Sundara Advanced Research on Artificial Intelligence (Sundara)
Vol. 1, No. 2, October, 2025, pp. 82−89
E-ISSN: xxxx-xxxx | P-ISSN: xxxx-xxxx, DOI:10.34306

Artificial Intelligence Integration for Sustainable Business Model Innovation Insights from Global Startups

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Article Info

Article history:

Submission August 24, 2025
Revised September 18, 2025
Accepted October 17, 2025
Published October 25, 2025

Keywords:

Artificial Intelligence
SBM
Technopreneurship
Data Analytics
AI Products Services

ABSTRACT

The rapid growth of startups integrating Artificial Intelligence (AI) into their business models reflects the ongoing digital transformation and the need for innovative strategies to sustain competitiveness. Startups are increasingly leveraging AI technologies to automate processes, analyze data, and enhance decision making, positioning AI as a central element in shaping the modern entrepreneurial landscape. **This study aims to analyze** and compare AI-driven business models with traditional IT organizations to identify their differences in value creation, strategic implementation, and operational efficiency. **Using a dataset of 162** global startups collected from Kaggle, the research applies a systematic categorization framework to identify key patterns and develop a taxonomy of AI-based business models, including Deep Tech Researcher, Data Analytics Provider, AI Product/Service Provider, and AI Development Facilitator. **The findings reveal** four archetypal AI business models, each offering unique value propositions through data driven insights, automation, and personalized digital services. The results also demonstrate that AI adoption enhances innovation, efficiency, and decision making while presenting challenges related to ethics, data governance, and talent readiness. **This study concludes** that AI not only acts as a technological enabler but also as a strategic catalyst for sustainable business model innovation. The developed taxonomy contributes to a deeper understanding of AI role in entrepreneurship and provides valuable insights for practitioners and researchers to guide future innovation in AI-driven startup ecosystems.

DOI: https://doi.org/10.34306/sundara.v1i1.37

1. INTRODUCTION

The integration of Artificial Intelligence in global startup ecosystems directly contributes to Sustainable Development Goal (SDG) 8, which emphasizes promoting sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all [1]. AI-driven startups are generating new opportunities in high value industries such as data analytics, automation, and digital services, fostering innovation

driven economies. By leveraging intelligent systems, startups can increase productivity, optimize operations, and create more efficient work processes, ultimately driving global economic competitiveness [2]. This transformation not only enhances business agility but also empowers human capital development by introducing new job categories that demand advanced technological and analytical skills [3].

This study also aligns with SDG 9, which focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation [4]. The emergence of AI-based business models represents a major step toward strengthening industrial innovation through data driven processes and intelligent automation. By integrating AI into their operations, startups develop adaptive infrastructures capable of supporting predictive analytics, efficient resource allocation, and continuous innovation [5]. These advancements help establish smarter industries that combine digital transformation with sustainability, encouraging both established corporations and emerging enterprises to adopt intelligent, future-ready business practices [6].

Furthermore, AI integration in startup business models supports SDG 12, which advocates for responsible consumption and production [7]. AI enables startups to optimize supply chains, reduce resource waste, and make environmentally conscious decisions through data analytics and predictive modeling [8]. Intelligent systems help organizations identify more sustainable production patterns and minimize inefficiencies, leading to cleaner and more efficient business operations [9]. As startups increasingly incorporate ethical AI frameworks and transparent governance mechanisms, they contribute to building a sustainable entrepreneurial ecosystem that balances profitability with environmental and social responsibility [10].

2. LITERATURE REVIEW

The Literature Review highlights the crucial role of Artificial Intelligence (AI) in driving innovation within technopreneurial business models [11]. AI not only enhances automation but also strengthens value creation, adaptability, and sustainable competitiveness through predictive analytics, automation, and data driven insights [12]. For technopreneurs, AI enables the development of new value propositions and innovative revenue mechanisms such as AI-as-a-Service, data monetization, and product personalization, helping small and emerging firms compete with larger corporations through agility and algorithmic efficiency [3]. More broadly, AI fosters creativity, experimentation, and digital transformation by reshaping traditional operational structures into intelligent, adaptive systems that promote sustainability, ecosystem collaboration, and continuous innovation [13]. However, integrating AI also presents challenges related to data ethics, talent readiness, and regulatory uncertainty. Therefore, successful adoption requires not only technical expertise but also strategic vision, responsible governance, and continuous learning [14, 15].

2.1. AI as a Catalyst for Business Model Innovation

AI acts as both a technological and strategic enabler of Business Model In novation (BMI) [16]. Research shows that AI supports the creation of new value propositions through predictive analytics, customer personalization, and intelligent service design [17]. Or technopreneurs, AI facilitates the emergence of entirely new revenue streams such as “AI-as-a-Service,” personalized digital platforms, and data monetization [18].

2.2. Scope and Overview

The integration of Artificial Intelligence (AI) has become a transformative force in shaping innovative technopreneurial business models [19]. AI not only supports automation but also drives value creation, business agility, and sustainable competitiveness. Systematic reviews emphasize that AI enables new forms of entrepreneurial innovation by combining data-driven insights, intelligent automation, and predictive decision-making capabilities [20].

