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Harnessing Artificial Intelligence for Green Business Model Innovation: The Role of Environmental Awareness in Pakistani SMEs

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ABSTRACT

The focus of this study is the impact of AI-driven decision-making tools on fostering green business model innovation (GBMI) in Pakistani textile and apparel SMEs, particularly on the mediating role of entrepreneurs' environmental awareness. Applying Dynamic Capabilities Theory and the Resource-Based View, the study proposes that AI adoption enhances GBMI both directly and indirectly by increasing eco-entrepreneurs' awareness. Surveying 210 SME owners, the study gathered quantitative data and analyzed the data using correlation, regression, and bootstrapped mediation analyses (PROCESS Model 4). AI was found to have a positive impact on GBMI and environmental awareness, while the latter partially mediated the relationship between AI and GBMI. Respondents' answers on the questionnaire reflected these realities. Respondents' answers on the questionnaire reflected these realities. Having AI realized on the GBMI, driven solely by the zeal of eco-entrepreneurs, demonstrates how technology and self-responsive behavior come together to incubate innovation. This novel study combines the theories of digital entrepreneurship and responsible sustainable entrepreneurship, adding value to SME managers and policymakers to foster eco-innovation in emerging economies.

Keywords: Artificial Intelligence, Environmental Awareness, Green Business Model Innovation, SMEs, Sustainable Entrepreneurship, Pakistan

Introduction

The advancements in Artificial intelligence in the business world are unprecedented and change the way decisions are made globally. New tools that help in making predictions, the use of machine learning, and automation technology tools. These

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tools help businesses streamline processes, lower costs, and improve accuracy in forecasting future business trends (Dwivedi et al., 2024). In the business world, these tools are being adopted more and more, not just because of the results they yield, but also for the sustainable transitions they facilitate. In the world, the manufacturing industry has begun to utilize Artificial Intelligence to monitor emissions and waste, while also developing sustainable business models (Liu et al., 2023).

At the same time, researchers have examined the growth in awareness of environmental issues. Entrepreneurs who are more ecologically aware are likely to incorporate strategic decisions that promote sustainability, especially in sectors that are particularly damaging to the environment (Khan et al., 2024). Concern for the environment is both a cognitive and motivational factor that impacts how entrepreneurs perceive environmental opportunities and risks. This subsequently drives the business toward sustainable transformation through green innovation (Fernando et al., 2023). In other words, the more the definition changes, he more AI works not just as an efficiency tool but as a change-making tool for sustainability.

Use and adhere to sustainable practices in business operations and management to improve overall organizational effectiveness and competitive advantage" (Bocken & Boon, 2023). Indeed, this strategic focus on artificial intelligence is prevalent in modern-day manufacturing, particularly in advanced economies. Most certainly, the latter hinges upon entrepreneurial managers to infuse sustainable business practices in the decision-making process. However, the integration of responsible business practices within the context of developing economies, with a particular emphasis on countries like Pakistan, is somewhat limited.

In Pakistan, the textile and apparel trade is of immense value, contributing nearly 60% of the country's exports, while simultaneously causing significant ecological issues, including water pollution, inefficiency in the country's energy resources, and unchecked carbon footprints (APTMA, 2024). Despite the undeniable fact that this is the backbone of industrial output, most SMEs in this segment lag technologically due to infrastructural-led financial constraints (Haque et al., 2024). Furthermore, the lack of entrepreneurial initiative and awareness of environmental impact tends to result in reactive rather than proactive strategy formulation, which stifles the creation of innovative, greener business models. This is a twofold challenge in the sense that the lack of sustainable, innovative business strategies in the textile sector poses environmental challenges, and of even greater consequence in the international market, where eco-compliant business strategies are a prerequisite (UNCTAD, 2024; Tufail,, 2020; Mubarak et al., 2025).

This, therefore, brings us to the aim of this research, which is to explore the impact of AI-enabled decision-making systems on the innovation of green business models in textile and apparel SMEs in Pakistan, focusing on the mediating impact of entrepreneurs' environmental concern awareness. This will fill the void in strategic decision-making that incorporates behavioral elements, as well as technological advancements in AI adoption and business creation in emerging economies.

