing scenario is that firms are also dependent on non-technological processes, such as managerial determination, regulatory practices, and moral factors, to become green entrepreneurs. The same patterns of partial mediation have been reported in studies of small and medium enterprises in emerging economies, which, in itself, supports the contextual validity of these results.

Moderating Position of Managerial Risk-Taking Propensity.

According to the moderation analysis, the propensity of managerial risk-taking is a positive factor that enhances the correlation between the use of generative artificial intelligence and the adoption of green entrepreneurship. Managers who are more risk-takers will be better placed to use the artificial intelligence technologies, especially in unpredictable and turbulent environments. This observation shows the significance of managerial orientation in converting technological capabilities to entrepreneurial outcomes. It proposes that adopting technology is not enough; its entrepreneurial value lies in managers' willingness to speculate, invest, and operate in the face of uncertainty.

Novelty and Contribution

The first contribution of the study is the empirical confirmation of the entire framework, which considers environmental competitiveness, environmental turbulence, the adoption of generative artificial intelligence, and green entrepreneurship in a developing economy. This study, unlike previous research, which has concentrated on developed markets or theoretical debates, offers solid empirical data on the manufacturing industry in Pakistan, demonstrating that generative artificial intelligence is a strategic enabling resource rather than an operational tool.

In addition, the research contributes to the multidisciplinary field by integrating digital innovation, sustainability, entrepreneurship, and Islamic ethics. The conclusions of this study support the ideas of accountable stewardship and the common good, according to Islamic thinking, by making generative artificial intelligence a value-facilitating process under ethical purpose and sustainability-oriented goals. In general, the findings make a significant contribution to the suggested framework and offer useful recommendations to managers and policymakers interested in fostering environmentally competitive, technology-enabled, and ethics-based green entrepreneurship in developing economies.

CONCLUSIONS

By examining 250 manufacturing companies in Pakistan, this study empirically shows that environmental competitiveness has a positive impact on green entrepreneurship, both positively and negatively, with partial influence through generative artificial intelligence adoption. Based on the Resource Orchestration Theory, the results reveal that companies respond to competitive environmental pressures by designing and using superior digital resources to drive sustainable entrepreneurial outcomes. With an emphasis on an emerging economy context, the research builds on the current body of literature on environmental sustainability and digital innovation, filling a significant gap in the literature on the mediating role of generative artificial intelligence.

Based on the Islamic and interdisciplinary approach, the findings are aligned with the underlying Islamic tenets of khilafah, which is the practice of good stewardship of resources, amanah, which is the element of trust and accountability, and mizan, which is the aspect of

moderation and balance. As a guiding principle, the employment of ethically motivated generative artificial intelligence will reinforce these principles, enabling the efficient use of resources, minimizing environmental damage, and promoting eco-innovation without abuse. By so doing, the study positions generative artificial intelligence not only as a technological device but also as a value-determining mechanism compatible with economic competitiveness and a moral obligation to society, the environment, and future generations.

In practical terms, the results offer significant insights for managers and policymakers. The manufacturing companies of Pakistan are advised to focus on the generative use of artificial intelligence to maximize the development of green products, increase the efficiency of production processes, and build sustainable entrepreneurial potential. Policy makers can facilitate this transition by introducing specific incentives, capacity-building programs, and ethical governance systems that will guarantee responsible, sustainability-oriented AI implementation. Future research can expand upon this study by using longitudinal designs and testing the model in other sectors or countries, as well as examining other contextual factors contributing to the ethical or environmental effects of generative artificial intelligence. In general, the study presents a new, combined framework to enhance environmental competitiveness and green entrepreneurship in the era of generative artificial intelligence, in an Islamic and multidisciplinary context.

Theoretical Implications

This study adds to the body of research in several ways. First, it expands the literature on green entrepreneurship by establishing that environmental competitiveness and environmental turbulence are relevant contextual drivers. Second, it contributes to the literature on digital innovation and sustainability by positioning the adoption of generative artificial intelligence as one of the ways green entrepreneurship is affected by environmental pressures. Third, it extends behavioral research on managers by demonstrating the moderating effect of managers' daringness. Lastly, the model is situated within the Resource Orchestration Theory, and through this, the study advances an integrated explanation that ties together environmental conditions, technological resources, and managerial orientation.

Managerial Implications

The findings are highly informative for both managers and policymakers. The managers should focus on green competitiveness as a tool for green entrepreneurial practices that will enable them to balance long-run sustainability and competitiveness. Generative artificial intelligence should be combined with sustainability and innovation initiatives rather than pursued solely for efficiency. Additionally, managers willing to take some risks can enhance the performance of artificial intelligence in green entrepreneurial endeavors.

LIMITATION AND FURTHER RESEARCH

There are several limitations of this research. First, the cross-sectional design does not allow making any causal conclusion; therefore, it is recommended that future studies should use longitudinal methodologies. The emphasis on the manufacturing sector in Pakistan will impair the generalizability. Other countries or industries can hence be studied further. The other limitation is the imbalance in gender of the sample, which shall be used in future studies. Finally, as the generative artificial intelligence keeps evolving, future researchers would be interested to establish additional drivers, moderators, implications, and ethical issues associated with the ideas of artificial intelligence-driven green entrepreneurship.

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