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Designing an Entrepreneurial Marketing Model for Decentralized AI and Blockchain Adoption in Sustainable Smart Buildings: A Grounded Theory Approach

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Abstract: This study develops an entrepreneurial marketing framework to facilitate the adoption of decentralized artificial intelligence (AI) and blockchain technologies in environmentally sustainable smart buildings. Employing Corbin and Strauss's grounded theory approach, data were collected through semi-structured interviews with 18 experts from academia, industry, and digital technology sectors until theoretical saturation was reached. Data analysis, performed via open, axial, and selective coding, identified six core categories: causal conditions (e.g., transparency, sustainability demands, and green branding), contextual conditions (e.g., digital infrastructure and government support), intervening conditions (e.g., high costs and expertise shortages), strategies (e.g., personalized AI campaigns, blockchain smart contracts, stakeholder education, and interactive platforms), consequences (e.g., reduced carbon footprint, enhanced trust, and competitive advantage), and the central phenomenon (the entrepreneurial marketing framework itself). The proposed framework integrates AI-driven personalization with

blockchain-enabled transparency to build stakeholder trust, improve operational efficiency, and accelerate technology adoption in sustainable construction. Findings offer practical recommendations for policymakers and industry practitioners aiming to promote green smart buildings. This research bridges the gap between technology innovation and marketing strategy in the built environment.

Keywords: Artificial Intelligence, Blockchain Technology, Smart Buildings, Marketing Strategies, Technology Adoption

1. Introduction

The integration of decentralized artificial intelligence (AI) and blockchain technology in environmentally sustainable smart buildings represents a transformative development in the construction and real estate industries. As demand for sustainable construction grows, marketing strategies must evolve accordingly to effectively promote these technologies, which enhance operational efficiency, energy management, and transparency in construction processes (Sivakumar & Visshal, 2025; Zhuang, 2023). Decentralized AI enables distributed data processing, improving decision-making speed and data security—particularly valuable for optimizing energy consumption and reducing waste in green buildings. Blockchain, meanwhile, fosters trust among stakeholders through transparent and tamper-proof systems, which is essential in an industry reliant on secure payments, complex contracts, and precise data exchange (Mdoe et al., 2023). For these technologies to achieve widespread adoption, innovative marketing strategies are needed—ones that educate consumers and highlight benefits such as reduced energy costs, improved urban quality of life, enhanced safety, and greater transparency (Choudhary, 2025). AI-driven personalized marketing can further analyze consumer behavior to deliver tailored content, increasing adoption and trust (Popa et al., 2024). Blockchain similarly strengthens consumer trust by ensuring secure, transparent transactions and protecting customer data from fraud (Labib, 2024), addressing an industry frequently challenged by contract credibility and data integrity issues. AI also plays a growing role in marketing more broadly, automating repetitive tasks and analyzing big data to generate actionable insights (Bajwa et al., 2024), enabling optimized campaigns, precise targeting, and personalized experiences (Ahmed et al., 2022). Blockchain's role in ensuring transaction and data security remains equally critical in the smart building context (Divaneth et al., 2024). Ultimately, successful adoption of decentralized AI and blockchain in green smart buildings depends on marketing strategies that emphasize environmental benefits, performance, data transparency, and consumer trust (Luo, 2022; Sleem & Elhenawy, 2023). stakeholder engagement, digital technology innovation, and ethical considerations constitute key determinants of the successful adoption of artificial intelligence technologies and the advancement of sustainable solutions (Derakhshan Nezhad et al., 2025). Despite progress in this integration, significant research gaps remain regarding effective marketing strategies for adoption. This study addresses that gap by formulating innovative marketing strategies to accelerate adoption of decentralized AI and blockchain in sustainable construction, emphasizing environmental benefits, operational

efficiency, and data transparency. The central research question is: How can smart marketing strategies enhance the adoption of decentralized AI and blockchain in green smart buildings? The novelty of this study lies in proposing a comprehensive, user-centric, technology-driven marketing framework leveraging AI-driven analytics and blockchain transparency to strengthen stakeholder trust (Plevris et al., 2022; Ebrahim et al., 2022), contributing to sustainable and smart urban development.

Table 1. Research gap and innovation of the present study

Author/Year	Main Focus of the Study	Methodology	Key Findings	Gaps Identified	How the Current Study Addresses Novelty
Sivakumar & Visshal (2025)	Examination of the role of emerging technologies in sustainable real estate development	Analytical review of technology-driven sustainability practices in real estate	Highlighted improvements in operational efficiency and energy management through advanced technologies	Absence of a clear marketing-oriented analysis; no framework for promoting AI and blockchain adoption through entrepreneurial or strategic marketing	The current study introduces an entrepreneurial marketing framework that integrates data transparency and technology communication to enhance adoption within environmentally sustainable smart buildings.
Zhuang (2023)	Development of IoT-based data fusion algorithms for intelligent buildings	Technical research on data fusion algorithms for smart building systems	Strengthened real-time decision-making through integrated data streams	Technically oriented; lacks exploration of marketing requirements, user adoption behavior, and blockchain/AI acceptance factors	The current study incorporates a marketing and user-centric perspective using grounded theory, offering a comprehensive adoption model aligned with sustainability principles.
Mdoe et al. (2023)	Influence of AI and blockchain on marketing strategies for SMEs	Conference-based review of strategic transformations in marketing	Demonstrated significant shifts in SME marketing due to AI and blockchain technologies	Limited to SMEs; no specific link to smart buildings, construction sector sustainability, or adoption challenges	The current study applies AI–blockchain marketing concepts specifically to sustainable smart buildings, introducing an entrepreneurial marketing approach to strengthen stakeholder trust.
Choudhary (2025)	AI-driven transformation of	Conceptual examination of	Identified enhanced	Focused solely on AI, without	The current study advances a