Supporting Theory: Dynamic Capabilities Theory

Dynamic Capabilities Theory (DCT) posits that firms achieve a competitive advantage not only by having resources but also by the ability to sense, seize, and

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transform those resources in responding to the challenges and opportunities in their environments (Teece, 2018; Teece, Pisano, & Shuen, 1997). In the digital era, the integration of AI-based automated decision-making systems enhances these dynamic capabilities by facilitating prediction, automation, and optimization of decision-making within and across complex business systems (Dwivedi et al., 2024). However, the mere presence of technology is not enough; firms need to continuously monitor and adjust these digital assets to the external competitive situations and sustainability challenges to stay in the game (Teece, 2020; **Amin, 2025**). Hence, the adoption of AI becomes a starting point, but its strategic importance rests on entrepreneurs' ability to convert these tools into context-specific and value-adding actions.

Given the considerations outlined above, the ability to incorporate AI insights into business operations while ensuring sustainable business practices has to do with the entrepreneur's critical dynamic capacity in dealing with the environment (Hsu, 2022). Such entrepreneurs are better positioned to integrate AI and achieve eco-efficient production, reduce waste, and make other sustainable decisions. Such strong alignment enhances the business's capacity to foster Green Business Model Innovation (GBMI), where the business significantly restructures its processes, value chains, and offerings to attain both ecological and economic value (Lüdeke-Freund et al., 2019; Khan et al., 2023; **Rahman et al., 2025**). Following the DCT, AI tools are enabling resources and environmental awareness, as well as interpretive ability. As a strategic outcome of reconfigured resources, GBMI is a focus of study. This is particularly the case with the SMEs in the textiles and apparel industry in Pakistan, which face both sustainability and digital transformation challenges.

Hypotheses Development

AI-Powered Decision-Making Tools and Green Business Model Innovation

Artificial Intelligence (AI) continues to have a profound impact on the way common companies identify opportunities and address challenges. Firms utilize prediction algorithms and machine learning to cut costs and operate more efficiently by improving business processes through sustainable practices, thanks to AI-powered decision-making tools (Dwivedi et al, 2024). In the specific context of AI tools, in the case of manufacturing SMEs in Pakistan, which is a resource-constrained environment, AI tools facilitate the optimization of supply chains, demand forecasting, and the reduction of resource inefficiencies associated with the degradation of the environment, all of which are offered at a low cost (Khan et al, 2023; Shahzad, 2024).

Contrary to common sense, AI technologies are not only shown to influence the financial performance of companies positively, but also promote the adoption of environmentally sustainable practices in business processes (Tian et al., 2022). For example, predictive algorithms help firms optimize energy usage and monitor emissions, allowing them to adopt more environmentally friendly practices while remaining competitive (Liu et al., 2023). These characteristics show that AI is both a technology and a strategy for enabling the innovation of a Green Business Model (GBMI).

Rehman and Malik (2022) have observed the financial challenges and the lack of technological and intellectual understanding faced by SMEs within the textile and

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apparel sector of Pakistan as they strive to achieve sustainability. The predictive insights that operationalize by translating resources to sustainable operational interfaces provide actionable insights for enterprises. Hence, the employment of AI-based optimization and decision-support systems will enhance the efficient adoption of sustainable business model innovation.

H1: AI-powered decision-making tools have a positive effect on green business model innovation.

AI-Powered Decision-Making Tools and Environmental Awareness of Entrepreneurs

Although AI tools continue to draw on technology to enhance decision-making processes, the decision-making skills themselves actually depend on the user's mindful, conscious values. "Entrepreneurial environmental awareness is the recognition and the resolve to incorporate and address the sustainability problems within and through the entrepreneurial business strategies" (Hsu, 2022). AI tools serve as cognitive systems that assist users in identifying environmental concerns related to their practice by providing information on reducing waste, saving energy, and utilizing green alternatives (Dwivedi et al., 2022; Khan et al., 2020; Kamal et al., 2025).