3. RESEARCH METHODOLOGY

The Research Methodology section of your paper explains a systematic, data driven approach to analyzing AI based technopreneurial business models [21]. The study began by identifying key business characteristics across global startup ecosystems using a stratified random sampling method to select 162 representative AI startups, ensuring diversity and accuracy [22]. Data were collected primarily from Kaggle, focusing on firms in deep learning, natural language processing, computer vision, and robotics [23]. Strict selection criteria excluded startups with funding above $1 million or founded after 2022 to ensure relevance to current AI developments [24]. The dataset comprising 8,076 companies was refined into 162 cases for in depth analysis.

Multiple data sources, including company websites, business portals, white papers, and investor interviews, were examined, averaging 3.8 sources per startup to ensure reliability [25]. The researchers then developed a categorization framework to analyze patterns in business strategies and identify four dominant AI driven business model archetypes, forming the empirical foundation for subsequent results and discussion [26].

3.1. Determining Business Characteristics

The subsection Determining Business Characteristics explains that the researchers identified key attributes of global AI startups by selecting 162 diverse startups using stratified random sampling to ensure representative coverage of the global AI ecosystem [27]. A systematic categorization framework was then developed to analyze business strategies across countries, resulting in the identification of four dominant business models [28]. The data were sourced from Kaggle, focusing on startups involved in deep learning, NLP, computer vision, and robotics, and applying strict criteria that excluded companies with funding above $1 million or founded after 2022, resulting in a refined dataset of 8,076 companies to ensure reliability and relevance [29].

Table 1. Criteria for Selecting Startups

Subject	Criteria	Rationale
State of Operation	Raised 1M+ and stable	Include solid startups with clear plans.
Year of Founding	After 2022	Focus on firms adopting recent AI advances.
Website	Available in German or English	Ensure enough data to classify startups.
Business model	Core product or service uses AI	Include only companies relevant to the study.
Business mode	Main product or service involves AI	Include only study-relevant companies.

Table 1 presents the criteria for selecting startups, which include five key aspects (1) companies must have raised over $1 million and be stable, (2) founded after 2022 to reflect the latest AI developments, (3) have websites in English or German for accessible data, and (4–5) have core or main products and services directly involving AI [30]. These criteria ensured that only financially stable, up to date, and AI focused startups were included, providing a strong foundation for analyzing global AI business models [31].

3.2. Generating Case Dataset

This process resulted in a curated collection of 164 global startups, detailed in Table 1. Various data sources, including websites, business portals like Kaggle, white papers, and investor interviews, were utilized to comprehensively understand each startup operations, performance, and strategic direction [32]. On average, 3.8 different data sources per startup were consulted, demonstrating our commitment to thorough research.

3.3. Determining Business Characteristics

This study identify crucial business characteristics, focusing on global startup environments and unique attributes of our firm [33]. We start by selecting 162 diverse global startups as representative cases, ensuring a representative sample through stratified random sampling techniques to capture the heterogeneity of global AI startup ecosystems [34]. We then develop a systematic categorization system tailored for global operations, analyzing business strategies across various countries. This results in a comprehensive historical analysis revealing four dominant business models [35]. The methodology involves selecting 162 global startups and developing a systematic categorization to reveal dominant business models.

4. RESULTS AND DISCUSSION

The Results and Discussion section reveals that the integration of Artificial Intelligence (AI) significantly enhances technopreneurial innovation by automating processes, enabling predictive analytics, and improving service personalization [36]. The study identifies four main AI driven business model archetypes deep technology innovator, data and analytics providers, AI based product or service developers, and AI enablers each with distinct revenue structures and capability requirements [37]. AI adoption improves operational efficiency and decision making but faces challenges such as data quality, model bias, and the need for technical expertise. The discussion highlights that AI incorporation creates new value propositions and revenue mechanisms like feature based subscriptions, licensing, and customized AI services [38]. Success in AI driven technopreneurship depends on an organization ability to embed AI into its business processes supported by strong talent, infrastructure, and adaptive management. Additionally, ethical and governance challenges including data privacy and fairness necessitate transparent and accountable AI frameworks [36].

4.1. Research Implementation: Categorizing Global Startup Business Models

When classifying Worldwide Startup business models based on their value propositions, a detailed strategy includes key criteria such as principal AI technology, data type, data source, and hardware provision [39]. ”Principal AI technology” refers to core AI technology essential for a company functionality and marketing.