	modern marketing strategies	AI's role in marketing	personalization and improved adoption through AI-enabled marketing tools	integrating blockchain or addressing adoption strategies in sustainable construction	combined AI-blockchain marketing framework tailored to green smart buildings, improving personalization, communication, and transparency.
Alawag et al. (2024)	Blockchain adoption in smart construction projects	Systematic review and bibliometric analysis	Highlighted blockchain's benefits in transparency, traceability, and project security	Lacks integration of AI; no entrepreneurial or technology-adoption marketing framework	The current research combines AI + blockchain while proposing a user-centric entrepreneurial marketing structure to drive sustainable adoption.
Wang & Wang (2024)	IoT and cloud-computing applications in smart campus systems	Technical examination of smart campus architectures	Demonstrated improved system efficiency and digital integration	Technical and domain-specific; does not address marketing, user adoption, or sustainable smart building applications	The present study shifts focus to entrepreneurial marketing and investigates AI–blockchain adoption specifically within environmentally sustainable building contexts.
Popa et al. (2024)	Integration of AI in organizational marketing strategies	Analytical examination of AI-enabled marketing	Showed improved targeting, personalization, and optimized campaign performance	Generalized AI focus; no blockchain integration or relevance to sustainable buildings	The current study innovates by merging AI with blockchain within a unified marketing framework designed for green smart buildings.
Labib (2024)	Current and emerging trends of AI in marketing	Conceptual analysis of AI-driven marketing developments	Identified advances in automation and data-driven decision-making	No emphasis on blockchain, sustainability, or the built environment	The current study offers a holistic entrepreneurial marketing model integrating AI and blockchain to improve trust, transparency, and sustainability outcomes.
Arman & Feiz (2025) – Current Study	Development of an entrepreneurial marketing framework for promoting AI and	Grounded Theory (Corbin & Strauss) using semi-structured interviews	Identified causal, contextual, intervening, strategic, and consequence categories;	—	Novelty: First comprehensive entrepreneurial marketing framework integrating AI and

blockchain adoption in environmentally sustainable smart buildings	proposed a comprehensive user-centric marketing framework	blockchain to advance environmental sustainability, strengthen stakeholder trust, and accelerate smart-city transformation.

1.1. Theoretical Foundations

Smart buildings, a key element of sustainable smart buildings, utilize advanced technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) to improve energy efficiency, occupant comfort, and operational performance (Bajwa et al., 2024; Ahmed et al., 2022), while addressing urbanization challenges and promoting sustainability and resilience (Divaneth et al., 2024). AI transforms smart building management systems (SBMS) through predictive maintenance, real-time decision-making, and energy optimization (Bajwa et al., 2024). Machine learning optimizes HVAC systems, reduces energy waste (Luo, 2022), and enhances occupant comfort (Sleem & Elhenawy, 2023). Blockchain offers decentralized, secure, and transparent infrastructure via immutable ledgers (Alawag et al., 2024), with smart contracts automating interactions and eliminating intermediaries (Plevris et al., 2022) while strengthening cybersecurity (Ebrahim et al., 2022). The synergy of AI and blockchain enables advanced data processing and secure, tamper-proof operations (Salah et al., 2019; Li et al., 2024). IoT supports real-time monitoring and data integrity (Olimat et al., 2023; Wang & Wang, 2024). Digital twins and edge computing further enhance optimization, responsiveness, efficiency, and security (Alnaser et al., 2024; Badidi, 2022; Sadri, 2025). Challenges include scalability, algorithmic complexity, regulatory barriers (Kumar, 2024), high costs, and the need for multidisciplinary expertise (Denis et al., 2025). Policymakers must address privacy, security, interoperability, and ethics (Jørgensen & Ma, 2025). Traditional marketing is often ineffective for emerging technologies in uncertain environments (Morris et al., 2002). In contrast, entrepreneurial marketing prioritizes innovation, opportunity recognition, risk-taking, and customer focus (Morris et al., 2002), making it suitable for the construction industry. Rogers' Diffusion of Innovations Theory (Rogers, 2003) explains adoption via relative advantage and adopter categories, though primarily in consumer contexts. This study integrates entrepreneurial marketing with technology adoption factors to develop a context-specific model for decentralized AI and blockchain in sustainable smart buildings. Figure 1 presents a synthesized conceptual framework centered on smart buildings. It maps technology integration (IoT, digital twins) through data management and security to implementation challenges on the left; innovation supported by interdisciplinary collaboration and user-centered design in the center; and synergistic AI-blockchain effects leading to energy efficiency, sustainable urban environments, and future research directions on the right. The figure shows smart buildings as the result of converging technologies that advance sustainability while balancing opportunities and challenges

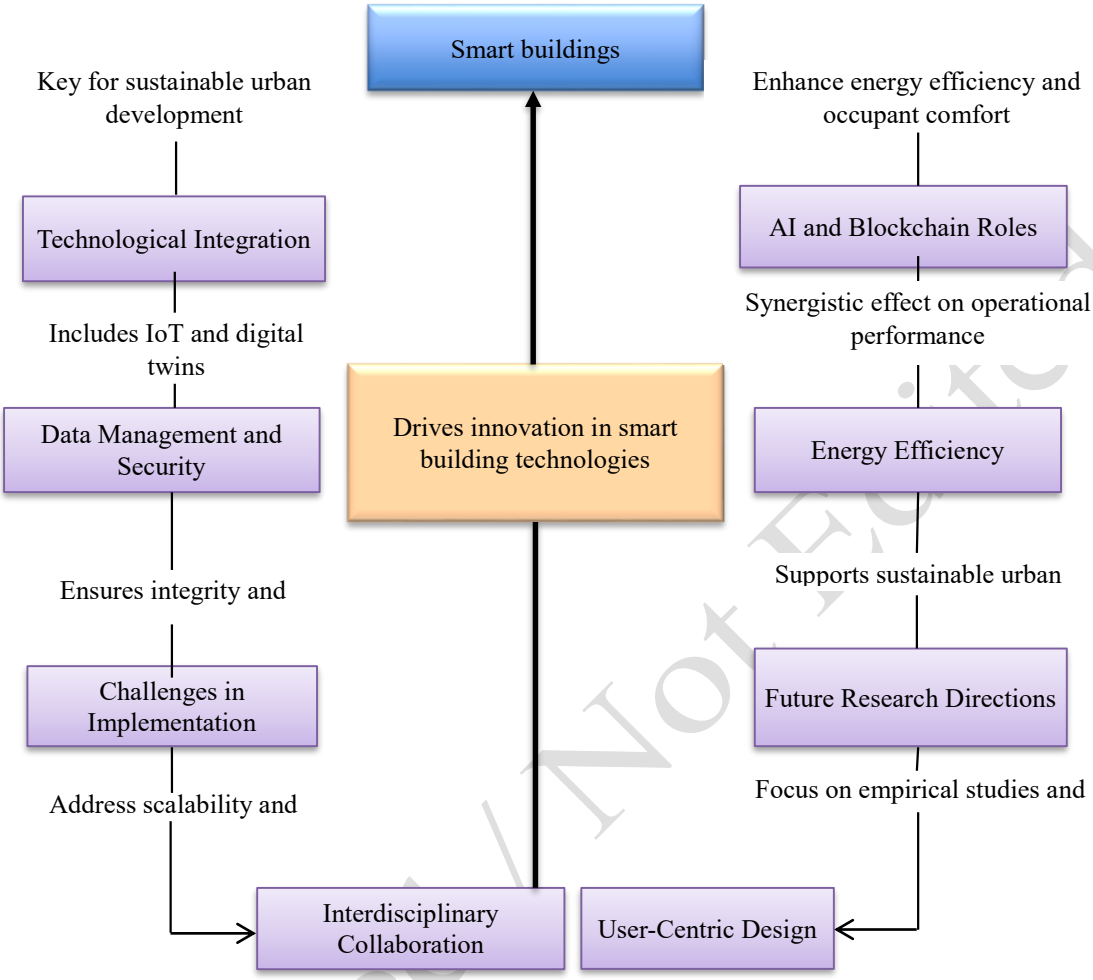

Fig. 1. Marketing Strategies for the Adoption of Artificial Intelligence in Smart Buildings