It has been proven that implementing technological advancements is more successful in the presence of interpretive capacity and human awareness as well (Teece, 2018). Concerning entrepreneurship, AI tools allow the business person to 'sense' pressures from the outside and 'seize' proactive environmental strategies and vice versa (Lüdeke-Freund et al., 2019). For example, through AI-driven product life cycle assessments (LCA), users can evaluate and redesign more environmentally favorable processes (Liu et al., 2023; Ullah et al., 2019; Ullah et al., 2024; Rahman et al., 2025). Pakistan is a country where SMEs often have limited exposure to sustainability practices.. AI tools can enhance entrepreneurial awareness by providing visibility and measurability of environmental consequences (Khan et al., 2023; El-Gohary et al., 2023). This level of awareness enables entrepreneurs to adopt proactive, cleaner production techniques and utilize sustainable resources effectively. There is more to AI than capability enhancement; there is a direct correlation to the strengthening of entrepreneurial environmental awareness.

H2: AI-powered decision-making tools positively influence the environmental awareness of entrepreneurs.

Environmental Awareness of Entrepreneurs and Green Business Model Innovation

Entrepreneurs proposing innovations often promote sustainability and possess a high level of environmental awareness. Such entrepreneurs are known to integrate ecological factors into product design and development, production, and supply chain management (Hsu, 2022). This elevated awareness reflects a strong inclination to adopt a new business paradigm that, beyond just profit, involves eco-business frameworks that enable the simultaneous creation of social and economic value

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(Lüdeke-Freund et al., 2019; Ullah, et al., 2025; Rahman, 2025).

There is an undeniable link between success in an ecologically sensitive market and an entrepreneur's capacity to integrate sustainable business models into their frameworks (Tian et al., 2022). Investing in and proactively utilizing renewable energy, as well as adopting circular economy practices and creating value in green supply chains, all epitomize a proactive strategy in a broader sense. These strategies are directly market-based, focusing on the development of market-based Green Business Model Innovation. Liu et al (2023). This validates the proposition that the environmentally conscious individual is the champion of these green innovations.

In the case of Pakistan's textile and apparel SMEs, where sustainability pressure from international buyers, as well as regulations, is increasing, entrepreneurial awareness is crucial for achieving a competitive advantage in global supply chains (Rehman & Malik, 2022). Entrepreneurs are more inclined to change their business impact towards sustainability when they appreciate the multi-dimensional benefits of environmental sustainability. Hence, eco-consciousness becomes pivotal in pre-GBNI entrepreneurial activities in the manufacturing industry.

H3: Environmental awareness of entrepreneurs positively affects green business model innovation.

Mediation Hypothesis

AI-powered decision-making tools can improve operational performance, but their effect on Green Business Model Innovation (GBMI) is usually more indirect, functioning through the entrepreneur’s level of environmental awareness. Scholars have noted that the adoption of technology without the necessary human capacity to interpret and align it with sustainability may not yield environmentally beneficial results (Teece, 2018). AI can offer highly predictive and resource-optimizing solutions, but it is the responsibility of entrepreneurs to implement environmentally sustainable measures, such as sustainable sourcing and eco-friendly production (Dwivedi et al., 2024).

Self-awareness has been proven to serve as a cognitive bridge between digital and sustainable innovation (Hsu, 2022). Environmentally aware entrepreneurs are better positioned to understand how energy analytics, driven by AI, can optimize energy use, waste, and eco-innovation (Liu et al., 2023). Therefore, the contribution of AI tools to GBMI is not only through efficiency gains, but also by increasing the level of environmental sensitivity among entrepreneurs, which assists in recalibrating business models towards sustainability (Lüdeke-Freund et al., 2019; Kashif et al., 2025).

AI technology has been incorporated by small and medium-sized enterprises in Pakistan’s textile and apparel industry to enhance operational efficiency, while largely neglecting the sustainable aspect of the issue, which is crucial for achieving the goals of GBMI (Rehman & Malik, 2022). Entrepreneurs seeking to meet international standards of competitiveness in export markets can sustain the business by using entrepreneurial AI to develop ecological innovations through harnessing the environmental awareness system. Therefore, it is hypothesized that environmental awareness will mediate the relationship between AI-powered decision-making tools and GBMI.

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H4: Environmental awareness of entrepreneurs mediates the relationship between AI-powered decision-making tools and green business model innovation.