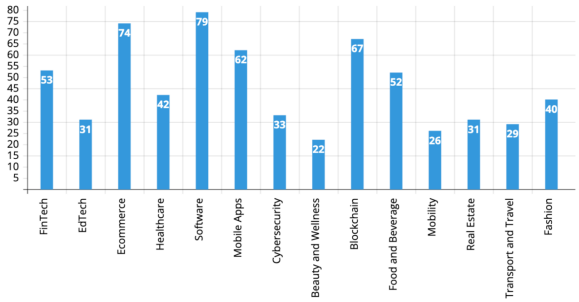

Figure 1. Data Visualization of the Worldwide Startup

Figure 1 Data Visualization of the Worldwide Startup illustrates the distribution of Artificial Intelligence (AI) based startups across various global industry sectors [40]. The visualization shows that the Software sector has the highest number of startups (79), followed by E-commerce (74), Blockchain (67), and Food and Beverage (52), indicating that these fields have the most extensive adoption of AI for business innovation. Meanwhile, sectors such as Real Estate (26), Mobility (29), and Cybersecurity (22) have fewer startups, reflecting that AI adoption in these areas is still developing [41].

Characteristic						Dimension	
Software		Software and services		Software, services and physical products		Offering	Value proposition
B2C		B2B		B2B and B2C		Customer Segment	
Cost saving	Cost saving and additional revenue		Additional revenue		Intangible value	Monetary value	
Co-creation	Investment and trade	Energy consumption efficiency	Maintenance and safety	Energy Storage	Decision and strategy	Key activity	
Computer Vision	Natural Language		Data Processing		Robotics	AI Technology	Value architecture
Independent		Central		Decentral		Energy System	Value Network
Energy Generation	Consumption Oriented		Distributed Oriented		Overarching	Supply Chain	
Product & License		Subscription		Performance Based		Revenue Stream	Value Finance

Figure 2. Business Model Taxonomy of AI Startups

Figure 2 Business Model Taxonomy of AI Startups illustrates the classification framework of AI-based startup business models across four main dimensions: Value Proposition, Value Architecture, Value Network, and Value Finance. In the Value Proposition dimension, AI startups combine software products and services targeting both B2B and B2C segments, emphasizing cost efficiency, additional revenue generation, and intangible value through energy efficiency and strategic decision making. The Value Architecture highlights the use of core AI technologies such as Computer Vision, Natural Language Processing, Data Processing, and Robotics to support key business activities. The Value Network dimension showcases variations in energy systems and supply chainsranging from independent to distributed models reflecting operational flexibility among AI startups. Finally, the Value Finance dimension outlines diverse revenue models including product licensing, subscriptions, and performance based income.

5. MANAGERIAL IMPLICATIONS

Managers should strategically invest in AI infrastructure, skilled talent, and analytical systems to build sustainable innovation capabilities. Developing flexible business models is essential, enabling revenue generation through AI-based subscriptions, licensing, or customized solutions. Strong data governance and ethical frameworks must be established to ensure transparency, fairness, and stakeholder trust. Organizations are encouraged to adopt rapid experimentation and market validation approaches to align AI-driven products

with customer needs. Leadership plays a key role in fostering an adaptive culture that supports continuous learning and innovation. Furthermore, implementing AI technologies requires a commitment to long-term development, which includes addressing the challenges of data quality, model bias, and scalability issues. Finally, effective risk management and organizational readiness are crucial to addressing challenges related to data quality, bias, and the cost of AI implementation, while ensuring that AI initiatives align with overall strategic objectives.

6. CONCLUSION

The rapid integration of Artificial Intelligence (AI) in the entrepreneurial ecosystem has fundamentally transformed how startups innovate, operate, and create value. This study demonstrates that AI acts as both a technological driver and strategic enabler for developing novel business models that differ significantly from traditional IT based organizations. By analyzing 162 global startups, the research identified four archetypal business models Deep Tech Researcher, Data Analytics Provider, AI Product/Service Provider, and AI Development Facilitator each offering distinctive approaches to leveraging AI technologies for competitive advantage and sustainable innovation. These findings confirm that AI not only enhances operational efficiency and decision making but also introduces new forms of value creation through data utilization, automation, and intelligent personalization.

Moreover, the study underscores that successful AI driven technopreneurship relies on the alignment between technology, organizational capability, and ethical governance. Startups that effectively integrate AI into their business strategies tend to demonstrate agility, adaptability, and scalability in dynamic markets. However, the research also highlights persistent challenges related to data quality, bias, talent scarcity, and regulatory uncertainty, all of which require strong ethical frameworks and responsible governance. Therefore, the implementation of AI should go beyond technical innovation, emphasizing transparency, inclusivity, and continuous learning to ensure that technology serves both business goals and societal well being.

Finally, this study contributes to the broader understanding of AI role in entrepreneurship and provides a foundation for future research exploring the evolving interplay between AI technologies and business strategies. The proposed taxonomy serves as a useful tool for both academics and practitioners in categorizing and understanding AI based business model innovations globally. Future studies should investigate how emerging technologies such as generative AI, edge computing, and autonomous systems will further reshape technopreneurial models and value creation mechanisms.

7. DECLARATIONS

7.1. About Authors

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7.2. Author Contributions

Conceptualization: WU; Methodology: MM; Software: FP; Validation: OP and ES; Formal Analysis: OP and FP; Investigation: MM; Resources: ES; Data Curation: MM; Writing Original Draft Preparation: WU and MM; Writing Review and Editing: OP and ES; Visualization: FP; All authors, WU, MM, FP, OP, and ES, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7.4. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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