1.2. Research Methodology

This study is fundamental in purpose and qualitative in nature and method, employing a grounded theory approach. The primary objective is to design an entrepreneurial marketing framework to facilitate the adoption of decentralized artificial intelligence (AI) and blockchain technologies in environmentally sustainable smart buildings. To this end, the Corbin and Strauss approach was selected due to its systematic and process-oriented structure, which is particularly suitable for developing conceptual models in qualitative research, especially in emerging fields such as digital technologies in the construction industry. This approach was deemed more appropriate than other grounded theory methodologies, such as emergent or constructivist approaches. The participant population consisted of 25 experts in fields related to smart buildings and digital technologies. These included university professors from reputable institutions (Tehran, Semnan, Mazandaran, Qom, and Abadan) in the disciplines of management, civil engineering, and information technology; managers of

sustainable construction projects; entrepreneurs in the technology sector; digital marketing specialists; researchers active in AI and blockchain; and experts from companies involved in smart building development. The selection criteria for experts included a minimum of four years of professional or research experience in digital technologies or sustainable construction project management, in-depth knowledge of entrepreneurial marketing or smart building technologies, and a record of publishing scientific articles or implementing relevant practical projects. Purposive sampling was used to select participants to ensure the collection of rich and meaningful data. The sampling process continued until theoretical saturation was achieved, which occurred after conducting 18 semi-structured interviews. The primary data collection tool was semi-structured interviews. The research questions were as follows:

1) What key factors motivate or encourage stakeholders (e.g., investors, project managers, and residents) to adopt decentralized AI and blockchain technologies in the marketing of smart buildings?
2) What contextual conditions influence the design and implementation of entrepreneurial marketing strategies for the adoption of decentralized AI and blockchain in smart buildings?
3) What intervening barriers or challenges affect the adoption and implementation of entrepreneurial marketing strategies for decentralized AI and blockchain technologies in smart buildings?
4) What entrepreneurial marketing strategies can be employed to enhance stakeholder adoption and engagement in environmentally sustainable smart buildings?
5) What are the implications of adopting entrepreneurial marketing strategies based on decentralized AI and blockchain for environmentally sustainable smart buildings?
6) How can the interplay of causal, contextual, and intervening factors, along with entrepreneurial marketing strategies, lead to the development of a comprehensive framework for the adoption of decentralized AI and blockchain in the marketing of smart buildings?

The interview questions were designed based on the research objectives, focusing on marketing strategies, barriers to adopting decentralized AI and blockchain technologies, and their role in the sustainability of smart buildings. These questions were refined and adjusted during the interview process based on feedback and research needs. In addition to interviews, documents and reports related to smart building projects and digital technologies were analyzed as supplementary data.

Data analysis was conducted following the Corbin and Strauss approach in three stages:

1) Open Coding: In this stage, raw interview and document data were broken down into initial concepts. Key phrases and themes related to marketing, digital technologies, and sustainability were identified and coded.
2) Axial Coding: Initial concepts were linked to main categories, and relationships among these categories (e.g., conditions, actions/interactions, and consequences) were examined using Corbin and Strauss's paradigmatic model.
3) Selective Coding: The main categories were organized around a central category (the entrepreneurial marketing framework for technology adoption) to form a comprehensive conceptual model.

This systematic process enabled the researchers to articulate a precise and transparent process model for the adoption of decentralized AI and blockchain technologies in the marketing of smart buildings. Ultimately, this study resulted in the

development of a comprehensive and systematic entrepreneurial marketing framework to facilitate the adoption of decentralized AI and blockchain in environmentally sustainable smart buildings. This framework, emphasizing environmental benefits, data transparency, and stakeholder trust, provides a practical structure for developing innovative marketing strategies that can accelerate technology adoption in the construction industry. To ensure the validity of the findings, triangulation was employed. Data were collected from three distinct sources:

Industry and Technology Experts: Including managers of sustainable construction projects, specialists in decentralized AI and blockchain technologies from companies active in smart building development, and entrepreneurs in the digital technology sector.

Academic Faculty Members: Professors from the universities of Tehran, Semnan, Mazandaran, Abadan, and Qom in the fields of marketing management, civil engineering, and information technology, with research or practical experience in digital technologies and smart buildings.

Marketing and Technology Researchers: Researchers engaged in entrepreneurial marketing, AI, and blockchain, often affiliated with knowledge-based companies, who have published scientific articles or participated in projects related to this domain.

These sources provided diverse perspectives on marketing strategies for adopting decentralized AI and blockchain in smart buildings. To verify data consistency, codes and categories extracted from each source were compared. Additionally, the existing theoretical and empirical literature on AI, blockchain, and smart building technologies (Bajwa et al., 2024; Ahmed et al., 2022; Divaneth et al., 2024) was used as a supplementary source to validate the findings.

To further enhance validity, initial analysis findings were shared with six interviewees for member checking. Feedback led to refinements in some codes and categories to better align with participants' intended meanings. Furthermore, review sessions were held with two independent researchers specializing in qualitative methodology to evaluate the coding and category extraction process.

To ensure the reliability of the research instruments, several measures were implemented:

Clear Definition of Key Concepts: Core concepts, including decentralized AI, blockchain, entrepreneurial marketing, and smart buildings, were clearly and precisely defined based on credible sources.

Review and Testing of Interview Questions: The interview questions were revised and refined multiple times. A pilot study was conducted with four experts (two from the construction industry and two from digital marketing).

Consistent Interview Execution: Interviews were conducted by the primary researcher following a standardized protocol, including a fixed question sequence, consistent environment, and precise response recording (using audio recordings and note-taking).