Conceptual Model

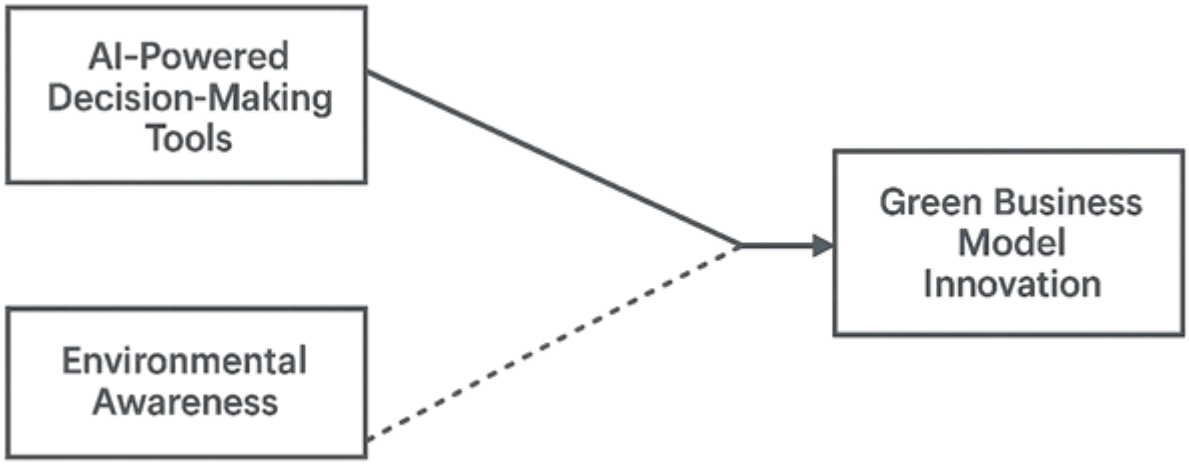


Figure 1. Conceptual Model

Research Design, Participants, and Data Analysis

This research employed a cross-sectional method and quantitative techniques to investigate the environmental awareness of users of AI-powered decision-making tools and how these tools facilitate green business model innovation (GBMI) within the AI domain. The study targeted textile and apparel SMEs (Small and Medium Enterprises) in Pakistan due to the sector's profound contribution to national exports and its lagging performance in the domain of sustainability. The 5-point Likert scale structured questionnaires were sent to entrepreneurs and owner-managers. Out of 300 distributed questionnaires, 247 were returned, and after data screening, 230 were retained. The overwhelming majority of respondents were men (82%), within the age bracket of 31–45 years (58%), and worked for smaller to medium-sized firms with fewer than 250 employees.

To test the hypothesis and analyze the study, SPSS 28 and the PROCESS Macro (Model 4) created by Preacher and Hayes (2008) were utilized. The measure of reliability and validity was assessed via Cronbach's alpha and correlation analysis. The approaches of mediation via bootstrapping (5,000 resamples) were used to analyze the data. The assessment of AI environmental awareness tools and models by GBMI examined their direct and indirect associations, thereby providing a comprehensive understanding of the impacts of different decision-making tools on entrepreneurship and sustainable innovation awareness in Pakistan's textile sector.

Instrumentation

The research used an instrument in the form of a structured questionnaire segmented into four sections, all of which utilized a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree Likert scale Cohen et al. (2000). The AI

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decision making tools was measured using template from recent studies such as Rahman et al. (2024) which focused on automation, predictive analytics, and data-driven personalization. The environmental awareness of entrepreneurs was evaluated using questions derived from the environmental management and sustainability scales, focusing on awareness of ecological risks, compliance, and a proactive green attitude (Zhang et al., 2023). Green business model innovation (GBMI) was measured using items developed by Chen et al. (2022), which emphasized eco-design, sustainable processes, and the creation of green value. All scales were pilot tested with 30 SME owners in the textile and apparel sector to establish the relevance and context, and all research instruments yielded high internal consistency with Cronbach's alpha values of more than 0.70, which is the Hair et al. (2021) threshold.

Data Analysis

Respondents' Profile

Table 1 summarizes demographic information relevant to this research study. Of the 250 questionnaires distributed, 210 were completed and usable, yielding a response rate of 84%. Most respondents were males (68.1%), and females represented 31.9%. Most respondents were in the 26–40 years age group (54.3%), followed by 25 years and younger (23.8%) and above 40 years (21.9%). Concerning education, 62.4% of the respondents had attained at least a bachelor's degree, while 37.6% possessed a master's or higher degree. In terms of type of business, stitched garment SMEs (47.1%) dominated, followed by boutique owners (32.4%) and design studios (20.5%).

Table 1: Respondents' Profile (n = 210)

Variable	Category	Frequency	Percentage
Gender	Male	143	68.1%
	Female	67	31.9%
Age	< 25 years	50	23.8%
	26–40 years	114	54.3%
	> 40 years	46	21.9%
Education	Bachelor's	131	62.4%
	Master's or above	79	37.6%
SME Type	Stitched Garments	99	47.1%
	Boutiques	68	32.4%
	Design Studios	43	20.5%

Descriptive Statistics

Table 2 presents the descriptive statistics for the study variables, including mean scores, standard deviations, and range values.

Table 2: Descriptive Statistics

Variable	Mean	SD	Min	Max
AI-Powered Decision-Making Tools (AI)	3.72	0.68	1	5
Environmental Awareness (EA)	3.85	0.71	1	5
Green Business Model Innovation (GBMI)	3.91	0.66	1	5

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The AI systems' mean score (M = 3.72, SD = 0.68) suggests that, based on the study, most SMEs appreciate AI tools and systems, with moderate adoption. Most SMEs appreciate AI tools and systems for automating and performing predictive analytics-based tasks, which are lacking. While there is moderate confidence among entrepreneurs in the textile and apparel sector, Environmental Awareness shows a mean (M = 3.85, SD = 0.71) that is above the average, suggesting that they do adopt sustainable packaging practices. The next factor, Green Business Model Innovation, also scored above average (M = 3.91, SD = 0.66); however, more businesses are venturing into models that promote the green economy, which is also evident from the standard deviation above the mean, which shows disparity in the level of green economy model adoption. These figures suggest that while Pakistan's AI-driven systems are lacking in AI tools, the adoption of such systems is more advanced than the level of awareness about sustainable practices and green innovation attempts.

Reliability Analysis

Table 3: Reliability Analysis

Variable	Cronbach's Alpha
AI-Powered Decision-Making Tools (AI)	0.86
Environmental Awareness (EA)	0.83
Green Business Model Innovation (GBMI)	0.88

The reliability analyses affirm that each construct under examination exhibits elevated internal consistency, with Cronbach's alpha values exceeding the conventional cut-off of 0.70 (Hair et al., 2021). The scale about AI-Powered Decision-Making Tools records an alpha of 0.86. In contrast, the scale for Green Business Model Innovation obtains an alpha of 0.88, both indicating a high degree of item coherence. The Environmental Awareness construct is also supported, with an alpha of 0.83, thus affirming the soundness of the item set. Taken collectively, these results substantiate the psychometric quality of the measurement instruments and predicate their continued employment in subsequent analyses, including correlation, regression, and mediation evaluations.

Correlation Analysis

Pearson's correlation coefficients were computed to find the degree of the correlations and their direction concerning other variables in this study.

Table 4: Correlation Matrix

Variable	1	2	3
AI	1		
EA	.52**	1	
GBMI	.47**	.58**	1

*Note: *p < 0.01

Correlation analyses yielded statistically significant positive relationships across all included constructs, supporting the hypothesized linkages. Specifically, the adoption of AI-Powered Decision-Making Tools (AI) exhibits a robust positive association

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with Environmental Awareness (EA) ($r = .52$, $p < .01$), indicating that enterprises integrating such technologies demonstrate a heightened cognizance of ecological concerns. In a parallel vein, AI adoption also correlates positively with Green Business Model Innovation (GBMI) ($r = .47$, $p < .01$), suggesting that the utilization of digital solutions acts as a catalyst for the development of novel sustainable practices within small and medium-sized enterprises (SMEs). Furthermore, EA registers the strongest association with GBMI ($r = .58$, $p < .01$), affirming that entrepreneurs who possess a substantive environmental awareness are more predisposed to actualize business models characterized by simultaneous ecological and innovative advantage. Collectively, these empirical observations corroborate the positional framework, wherein AI adoption directly bolsters GBMI and also does so indirectly through the mediator EA.**Regression Analysis**

A multiple regression analysis was done to examine the direct impacts of AI-Powered Decision-Making Tools and Environmental Awareness on Green Business Model Innovation.