These measures ensured that the research instruments and data analysis process were highly reliable and valid. Consequently, this study successfully developed a comprehensive and systematic entrepreneurial marketing framework for the adoption of decentralized AI and blockchain technologies in environmentally sustainable smart buildings, aligned with stakeholders' real-world perspectives and scientifically robust.

2. Data Analysis and Findings

In this study, to identify and analyze the dimensions of entrepreneurial marketing with an emphasis on decentralized artificial intelligence (AI) and blockchain technologies in environmentally sustainable smart buildings, semi-structured interviews were conducted with 18 experts and specialists in related fields. These participants included managers of sustainable construction projects, developers and engineers of AI and blockchain technologies, digital marketing consultants, and university professors specializing in entrepreneurial marketing and digital technologies. In terms of gender, 90% of the interviewees were male (16 individuals) and 10% were female (2 individuals). Regarding age groups, 30% of the participants were under 35 years old, 50% were between 35 and 45 years old, and 20% were over 45 years old. In terms of educational background, 15% held a bachelor's degree, 35% held a master's degree, and 50% held a doctoral degree. Additionally, regarding professional experience, 20% had less than 8 years of experience, 50% had between 8 and 12 years of experience, and 30% had over 12 years of experience in fields related to sustainable construction, digital marketing, or digital technologies. The table below presents the demographic and professional characteristics of the 18 experts and specialists who participated in the semi-structured interviews. These individuals included managers of sustainable construction projects, developers and engineers of AI and blockchain technologies, digital marketing consultants, and university professors specializing in entrepreneurial marketing and digital technologies.

Table 2. Descriptive Statistics of the Study

Feature	Category	Number	Percentage
Gender	Man	16	90%
	Woman	2	10%
Age group	Under 35 years old	5	30%
	35 to 45 years old	9	50%
	Over 45 years old	4	20%
Education level	Bachelor's degree	3	15%
	Master's degree	6	35%
	PhD	9	50%
Professional history	Less than 8 years	4	20%
	8 to 12 years	9	50%
	More than 12 years	5	30%

The table below presents information on the sample of interviews conducted with experts in the field of entrepreneurial marketing for the adoption of decentralized artificial intelligence (AI) and blockchain technologies in environmentally sustainable smart buildings.

Table 3. Sample of Interviews with Experts

Interview Number	Interview Summary	Extracted Open Codes
Interview 1	Emphasis on the role of AI in analyzing customer behavior and designing targeted campaigns. Reference to blockchain transparency in enhancing investor trust and reducing financial costs. Need for government support to develop digital technologies in construction.	Customer behavior analysis with AI - Transaction transparency with blockchain - Transaction cost reduction - Government support policies - Personalized marketing campaigns
Interview 2	Focus on scalability barriers of digital technologies in construction projects. Need for stakeholder education to raise awareness of technology benefits. Reference to energy savings and improved efficiency as key outcomes of technology adoption.	Technology scalability challenges - Stakeholder education - Energy consumption savings - Improved operational efficiency
Interview 3	Emphasis on digital platforms for customer interaction. Reference to resistance from some stakeholders to new technologies. Importance of green marketing to attract environmentally conscious customers and strengthen the brand of construction companies.	Interactive digital platforms - Resistance to technology - Green and sustainable marketing - Strengthening construction company branding - Attracting environmentally conscious customers

Table 4. Open Codes of the Study

Core categories	Core category codes	Open Source
Causal Conditions	The need for transparency in construction processes	Transparency in construction contracts - Secure tracking of project data - Reducing fraud in transactions - Ensuring the accuracy of project information - Transparency in the supply chain - Providing reliable reports - Building trust with stakeholders - Reducing financial uncertainties
	Demand for environmental sustainability	Reducing carbon footprint - Using renewable resources - Reducing energy consumption - Protecting the environment - Responding to customers' green expectations - Improving environmental reputation - Attracting green investment - Aligning with sustainable development goals
	Gaining the trust of stakeholders	Building trust with data transparency - Securing transactions with blockchain - Reducing financial risks - Attracting investor support - Increasing resident confidence - Strengthening relationships with contractors - Providing credible evidence of performance - Reducing stakeholder uncertainty
	Reducing operating costs	Optimize energy consumption - Reduce maintenance costs - Increase the efficiency of HVAC systems - Reduce resource waste - Improve project management - Reduce transaction costs - Save on regulatory costs - Increase project profitability
	Competitive pressure for innovation	Need for differentiation in the market - Competing with new technologies - Pressure for innovative branding - Attracting technology-driven customers - Improving competitive position - Responding to market expectations - Developing competitive technologies - Leading the industry

	Improving the efficiency of construction projects	Optimization of construction processes - Reduction of project execution time - Improvement of resource management - Increase of forecast accuracy - Process automation - Improvement of team coordination - Reduction of errors in the project - Increase of operational efficiency
	Tendency towards green branding	Creating a sustainable brand image - Attracting environmentally conscious customers - Promoting environmental benefits - Strengthening brand reputation - Attracting green investment - Sustainability-based marketing - Creating green differentiation in the market - Aligning with environmental values
	Technology-driven competitiveness	Using new technologies - Leading in innovation - Responding to the digital needs of the market - Developing competitive technologies - Attracting technology-driven customers - Improving market position - Strengthening competitive advantage - Responding to technology trends
Background conditions	Digital technology infrastructure	Access to advanced technologies - High-speed internet infrastructure - Data management systems - Integrated digital platforms - Big data analysis tools - Cloud infrastructure - Secure blockchain networks - IoT systems in buildings
	Innovative organizational culture	Embracing innovation in companies - Encouraging risk-taking - A culture of interdisciplinary collaboration - Supporting new ideas - Motivating digital transformation - Focusing on sustainable innovation - Enhancing creativity in teams - Embracing new technologies
	Government support policies	Financial incentives for sustainability - Laws supporting green technology - Subsidies for digital projects - Investment incentive policies - Facilities for startups - Support for smart cities - Environmental laws - Sustainable development programs
	Stakeholder awareness level	Awareness of the benefits of blockchain - Knowledge about artificial intelligence - Knowledge of green technologies - Understanding sustainability needs - Awareness of digital trends - Technology-based training - Recognition of competitive advantages - Awareness of technology challenges
	Access to financial resources	Funding for digital technologies - Investment in green projects - Access to low-interest loans - Financial support for innovation - Attracting private investment - Public-private partnerships - Financing startups - Funding for research and development
	Interdisciplinary collaboration	Collaboration between engineers and marketers - Interaction with policymakers - Partnership with universities - Networking with startups - Interdisciplinary knowledge exchange - Collaboration with industry stakeholders - Creation of multidisciplinary teams - Development of joint projects
	Smart city ecosystems	Smart Cities Development - Urban Digital Infrastructure - Advanced Communication Networks - Smart Management Systems - Urban Data Platforms - Urban Green Technologies - Digital Urban Collaborations - sustainable smart buildings
	Technology adoption in the manufacturing industry	Adoption of artificial intelligence in projects - Use of blockchain in contracts - Adoption of IoT in management - Technology-oriented culture in the industry - Technology training for employees - Digital transformation in manufacturing - Adoption of automated systems - Development of new technologies
Intervening conditions	High technology costs	Software development costs - Digital infrastructure costs - Technology training costs - Blockchain implementation costs - Data