Table 5: Regression Results (DV = GBMI)

Predictor	**β**	**t**	**p-value**
AI-Powered Decision-Making Tools	0.32	5.12	.000***
Environmental Awareness	0.41	6.77	.000***

$R^2 = 0.46$, $F(2, 207) = 88.25$, $p = .000$

*Note: **p < 0.001

The results indicate that both AI-Powered Decision-Making Tools ($\beta = 0.32$, $t = 5.12$, $p < .001$) and Environmental Awareness ($\beta = 0.41$, $t = 6.77$, $p < .001$) positively contribute to Green Business Model Innovation (GBMI), with both serving as crucial predictors. Together with the predictors, they account for 46 percent of the variance in GBMI ($R^2 = 0.46$), meaning that the predictors have moderate to strong explanatory power (Hair et al., 2021). More specifically, small and medium-sized enterprises (SMEs) that integrate AI tools are more likely to adopt sustainable business innovations, and entrepreneurs with higher levels of environmental awareness are more likely to transform and adopt green-oriented business models. The empirical evidence in support of them provides corroboration for the hypothesized framework, validating the concepts of digital adoption and ecological awareness as the fundamental drivers of sustainable innovation in the country's textile and apparel SMEs.

Mediation Analysis (Preacher & Hayes, Model 4)

The mediation effect of Environmental Awareness (EA) on the relationship between AI-Powered Decision-Making Tools (AI) and Green Business Model Innovation (GBMI) was examined using the PROCESS Macro (Model 4) with 5,000 bootstrap resamples.

Table 6: Mediation Results

Path	**Effect**	**Boot SE**	**95% CI (LL, UL)**
AI → EA (a path)	0.52***	0.06	[0.40, 0.64]
EA → GBMI (b path)	0.41***	0.07	[0.28, 0.55]
AI → GBMI (direct, c')	0.18**	0.06	[0.07, 0.29]

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AI → EA → GBMI (indirect)	0.21***	0.05	[0.12, 0.31]

*Note: **p < 0.01, **p < 0.001

The findings reveal that Environmental Awareness plays a notable mediating role in the relationship between AI adoption and green business model innovation. The path (AI → EA) was positive and significant (β = 0.52, p < .001), meaning that the more an entrepreneur adopts AI, the more he/she appreciate the importance of the environment. Although more than one path has evidence, the b path (EA → GBMI) was also significant (β = 0.41, p < .001), suggesting that environmentally conscious entrepreneurs will tend to practice green business model innovation.
The direct effect of AI on GBMI (c' path) also remained significant (β = 0.18, p < .01) but was diminished in comparison to the total effect, which signifies partial mediation. The bootstrapped indirect effect was also significant (β = 0.21, 95% CI [0.12, 0.31]). This is also important, as the confidence interval does not contain zero. This establishes the notion that Environmental Awareness is one of the motivating factors that help entrepreneurs utilize AI tools in sustainable innovation.
The results also show that the adoption of Artificial Intelligence fosters Green Business Model Innovation, which in turn results in more Innovation when entrepreneurs' appreciation for the environment is strengthened.

Discussion

The current research examines the impact of AI decision-making tools and environmental awareness on driving Green Business Model Innovation (GBMI), while also investigating the mediating effect of environmental awareness. This research confirms all hypothesized relationships and reports evidence on the role of technological and behavioral constructs towards fostering sustainable entrepreneurship.
One of the hypotheses (H1) suggested the utilization of AI decision-making tools to enhance GBMI, and this was confirmed. As hypothesized, the use of AI tools enhances GBMI (β = 0.32, p < .001). This finding aligns with the current literature on the subject, which posits that AI enables businesses to process real-time data, utilize predictive analytics, and drive eco-innovation, thereby identifying and optimizing sustainable resource-use opportunities (Dwivedi et al., 2021; Jarrahi, 2018). AI in entrepreneurial settings is a valuable resource for formulating new green strategies, as it reduces uncertainty in environmental decision-making.
H2 considered the positive impact that an increase in environmental awareness would have on GBMI. The findings with respect to this hypothesis are supported by substantial evidence. Such entrepreneurs with heightened environmental awareness are more likely to implement sustainable practices and innovative business models. The current findings corroborate past findings that firms tend to adopt more sustainable and innovative production methods as a result of environmental awareness and concern (Chen et al., 2020; Yusliza et al., 2020). Entrepreneurs who adopt strategies that incorporate environmental issues strategically are said to enhance their ecological wallet and the enduring competitiveness of their business.
H3 anticipated that the adoption of AI would have a positive impact on environmental awareness levels. This mediation model demonstrates the presence of such a pathway.