		analysis costs - System maintenance costs - Research and development costs - Technology upgrade costs
	Lack of skilled workers	Shortage of AI experts - Shortage of blockchain experts - Need for specialized training - Shortage of technical staff - Shortage of digital consultants - Need for advanced skills - Shortage of multidisciplinary staff - Limitations in attracting talent
	Scalability challenges	Blockchain Scalability Limitations - AI Scalability Problems - Infrastructure Limitations - Technology Integration Challenges - Data Scalability - Project Scalability Problems - Network Limitations - Market Scalability Challenges
	Resistance to change	Resistance of traditional managers - Residents' hesitation in acceptance - Contractors' resistance - Fear of new technologies - Organizational resistance - Non-acceptance of innovation - Concern about technological complexity - Resistance to digital transformation
	Regulatory complexities	Stringent technology regulations - Privacy regulations - Project permit complexities - Environmental laws - Digital legal restrictions - Legal compliance challenges - Data security regulations - Lack of regulatory transparency
	Limitations of quality data	Lack of reliable data - Data quality issues - Data access limitations - Data collection challenges - Incomplete project data - Need for real-time data - Data integrity issues - Market data limitations
	Intense competition in the market	Competition with traditional technologies - Competition between digital companies - Pressure on pricing - Competition in attracting capital - Competition in innovation - Competition in marketing - Competitive market pressure - Competition in attracting customers
	Insufficient awareness of stakeholders	Ignorance of the benefits of blockchain - Lack of understanding of artificial intelligence - Lack of digital training - Ignorance of sustainability - Lack of market information - Ignorance of green technologies - Lack of competitive awareness - Lack of technical knowledge
Strategies	Personalized campaigns	Customer behavior analysis with artificial intelligence - targeted digital advertising - customized offers - data-driven marketing - use of predictive algorithms - stakeholder preference analysis - artificial intelligence-based advertising - improving customer experience
	Blockchain smart contracts	Automating contracts - Transparency in transactions - Reducing intermediaries - Payment security - Tracking contracts - Reducing financial risks - Ensuring contract execution - Improving trust in transactions
	Stakeholder education	Technology workshops - Sustainability benefits training - Digital awareness programs - Blockchain application training - Artificial Intelligence training - Contractor training - Investor training - Green training programs
	Big data analysis	Market data analysis - Forecasting market trends - Analyzing customer behavior - Optimizing campaigns - Identifying consumption patterns - Analyzing project data - Improving marketing decision-making - Evaluating campaign performance
	Interactive digital platforms	Building construction apps - Customer engagement platforms - Digital management systems - Project transparency platforms - Digital communication tools - Real-time data dashboards - Stakeholder collaboration platforms - Customer-centric digital systems
	Collaboration with technology startups	Partnering with blockchain startups - Collaborating with AI startups - Innovating through startups - Attracting new technologies - Developing digital solutions - Collaborating in R&D - Creating joint projects - Supporting startup innovation

	Visual content and storytelling	Sustainability Visual Advertising - Environmental Storytelling - Engaging Digital Content - Green Advertising Videos - Technology-Based Content - Brand Storytelling - Interactive Digital Advertising - Customer-Centric Content
	Sustainability-based marketing	Promoting environmental benefits - Green and sustainable marketing - Attracting environmentally conscious customers - Developing green campaigns - Introducing clean technologies - Sustainability-based branding - Environmental advertising - Attracting green support
Consequences	Increasing technology adoption	Widespread adoption of artificial intelligence - Adoption of blockchain in projects - Increased use of green technology - Expansion of digital technologies - Adoption of automated systems - Increased use of IoT - Adoption of smart contracts - Development of new technologies
	Reducing carbon footprint	Reducing greenhouse gas emissions - Using clean energy - Reducing energy consumption - Sustainable resource management - Improving environmental efficiency - Reducing environmental impacts - Using green technologies - Protecting natural resources
	Cost savings	Reduce operating costs - Save energy - Reduce maintenance costs - Improve project profitability - Reduce transaction costs - Save resources - Reduce regulatory costs - Increase financial returns
	Gaining the trust of stakeholders	Increasing investor confidence - Attracting resident satisfaction - Strengthening relationships with contractors - Increasing project transparency - Improving brand reputation - Attracting customer support - Increasing market confidence - Strengthening stakeholder relationships
	Strengthening the brand of construction companies	Creating a sustainable brand - Strengthening reputation in the market - Attracting technology-driven customers - Improving competitive position - Green branding - Increasing brand recognition - Attracting new customers - Differentiating in the market
	Developing smart cities	Expanding digital infrastructure - Developing sustainable cities - Improving urban management - Increasing the quality of urban life - Developing urban technologies - Creating smart ecosystems - Improving green infrastructure - Strengthening urban sustainability
	Competitive advantage in the industry	Leading in technology - Attracting competitive customers - Increasing market share - Developing competitive innovations - Improving position in the industry - Attracting competitive investment - Strengthening digital advantage - Technology-driven competitiveness
	Improve operational efficiency	Optimization of construction processes - Reducing project time - Improving resource management - Increasing forecast accuracy - Automating processes - Improving project coordination - Reducing operational errors - Increasing project productivity
Pivotal phenomenon	Entrepreneurial Marketing Model Design	Developing a digital marketing framework - Creating new marketing models - Designing sustainability-oriented models - Integrating digital technologies - Developing entrepreneurial strategies - Creating customer-oriented models - Designing transparent frameworks - Green marketing modeling
	Synergy between artificial intelligence and blockchain	Combining AI and Blockchain - Improving Transparency with Technology - Increasing Marketing Efficiency - Strengthening Data Security - Automating Marketing Processes - Advanced Data Analytics - Improving Digital Decision Making - Creating Integrated Systems
	Engaging stakeholders	Engaging with investors - Attracting contractor participation - Attracting technology-oriented residents - Collaborating with

		policymakers - Engaging with startups - Partnering with universities - Attracting customer support - Multilateral collaborations
	Strengthening environmental sustainability	Reducing environmental impacts - Promoting sustainability in marketing - Attracting green customers - Developing sustainable projects - Using clean technologies - Supporting green goals - Reducing resource consumption - Improving environmental reputation
	Creating a competitive advantage	Leading in innovation - Differentiating in the technology market - Attracting competitive customers - Strengthening position in the industry - Developing competitive technologies - Improving competitive brand - Increasing market share - Digital competitiveness
	Responding to market needs	Responding to sustainability expectations - Attracting technology-driven customers - Responding to digital needs - Improving customer experience - Developing green services - Responding to market trends - Attracting market trust - Improving market interactions
	Development of digital technologies	Expanding artificial intelligence in marketing - Developing blockchain applications - Using IoT in advertising - Developing digital platforms - Creating analytical tools - Expanding green technologies - Developing automated systems - Innovation in marketing technologies
	Strengthening transparency and trust	Transparency in marketing processes - Building trust with blockchain - Improving data transparency - Gaining customer trust - Reducing marketing risks - Providing transparent reports - Strengthening stakeholder relationships - Increasing brand credibility

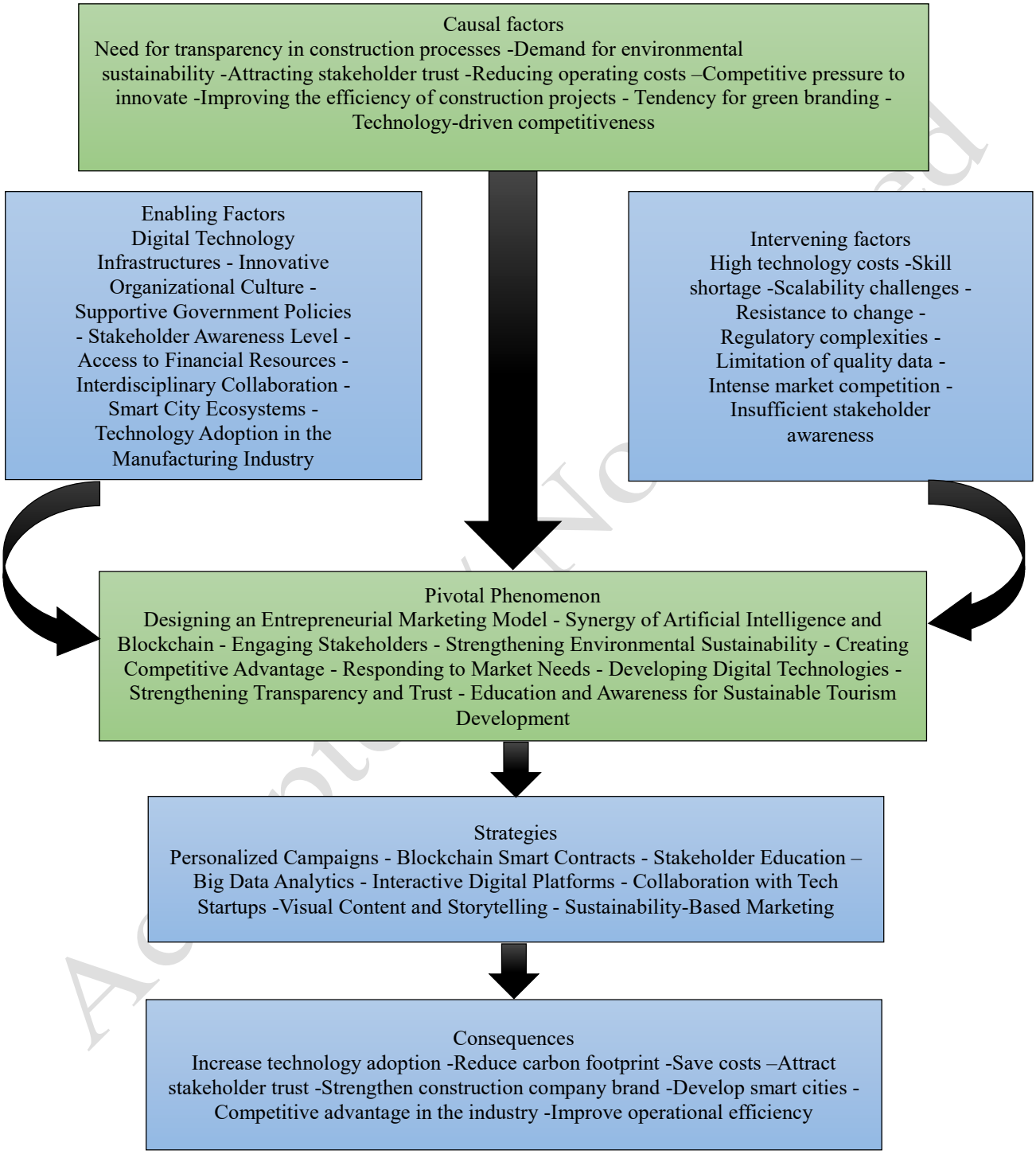

Fig. 2. Research model

3. Discussion

This study aimed to design an entrepreneurial marketing framework for the adoption of decentralized AI and blockchain technologies in environmentally sustainable smart buildings. Using the Corbin and Strauss grounded theory approach and expert perspectives, the final model was developed with six core categories: causal conditions, contextual conditions, intervening conditions, central phenomenon, strategies, and consequences. This integrated process-oriented framework is presented in Figure 2. Figure 2 shows causal drivers at the top shaping the central phenomenon (the design of an entrepreneurial marketing model based on AI-blockchain synergy). Contextual conditions appear on the left as enablers, while intervening conditions on the right act as constraints. Strategies are positioned in the middle-lower section, with consequences at the bottom. The model highlights the need for alignment among drivers, contexts, challenge management, and targeted strategies, emphasizing the dynamic and multidimensional nature of technology adoption in sustainable construction.