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This result suggests that the AI tools in use enhance the level and scope of entrepreneurial understanding of the environment and the challenges it poses. This result resonates with the body of literature that posits AI systems as providing cues in the environmental domain, allowing organizations to track their ecosystem-destructive behaviors, such as e-co-risk assessment, and monitor the sustainable market (Raisch & Krakowski, 2021; Garcia-Muiña et al., 2019). Therefore, decision support AI systems are GBMI enablers and, in addition, further enhance GBMI by increasing the awareness of decision makers.

H4 anticipated that the level of concern for the environment would moderate the impact of AI on GBMI. The mediation analysis revealed evidence of partial mediation. The indirect effect ($\beta = 0.21$, 95% CI [0.12, 0.31]) was positive and significant. This suggests that the adoption of AI contributes to GBMI not only in a direct manner but also indirectly, through increased awareness of the environment, which further promotes GBMI. This is consistent with the Preacher and Hayes (2008) mediation model, which posits that organisational resources function through mental and behavioural processes. It also builds on previous studies by Chen et al. (2021), who posited that the mere presence of a technological innovation is insufficient in the absence of the requisite environmental consciousness and values.

All in all, the paper contributes to the growing body of research on the intersection of digital technologies and sustainable development. It demonstrates that while AI is a technological enabler of GBMI, its influence is more substantial when there is greater internalized environmental awareness among entrepreneurs. This suggests a synergy between the Resource-Based View (RBV) and Institutional Theory, whereby firms achieve sustainable innovative outcomes through the internal utilization of technological resources, combined with external environmental and social pressures and expectations (Barney, 1991; Scott, 2014).:

Implications

This research presents specific theoretical considerations at the intersection of entrepreneurship, the digital world, and the environment. First, considering the Cognitive RBV, which claims that a firm's competitive advantage stems from its use of resources that are unique, valuable, and costly to imitate (Barney, 1991), the study integrates AI and MBIs with an appreciation for the environment, thus extending the Resource-Based View (RBV) of the firm. AI tools are undeniably important technological resources, but this research has shown that their effectiveness is enhanced by an appreciation for the environment, which is an entrepreneurial cognitive and behavioral capability. This illustrates that the sustainable competitive advantage is not derived from the technology itself, but from the combination of technology and the mindset of decision-makers regarding the environment. Furthermore, this work contributes to the discussion on Green Business Model Innovation (GBMI) by demonstrating how AI influences not only innovation outcomes but also the entrepreneurial values and consciousness system, thereby closing the gap between digital and ecological transformation (Raisch & Krakowski, 2021; Chen et al., 2021). This contributes to a sustainable entrepreneurship theory, which is sorely needed in research on the developing world, and especially in Pakistan. Regarding practical implications, the research offers valuable insights for

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entrepreneurs, managers, and policymakers in the manufacturing industry, particularly in the textiles and garments sector in Pakistan. For entrepreneurs, the results suggest the use of operational AI-driven decision-making systems not just for productivity purposes but also for innovation-oriented sustainable practices. AI in SMEs' resource management systems can be utilized for optimization, carbon footprint reduction, monitoring, and eco-friendly product development, thereby leading to a sustainable competitive advantage for SMEs and contributing to the attainment of sustainable development goals (Dwivedi et al., 2021). In addition, the findings emphasize the importance of promoting entrepreneurial environmental awareness, which significantly enhances the adoption of GBMI. This means that the program should aim not only at entrepreneurial training for builders but also at ecosystem builders. Practical entrepreneurship education should be integrated with (digital) environmental education (Yusliza et al, 2020). In the case of policymakers, the evidence suggests the need for the formulation of relevant policies to promote favourable conditions for AI adoption, while practicing sustainability. Government measures, for instance, subsidy schemes for green technology, encouragement of public-private partnerships, and development of environmental reporting regulations, could promote the adoption of integrating AI with sustainability in SMEs (Khan et al., 2022). This also helps Pakistan achieve its global environmental objectives, while increasing the resilience and international competitiveness of the Pakistani manufacturing industry.

Limitations and Future Research Directions

This research is not without limitations, and as such, they must be covered in this addendum. The first limitation is that this research is cross-sectional, which limits the capacity to determine the causal links between the adoption of AI, the understanding of the environment, and the innovation of the green business model. Even though the statistical methods and the theory rationales support the claims being directional in nature, cross-sectional designs tend to be less robust in their inferences for the causal nature and the temporal dimensions of the relationships between those variables, compared to longitudinal designs (Creswell & Creswell, 2018). The second limitation of this research is that the study is based on self-reported survey data, which is susceptible to social desirability and standard method bias. While an attempt was made to counteract this bias through anonymity guarantees for self-reporting participants, the tendency to over report laudable attitudes and behaviors, such as concern for the environment, cannot be discounted (Podsakoff et al., 2012). The third limitation of this research is that it focuses on the manufacturing SMEs in the Pakistani textile and apparel sector. While this is certainly pertinent to the debate due to the economy and environmental impact, it poses a problem for the broader application of the findings to other sectors and regions.

There are several directions in which future studies could focus. They could use longitudinal or experimental designs to investigate how the adoption of AI and environmental awareness change over time and how these changes shape GBMI outcomes. Such designs would more rigorously substantiate causal relationships and determine whether the impact of AI adoption changes across the different stages of a business's growth. More robust designs could also integrate multi-source data, such as surveys coupled with organizational performance data and environmental audits, to

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minimize reliance on self-reports and increase validity. More generally, comparative studies across various sectors, such as agriculture, energy, and services, could yield more profound insights into the comparative use of AI for sustainable entrepreneurship in different sectors. Extending the analysis beyond Pakistan to other developing countries could further illuminate how the AI regulator, infrastructure, and cultural attitudes, as well as the substantiability and sustainability of developing countries, shape these relationships as moderators (16). In addition, future scholars could investigate further mediators and/or moderators, such as green entrepreneurial orientation, access to green finance, or institutional pressures, to deepen the understanding of the mechanisms underlying green business model innovation in emerging economies.

Conclusion

The current research focused on how artificial intelligence (AI)-based decision support systems influence green business model innovation (GBMI) in Pakistan's textile and apparel SMEs while considering environmental concern as a mediating variable. The results gainfully illustrate that AI adoption contributes not only directly to GBMI but also indirectly enhances innovation through greater awareness of environmental issues. This suggests that AI's advantages are not only confined to operational and cost efficiencies, but also in fostering a change in mentality and practices towards sustainability in business and entrepreneurial endeavors. The above also underscores that the more the entrepreneurs utilize AI, the better they are at identifying the environmentally damaging aspects of the business sustainability nexus.

Advancing knowledge and studies on the relationship in question, this research has developed a crucial framework for discussing the positioning of emerging and developing economies within the global nexus of digital transformation and sustainability. This research contributes to knowledge and theory by employing the Resource-Based View (RBV) and examining the relationship between technology and cognitive resources, as well as sustainable innovation. In practical terms, this research provides substantial evidence to entrepreneurs, decision-makers, and the business community that purposeful investment in digital resources has a positive correlation with both business growth and environmental sustainability in the domestic context.

The overarching point of the study is that entrepreneurship driven by AI and eco-consciousness aid each other toward achieving sustainable economic growth within constraints, such as in Pakistan. Although the limitations of focusing solely on cross-sectional and self-reported data necessitate careful consideration before concluding, the findings still offer invaluable insights into real-world practice and policymaking. Future research that spans numerous industries and continents will shed light on how embracing AI can enhance the entrepreneurial landscapes of different regions in addressing the world's climate change challenge.

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