3.1. Causal Conditions

Causal conditions provide the primary motivation for adopting decentralized AI and blockchain in smart buildings. Key factors include transparency, environmental sustainability, stakeholder trust, cost reduction, competitive pressure, project efficiency, green branding, and technology-driven competitiveness. Blockchain enhances transparency and trust, while sustainability demands and cost optimization drive adoption. Prior studies confirm these influences: transparency and trust via blockchain (Sivakumar & Visshal, 2025; Zhuang, 2023), environmental sustainability and energy efficiency (Mdoe et al., 2023; Choudhary, 2025), and competitive innovation (Alawag et al., 2024). Interpreted through entrepreneurial marketing theory (Morris et al., 2002) and Diffusion of Innovations Theory (Rogers, 2003), these factors align with value creation, opportunity focus, relative advantage, and compatibility. A notable surprise is the strong role of blockchain transparency and green branding in Iran's conservative construction sector. Compared to prior literature (e.g., Alawag et al., 2024), this study emphasizes implementation costs and expertise gaps more, reframing them as strategic entrepreneurial marketing opportunities (Table 5).

3.2. Contextual Conditions

Contextual conditions include digital infrastructure, innovative organizational culture, supportive government policies, stakeholder awareness, financial resources, interdisciplinary collaboration, and smart city ecosystems. These enable or constrain technology adoption. Prior studies highlight digital infrastructure (Wang & Wang, 2024), organizational culture and collaboration (Popa et al., 2024), government support (Labib, 2024), and awareness (Bajwa et al., 2024). Through entrepreneurial marketing (Morris et al., 2002) and Diffusion of Innovations (Rogers, 2003), they relate to innovativeness, resource leveraging, compatibility, and trialability. In Iran, digital infrastructure and policies stand out prominently. Unlike some studies (e.g., Bajwa et al., 2024), this research prioritizes organizational culture and collaboration. These conditions are elevated to a foundational basis for entrepreneurial marketing strategies (Table 5), a key novelty.

3.3. Intervening Conditions

Intervening conditions are barriers such as high costs, expertise shortages, scalability

issues, resistance to change, regulatory complexities, data limitations, market competition, and low awareness. Prior research identifies similar barriers: costs (Ahmed et al., 2022), expertise shortages (Divaneth et al., 2024), scalability (Bajwa et al., 2024), resistance (Luo, 2022), regulations and data issues (Sleem & Elhenawy, 2023), and competition (Alawag et al., 2024). Interpreted via entrepreneurial marketing (Morris et al., 2002) and Diffusion of Innovations (Rogers, 2003), they relate to resource leveraging, complexity, and observability. In Iran, regulatory complexities and competition are especially prominent. Compared to prior studies (e.g., Alawag et al., 2024; Bajwa et al., 2024), this study prioritizes cost and expertise barriers, reframing them as opportunities for marketing interventions (Table 5), a major contribution.

3.4. Strategies

Strategies include personalized marketing campaigns, blockchain smart contracts, stakeholder education, big data analytics, interactive platforms, startup collaborations, visual storytelling, and sustainability-focused marketing.

Prior studies support these: personalized AI campaigns (Divaneth et al., 2024), smart contracts (Bajwa et al., 2024), education (Luo, 2022), digital content (Sleem & Elhenawy, 2023), and analytics/startup collaboration (Alawag et al., 2024).

Aligned with entrepreneurial marketing (Morris et al., 2002) and Diffusion of Innovations (Rogers, 2003), they enhance customer intensity, innovativeness, and observability. A surprise is the elevation of smart contracts and personalized campaigns as core marketing tools. This study integrates them holistically into an entrepreneurial framework with six actionable recommendations (Table 5), a key novelty.

3.5. Implications

Implications include increased technology adoption, reduced carbon footprints, cost savings, enhanced trust, stronger branding, smart city development, competitive advantage, and operational efficiency. Prior studies note similar outcomes: sustainability and efficiency (Sivakumar & Visshal, 2025; Mdoe et al., 2023), trust and branding (Zhuang, 2023). Through entrepreneurial marketing (Morris et al., 2002) and Diffusion of Innovations (Rogers, 2003), they reflect value creation, customer intensity, and relative advantage. A surprise is the strong link to branding and smart cities via marketing. This study positions implications as direct results of entrepreneurial strategies (Table 5), a notable contribution.

3.6. Central Phenomenon

The central phenomenon is the design of an entrepreneurial marketing framework for decentralized AI and blockchain adoption, integrating technological synergy, stakeholder engagement, sustainability, transparency, and trust.

It yields implications such as reduced emissions, trust, branding, and smart city development (Sivakumar & Visshal, 2025; Zhuang, 2023; Mdoe et al., 2023).

Interpreted via entrepreneurial marketing (Morris et al., 2002) and Diffusion of Innovations (Rogers, 2003), it emphasizes innovativeness, value creation, relative advantage, and compatibility. A surprise is its transformation into a comprehensive marketing framework. This study shifts it from technical to practical and user-centric, integrated with actionable strategies (Table 5), representing a key novelty.

4. Conclusion

This study This study presents a comprehensive entrepreneurial marketing framework that provides a systematic approach for the adoption and implementation of decentralized artificial intelligence and blockchain technologies in environmentally sustainable smart buildings. By emphasizing causal, contextual, and intervening conditions, strategies, consequences, and the central phenomenon, the framework offers a set of practical solutions to promote these technologies.

The proposed entrepreneurial marketing model in this research expands and enriches existing theoretical frameworks. It integrates the key dimensions of entrepreneurial marketing by Morris et al. (2002) — including opportunity focus, innovativeness, calculated risk-taking, and customer intensity — with Rogers' (2003) Diffusion of Innovations theory, thereby offering an integrated and context-specific approach. While previous studies have largely examined these two theories separately or within general technological contexts, the present model, grounded in grounded theory methodology, combines them into a process-oriented and operational framework tailored to the sustainable construction industry in Iran. This model transforms marketing from a mere communication tool into a transformative strategic instrument that capitalizes on the synergy between decentralized artificial intelligence and blockchain technology. Specifically, artificial intelligence enables personalized and data-driven customer engagement through behavioral analysis, while blockchain enhances transparency and stakeholder trust through smart contracts and immutable transaction records. This approach not only deepens the theoretical understanding of technology adoption in complex and uncertain environments but also translates abstract theoretical concepts into six practical and actionable marketing strategies, thereby bridging the gap between innovation diffusion theory and entrepreneurial marketing practice in the domain of sustainable smart buildings.

In this regard, addressing barriers such as high implementation costs and the shortage of specialized expertise, alongside the adoption of innovative strategies such as personalized campaigns and smart contracts, can significantly accelerate the technology adoption process. This model not only contributes to environmental sustainability but also enhances transparency, stakeholder trust, competitive advantage, and operational efficiency within the construction industry. Furthermore, future research could focus on the empirical evaluation of this framework in real-world projects and the examination of its long-term impacts.

Based on the findings of this study, six practical, precise, and actionable recommendations are provided for designing and implementing entrepreneurial marketing strategies to facilitate the adoption of decentralized artificial intelligence and blockchain technologies in environmentally sustainable smart buildings:

1. Implementing AI-Powered Personalized Marketing Campaigns

Leverage AI algorithms to analyze customer behavior and preferences, designing targeted marketing campaigns. These campaigns can deliver customized promotional content (e.g., tailored offers for residents or investors), increasing engagement and adoption of smart technologies. For example, using AI analytics to identify the needs of environmentally conscious customers and offering tailored solutions can improve adoption rates.

2. Utilizing Blockchain Smart Contracts for Transaction Transparency

Employ blockchain smart contracts to automate and secure transactions and

contracts in construction projects. These contracts ensure transparency in financial and operational processes, fostering trust among investors and contractors. For instance, developing a blockchain platform for secure payment and contract tracking can reduce financial risks and enhance stakeholder trust.

3. Conducting Educational Workshops to Increase Stakeholder Awareness

Organize specialized training programs and workshops for stakeholders (e.g., investors, contractors, and residents) to raise awareness of the benefits of decentralized AI and blockchain in smart buildings. These programs should focus on environmental benefits, cost savings, and improved efficiency. For example, educating contractors about blockchain applications in supply chain management can reduce resistance to technology adoption.

4. Developing Interactive Digital Platforms to Enhance Customer Engagement

Design digital platforms, such as mobile applications or web dashboards, that provide real-time information on smart building performance (e.g., energy consumption or data security). These platforms can strengthen customer engagement and promote green branding. For instance, an application displaying transparent blockchain-based reports can build resident trust.

5. Collaborating with Technology Startups for Marketing Innovation

Partner with startups active in AI and blockchain to develop innovative marketing solutions. These collaborations can include creating advanced analytical tools or technology-driven marketing platforms to attract tech-savvy customers. For example, partnering with a blockchain startup to develop project data tracking systems can enhance a company's competitive position.

6. Producing Visual and Storytelling Content Emphasizing Environmental Sustainability

Utilize engaging visual content, such as promotional videos and environmental storytelling, to highlight the benefits of smart buildings. This content should focus on reducing carbon footprints, energy savings, and improving quality of life to attract environmentally conscious customers. For example, a video campaign narrating the success story of a smart building powered by blockchain and AI can enhance brand reputation.

These recommendations, grounded in the study's findings, particularly the strategies and implications categories, are designed to be practically implemented in smart building projects to accelerate the adoption of decentralized AI and blockchain technologies and contribute to the development of sustainable and smart cities.

Table 5. Comparison of the results of the present study

Author/Year	Key Outcome Reported in Cited Study	Overlap with Present Study	Novelty/Difference of Present Study (Arman & Feiz)
Zhuang (2023)	Transparency in contracts & data, reduced financial ambiguity, higher stakeholder trust	Aligned with "transparency & trust"	Present study turns this transparency into actionable marketing strategies (smart contracts + personalized campaigns).
Ahmed et al. (2022)	Energy optimization, GHG reduction, better resource management	Aligned with "reduced carbon footprint" & "cost savings"	Present study links these technical outcomes directly to an entrepreneurial marketing framework.

Ahmed et al. (2022)	Smart-city development, improved urban quality of life, expanded sustainable infrastructure	Aligned with "smart-city development"	Present study operationalizes this macro outcome through practical marketing strategies and interactive platforms.
Wang & Wang (2024)	Importance of digital infrastructure & high-speed connectivity	Aligned with contextual conditions	Present study transforms this infrastructure into the foundation for digital marketing execution.
Popa et al. (2024)	Innovative organizational culture & interdisciplinary collaboration	Aligned with startup collaboration strategy	Present study makes such collaboration one of the six core marketing recommendations.
Badidi (2022)	Government incentives and green-tech subsidies	Aligned with contextual conditions	Present study demonstrates how marketing can amplify the impact of these policies.
Alawag et al. (2024)	Stakeholder awareness → reduced resistance to change	Aligned with education & workshop strategy	Present study converts awareness into concrete educational workshops and storytelling content as marketing tools.
Plevris et al. (2022)	High implementation costs, especially for SMEs	Aligned with intervening conditions	Present study turns this barrier into a competitive advantage via personalized marketing and blockchain transparency.
Salah et al. (2019)	Shortage of AI & blockchain expertise	Aligned with intervening conditions	Present study offers marketing-oriented solutions: startup partnerships + training programs.
Li et al. (2024)	Scalability challenges & infrastructure limitations	Aligned with intervening conditions	Present study uses interactive digital platforms to demonstrate scalability to stakeholders.
Ebrahim et al. (2022)	Resistance from traditional managers & contractors	Aligned with intervening conditions	Present study counters resistance with visual/storytelling content and educational workshops.
Kumar (2024)	Regulatory complexity & lack of quality data	Aligned with intervening conditions	Present study simplifies complexity via blockchain transparency and educational campaigns.
Denis et al. (2025)	Intense market competition & insufficient stakeholder awareness	Aligned with intervening conditions	Present study directly targets both barriers with its six precise marketing strategies.
Present Study (Arman & Feiz, 2025)	Comprehensive entrepreneurial marketing framework with 6 actionable recommendations	All of the above + turning barriers into opportunities	The first and only integrated entrepreneurial marketing framework that translates all previous technical, environmental, and organizational outcomes into concrete, implementable marketing strategies.

5. Research Limitations

Limitations are an inevitable part of any research and can pave the way for future studies and innovative solutions. Some limitations of this study include:

1. Qualitative data analysis based on an interpretive paradigm may be influenced by the researcher's subjectivity and assumptions. However, efforts were made in this study to minimize bias by focusing on participants' experiences.

2. Data collection was conducted solely through interviews, which could be strengthened by incorporating complementary methods.

3. Conducting the study within a specific timeframe may not reflect dynamic changes in user behavior or market trends. Longitudinal

studies are recommended to examine these changes.

4. The gender composition of the sample (90% male) may limit the generalizability of the findings concerning stakeholder perspectives, as women's viewpoints or more gender-diverse perspectives are underrepresented. Future research could mitigate this by employing more gender-balanced samples."This addition strengthens the transparency of the study's limitations. The change is highlighted in the revised manuscript for easy reference

5. The exclusive focus of the sample on Iranian experts may limit the generalizability of the findings to other countries, as culture-specific, regulatory, and economic factors in Iran could influence the perspectives and proposed strategies. Future research could mitigate this by including experts from diverse international contexts.

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